April 4, 2021

National Highway Traffic Safety Administration
West Building
Ground Floor
Rm. W12-140
1200 New Jersey Avenue, SE
Washington, DC 20590

Attention: Docket No. NHTSA-2020-0093.

Volvo Car Corporation (Volvo Cars) appreciates the opportunity to submit comments in response to the Notice of Proposed Rulemaking that proposes updates to Federal Motor Vehicle Safety Standard (FMVSS) No. 213, "Child restraint systems" (CRS). Volvo Cars would be pleased to discuss our comments in further detail with you or members of your staff. If you need any additional information or have any questions, please do not hesitate to contact me at kyehl@volvocars.com.

Sincerely,

Katherine H. Yehl

Katherine H. Yehl
Vice President Government Affairs the Americas
Volvo Car Corporation

Enclosures

Introduction

Child occupant protection is the highest priority for Volvo Cars. Volvo Cars strongly supports an update to FMVSS No. 213 and below are our comments. FMVSS No. 213 is an essential tool for real-world child occupant protection.

Volvo Cars has a long history of prioritizing child occupant protection and we have been actively working on it for close to sixty years. Volvo Cars has been continuously working to develop and advance child occupant safety. In the mid-60s, we helped develop the world's first child seat prototype for protection of small children in cars (Aldman, 1964). In 1978, Volvo Cars developed and introduced the world's first booster seat (Norin et al., 1979). Later in 1990, Volvo Cars introduced the first integrated (built-in) booster seats, and in 2007 we introduced a second-generation integrated booster (Lundell et al., 1991, Jakobsson et al., 2007). In 2000, we developed the world's first rearward facing ISOFIX CRS. In addition, Volvo Cars and other experts initiated the ISO working group on Child Restraints in Cars. Volvo Cars has chaired this working group ever since its inception in 1989.

Volvo Cars shares the Agency's goal of "simplifying the standard's compliance tests to make them more reflective of the real-world use of CRS today". Simplicity should be the goal not only for test execution but also when designing the test and the Child Restraint Systems (CRS). The most effective way to ensure this is by always focusing on the fundamental principles of protection. Child occupant protection is a collaboration of the vehicle, the CRS and the user. Hence, a CRS standard should enable assessment of the essentials for the CRS. It is critical to ensure that both the vehicle and user are included in this assessment. This is in line with the Agency's goal "to ensure the continued effectiveness of CRS in current and future crashes, thereby reducing the unreasonable risk of injury to children in motor vehicle crashes".

It is optimal that small children be protected in a rearward facing seat, where the shell of the CRS provides the fundamental protection principles of distributing the load over a large surface of the child. This protects the child's vulnerable neck and head, in frontal as well as side impact crashes. Volvo Cars strongly believes that children should stay rearward facing until at least 4 years old. This is based on 50 years of experience in Sweden, and evidence that this is possible and proven superiorly safe is summarized in Jakobsson (2017).

When a child has outgrown the toddler CRS, and is four years old, the child can benefit from the vehicle seatbelt, if used together with a booster seat. The protection principle of a seatbelt is to restrain the strong parts of the body; the pelvic bones, and across the chest and over the shoulder. A booster seat that elevates the child, and thereby positions the lap belt on the thighs (in contact with the pelvis) and the shoulder belt across the chest and over the shoulder, serves the purpose of a CRS. It is also essential that a booster seat shortens the seat cushion, helping the child to bend their knees comfortably and thereby reducing likelihood of slouching, resulting in a potential poor lap belt fit. These are the fundamental protection principles of a booster seat. In addition, a seatbelt performs best when it is routed as straight as possible. When extensively re-directed or re-routed, the seatbelt's protective functions will be impacted due to introduction of slack.

The development of the rearward facing CRS was the starting point for child occupant protection in cars (Aldman, 1964, Jakobsson, 2017). They came into production in 1967 and were mainly sold in the Nordic countries. Some of the CRS during the 1970s even accommodated children up to 6 years old. These seats could either be mounted on the front seat chassis (removed seat cushion) or placed on the front or rear seat leaning against the dashboard or front seat. They were upright in position with a rigorous fixation to the vehicle. Starting with the UN ECE Regulation No. 44 (ECE R44), the use of the vehicle seatbelt became best practice. In addition to the seatbelt, straps to the floor or the seat rails in front, are used to restrict the child seat motion in a rear-end impact. This also protects the child during a rebound in a frontal impact and in the case of a rollover or other complex crash events. In addition, if a child is placed in the rear seat, a support leg is used. These principles still apply for rearward facing toddler CRS in Sweden and other countries with UN ECE Contracting Parties (1958 Agreement).

