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Federal Motor Vehicle Safety Standards; Head Restraints; Final Rule

DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Part 571

[Docket No. NHTSA–2004–19807]

RIN 2127–AH09

Federal Motor Vehicle Safety Standards; Head Restraints

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

ACTION: Final rule.

SUMMARY: This final rule upgrades NHTSA's head restraint standard in order to reduce whiplash injuries in rear collisions. For front seats, the rule establishes a higher minimum height requirement, a requirement limiting the distance between the back of an occupant's head and the occupant's head restraint, as well as a limit on the size of gaps and openings within head restraints. The rule also establishes new strength and dynamic compliance requirements, and amends most existing test procedures. In addition, the rule establishes requirements for head restraints voluntarily installed in rear outboard designated seating positions. The upgraded standard becomes mandatory for all vehicles manufactured on or after September 1, 2008. Until that time, the manufacturers may comply with the existing NHTSA standard, the upgraded NHTSA standard or the current European regulations.

DATES: *Effective Date:* This rule is effective March 14, 2005.

Incorporation by reference: The incorporation by reference of certain publications listed in the regulations is approved by the Director of the Federal Register as of March 14, 2005.

Petitions: Petitions for reconsideration must be received by January 28, 2005.

ADDRESSES: Petitions for reconsideration should refer to Docket No. NHTSA–2004–19807 and be submitted to: Administrator, Room 5220, National Highway Traffic Safety Administration, 400 Seventh Street, SW., Washington, DC 20590. Please see the Privacy Act heading under Regulatory Notices.

FOR FURTHER INFORMATION CONTACT: For non-legal issues, you may contact Louis Molino of the Office of Rulemaking, Office of Crashworthiness Standards, Light Duty Vehicle Division, NVS–112, (Phone: (202) 366–2264; Fax: (202) 366–4329; E-mail: *Louis.Molino@nhtsa.dot.gov*).

For legal issues, you may contact George Feygin of the Office of Chief Counsel, NCC–112, (Phone: (202) 366–2992; Fax (202) 366–3820; E-mail: *George.Feygin@nhtsa.dot.gov*).

You may send mail to both of these officials at the National Highway Traffic Safety Administration, 400 7th Street, SW., Washington, DC 20590.

SUPPLEMENTARY INFORMATION:

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I. Executive Summary

This final rule upgrades Federal Motor Vehicle Safety Standard No. 202, *Head Restraints* (FMVSS No. 202). The standard, which seeks to reduce whiplash injuries in rear collisions, currently requires head restraints for front outboard designated seating positions in passenger cars and in light multipurpose passenger vehicles, trucks and buses.

To provide better whiplash protection for a wider range of occupants, this rule requires that front outboard head restraints meet more stringent height requirements. Fixed front head restraints must be not less than 800 mm. In their lowest adjustment position, adjustable head restraints must not be lower than 750 mm, and in their highest position, they must be at least 800 mm. To reduce the distance that a vehicle occupant's head can be whipped backward in a rear end crash, this rule establishes new requirements limiting backset in front seats, *i.e.*, the distance between the back of a person's head and his or her head restraint, and limiting the size of gaps and openings in the restraints. The rule also establishes new strength and position retention requirements. Finally, it significantly amends the dynamic compliance test option currently in the standard to encourage continued development and use of ''active'' head restraint systems because the test is designed to allow a manufacturer the flexibility necessary to offer innovative active head restraint designs while still ensuring a minimal level of head restraint performance.

After a careful consideration of the public comments and further analysis of our proposal to require head restraints in each rear outboard designated seating position, we have decided not to adopt that proposal. In the Notice of Proposed Rulemaking (NPRM),[1] we expressed concern that the proposal had a high cost per equivalent life saved. We have now made a more refined estimate of costs and benefits and found that the cost per equivalent life saved for such a requirement is even greater than originally thought. In response to the NPRM, several manufacturers raised visibility concerns associated with mandatory rear head restraints in all vehicles. While not a universal problem, we believe reduced visibility is a legitimate problem in some vehicles. Finally, in commenting on the NPRM, vehicle manufacturers expressed concern that adoption of the requirement would reduce vehicle utility by interfering with or even reducing the ability to provide the sort of folding seats currently available in ''multi-configuration'' vehicles such as vans and multipurpose vehicles. We believe that those concerns may have some merit.

However, in order to ensure that head restraints voluntarily installed in rear outboard seating positions do not pose a risk of exacerbating whiplash injuries, this final rule requires that those head restraints meet certain height, strength, position retention, and energy absorption requirements. NHTSA notes that the head restraint regulation of the United Nations/Economic Commission

[1] *See* 66 FR 968 (January 4, 2001).

for Europe (UN/ECE) similarly does not mandate rear seat head restraints, but does regulate the performance of voluntarily installed ones. The ECE regulation is discussed at greater length several paragraphs below and in Appendix A.

In the future stages of our efforts to improve occupant protection in rear impacts,[2] NHTSA intends to evaluate the performance of head restraints and seat backs as a single system to protect occupants, just as they work in the real world, instead of evaluating their performance separately as individual components. Accordingly, in making our decisions about the upgraded requirements for head restraints in this final rule, we sought, *e.g.*, through upgrading our dynamic test procedure option, to make those requirements consistent with the ultimate goal of adopting a method of comprehensively evaluating the seating system.

This final rule harmonizes the FMVSS requirements for head restraints with the head restraint regulation of the UN/ECE, except to the extent needed to provide increased safety for vehicle occupants or to facilitate enforcement.[3] In some instances, a desire to achieve increased safety in a cost effective manner made it necessary for us to go beyond or take an approach different from that in the ECE regulation.

While some of the requirements of this final rule are more stringent than those of the ECE regulation, the latter is functionally equivalent to the current FMVSS No. 202.[4] For this reason, in the interim before the mandatory compliance date of this rule (September 1, 2008), the agency is giving manufacturers the option of complying with any of three alternatives: the existing FMVSS No. 202, the ECE 17, or the new, upgraded FMVSS No. 202, designated as FMVSS No. 202a.[5]

The agency estimates that approximately 272,464 whiplash injuries occur annually. This final rule will result in approximately 16,831 fewer whiplash injuries, 15,272 involving front seat occupants and 1,559 involving rear seat occupants. The estimated average cost in 2002 dollars, per vehicle, of meeting this rule will be $4.51 for front seats, and $1.13 for rear seats currently equipped with head restraints, for a combined cost of $5.42.[6] The cost per year is estimated to be $70.1 million for front head restraints and $14.1 million for optional rear head restraints, for a combined annual cost of $84.2 million. This final rule is economically significant because we estimate that the final rule will result in economic benefits in excess of $100 million.

II. Background

Vehicle manufacturers currently use three types of head restraints to meet the requirements of FMVSS No. 202. The first type is the ''integral head restraint,'' which is non-adjustable and is built into the seat. It typically consists of a seat back that extends high enough to meet the height requirement of the standard. The second type is the ''adjustable'' head restraint, which consists of a separate cushion that is attached to the seat back, typically by a two sliding metal shafts. Adjustable head restraints typically adjust vertically to accommodate different occupant seating heights. Some also provide adjustments to allow the head restraint to be moved closer to the occupant's head. The third type is the active head restraint system, which deploys in the event of a collision to minimize the potential for whiplash. During the normal vehicle operation, the active head restraint system is retracted.

a. The Safety Concern

Whiplash injuries are a set of common symptoms that occur in motor vehicle crashes and involve the soft tissues of the head, neck and spine. Symptoms of pain in the head, neck, shoulders, and arms may be present along with damage to muscles, ligaments and vertebrae, but in many cases lesions are not evident. The onset of symptoms may be delayed and may only last a few hours; however, in some cases, effects of the injury may last for years or even be permanent. The relatively short-term symptoms are associated with muscle and ligament trauma, while the long-term ones are associated with nerve damage.

Based on National Analysis Sampling System (NASS) data, we estimate that between 1988 and 1996, 805,581 whiplash injuries[7] occurred annually in crashes involving passenger cars and LTVs (light trucks, multipurpose passenger vehicles, and vans). Of these whiplash injuries, 272,464 occurred as a result of rear impacts. For rear impact crashes, the average cost of whiplash injuries in 2002 dollars is $9,994 (which includes $6,843 in economic costs and $3,151 in quality of life impacts, but not property damage), resulting in a total annual cost of approximately $2.7 billion.

b. Understanding Whiplash

Although whiplash injuries can occur in any kind of crash, an occupant's chances of sustaining this type of injury are greatest in rear-end collisions. When a vehicle is struck from behind, typically several things occur in quick succession to an occupant of that vehicle. First, from the occupant's frame of reference, the back of the seat moves forward into his or her torso, straightening the spine and forcing the head to rise vertically. Second, as the seat pushes the occupant's body forward, the unrestrained head tends to lag behind. This causes the neck to change shape, first taking on an S-shape and then bending backward. Third, the forces on the neck accelerate the head, which catches up with—and, depending on the seat back stiffness and if the occupant is using a shoulder belt, passes—the restrained torso. This motion of the head and neck, which is like the lash of a whip, gives the resulting neck injuries their popular name.

Previous regulatory approach. As discussed in the NPRM preceding this final rule, a historical examination of head restraint standards in this country indicates that the focus has been the prevention of neck hyperextension (the rearward movement of the head and neck over a large range of motion relative to the torso), as opposed to controlling lesser amounts of head and neck movement in a crash. The predecessor to FMVSS No. 202 was General Services Administration (GSA) Standard 515/22, which applied to vehicles purchased by the U.S. Government and went into effect on October 1, 1967. GSA 515/22 required that the top of the head restraint achieve a height 700 mm (27.5 inches (in)) above the H-point.[8] Also in 1967, research

[2] As part of this effort, NHTSA issued a final rule upgrading the performance of vehicle fuel systems in rear impacts. (68 FR 67068, December 1, 2003).

[3] The regulation, adopted by the UN/ECE's Working Party 29, World Forum for Harmonization of Vehicle Regulations, is ECE 17, Uniform Provisions Concerning the Approval of Vehicles With Regard to the Seats, Their Anchorages, and Any Head Restraints (*http://www.unece.org/trans/main/wp29/wp29regs/r017r4e.pdf*). A comparison of this final rule with ECE 17 is in Appendix A.

[4] We determined that the current FMVSS No. 202 is functionally equivalent to the applicable ECE regulation using the method described in Appendix B of 49 CFR part 553.

[5] Once the FMVSS No. 202a becomes fully effective on September 1, 2008, it will be re-designated as FMVSS No. 202.

[6] Because this rule does not require head restraints in rear outboard designated seating positions, it does not impose any costs associated with installing head restraints where none were previously installed.

[7] Non-contact Abbreviated Injury Scale (AIS) 1 neck.

[8] The H-point is defined by a test machine placed in the vehicle seat (Society of Automotive Engineers (SAE) J826, July 1995). From the side, the H-point represents the pivot point between the torso and upper leg portions of the test machine. It can be

Continued

using staged 48 kilometer per hour (kph) (30 mile per hour, mph) crashes concluded that a head restraint 711 mm (28 in) above the H-point was adequate to prevent neck hyperextension of a 95th percentile male. FVMSS No. 202, which became effective on January 1, 1969, required that head restraints be at least 700 mm (27.5 in) above the seating reference point or limit the relative angle between the head and the torso to 45 degrees or less during a dynamic test.

Current knowledge. There are many hypotheses as to the mechanisms of whiplash injuries. Despite a lack of consensus with respect to whiplash injury biomechanics, there is research indicating that reduced backset will result in reduced risk of whiplash injury. For example, one study of Volvo vehicles reported that, when vehicle occupants involved in rear crashes had their heads against the head restraint (an equivalent to 0 mm backset) during impact, no whiplash injury occurred.[9] By contrast, another study showed significant increase in injury and duration of symptoms when occupant's head was more than 100 mm away from the head restraint at the time of the rear impact.[10]

In addition, the persistence of whiplash injuries in the current fleet of vehicles indicates that the existing height requirement is not sufficient to prevent excessive movement of the head and neck relative to the torso for some people. Specifically, the head restraints do not effectively limit rearward movement of the head of a person at least as tall as the average occupant. Research indicates that taller head restraints would better prevent whiplash injuries because at heights of 750 to 800 mm, the head restraint can more effectively limit the movement of the head and neck.

In a recent report from the Insurance Institute for Highway Safety (IIHS), Farmer, Wells, and Lund examined automobile insurance claims to determine the rates of neck injuries in rear end crashes for vehicles with the improved geometric fit of head restraints (reduced backset and increased head restraint height).[11] Their data indicate that these improved head restraints are reducing the risk of whiplash injury. Specifically, there was an 18 percent reduction in injury claims. Similarly, NHTSA computer generated models have shown that the reduction of the backset and an increase in the height of the head restraint reduces the level of neck loading and relative head-to-torso motion that may be related to the incidence of whiplash injuries.[12]

With respect to impact speeds, research and injury rate data indicate that whiplash may occur as a result of head and neck movements insufficient to cause hyperextension. Staged low speed impacts indicate that mild whiplash symptoms can occur without a person's head exceeding the normal range of motion. This means that our previous focus on preventing neck hyperextension is insufficient to adequately protect all rear impact victims from risks of whiplash injuries. Instead, to effectively prevent whiplash, the head restraint must control smaller amounts of rapid head and neck movement relative to the torso.

In sum, in light of recent evidence that whiplash may be caused by smaller amounts of head and neck movements relative to the torso, and that reduced backset and increased height of head restraints help to better control these head and neck movements, we conclude that head restraints should be higher and positioned closer to the occupant's head in order to be more effective in preventing whiplash.

Further, information about consumer practices regarding the positioning of adjustable head restraints indicates that there is a need to improve consumer awareness and knowledge of importance of properly adjusted head restraints. Specifically, in 1995, NHTSA surveyed 282 vehicles to examine how well head restraints were adjusted and if the restraints should have been adjusted higher. Approximately 50 percent of adjustable head restraints were left in the lowest adjustable position. Three quarters of these could have been raised to decrease whiplash potential by bringing the head restraint higher in relation to the center of gravity of the occupant's head.

III. Notice of Proposed Rulemaking

Using the new information gained about the effectiveness of head restraints, NHTSA published the NPRM for this final rule to improve on the effectiveness of head restraints. The continued persistence of high numbers of whiplash injuries indicated a need for the rulemaking.

The NPRM proposed new height and backset requirements, and other requirements, described below. NHTSA also proposed that head restraints be required in the rear outboard seating positions.

In the proposed FMVSS No. 202a, manufacturers were given the option of meeting either of two sets of requirements. The first set is a comprehensive group of dimension and strength requirements, compliance with which is measured statically. The second set was made of requirements that would have to be met in a dynamic test.[13]

Proposed requirements for head restraints tested statically. To ensure that head restraints would be properly used in a position high enough to limit hyperextension, the NPRM proposed the following height requirements. The top of the front integral head restraint would have to reach the height of at least 800 mm above the H-point. The top of the front adjustable head restraint would have to reach the height of at least 800 mm above the H-point, and could not be adjusted below 750 mm. The top of the rear mandatory head restraint would have to reach the height of at least 750 mm above the H-point. The NPRM also proposed that adjustable head restraints must lock in their adjustment positions. NHTSA proposed to retain existing requirements for head restraint width.[14] To control even smaller amounts of rapid head and neck movement relative to the torso than the amount of relative motion resulting in neck hyperextension, the NPRM proposed also to limit the amount of backset to 50 mm (2 in). In addition, the NPRM also proposed maximum gap requirements for head restraints openings within the perimeter of the restraint, and for height adjustable head restraints, between the seat and head restraint. Head restraints must remain locked in specific positions after being set by the user.

The agency also proposed to prohibit head restraints in the front seats from being removable solely by hand, i.e., without use of tools. Comments were requested on applying such a requirement to rear seat head restraints. Rear seat head restraints could be folded or retracted to ''non-use'' positions if

thought of, roughly, as the hip joint of a 50th percentile male occupant viewed laterally.

[9] Jakobsson *et al., Analysis of Head and Neck Responses in Rear End Impacts—A New Human-Like Model.* Volvo Car Corporation Safety Report (1994).

[10] Olsson *et al., An In-depth Study of Neck Injuries in Rear-end Collisions.* International IRCOBI Conference, pp 269–280 (1990).

[11] Farmer, Charles, Wells, JoAnn, Lund, Adrian, ''Effects of Head Restraint and Seat Redesign on Neck Injury Risk in Rear—End Crashes,'' Insurance Institute For Highway Safety, October 2002.

[12] ''*Effect of Head Restraint Position on Neck Injury in Rear Impact,*'' World Congress of Whiplash-Associated Disorders (1999), Vancouver, British Columbia.

[13] The current version of FMVSS No. 202 also features two sets of requirements; one applies to statically tested head restraints and the other to dynamically tested head restraints.

[14] 254 mm (10 in) for restraints on bench-type seats, and 171 mm (6.75 in) for restraints on individual seats.

they give the occupant an ''unambiguous physical cue'' that the restraint is not properly positioned by altering the normal torso angle of the seat occupant or automatically returning to a ''use'' position when the seat is occupied.

In addition, the NPRM proposed that these statically-tested head restraints would have to meet a new energy absorption requirement, compliance with which would be measured using a free-motion impactor. Additionally, the agency proposed placing a minimum on the radius of curvature for the front surface of the vehicle seat and head restraint. The NPRM proposed modifications to the existing strength versus displacement test procedure to require simultaneous loading of the back pan [15] and the head restraint, and to remove the allowance for seat back failure.

Proposed requirements for head restraints tested dynamically. The NPRM proposed a dynamic test alternative and said that the purpose was to ensure that the final rule does not discourage or preclude continuing development and implementation of active head restraints and other advanced seat back/head restraint systems designed to minimize rear impact injuries. Specifically, the NPRM proposed that head restraints tested dynamically would have to meet a Head Injury Criterion (HIC) limit of 150 with a 15 millisecond (ms) window. In addition, NHTSA proposed a head-to-torso rotation limit of 20 degrees when testing with a 95th percentile male dummy in front outboard seats, and of 12 degrees when testing with a 50th percentile male dummy in all outboard seats.[16] Further, the NPRM proposed that the head restraints must have the same lateral width specified for statically tested restraints. Comments were requested on whether dynamically tested restraints should be subject to the width requirement or any of the other dimensional requirements used in the static test option.

IV. Summary of Comments on the NPRM

The agency received approximately 50 comments on the NPRM, from motor vehicle manufacturers, seat suppliers, members of the engineering and research community, insurance companies, consumer groups, and governments and members of Congress. Overall, commenters supported upgrading FMVSS No. 202 while expressing concerns about and recommending changes to various proposals made in the NPRM.

A majority of the commenters generally supported the new height proposal, particularly as applied to head restraints for front seats. While few commenters had knowledge of any specific data regarding benefits of the proposed height increase, most commenters agreed that the new height requirement is potentially beneficial in reducing whiplash injury and had merit in harmonizing with ECE 17. Nonetheless, some concerns were expressed. Some comments supported the position that increasing the height of head restraints would not obstruct a driver's rearward visibility, but there were concerns expressed that the new height requirements would reduce the ability of a driver in following vehicles to ''see through'' a vehicle in front of him or her. There was concern that the taller head restraints could make it more difficult to install seats during vehicle assembly. Several manufacturers commented that the taller head restraints might not be able to fit in the rear seats of some vehicles or may impede seat folding, thus limiting cargo capacity.

As to the proposed width of head restraints, all of the vehicle manufacturers believed that a 254 mm width requirement for rear seat head restraints would reduce rearward visibility and is unwarranted. In contrast, Advocates for Highway Safety (Advocates) believed that the current widths of head restraints do not protect occupants in offset collisions and should be increased.

Commenters expressed differing opinions with regard to the proposed backset requirement. Insurers, consumer groups and Transport Canada supported 50 mm as the maximum allowable backset. A majority of the seat and vehicle manufacturers supported a backset of more than 50 mm, because they believed that a backset of 50 mm could result in occupant discomfort, particularly to smaller occupants who, commenters maintained, tend to use steeper seat back angles. Some manufacturers suggested that NHTSA allow for an adjustable backset of up to 100 mm. Manufacturers also generally wanted to measure backset with the seat back at the manufacturer's design seating angle rather than placed at a 25-degree angle. Some had concerns about the suitability of the head restraint measuring device for measuring backset.

There were no significant objections to the 60 mm gap limit for gaps within the perimeter of head restraints. However, manufacturers and others had questions about the proposal that adjustable head restraints in their lowest position must have some position of backset adjustment at which the gap between the seat and the head restraint is less than 25 mm.

A majority of industry commenters opposed the prohibition against the removability of head restraints. Some suggested allowing removability by hand, particularly of rear seat head restraints. Manufacturers stated that no limitations should be placed on non-use positions.

Several manufacturers and suppliers objected to the proposed height retention test requirement. Some believed current head restraints do not move downward during crashes. Others were concerned that the requirement does not account for the compression of head restraint foam. In contrast, some non-industry commenters believed that the height retention requirement is needed to prevent designs that tend to ''fall'' to their lowest position during normal vehicle operation.

With regard to the energy absorption test, all manufacturers suggested use of a pendulum impactor instead of the free-motion head form. Most manufacturers expressed concerns about the need for or wide-reaching application of the proposed limit on the radius of curvature of vehicle seats or head restraints (proposed S4.2(b)(8)).

Most manufacturers and suppliers believed that rear seat head restraints should not be required. Concerns were raised about the safety need for them, and about possible interference of the head restraints with child restraint use in rear seats. Honda, Advocates and others believed that rear seat head restraints should be mandated.

Concerning the proposed changes to the dynamic compliance test procedures, some commenters believed that the proposals should not be adopted at this time. Commenters disagreed on the most appropriate dummy to use for the dynamic test. Most vehicle manufacturers and some seat suppliers objected to the proposed HIC_{15} 150 limit, seeing no correlation between HIC and the reduction of neck injuries. Some commenters stated that the dynamic test should be with the seat attached to a test buck, instead of the actual vehicle.

In response to the NPRM's request for comments on the need to require vehicle manufacturers to provide

[15] The back pan is the portion of the SAE J826 manikin (July 1995) that comes in contact with the seat back. Its shape is intended to simulate the shape of an occupant's back and thus allow for a realistic load distribution.

[16] Changes to the dynamic test procedures were also proposed, including a new sled pulse corridor. Also, the entire vehicle would be mounted on the test sled, not merely the seat.

information in vehicle owners' manuals on how to properly adjust head restraints, the Insurance Corporation of British Columbia (ICBC) commented that it believed that consumer education has a positive influence on proper head restraint adjustment. Several manufacturers commented that most manufacturers already provide information in vehicle owners' manuals about proper head restraint use.

V. Summary of the Final Rule

Based on our consideration of the comments and other available information, the agency is issuing a final rule that upgrades existing FMVSS No. 202. As noted above, the new upgraded version of the standard is designated as FMVSS No. 202a.

Under this final rule, the top of the front outboard integral head restraint must reach the height of at least 800 mm above the H-point, instead of the 700 mm above the seating reference point (SgRP) [17] currently required. The top of the front outboard adjustable head restraint must be adjustable to at least 800 mm above the H-point, and cannot be adjusted below 750 mm. Rear outboard head restraints are optional. However, if a manufacturer chooses to install head restraints in rear outboard seating positions, these head restraints must meet certain height,[18] strength, position retention, and energy absorption requirements. The rear outboard head restraint is defined as a rear seat back, or any independently adjustable seat component attached to or adjacent to the rear seat back, that has a height equal to or greater than 700 mm, in any position of backset and height adjustment, as measured with the J826 manikin.[19] Accordingly, any rear outboard seat back or any independently adjustable component attached or adjacent to that seat back that exceeds 700 mm above the H-point, must meet the above requirements.

In recognition of the manufacturing and measurement variability concerns highlighted by the industry commenters, the agency has increased the maximum allowable backset for front head restraints from the proposed 50 mm to 55 mm. Backset adjustment to less than 55 mm is permitted. However, the backset may not be adjustable to greater than 55 mm when the top of the front head restraint is positioned between 750 and 800 mm, inclusive, above the H-point. There is no backset limit for optional rear head restraints. The agency will use an HRMD, consisting of a head form developed by ICBC attached to the SAE J826 manikin (rev. Jul 95), for measuring backset compliance.

The minimum width requirement for front outboard head restraints in vehicles without a front center seating position, and for optional rear head restraints is 170 mm. The minimum width requirement for front outboard head restraints in vehicles with a center seating position between the outboard positions is 254 mm. For integral head restraints, there is a limit of 60 mm on the maximum gap between the head restraint and the top of the seat. The gap limit for adjustable head restraints in their lowest position of adjustment and any position of backset adjustment is similarly 60 mm. The final rule does not adopt the proposed 25 mm limitation for adjustable head restraints in their lowest position of adjustment and single position of backset adjustment proposed in the NPRM. For all head restraints, gaps within the restraint are limited to not more than 60 mm.

Under today's rule, an adjustment retention mechanism that locks into place is mandatory for all adjustable head restraints. NHTSA will test retention of the head restraint in its vertical position using a loading cylinder measuring 165 mm in diameter and 152 mm in length. The rearward (with respect to the seat direction) position retention testing will be conducted using a loading sphere, with the seat back braced. Under both tests, the head restraint must return to within 13 mm of the initial reference point, an increase from the proposed 10 mm return requirement.

The energy absorption test procedure will be conducted using a linear impactor, rather than the proposed free-motion impactor or the pendulum impactor used in ECE 17.

The dynamic compliance option will utilize a Hybrid III 50th percentile adult male test dummy only, as the 95th percentile Hybrid III dummy is not yet available for compliance purposes. The head-to-torso rotation is limited to 12 degrees, and the maximum HIC_{15} is limited to 500 instead of 150 in the NPRM. These performance limits must be met with the head restraint midway between the lowest and the highest position of adjustment.

Between the effective date of today's rule and September 1, 2008, manufacturers may comply with FMVSS No. 202 by meeting: (1) All the requirements of the current FMVSS No. 202, (2) the specified requirements of ECE 17, or (3) all the requirements of FMVSS No. 202a. NHTSA has found that ECE 17 is functionally equivalent to the existing FMVSS No. 202, so we are permitting compliance with ECE 17 during the interim.

The ECE has two regulations applicable to head restraints, ECE 17 and ECE 25.[20] The two regulations have similar requirements. However, the provisions of ECE 17 supersede the requirements of ECE 25 for most vehicles subject to this final rule. Specifically, as amended in July 2002, ECE 17 applies to vehicles in the following categories:

1. Passenger vehicles, including multipurpose passenger vehicles (MPVs) with 9 or fewer designated seating positions (''M1'').
2. Passenger vehicles, MPVs and buses with more than 9, but less than 17 designated seating positions (''M2'' and ''M3'').[21]
3. Trucks (''N'').

This final rule applies to passenger cars, MPVs, trucks and buses with a GVWR of 4,536 kg or less. Accordingly, the only vehicles that will be subject to this final rule, but will not fall under the requirements of ECE 17, are buses with at least seventeen designated seating positions. Because of the GVWR limit, it is unlikely that such buses will be subject to this final rule. Nevertheless, we note that the requirements of ECE 25 are more stringent than those of this final rule because they mandate rear head restraints. Since we want to provide a compliance option for the interim period that is functionally equivalent to the current standard, we decided that all vehicles, including large capacity buses subject to this final rule, may certify to the specified ECE 17 requirements instead of ECE 25.[22]

During this interim period, manufacturers must irrevocably elect one of the compliance options in its entirety and may not certify under an alternative compliance option, if there is a noncompliance. This restriction is necessary because each certification option addresses the risks associated

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[17] The term ''seating reference point'' is fully defined in 49 CFR 571.3. It represents a unique design H-point. The H-point is the mechanically hinged hip point of an SAE J826 (July 1995) three-dimensional manikin (SAE J826 manikin), which simulates the actual pivot center of the human torso and thigh.

[18] Exceptions to the height requirements for rear head restraints are discussed in Sections VI(b) and IX.

[19] Section XII(a) explains how we arrived at our definition of rear head restraints.

[20] ECE 25, Uniform Provisions Concerning the Approval of Head Restraints (Head Rests), whether or not Incorporated in Vehicle Seats (*http://www.unece.org/trans/main/wp29/wp29regs/r025r1e.pdf*).

[21] We note that buses with at least 17 designated seating positions are still classified as M2, M3. However, ECE 17 specifically excludes these vehicles.

[22] We note that ECE 17, Paragraph 5.3.1 expressly allows other categories of vehicles equipped with head restraints to be certified to ECE 17.

with poor head restraint design differently, and because individual parts of each of the compliance options provide different levels of safety. We note, however, that the manufacturer may select different compliance options for different designated seating positions.

Major differences between this final rule and the NPRM. The following highlights the major differences between the NPRM and the final rule:

• This final rule does not require head restraints in rear outboard designated seating positions. However, if a manufacturer chooses to install head restraints in rear outboard seating positions (as defined in FMVSS No. 202a.), these head restraints must meet the new height, strength, position retention, and energy absorption requirements, but not backset requirements.

• The maximum allowable backset for front head restraints has been increased from 50 mm to 55 mm;

• The 25 mm gap limit for adjustable head restraints in their lowest height position and a single position of backset adjustment has been eliminated, leaving the 60 mm limit at any position of backset adjustment;

• With respect to position retention, the head restraint must return to within 13 mm of the initial reference point, instead of to within 10 mm, as proposed;

• The proposed radius of curvature requirement has not been adopted;

• The energy absorption testing procedure will be conducted using a linear impactor, instead of the proposed free-motion impactor;

• The dynamic compliance option will require that the head-to-torso rotation be limited to 12 degrees, when tested with a 50th percentile male Hybrid III dummy with the head restraint midway between the lowest and the highest position of adjustment (there will be no test with a 95th percentile dummy);

• The dynamic compliance option mandates a maximum HIC_{15} limit of 500, as opposed to 150 proposed in the NPRM, and;

• Vehicle owner's manual must include information describing the vehicle's head restraint system, how to properly adjust head restraints, and how to remove and re-install head restraints.

VI. Height and Width Requirements

a. Requirements for Front Seats

Height of front seat head restraints. FMVSS No. 202 currently requires that front head restraints be capable of reaching a height of at least 700 mm above the SgRP. The NPRM proposed amending the standard to increase the minimum height of front integral head restraints to 800 mm above the H-point. It proposed that if the head restraints were adjustable, they must adjust up to at least 800 mm, and not below 750 mm, with respect to the H-point. This adjustment range was estimated to ensure that the top of the head restraint exceeded the head C.G. (center of gravity) for an estimated 93 percent of all adults.

A majority of the manufacturers and other commenters, among them the Alliance of Automobile Manufacturers (Alliance), General Motors North America (GM), TRW Automotive (TRW), the Association of International Automobile Manufacturers, Inc. (AIAM) and IIHS, generally supported the new height proposal. IIHS's support was based, in part, on a new standard for evaluating head restraints promulgated by the Research Council for Automobile Repairs (RCAR), which deems taller head restraints to be superior to shorter ones.[23] In contrast, Advocates commented that fixed and adjustable head restraints should be subject to the same height requirements. According to Advocates, the NPRM did not justify allowing a 750 mm height for adjustable restraints in front seats.