Volvo Cars strongly supports the Agency's ambition to increase usage of rearward facing CRS. However, we would like to highlight that our experience and research has shown that the design and attachment of the CRS is important to ensure optimal protection. The principles of a seatbelt or LATCH attachment only, without an anti-rotational device, such as a support leg or use a of Top Tether, is valid only for an infant. With increased weight and stature, the CRS needs to be stabilized to reduce risk of forward tilting. Substantial forward tilting will expose the child's head to impacts, and this increases the risk of injury. This would counteract the purpose of the CRS and the Agency's goal to increase the number of older children that are rearward facing.

In line with the ambitions of real-world child occupant protection and simplicity, the standard seat assembly should resemble vehicle content of today. This allows the focus to be on the essential purpose of the CRS. An updated seat assembly encompasses several improvements including an updated cushion and the change to a shoulder and lap belt. Volvo Cars supports these updates. However, a retractor function is needed to fully resemble today's cars. This is especially important for booster seat assessment. In the future, we foresee the need to include additional seatbelt technologies, such as pretensioners and load-limiters.

From the user or customer perspective, factors like the child's comfort, ease-of-use, as well as risk of misuse and the consequences of that misuse, are important to consider. To address the child's comfort in rearward facing CRS, the toddler CRS should be designed differently than the infant CRS. While the infant CRS is more reclined and designed to be carried along (Figure 1a), the toddler CRS should be more upright to allow for more leg space and comfort (Figure 1b). Figure 1b shows a typical rearward facing toddler CRS available in UN ECE Contracting Parties (1958 Agreement). They are frequently used in the Nordic countries. They are restrained using the seatbelt (or ISOFIX attachment), a support leg towards the floor and straps either to the floor or the seat rails in front. This provides a stable and robust attachment.

Figure 1a. Rearward facing infant CRS

Figure 1b. Rearward facing toddler CRS

As emphasized by the Agency, CRS misuse is a major problem with respect to child occupant safety today. Loose CRS installation or loose harnesses are among the most common errors (Klinich et al., 2014). In a frontal impact crash (which is the most common and severe type of crash), the rearward facing CRS for toddlers is not as sensitive to a slack issue in the child seat attachments nor to slack issue in the harness. This is simply because the seat shell is the main interaction with the child. When comparing data from crash tests performed with three convertible CRS; the two travel modes confirmed that loose harness or tethers had significant impact when forward-facing, while minor impact when rearward facing (Manary et al., 2019b).

Hence, the rearward facing CRS is a technical solution that provides a robust design to address the main causes of misuse for toddler CRS. In Sweden, these systems are used and there are very few child passenger fatalities in such CRS. Carlsson et al. (2013) summarized all child car passenger fatalities in Sweden 1956-2011. Over the course of these years only 15 of the fatally injured children were restrained in rearward-facing CRSs. The low relative numbers and the situations in which the few cases occurred confirm that rearward-facing CRS are extraordinarily safe and robust protection systems. Swedish parents are not likely to be better at tightening the harnesses and tethers than any other parent.

For years, Volvo Cars has strongly encouraged the Agency to make the necessary amendments to update FMVSS 213. These changes would enable the use of state-of-the-art rearward facing CRS in order to address the needs of toddlers, and to promote safe booster seats. The necessary amendments/revisions, in addition to some other items raised in the NPRM, are addressed below.

Updating the standard seat assembly (Sections III-V)

Overall, Volvo Cars supports the updated standard seat assembly which targets state-of-the art seat geometry and seat cushion characteristics. In order to target and achieve state-of-the art CRS, the vehicle content should be as contemporary as possible. The proposed change from Type 1 (lap belt) to Type 2 (shoulder and lap belt) belt system is s critical and much needed improvement. Volvo Cars strongly supports this, and it is in-line with the rationale in the NPRM and also consistent with Canada’s CMVSS No. 213.

In addition, Volvo Cars recommends inclusion of a vehicle retractor function in the FMVSS 213 standard seat assembly. A retractor function, that is currently available in all cars, would further align with the ambitions of reflecting real-world use of CRS today. We believe that a retractor function is essential when assessing booster seats. This is further elaborated in a sub-chapter to follow.

To achieve the ambitions of rearward facing CRS for older children, the standard seat assembly and test specifications should include the necessary prerequisites to certify state-of-the-art rearward facing CRS. Revisions (including use of attachments, anti-rotational devices and positioning procedures) are required to accommodate an assessment of best practice rearward facing CRS for up to at least 4-year olds. Volvo Cars maintains our position on the importance and relevance of including a floor in the standard seat assembly (see attached petition filed in 2011). A separate sub-chapter will follow on this topic.