There were some concerns expressed about the effect of taller front outboard head restraints on driver visibility through the backlight,[24] and on the ability of drivers in following vehicles to see through the backlight of a vehicle in front of them. Honda and Ford also said that taller front seats would contribute to rear seat occupants feeling closed-in.

Several manufacturers also stated that the taller head restraints could make it more difficult to install seats during vehicle assembly.

Agency response: The persistence of high numbers of whiplash injuries in the current fleet of vehicles indicates that the height requirement currently in effect for front outboard head restraints is not preventing excessive movement of the head and neck relative to the torso. The current requirement allows head restraints that do not effectively limit rearward movement of an average occupant's head at its center of gravity, resulting in continuing high numbers of whiplash. Research indicates that a minimum height of 800 mm above the H-point for integral head restraints, and a minimum height of 750 mm for adjustable head restraints in their full down position and at least 800 mm in their full upward position, will prevent whiplash injuries because at this height the head restraints can effectively limit the movement of the head and neck.

We have decided against adopting Advocates' suggestion that adjustable head restraints should not be allowed to have an adjustment position below the minimum 800 mm requirement set for integral head restraints.[25] Advocates' argument was based on the possibility that occupants will not adjust their head restraints to an effective position. We acknowledge that head restraint misuse has been a problem in the past and that some consumers may not receive the full benefit of an adjustable head restraint if they leave them in the lowest possible position of adjustment. However, we believe that misuse will decrease as consumers become more aware of the merit of raising their head restraints.

Further, prohibiting any position less than 800 mm for adjustable head restraints would likely result in a substantial increase in the overall height of the seat back. (The gap between the top of the seat back and the head restraint in its lowest position could not be widened substantially, because of the restrictions in today's rule that restricts such gaps to 60 mm.) The practical effect of adopting Advocates' suggestion would be to require integral head restraints, which we believe is unwarranted and overly design restrictive. Adjustable head restraints may allow shorter and very tall occupants to position their head restraints more optimally. Further, even occupants of average size may benefit from certain adjustment features, such as head restraint backset adjustment to positions closer than 55 mm, if they find it comfortable. Finally, when properly designed to maintain their position, adjustable head restraints can provide protection comparable to that provided by integral head restraints.

We note that integral head restraints have in the past been considered more effective than adjustable head restraints, largely because many occupants do not properly position adjustable head restraints. In 1982, NHTSA assessed the performance of head restraints installed

[23] RCAR is an international organization intended to reduce insurance costs by improving automotive damageability, repairability, safety and security (*www.RCAR.org*). Under the RCAR standards, the head restraint is tested with the HRMD to evaluate the restraint geometry and then is rated as good, acceptable, marginal, or poor. These types of rating systems do not contain the level of objectivity or specificity to translate easily into a regulatory requirement.

[24] Backlight is the window located at the rear of the roof panel (SAE J953).

[25] We note that heights greater than 800 mm are permitted for both integral and adjustable head restraints.

pursuant to FMVSS No. 202 and reported that integral head restraints are 17 percent effective at reducing neck injuries in rear impacts and adjustable head restraints are 10 percent effective at doing so. The difference was due to integral head restraints' being higher with respect to the occupant's head than adjustable head restraints, which were normally left down. More recently, however, the Preliminary Economic Assessment (PEA) for the NPRM found no statistical difference in the protection offered by adjustable and integral head restraints. This may be attributable to increases in the height of adjustable head restraints relative to integral head restraints since the 1982 NHTSA study.

With respect to comments on visibility concerns, we do not believe that the greater height of front seat head restraints will decrease rearward visibility. Numerous vehicles currently produced for the U.S. market already have head restraints reaching 800 mm without reports of visibility problems. In its comment, Transport Canada referred to a study conducted by Biokinetics & Associates entitled, ''The Effects of Increased Head Restraint Height on Driver Visibility,'' in support of its suggestion that increasing the height of head restraints would not result in any major visual obstruction. The study indicated that a fixed head restraint tall enough to accommodate a 95th percentile male would have a negligible effect on driver visibility in 83 percent of vehicles in the fleet, as compared to an adjustable head restraint in the lowest position.

With regard to concerns about the difficulty of manufacturing vehicles with taller head restraints, we do not believe this is a major manufacturing obstacle. Numerous manufacturers already comply with ECE17, which requires front head restraints to be as tall as in this rule.[26] Further, the manufacturers will have ample opportunity to address vehicle assembly processes during the interim period before the final rule becomes effective.

Some commenters believed that taller front seat head restraints will make rear seat passengers feel ''closed in'' and claustrophobic. There has been no indication of such problems from the European markets where rear seat passengers are already subjected to taller head restraints in the front outboard seating positions. We are unable to conclude, without supporting data, that a head restraint that is less than 100 mm (4 inches) higher than current restraints is generally likely to have this effect on passengers.

Nissan and ICBC requested that height and backset requirements, as applied to active or dynamically deployed head restraints, be measured when such head restraints are fully activated. Unless the system is tested when fully activated, Nissan claimed that the active head restraint system currently featured in several Nissan and Infiniti vehicles would not pass under the new static testing requirements.

We believe that it may be difficult to deploy these systems manually and to keep them deployed while making static measurements, unless the actual seat is partially disassembled. Further, this artificially deployed position may not accurately represent position of the head restraint when the occupant's head comes in contact with it during a rear impact. The agency knows of no practicable way to address these issues in the context of a static test nor did any commenter present one. Accordingly, this rule requires that front outboard active head restraint systems be tested for height in their un-deployed position. We note that there are practical limitations of any static test procedure on a system with dynamic properties.[27] However, if an active head restraint were to meet the static test procedure requirements, this would not eliminate the value of the active nature of those head restraints since further gains in controlling the occupant's head-to-torso motion and energy absorption could be achieved.

Front head restraints in low roofline vehicles. This rule permits a lower minimum height for head restraints for front outboard-designated seating positions to allow a maximum of 25 mm of vertical clear space between the top of the front head restraint and the roofline. The NPRM proposed to permit a similar exception during the interim period as part of the option of complying with ECE 17. ECE 17, paragraph 5.5.4 allows for up to 25 mm of clear space between front head restraint and any fixed vehicle structure, provided that use of the exception does not result in a height lower than 700 mm.

For front head restraints, DaimlerChrysler, Nissan, Alliance, Volkswagen, and Porsche requested that the 25 mm clearance exemption remain in the final rule to accommodate the possible situation in which the 800 mm head restraint may not clear the roof or front header when the seat back is folded for egress to or ingress from the rear seat area. In response to these comments we decided to adopt a 25 mm height allowance in this final rule. As in ECE 17, paragraph 5.5.4, the 25 mm height allowance is limited to the extent that the resulting front head restraint height cannot fall below 700 mm. However, this rule permits the 25 mm height allowance only in situations in which a full height front head restraint would interfere with the roofline, but not with any fixed vehicle structure, as allowed by ECE. We believe adopting the full ECE exception could provide relief in instances in which none may be needed. For example, an upper seat belt anchorage or the side of the vehicle's interior could be within 25 mm of the head restraint and yet would likely not create any compliance difficulties for vehicle manufacturers or unduly restrict visibility.

The 25 mm height allowance for rear head restraints is described in the next section.

Width of front seat head restraints: The NPRM proposed to maintain the existing width requirements of FMVSS No. 202: *i.e.*, that both front and rear outboard seat head restraints must be at least 171 mm (6.7 in) wide on single seats and 254 mm (10 in) wide on bench seats.[28] We note that ECE 17 regulation provides a 170 mm minimum width requirement for all head restraints. In the NPRM, we stated that bench seat head restraints should be wider because occupants seated on bench seats are freer than occupants of single seats to position themselves so that they are not directly in front of the head restraint.

AIAM called the proposed 254 mm head restraint width for bench seats unreasonable, stating that NHTSA should instead adopt the same 170 mm width for bench seat head restraints. AIAM asserted that comfort factors and seat belt placement on most bench seats help place occupants in the proper seating positions. In contrast, Advocates

[26] We also note that some vehicles already feature rear seat head restraints that would comply with the new height, backset, strength, position retention, and energy absorption requirements for optional rear outboard head restraints.

[27] We note that the manufacturers' concerns are alleviated by the availability of the dynamic compliance option. The dynamic compliance option provides an alternative for those manufacturers who are now utilizing active or dynamic head restraint systems. Agency testing and other published research have shown that an active head restraint system can be designed to meet dynamic testing requirements with a comfortable compliance margin. Further, a manufacturer electing to certify compliance via dynamic testing is relieved from multiple static performance requirements. Our analysis also indicates that several active head restraint systems currently on the market would pass our static compliance requirements in their normal or non-deployed position. Accordingly, we believe most head restraints will be able to meet today's static test requirements. For those that cannot, the dynamic compliance option remains available.

[28] A bench seat is a seat that has a center designated seating position between the two outboard designated seating positions.

expressed concern that requiring a 254 mm width for bench head restraints and a 170 mm width for non-bench head restraints would protect only target occupants in centered, perpendicular rear impacts, not occupants in offset collisions, causing head/neck excursion to one side of the restraint. Given those concerns, Advocates stated it did not understand why all restraints, especially front head restraints, should not have a minimum width of 254 mm.

For front bench seats we disagree with AIAM that the width requirement should be reduced. The 254 mm width requirement for these head restraints on bench seats has been in effect since January 1, 1969. We are not aware of any evidence showing that the present level of protection should be reduced. We decided to maintain wider head restraints for front bench-type seats because wider head restraints tend to better reduce relative head-to-torso motion in off-axis impacts. However, rather than use the term ''bench,'' which some commenters felt required further clarification, we have defined the requirement in terms of front outboard designated seating positions in vehicles that have a front center designated seating position.

With regard to Advocates' comment, NHTSA declines to require all head restraints to have a minimum width of 254 mm. With respect to front outboard seating positions, we note that front outboard non-bench seats have a defined contour that, in addition to belt use, better prescribe occupant seating position relative to the head restraint. Therefore, the front non-bench head restraints can be narrower than the front bench seat head restraints. With respect to rear outboard seating positions, we believe that the rearward visibility concerns associated with wider rear head restraints outweigh an unquantified off-axis rear impact benefit of wider restraints in all seats at this time.

b. Requirements for Rear Seats Equipped With Head Restraints

In the NPRM, we proposed to require head restraints in rear outboard seating positions. Presently, neither FMVSS No. 202 nor ECE 17 requires head restraints in rear outboard seating positions. Based on further analysis of the proposal and submitted comments, we have decided not to require head restraints in rear outboard designated seating positions. For a more detailed discussion of our decision not to require head restraints, please see section XII.

While rear head restraints are not required, this final rule does impose certain requirements on head restraints voluntarily installed in outboard designated seating positions. The strength, position retention, and energy absorption requirements are the same for front outboard and optional rear head restraints. However, the requirements for height and width differ from those applicable to front outboard head restraints.

Height of rear seat head restraints. The NPRM proposed that rear restraints have a minimum height of 750 mm if integral and, if adjustable, not be adjustable to a height below 750 mm.

DaimlerChrysler, GM, Honda, and the Alliance expressed concern about diminished visibility and decreased functionality of rear seat storage due to the taller rear seat head restraints. As a result of this expected decline in visibility and utility, DaimlerChrysler indicated that customer dissatisfaction with the restraints could trigger misuse or removal. Johnson Controls expressed concerns pertaining to reduced rearward visibility (particularly for shorter drivers), as well as feasibility issues, including difficult ingress/egress for third-row SUV or van seating, inability to fold and install all rows of seats, and lack of clearance between head restraints and the rear backlight area for sport coupes with rear seating.

Porsche objected to the 750 mm rear head restraint height, claiming impracticability and lack of safety need. Porsche indicated that some of its current fleet would be unable to meet the new height requirements for rear head restraints. Specifically, Porsche presented their computer aided design data showing that several models, including the 911, have less than 750 mm of distance between the rear seat H-point and the roofline, making compliance with the proposed requirements impossible.[29] Accordingly, Porsche asked that the final rule either not require rear head restraints, or provide an exception for low roofline vehicles. Magna and Volkswagen also requested that a 25 mm clearance between the top of head restraint and the roofline be allowed regardless of the actual head restraint height measurement. Such a provision would be similar to an ECE 17, Paragraph 5.5.4, which allows head restraints to have a lower maximum height in order to provide 25 mm of clear space between the head restraint and the roofline. Nissan suggested allowing a 25 mm clearance between the head restraint and interior vehicle structures as necessitated by vehicle design.

In contrast, Advocates argued for an 800 mm minimum height for rear seat head restraints, in order to include (according to the commenter) sufficient whiplash protection for 95th percentile male adults.

Agency response: As discussed above, NHTSA has concluded that any voluntarily installed rear head restraints must meet the height requirements proposed in the NPRM. Specifically, the optional rear head restraints must reach a minimum height of not less than 750 mm above the H-point.

In the NPRM, we indicated that the 750 mm minimum head restraint height would reach above the head center of gravity of approximately 93 percent of all adults. We note that with respect to the rear seat head restraint target population, the 750 mm height would sufficiently protect an even higher percentage of rear seat passengers because larger occupants typically sit in front seats.

Some manufacturers stated that a taller rear head restraint might interfere with seat mechanisms designed to provide access to and from third row seats. Because we have decided not to require rear head restraints, a manufacturer concerned with functionality of these mechanisms need not install a head restraint in the affected seats. Additionally, as will be discussed in sections IX.b. and c., the manufacturers will be allowed to install removable rear outboard head restraints or rear outboard head restraints with ''non-use positions.''

Several commenters discussed the possible effects of the proposed head restraint height increases on vehicle utility with respect to seat folding and cargo capacity. The Alliance, DaimlerChrysler, Honda and GM commented that the rear head restraint heights proposed in the NPRM could impede seat folding, thus limiting cargo capacity, or otherwise limit interior configuration possibilities.

Since rear outboard head restraints will not be mandatory, vehicle manufacturers need not equip their rear seats with head restraints. Further, as will be discussed in section IX, if the manufacturers provide rear outboard head restraints, they will be allowed to make them removable and to design them so that they can be moved into ''non-use positions.'' As a result, manufacturers will have ample design flexibility to address the cargo carrying needs of their customers.

[29] The distance from the H-point to the point 25 mm below the roofline for 911 Coupe, Targa, and Cabrio models is 693, 666, and 691 mm, respectively. Porsche also noted that requiring rear head restraints in such vehicles would create an almost 100 percent rear window obstruction (Docket No. NHTSA–2000–8570–39).

Rear head restraints in low roofline vehicles. This rule permits a lower minimum height for rear outboard seating positions equipped with optional head restraints to allow a maximum of 25 mm of vertical clear space between the top of the rear head restraint and the roofline or the backlight. The NPRM proposed to permit a similar exception during the interim period as part of the option of complying with ECE 17. ECE 17, paragraph 5.5.4 allows for up to 25 mm of clear space between rear head restraint and any fixed vehicle structure, provided that use of the exception does not result in a height lower than 700 mm.

We decided to adopt a similar provision for the long term. However, this rule permits the 25 mm height allowance only in situations in which the rear head restraint interferes with the roofline or the rear window, but not with any fixed vehicle structure as allowed by ECE. Further, the 25 mm height allowance is permitted only if the interference occurs when seats are positioned as intended for occupant use.[30]

In their comments, DaimlerChrysler, Nissan, Alliance, Volkswagen, and Porsche asked for a permanent 25 mm height allowance and suggested that the clearance should apply in situations where the seat interferes with all fixed vehicle structures, including roof liners, seat backs, headers, and rear windows. Further, they stated the clearance should be allowed regardless of whether the seats are placed in either upright or folded down positions.

This final rule does not permit a 25 mm height allowance in situations in which the rear head restraint interferes with fixed vehicle structures other than the roofline or the backlight. We believe adopting the full ECE exception could provide relief in instances in which remedies other than changing the basic vehicle structure are available.

As previously stated, the rear seat 25 mm height allowance in this final rule applies only to seat adjustment positions intended for occupant use.[31] That is, if a second row seat folds forward to permit ingress and egress and would hit the seat in front of it or some other vehicle structure, the 25 mm height allowance is not available for that situation. In situations in which interference occurs when a seat is not in a position intended for occupant use, the manufacturers may choose to utilize the ''non-use'' head restraint positions described later in this document, or redesign the seat fold-down mechanisms. We note that redesigning the fold down mechanism, though not necessitated by this final rule, can provide a practicable resolution at a reasonable cost.

The ECE 25 mm height allowance is limited to the extent that the resulting head restraint height cannot fall below 700 mm. As a practical matter, however, this requirement is moot with respect to the upgraded standard because the rear seat backs and attached or adjacent components that have a height of less than 700 mm are not considered rear head restraints under this final rule.

Width requirements for rear head restraints. The agency tentatively concluded in the NPRM that a 171 mm width for single seats and a 254 mm width for bench seats were the appropriate specifications for all outboard seating positions. These proposed widths differed from ECE 17, Paragraph 5.10, which provides a 170 mm minimum width requirement for all head restraints. The NPRM asked whether NHTSA should implement specific requirements for rear seat head restraints in order to alleviate problems associated with potential visibility losses.

All industry commenters agreed that the appropriate width requirement for rear seat head restraints should be 170 mm, and that 254 mm is overly wide. Honda commented that the 254 mm bench seat width requirement could reduce rearward visibility and was unwarranted, given the unknown safety problems of rearward visibility reduction and the unidentified need for wider head restraints. Honda attached the results of a simulation it conducted to show the decreased visibility created when 750 mm high, 254 mm wide head restraints are installed in a coupe and a hatchback vehicle. When 254 mm wide head restraints were installed on a second row rear bench seat of a coupe model, Honda's simulation showed a 40 percent decline in rearward visibility. Similarly, when installed on a hatchback model, the 254 mm wide head restraints produced a 60 percent loss of rearward visibility. To rectify this reduction of rearward visibility, Honda suggested a head restraint minimum width requirement of 170 mm for both bench seats and individual seats. Honda based this 170 mm requirement for both types of seats on ECE 25.

Ford presented data from a study it conducted, showing that rear head restraints with widths of 171 mm trimmed backlight visibility by 10–12 percent, while 254 mm wide rear head restraints reduced visibility by 15–17 percent.

In contrast, Advocates stated that it believed that all restraints should have a minimum width of 254 mm.

Upon reviewing the comments, NHTSA has decided to require a 170 mm minimum width for all voluntarily installed rear head restraints. This decision was made to further reduce the effects of this rule on rearward visibility. In order to harmonize our requirements with that of ECE 17, we are adopting a 170 mm minimum width, as opposed to the 171 mm proposed in the NPRM.

VII. Backset Requirements for Front Seats

In the NPRM, we proposed that the front and rear outboard head restraints have a backset of no more than 50 mm, as measured by HRMD. ''Backset'' means the minimum horizontal distance between the back of a representation of the head of a seated 50th percentile male occupant and the head restraint (*i.e.,* the back of the ICBC head form and the head restraint). The 50 mm maximum backset requirement was to be met at all head restraint heights between 750 mm and 800 mm. We solicited comments on whether a maximum 50 mm backset limit would be effective in preventing whiplash injuries; whether 50 mm backset would provide sufficient comfort for the occupants; and whether an adjustable backset would be more appropriate.

Commenters offered a range of opinions about the need for, and acceptable level of, a maximum backset requirement. Several commenters, including ICBC, IIHS, Transport Canada, and Advocates, supported establishing 50 mm as the maximum allowable backset. ICBC and Magna Seating Systems argued that Mathematical Dynamic Model (MADYMO) simulations performed by NHTSA confirm the decreasing safety benefit of head restraints with backsets greater than 50 mm. Therefore, ICBC believes 50 mm is sufficient to reduce whiplash significantly.

ICBC provided data showing 49 of 164 vehicles manufactured in 2001 by 19 different manufacturers have a backset of 50 mm or less.[32] IIHS stated that a group of model year (MY) 2001 vehicles,

[30] The term ''intended for occupant use'' has been defined in the final rule to apply to seat positions other than those intended solely for the purpose of allowing ease of ingress and egress of occupants and access to cargo storage areas of a vehicle.

[31] We note that both front and rear optional head restraints must meet the applicable height requirements with the seat positioned as intended for occupant use.

[32] We note that the ICBC evaluated backset using the measurement technique and seat back angle identical to that of this final rule.

among them Jeep Cherokee, Ford Ranger, Toyota Camry, and Volvo S80 already have 50 mm or smaller backsets. Because many newer vehicles already have backsets of 50 mm, these commenters claimed it was evident that the 50 mm requirement provides sufficient head clearance and that passenger comfort would not be compromised in a significant manner. IIHS stated that it was unaware of any significant comfort issues.

In opposition, a majority of the manufacturers, among them GM, Magna, Johnson Controls, AIAM, the Alliance, Nissan, Porsche, DaimlerChrysler, and Ford, suggested that vehicle occupants would prefer a head restraint backset of more than 50 mm. Specifically, they maintained that smaller female occupants tend to utilize steeper seat back angles. According to these commenters, a backset of 50 mm may cause significant intrusions into the space where these occupants typically place their heads, forcing their heads into an unnatural forward-tilting position. DaimlerChrysler indicated that a recent decrease in the backset to 50 mm in one of its models yielded four times as many warranty claims for the new head restraint. It did not elaborate on the basis for these claims. Autoliv commented that even a 50 mm backset is not a guarantee to prevent whiplash, and that it will lead to discomfort for more than 20 percent of the occupants. General Motors and Ford suggested that an 80 mm backset is more appropriate to accommodate consumer comfort.

Some commenters stated that IIHS rates backsets of 70 to 90 mm ''acceptable'' and so that backset requirement should be increased to that range.

The University of Michigan Transportation Research Institute (UMTRI) commented that it had conducted an extensive study of vehicle occupants' posture and position. Based on its research, a 50 mm backset would result in head restraint interference for 13 percent of the driving public.[33] The head restraint would actually come in contact with the hair of approximately 33 percent of drivers, assuming a hair margin of 25 mm. Based on their calculations, the individuals who preferred seat back angles more upright than 25 degrees (usually small stature people) were most likely to be subject to the head restraint interference. UMTRI estimated that with current seat designs, a backset of 91 mm would accommodate the preferred head positions of 99 percent of the population and a 70 mm maximum backset would accommodate all but a small percentage of the population.

Ford cited 3 studies by Eichberger *et al.*,[34] Szabo *et al.*,[35] and Davidsson *et al.*,[36] which used sled-mounted seats to simulate low speed rear impacts. Eichberger *et al.* tested volunteers on 9 different seat types at simulated impact speed changes (delta Vs) of 8 and 11 km/h. When the measured backset was less than 70 mm, none of the volunteers complained of any discomfort or pain. Szabo *et al.* tested 5 volunteers at delta Vs of 8–10 km/h under two conditions: an unmodified head restraint, and the same head restraint with 50 mm of additional padding. Backsets for the volunteers ranged between 76 to 114 mm with the unmodified head restraint, and by assumption between 26 to 64 mm with the modified head restraints. None of the volunteers reported any discomfort or pain after either test. Davidsson *et al.* subjected 13 volunteers to multiple sled tests (2–4) with delta Vs of 5 to 7 km/h. The measured backsets ranged from 70 to 160 mm. The head restraint position was not varied during the test so the variation in backset for the different occupants was due to occupant size differences. Only one subject reported any symptoms. The symptom was a headache, which occurred after his third run, and desisted within 36 hours.

We also received a comment from Cervigard, Inc., which has designed a head restraint that incorporates a contoured shape intended to match the curvature of the head and cervical spine, which is essentially a neck bolster. In Appendix B of this NPRM, we discuss our reasons for not adopting a requirement for a neck bolster.

Agency response: This final rule requires that front outboard head restraints meet the backset requirements described below. Because of occupant comfort countermeasure issues unique to rear seats, the agency decided not to regulate backset in the rear designated seating positions voluntarily equipped with head restraints. We concluded that comfort-related issues are not insurmountable in front seats because front seat backs can be adjusted to alleviate discomfort. Further, as explained further below, our Final Regulatory Impact Analysis (FRIA) does not attribute any safety benefits to vehicle occupants as a result of regulating backset in rear seats.

For front outboard designated seating positions, we have decided to increase the maximum allowable backset to 55 mm, with the seat back positioned at an angle that gives the HRMD a torso reference line angle of 25 degrees. Our decision to relax the maximum allowable backset requirement is based on the ± 5 mm tolerance of the measuring device. This tolerance is discussed more fully in the next section. Briefly stated, a 5 mm increase beyond the 50 mm limit proposed in the NPRM represents the variability associated with measuring backset with the ICBC measuring device.

In sum, under today's rule, the backset for front outboard head restraints must not be adjustable beyond the new maximum allowable distance of 55 mm when the head restraint is at a height between 750 mm and 800 mm, inclusive. Backset adjustment to distances below 55 mm is allowed. Also, backset adjustment of above 55 mm at head restraint positions higher than 800 mm is allowed. For manufacturers of active head restraint systems who choose to certify to the static dimension and strength requirements, the backset measurements will be taken with the head restraints in non-deployed position because we believe that the artificially deployed position may not accurately represent the actual position of the head restraint when the occupant's head comes in contact with it.

Necessity for a limited backset. Our decision to propose a 50 mm backset was based on published research, testing, computer modeling, and real world crash data.

The consensus within the biomechanics community is that the backset dimension has an important influence on forces applied to the neck and the length of time a person is disabled by an injury. As early as 1967, Mertz and Patrick first showed that reducing the initial separation between the head restraint and head minimizes loading on the head during a rear impact.[37] More recently, the Olsson

[33] The UMTRI evaluated backset of 50 mm at the seat back angle of 25 degrees, using a CAD representation of a HRMD and a typical seat.

[34] Eichberger A, Geigl BC, Moser A, Fachbach B, Steffan H, Hell W, Langwieder K; Comparison of Different Car Seats Regarding Head-Neck Kinematics of Volunteers During Rear End Impact; Proceedings of the 1996 International IROCBI Conference on the Biomechanics of Impact; September 1996; pp. 153–164.

[35] Szabo TJ, Welcher JB; Human Subject Kinematics and Electromyographic Activity during Low Speed Rear Impacts, Proceedings of the 40th Stapp Car Crash Conference; November 1996, 962432, pp. 235–315.

[36] Davidsson J, Deutscher C, Hell W, Linder A, Lovsund P, Svensson: Proceedings of the 1998 International IRCOBI Conference of the Biomechanics of Impact: September 1998; pp. 289–301.

[37] Mertz, H.J.; Patrick, L.M.: ''Investigation of the Kinematics and Kinetics of Whiplash,'' Proceedings of the 11th Stapp Car Crash Conference, Anaheim, California, 1967; pp. 267–317.

study, which examined neck injuries in rear end collisions and the correlation between the severity of injuries and vehicle parameters, showed that the duration of neck symptoms was correlated to the head restraint backset. Specifically, reduced backset, coupled with greater head restraint height, results in lower injury severity and shorter duration of symptoms.[38]

A different study examined sled tests to determine the influence of seat back and head restraint properties on head-neck motion in rear impacts. The study concluded that the head restraint backset had the largest influence on the head-neck motion among all the seat properties examined. With a smaller backset, the rearward head motion was stopped earlier by the head restraint, resulting in a smaller head to torso displacement. The findings indicated that a reduction in backset from 100 mm to 40 mm would result in a significant reduction in whiplash injury risk.[39]

A study conducted by Eichberger examined real world rear crashes and sled tests with human volunteers to determine whiplash injury risk and vehicle design parameters that influence this risk. The study found a positive correlation between head restraint backset and head to torso rotation of the volunteers and to the reported whiplash injury complaints. The most important design parameters were a low horizontal distance between the head and head restraint as well as the head restraint height.[40]

A study conducted by Dr. Allan Tencer, PhD, used rigid occupant body models enhanced with finite element models of the cervical spine for simulating rear impacts in order to examine the effect of backset on neck kinematics and forces and moments in the neck. The study concluded larger backset correlates to greater displacement between cervical vertebrae and shearing at the facet capsules that are likely associated with whiplash injury. With the head initially closer to the head restraint, the time difference between the occurrences of the peak upper and lower neck shear forces are smaller. At 50 mm backset and lower, the head moved more in phase with the torso and extension of the head was reduced indicating a lower risk of whiplash injury.[41] IIHS, in its studies of head restraints, considers a backset of 70 mm (2.8 inches) or less to be ''good.''[42]

NHTSA used computer modeling described in the NPRM to verify our assumption regarding the benefits of a smaller backset. Our research indicates that lower head-to-torso rotation values were seen when the backset was approximately 50 mm in comparison to head restraints with large backset values. As discussed further in this notice, lower head-to-torso rotation values are predicted to result in a lower probability of whiplash injury. Therefore, we continue to conclude that 50 mm of backset is an appropriate upper limit for all outboard seating positions. No data presented in the comments have indicated that a higher backset value is more appropriate from the occupant safety-standpoint. Other than Ford's comments, all of the comments opposing the proposed 50 mm maximum backset were related to comfort issues and the repeatability of placement of the proposed test device. In sum, research indicates that limiting backset is critical to reducing whiplash injuries occurring in rear impacts.

In its comments, Ford referred to three crash studies conducted at delta V's ranging from 5 to 11 km/h with varying degrees of backset and occupant size. Ford emphasized that there were no occupant injuries both with and without the backset reduction. We note that all of these tests utilized volunteers and therefore, the impact delta Vs were intended to be below the injury threshold. The primary goal of these studies was to understand occupant kinematics. The same research also indicated that when backset was reduced from 76 mm to 26 mm and from 114 mm to 64 mm, the head acceleration, rearward head displacement and cervical extension were all reduced. These data confirm our contention that injury measures, including head-to-torso rotation, decrease with smaller backset and predict a lower probability of injury. While some of the data supplied by Ford seems to suggest that smaller backsets have no bearing on the occurrence of whiplash injuries at low speeds, we note that if all impacts in the real world were limited to this very slow speed, the backset limit indeed might not be as critical. The same data seem to support our rulemaking efforts, as Eichberger observed that backset ''is very important for a good seat design. Even a head restraint placed high enough can only prevent neck injuries when the head is sustained as soon as possible by the head restraint during rear end collision.''[43]

Finally, we note that other seat parameters beyond the head restraint geometry play a role in risk of injury in rear impacts. Specifically, seat back frame force deflection characteristics and seat upholstery compliance characteristics can influence the occupant's kinematics. Thus, the head restraint geometric requirements specified in this final rule should be thought of as an interim step in the agency's goal of a unified seat/head restraint standard.

Comfort of the seat occupant. In selecting a backset limit, we have attempted to balance comfort, safety and measurement variability concerns. As noted above, no commenter disputed scientific data indicating that the closer the head restraint is to the occupant's head at the time of impact, the better the protection the head restraint offers. Numerous commenters, however, stated that occupants may be intolerant of head restraints very close to the back of their head. Further, because of differences in the occupant size, posture and seat angle preference, the same head restraint can yield different amounts of backset clearance for different individuals.

Several manufacturers argued that some occupants would select a steeper or more upright front seat back angle, thus causing the backset distance to be below 50 mm. They contend that a backset of less than 50 mm will interfere with the normal position of the head. However, since ICBC reported that 49 of 164 vehicles from model year 2001 met the 50 mm backset limit, it appears that occupant discomfort in front seats is not an insurmountable obstacle. Accordingly, we conclude that the available information does not substantiate the industry concerns associated with discomfort from front seat back adjustment to a more upright position.

UMTRI commented that a 50 mm backset causes interference with 13 percent of drivers ''preferred'' head position. Generally, these tend to be smaller occupants, who prefer a more

[38] Olsson, I., Bunketorp, O., Carlsson G., Gustafsson, C., Planath, I., Norin, H., Ysander, L. An In-Depth Study of Neck Injuries in Rear End Collisions, 1990 International Conference on the Biomechanics of Impacts, September, 1990, Lyon, France. See Table IV and the Appendix.

[39] Svensson, M., Lovsund, P., Haland, Y., Larsson, S. The Influence of Seat-Back and Head-Restraint Properties on the Head-Neck Motion During Rear-Impact, 1993 International Conference on the Biomechanics of Impacts, September, 1993, Eindhoven, Netherlands.

[40] Eichberger A, Geigl BC, Moser A, Fachbach B, Steffan H, Hell W, Langwieder K. Comparison of Different Car Seats Regarding Head-Neck Kinematics of Volunteers During Rear End Impact, International IRCOBI Conference on the Biomechanics of Impact, September, 1996, Dublin.

[41] Tencer, A., Mirza, S., Bensel, K. Internal Loads in the Cervical Spine During Motor Vehicle Rear-End Impacts, SPINE, Vol. 27, No. 1 pp 34–42, 2002.

[42] The IIHS head restraint rating criteria is discussed at: *http://www.iihs.org/vehicle_ratings/head_restraints/head.htm.*

[43] *See* Eichberger at pp. 153–164.

upright seat back angle. The ''preferred'' backset position, as articulated by UMTRI, may merely refer to a position that the drivers are most accustomed to. The term does not necessarily mean that the position is the only acceptable one or even the safest one for a given occupant. We note that the driving population as a whole is accustomed to a backset position that is, while comfortable, not optimal to prevent whiplash injuries.

We believe that no significant deviation from our proposed backset limit of 50 mm is necessary to provide an overwhelming majority of front seat occupants with an acceptable backset position. Further, any potential discomfort can be reduced by a slight increase in seat back angle. We believe that most front seat occupants can increase the seat back angle slightly without compromising their ability to reach the steering wheel comfortably or see the road ahead. For every additional degree of inclination, approximately 3 mm of additional backset clearance would be obtained. For example, a 2-degree increase in seat back angle will result in additional 6 mm of backset.

In addition to potential ways to alleviate potential discomfort, we note that our own measurements of 14 vehicles showed that the front seat head restraints in the MY 1999 Toyota Camry, Chevy C1500, Chevy S10, Saab 9–5, and Chevy Malibu, all had backsets within the proposed 50 mm limit. This supports comments by ICBC and IIHS that many vehicles already have a 50 mm backset. We think the seat manufacturers can provide a front seating system design, such as a different head restraint shape, that would allow for better comfort.

With respect to rear seats, however, the agency believes that potential occupant discomfort cannot be as easily reduced because most rear seat backs in passenger cars are not adjustable. In many vehicles, the rear seat back angle cannot be changed to provide additional backset clearance. Consequently, some vehicle occupants may experience interference with the normal position of their head, and could decide to completely remove the optional rear head restraints. NHTSA believes that it is preferable that the rear head restraints remain in the vehicle instead of being removed due to occupant discomfort, because we estimate that the increased height of optional rear head restraints will result in 1559 fewer whiplash injuries each year. Further, we are concerned that some manufacturers may choose not to install optional rear head restraints due to concerns of customer dissatisfaction with uncomfortable rear head restraints.

Because of rear seat occupant comfort concerns, the agency decided not to limit the amount of backset in the rear designated seating positions equipped with optional head restraints.[44] Because of abundant scientific evidence showing that smaller backset reduces instances of whiplash injuries, we believe that the vehicle manufacturers will install optional rear head restraints in a manner that will strike a proper balance between rear seat occupant safety and comfort.

In addition to rear occupant comfort concerns, we note that our FRIA does not attribute any safety benefits to vehicle occupants as a result of regulating backset in rear seats. By contrast, we estimated that for front seats, the limit on backset would result in 15,272 fewer whiplash injuries each year. As explained in Section XVI of this notice, we based our estimates of benefits on either increased height or reduced backset, but not both. We could not combine effectiveness of increased height and reduced backset because this, in some instances, would result in ''double-counted'' benefits. For front seats, we attribute the benefits to the backset limit. We estimate that greater share of the safety benefits will come from the backset limit because many current vehicles already include taller front seat head restraints. For rear seats, we attribute the benefits to height because we anticipate that the greater share of the benefits will come from regulating the height of optional head restraints.

Adjustable backset suggestion. Several seat and automobile manufacturers argued that, to accommodate occupant comfort, a 50 mm backset requirement should be supplemented with an allowance for backset to be adjustable to distances of up to 100 mm, so long as it could also be adjustable to a minimum setting of 50 mm. In contrast, most consumer groups voiced opposition to allowing a backset distance of up to 100 mm, even if it would be adjustable to a shorter distance of 50 mm. Advocates argued that the backset should be limited to 50 mm or less, and there should not be an allowance for an adjustable 100 mm backset, because it is commonly known that most occupants will not properly adjust their head restraints. Florida International University (FIU) students claimed that most occupants would simply leave their head restraints adjusted at a backset of 100 mm because of the lack of adequate consumer awareness. Johnson Controls was similarly opposed to an adjustable backset, stating that it is evident that most head restraints would be misadjusted. Johnson Controls stated that 60 to 80 percent of occupants do not properly adjust their head restraints. ICBC was similarly opposed to head restraints with adjustability beyond 50 mm, stating that it would lead to misadjustment and reduced effectiveness.

We were not persuaded to allow a head restraint system featuring adjustable backset mechanism that would allow as much as 100 mm of backset, even if such mechanism would be capable of achieving a 50 mm backset measurement. We agree with arguments put forth by ICBC and Advocates that the possibility of misadjustment is too great. In case of vertical adjustment, the height between the ears and the top of the head provides a clear target zone for adjustment. There is no such clear target adjustment zone for backset. Further, if a vertically adjustable front head restraint is adjusted to its lowest position, it still provides an acceptable level of protection at a height of 750 mm. If the head restraint is adjusted too high, it provides an obvious visual cue to the seat occupant. In the case of backset misadjustment, there would not be a minimally acceptable level of protection at 100 mm of backset, because such measurement does not provide sufficient protection against excessive head-to-torso rotation. Further, a head restraint with a misadjusted backset would not provide an occupant with an obvious visual cue, as most occupants are unaware of the necessity for proper backset adjustment. In sum, we conclude that allowing for an adjustable backset could end up defeating the purpose of the new backset requirement.

Seat back angle for backset measurement. We are aware of certain variability concerns associated with backset measurement using the HRMD device with a SAE J826 manikin torso reference line angle of 25 degrees. We will refer to the torso reference line angle of the J826 manikin and seat back angle interchangeably. Concerns associated with the use of HRMD device are discussed in Section IX. The seat back angle of 25 degrees was chosen because it is on the edge of the range of normally selected seat back angles and would most likely be selected by larger occupants. ICBC, which developed the HRMD, designed it to be used at 25 degrees. Of course, for some fixed

[44] We note that the decision not to regulate the backset of rear head restraints has the effect of making our upgraded standard consistent with the ECE regulation on this point.

position rear seats, this is not possible. The 25-degree angle is also consistent with the methods used by IIHS and RCAR for measurement of height and backset. ECE 17 does not specify a limit on backset, but for height measurement the seat back is set to 25 degrees unless the manufacturer's recommended seat back angle is specified. While several manufacturers stated that measuring head restraint height at steeper (*i.e.*, smaller) seat back angles result in smaller measured height, our own data indicate that reducing seat back angle by one degree results only in a 2 to 3 mm reduction in head restraint height measurement. We also find persuasive the information provided by ICBC stating that a ±1-degree error in torso angle results in a change in backset measurement of only ±3 mm.

We note that the 25-degree seat back angle in comparison to steeper angles represents a more stringent requirement for backset measurements because it maximizes the distance between the head and head restraint. However, a 25-degree angle is less stringent for measuring head restraint height. Indeed, if we decided to adopt the manufacturer's design seat back angle, typically around 23 degrees,[45] we would in fact be requiring even taller head restraints. Although we considered measuring height at a steeper angle than 25 degrees, we decided against it. Rather, we are adopting a single measurement angle for both height and backset in order to reduce unnecessary complexity in measurements and increase accuracy of testing results. We believe the 25-degree specification will not compromise safety for shorter or taller occupants. Finally, using the same angle for the measurement of backset and height for every seat, rather than the manufacturer's design seat back angle, will allow comparison of height and backset measurement from seat to seat.

VIII. Measurement of Backset and Height

NHTSA proposed that compliance with the backset and height requirements be measured through use of the ICBC HRMD. The HRMD consists of a SAE J826 three-dimensional manikin with a head form designed by ICBC attached. The ICBC head form contains a probe that slides rearward until contact is made with the head restraint, thus allowing a backset measurement. For height measurement, the SAE J826 manikin is used without the HRMD. The SAE J826 manikin provides a scale that gives the distance from the H-point along the torso line, thus allowing a height measurement.[46] If the seat cushion adjusts vertically independently of the seat back, the measurements will be taken with the seat cushion adjusted to the most unfavorable position; *i.e.*, the position that minimizes head restraint height.

Most vehicle manufacturers and seat suppliers opposed the use of the HRMD. Generally, they questioned the accuracy and repeatability of head restraint geometry measurements made using that device. Further, the HRMD was deemed too sensitive to foam, trim, actual H-point, temperature, and humidity variations. Johnson Controls, Nissan, Magna, Ford, VW, and GM commented that the HRMD was not appropriate for compliance testing because repeated testing on the same seat assembly yielded different results. For example, Ford noted that the 2000 Ford Taurus and 2000 Mercury Sable received different ratings despite the fact that they are manufactured on the same platform and have identical front seats. Additionally, DaimlerChrysler commented that NHTSA's own compliance procedure for Standard No. 208, involving the J826 manikin, allows for variability of ±12.5 mm for the Hybrid III test dummy's H-point in comparison to the J826 H-point and that the Hybrid III is a more biofidelic representation of a seated occupant. Ford stated that when measuring a head restraint reaching 800 mm, a manikin torso angle variation of ±1 degree produced a 28 mm variation in the backset measurement. Porsche stated that the HRMD device could not be properly positioned in the seats that have strong-contoured shape, therefore preventing accurate measurements. Honda provided data showing repeated backset measurement of a single seat by 3 test technicians. The largest range for any technician was 10 mm and the overall range of backset was 17 mm.

On the other hand, Transport Canada reported that a study commissioned by several Canadian insurance companies, conducted by Rona Kinetics and Associates, Ltd., entitled ''Head Restraint Field Study,'' concludes that HRMD is repeatable and an effective predictor of head restraint positions. Transport Canada has used HRMD for years and finds it to be a convenient and accurate tool.

In addressing accuracy concerns, ICBC said that the HRMD yields a level of accuracy of ±5 mm when used by competent, well-trained operators. ICBC stated further that manufacturers have historically had to accommodate similar tolerance levels with other compliance testing based on the H-point machine. Further, according to ICBC, 1 degree in seat back variance yields a deviation of no more than 3 mm as opposed to 13–28 mm as suggested by some commenters. In addressing Ford's comments on different measurement results for virtually identical vehicles, ICBC stated that the two seats, while identical in theory, had different upholstery materials (leather and cloth) and also had different stitching patterns. As a result, the deviation between two seat measurements was 5 mm, which ICBC noted was enough to warrant awarding two different vehicle head restraint ratings.

The SAE cautioned that the current H-point machine is undergoing considerable revision and the ICBC device could not be mounted on the new manikin. It argued that if the ICBC device were mandated, the manufacturers would be forced to use an otherwise outdated compliance device. Magna suggested that we consider the ASPECT (Automotive Seat and Package Evaluation and Comparison Tools) manikin as a compliance tool, instead of the HRMD.

According to several manufacturers, including Magna, Porsche and Honda, a more appropriate measurement methodology would utilize SgRP. The SgRP is a theoretical point in the vehicle, usually representing the most rearward normal riding or driving H-point, as determined by the manufacturer. Further, they requested that a CAD drawing be used to obtain the most precise height and backset measurements. Specifically, Magna recommended that we use a CAD design tool to measure the required head restraint height. Similarly, Porsche has asked us to consider virtual measurement methods using Ramsis software. Honda suggested that the HRMD assembly be translated into electronic data and the measurements be taken electronically.

UMTRI also recommended a height and backset measurement technique that uses the H-point as the reference. Once the H-point is established, a 165 mm sphere would be rolled vertically. The most rearward part of the sphere would map a path. From this path, the height of the head restraint and backset can be calculated at any height. The procedure could be done at any position of head restraint adjustment.

In response to the suggestion of alternative measuring devices, ICBC

[45] SAE J1100—Motor Vehicle Dimensions. All 1999–2000 make and model data submitted to NHTSA. The data ranged from 18 to 28 degrees.

[46] Although HRMD has a probe that makes it possible to measure head restraint height vertically down from the top of the HRMD, this probe will not be used because it is not consistent with measurement along the torso line.

commented that it developed the HRMD because there were no similar tools available to produce accurate and repeatable measurements. It claimed the HRMD is more biofidelic than other similar or proposed devices, because it has an articulating neck joint that approximates the C7–T1 joint (*i.e.*, the location on the spine between the most inferior cervical vertebra and the most superior thoracic vertebra). This allows the operator to approximate human posture at any seat back angle. The ICBC noted that there are 35 HRMD devices now in use, arguing this makes it a well-accepted compliance tool; the device is readily available from ICBC. Further, the HRMD represents a small cost for demonstrating compliance.

ICBC further stated that despite industry comments to the contrary, the ICBC device does not add extra weight to the H-point machine. The ICBC weight closely approximates the weight of the 50th percentile head and neck. No extra weight is added to the H-point machine because some upper torso weights are removed from the manikin to compensate for the ICBC device. Specifically, the HRMD with two ''replacement weights'' substitutes for 4 out of 8 H-point machine weights.

Generally, ICBC suggested that the HRMD device be used instead of a computer-based method of determining compliance. However, if some sort of electronic compliance were implemented, it believes Honda's proposal is preferable because it contemplates the use of ''virtual'' HRMD, which most closely replicates actual human seating positions. In response to SAE's concern with the forthcoming development of the revised J826 H-point machine, ICBC pledged full cooperation to ensure that HRMD can fit the future H-point machine.

RCAR submitted a test procedure it developed for head restraint measurement that uses the HRMD. It recommended using its measurement procedures in determining compliance with the new criteria.

Agency response: Despite the objections of numerous commenters, we have decided to adopt the HRMD for our compliance tests. Under the current version of FMVSS No. 202, the manufacturers provide NHTSA with the theoretical location of the SgRP with respect to some vehicle reference point. The new rule eliminates the need for obtaining a theoretical point from the vehicle manufacturer, determined by a CAD technique, because the HRMD defines the H-point of the specific seat being measured. In addition, the H-point can be found for any position of seat cushion adjustment, thus allowing the worst-case head restraint height to be measured.

We conclude that the ICBC comments related to a CAD technique for determining head restraint geometry are the most compelling. Specifically, ICBC noted that various techniques suggested by the manufacturers all have the limitation of not measuring the actual seat, as it exists in the real world. Instead, they rely upon measurements made in a virtual or computer generated environment. The current FMVSS No. 202 height measurement technique has the same weakness, as it uses the SgRP determined by drawing techniques and a seat position defined by the manufacturer. While we appreciate the numerous benefits associated with CAD techniques in the design of vehicles and their components, we believe these techniques are not yet appropriate for a regulatory environment. Any CAD method would not only have to rely on an adequate model of the J826 manikin, but, even more importantly, an accurate representation of the vehicle seats. Each seat model would require extensive validation to assure that the CAD results would match the results achieved by direct measurement. A design change such as new upholstery foam or covering material would likely require a re-validation of the model. This type of process is appropriate for research or product development, but is not yet ready for regulatory purposes.

In regard to the backset and height measurement technique suggested by UMTRI, we conclude that the technique is useful to the extent it allows backset to be calculated for an occupant of any height rather than just for a 50th percentile male. However, we are not aware of any physical device currently available to map out the continuous backset. Thus, in order for the agency to adopt the UMTRI method, a CAD technique would have to be adopted, unless a new physical testing device is developed. We have rejected the use of CAD methods for the reasons specified above.

Numerous commenters questioned the accuracy of the HRMD device. Specifically, the manufacturers questioned repeatability of measurements and stated that the HRMD is incapable of accounting for foam, trim, actual H-point, temperature, and humidity variations. However, ICBC submitted data showing accuracy of ±5 mm. Because ICBC has a significant amount of experience in using the HRMD, its assertion that the overall level of repeatability of its device is within a ±5 mm, when used correctly, is persuasive.

We also conclude that ICBC provided adequate explanation for the discrepancy between the measurement results for Ford Taurus and Mercury Sable, a discrepancy that would not have been found using a CAD technique. Different upholstery and stitching patterns can result in different measurements. If these differences are significant, the difference in both height and backset may be significant. Further, a Transport Canada study concluded that the HRMD is repeatable and an effective predictor of head restraint position of humans. Transport Canada has used the HRMD for years and finds it to be a convenient and accurate tool. There are at least 35 HRMDs now in use, and the head form is readily available from ICBC.

We found that while measuring head restraint geometries with the HRMD for use in a cost study, the backset measurements varied by a total of 10 mm when NHTSA's Vehicle Research and Test Center (VRTC) repeated the measurement of a single vehicle seat 3 times. This is consistent with the ICBC statements showing ±5 mm accuracy. Further, experience indicates that greater familiarity with the device reduces the variability of measurements. Thus, the measurement variance shown in the Honda data (10 mm for 1 operator and 17 mm for 3 operators) may have been due to a lack of familiarity with HRMD.

Porsche stated that the HRMD device could not be properly positioned in the seats that have ''strong-contoured shape,'' therefore preventing accurate measurements. However, Porsche did not provide any data comparing the position of HRMD head form to the position of an actual occupant's head in one of its ''strong-contoured shape'' seats. We believe that Porsche must currently use the SAE J826 manikin to find the reference H-point position of the Hybrid III 50th percentile manikin for frontal barrier tests in FMVSS No. 208, and therefore has some familiarity with how to properly position the device. Generally, we believe that experienced operators will not encounter any difficulties in measuring seating structures with HRMD.

Several comments suggested that the HRMD device is insufficiently biofidelic. However, we are persuaded by ICBC's comments that HRMD is more biofidelic than other similar devices because it has an articulating neck joint that approximates the C7–T1 joint. This design feature allows the operator to level HRMD's head regardless of the seat back angle, similar to the posture of a human occupant, resulting in superior accuracy of backset measurement. While we are aware that the SAE has updated the J826 manikin in the form of the ASPECT manikin in July 2002, this new device has yet to be evaluated by the agency for incorporation into FMVSS.

Based on the comments and analysis presented above, we have decided that the HRMD will be the measurement tool.

IX. Maximum Gap Allowance and Removability

a. Maximum Gap Allowance

The NPRM proposed allowing for gaps within the perimeter of the front (anterior) surface of head restraints in order to provide for better rearward visibility for drivers.[47] The NPRM proposed two types of maximum gap allowances. First, for both integral and adjustable head restraints, a gap within the perimeter of the head restraint could not exceed 60 mm. Because there may not be a clear distinction between the end of the seat back and the beginning of the head restraint in integral head restraints, compliance with this first gap limit is determined by measuring any point on the front surface of the seat back 540 mm above the H-point and within the minimum head restraint width. We note that ECE 17, Paragraph 5.8, similarly regulates gaps at heights above 540 mm.

The second type of gap allowance was between an adjustable head restraint in its lowest position and the seat. There were two levels of requirements. First, an adjustable head restraint in its lowest position must have some backset position in which the gap between the seat and the head restraint was less than 25 mm. Second, an adjustable head restraint in its lowest position, with the backset in any position of adjustment, must not have a gap between the head restraint and the seat back of greater than 60 mm.

The HRMD used for measuring backset has a probe that slides out of the center of the back of the head form. The probe is relatively thin laterally, and cannot adequately measure gaps within the perimeter of the head restraints and between the head restraint and the seat. Accordingly, the gaps were to be measured with a 165 mm diameter sphere placed against them.

Gaps within the perimeter of the restraint. Nearly all industry commenters concurred with the proposal for a 60 mm limit for gaps within the perimeter of any head restraint, because it was consistent with ECE 17 requirements. There were no significant objections to the specific value of 60 mm. The Alliance indicated that while it did not know of any data supporting the need for the 60 mm gap limit for a seat with an integral head restraint, it did not object because the dimension matched the ECE limit. Honda, GM and DaimlerChrysler stated that they did not have any data addressing the 60 mm gap limits but supported harmonizing the requirement with ECE 25.

In contrast, Advocates argued against allowing gaps of any size, as it was not convinced by the NPRM's arguments pertaining to the proposed gap allowances.

Agency response: NHTSA has adopted the 60 mm gap limit rather than allowing for gaps of any size in the perimeter of the head restraint, as is the case under the current standard. In doing so, NHTSA does not harmonize the final rule with the ECE regulation merely for the sake of harmonization, as Advocates alleged. Rather, the agency is harmonizing the requirement because while we believe that some gaps are beneficial for visibility, we also believe that gaps of excessive size can significantly reduce effectiveness of head restraints through effectively increasing backset. Absent evidence that the ECE 17, Paragraph 5.7 requirement is ineffective at balancing the need for adequate rearward visibility and a reduction in injuries, NHTSA is adopting the same 60 mm gap limit.

Gaps between seat back and adjustable restraint. The Alliance stated that it did not understand why a limit of 25 mm would be placed on any gap between the top of the seat and the bottom of the head restraint. It stated that while the 25 mm gap limit is identical to the ECE 17 limit, the measurement procedure utilizing the 165 mm diameter sphere differs from that in the ECE regulation. ECE 17 only measures the distance directly between the bottom of the head restraint and the top of the seat back. The Alliance recommended NHTSA adopt a linear measurement technique employed by ECE 17.

Honda commented on gap requirements in ECE 25 instead of ECE 17, and the gap limits proposed in the NPRM. Specifically, Honda submitted a figure showing that its Accord sedan with the head restraint in its lowest position complies with ECE 25 with no gap between the top of the seat back and the bottom of the head restraint. However, the Accord would not meet the proposed gap limit, because its gap would measure 44.8 mm. That is, the Accord head restraint in its lowest position has a 44.8 mm gap in the front surface between the seat back and head restraint when measured with the 165 mm diameter sphere. Accordingly, Honda requested complete harmonization with the gap requirements in ECE 25, which would exclude use of the 165 mm sphere for this gap limit. Honda stated that some of its current seat designs would need drastic modifications in order to comply with the 25 mm gap limit, as measured with the 165 mm sphere.

GM remarked that if NHTSA considers gaps of 60 mm acceptable within a restraint, the need for a 25 mm gap limit between the top of the seat and the bottom of the head restraint is unclear. DaimlerChrysler said that the 25 mm gap limit, as applied to rear head restraints, could lead to an additional loss in visibility. DaimlerChrysler also stated that a head restraint making direct contact with the seat back with a 15 mm radius at the head restraint's bottom front contour and seat back's top front contour would create a gap of more than 25 mm. AIAM expressed its support for all the proposed gap limits except for the 25 mm limit on gaps between the seat and the head restraint for adjustable head restraints with adjustable backsets. In view of this, AIAM argued that unless NHTSA could show a safety necessity for backset adjustability, NHTSA should only mandate the head restraint specifications independent of backset adjustability, provided that the adjustability does not have a material effect on height. AIAM advocated, then, that the final rule should require that the gap be less than 25 mm at any position of backset adjustment, which is more stringent than the NPRM.

In contrast, Advocates opposed allowing gaps of any size between an adjustable head restraint and seat back in any position of adjustment. Johnson Controls expressed support for a universal 25 mm gap limit between the lower edge of a head restraint and the seat for both adjustable and integral head restraints.

Agency response: In consideration of comments submitted by GM and other manufacturers, we have decided not to adopt the 25 mm maximum gap limit for adjustable head restraints in their lowest height position and a single position of backset adjustment. After considering the comments, NHTSA does not believe there is a safety benefit in measuring the smallest space between the bottom of an adjustable head restraint and top of the seat back because an occupant's head does not necessarily come into contact

[47] The gap limits are applied between two vertical longitudinal planes, which are one half the minimum head restraint width from the head restraint centerline. Thus, any part of the front surface of the head restraint outside of the minimum width requirement is excluded from the gap limits.

with these areas. Instead, a limit on gaps will focus on gaps in the front surface of the head restraint, *i.e.*, the area designed to restrain an occupant's head in a rear impact collision. The maximum gap limit for adjustable head restraints in their lowest position and any backset position will be 60 mm. Thus, there is a single requirement for this type of gap, regardless of backset adjustability.[48]

Gaps between seat back and raised restraint. Comments were requested on whether there should be a maximum gap allowance between adjustable head restraints and the seat back when the restraint is in a raised position. NHTSA indicated in the NPRM that if such a maximum gap limit were adopted, most adjustable head restraints currently on the market would not meet it.

The Alliance and Johnson Controls said that they did not know of any data supporting the need for this limit or any data indicating that such a requirement would be appropriate. DaimlerChrysler commented that there is not any known safety benefit related to such a limit. When head restraints are misadjusted, DaimlerChrysler said, they are most often in the full down position. Because a maximum gap limit between the seat and head restraint in its highest position potentially would only benefit shorter drivers who would most likely be positioned in a seat with a head restraint in the lowest position, DaimlerChrysler surmised that the maximum gap allowance is unnecessary. Taller drivers, according to DaimlerChrysler, would face no risks from this gap because their potential risks exist in head restraints not positioned high enough, not in head restraints adjusted too high.

AIAM also commented with respect to the effect of a maximum gap limit on taller or shorter drivers. It commented that if a seat represents the lower stop of a head restraint for which the highest possible position is 800 mm, the gap could only be 50 mm unless a head restraint provides for positions higher than 800 mm. If higher positions are possible, AIAM asserted that such a head restraint would only be positioned higher than 800 mm when a taller person occupies the seat. AIAM acknowledged that there might be instances in which a shorter person sits in a seat with a head restraint adjusted in the higher position, but it commented that in such instances, the likelihood of injury to shorter occupants is unknown.

Advocates believed that NHTSA should require adjustable head restraint designs such that no gap would exist when the head restraint is placed in its uppermost position.

Agency response: After considering the comments, NHTSA concludes that there is no need to adopt a maximum gap limit when the head restraint is in its uppermost position. Transport Canada data indicate that head restraints are usually improperly adjusted too low rather than too high. AIAM's comment suggests that any minimum gap limit could have the effect of eliminating head restraint designs providing positions higher than 800 mm, which would adversely affect the protection offered for taller adults.

b. Removability

The NPRM proposed prohibiting the removability of head restraints in front seats ''solely by hand,'' but allowed removability of rear seat head restraints in this manner. The NPRM noted that, given the lower occupancy rate of rear seats than of front seats, a rule allowing rear seat head restraints to be removed by hand might be warranted if it would have a positive effect on visibility.

A number of commenters opposed any prohibition against the removability of head restraints, front or rear. AIAM asserted that all head restraints should be removable by hand in order to improve rear vision, cargo carrying, and overall functionality. In addition, it contended that allowing removability by hand would help prevent permanent damage to head restraint mountings caused when occupants use tools to temporarily remove head restraints that are non-removable by hand. Nissan asserted that there are potential production difficulties arising from front head restraint non-removability. Installing a large seat fitted with a head restraint into a small vehicle, Nissan asserted, might be an arduous task.

Honda wanted all restraints to be removable by hand, out of concern that non-removable head restraints would limit seat design flexibility. Honda believed that a non-removability prohibition would prevent it from offering the ''fully flat seat'' option in its CRV model vehicle.[49]

In contrast, some commenters supported prohibiting head restraints from being removable by hand. Magna expressed concern that if head restraints were removable, they might not be replaced or correctly reinstalled. Advocates believed that head restraint removal and misuse would be similar to occupants placing both arms over shoulder belts or placing shoulder belts behind their torsos, effectively defeating the safety purposes of the safety system. DaimlerChrysler concurred with making front seat head restraints more difficult to remove than rear seat restraints because of their safety benefits and the absence of a need to remove them for visibility and functionality reasons. DaimlerChrysler also agreed that there should be some means to remove front head restraints for purposes such as seat cover installation. However, DaimlerChrysler wanted the word ''tool'' to be interpreted as including the mechanism in their current vehicles requiring two hands to operate.

A majority of industry commenters wanted NHTSA to allow removability of rear head restraints in the final rule. Ford believed that removability of rear head restraints would allow occupants to fold seats to increase space and would reduce possible incompatibility with child restraints. Ford stated that while many vehicles are currently designed with head restraints that are removable by hand, Ford does not know of any data regarding misuse or improper adjustment of head restraints caused by hand removability. DaimlerChrysler believed that NHTSA should permit rear seat head restraint removability to facilitate increased vehicle utility and rearward visibility.

Agency response to comments on head restraint removability: After considering comments, NHTSA decided to allow removability of head restraints solely by hand. However, for both front and rear optional head restraints, removal must be by means of a deliberate action that is distinct from any act necessary for adjustment. That is, the ''action'' required for removal must be distinct from that required for adjustment. For example, the head restraint may be removed by depressing a special button or operating a lever located somewhere on the head restraint or the seat back. However, the action involved in adjusting head restraints must be different. This insures that head restraints are not accidentally removed when being adjusted. The new removability requirement uses language very similar to that in ECE 17, Paragraph 5.13.

We are establishing the new head restraint requirements to ensure that vehicle occupants receive better protection from whiplash and related injuries. To achieve this purpose, the agency wants to take reasonable steps to increase the likelihood that a head restraint is available when needed. If head restraints were too easily

[48] We note that all head restraints subject to this final rule must meet the backset limit of 55 mm irrespective of 60 mm gap allowances.

[49] In alternative, Honda recommended that we allow head restraint removal by use of some tool included with the vehicle.

removable, chances are greater that they will be removed. That, in turn, increases the chances that the restraints might not be reinstalled correctly, if at all. By prohibiting removability without the use of deliberate action distinct from any act necessary for adjustment, the likelihood of inadvertent head restraint removal will be reduced, thus increasing the chances that vehicle occupants will receive the benefits of properly positioned head restraints.

While NHTSA wants to increase the likelihood that a head restraint is available when needed, we also want to ensure that head restraints, especially in the rear outboard designated seating positions, can be removed in order to improve rear visibility, child restraint accommodation, and cargo carrying capacity. In certain very limited circumstances discussed by DaimlerChrysler, it may also be necessary to remove front head restraints. We are also persuaded by AIAM's comments concerning potential damage to head restraint mountings and locking mechanism that could be caused by occupants using a tool to temporarily remove the head restraints. Further, we believe that unforeseen problems could arise if the tool provided by the manufacturer for the purpose of removing head restraints is lost or otherwise unavailable at the time the head restraint must be removed. Because of these concerns, we decided not to adopt a proposed requirement that would have mandated that head restraints could not be removed without the use of a tool.