In addition, it is likely in the future that there will be an increase of rear seat seatbelt technologies, including pretensioners and load limiters, in the US. This will likely be driven by consumer testing that includes rear seat passengers. When EuroNCAP introduced a new rear seat test protocol in 2016, a rapid increase in seatbelt technologies occurred. During the first year with the new protocol, 82% of the tested vehicles were equipped with outboard rear seat seatbelt pretensioners and load limiters (van Ratingen et al., 2016). The same trend is likely to happen in the US because of the Insurance Institute of Highway Safety (IIHS) initiative which will include rear seat evaluation in 2023. Therefore, Volvo Cars encourages further research and dialogue on these issues.

A retractor for booster seat tests

When assessing booster seat performance, it is important to simulate the vehicle retractor function in the seat assembly in a realistic way. This is essential for capturing the booster seat's dynamic performance. Specifically, the slack (film-spool effect) introduced by the retractor, is not present with the fixed attachment that is used in the test bench today. There are several studies that conclude a retractor function in the seatbelt is important and there are also proposals on how to include it in the seat assembly.

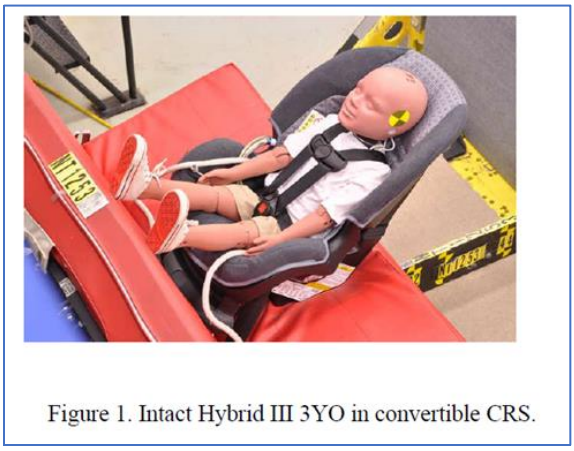
UMTRI has developed a surrogate retractor and performed a test using the FMVSS 213 test bench. This provided results on similar kinematics to those achieved with a production seatbelt (Manary et al. 2019a). Using the surrogate retractor, Klinich et al. (2020) conducted a comparative study of booster seats and this concluded that tests with a surrogate retractor were as repeatable as the tests performed with current the FMVSS 213 conditions. Also, a simplified version of the UMTRI surrogate retractor was designed and used in a test series by Transport Canada, and this showed similar results when added to the proposed FMVSS 213 test bench (Tang et al., 2019). Other studies have shown differences in dummy responses when comparing standard FMVSS 213 test bench tests and vehicle crashes (Tylko et al., 2016 and 2017). This further proves that the test bench tests were not able to replicate the variety seen in vehicle crash tests.

Volvo Cars, therefore encourages the Agency to include a vehicle retractor function in the FMVSS 213 standard seat assembly. This would better represent vehicle crash tests when using the test bench. This is necessary to assess booster seat designs and to discriminate between different types of booster seat design.

A floor for assessment of optimal protection for toddlers

Volvo Cars appreciates that the Agency has now addressed an update to the sled standard seat assembly and the lap/shoulder belt in the test procedure. This is in line with Volvo Cars' petition filed in January 2011(attached). However, we strongly urge the Agency to reconsider adding a floor to the test bench. The arguments raised in our petition are still valid. Volvo Cars would like to take this opportunity to clarify some of them. In addition, we would like to provide more research that has been performed since our petition.

a) Top view of two rearward facing seats; Q6 (left) and Q3 (right).



b) Convertible CRS in rearward facing mode; Hybrid III 3YO. Source: Manary et al., (2018)

Figure 2. Illustrating the effect on leg space, comparing a rearward facing CRS using support leg and lower tether attachments to the floor (a) and a convertible CRS in rearward facing mode (b).

Currently, it is not possible to use international best-practice (state-of-the-art) rearward facing CRS and apply them for the US market. This has significant impact on overall protection for children in US cars. The rearward facing toddler CRS (Figures 1b, 2a and 3b), enables safe and robust rearward facing CRS for a child up to at least 4 years old. By using a support leg, the CRS can be positioned further forward on the vehicle seat, allowing for more leg room as shown in Figure 2, and thus, allows a toddler to sit more comfortably in the seat.

In addition, this allows for a more stable upright seat position so it enhances both comfort and protection. Volvo Cars is concerned that FMVSS 213 does not include these types of CRS designs and thus the US will not obtain all the benefits of rearward facing that is seen in other countries.

Additionally, if the CRS is restrained by seatbelt or LATCH only, without an anti-rotational device (such as a Top Tether, a support leg or the possibility of leaning towards the front seat), protection will not be optimal. In the case of a real-world frontal impact crash, extensive forward tilting of the CRS will likely occur due to the weight and height of the child. This then increases the risk of a head impact with the back of the front seats. A support leg reduces forward tilting and helps keep the CRS upright during this type of impact and is therefore the preferred way of protection.