We have considered Advocates' comments that head restraint removal would defeat the purpose of the safety device. We believe that out approach strikes a balance between the need to ensure that a head restraint is available when needed and the need to improve rear visibility, cargo carrying capacity and accommodate child restraints. Further, with respect to rear seats, prohibiting head restraint removal when no head restraint is required could have the effect of encouraging manufacturers to design vehicles without rear head restraints. Our preference is that when possible, manufacturers install optional rear head restraints.

c. Non-use Positions

In connection with its proposal to mandate rear head restraints, NHTSA proposed to address concerns about the potential effect of those head restraints on the driver's view to the rear by allowing them to be foldable or retractable if they met certain requirements. Specifically, if a head restraint was adjusted to a ''non-use'' position (any position in which a head restraint's minimum height was less than the proposed 750 mm height or its backset was more than the 50 mm proposed backset), it would have been required to either return automatically to its proper use position when a dummy representing a person was placed in the seat, or give a person who occupied the seat an ''unambiguous physical cue'' of the improper head restraint position by significantly altering the torso angle of the occupant. If the head restraint was designed to return automatically from a non-use position to a normal use position, this had to occur when either a 5th percentile female or a 50th percentile male test dummy was placed in the seating position. To determine if the head restraint in a non-use position provided an ''unambiguous physical cue,'' the SAE J826 manikin was to be placed in the seat position. The torso angle of the manikin would have been required to be at least 10 degrees closer to the vertical than when the head restraint was in a normal use position.

Industry commenters uniformly favored a final rule permitting non-use positions for rear head restraints. However, many stated that because non-use positions in current vehicle designs are obvious to occupants, NHTSA need not condition allowance of those positions upon either automatic repositioning or 10-degree torso angle displacement. GM contended that designing head restraints to fold forward into non-use positions is not always feasible, especially given the proposed 254 mm minimum rear head restraint width for bench seats. GM, Honda and others remarked that folding or retractable head restraints with automatic return capabilities might not be practical and could result in excessive cost.

Other commenters asked NHTSA to permit methods different from the 10-degree torso displacement angle to alert vehicle occupants to non-use head restraint positioning. Specifically, VW and Honda advocated harmonization with ECE 17, Paragraph 5.5.3.3, which allows for head restraints to be retracted into non-use positions as long as this position is ''clearly recognizable to the occupant.'' Similarly, Ford stated it believed that the NPRM's 10-degree proposed displacement rule would be excessively burdensome and would require substantial redesign of seating systems.

Several commenters opposed allowing non-use positions. State Farm suggested that NHTSA should only permit non-use positions for rear head restraints if NHTSA determines either visibility or child restraint incompatibility are issues meriting consideration. Advocates noted that automatically retracting or manually folding head restraints might malfunction or become stuck in a non-use position. Advocates opposed the proposal to the extent that it did not specifically require that non-use positions for rear head restraints remain limited to ones achieved by folding or retracting. Moreover, Advocates expressed doubt about the objectivity of the ''unambiguous physical cue'' as an occupant's indication of a non-use position, stating that the subjective standard would create the potential for ambiguous designs that would give rise to misuse.

Transport Canada and Honda asserted that forward-folding head restraint designs might be misused in that an occupant may sit in the seat without returning the head restraint to an in-use position. Honda commented that smaller occupants might not recognize that the seating position moved 10 degrees closer to vertical is a warning of a non-use position. Instead, according to Honda, smaller stature occupants might consider the more upright position comfortable without understanding that the head restraint was positioned for non-use. In addition, Transport Canada stated that the proposal to require manufacturers to design their head restraints so that the torso angle of the SAE J826 manikin at least 10 degrees changes when the head restraint is in a non-use position might bring about a low fulcrum, which would increase neck injury in a rear impact collision.

Agency response: NHTSA does not believe that non-use positions for rear head restraints should be allowed without any limitations. Instead, there must be objective performance requirements established to reduce the chances of injuries stemming from misused head restraints. Accordingly, the final rule adopts non-use position requirements proposed in the NPRM, but with some modifications. Further, this rule changes the test procedure and the test device to be used in determining compliance. Specifically, we are adopting the following: (1) A head restraint in a non-use position must automatically return to a normal ''use position'' when the seat is occupied by a 5th percentile female dummy whose midsagittal plane is aligned within 15 mm of the head restraint centerline; or (2) a head restraint must be capable of manually rotating at least 60 degrees forward or rearward in a vehicle vertical longitudinal plane between the ''use position'' and the non-use position.

The final rule does not require that the non-use positions cause a 10-degree change of the torso angle of the J826 manikin. Our proposal was based on the premise that the non-use position should give the occupant an obvious physical cue when the head restraint is not properly positioned. We have reassessed this requirement in light of our decision not to mandate rear head restraints and to allow head restraints to be removable without the use of tools. Given those decisions, it would be incongruous to mandate a possibly complex seat mechanism to ensure that non-use positions provide a physical cue to the occupant in the form of a 10-degree change to the torso reference angle. The changes to the non-use position requirements will also address comments made by Ford, GM and Transport Canada with respect to complexity, inconvenience and possible neck injury risk increase associated with the proposed requirement of 10 degree change in the torso reference angle.

We note that our requirements remain consistent with the ECE 17, Paragraph 5.5.3.3 to the extent that it mandates that a head restraint be capable of achieving a non-use position that is ''clearly recognizable to the occupant.'' With respect to Advocates' concerns that the ''unambiguous physical cue'' language in the NPRM was subjective, we note that unlike the ECE requirements, this rule provides an objective test procedure to assess the ''clearly recognizable'' factor. Specifically, if the head restraint is capable of rotating forward or rearward by at least 60 degrees to achieve a non-use position, it is deemed ''clearly'' in a non-use position. This restriction is necessary to clearly inform the occupant that the head restraint is available, but out of place.

The final rule does not require that the rear head restraint automatically rotates the full 60 degrees or that the head restraint remains in this fully retracted position. In order to meet the strength requirements of this final rule, a head restraint that rotates rearward would likely need to have some mechanism that releases the head restraint from the position intended for occupant use. Accordingly, the head restraint would only be placed in a non-use position because of a particular need. It is possible that some vehicle operators may not rotate such head restraint fully. However, we believe in most instances the rear head restraint would be rotated the entire 60 degrees because this would best accommodate the vehicle operator's particular interest in adjusting the head restraint to a non-use position.

For head restraints that automatically return to a use position when occupied, the final rule does not require the use of a 50th percentile male dummy in addition to the 5th percentile female dummy, as was the case in the NPRM. Based on our review of current sensing technology, we assume the head restraint systems that will be designed to automatically return to a normal use position when a seat becomes occupied will use weight or optically based occupant-sensing technology. Thus, the use of the taller and heavier 50th percentile male dummy would be redundant since it would be more difficult to detect the shorter and lighter 5th percentile female dummy.[50]

In response to Transport Canada and Honda's concern with respect to fold-forward designs, we note that non-use positions can be achieved by means other than fold-forward head restraints. Further, in allowing this type of design, we anticipate that a forward-folded head restraint will provide both a physical and visual cue to the occupant to properly position the head restraint.[51]

NHTSA concludes that the allowing for non-use positions will facilitate better rearward visibility because the manufacturers will be able to design optional rear head restraints that fold or retract when rear seats are unoccupied, encouraging manufacturers to install rear head restraints.

X. Position Retention

In the NPRM, we proposed two loading test procedures to ensure that the head restraints remain in their position of adjustment (lock) upon application of force. These test procedures ensure that the head restraints can withstand the forces associated with normal pressure applied upon the head restraint during ingress and egress, as well as in the event of a crash. We note that while the ECE 17, Paragraph 5.1.1 requires locks on adjustable head restraints, it does not mandate that these locks meet vertical and horizontal position retention requirements to insure their functionality. In contrast, we proposed vertical and horizontal position retention requirements to ensure test objectivity associated with retention lock requirements.

The first test provided for the vertical, downward application of force upon a head restraint when placed at its highest position of adjustment and not less than, but closest to 800 mm for front seats and 750 mm for rear seats. A head restraint with an adjustable backset must meet the height retention requirements in any position of adjustment. Under the proposed procedure, a small, 50 N initial load would first be applied to the head restraint to provide a reference position for the head restraint. The reference position would be measured to eliminate variability associated with the soft upholstery of the head restraint. Next, a larger load would be applied to test the locking mechanism. The load would be increased to 500 N and held for 5 seconds. The load would then be reduced to the level of 50 N, at which point the head restraint would be required to return to within 13 mm of the initial reference position.

The second test procedure provided for a rear (posterior—rear with respect to the direction that the seat is facing) application of force perpendicular to the torso line. Testing for this position retention requirement to the rear is performed in the context of the displacement and ultimate strength requirements. This test is performed at any position of backset adjustment (if applicable) with the height adjusted to not less than, but closest to 800 mm for front seats and 750 mm for rear seats. In this instance, the NPRM proposed that a load producing a 373 Nm moment be applied to the back pan about the H-point to establish a displaced torso reference line. Next, a force producing 37 Nm would be applied to the head restraint to provide a reference position. The load would then be increased until it produced 373 Nm moment about the H-point and this load would be held for 5 seconds. At this point, any displacement beyond the displaced torso reference line would be limited to 102 mm. The head restraint load would then be reduced back to the level of 37 Nm, at which point the head restraint must return to within 13 mm of the initial reference position. To satisfy the ultimate strength requirement, the head restraints must be capable of providing resistance to an 890 N load for a period of 5 seconds.

We stated in the NPRM that the 500 N downward force and 373 Nm[52] rearward moment are representative of the peak loads likely to be encountered in moderate to severe rear impacts. The agency has reviewed upper neck shear loading from 33 rigid moving barrier,

[50] We believe Advocates' statement that automatic return head restraints may fail to function overstates the safety concern. Although such failures are possible, they can occur with any safety mechanism.

[51] We note that Volvo uses such a design in their S60 and S80 sedans.

[52] For an 800 mm high head restraint, the 373 Nm moment is achieved by applying a load 65 mm below the top of the head restraint. Thus the applied load is 507 N = 373 Nm/0.735 m.

rear impact (48 km/h (30 mph)) FMVSS No. 301 tests and found the average maximum load caused by the head being loaded in the forward direction with respect to the torso is 351 N. This direction of shear load is a good indicator of head restraint loading on the head and, therefore, head loading on the head restraint. Thus, the 373 Nm rearward moment and 500 N downward force are representative of the peak loads likely to be encountered in moderate to severe rear impacts. We asked for comments on the appropriateness of load values proposed for the two tests as well as the role of the retention locks in preventing head restraint maladjustment.

Several commenters disagreed with the proposed height retention test requirement. Johnson Controls commented that it is unaware of any situations in which head restraints would move downward during accidents and thus does not understand the need for the vertical position retention test. In its opinion, the new requirement would unnecessarily complicate the locking adjustment mechanism, which consumers already find hard to use. Other commenters requested that NHTSA alter or simplify its height retention requirement. GM recommended that the testing criteria require that the head restraints simply ''remain in their adjusted position'' after an application of the required loads. According to GM, a more specific requirement that the head restraint be within 10 mm of its initial position, after position retention tests, might be difficult to meet because of possible compression of the head restraint foam. Similarly, DaimlerChrysler stated that the proposed height-retention test is inadequate to account for low recovery rate of crushable ''friendly'' materials designed to cushion an occupant's head upon contact.

Both Magna Seating Systems and DaimlerChrysler submitted the same test data showing a vertical load test in which an upholstered head restraint returned to within 22 mm of its initial position. The same head restraint with the upholstery removed returned to within 1 mm of its initial position. According to DaimlerChrysler, instead of testing the adjustment mechanism integrity, the proposed test indirectly measures the entire seating system, which includes energy-absorbing components. Therefore, a more appropriate solution is to simply measure head restraint position at the adjuster mechanism. Additionally, DaimlerChrysler stated that 500 N vertical load for position retention test may be excessive and unnecessarily harsh, and may end up requiring manufacturers to produce seats that are unnecessarily rigid and would result in potential harm to the passengers.

The Alliance generally agreed with most aspects of the proposed head restraint loading procedure. However, it was not aware of any reasons for the 5-second ''hold'' requirement in the position retention test. The Alliance recommended that the ''hold'' requirement be completely stricken or, in the alternative, limited to one second. AIAM was likewise of the opinion that the stringent height retention requirements would in fact discourage adjustability, because a mechanism meeting such requirements would be unduly difficult to design and use. Therefore, it recommended that the height retention requirement be eliminated from the proposed rule.

Honda commented that the problem with the vertical load test procedure is the shape and initial position of the loading device. Honda believed that this would cause the loading sphere to slip off of the head restraint. Honda recommended that loading test for height retention requirement be performed using a flat plate as opposed to a head form. Honda commented that no further height retention position testing (other than upper most position) should be tested, because the upper most position can be regarded as the worst position.

VW stated, ''[s]ome Volkswagen and Audi vehicles provide head restraint adjustment above 800 mm to accommodate tall occupants, but in this situation a locking system at the maximum height is not provided.'' They requested that the height retention requirement not be applied to position of adjustment above 800 mm. They contended that when a seat back is folded the head restraint might interfere with the roof and cause damage to a locked head restraint.[53]

In contrast, IIHS commented that the height retention test is necessary to prevent poor head restraint designs that, for example, tend to ''fall'' to their lowest position during normal road movement. IIHS cautioned that many occupants place their hand or arm on the head restraints in getting into and out of the vehicles, thus applying vertical and non-vertical pressure on the restraint mechanism.

[53] Volkswagen also commented on the backset retention requirement. They asked that the agency clarify their interpretation that the initial reference position to which that the test device must return within 10 mm (now 13 mm in the final rule) is the position the test device obtains after the 37 Nm reference load. The agency confirms this interpretation of the test procedure.

There were no comments regarding the likelihood of misadjustment due to the absence of retention locks. There were no comments regarding the horizontal displacement requirement, other than the IIHS comment that the NPRM did not propose a horizontal loading requirement.

Agency response: We have decided to adopt the position retention tests, both in the vertical and rearward directions, largely as proposed. As previously stated, ECE 17 requires locks on adjustable head restraints but does not mandate that these locks meet vertical and horizontal position retention requirements to insure their functionality. However, we find it necessary to require a certain minimal level of performance to ensure that the retention locks perform their function. Accordingly, the vertical and horizontal position retention requirements of this final rule apply to all front outboard head restraints and voluntarily installed rear outboard head restraints.

We proposed performance requirements for adjustable head restraints to assure that they remain locked in a specific position and are not unduly difficult to properly adjust. A 1982 NHTSA study found that the effectiveness of integral head restraints was greater than adjustable head restraints. The study concluded that the difference in effectiveness was due, in part, to adjustable head restraints being improperly positioned. Furthermore adjustable restraints can be pushed down inadvertently during occupant ingress and egress, and can collapse in a collision. Adjustment retention locks can mitigate this problem by helping to retain the adjusted position. Our new height and backset requirements are expected to improve performance of all head restraints. The performance of adjustable head restraints will be further improved if steps are taken to ensure that a restraint remains locked in a position selected by the user.

Today's rule requires that the head restraints remain within 13 mm of their vertical and horizontal position under the application of a downward and rearward force. For front seats, the height position retention requirements must be met at any backset position of adjustment and with the head restraint at a height not less than, but closest to 800 mm, and at the highest position of vertical adjustment. For optional rear seats, the height position retention requirements must be satisfied at a height not less than, but closest to 750 mm and at the highest position of vertical adjustment. The horizontal position retention requirements must be met at the height of 800 mm for front head restraints and 750 mm for rear head restraints.

We are not persuaded by the arguments presented by GM and the Alliance related to the load hold time of five seconds. These commenters argue that a 5 second hold time is not consistent with ECE 17 requirements. Instead, they suggest a one second limit. We believe the ECE requirements are insufficient in this regard in that they do not specify a loading rate or hold time. Despite our attempts to bring the new rule into harmony with the ECE regulations when adopting a requirement already covered by the ECE, there are instances in which we need to further clarify the test compliance procedure to provide an objective measurement, as required by statute. This is one of those instances. We do not believe a 5 second hold period is onerous and have adopted it as part of the final rule. We further note availability of strong and properly functioning retention locks should not have any negative effect on occupants' ability to properly adjust their head restraints.

We disagree with VW's objection to head restraints locking in the highest adjusted position above 800 mm. To the extent that such an adjustment position is provided, it would be intended to protect the tallest occupants. However, without the ability to lock in this position, the head restraint could slip down to the 800 mm position or perhaps even lower during normal use, or in a rear impact. Thus, the head restraint would not offer the intended protection, while giving these taller occupants the impression that they are well protected. We are not persuaded by Volkswagen's argument that the locking mechanism may be damaged if the front seat head restraint comes in contact with the vehicle roof when folded forward for rear seat access. We acknowledge that in some vehicles this interference between the roof and head restraint may exist. In fact, such interference may exist between rear seat head restraints and more forward seats. However, we are not convinced that such contact would be damaging to the locking mechanism. If a manufacturer were concerned about damage to their locking mechanism, two solutions would be to either increase the robustness of the lock or to decrease the spring load in the seat back folding mechanism. Another design alternative discussed above in the context of non-use positions, although more mechanically involved, would be a design that disengages both the seat back and head restraint simultaneously.

We proposed a 10 mm performance limit on the return position of the actual loading device to the reference point because we considered this to be the most objective method of determining the actual performance of locks. Some vertical loading data provided by the industry indicated a return position as much as 22 mm from the initial position. No similar data were provided for the horizontal loading test. In order to verify that the performance value selected for the position retention requirement is reasonable, we performed a series of static tests on several seats. The tests were performed at General Testing Laboratories (GTL), under the FMVSS No. 202 compliance-testing contract. The tests were performed in January 2002, on five MY 2001 vehicles.[54]

The test program assessed the ability of current head restraint designs to comply with the position retention requirements. We tested feasibility of the 10 mm limit on displacement from the initial position. Both the height retention and backset retention were tested. (*See* Table 1.) All head restraints were vertically adjustable and one (Mercedes E320) had rotational adjustment.

Table 1 shows the results of the height position retention tests and Table 2 shows the result of the backset position retention tests. One determination made by analysis of the test results was that the head restraint should not be allowed to displace more than 25 mm during the application of a pre-load to account for foam compression and other mechanical tolerances in the head restraint attachment as well as the situation in which the locking mechanism is so weak it cannot resist the preload.

The test results suggest that the backset displacement is less than the height displacement if the characteristics of the vehicle seat are accounted for. Therefore, if a single compliance value is selected for both the backset and height retention, we believe it is reasonable to allow the results of the height retention tests to drive the selection. However, if one does not account for seat characteristics, the horizontal displacement may be larger because of those characteristics.

Based on this limited data set, we believe that it is reasonable to alter the position retention tests to allow the seat back frame to be braced. Further, we have determined that the displacement limit after full load and return to preload should be increased to 13 mm from 10 mm. We believe using the limit of 13 mm would allow most vehicles to comfortably meet the requirement for both the height and backset retention. Therefore, we do not agree with DaimlerChysler's comments that suggested the 500 N vertical load for the position retention test is excessive.

TABLE 1.—HEIGHT POSITION RETENTION, FINAL DISPLACEMENT VALUES (MM)

Reference load	Vehicle model	Final displacement (mm)
50 N—not braced	Mercedes E320	6.4
50 N—not braced	Honda Civic	21.8
50 N—braced	Toyota Echo	11.4
100 N—not braced	Dodge Stratus	24.0
100 N—braced	Buick LeSabre*	Moved at Reference Load†

* Detents but no locking mechanism.
† No lock.

[54] For complete test results, please see Docket No. NHTSA–2000–8570–60, 61, 62, 63, 64.

TABLE 2.—BACKSET POSITION RETENTION, FINAL DISPLACEMENT VALUES (MM)

Reference load	Vehicle model	Final displacement (mm)
50 N—not braced.	Mercedes 320.	10.9‡
50 N—not braced.	Honda Civic.	10.6
50 N—braced	Toyota Echo.	6.9
100 N—not braced.	Dodge Stratus.	24.0
100 N—braced.	Buick LeSabre*.	20.3†

‡ Rotational Adjustment.
* Detents but no locking mechanism.
† No Lock.

In response to comments provided by Honda, we believe that the vertical load test can be improved by replacing the loading sphere with a loading cylinder measuring 165 mm in diameter and 152 mm in length. We believe that any potential slippage of the head restraint with respect to the loading sphere, if it were to occur, would be primarily in the longitudinal direction. Since the long axis of the cylinder will be oriented in the vehicle longitudinal direction, the potential of slippage will be substantially reduced. Further, we have no experience with using a flat plate as the loading device, while the loading cylinder is currently an option in FMVSS No. 202. The cylinder is to be loaded at the point on the head restraint with the greatest vertical position, rather than at the ''top'' as previously defined in the standard. The term ''top'' has been defined as the highest point of the head restraint at which a plane that is perpendicular to the torso reference line of the J826 manikin intersects the head restraint. For the backset position retention loading test, however, the lower edge of the cylinder may inhibit the return of the head restraint during the unloading phase. Therefore the loading sphere, positioned perpendicular to the torso line, will be kept for this test.

We believe that DaimlerChrysler's comments related to upholstery crush and Honda's comments related to the loading sphere slipping might have merit. However, we disagree with the commenters who have suggested that these issues can be resolved by simply specifying that the head restraint stay in its pre-load adjusted position. Although similar wording is used in other regulations, including Standard No. 207, such a performance requirement can in certain instances be difficult to enforce. We acknowledge that removing the head restraint upholstery and loading only the underlying structure would make it easier to determine lock failure and would remove the foam variability from the test. However, this would not be a realistic way of loading the head restraint and may, in fact, change the path of loading. We also note that measuring the movement of the loading device instead of directly measuring the head restraint (pre- and post-condition) produces more accurate measurements for compliance purposes.

We believe that the proposed height and backset position retention requirements are comprehensive and that requirements for other positions than those mentioned above are unnecessary and would not result in significant additional safety benefits. We note, however, that manufacturers are not precluded from providing additional lockable positions within the range of the head restraint adjustment.

XI. Energy Absorption

The NPRM proposed that a specified area of the head restraint would have to limit the deceleration of a 6.8 kg mass impactor, traveling at 24.1 km/h, to 80 g's. The impactor was a free-motion head form. In addition, we proposed that any portion of the head restraint that was outside of the impact area and that had a radius of curvature of less than 5 mm would be required to pass the energy absorption test. We requested comments on whether a free-motion head form was an appropriate testing device and whether the radius of curvature requirement was necessary.

Impactor. Industry commenters were unanimous in their desire for the use of the pendulum impactor instead of the free-motion head form. Johnson Controls and Honda suggested that the use of a pendulum impactor, as specified in ECE 17, Paragraph 5.1.3, is preferable to the use of a free-motion impactor for the energy absorption compliance testing. According to Honda, the primary reason for the desirability of the pendulum impactor is that conducting testing using this device would allow the manufacturers to use existing testing facilities and equipment.

Agency response: In proposing the free-motion head form, we intended to simplify the ECE energy absorption test by making the impactor similar to that used for the upper interior impact portion of Standard No. 201. We also attempted to assure consistency with the ECE testing results by making the mass of the proposed free-motion impactor identical to that of the ECE 17 pendulum impactor (6.8 kg).

We have decided to adopt a linear impactor, as opposed to a pendulum impactor or free-motion head form, as the compliance tool. Our decision was based on several factors. First, the use of a pendulum impactor could prevent us from running compliance tests on the actual vehicle without significant vehicle alteration, because of the interference of the vehicle interior with that type of impactor. If, as suggested by the manufacturers, a pendulum impactor were used, the seats would either have to be removed to allow for the pendulum swing or the roof of the vehicle would have to be cut open. Because of the cost involved, we often use the same vehicle to run multiple compliance tests. Removing seats or cutting into the vehicle to accommodate test equipment would limit our ability to run subsequent compliance tests for other standards.

Second, the differences between the linear impactor and free-motion impactor are insignificant in terms of their ability to measure compliance with the energy absorption requirement. The linear impactor is constrained so that it moves along a line, while the free-motion impactor is free to rotate upon impact or to have a rotation imposed upon it at the time of launch. This unconstrained motion is beneficial for use with types of impactors that have an irregular surface, such as a surface simulating a human face. However, since the impactor for the energy absorption test is spherical, there is no need for the free motion.

Third, the linear impactor is easier to target than the free motion head form, leading to more repeatable results. Currently, a linear impactor is used for the instrument panel and seat back impact testing under Standard No. 201. Fourth, we believe that the results obtained from a linear impactor will in fact be very similar to the results obtained from a pendulum impactor or free-motion impactor because the impactors have the same mass and impact velocity.

Radius of curvature. We proposed an energy absorption requirement for all surfaces with less than a 5 mm radius of curvature to eliminate potential sources of high-pressure contacts between occupants and head restraints. We have decided against adopting this requirement.

The Alliance stated that it is unaware of a need for a ''radius of curvature of less than 5 mm requirement,'' and recommended its deletion. Honda commented that the ECE 25 requirement for 5 mm radius of curvature limit is intended to apply to unpadded structures or structures padded with material softer than 50 Shore A hardness.

Agency response: In our opinion, the burden associated with the enforcement of this requirement outweighs its benefits. In order to determine that structures with the soft upholstery have radii of less than 5 mm, we would be forced to remove the soft upholstery. Thereafter, a second, upholstered head restraint would have to be subjected to the impact test. No commenter provided information supporting such a requirement. Accordingly, we are not adopting our proposal regarding areas on the front surface of the head restraint that are outside of the impact area.

As previously discussed, this final rule does not mandate rear outboard head restraints. However, this rule does require that the voluntarily installed rear outboard head restraints meet the energy absorption requirements discussed above.

XII. Issues Unique to Rear Head Restraints

a. Optional Head Restraints for Rear Seating Positions

The NPRM proposed mandating head restraints for all rear outboard seating positions, but asked whether NHTSA should limit the final rule to front seating positions. This question was based on visibility concerns as well as the lower safety benefits that would be obtained from rear seat head restraints, as compared to those from front seat head restraints, given lower occupancy rates for rear seats. Most of the industry commenters stated that, consistent with ECE 17, rear head restraints should remain optional. ECE 17 treats rear head restraints as an option, but regulates them if they are installed in a vehicle. Johnson Controls reasoned that because the dangers for rear seat occupants are less than those for front seat occupants, rear head restraints should not be mandated. GM, the Alliance, and others believed that rear head restraints should be an option because of rear seats' lower occupancy rates, occupancy of rear seats usually by shorter individuals, potential child seat interference with rear head restraints, and the potential reduction of direct and indirect rear vision. In supplemental comments, GM stated its concern that rear seat head restraints will affect its ability to comply with the requirements of FMVSS No. 111, *Rear View Mirrors.*[55]

In contrast, Magna, Honda, Advocates, and the FIU students commented that NHTSA should mandate rear seat head restraints in addition to front seat head restraints. Magna stated that rear seats are designed to accommodate occupants ranging in size from the 5th percentile female to the 95th percentile male. Accordingly, Magna maintained that head restraints should support the entire range of rear seat occupants. Honda requested an additional three years of lead time to comply with the rear head restraint mandate, beyond the NPRM's proposed three-year lead time.[56]

Agency response: As noted previously in this document, this final rule does not mandate head restraints in rear outboard designated seating positions. Instead, this final rule regulates only voluntarily installed rear head restraints. Our decision was based on the several factors described below.

First, additional analysis produced a more refined estimate of costs and benefits associated with mandating head restraints. Specifically, the benefits derived from: (a) Designing and installing compliant rear head restraints where none were previously provided, and (b) redesigning vehicles featuring multiple seating configurations (usually SUVs and minivans) that feature head restraints that do not meet the proposed requirements, are lower than originally estimated. The relationship of costs to benefits is represented as a cost per equivalent life saved. In the NPRM, the agency estimated that the cost per equivalent life saved for rear outboard head restraints was $9 million as compared to $3 million for front outboard head restraints.[57] We now estimate the cost per equivalent life saved for mandatory rear outboard head restraints to be greater than $13.8 million, as compared to approximately $2.4 million for front outboard head restraints.[58] The primary reason for the difference in the cost per equivalent life saved for front and rear seat head restraints is the difference in the numbers of front and rear seat occupants exposed to risk of whiplash injury in rear impacts and the difference between the costs of upgrading front head restraints and the costs of installing or upgrading rear head restraints.

Fewer rear seat occupants are exposed to risks in rear impacts because rear seats are much less likely to be occupied than front seats. An analysis of the distribution of occupants by seating position for all vehicle types in 2001 to 2003 NASS shows that 10 percent of all occupants sit in the second (or higher) row of outboard seats. We note that children and small adults derive less benefit from taller head restraints because their head center of gravity often does not reach the height of 750 mm above the H point. Therefore, if we further refine these data to include only occupants who are 13 years or older, the relevant percentage is reduced to approximately 5.1.[59] Our conclusions about rear seat occupancy are further supported by the FRIA data, which indicate that out of a total of 272,464 annually occurring whiplash injuries, approximately 21,429 (7.8%) occur to the rear seat occupants. In sum, only a small percentage of occupants who are tall enough to benefit from taller head restraints sit in rear outboard seating positions.

We have also reevaluated our compliance cost estimates. The cost of upgrading or installing rear head restraints in response to a mandate would have been significantly greater than the cost of upgrading front head restraints.[60] Our data indicate that, on average, front seats were closer to meeting the proposed front head restraint requirements than the rear seats were to meeting proposed rear head restraint requirements. In fact, some vehicles currently in production already comply with the front head restraint height requirement because they were manufactured to comply with ECE 17. However, because ECE 17 does not require rear head restraints, we are not aware of any passenger vehicles that comply with the proposed requirements for rear seats.

In addition to cost effectiveness, our decision not to require rear head restraints was influenced by comments indicating that rear head restraints would significantly reduce a driver's view through the rear view mirror in some vehicles. Although we are not able to estimate the associated adverse effects that might result from the rearward visibility losses, it is the likely that the effect would not be safety neutral for some vehicles.

Finally, based on submitted comments, we conclude that mandating rear outboard head restraints could either decrease availability of certain

[55] GM's concern that rear head restraints will affect compliance with FMVSS No. 111 is not warranted because head restraints are an allowable obstruction. In addition, if the rear window field of view requirements are not met, compliance could be achieved by adding passenger side outside mirrors. These side mirrors are standard equipment on most vehicles.

[56] As discussed in a later section, the rule does not provide Honda's suggested additional lead time.

[57] *See* 66 FR 963 at 981.

[58] By contrast, the cost per equivalent life saved for voluntarily installed rear head restraints is $4.71 million.

[59] We further note that approximately 2 percent of rear seat occupants sit in the center seating positions.

[60] We estimated that equipping rear seats with head restraints would result in the annual costs of approximately $103 million.

utility features currently available in ''multi-configuration'' vehicles such as minivans and SUVs, or make it necessary for vehicle manufacturers to alter interior or seat designs to maintain these features. At least initially, these alterations could significantly increase the cost of manufacturing these ''multi-configuration'' vehicles. Alternatively, such designs would necessitate the ability to remove the rear head restraints to allow seat folding.

As previously discussed, we were aware of low occupancy rates and potentially detrimental effect on rearward visibility when we proposed to require head restraints at each rear outboard designated seating position. These factors alone, however, were not decisive enough to convince us that we should not to propose requirements for mandatory rear head restraints and obtain public comment before making a final judgment on the merits. At the time, we tentatively concluded that the philosophy that commonly used seating positions should offer similar levels of protection to their occupants warranted further exploration of the merits of a mandate. However, in light of the newly refined, higher estimates of the cost per equivalent life saved, we conclude that rear head restraints should not be mandated.[61]

Nevertheless, in order to ensure that voluntarily installed rear seat head restraints do not pose a risk of exacerbating whiplash injuries, this final rule requires that those head restraints meet certain height, strength, position retention and energy absorption requirements proposed in the NPRM. We are considering inclusion in our annual ''Buying a Safer Car'' brochure, and on our web site, the list of vehicles equipped with rear head restraints. We believe this could provide an added incentive for the manufacturers to equip their vehicles with optional rear head restraints.

The definition of a rear head restraint: This final rule provides an objective definition and a test procedure for determining the presence of a rear head restraint. We decided that a vehicle seat will be considered to have a rear head restraint if the seat back, or any independently adjustable seat component attached to or adjacent to the rear seat back, that has a height equal to or greater than 700 mm, in any position of backset and height adjustment, as measured with the J826 manikin.

We chose this method for the following reasons. Based on the survey of vehicles used to determine the cost effectiveness of this regulation, we found that a 700 mm threshold captured all of the seats that had adjustable cushion components at the top of the seat back; *i.e.,* what the general public would probably consider being a head restraint.[62] Further, this definition of the rear head restraint will allow the manufacturers to provide a relatively tall seat back (up to 700 mm) without having to comply with rear head restraint requirements. We anticipate that such taller seat backs might offer some safety benefits to a certain portion of rear seat occupants. We note that the current head restraint standards do not require a height of above 700 mm even for front head restraints.

Because rearward visibility remains a concern, we note that the manufacturer will be able to determine whether providing a seat back structure above 700 mm would be consistent with the amount of rearward visibility they wish to provide.

As discussed previously, the agency has made significant accommodations to mitigate possible visibility losses associated with rear head restraints. First, the agency is making their installation voluntary. Second, the agency allows non-use positions that can move the head restraints out of view when the seat is unoccupied. Third, the agency allows rear head restraints to be removable. Fourth, the maximum required head restraint width for rear bench seats is 84 mm less than for front bench seats. Fifth, gaps as large as 60 mm can be provided within the perimeter of the head restraint.

b. Exception for Seats Adjacent to an Aisle

Johnson Controls expressed a concern that the NPRM's proposed heights for head restraints for third-row seating in vehicles would create a problem for outboard designated seating positions that are next to an aisle. The commenter suggested that the 750 mm proposed head restraint height requirement could create ingress and egress difficulties for people using these third-row seats, which could pose a safety problem in certain vehicle emergencies.

NHTSA believes that these concerns are now addressed by making the head restraints optional for rear outboard seating positions. If a manufacturer believes that it is better not to place the head restraints in designated seating positions adjacent to the aisles in order to facilitate ingress and egress into third and higher rows, it may act accordingly.

c. Potential Interference With Child Restraints and Tethers

The NPRM solicited comments related to safety concerns arising from potential interference of rear seat head restraints with the attachment of upper tethers of child restraint systems. The NPRM asked for test data and related comments regarding whether the passage of tethers over or under adjustable head restraints would affect the amount of head excursion of child restraint occupants in a crash or the lateral stability of child restraints.

Interaction between tethers and head restraints. NHTSA received numerous responses to these requests and questions. Advocates believed that the performance of child seat tethers would not be negatively affected by the proposed FMVSS No. 202 amendments. Nevertheless, Advocates recommended that NHTSA's final rule prohibit child seat tethers from being designed so that their use necessitates either removing rear head restraints or placing them in the non-use position.

Some industry commenters expressed concerns about, but did not provide any specific test data on, the safety impact of incompatibilities between child restraint tethers and rear seat head restraints. Johnson Controls asserted that safety concerns exist with respect to integral or adjustable head restraints and the proper management of child tether placement and loading. Johnson Controls commented that misuse or improper installation could occur. DaimlerChrysler suggested that a tether routed over the top of a head restraint would provide less effective safety protection in a side impact, given the longer tether length and routing. Honda believed that the perceived potential safety concern pertained to misuse that could occur when the tether strap is positioned over the head restraint and attached to the tether anchor when the head restraint is not positioned in the lowest possible adjustment position.

Ford acknowledged its lack of information regarding any head excursion effects of child restraint routing over or under a head restraint.

[61] As the agency noted in its 1995 final rule establishing upper interior head impact protection requirements, the application of the philosophy of providing similar levels of protection in all seating positions is subject to the limits of reasonableness:

While the costs per equivalent life saved still vary according to seating position, the conclusive factor in determining whether to regulate a particular seating position should not be the existence of such variations, but the reasonableness of the cost for that particular position. * * * So long as the cost per equivalent life is reasonable, NHTSA believes that a vehicle should be designed to offer the same level of protection to all occupants, regardless of the occupant's choice of seat. 60 FR 43031, at 43046; Aug. 18, 1995.

[62] The survey included twelve 1999 model year vehicles (9 passenger cars, 1 minivan, and 2 SUVs). Five of the twelve vehicles featured rear seating systems that fell under our definition of the rear head restraint.

Ford indicated that in some frontal sled tests it conducted, it discovered a degree of tether slippage to the side of the head restraint when the tether was routed over head restraints. Ford assumed this slippage would increase head excursion, although Ford's tests did not produce evidence of excessive head excursions. Ford stated that increased head restraint heights also might increase the effects of slippage on chest acceleration, neck loads, and HIC.

Transport Canada said that it has investigated whether interference between head restraints and child restraint tethers might alter the angle at which the tethers depart the child restraint, or create slack in the strap, in a manner that would affect the performance of the child restraint. Transport Canada conducted numerous sled tests to discern any effects of varying strap angles and slack on child seat tether performance. Transport Canada's data indicated that tethers remained effective even at rather large strap angles. The data additionally showed that tethers retained their effectiveness up to the point at which large amounts of slack were incorporated into the tests.

The Alliance commented that the extent of head restraint and tether interference varies depending on the exit point of the tether from the child restraint, as—the commenter believed—a lower exiting tether will produce greater interference. With respect to the NPRM's suggestion that a Y-shaped tether strap design might be used to go around the head restraint, the Alliance maintained that no child restraints currently on the market are equipped with Y-shaped tethers. However, it noted the availability of a V-shaped tether strap design on a few high-priced child restraints.

Less of a snug fit between child restraint and vehicle seat because of head restraints.

Several commenters believed that the proposed backset and gap requirements could interfere with proper child restraint and booster seat installation.

The Partners for Child Passenger Safety (PCPS) said that there is an existing incompatibility between rear head restraints and some high-back convertible child restraints and boosters. In particular, PCPS asserted that a rear head restraint might affect the tightness of a hybrid child restraint's [63] fit on the seat when the child restraint is used as a forward-facing seat. The Alliance commented that many existing child restraint systems have higher and straighter backs that could interfere with head restraints meeting the proposed 50 mm backset limit, thus causing child restraint fit problems. The Alliance further indicated that head restraint interference causes tipping and sliding of high-back boosters during cornering due to the lack of contact between the back of the booster and the vehicle's seat back. The Alliance asserted that the interference of head restraints with reduced backsets with high-back belt-positioning boosters could push the booster seat forward, causing an adverse effect on the positioning of lap and shoulder belts.

Effect of new head restraints on child restraint anchorage systems. Several commenters raised concerns about the effect that the new head restraints might have on the design and testing of child restraint anchorage systems (pursuant to FMVSS No. 225). DaimlerChrysler expressed concern about the issue of interference with the child restraint and the Child Restraint Fixture (CRF) used by NHTSA to test the strength and positioning of child restraint anchorage systems in vehicles under FMVSS No. 225. Less desirable relocation of lower anchors for child seats, the Alliance contended, might also result from reduced backset due to head restraint interference with the CRF design.

Agency response regarding child restraints and tethers: NHTSA reviewed the comments submitted with respect to potential child restraint and/or tether interference. These comments pertain exclusively to rear seats. Since the final rule does not require rear seat head restraints, any incompatibility can be addressed by the manufacturers. Therefore, we have concluded that the final rule's head restraint requirements will not adversely affect child restraint safety. In addition, we believe that optional rear head restraints will not have a significantly negative effect on child restraint compatibility. Below we provide responses specific to several areas of commenters' concern if a head restraint is present.

Agency response regarding tethers: As the agency stated in the NPRM, tethered child restraint requirements have been in effect for quite some time in Canada and Australia, and vehicles with rear head restraints meeting requirements similar to those of today's final rule are relatively common in those countries. Transport Canada indicates that interference between rear head restraints and child restraint tethers has not created any significant problems. To the extent that interference occurs, it creates incentives for child restraint manufacturers to design child restraints to assure maximum child protection. For example, a demand would likely develop for Y- or V-shaped tethers, if such tethers make attaching to a tether anchor easier.

As indicated above, Johnson Controls, Honda, DaimlerChrysler, and Ford suggested that routing tethers over head restraints might lead to increased head excursions. However, industry commenters did not provide any data on this issue, while Transport Canada's data indicate that tethers remain effective up to the point at which large amounts of slack are introduced.

NHTSA assumes that the worst-case tether location is floor mounting because floor-mounted tethers have the potential to introduce the most slack in a collision, while deck-mounted and roof-mounted tethers likely would not produce significant slack because of their shorter distance to the child restraint. If current voluntarily installed rear seat head restraints are an indication of future systems, NHTSA anticipates manufacturers will install adjustable systems, in which case the tether could be routed under the adjustable head restraints, reducing the potential for excessive amounts of slack.

Vehicle manufacturers are required to provide instructions for proper attachment of the child restraint tether under FMVSS No. 225. Manufacturers must determine how child restraint tethers should be routed with respect to the particular head restraints in their vehicles, and how the head restraint should be adjusted. In some instances, a manufacturer may recommend that the head restraint be temporarily removed.

Agency response regarding fit of child restraints: With respect to comments pertaining to the potential incompatibility between rear head restraints and some high-back hybrid child restraints and boosters, NHTSA notes that high-back child restraints are used in Europe with no reports of incompatibilities. As Magna commented, rear seat head restraints are much more common in Europe due to competitive pressures. Nonetheless, if incompatibilities arise in this country, they can be resolved by several means. First, we believe that an adjustable head restraint is likely to have a position that does not interfere with high back hybrid child restraints. That is, raising the head restraint may alleviate the potential interference. Second, the high-back child restraint can be installed in a seating position for which a head restraint is not provided, removable, or has a non-use position. We note that even where rear outboard head restraints are provided, many vehicles do not provide a head restraint in the

[63] A hybrid child restraint is one that can be used as a forward facing seat below a certain child weight and a belt positioning booster seat above.

center seating position.[64] We recognize that, even with the flexibility afforded to the manufacturers with respect to rear seat head restraints, there may be isolated situations where certain high back child restraints are not compatible with specific seating positions in certain vehicles. However, we expect this to be relatively infrequent. In short, the agency does not believe that the possible incompatibilities are insurmountable even in situations in which rear seats are equipped with optional head restraints. The agency will monitor these and other issues associated with the implementation of this final rule.

Agency response regarding testing of child restraint anchorage system: NHTSA disagrees with the Alliance's comments asserting that rear head restraints will cause interference with the CRF, thereby resulting in unfavorable positioning of lower anchors. In an earlier rulemaking on FMVSS No. 225, the agency modified the CRF so that it can be broken down into a short-back configuration, eliminating the potential for head restraint interference.

XIII. Dynamic Test Alternative

In the NPRM, we proposed a dynamic compliance option for forward facing seats as an alternative to static requirements of this final rule. The dynamic compliance option was proposed primarily for two reasons. First, the dynamic test better represents ''real-world'' injury-causing events and thus produces greater assurance than the static measurement option of effective real world performance. Second, as explained below, we believe that the dynamic test will help to encourage continued development and use of ''active'' head restraint systems because the test is designed to allow a manufacturer the flexibility necessary to offer innovative active head restraint designs while still ensuring a minimal level of head restraint performance.

Active head restraint systems deploy[65] in the event of a collision to minimize the potential for whiplash. During the normal vehicle operation, the active head restraint system is ''retracted.'' Because an active head restraint system requires a certain range of motion to work effectively, an ''un-deployed'' active head restraint system might not meet the static measurement requirements of FMVSS No. 202a.

Several manufacturers now offer active head restraints. For example, Volvo offers the Whiplash Head Impact Protection System (WHIPS) in which the seat back recliner is designed to control the rearward motion of the seat back relative to the seat base in a rear impact. Volvo believes that this allows the head and torso to be more uniformly supported. A number of other vehicle models including Saab, Infiniti, and BMW also offer active head restraints in their vehicles.

Although the dynamic compliance option is intended to ensure that the final rule encourages continuing development of active head restraint systems, the option is available to both active and conventional, or ''static'' head restraint systems. That is, both types of head restraints can be certified to either static requirements or the dynamic compliance option. As explained above in the discussion of the height requirements for front seat head restraints, if the choice were made to certify to the static requirements, an active head restraint would have to meet these requirements in its undeployed state. If an active head restraint were unable to do this, the dynamic compliance option provides an alternative means of certification. Head restraints certified to the dynamic compliance option must still meet the static width requirements of this final rule. As discussed below, a manufacturer's selection of a compliance option would be irrevocable. However, the manufacturer may select different compliance options for different designated seating positions.

The current dynamic test in FMVSS No. 202 accelerates a seat to an 8 g half sine acceleration pulse over 80 ms. The NPRM proposed a new dynamic compliance test option involving a sled test with a target pulse of 86 m/s^2 over an 88 ms duration and a 17.3 ± 0.6 km/h change of velocity.

Most commenters on the NPRM agreed with maintaining an alternative dynamic compliance option. However, as IIHS noted, that there has been no strong interest in the industry to take advantage of a dynamic compliance option. Because the dynamic test requirements are based on the static location requirements, the AIAM commented that there is little incentive to use the dynamic testing option. King[66] commented in favor of dynamic testing. The final rule adopts the proposed dynamic compliance option, with modification, because we believe it desirable and necessary to encourage continued development and use of ''active'' head restraint systems. Especially as modified, the test is designed to allow a manufacturer the flexibility necessary to offer innovative active head restraint designs while still ensuring a minimal level of head restraint performance.

Test Dummies. For the dynamic compliance test option, the NPRM proposed the use of a 95th percentile male dummy in a front seat with the head restraint at a single manufacturer selected position, and a 50th percentile male dummy in the front and rear seats with the head restraint midway between the lowest and the highest position of vertical adjustment. In vehicles in which the seat cushion adjusts independently of the seat back, the dynamic measurements were to be taken with the seat cushion adjustment in the most unfavorable position.[67]

The Alliance commented that there are many potential test dummy candidates, but no consensus on the most appropriate one to use for a dynamic head restraint test. Magna argued in favor of using 5th percentile female, 50th percentile male and 95th percentile male dummies. Honda stated that the 95th percentile male dummy should have priority in testing. DaimlerChrysler said that a 5th percentile female dummy is not needed for testing because if a head restraint is high enough for a 50th percentile male, it will also be high enough for a 5th percentile female. Tencer suggested that in order to be certain that a smaller occupant's head contacts the intended surface of the head restraint, there should be some indication of how a small female would fit the seat. Autoliv commented that since the most common neck-injured occupant is an average size female, a 50th percentile female dummy should be used in dynamic testing. Autoliv also said that a BioRID[68]

[64] NHTSA has issued an NPRM that would mandate installation of lap/shoulder belt restraint systems in the center rear seating position (68 FR 46546), which will ensure availability of restraints for use with an older child in a belt positioning booster.

[65] Besides mechanical deployment, some systems use other methods. For example, BMW 760Li uses a pyrotechnic head restraint system that utilizes a gas discharge to deploy head restraints.

[66] Albert I. King, PhD, Bioengineering Center, Wayne State University.

[67] If the seat cushion adjusts independently of the seat back, the seat cushion would be positioned such that the highest H-point position is achieved with respect to the seat back, as measured by the HRMD.

[68] BioRID stands for Biofidelic Rear Impact Dummy. It was developed by a consortium of Chalmers University of Technology in Sweden, Autoliv, Saab and Volvo to help safety engineers evaluate the relative motion of the head and torso in rear crashes. BioRID has a flexible spine with 24 vertebra-like segments, the same number as in the human spine. It has joints that allow for forward and backward movement of the head, and integrates spring-loaded cables that simulate the action of human neck muscles. Its spine is said to interact with vehicle seats in a more humanlike way than the Hybrid III's rigid spine. Further, its neck is

dummy, with its flexible spine, should be used in dynamic testing instead of the Hybrid III dummy. IIHS commented that the Hybrid III dummies are not biofidelic for rear impacts, that they represent large adult males, and that dynamic testing based on them may lead to dynamic head restraint designs that are not effective for smaller occupants such as children and females. King agreed that there is not any truly biofidelic dummy now available for rear impacts, but recommended use of the Hybrid III dummy as the best alternative currently available. He specifically recommended against the use of the BioRID dummy, stating that it had not been validated against cadaveric data in detail and that relative displacements between the pinned joints are not available. Advocates supported dynamic testing with 5th percentile female dummies to limit the negative effects of head restraints that are adjusted too high. Advocates also stated that the 95th percentile male dummy should be used in the rear seat as well as the front seat.

Agency Response: There was no consensus among the commenters on the use of the Hybrid III dummy or the range of dummy sizes to be utilized. NHTSA is aware of the criticism associated with Hybrid III. Specifically, many commenters assert that the 50th percentile male Hybrid III neck lacks sufficient biofidelity to be a useful tool for rear impact testing. Because of likely design similarities, the same criticism could be made of the 95th percentile male and 5th percentile female dummy necks. We are aware of a newly developed test devices, BioRID II and RID 2, which purport to model a human neck more accurately. We are also familiar with a paper by Ford (SAE 973342), which argues that the 50th percentile male Hybrid III neck is sufficiently biofidelic in the rearward direction. Another recent publication indicated that the overall flexibility of the Hybrid III dummy is comparable to that of a tensed volunteer, while the flexibility of the BioRID II and RID 2 are greater than those of tensed volunteers and embalmed cadavers.[69] We are likely to revisit the decisions made in this final rule about dynamic performance values and the test device as more advanced dummies are developed and the injury criteria achieve broader consensus.

Any consensus advancement in adaptation of a new, more biofidelic dummy will be welcomed by the agency and considered as part of future possible modifications to the standard. However, we believe the introduction of a modified dynamic test alternative should not be delayed, even if it is only an interim step toward a more advanced test procedure. We find especially persuasive King's comments, stating that the Hybrid III dummy is the only reasonable option at this time.

In our opinion, the 95th male dummy in the front, and 50th percentile male dummy in the rear, provide for a relatively worst-case scenario in terms of potential occupants and assure that the head restraint has sufficient height. However, the 95th percentile male dummy is not yet available and thus has not been incorporated into 49 CFR part 572, *Anthropomorphic Test Devices.* Therefore, the final rule does not use the 95th percentile male dummy in the dynamic compliance option for front seats. Instead, as discussed further below, this final rule requires that the head-to-torso rotation be limited to 12 degrees with the 50th percentile male dummy with the head restraint midway between the lowest and the highest position of vertical adjustment. Ideally, it would be preferable that the dynamic testing be performed with the 5th percentile female and 95th percentile male dummy. However, we conclude that the 50th percentile male dummy with the 12-degree head-to-torso rotation performance limit is sufficient to discern between acceptably safe head restraint systems and those that allow unacceptable levels of head-to-torso rotation for the taller occupants. We note that sled testing performed by the agency and described further below shows that the 50th percentile male dummy is capable of discerning the difference between 800 mm and 750 mm high head restraints. This data set did not vary backset. However, previous agency modeling results presented in the NPRM and sled testing by Viano have shown the 50th percentile male Hybrid III dummy to be sensitive to changes in backset as well.[70] Thus, the 50th percentile male Hybrid III can, for the time being, be used as to determine the adequacy of head restraints for taller occupants.

In regard to commenters who preferred testing with a 5th percentile female dummy, we conclude that it is not necessary to use such a dummy to determine if the tested head restraint has the height and backset required to protect most occupants. Recent agency testing of several modified seat designs showed that dummy head-to-torso rotation is lower for a 5th percentile female than for a 50th percentile male dummy. Accordingly, a test featuring the 50th percentile male dummy captures the injury criteria associated with a 5th percentile female. We note, however, that this may not be the case for all seat designs. Any future upgrade proposals for dynamic rear impact testing in general, and the development of more refined injury criteria in particular, should consider incorporation of a small female dummy.[71]

Injury criteria. In the NPRM, we proposed two criteria for the dynamic performance option: A maximum head-to-torso rotation criterion and a maximum HIC15 level. Johnson Controls commented that the criteria should bear a direct relationship to whiplash injury prevention. Magna, along with AIAM, requested that a performance corridor be established for the dynamic testing alternative.

Maximum head-to-torso rotation: The NPRM proposed a maximum head-to-torso rotation of 20 degrees for a 95th percentile male test dummy in front outboard seats and 12 degrees for a 50th percentile male test dummy in all outboard seats. With the 95th percentile male dummy, the head restraint could be at a single manufacturer selected position of adjustment. With the 50th percentile dummy, the head restraint could be at any position of adjustment.

Tencer and King both suggested time-dependent limits in their comments regarding the head-to-torso rotation performance criterion. Tencer believes that the extent of "S" shape curve correlates to the magnitude and time difference in the forward shear of the upper and lower neck. King believes that facet capsule stretch between the vertebrae could be a source of injury. In low speed impacts with a rigid seat back, the measured peak stretch occurs 100–120 ms after impact. He suggested that head restraint contact should be made within 50 ms. AIAM recommended that the head-to-torso rotation be tested only at maximum backset. GM commented that because there is not yet a consensus on neck injury criteria, a limit of 12 degrees should not yet be established. The Alliance expressed concerns because the specified head rotation limits may be too restrictive. Advocates voiced

capable of producing the S-shape observed in human necks during rear crashes.

[69] Kim, A., Anderson, K., Berliner, J., Hassan, J., Jensen, J, Mertz, H., Pietzch, H., Rao, A., Schere, R., Sutterfield, A, (2003) Stapp Car Crash Journal, Vol. 47, pp. 489–523.

[70] Viano, D., Davidsson, J., "Neck Displacement of Volunteers, BioRid P3 and Hybrid III in Rear Impacts: Implications to Whiplash Assessment by a Neck Displacement Criterion (NDC)," Traffic Injury Prevention, 3:105–116, 2002.

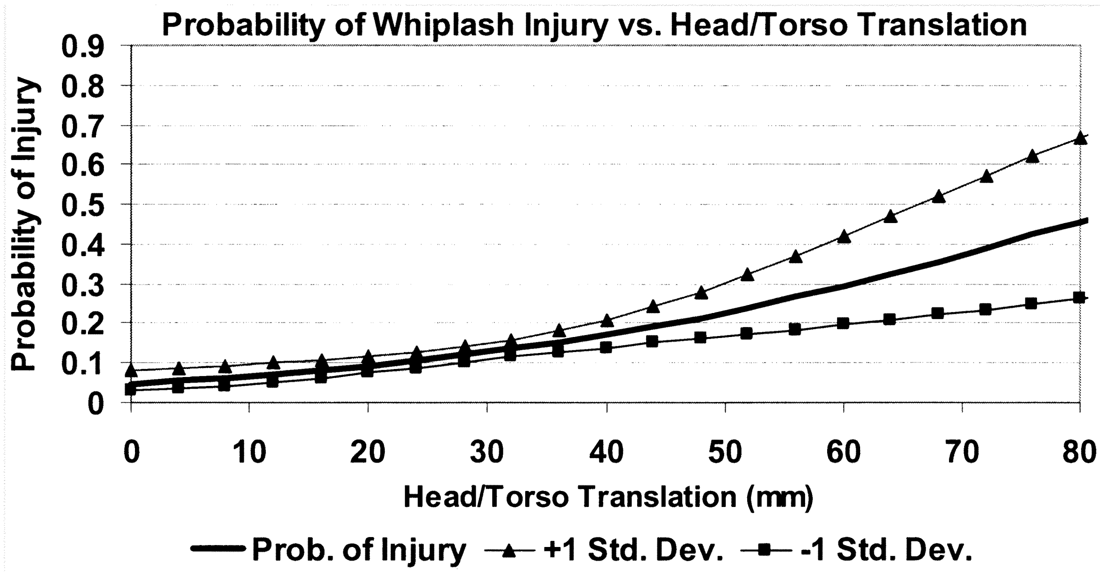
[71] In response to Autoliv's suggestion that we test with a 50th percentile adult female dummy, we note that there currently is no test dummy representing a 50th percentile female.

concerns that the 20-degree rotation limit for the 95th percentile male dummy in front seats is too large.

Under today's rule, we are adopting a maximum relative head-to-torso rotation value of 12 degrees with the 50th percentile male dummy in all outboard seats, with the head restraint adjusted vertically midway between the lowest and the highest position of adjustment.[72]

We decided to require that the head restraint be positioned at one middle position of vertical adjustment instead of requiring that the head restraint meet the dynamic compliance option requirements at all positions of head restraint vertical adjustment because we are concerned with the effects of this final rule on active head restraint systems. As previously stated, we want to ensure that the dynamic compliance option encourages continuing development of active head restraint systems. As discussed below, research indicates that current head restraint systems can easily meet the head-to-torso rotation limit in this final rule when the head restraint is adjusted midway between the lowest and the highest position of adjustment.

Using published data of low speed rear impact testing of original equipment manufacturer (OEM) seats with Hybrid III 50th percentile male dummies (Viano *et al.*, 2002), and information on whiplash injuries sustained by occupants of these seats, the agency used logistic regression to develop a probability of whiplash injury as a function of dummy head-to-torso rotation. The function is shown below:



$$\text{Probability of Whiplash} = (1 + e^{(3.295 - 0.063*\theta)})^{-1}$$

A 12-degree head-to-torso rotation corresponds to a 7.3 percent probability of whiplash. This criterion was selected to ensure adequate protection for occupants who range in stature from shorter females up to and including taller males, for all outboard seats. In evaluating the head-to-torso rotation limit, we note that in the past there has not been a consensus among the biomechanics community on how best to measure the potential for whiplash injury. This lack of consensus is evidenced by the related, yet different, criteria recommended by King and Tencer. In our opinion, the relative head-to-torso rotation is presently the best criterion available, and will assure early head restraint interaction consistent with King's recommendation. Our goal in selecting performance criterion limits for the dynamic compliance option was to provide a level of safety similar to that provided by the static requirements. Our research shows that it is feasible to meet these limits with both active and static head restraints.

The agency performed sled testing as specified in the dynamic compliance option on a specially designed seat to explore how various seat characteristics affect relative head rotation and other dummy injury measures.[73] An OEM seat with an adjustable head restraint was modified by removing the original recliner mechanism and replacing it with a pin joint free to rotate. The seat back was also reinforced with steel channels that provided the attachment points for a spring and damper system on each side of the seat. Seat back strength in the rearward direction was modified by changing the springs and/or their location of attachment relative to the hinge joint. In addition to seat back strength, sensitivity analyses to head restraint attachment strength and seat back upholstery compliance were also performed. Tests were performed with belted 5th percentile female, 50th percentile male and 95th percentile male Hybrid III dummies.

[72] We note that the manufacturer may select different compliance options for different designated seating positions to which the requirements of this section are applicable.

[73] For full details of these tests, please see Docket No. NHTSA–2002–8570–57, 58, 59.

The head restraint height was either 750 mm or 800 mm and the backset was always 50 mm as measured by the HRMD. However, the majority of tests (20 tests) were performed with the 50th percentile male dummy with a 750 mm high head restraint. For all seat back parameters tested with this configuration of dummy and head restraint height, the range of relative head-to-torso rotation was 6 to 16 degrees. HIC_{15} was measured for half of these tests and ranged from 40 to 75. Nearly half of the seat configurations (9 of 20) met the 12-degree limit placed on the dynamic compliance option for a head restraint in the lowest adjustment position (750 mm). In general, the smallest relative rotations were seen for the baseline seat back strength [74] and non-rotating seat backs irrespective of the other seat/head restraint parameters. From these tests, we conclude that the head rotation and HIC limits selected can be met with typical seat back/head restraint designs when appropriate consideration is given to design in terms of height, backset and strength of head restraint attachment.

In a separate set of tests, the agency subjected a MY 2000 Saab 9–3 seat to the sled pulse of the dynamic compliance option. A 95th percentile male Hybrid III dummy occupied the seat. The Saab 9–3 has an active head restraint system, and the head restraint was set to its highest position of adjustment. The maximum head-to-torso rotation was 9 degrees. Viano and Davidsson (2002) also sled tested a 9–3 head restraint at a slightly lower, 16 km/h ΔV, with the seat occupied by a 50th percentile male Hybrid III dummy. With the head restraint in the up position, the relative head rotation was measured at 6.5 degrees. With the head restraint midway between the lowest and the highest position of adjustment, the relative head rotation was 10 degrees at 23.5 km/h ΔV. We believe that this configuration would yield an even smaller head rotation at the 17.2 km/h ΔV.[75]

TABLE 3.—VIANO REAR IMPACT SLED TEST DATA

Test type	Vehicle	DeltaV km/h	Backset mm	HR position in height	HIC15	Head-to-torso rotation (deg)
Sled	Saab 9–5 + SAHR	12.8	35	up	11	1
Sled	Saab 9–3 SAHR	16	41–43	up		4.6–6.5
Sled	Saab 9–5 + SAHR	30	35	up	39	11
Sled	Saab 9–3 SAHR	23.5	46	mid	35	10
Sled	Saab 9–3 SAHR	16	48–65	down		13.3–16

In sum, research indicates that the head-to-torso rotation limit of 12 degrees will not discourage the development of active head restraint systems. Current systems, such as the one in 2000 Saab 9–3, can readily meet the head-to-torso rotation limit in this final rule. Agency testing has also shown that current static head restraints/seats need more extensive modification to meet the head-to-torso rotation limits. These changes might include increasing the strength of attachment to the seat for adjustable head restraints and optimization of the seat back upholstery for compliance.

We also considered performance criteria other than head-to-torso rotation for the dynamic compliance option. Alternative criteria included N_{ij}, which is a combination of upper neck moments and forces introduced in the Advanced Air Bag Rulemaking (Docket NHTSA–98–4405); and NIC, which was developed by Chalmers University and has been used by IIHS in testing active head restraints; and individual values of force, moment and acceleration. We have decided in favor of head-to-torso rotation because, in the absence of generally accepted injury criteria specifically applicable to whiplash injuries, we believe that a head restraint's ability to prevent whiplash is primarily due to its ability to prevent the rearward translation and rotation of the occupant's head with respect to the torso. The sled tests showed that rearward head rotation seemed to correlate with head restraint position. Other biomechanics researchers have found a similar correlation and used head-to-torso rotations for the evaluation of whiplash injury.[76] The agency is willing to reconsider the dynamic performance criteria if and when more advanced whiplash injury criteria become available.

HIC_{15} *criterion:* The NPRM proposed a HIC_{15} limit of 150 for the dynamic compliance option. Johnson Controls, GM and the Alliance opposed the 150 HIC_{15} limit. They saw no correlation between HIC and the reduction of neck injuries. AIAM recommended that we adopt an ''acceleration limit,'' instead of 150 HIC_{15} limit requirement. Advocates supported the HIC_{15} limit as a prudent safeguard against head restraints that may meet a head rotation limit, but still inflict cranial trauma. The FIU students commented that the current 150 limit of HIC_{15} is sufficient for testing. No comments were made in favor of using a 36 ms window.

We are adopting a HIC_{15} window to be consistent with the new HIC criterion in Standard No. 208 (65 FR 30680; May 12, 2000). The agency did not propose the HIC_{15} limit as a means of limiting whiplash, but instead as a surrogate for the 80 g energy absorption test required for the static compliance option. If we were to eliminate the HIC_{15} limit from the dynamic compliance test, we would need to re-introduce the 80 g limit energy absorption test required for static compliance. Because HIC_{15} is easily measured during dynamic testing, it appears to be a more appropriate measuring tool. However, we have decided to specify a limit of 500 in the final rule rather than the 150 limit proposed in the NPRM. We raised the limit because of concerns that the 150 level is at a location on the injury risk curve that indicates a very small probability of injury. Thus, requiring head restraints not to exceed this level might inhibit innovative whiplash protection. The HIC_{15} level of 500 is associated with an 18.8 percent probability (95 percent confidence: 1.8

[74] The baseline seat back strength was obtained through static testing of OEM seats and modeling to determine the corresponding amount of seat back rotation. The static testing can be found in Docket NHTSA–1998–4064–26.

[75] Viano, D., Olsen, S., ''The Effectiveness of Active Head Restraint in Preventing Whiplash,'' Journal of Trauma, Injury, Infection, and Critical Care, Vol. 51, No. 5, 2001; and Viano, D., ''Role of the Seat in Rear Crash Safety,'' Society of Automotive Engineers Inc., Warrendale, PA, 2002.

[76] Geigl *et al.* (1994) The Movement of Head and Cervical Spine During Rear-end Impact, IRCOBI, pp 127–137.

to 32.5 percent) of moderate (AIS 2+) head injury.[77] While the 80 g limit and the HIC_{15} limit of 500 are not necessarily equivalent, the two requirements do share the same intent of mitigating potential injury related to the head's striking a rigid or insufficiently padded head restraint. We analyzed data from FMVSS No. 201 impactor tests on the back of head restraints and also vehicle seat sled test data. We superimposed a 80 g half sine acceleration on the time duration of the impacts from these tests. This resulted in range of HIC_{15} values from approximately 425 to 800. Accordingly, we believe a limit of 500 is appropriate. The greatest HIC_{15} value obtained in testing sled testing using a 50th percentile male dummy was 57. Thus, the HIC_{15} limit of 500 is practicable. The 500 HIC_{15} limit will give a strong indication of deleterious effects on the occupant's head and/or neck from deploying head restraints.

Summary of injury criteria: Table 4 summarizes the injury criteria to be met for the dynamic compliance option. Our research indicates that currently available dynamic head restraints can readily meet the requirements of this final rule. We believe that the dynamic compliance option is sufficiently flexible to encourage continuing development of dynamic head restraint systems. However, the agency remains open to alternative suggestions on dynamic criteria that would further encourage innovative active head restraint designs.

TABLE 4.—TESTING PARAMETERS FOR THE DYNAMIC COMPLIANCE OPTION

Seating position	Dummy size	Rotation limit	HIC_{15} limit	Height adjustment	Backset adjustment	Head restraint width
Front & Rear	50th Male Hybrid III.	12 Deg	500	Midway between the lowest and the highest position of adjustment.	Any position of adjustment	170 mm except 254 mm for front bench seats.

Other dynamic compliance option issues. There were three additional aspects of the dynamic compliance option that the agency discussed in the NPRM.

Minimum width requirement: The NPRM proposed that the same head restraint width requirement in the static compliance option be applicable to the dynamic compliance option as well. As discussed above, the final rule requires that all head restraints on front bucket seats and all voluntarily installed rear head restraints certified to the static compliance option have a minimum width of 170 mm. The bench seat head restraints located in the front outboard seating positions must have a minimum width of 254 mm. The final rule adopts the same width requirement for head restraint systems certified to the dynamic compliance option.

GM commented that the width requirement would be inappropriate, especially for active or deployable head restraints. Honda also stated that the requirement would be unnecessary. DaimlerChrysler had no concerns related to the width requirement in the dynamic option, except for the same visibility issues it had raised in the discussion of the static test requirements. Ford and the Alliance commented that the width requirement is necessary, and repeated their desire for a single 170 mm width for all seat types. Advocates commented in favor of adding the width criteria to the dynamic option.

There appears to be no industry consensus as to whether the width requirement should be included in the dynamic compliance option. We disagree with GM's assertion that the width requirement is inappropriate for deployable systems. Regardless of whether the head restraint pivots forward to contact the head in a collision or is permanently situated behind the head, the head restraint should be sufficiently wide to provide protection. We note that unlike height and backset, the dynamic test does not assure sufficient width because it decelerates the vehicle in the longitudinal plane which causes the occupant to move in that plane, rather to one side of the other as might occur in an off-axis impact.[78] Therefore, we have decided that vehicles certified to the dynamic compliance option must also meet the width requirements of the static compliance option. For reasons discussed in Section VI.a., we decline to adopt a single 170 mm width requirement for all head restraints.

Seating procedure: The seating procedure for the dynamic compliance option is set forth in S10 of Standard No. 208, with additional details added to address lateral positioning of the dummy. Since the manufacturers are already familiar with these procedures, they should not encounter any seating procedure difficulties while conducting the dynamic compliance test. Since testing of the head restraint is the focus of this procedure, we found it necessary to add provisions specifying that the dummy torso be placed within 15 mm of the head restraint centerline. In the event that the dummy cannot be seated because of space limitations, such as might be the case in the outboard rear seat of a vehicle, the dynamic option would not be available for that seating position.

Test fixture: For the dynamic compliance option, the NPRM proposed mounting the entire vehicle on a sled.

The Alliance, among other commenters, asked the agency to consider allowing the use of a seat attached to a test buck, instead of an actual vehicle for the dynamic compliance option. GM commented that no one would certify to the dynamic performance option because mounting the whole vehicle on the sled, instead of just the seat, imposes an undue level of complexity.

NHTSA concludes that attaching the seat to a test buck is problematic for compliance tests. NHTSA cannot use a vehicle for further testing involving a seat if we remove the seat for the purposes of dynamic compliance option testing. Accordingly, NHTSA will conduct its compliance testing using the whole vehicle. The manufacturers are, of course, free to conduct their

[77] Eppinger, R., *et al.* (1999) Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems—II. Available at *http://www-nrd.nhtsa.dot.gov/pdf/nrd-11/airbags/rev_criteria.pdf.*

[78] The test procedure specifies that the midsagittal plane of the dummy must be aligned within 15 mm of the head restraint centerline as opposed to off-center as a vehicle occupant might be positioned.

development and certification testing on a buck. To assure that any certification is in good faith, we would expect such a manufacturer to show a correlation between buck testing and full vehicle testing.

XIV. Consumer Information

In the NPRM, we asked for comments regarding whether vehicle users understand how to properly adjust head restraints and, if not, whether the rule should require manufacturers to provide information on this subject to consumers in vehicle owners' manuals or elsewhere. In addition, the NPRM solicited comments regarding whether vehicle users intentionally misadjust head restraints for reasons related to comfort, visibility, or other factors.

ICBC provided extensive comments on these issues. According to ICBC, most motorists are not aware of the need to properly adjust their head restraints. Results from focus group studies commissioned by ICBC in 1996 suggest that drivers do not perceive a head restraint as a safety device and do not understand how a head restraint protects them. Consumer education programs, ICBC asserted, can increase the rate of proper adjustment, and manufacturers should play a role in educating consumers through owners' manuals, advertising, and in vehicle showrooms. ICBC initiated media information and direct intervention with vehicle users at various locations, including emissions testing stations, ferry terminals, and insurance offices. Education at ferry terminals alone resulted in 79,000 of 190,000 vehicle drivers adjusting their head restraints. ICBC cited these results, as well as similar studies of Transport Canada, in support of its effort to show that consumer education programs can positively influence proper head restraint adjustment. Transport Canada relied on ICBC data and suggested that the public does not properly adjust head restraints in the absence of consumer information programs.

Johnson Controls and the Alliance noted that they knew of no data suggesting whether head restraints are intentionally or inadvertently misadjusted. Based on consumer surveys conducted by Johnson Controls, users adjust their head restraint height at most only once, in order to increase comfort, not to improve safety.

DaimlerChrysler believed vehicle users intentionally misadjust head restraints for reasons related to comfort, visibility, convenience, and a lack of knowledge about proper positioning. However, DaimlerChrysler indicated it did not have any data to show why this intentional misadjustment occurs as opposed to inadvertent misadjustment. DaimlerChrysler commented in favor of requiring additional literature, either in owners' manuals or elsewhere, to educate consumers about the proper use and positioning of head restraints. The Alliance stated that vehicle users generally do not fully understand the appropriate use and purpose of head restraints. The Alliance and GM stated that a consumer information program coordinated between NHTSA and industry members could substantially reduce the problem of improper head restraint adjustment.

Ford indicated that it voluntarily includes head restraint adjustment information in its owners' manuals and that such information is adequate to educate consumers about proper head restraint positioning. State Farm expressed support for requiring manufacturers to include head restraint positioning information in owners' manuals.

Agency response: NHTSA believes proper adjustment of head restraints is necessary to ensure that vehicle occupants realize the maximum whiplash protection from head restraints. In order to address head restraint misadjustment, this final rule requires that vehicle manufacturers include in owners' manuals information about appropriate head restraint adjustment. We note that most manufacturers already provide some of this information in their owners' manuals.

XV. Effective Date and Interim Compliance Options

In the NPRM, we proposed that compliance with the upgraded standard would be mandatory on the first September 1 that occurred following the three-year period that began with the publication of the final rule. We asked for comments on the appropriateness of the three-year lead time.

Today's final rule becomes mandatory for all vehicles manufactured on or after September 1, 2008. We decided to extend the lead time by one additional year in order to allow vehicle manufacturers to phase in the new head restraint requirements in conjunction with their natural product cycle. The four-year lead time will, in most instances, allow vehicle manufacturers to design compliant head restraints for newly introduced vehicles, as opposed to redesigning existing seating systems for vehicles currently in production.

Between March 14, 2005, the effective date of today's rule, and September 1, 2008, manufacturers have five compliance options. First, manufacturers may comply with ECE 17, except that they must meet the current width requirements of FMVSS No. 202. Second, manufacturers may comply with either dynamic or static requirements of the existing FMVSS No. 202. Third, they may comply with either dynamic or static requirements of the new FMVSS No. 202a. Consistent with our approach in other standards in which there are compliance options, the manufacturer must irrevocably elect a particular option prior to certification of the vehicle. However, the manufacturer may select different compliance options for different designated seating positions.

There were relatively few comments related to the proposed lead time or compliance choices during that time. Honda commented that an additional three years of lead time should be added for rear seat head restraint compliance, in addition to the three years for front seat head restraints. Magna requested that an additional 3-year phase-in period be included along with the proposed 3-year lead time period, to allow for proper product development. Porsche commented that limited line manufacturers should be provided additional lead time, or if a phase-in is utilized, they should be given until the end of the phase-in period to comply. The Alliance argued that the final rule implementation should be postponed, and compliance with the current version of FMVSS No. 202 be allowed until at least 2005. The Alliance also recommended a phase-in period of 3 years after the rule is finally published. DaimlerChrysler believed four years of lead time was in order, in light of significant deviations from the ECE standards. Advocates strongly supported the 3-year interim period followed by complete implementation of the new standard.

We believe that the requests for lead time in addition to the four years provided in this final rule are unwarranted. Unlike the NPRM proposal, this final rule does not require head restraints in rear outboard designated seating positions. With respect to height, this final rule harmonizes our head restraint requirements with those already in effect under the ECE 17 regulation. Accordingly, a significant number of vehicles for sale in the United States already meet the European height requirement. Finally, we believe the four-year lead time provides sufficient time to resolve any problems associated with the new backset requirement.

As previously discussed, most of the commenters agreed that the new requirements for head restraints that are taller and closer to the head are likely to reduce the instances of whiplash injuries. According to ICBC, numerous vehicles currently in production already satisfy the 55 mm backset requirement. Similarly, we believe that numerous vehicles currently in production satisfy the 800 mm requirement. Most of the manufacturers who requested additional lead time sell cars in Europe and, therefore, are already in compliance with the ECE regulation requiring similar head restraint height. In light of the aforementioned circumstances, we conclude that a four-year lead time allows ample opportunity to redesign head restraints in order to comply with the new standard.

In regard to comments made by Porsche on behalf of small, independent automobile manufacturers, we note that Porsche and other small line European manufacturers are, presumably, already manufacturing vehicles that are in compliance with ECE 17. Further, rear head restraints are optional, and the final rule does not consider a seat back lower than 700 mm above the H-point as a head restraint. Therefore, Porsche can continue to produce the 911 vehicle line without installing rear head restraints.[79] Moreover, we have allowed 25 mm clearance between the rear head restraint and the roofline, thus alleviating some of the concerns raised by Porsche. Accordingly, Porsche can take advantage of the 25 mm height allowance if they choose to equip the rear seats in their 911 vehicle line with head restraints.

We received a number of comments pertaining to the interim compliance options. Advocates called NHTSA's interim compliance proposals ''an eminently reasonable compromise'' and supported this approach in lieu of allowing a phase-in. TRW also supported the interim compliance options set forth in the NPRM, stating that allowing compliance options would spur the growth of better technologies.

AIAM disagreed with the requirement that a manufacturer must choose a particular compliance option prior to certification. For reasons explained in other rulemakings, the agency will not allow manufacturer to recertify under an alternative compliance option, if there is a noncompliance with the option to which the manufacturer initially certified.[80]

[79] A survey of 2004 model year Porsche 911 vehicles (911, 911 Targa, 911 4S, 911 Cabriolet, 911 Turbo, 911 GT2, 911 GT3) indicates that none currently feature rear head restraints.

[80] *See, e.g.,* 64 FR 10786 at 10808 (March 15, 1999) and 64 FR 69665 at 69668 (December 14, 1999).

The Alliance argued against the interim compliance option approach, instead favoring a phase-in schedule after NHTSA better identified the causes of soft tissue neck injuries. This phase-in approach, the Alliance contended, should give manufacturers credit for early compliance. DaimlerChrysler asserted that NHTSA should allow compliance with the interim options indefinitely or at least until NHTSA gained a better understanding of whiplash injuries.

Based on our consideration of ECE 17, and the existing version of FMVSS No. 202 under the functional equivalence process defined in Appendix B of 49 CFR Part 553, we have concluded that ECE 17 offers greater safety benefits than the existing version of FMVSS No. 202. The most notable differences between FMVSS No. 202 and ECE 17 are that while FMVSS No. 202 currently does not address head restraints for rear seating positions or contain any requirements for energy absorption, ECE 17 specifies requirements for head restraints that are voluntarily installed in rear seating positions and for energy absorption.

Accordingly, we will permit interim compliance with the specified requirements of ECE 17. As stated above, the final rule also permits certification using either of the existing FMVSS No. 202 requirements or either of the upgraded FMVSS No. 202a requirements. Upon expiration of the four-year interim period, however, manufacturers must comply with upgraded FMVSS No. 202a.

XVI. Costs and Benefits Associated With the Final Rule

The NPRM estimated that the proposed rule would reduce the annual number of whiplash injuries by 14,247 (9,575 for front outboard seats and 4,672 for rear outboard seats).[81] The cost of raising the front head restraint was estimated to be $4.21 per vehicle, resulting in a fleet cost of $65.5 million.[82] Installing two rear head restraints in vehicles that previously did not have rear head restraints was estimated at $12.34 per vehicle, resulting in a fleet cost of $74.8 million. Raising the rear head restraints in vehicles already equipped with rear head restraints was estimated at $3.61 per vehicle, resulting in a fleet cost of $19.6 million. Adding a locking mechanism would cost $0.15 per vehicle, for a total fleet cost of $5.9 million. The total estimated fleet cost for all changes required by the new rule was $171.9 million. The cost per equivalent life saved was estimated at $3 million for front seats and $9 million for rear seats.

[81] For details on the PEA, please see Docket No. NHTSA–2000–8570–4.

[82] The NPRM costs were estimated in 1999 dollars.

The sole commenter on the estimated costs of the upgrade was DaimlerChrysler, which estimated the cost of the proposal to be as high as $12 per head restraint. No commenter provided an estimate of potential benefits. The Alliance stated that the potential benefits are unproven. AIAM commented that general lack of understanding of the injury mechanism makes it nearly impossible to calculate the benefits of the proposal or any modifications to it.

ICBC stated that any figures pertaining to whiplash injury costs are underestimated because whiplash injury symptoms do not manifest themselves until 12 to 72 hours after the accident. Additionally, unlike other spinal injuries, whiplash has no linear relationship to crash severity. Low speed crashes may nevertheless result in whiplash. Many low speed rear end collisions resulting in whiplash are never reported to the police, because of little physical damage to the actual vehicles and lack of immediate injury symptoms. Advocates stated that the proposed rule would be a cost-effective advance in vehicle occupant safety, even if forecasted benefits were reduced to more conservative figures and costs of compliance were substantially higher. The FIU students stated that the rear outboard head restraint cost for equivalent lives saved would be approximately $9 million.

In support of this final rule, the agency has prepared and docketed a FRIA that contains a thorough analysis of the benefits and the costs associated with the new FMVSS No. 202a, as well as our response to the NPRM comments on our initial cost and benefits estimates.[83]

Costs: In the NPRM, we estimated the yearly costs of the proposed rule at approximately $171 million. Accordingly, the NPRM was deemed to be economically significant. As previously noted, the final rule will not require head restraints at each rear outboard designated seating position. Consequently, the costs associated with this final rule are significantly lower than the costs estimated in the NPRM. Specifically, the cost per year is estimated to be $70.1 million for front head restraints and $14.1 million for optional rear head restraints for a total yearly cost of $84.2 million. However,

[83] *See* Docket No. NHTSA–2004–19807.

the final rule remains economically significant because we estimate the benefits of this final rule to be in excess of $100 million. The average cost per vehicle is estimated to be:

(a) $4.51 for front seats

(b) $1.13 for rear seats previously equipped with head restraints

The cost per equivalent life saved is estimated to be:

(a) $2.39 million for front seats

(b) $4.71 million for rear seats equipped with optional rear head restraints

(c) $2.61 million for front seats and optional rear seats combined

Benefits: We estimate the annual number of whiplash injuries to be approximately 272,464. 251,035 of these injuries involve occupants of front outboard seats, 21,429 injuries involve occupants of rear outboard seats. The average economic cost of each whiplash injury resulting from a rear impact collision is $9,994,[84] which includes $6,843 in economic costs and $3,151 in quality of life impacts. The total annual cost of rear impact whiplash injuries is approximately $2.7 billion.

Based on a study conducted by Kahane in 1982, the agency estimates that current integral head restraints are 17 percent effective in reducing whiplash injury in rear impact crashes for adult occupants, while current adjustable head restraints are 10 percent effective in reducing whiplash injury in rear impact crashes for adult occupants.[85] The overall effectiveness of current head restraints for passenger cars is estimated to be 13.1 percent.

In the FRIA, we estimate that upgrading the head restraint requirements would yield the following benefits:

(a) For front seats, reducing the backset to 55 mm increases the head restraint effectiveness by 5.83 percent, resulting in 15,272 fewer whiplash injuries for front seat occupants each year.

(b) For rear seats, increasing the height of voluntarily installed rear head restraints increases the effectiveness of these head restraints by 17.45 percent, resulting in 1,559 fewer whiplash injuries for rear seat occupants each year.[86]

(c) The total annual reduction in rear impact whiplash injuries is thus estimated at (15,272 + 1,559) 16,831 or 6 percent of the annual number of whiplash injuries (272,464).[87]

In sum, we estimate that this rulemaking will further reduce the incidence of whiplash by an additional ≈6 percent (272,464 *.0618 = 16,831). We note that with respect to whiplash injuries, a 6 percent reduction in the incidence of whiplash is a significant step forward because the current head restraints only prevent 13.1 percent of whiplash injuries occurring in rear impact crashes. The agency anticipates further improvements in head restraint effectiveness if we decide, in the future, to combine evaluation of the head restraints and the seats in a single standard.

As was the case in the PEA, no estimate was made for potential injury mitigation other than for whiplash. Further, the agency has not prepared an analysis of the potential benefits of the position retention requirement. Although we have some estimates on the percentage of misadjusted head restraints, we have no data on how the availability of a lock would reduce this maladjustment.

We have several reasons to believe that the potential benefits of this regulation are understated. First, for the reason stated above, we did not perform a separate analysis of benefits associated with reduced position retention requirement. Second, we agree with the ICBC comments regarding inherent underestimation of whiplash injury costs due to the underreporting of such injuries. As previously stated, whiplash injuries are often underreported because of late onset of symptoms. Third, no estimate of the potential reduction of higher-level neck injury (>AIS 1) was made. Although such injuries are much less frequent, their associated costs are much greater.

XVII. Rulemaking Analyses and Notices

a. Executive Order 12866 and DOT Regulatory Policies and Procedures

NHTSA has considered the impact of this rulemaking action under Executive Order 12866 and the Department of Transportation's regulatory policies and procedures. The Office of Management and Budget reviewed rulemaking document under E.O. 12866, ''Regulatory Planning and Review.'' This rulemaking action has been determined to be significant under DOT Policies and Procedures and Executive Order 12866 because of public interest. Further, this rulemaking action is economically significant because the agency estimates yearly economic cost savings of approximately $127 million ($2.61 million × 48.79 equivalent fatalities). NHTSA is placing in the public docket a Final Regulatory Evaluation describing the costs and benefits of this rulemaking action. The costs and benefits are summarized in the previous section of this document. The total estimated recurring fleet cost for all changes required by the new rule is $84.2 million. The average economic cost of a whiplash injury (excluding quality of life values) in a rear impact is estimated be $9,994 in 2002 dollars, resulting in a total annual cost of approximately $2.707 billion for 272,464 whiplash injuries.[88] We estimate that when the new rule is fully implemented, it will reduce yearly instances of whiplash injuries by 6 percent or 16,831, resulting in yearly economic cost savings of approximately $127 million.

b. Regulatory Flexibility Act

NHTSA has considered the effects of this rulemaking action under the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) The final rule will affect motor vehicle manufacturers, alterers, and seating manufacturers. NHTSA has determined that this action will not have a significant economic impact on a substantial number of small entities.

First, NHTSA estimates that there are only four small passenger car and light truck manufacturers in the United States. These companies buy their seats from a seat manufacturer and install them in their vehicles. Accordingly, the necessary changes to seat design will be accomplished by seat manufacturers and not these small businesses.

Second, there are approximately 30 seat manufacturers in the U.S. Many of these fall under the category of small businesses. The final rule will have some effect on these small businesses by changing the requirements for head restraints. However, raising the height of an integral or adjustable head restraint or changing the design of a head restraint to meet the new backset limit is not a novel or complex task that would require significant financial expenditures. Further, numerous vehicles currently in production already meet the new requirements. Consequently, the agency does not believe that this rulemaking will have a

[84] The cost is estimated in 2002 dollars.

[85] Kahane, C., ''An Evaluation of Head Restraints, Federal Motor Vehicle Safety Standard 202.'' NHTSA, February 1982, DOT HS–806–108.

[86] In computing benefits, we based our estimates on the effectiveness of either increased height or reduced backset, but not both. We could not combine effectiveness of increased height and reduced backset because this, in some instances, would result in ''double-counted'' benefits. Since determining combined effectiveness is not possible, the agency notes that these estimates may underestimate the true effectiveness.

[87] For the full details of how the agency arrived at these estimates, please see FRE, in subsection entitled ''*Benefits Accrued From Increasing Height and Reducing Backset.*''

[88] Unless otherwise specified, all dollar alues in this document are represented in 2002 dollars.

significant impact on small seat manufacturers.

Third, this rulemaking could affect final stage vehicle manufacturers and vehicle alterers. Many final stage manufacturers and alterers install supplier-constructed seating systems. Some of those seats and head restraints will have to be redesigned to meet the new requirements. However, final stage manufacturers or alterers most often purchase seats that have already been tested by the seat manufacturers and rely on that testing to certify to the requirements of FMVSS No. 202. Accordingly, the agency does not believe that this rulemaking will have a significant impact on final stage manufacturers and vehicle alterers.

For the reasons discussed above, the small entities that will most likely be affected by the new rule are seat manufacturers. While these seat manufacturers will face additional compliance costs, the agency believes that raising the height of a head restraint is not a novel or complex engineering task. The agency notes that, in the unlikely event that a small vehicle manufacturer did face substantial economic hardship, it could apply for a temporary exemption for up to three years.[89] Additional information concerning the potential impacts of the new rule on small entities is presented in the FRIA.

c. National Environmental Policy Act

NHTSA has analyzed the final rule for the purposes of the National Environmental Policy Act. The agency has determined that implementation of this action will not have any significant impact on the quality of the human environment.

d. Executive Order 13132 (Federalism)

The agency has analyzed this rulemaking in accordance with the principles and criteria contained in Executive Order 13132 and has determined that it does not have sufficient federalism implications to warrant consultation with State and local officials or the preparation of a federalism summary impact statement. The final rule has no substantial effects on the States, or on the current Federal-State relationship, or on the current distribution of power and responsibilities among the various local officials. The final rule is not intended to preempt State tort civil actions.

e. Unfunded Mandates Reform Act

Section 202 of the Unfunded Mandates Reform Act of 1995 (UMRA) requires Federal agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of more than $100 million in any one year ($120,700,000 as adjusted for inflation with base year of 1995).

The total estimated fleet cost for all changes required by the new rule is $84.2 million. Because this final rule will not have a $100 million effect, no Unfunded Mandates assessment has been prepared. A full assessment of the rule's costs and benefits is provided in the FRIA.

f. Executive Order 12988 (Civil Justice Reform)

This final rule will not have any retroactive effect. Under 49 U.S.C. 30103, whenever a Federal motor vehicle safety standard is in effect, a State may not adopt or maintain a safety standard applicable to the same aspect of performance which is not identical to the Federal standard, except to the extent that the State requirement imposes a higher level of performance and applies only to vehicles procured for the State's use. 49 U.S.C. 30161 sets forth a procedure for judicial review of final rules establishing, amending or revoking Federal motor vehicle safety standards. That section does not require submission of a petition for reconsideration or other administrative proceedings before parties may file suit in court.

g. Paperwork Reduction Act

This final rule includes the following ''collections of information,'' as that term is defined in 5 CFR part 1320 Controlling Paperwork Burdens on the Public: The final rule requires that vehicle manufacturers include in owners' manuals information about appropriate head restraint adjustment. At present, OMB has approved NHTSA's collection of owner's manual requirements under OMB clearance No. 2127–0541 *Consolidated Justification of Owner's Manual Requirements for Motor Vehicles and Motor Vehicle Equipment.* This clearance will expire on 1/31/2005. NHTSA anticipates renewal of OMB clearance no. 2127–0541 before the requirements established by today's rule become mandatory.

h. Executive Order 13045

Executive Order 13045[90] applies to any rule that: (1) Is determined to be ''economically significant'' as defined under E.O. 12866, and (2) concerns an environmental, health or safety risk that NHTSA has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, we must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by us.

This rule is economically significant. However, this rule will not have a disproportionate effect on children. Most children do not need a head restraint because they are short enough for the seat back to adequately address a risk of whiplash injury. Once a child is tall enough to need a head restraint, this rule will provide additional protection because rear seats will now be equipped with head restraints, thus providing a new level of safety to taller children.

i. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act (NTTAA) requires NHTSA to evaluate and use existing voluntary consensus standards in its regulatory activities unless doing so would be inconsistent with applicable law (*e.g.,* the statutory provisions regarding NHTSA's vehicle safety authority) or otherwise impractical. In meeting that requirement, we are required to consult with voluntary, private sector, consensus standards bodies. Examples of organizations generally regarded as voluntary consensus standards bodies include the American Society for Testing and Materials (ASTM), the Society of Automotive Engineers (SAE), and the American National Standards Institute (ANSI). If NHTSA does not use available and potentially applicable voluntary consensus standards, we are required by the Act to provide Congress, through OMB, an explanation of the reasons for not using such standards.

Voluntary consensus standards are technical standards developed or adopted by voluntary consensus standards bodies. Technical standards are defined by the NTTAA as ''performance-based or design-specific technical specifications and related management systems practices.'' They pertain to ''products and processes, such as size, strength, or technical performance of a product, process or material.''

We have incorporated a Society of Automotive Engineers (SAE) Recommended Practice J211/1 (rev. Mar 95), ''Instrumentation for Impact Test—

[89] *See* 49 CFR part 555.

[90] 62 FR 19885, April 23, 1997.

Part 1—Electronic Instrumentation.'' We have incorporated a three-dimensional manikin from the Society of Automotive Engineers (SAE) J826 (rev. Jul 95). None of the voluntary consensus standards incorporated into this final rule provides a comprehensive head restraint geometry standard that could replace this rule in its entirety. Instead, certain specific components of the final rule were adopted from available voluntary consensus standard.

In sum, while two specific voluntary consensus standards are incorporated in the final rule, the overall need for extensive and precise new head restraint safety requirement precludes us from adopting of such voluntary consensus standards as a complete substitute for the final rule. No other voluntary consensus standards are addressed by this rulemaking. We were also were unable to identify any other relevant voluntary consensus standards.

j. Privacy Act

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.). You may review DOT's complete Privacy Act Statement in the **Federal Register** published on April 11, 2000 (65 FR 19477 at 19478).

Appendix A: Efforts To Harmonize With ECE 17

In proposing to upgrade FMVSS No. 202, we sought to harmonize with existing ECE regulations, except to the extent needed to increase safety of vehicle occupants and to facilitate enforcement. The ECE has two regulations pertinent to our efforts on upgrading FMVSS No. 202. ECE 17 and ECE 25 both regulate head restraints. However, the provisions of ECE 17 supersede the requirements of ECE 25 for most vehicles subject to this final rule. Specifically, ECE 17 governs the head restraint requirements in all passenger vehicles, light trucks, and buses with fewer than 17 designated seating positions. The ECE 25 applies only to buses with 17 or more designated seating positions. Because this final rule applies to vehicles with a GVWR equal or less than 4536 kg, it is unlikely that any buses subject to this final rule would fall under ECE 25. Accordingly, we sought to harmonize certain aspects of this final rule with ECE 17, and not ECE 25.

In some instances, achieving improved safety has made it necessary for us to go beyond or take an approach different from that in ECE 17. For example, this final rule limits the backset, while ECE 17 does not. We note that in most instances in which this rule is harmonized with the substance of the ECE requirements, the actual regulatory language is nevertheless drafted differently in order to facilitate enforcement. Specifically, we have found it necessary to specify different compliance procedures to facilitate their enforcement under our statutory provisions. For example, there are differences in the way in which gaps within head restraints are measured.

In response to the NPRM, industry commenters generally advocated harmonizing the new FMVSS No. 202 with ECE 17, which applies to most vehicles subject to this final rule, although Honda requested harmonization with ECE 25. GM and Volkswagen suggested that it would be more appropriate to harmonize with ECE 17, rather than ECE 25, because ECE 17 is utilized for the type approval of vehicles, while ECE 25 is used for the type approval of head restraints only.

As previously stated, this final rule is not fully harmonized with the ECE requirements. Instead, the rule adopts or modifies certain portions of ECE 17. Several of our newly adopted requirements do not have any counterparts in the ECE regulations. Among those is a limit on backset and position retention requirement for adjustable head restraints. In addition, our limit on gaps in adjustable restraints is different from that in the ECE regulations.

The discussions that follow provide a brief description of those instances in which the final rule does or does not harmonize with the ECE regulations.

A. Areas in Which the Final Rule Requirements and Procedures Are Harmonized With Those of the ECE Regulations

Neither this final rule nor ECE 17 requires head restraints for rear outboard seating positions. Although we proposed mandatory rear head restraints in the NPRM, we have decided against requiring head restraints in rear outboard seating positions because a more refined estimate of the cost effectiveness expressed as cost per equivalent life saved no longer supported this requirement and because we were concerned about potential visibility issues and with potential loss of certain features currently available in some ''multi-configuration'' vehicles.

This final rule and ECE 17 specify theoretically identical front and optional rear head restraint height requirements. For integral head restraints, the ECE 17, Paragraph 5.5.2 requires that front head restraints reach a height of 800 mm and rear head restraints reach the height of 750 mm. For adjustable head restraints, the ECE 17, Paragraph 5.5.3.1 requires that front head restraints be capable of reaching a height of 800 mm, and have no ''use positions'' with a height of less than 750 mm. The optional rear adjustable head restraints must reach the height of at least 750 mm and cannot have any ''use position'' below that height. Additionally, ECE 17, Paragraph 5.5.4 allows for a 25 mm exception to the head restraint height requirement for head restraints installed in low roofline vehicles.

This final rule likewise requires that the front integral head restraints reach a height of 800 mm above the H-point. The optional rear integral head restraints must reach the height of 750 mm above the H-point. For adjustable head restraints, the front head restraint must be capable of reaching the height of at least 800 mm above the H-point, and both front and optional rear head restraints cannot have an adjustment position below 750 mm above the H-point, unless it is a ''non-use'' position described above in Section IX c.

Additionally, the final rule allows for a 25 mm height exception for head restraints installed in low roofline vehicles. However, the application of the 25 mm height exception is narrower in this final rule. Specifically, ECE 17 allows for a 25 mm height exception if the head restraint interferes with any interior vehicle structure. By contrast, this final rule limits the 25 mm exception to situations in which a head restraint would interfere with the roofline or the backlight (for rear head restraint). The 25 mm height exception for low roofline vehicles is discussed in Section VI a. and b.

For height measurement ECE17, Paragraph 6.5.4 uses the R-point as the point of reference, while the final rule uses the H-point. Theoretically, these points are the same if the seat is placed in its rearmost normal riding or driving position, as specified by the vehicle manufacturer. The chief difference between the two points is that the H-point is referenced to the seat, while the R-point is referenced to the vehicle. NHTSA prefers the H-point as the point of reference because it takes into consideration the characteristics of the actual seat being tested.

The final rule and ECE 17 Paragraph 5.1.3 both have an energy absorption test procedure. However, the final rule specifies using a linear impactor, while ECE 17, Annex 6, Paragraph 1.2.1 specifies a pendulum impactor. Nonetheless, NHTSA believes that the compliance testing methods are substantially similar because the mass and velocity of the impactor specified in this final rule is the same as the impactor specified in ECE 17. We chose to test using the linear impactor in order to facilitate enforcement. For a more detailed explanation of our rationale with respect to the choice of impactor, please see Section XI.

ECE 17, Paragraph 5.10 mandates that the head restraint for a seat must extend at least 85 mm to each side of the centerline of the seat. In other words, a head restraint width must be at least 170 mm. This ECE 17 minimum width requirement applies to both bench seats and bucket seats. This final rule specifies identical requirements of 170 mm,[91] except for bench seats in the front outboard seating positions where the head restraint width must not be less than 254 mm.

Some of the head restraint gap allowances incorporated into the final rule harmonize with ECE 17. The final rule and ECE 17, Paragraphs 5.7, 5.8 all limit gaps within the perimeter of a head restraint to 60 mm. Similarly, for integral head restraints, the gap between the head restraint and the seat is limited to 60 mm in both regulations. However, the final rule requires different gap

[91] We note that the NPRM proposed a value of 171 mm rather than 170, which is consistent with the current regulation. We have reduced this value by 1 mm for consistency with ECE 17.

limits between the seat and the adjustable head restraint. The details of these requirements are discussed in the next section.

The ECE 17, Paragraph 5.1.1 requires locks on adjustable head restraints, but does not mandate that these locks meet vertical and horizontal position retention requirements to insure their functionality. By contrast, this rule requires that adjustable head restraints meet vertical and horizontal position retention requirements described above in Section X. We note, however, that both ECE 17, Paragraphs 5.11, 5.12 and this final rule impose horizontal displacement limits and strength requirements on all seating position equipped with head restraints.

Finally, both this final rule and ECE 17, Paragraph 5.13 allow removability of head restraints with a deliberate action distinct from any act necessary for adjustment. For a more detailed discussion on removability of front and rear head restraints, please see Section IX b.

B. Areas in Which the Final Rule Requirements and Procedures Differ From Those in the ECE Regulations

The chief difference between ECE 17 and this final rule is that we are requiring a backset limit of 55 mm for front seat head restraints. The ECE regulation does not limit the amount of backset. Studies show that a head restraint that is close to the back of an occupant's head reduces the potential for whiplash.[92] Further, backset is a critical component of head restraint geometry. For these reasons and those outlined in Section VII above, NHTSA believes it is necessary to depart from the ECE regulations and set a limit on backset.

To measure height of head restraints, the final rule specifies the use of SAE J826 manikin. To measure front seat backset, the final rule specifies the use of the Head Restraint Measurement Device (HRMD). ECE 17 does not specify any device for height measurement and, as noted above, has no backset requirement. We chose the SAE J826 manikin and HRMD instead of certain Computer Aided Design (CAD) programs, as suggested by the manufacturers, because the HRMD and SAE J826 manikin measure the actual seating system, instead of relying on the computer-generated seat model utilized by other computer-aided measuring techniques.

In addition to the measuring device, the height measuring procedure in this final rule in some circumstances differs from the measuring procedure of ECE 17. Specifically, this final rule specifies that the seat back angle for height measurement be as close as possible to 25 degrees. ECE 17, Paragraph 6.1.1 similarly specifies the 25-degree seat back angle if there is no manufacturer specified seat back angle. However, if there is a manufacturer specified seat back angle, the manufacturer specified angle is used instead of the 25-degree angle. Further, this final rule specifies that the seat cushion be adjusted to its most unfavorable position, *i.e.*, the highest position. ECE 17, Annex 3, Paragraph 2.13 specifies that the cushion is to be placed in the manufacturer specified position of adjustment. Positioning the cushion in the highest position of adjustment allows us to measure the height of head restraints in the "worst case scenario." That is, the minimum required height would be assured even if the seat occupant adjusts the seat cushion all the way up.

ECE 17, Paragraph 5.7 limits the gap between the lower edge of an adjustable head restraint and the top of the seat back to 25 mm when the head restraint is in its lowest position. The final rule, however, adopts a 60 mm gap limit between the seat back and the head restraint. Further, the final rule differs from the ECE requirements in that it specifies measuring this gap with a 165 mm diameter sphere placed on the front of the head restraint in lieu of measuring the smallest gap between the top of a seat back and the bottom of a head restraint. For a more detailed discussion on why we chose to adopt a different gap requirement and different measuring device, please see Section IX a.

ECE 17, Paragraph 5.5.3.4 permits non-use positions (resulting in a height of less than 750 mm) for front head restraints, provided that the head restraints automatically return from those positions to their proper use positions when the seats become occupied. With respect to rear head restraints, ECE 17, Paragraph 5.5.3.3 allows displacement to a position below 750 mm as long as the non-use position is "clearly recognizable to the occupant." In contrast, this final rule does not permit non-use positions for front head restraints. NHTSA believes non-use positions in front seats are unnecessary since the front head restraints do not raise the same visibility concern as the rear head restraints.

While we permit non-use positions for optional rear head restraints, our requirements differ from those of the ECE. That is, the final rule allows rear head restraint to be in non-use positions when seats are unoccupied, subject to meeting certain requirements. Specifically, a manually folding optional rear head restraint must rotate forward or rearward by at least 60 degrees between the "proper use position" and the "non-use position." No other "non-use positions" are allowed unless the head restraint returns automatically to its "proper use position when the seat becomes occupied" (as tested by placing a 5th percentile female dummy in the rear outboard seat with the optional head restraint in a "non-use position"). As with other procedural differences between this final rule and the ECE, this test procedure is necessary in order to facilitate enforcement.

The final rule also features a dynamic compliance option not found in ECE 17. For front outboard and optional rear outboard head restraints, with the head restraint midway between the lowest and the highest position of adjustment, the final rule requires a head-to-torso rotation limit of 12 degrees using the 50th percentile male Hybrid III dummy. The final rule limits HIC_{15} to 500 for all the dynamic compliance option tests.

The final rule specifies that adjustable head restraints must remain within 13 mm of their vertical and horizontal position under the application of force. Although ECE 17 requires locks on adjustable head restraints, the horizontal and vertical position retention requirements do not have a counterpart in the ECE regulations. However, we find it necessary to require a certain minimal level of performance to ensure that the retention locks perform their function.

Both ECE 17, Paragraphs 5.11, 5.12 and this final rule have limits on the horizontal displacement and strength requirements. The purpose of this requirement is to ensure that the head restraint can withstand the application of rearward force and will not fail when the occupant's head makes contact with the head restraint during a rear impact to the vehicle. The final rule and ECE both maintain a 373 Nm moment on the vehicle seat, applied through the back pan, as the head restraint is loaded. However, the head restraint loading sequence differs in the two standards. In the final rule, the loading device's reference position is located by first applying a force producing 37 Nm moment about the H-point. Then, the load is increased at a rate of 187 Nm/minute, until a 373 Nm moment is generated. This moment is held for 5 seconds and then reduced to 37 Nm. While the 373 Nm moment applied to the head restraint is being maintained, the head restraint must not allow the loading device to displace more than 102 mm. When the moment is reduced, the head restraint loading device must return to within 13 mm of the initial reference position. This horizontal position retention requirement is unique to our final rule. While the ECE regulations do contain a similar rearward displacement test that limits displacement to 102 mm, they do not require that the head restraint loading device return to within 13 mm of its reference position. Further, the ECE regulations do not specify a loading rate and hold time. NHTSA believes the 5-second hold time and loading rate specifications are a necessary clarification of the test procedure.

Finally, the ECE 17, Paragraph 5.5.4 allows a 25 mm height allowance in those instances in which the front or rear head restraint would otherwise interfere with any fixed vehicle structure, when the seat is in the "use" or "non-use" position of adjustment. This final rule permits a 25 mm height allowance only in situations in which the head restraint interferes with either the roofline or the backlight. We decided against allowing a 25 mm height allowance in situations in which the head restraint interferes with other fixed vehicle structures because we believe that such an exception would provide relief in instances in which none is needed. For a more detailed explanation of our rationale with respect to the 25 mm height allowance please see Section VI a. and b.

Appendix B: Cervigard Suggestion

Cervigard, Inc. is a New Jersey based company that designed a head restraint incorporating a contoured shape intended to match the curvature of the head and cervical spine. The portion of the head restraint that protrudes forward adjacent to the neck is referred to as a neck bolster.

Cervigard submitted two sets of test data, comparing conventional head restraints

[92] *See* ICBC comments and attached research papers (Docket No. NHTSA–2000–8570–16).

against the Cervigard Head Restraint System using a special neck-bolstering contour. The first set came from an experiment that was conducted by Cadillac and Lear, which used Hybrid III dummies representing a 5th percentile female, 50th percentile male, and 95th percentile male in sled tests at 16 and 24 km/h delta-Vs. Specific positions of the test head restraints relative to the occupants were not given. Instead, they were designated as ''Full Up'' or ''Full Down.'' These were described as being ''In-Position'' or ''Out-of-Position.'' HIC, NIC,[93] upper neck shear and moment were provided. ''Out-of-Position'' results were provided for the 5th percentile female, 50th percentile male and 95th percentile male. ''In-Position'' results were provided for the 50th percentile male only. In general, the results provided indicated lower injury measures for the Cervigard head restraint tests.

The second set of tests was performed by Wayne State University using a computer simulation model. The model appeared to be of a head and neck without a torso. A standard OEM head restraint was compared to what was called the Cervigard head restraint. Both restraints were modeled with the backsets shown in the table below. The height measurement of the head restraint relative to the head was not disclosed. Thus, it is unclear whether the head restraint height was within the range specified in the NPRM. The commenter states that, according to a researcher from Wayne State University, the Cervigard head restraint performed much better, better, or as good as a standard head restraint.

Head restraint	Backset
Standard Down	70 mm
Standard Up	70 mm
Cervigard Down	75 mm
Cervigard Up	30 mm

Based on their submissions, Cervigard requested that the new rule require a neck-bolstering device. According to an engineering report from Cervigard, the Cervigard head restraint exhibited 23 percent to 38 percent lower NIC and neck shear forces compared to samples of presently used head restraints, modified to comply with the proposed rule. Cervigard commented that a 50 mm backset position without neck-bolstering device might actually be too close to the head, which could result in potentially exacerbating the injury. We note that no other commenter or research source indicated that a 50 mm backset position may prove to be too close to the head, as it relates to occupant safety, or somehow dangerous to the occupant.

In support of its recommendation, Cervigard asserted that the additional costs of adding a neck-bolster device would be minimal if the requirement were added to the new rulemaking immediately, because seat manufacturers will be retooling for a new standard anyway. Specifically, Cervigard provided an estimate of $3.50 per each head restraint.

Several lawmakers, among them Senator Torricelli of New Jersey, Congressman Bill Pascrell Jr. of the 8th District of New Jersey, New Jersey State Senator Anthony R. Bucco, and New Jersey Assemblyman Alex DeCroce submitted comments in support of Cervigard. Collectively, they urged NHTSA to incorporate a neck-bolstering requirement into the new rule, in light of minimal additional cost to manufacturers, support from safety and medical experts, and the societal benefit of reducing instances of neck trauma.

Several chiropractors and other medical professionals submitted comments to support the addition of a requirement for the Cervigard device to the upgraded head restraint standard. In general, most commented that the Cervigard device reduces facet joint injury in the lower cervical region by maintaining normal curvature of the spine at time of impact.

In contrast, according to the comments submitted by Lear Corporation and General Motors, Cervigard has put forth an incomplete and inaccurate summary of tests performed by Lear using the Cervigard device. Evaluations of the Cervigard device were conducted with the head restraints improperly positioned. Lear has never compared Cervigard head restraints to optimally positioned head restraints or latest head restraint designs and never stated that Cervigard head restraints performed ''as good'' or ''better'' than conventional head restraints. Indeed, GM opines that any improvement was due to decreased backset distance and not necessarily to Cervigard contour (*See* David E. Calder Engineering Report No. 2, top graph, Docket NHTSA–00–8570–42). GM further stated that any assertion indicating that Cervigard head restraints passed the ''do no harm'' criteria is false because no such criteria exists.

Lear cautioned that the submitted data results were based on preliminary, unapproved data that have since been revised. Additionally, Cervigard omitted data showing that its device consistently increased certain injury parameters. Lear also indicated that what was reported by Cervigard as upper neck extension moment was actually lateral bending moment, which one would expect to be much lower than the extension moment. In fact, the Cervigard device often increased neck tension. Lear's own research indicated that the Cervigard device increased risk of neck injury in 62.5 percent of ''Out of Position'' head restraint conditions tested.

In examining the test data from Wayne State, we conclude that the results confirm our position that the backset is a critical parameter in head restraint performance. It is not surprising that the Cervigard device tested with a 30 mm backset was able to limit the head's rearward motion to a much greater degree, compared to other configurations, with a much greater backset. Because the rest of the Wayne State testing was performed with backset greater than 70 mm, it is impossible to draw any conclusions about the benefits of a head restraint with a neck bolster in comparison to those of a conventional head restraint, positioned, as we will require.

In regard to the sled testing performed by Lear for GM, the docket submission by Cervigard did not provide positioning information. Additionally, as the proprietors of the data (Lear and GM) have indicated, the comparative sled testing between conventional head restraints and Cervigard did not take place with the same backset values. Our conclusion is that there is no way to determine from this information whether the neck bolster was actually helpful. In sum, we believe that a head restraint meeting the new height and backset requirements will serve to restrain the head with respect to the torso. The proposed neck bolster has not yet been shown to provide any additional benefit.

We have an additional concern about a neck bolster. Unless the bolstered head restraint is precisely positioned at the appropriate height, the neck bolster will not support the neck. Currently, adjustable head restraints need only be adjusted such that the top is at least as high as the occupant's head C.G. If the adjustable restraint were supplemented by a neck bolster, positioning would need to be more precise. It appears that, for integral or fixed head restraints, the bolstered restraint would only fit an individual of a specific height. Thus, any neck bolster requirement would by necessity eliminate integral head restraint designs. We also conclude that it would be difficult to require a specific neck bolster contour that would fit a majority of occupants. Further, we note that we did not propose to adopt a neck bolster in the NPRM. Therefore, adopting such a requirement in this final rule would fall outside the scope of notice. Based on the comments and analysis presented above, we are not adopting any requirements for a neck bolster.

List of Subjects in 49 CFR Part 571

Imports, Incorporation by Reference, Motor Vehicle Safety, Motor Vehicles, and Tires.

■ In consideration of the foregoing, 49 CFR part 571 is amended as follows:

PART 571—FEDERAL MOTOR VEHICLE SAFETY STANDARDS

■ 1. The authority citation for part 571 of title 49 continues to read as follows:

Authority: 49 U.S.C. 322, 30111, 30115, 30117, and 30166; delegation of authority at 49 CFR 1.50.

■ 2. Section 571.202 is amended as follows:

■ A. Revise the section heading, S2, S3, S4, and S4.1 through S4.3;

■ B. Add S4.4, S4.5, and S4.6; and

■ C. Revise S5, S5.1 introductory text, S5.1(a)(2), (a)(3), and (b), S5.2 introductory text, and S5.2(b) to read as follows:

[93] NIC is a whiplash criterion developed by Adman and Bostrom *et al.* NIC = 0.2 a_{rel} + $v_{rel}2$, where a_{rel} is the resultant relative acceleration between first thoracic vertebra (T1) and first cervical vertebra (C1), v_{rel} is the resultant relative velocity between T1 and C1.

§ 571.202 Standard No. 202; Head restraints; Applicable at the manufacturers option until September 1, 2008.

* * * * *

S2. *Application.* This standard applies to passenger cars, and to multipurpose passenger vehicles, trucks and buses with a 4,536 kg or less, manufactured before September 1, 2008. Until September 1, 2008, manufacturers may comply with the standard in this § 571.202, with the European regulations referenced in S4.3 of this § 571.202, or with the standard in § 571.202a.

* * * * *

S3. *Definitions.*

Head restraint means a device that limits rearward displacement of a seated occupant's head relative to the occupant's torso.

Height means, when used in reference to a head restraint, the distance from the H-point, measured parallel to the torso reference line defined by the three dimensional SAE J826 (rev. Jul 95) manikin, to a plane normal to the torso reference line.

Top of the head restraint means the point on the head restraint with the greatest height.

S4. *Requirements.*

S4.1 Each passenger car, and multipurpose passenger vehicle, truck and bus with a 4,536 kg or less, must comply with, at the manufacturer's option, S4.2, S4.3 or S4.4 of this section.

S4.2 Except for school buses, a head restraint that conforms to either S4.2 (a) or (b) of this section must be provided at each outboard front designated seating position. For school buses, a head restraint that conforms to either S4.2 (a) or (b) of this section must be provided at the driver's seating position.

(a) When tested in accordance with S5.1 of this section, limit rearward angular displacement of the head reference line to 45 degrees from the torso reference line; or

(b) When adjusted to its fully extended design position, conform to each of the following:

(1) When measured parallel to the torso line, the top of the head restraint must not be less than 700 mm above the seating reference point;

(2) When measured either 64 mm below the top of the head restraint or 635 mm above the seating reference point, the lateral width of the head restraint must be not less than:

(i) 254 mm for use with bench-type seats; and

(ii) 170 mm for use with individual seats;

(3) When tested in accordance with S5.2 of this section, any portion of the head form in contact with the head restraint must not be displaced to more than 102 mm perpendicularly rearward of the displaced extended torso reference line during the application of the load specified in S5.2 (c) of this section; and

(4) When tested in accordance with S5.2 of this section, the head restraint must withstand an increasing load until one of the following occurs:

(i) Failure of the seat or seat back; or,

(ii) Application of a load of 890N.

S4.3 *Incorporation by reference.* The English language version of the Economic Commission for Europe (ECE) Regulation 17: ''Uniform Provisions Concerning the Approval of Vehicles with Regard to the Seats, their Anchorages and any Head Restraints'' ECE 17 Rev. 1/Add. 16/Rev. 4 (31 July 2002) is incorporated by reference in S4.4(a) of this section. The Director of the Federal Register has approved the incorporation by reference of this material in accordance with 5 U.S.C. 552(a) and 1 CFR Part 51. A copy of ECE 17 Rev. 1/Add. 16/Rev. 4 (31 July 2002) may be obtained from the ECE Internet site: *http://www.unece.org/trans/main/wp29/wp29regs/r017r4e.pdf*, or by writing to: United Nations, Conference Services Division, Distribution and Sales Section, Office C.115–1, Palais des Nations, CH–1211, Geneva 10, Switzerland. A copy of ECE 17 Rev. 1/Add. 16/Rev. 4 (31 July 2002) may be inspected at NHTSA's Technical Information Services, 400 Seventh Street, SW., Plaza Level, Room 403, Washington, DC, or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to: *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.*

S4.4. Except for school buses, a head restraint that conforms to S4.4 (a) and (b) of this section must be provided at each outboard front designated seating position. For school buses, a head restraint that conforms to S4.4 (a) and (b) of this section must be provided at the driver's seating position.

(a) The head restraint must comply with Paragraphs 5.1.1, 5.1.3, 5.3.1, 5.5 through 5.13, 6.1.1, 6.1.3, and 6.4 through 6.8 of the English language version of the Economic Commission for Europe (ECE) Regulation 17: ECE 17 Rev. 1/Add. 16/Rev. 4 (31 July 2002).

(b) The head restraint must meet the width requirements specified in S4.2(b)(2) of this section.

S4.5 Except for school buses, head restraints that conform to the requirements of § 571.202a must be provided at each front outboard designated seating position. If a rear head restraint (as defined in § 571.202a) is provided at a rear outboard designated seating position, it must conform to the requirements of § 571.202a applicable to rear head restraints. For school buses, a head restraint that conforms to the requirements of § 571.202a must be installed at the driver's seating position.

S4.6 Where manufacturer options are specified in this section or § 571.202a, the manufacturer must select an option by the time it certifies the vehicle and may not thereafter select a different option for that vehicle. The manufacturer may select different compliance options for different designated seating positions to which the requirements of this section are applicable. Each manufacturer must, upon request from the National Highway Traffic Safety Administration, provide information regarding which of the compliance options it has selected for a particular vehicle or make/model.

S5. *Demonstration procedures.*

S5.1 Compliance with S4.2(a) of this section is demonstrated in accordance with the following with the head restraint in its fully extended design position:

(a) * * *

(2) Rotate the head of the dummy rearward until the back of the head contacts the flat horizontal surface specified in S5.1(a)(1) of this section.

(3) Position the SAE J–826 two-dimensional manikin's back against the flat surface specified in S5.1(a)(1) of this section, alongside the dummy with the H-point of the manikin aligned with the H-point of the dummy.

* * * * *

(b) At each designated seating position having a head restraint, place the dummy, snugly restrained by Type 2 seat belt, in the manufacturer's recommended design seating position.

* * * * *

S5.2 Compliance with S4.2(b) of this section is demonstrated in accordance with the following with the head restraint in its fully extended design position:

* * * * *

(b) Establish the displaced torso reference line by applying a rearward moment of 373 Nm about the seating reference point to the seat back through the test device back pan specified in S5.2(a) of this section.

* * * * *

■ 3. Section 571.202a is added to read as follows:

§ 571.202a Standard No. 202a; Head restraints; Mandatory applicability begins on September 1, 2008.

S1. *Purpose and scope.* This standard specifies requirements for head restraints to reduce the frequency and severity of neck injury in rear-end and other collisions.

S2. *Application & incorporation by reference.*

S2.1 *Application.* This standard applies to passenger cars, and to multipurpose passenger vehicles, trucks and buses with a GVWR of 4,536 kg or less, manufactured on or after September 1, 2008. Mandatory applicability begins on September 1, 2008. Until September 1, 2008, manufacturers may comply with the standard in this § 571.202a, with the standard in § 571.202, or with the European regulations referenced in S4.3(a) of § 571.202.

S2.2 *Incorporation by reference.*

(a) Society of Automotive Engineers (SAE) Recommended Practice J211/1 rev. Mar 95, ''Instrumentation for Impact Test—Part 1—Electronic Instrumentation,'' SAE J211/1 (rev. Mar 95) is incorporated by reference in S5.2.5(b), S5.3.8, S5.3.9, and 5.3.10 of this section. The Director of the Federal Register has approved the incorporation by reference of this material in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. A copy of SAE J211/1 (rev. Mar 95) may be obtained from SAE at the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096. A copy of SAE J211/1 (rev. Mar 95) may be inspected at NHTSA's Technical Information Services, 400 Seventh Street, SW., Plaza Level, Room 403, Washington, DC, or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to: *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.*

(b) Society of Automotive Engineers (SAE) Standard J826 ''Devices for Use in Defining and Measuring Vehicle Seating Accommodation,'' SAE J826 (rev. Jul 95) is incorporated by reference in S3, S5, S5.1, S5.1.1, S5.2, S5.2.1, S5.2.2, and S5.2.7 of this section. The Director of the Federal Register has approved the incorporation by reference of this material in accordance with 5 U.S.C. 552(a) and 1 CFR Part 51. A copy of SAE J826 (rev. Jul 95) may be obtained from SAE at the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096. A copy of SAE J826 (rev. Jul 95) may be inspected at NHTSA's Technical Information Services, 400 Seventh Street, SW., Plaza Level, Room 403, Washington, DC or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to: *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.*

S3. *Definitions.*

Backset means the 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.

Head restraint means a device that limits rearward displacement of a seated occupant's head relative to the occupant's torso.

Head restraint measurement device (HRMD) means the Society of Automotive Engineers (SAE) (rev. Jul 95) J826 three-dimensional manikin with a head form attached, representing the head position of a seated 50th percentile male, with sliding scale at the back of the head for the purpose of measuring backset. The head form is designed by and available from the ICBC, 151 West Esplanade, North Vancouver, BC V7M 3H9, Canada (*www.icbc.com*).

Height means, when used in reference to a head restraint, the distance from the H-point, measured parallel to the torso reference line defined by the three dimensional SAE J826 (rev. Jul 95) manikin, to a plane normal to the torso reference line.

Intended for occupant use means, when used in reference to the adjustment of a seat, positions other than that intended solely for the purpose of allowing ease of ingress and egress of occupants and access to cargo storage areas of a vehicle.

Rear head restraint means, at any rear outboard designated seating position, a rear seat back, or any independently adjustable seat component attached to or adjacent to a seat back, that has a height equal to or greater than 700 mm, in any position of backset and height adjustment, as measured in accordance with S5.1.1.

Top of the head restraint means the point on the head restraint with the greatest height.

S4. *Requirements.* Except as provided in S4.4 and S.4.2.1(b)(2) of this section, each vehicle must comply with S4.1 of this section with the seat adjusted as intended for occupant use. Whenever a range of measurements is specified, the head restraint must meet the requirement at any position of adjustment within the specified range.

S4.1 *Performance levels.* In each vehicle other than a school bus, a head restraint that conforms to either S4.2 or S4.3 of this section must be provided at each front outboard designated seating position. In each vehicle equipped with rear head restraints, the rear head restraint must conform to either S4.2 or S4.3 of this section. In each school bus, a head restraint that conforms to either S4.2 or S4.3 of this section must be provided for the driver's seating position. At each designated seating position incapable of seating a 50th percentile male Hybrid III test dummy specified in 49 CFR Part 572, subpart E, the applicable head restraint must conform to S4.2 of this section.

S4.2 *Dimensional and static performance.* Each head restraint located in the front outboard designated seating position and each head restraint located in the rear outboard designated seating position must conform to paragraphs S4.2.1 through S4.2.7 of this section:

S4.2.1 *Minimum height.*

(a) *Front outboard designated seating positions.* (1) Except as provided in S4.2.1(a)(2) of this section, when measured in accordance with S5.2.1(a)(1) of this section, the top of a head restraint located in a front outboard designated seating position must have a height not less than 800 mm in at least one position of adjustment.

(2) Exception. The requirements of S4.2.1(a)(1) do not apply if the vehicle roofline physically prevents a head restraint, located in the front outboard designated seating position, from attaining the required height. In those instances in which this head restraint cannot attain the required height, when measured in accordance with S5.2.1(a)(2), the maximum vertical distance between the top of the head restraint and the roofline must not exceed 25 mm. Notwithstanding this exception, when measured in accordance with S5.2.1(a)(2), the top of a head restraint located in a front outboard designated seating position must have a height not less than 700 mm in the lowest position of adjustment.

(b) *All outboard designated seating positions equipped with head restraints.* (1) Except as provided in S4.2.1(b)(2) of this section, when measured in accordance with S5.2.1(b)(1) of this section, the top of a head restraint located in an outboard designated seating position must have a height not less than 750 mm in any position of adjustment.

(2) Exception. The requirements of S4.2.1(b)(1) do not apply if the vehicle

roofline or backlight physically prevent a head restraint, located in the rear outboard designated seating position, from attaining the required height. In those instances in which this head restraint cannot attain the required height, when measured in accordance with S5.2.1(b)(2), the maximum vertical distance between the top of the head restraint and the roofline or the backlight must not exceed 25 mm.

S4.2.2 *Width.* When measured in accordance with S5.2.2 of this section, 65 ± 3 mm below the top of the head restraint, the lateral width of a head restraint must be not less than 170 mm, except the lateral width of the head restraint for front outboard designated seating positions in a vehicle with a front center designated seating position, must be not less than 254 mm.

S4.2.3 *Front Outboard Designated Seating Position Backset.* When measured in accordance with S5.2.3 of this section, the backset must not be more than 55 mm, when the seat is adjusted in accordance with S5.1. For adjustable restraints, the requirements of this section must be met with the top of the head restraint in any height position of adjustment between 750 mm and 800 mm, inclusive. If the top of the head restraint, in its lowest position of adjustment, is above 800 mm, the requirements of this section must be met at that position. If the head restraint position is independent of the seat back inclination position, the head restraint must not be adjusted such that backset is more than 55 mm when the seat back inclination is positioned closer to vertical than the position specified in S5.1.

S4.2.4 *Gaps within head restraint and between the head restraint and seat.* When measured in accordance with S5.2.4 of this section using the head form specified in that paragraph, there must not be any gap greater than 60 mm within or between the anterior surface of the head restraint and anterior surface of the seat, with the head restraint adjusted to its lowest height position and any backset position.

S4.2.5 *Energy absorption.* When the anterior surface of the head restraint is impacted in accordance with S5.2.5 of this section by the head form specified in that paragraph at any velocity up to and including 24.1 km/h, the deceleration of the head form must not exceed 785 m/s^2 (80 g) continuously for more than 3 milliseconds.

S4.2.6 *Height retention.* When tested in accordance with S5.2.6 of this section, the cylindrical test device specified in S5.2.6(b) must return to within 13 mm of its initial reference position after application of at least a 500 N load and subsequent reduction of the load to 50 N ± 1 N. During application of the initial 50 N reference load, as specified in S5.2.6(b)(2) of this section, the cylindrical test device must not move downward more than 25 mm.

S4.2.7 *Backset retention, displacement, and strength.*

(a) *Backset retention and displacement.* When tested in accordance with S5.2.7 of this section, the described head form must:

(1) Not be displaced more than 25 mm during the application of the initial reference moment of 37 ± 0.7 Nm;

(2) Not be displaced more than 102 mm perpendicularly and posterior of the displaced extended torso reference line during the application of a 373 ± 7.5 Nm moment about the H-point; and

(3) Return to within 13 mm of its initial reference position after the application of a 373 ± 7.5 Nm moment about the H-point and reduction of the moment to 37 ± 0.7 Nm.

(b) *Strength.* When the head restraint is tested in accordance with S5.2.7 (b) of this section with the test device specified in that paragraph, the load applied to the head restraint must reach 890 N and remain at 890 N for a period of 5 seconds.

S4.3 *Dynamic performance and width.* At each forward-facing outboard designated seating position equipped with a head restraint, the head restraint adjusted midway between the lowest and the highest position of adjustment, and at any position of backset adjustment, must conform to the following:

S4.3.1 *Injury criteria.* When tested in accordance with S5.3 of this section, during a forward acceleration of the dynamic test platform described in S5.3.1, the head restraint must:

(a) *Angular rotation.* Limit posterior angular rotation between the head and torso of the 50th percentile male Hybrid III test dummy specified in 49 CFR Part 572, Subpart E to 12 degrees for the dummy in all outboard designated seating positions;

(b) *Head injury criteria.* Limit the maximum HIC_{15} value to 500. HIC_{15} is calculated as follows: for any two points in time, t_1 and t_2, during the event which are separated by not more than a 15 millisecond time interval and where t_1 is less than t_2, the head injury criterion (HIC_{15}) is determined using the resultant head acceleration at the center of gravity of the dummy head, a_r, expressed as a multiple of g (the acceleration of gravity) and is calculated using the expression:

$$HIC = \left[\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a_r dt \right]^{2.5} (t_2 - t_1)$$

4.3.2 *Width.* The head restraint must have the lateral width specified in S4.2.2 of this section.

S4.4 *Folding or retracting rear head restraints.* A rear head restraint may be adjusted to a position at which its height does not comply with the requirements of S4.2.1 of this section. However, in any such position, the head restraint must meet either S4.4 (a) or (b) of this section.

(a) The head restraint must automatically return to a position in which its minimum height is not less than that specified in S4.2.1(b) of this section when a test dummy representing a 5th percentile female Hybrid III test dummy specified in 49 CFR Part 572, Subpart O is positioned according to S5.4(a); or

(b) The head restraint must, when tested in accordance with S5.4(b) of this section, be capable of manually rotating forward or rearward by not less than 60 degrees from any position of adjustment in which its minimum height is not less than that specified in S4.2.1(b) of this section.

S4.5 *Removability of head restraints.* The head restraint must not be removable without a deliberate action distinct from any act necessary for adjustment.

S4.6 *Compliance option selection.* Where manufacturer options are specified in this section, the manufacturer must select an option by the time it certifies the vehicle and may not thereafter select a different option for that vehicle. The manufacturer may select different compliance options for different designated seating positions to which the requirements of this section are applicable. Each manufacturer must, upon request from the National Highway Traffic Safety Administration, provide information regarding which of the compliance options it has selected for a particular vehicle or make/model.

S4.7 *Information in owner's manual.*

S4.7.1 The owner's manual for each vehicle must emphasize that all occupants, including the driver, should not operate a vehicle or sit in a vehicle's seat until the head restraints are placed in their proper positions in order to minimize the risk of severe injury in the event of a crash.

S4.7.2 The owner's manual for each vehicle must—

(a) Include an accurate description of the vehicle's head restraint system in an easily understandable format. The owner's manual must clearly identify which seats are equipped with head restraints;

(b) If the head restraints are removable, the owner's manual must provide instructions on how to remove the head restraint by a deliberate action distinct from any act necessary for adjustment, and how to reinstall head restraints;

(c) Warn that all head restraints must be reinstalled to properly protect vehicle occupants.

(d) Describe in an easily understandable format the adjustment of the head restraints and/or seat back to achieve appropriate head restraint position relative to the occupant's head. This discussion must include, at a minimum, accurate information on the following topics:

(1) A presentation and explanation of the main components of the vehicle's head restraints.

(2) The basic requirements for proper head restraint operation, including an explanation of the actions that may affect the proper functioning of the head restraints.

(3) The basic requirements for proper positioning of a head restraint in relation to an occupant's head position, including information regarding the proper positioning of the center of gravity of an occupant's head in relation to the head restraint.

S5. *Procedures.* Demonstrate compliance with S4.2 through S4.4 of this section with any adjustable lumbar support adjusted to its most posterior nominal design position. If the seat cushion adjusts independently of the seat back, position the seat cushion such that the highest H-point position is achieved with respect to the seat back, as measured by SAE J826 (rev. Jul 95) manikin, with leg length specified in S10.4.2.1 of § 571.208.

S5.1 Except as specified in S5.2.3 of this section, if the seat back is adjustable, it is set at an initial inclination position closest to 25 degrees from the vertical, as measured by SAE J826 manikin (rev. Jul 95). If there is more than one inclination position closest to 25 degrees from vertical, set the seat back inclination to the position closest to and rearward of 25 degrees.

S5.1.1 *Procedure for determining presence of head restraints in rear outboard seats.* Measure the height of the top of a rear seat back or the top of any independently adjustable seat component attached to or adjacent to the rear seat back in its highest position of adjustment using the scale incorporated into the SAE J826 (rev. Jul 95) manikin or an equivalent scale, which is positioned laterally within 15 mm of the centerline of the rear seat back or any independently adjustable seat component attached to or adjacent to the rear seat back.

S5.2 *Dimensional and static performance procedures.* Demonstrate compliance with S4.2 of this section in accordance with S5.2.1 through S5.2.7 of this section. Position the SAE J826 (rev. Jul 95) manikin according to the seating procedure found in SAE J826 (rev. Jul 95).

S5.2.1 *Procedure for height measurement.* Demonstrate compliance with S4.2.1 of this section in accordance with S5.2.1 (a) and (b) of this section, using the scale incorporated into the SAE J826 (rev. Jul 95) manikin or an equivalent scale, which is positioned laterally within 15 mm of the head restraint centerline. If the head restraint position is independent of the seat back inclination position, compliance is determined at a seat back inclination position closest to 25 degrees from vertical, and each seat back inclination position less than 25 degrees from vertical.

(a)(1) For head restraints in front outboard designated seating positions, adjust the top of the head restraint to the highest position and measure the height.

(2) For head restraints located in the front outboard designated seating positions that are prevented by the vehicle roofline from meeting the required height as specified in S4.2.1(a)(1), measure the clearance between the top of the head restraint and the roofline, with the seat adjusted to its lowest vertical position intended for occupant use, by attempting to pass a 25 mm sphere between them. Adjust the top of the head restraint to the lowest position and measure the height.

(b)(1) For head restraints in all outboard designated seating positions equipped with head restraints, adjust the top of the head restraint to the lowest position other than allowed by S4.4 and measure the height.

(2) For head restraints located in rear outboard designated seating positions that are prevented by the vehicle roofline or rear backlight from meeting the required height as specified in S4.2.1(b)(1), measure the clearance between the top of the head restraint or the seat back and the roofline or the rear backlight, with the seat adjusted to its lowest vertical position intended for occupant use, by attempting to pass a 25 mm sphere between them.

S5.2.2 *Procedure for width measurement.* Demonstrate compliance with S4.2.2 of this section using calipers to measure the maximum dimension perpendicular to the vehicle vertical longitudinal plane of the intersection of the head restraint with a plane that is normal to the torso reference line of SAE J826 (rev. Jul 95) manikin and 65 ± 3 mm below the top of the head restraint.

S5.2.3 *Procedure for backset measurement.* Demonstrate compliance with S4.2.3 of this section using the HRMD positioned laterally within 15 mm of the head restraint centerline. Adjust the front head restraint so that its top is at any height between and inclusive of 750 mm and 800 mm and its backset is in the maximum position other than allowed by S4.4. If the lowest position of adjustment is above 800 mm, adjust the head restraint to that position. If the head restraint position is independent of the seat back inclination position, compliance is determined at each seat back inclination position closest to and less than 25 degrees from vertical.

S5.2.4 *Procedures for gap measurement.* Demonstrate compliance with S4.2.4 of this section in accordance with the procedures of S5.2.4 (a) through (c) of this section, with the head restraint adjusted to its lowest height position and any backset position.

(a) The area of measurement is anywhere on the anterior surface of the head restraint or seat with a height greater than 540 mm and within the following distances from the centerline of the seat—

(1) 127 mm for seats required to have 254 mm minimum head restraint width; and

(2) 85 mm for seats required to have a 170 mm head restraint width.

(b) Applying a load of no more than 5 N against the area of measurement specified in S5.2.4(a) of this section, place a 165 ± 2 mm diameter spherical head form against any gap such that at least two points of contact are made within the area. The surface roughness of the head form is less than 1.6 μm, root mean square.

(c) Determine the gap dimension by measuring the vertical straight line distance between the inner edges of the two furthest contact points, as shown in Figures 2 and 3 of this section.

S5.2.5 *Procedures for energy absorption.* Demonstrate compliance with S4.2.5 of this section in accordance with S5.2.5 (a) through (e) of this section, with the seat back rigidly fixed and the adjustable head restraints in any height and backset position of adjustment.

(a) Use an impactor with a semispherical head form and a 165 ± 2 mm diameter and a surface roughness of less than 1.6 μm, root mean square. The head form and associated base have a combined mass of 6.8 ± 0.05 kg.

(b) Instrument the impactor with an acceleration sensing device whose output is recorded in a data channel that conforms to the requirements for a 600 H_z channel class as specified in SAE Recommended Practice J211/1 (rev. Mar 95). The axis of the acceleration-sensing device coincides with the geometric center of the head form and the direction of impact.

(c) Propel the impactor toward the head restraint. At the time of launch, the longitudinal axis of the impactor is within 2 degrees of being horizontal and parallel to the vehicle longitudinal axis. The direction of travel is posteriorly.

(d) Constrain the movement of the head form so that it travels linearly along the path described in S5.2.5(c) of this section for not less than 25 mm before making contact with the head restraint.

(e) Impact the anterior surface of the seat or head restraint at any point with a height greater than 635 mm and within a distance of the head restraint vertical centerline of 70 mm.

S5.2.6 *Procedures for height retention.* Demonstrate compliance with S4.2.6 of this section in accordance with S5.2.6 (a) through (d) of this section.

(a) Adjust the adjustable head restraint so that its top is at any of the following height positions at any backset position—

(1) For front outboard designated seating positions—

(i) The highest position; and

(ii) Not less than, but closest to 800 mm; and

(2) For rear outboard designated seating positions equipped with head restraints—

(i) The highest position; and

(ii) Not less than, but closest to 750 mm.

(b)(1) Orient a cylindrical test device having a 165 ± 2 mm diameter in plane view (perpendicular to the axis of revolution), and a 152 mm length in profile (through the axis of revolution) with a surface roughness of less than 1.6 μm, root mean square, such that the axis of the revolution is horizontal and in the longitudinal vertical plane through the longitudinal centerline of the head restraint. Position the midpoint of the bottom surface of the cylinder in contact with the head restraint.

(2) Establish initial reference position by applying a vertical downward load of 50 ± 1 N.

(c) Increase the load at the rate of 250 ± 50 N/minute to at least 500 N and maintain this load for not less than 5 seconds.

(d) Reduce the load at the rate of 250 ± 50 N/minute to 50 ± 1 N and determine the position of the cylindrical device with respect to its initial reference position.

S5.2.7 *Procedures for backset retention, displacement, and strength.* Demonstrate compliance with S4.2.7 of this section in accordance with S5.2.7 (a) and (b) of this section. The load vectors that generate moment on the head restraint are initially contained in a vertical plane parallel to the vehicle longitudinal centerline.

(a) *Backset retention and displacement*—

(1) Adjust the head restraint so that its top is at a height closest to and not less than:

(i) 800 mm for front outboard designated seating positions (or the highest position of adjustment for head restraints subject to S4.2.1(a)(2)); and

(ii) 750 mm for rear outboard designated seating positions equipped with head restraints (or the highest position of adjustment for rear head restraints subject to S4.2.1(b)(2)).

(2) Adjust the head restraint to any backset position.

(3) In the seat, place a test device having the back pan dimensions and torso reference line (vertical center line), when viewed laterally, with the head room probe in the full back position, of the three dimensional SAE J826 (rev. Jul 95) manikin;

(4) Establish the displaced torso reference line by creating a posterior moment of 373 ± 7.5 Nm about the H-point by applying a force to the seat back through the back pan at the rate of 187 ± 37 Nm/minute. The initial location on the back pan of the moment generating force vector has a height of 290 mm ± 13 mm. Apply the force vector normal to the torso reference line and maintain it within 2 degrees of a vertical plane parallel to the vehicle longitudinal centerline. Constrain the back pan to rotate about the H-point. Rotate the force vector direction with the back pan.

(5) Maintain the position of the back pan as established in S5.2.7 (4) of this section. Using a 165 ± 2 mm diameter spherical head form with a surface roughness of less than 1.6 μm, root mean square, establish the head form initial reference position by applying, perpendicular to the displaced torso reference line, a posterior initial load at the seat centerline at a height 65 ± 3 mm below the top of the head restraint that will produce a 37 ± 0.7 Nm moment about the H-point. Measure the posterior displacement of the head form during the application of the load.

(6) Increase the initial load at the rate of 187 ± 37 Nm/minute until a 373 ± 7.5 Nm moment about the H-point is produced. Maintain the load level producing that moment for not less than 5 seconds and then measure the posterior displacement of the head form relative to the displaced torso reference line.

(7) Reduce the load at the rate of 187 ± 37 Nm/minute until a 37 ± 0.7 Nm moment about the H-point is produced. While maintaining the load level producing that moment, measure the posterior displacement of the head form position with respect to its initial reference position; and

(b) *Strength.* Increase the load specified in S5.2.7(a)(7) of this section at the rate of 250 ± 50 N/minute to at least 890 N and maintain this load level for not less than 5 seconds.

S5.3 *Procedures for dynamic performance.* Demonstrate compliance with S4.3 of this section in accordance with S5.3.1 though S5.3.9 of this section with a 50th percentile male Hybrid III test dummy specified in 49 CFR part 572 subpart E, with the head restraint midway between the lowest and the highest position of adjustment, and at any position of backset adjustment.

S5.3.1 Mount the vehicle on a dynamic test platform at the vehicle attitude set forth in S13.3 of § 571.208, so that the longitudinal centerline of the vehicle is parallel to the direction of the test platform travel and so that movement between the base of the vehicle and the test platform is prevented. Instrument the platform with an accelerometer and data processing system. Position the accelerometer sensitive axis parallel to the direction of test platform travel.

S5.3.2 Remove the tires, wheels, fluids, and all unsecured components. Remove or rigidly secure the engine, transmission, axles, exhaust, vehicle frame and any other vehicle component necessary to assure that all points on the acceleration vs. time plot measured by an accelerometer on the dynamic test platform fall within the corridor described in Figure 1 and Table 1.

S5.3.3 Place any moveable windows in the fully open position.

S5.3.4 *Seat adjustment.* At each outboard designated seating position, using any control that primarily moves the entire seat vertically, place the seat in the lowest position. Using any control that primarily moves the entire seat in the fore and aft directions, place the seat midway between the forwardmost and rearmost position. If an adjustment position does not exist midway between the forwardmost and rearmost positions, the closest adjustment position to the rear of the midpoint is used. Adjust the seat cushion and seat back, without using any controls that move the entire seat, as required by S5 and S5.1 of this section. If the specified position of the H-point can be achieved with a range of seat cushion inclination angles, adjust the seat inclination such that the most forward part of the seat cushion is at its lowest position with respect to the most rearward part. If the head restraint is adjustable, adjust the top of the head restraint to a position midway between the lowest position of adjustment and the highest position of adjustment. If an adjustment position midway between the lowest and the highest position does not exist, adjust the head restraint to a position below and nearest to midway between the lowest position of adjustment and the highest position of adjustment.

S5.3.5 *Seat belt adjustment.* Prior to placing the Type 2 seat belt around the test dummy, fully extend the webbing from the seat belt retractor(s) and release it three times to remove slack. If an adjustable seat belt D-ring anchorage exists, place it in the adjustment position closest to the mid-position. If an adjustment position does not exist midway between the highest and lowest position, the closest adjustment position above the midpoint is used.

S5.3.6 Dress and adjust each test dummy as specified in S8.1.8.2 through S8.1.8.3 of § 571.208.

S5.3.7 *Test dummy positioning procedure.* Place a test dummy at each outboard designated seating position equipped with a head restraint.

S5.3.7.1 *Head.* The transverse instrumentation platform of the head is level within ½ degree. To level the head of the test dummy, the following sequences is followed. First, adjust the position of the H point within the limits set forth in S10.4.2.1 of § 571.208 to level the transverse instrumentation platform of the head of the test dummy. If the transverse instrumentation platform of the head is still not level, then adjust the pelvic angle of the test dummy. If the transverse instrumentation platform of the head is still not level, then adjust the neck bracket of the dummy the minimum amount necessary from the non-adjusted ''0'' setting to ensure that the transverse instrumentation platform of the head is horizontal within ½ degree. The test dummy remains within the limits specified in S10.4.2.1 of § 571.208 after any adjustment of the neck bracket.

S5.3.7.2 *Upper arms and hands.* Position each test dummy as specified in S10.2 and S10.3 of § 571.208.

S5.3.7.3 *Torso.* Position each test dummy as specified in S10.4.1.1, S10.4.1.2, and S10.4.2.1 of § 571.208, except that the midsagittal plane of the dummy is aligned within 15 mm of the head restraint centerline. If the midsagittal plane of the dummy cannot be aligned within 15 mm of the head restraint centerline then align the midsagittal plane of the dummy as close as possible to the head restraint centerline.

S5.3.7.4 *Legs.* Position each test dummy as specified in S10.5 of § 571.208, except that final adjustment to accommodate placement of the feet in accordance with S5.3.7.4 of this section is permitted.

S5.3.7.5 *Feet.* Position each test dummy as specified in S10.6 of § 571.208, except that for rear outboard designated seating positions the feet of the test dummy are placed flat on the floorpan and beneath the front seat as far forward as possible without front seat interference. For rear outboard designated seating position, if necessary, the distance between the knees can be changed in order to place the feet beneath the seat.

S5.3.8 Accelerate the dynamic test platform to 17.3 ± 0.6 km/h. All of the points on the acceleration vs. time curve fall within the corridor described in Figure 1 and Table 1 when filtered to channel class 60, as specified in the SAE Recommended Practice J211/1 (rev. Mar 95). Measure the maximum posterior angular displacement.

S5.3.9 Calculate the angular displacement from the output of instrumentation placed in the torso and head of the test dummy and an algorithm capable of determining the relative angular displacement to within one degree and conforming to the requirements of a 600 H_z channel class, as specified in SAE Recommended Practice J211/1, (rev. Mar 95). No data generated after 200 ms from the beginning of the forward acceleration are used in determining angular displacement of the head with respect to the torso.

S5.3.10 Calculate the HIC_{15} from the output of instrumentation placed in the head of the test dummy, using the equation in S4.3.1(b) of this section and conforming to the requirements for a 1000 H_z channel class as specified in SAE Recommended Practice J211/1 (rev. Mar 95). No data generated after 200 ms from the beginning of the forward acceleration are used in determining HIC.

S5.4 Procedures for folding or retracting head restraints for unoccupied rear outboard designated seating positions.

(a) Demonstrate compliance with S4.4 (a) of this section, using a 5th percentile female Hybrid III test dummy specified in 49 CFR part 572, subpart O, in accordance with the following procedure—

(1) Position the test dummy in the seat such that the dummy's midsaggital plane is aligned within the 15 mm of the head restraint centerline and is parallel to a vertical plane parallel to the vehicle longitudinal centerline.

(2) Hold the dummy's thighs down and push rearward on the upper torso to maximize the dummy's pelvic angle.

(3) Place the legs as close as possible to 90 degrees to the thighs. Push rearward on the dummy's knees to force the pelvis into the seat so there is no gap between the pelvis and the seat back or until contact occurs between the back of the dummy's calves and the front of the seat cushion such that the angle between the dummy's thighs and legs begins to change.

(4) Note the position of the head restraint. Remove the dummy from the seat. If the head restraint returns to a retracted position upon removal of the dummy, manually place it in the noted position. Determine compliance with the height requirements of S4.2.1 of this section by using the test procedures of S5.2.1 of this section.

(b) Demonstrate compliance with S4.4 (b) of this section in accordance with the following procedure:

(1) Place the rear head restraint in any position meeting the requirements of S4.2 of this section;

(2) Strike a line on the head restraint. Measure the angle or range of angles of the head restraint reference line as projected onto a vertical longitudinal vehicle plane;

(3) Fold or retract the head restraint to a position in which its minimum height is less than that specified in S4.2.1 (b) of this section or in which its backset is more than that specified in S4.2.3 of this section;

(4) Determine the minimum change in the head restraint reference line angle as projected onto a vertical longitudinal vehicle plane from the angle or range of angles measured in S5.4(b)(2) of this section.

TABLE 1 OF § 571.202A.—SLED PULSE CORRIDOR REFERENCE POINT LOCATIONS.

Reference point	Time (ms)	Acceleration (m/s²)
A	0	10
B	28	94
C	60	94
D	92	0
E	4	0
F	38.5	80
G	49.5	80
H	84	0

Figure 1 of §571.202a - Sled pulse acceleration corridor. The target acceleration with time expressed in milliseconds is a = 86 Sin(πt/88) m/s^2, for V = 17.3 ± 0.6 km/h. The time zero for the test is defined by the point when the sled acceleration achieves 2.5 m/s^2 (0.25 G's).

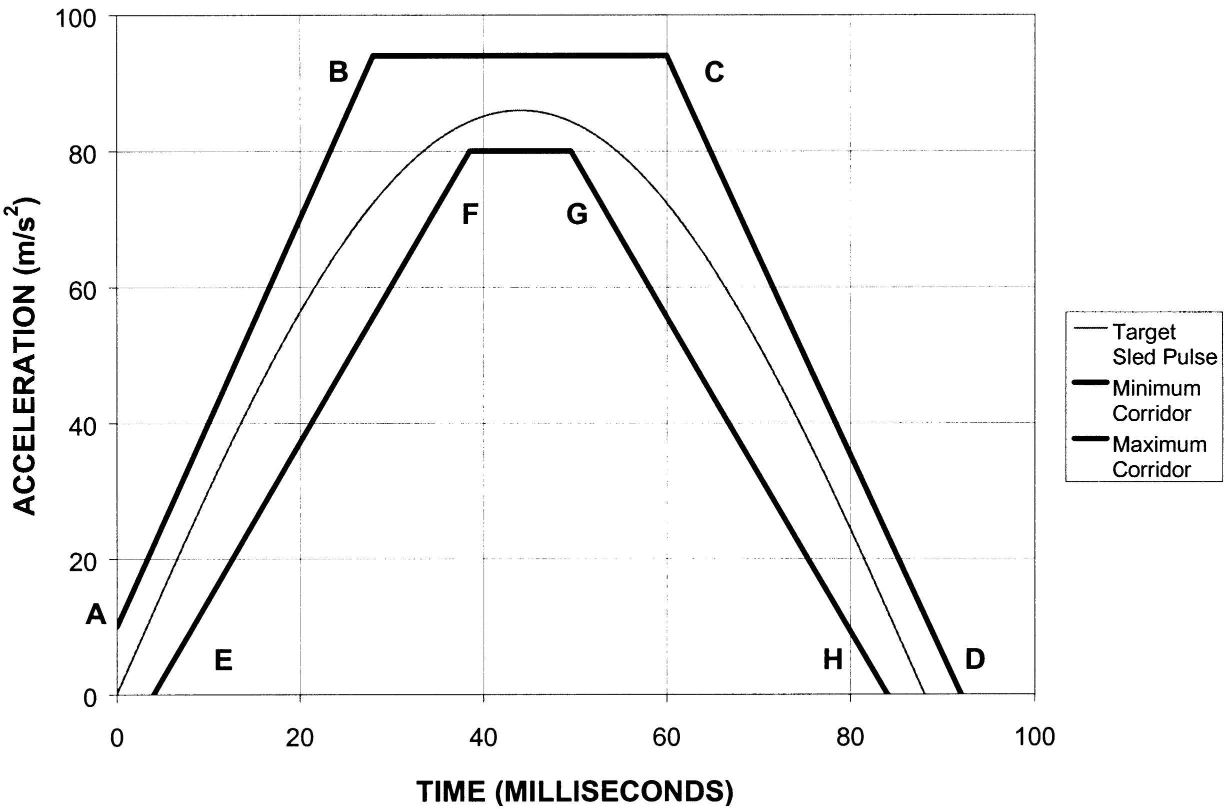


Figure 2 of §571.202a - Measurement of a vertical gap "a".

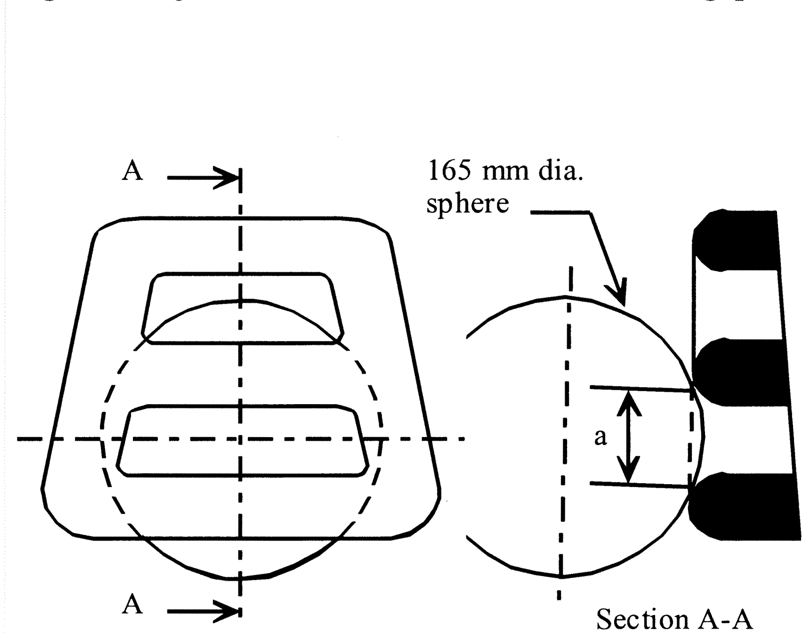
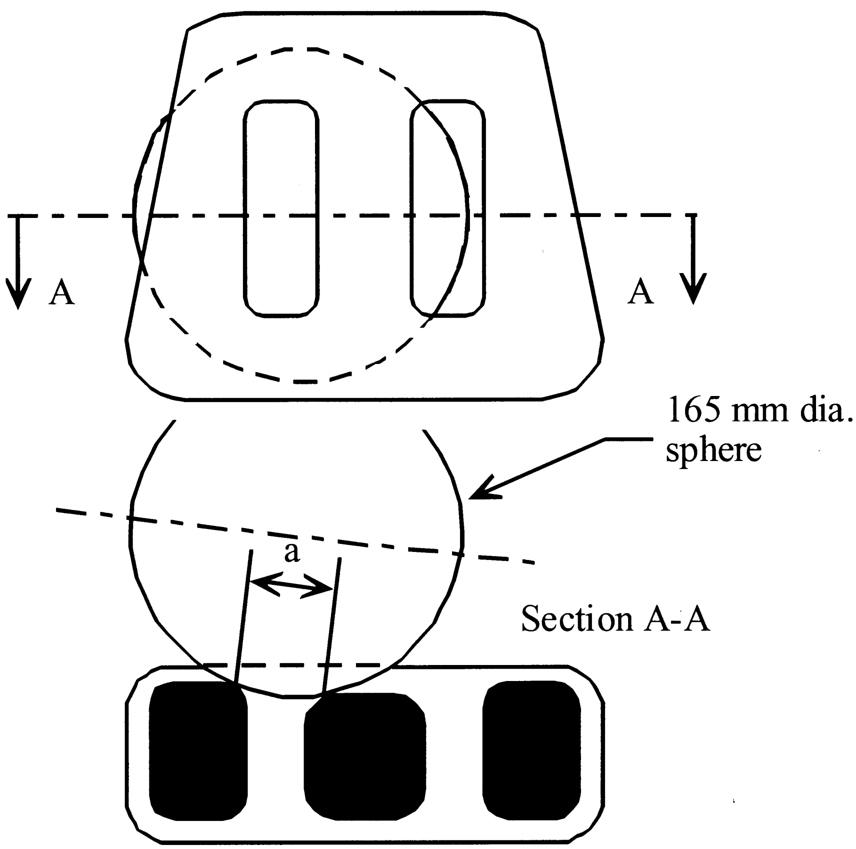


Figure 3 of §571.202a - Measurement of a horizontal gap "a".



Dated: November 28, 2004.

Jeffrey W. Runge,

Administrator.

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