A support leg is a well-known alternative anti-rotational device to a Top Tether. While it serves the same purpose as the Top Tether, it has some additional benefits. In Europe it is used to a substantially higher degree (than a Top Tether), for both large rearward facing CRS and for forward-facing CRS, examples provided in Figure 3. It is advantageous because it is easy and fairly obvious how to use a support leg. It is substantially more visible than the Top Tether, thereby less likely to mis-use or install incorrectly. The support leg is simply in the way if not used or hanging loosely, which would be plainly visible to the user. When used, the support leg is placed towards the floor but not attached to it. Most support legs have indicators providing guidance that assists the user and reduces misuse.

Figure 3a. A convertible CRS with support leg in forward-facing mode; a Maxi Cosi 2way Pearl with 2wayFix base in a Volvo car.

Figure 3b. Rearward facing child seat with support leg, Q6 dummy in a Volvo rearward facing child seat in a Volvo car.

It is important to note that the support leg is not a vehicle specific solution and it has never been. For many years it has been an essential part of the UN R44. More recently it is also included in the UN ECE Regulation No. 129 (ECE R129) for ‘Enhanced Child Restraint Systems’ and part of the UN ECE Regulation No. 145 (ECE R145). These regulations acknowledge that a floor is a natural part of a vehicle interior and should be used for enhancing child occupant protection. The floor of the test bench of ECE R129 is rigid. The ECE R129 and

ECE R145 include specifications for support leg adjustability and floor geometry. These specifications are based on measurements that include a wide range of vehicles and so could be used when determining the floor position for the FMVSS 213 test bench.

In addition, a floor strength test method has been developed and this addresses the interaction with support legs. It is included in ECE R145 for i-Size seating positions. While Volvo Cars does not see this as a prerequisite when including a floor in the standard seat assembly test bench for CRS assessment, we believe it is worth mentioning. Targeting CRS-to-vehicle compatibility in the i-Size seating position concept, the strength method was included in the ECE R145. This was done mainly to address floors with storage compartments, and it served to improve their stability when loaded by a support leg in a crash.

While this development may have had good intentions, the real-world benefit of this step is significantly lower than the important step of introducing a support leg. The reason for this is that the support leg will help protect the child even if some floor deformation occurs. Due to available space in the floor, the deformation will not be substantial and no separations in the CRS attachments are likely to occur due to this. It will result in somewhat more forward tilting of the CRS. However, the initial positions of these CRS are likely upright, and will thus likely prevent a more forward tilted position than that of a CRS without a support leg. The overall real-world benefits of the 'Swedish' type of rearward facing toddler seats are superior to the potential consequences of a floor deformation. This is supported by decades of real-world benefits of these types of CRS used in Sweden (Carlsson et al., 2013).

Although the 'floor straps' are not necessary for fulfilling the frontal impact standard test, adding a floor to the test bench might also encourage the use of these floor straps, as specified in Part 4 of the standard ISO 13216. ISO 13216 is the basis of the LATCH requirement, that was initially published in 1999 (parts 1-3). During 2020, ISO 13216-4 was published, and this provides similar specifications for vehicle anchorages for 'floor straps' comparable to the Top Tether specifications outlined in ISO 13216-2. These are state-of-the-art attachments for large rearward facing CRS. The 'floor straps' serve several functions, including helping restrain the CRS in a rear-end impact, a frontal impact (rebound phase) and in turn- and rollover crash events. They provide additional real-world protection to the child.

In summary, in-line with the Agency's ambition of increasing use of rearward facing CRS for older children, a floor is needed as part of the standard seat assembly test bench. By including a floor and thereby enabling the use of a support leg, the CRS can be made more comfortable, attractive and safer for the toddlers. As in ECE R129, a floor in the test bench would allow for safe rearward facing CRS usage for older toddlers in any vehicle, not specially in Volvo cars.

The floor of the test rig can be rigid and the data for the support leg adjustability envelope in ECE R129 and ECE R145 can be used to identify a representative position of the floor. Volvo Cars also believes adding some anchorages as specified in ISO 13216-4, would mean an increased use of 'floor straps'. As a minimum, Volvo Cars urges the Agency to review test execution and specifications to assure the real-world benefits and enforce appropriate retention of the rearward facing CRS for toddlers. In addition, including Top Tether use (or other anti-rotational devices) for all CRS in rearward facing mode, and not just for those that are LATCH attached, would be an improvement.

Communicating and use of ATDs (Sections VIII-IX)

With respect to consumer information on how to correctly use CRS, Volvo Cars believes that it must be clear which size child can use the CRS and it would also be beneficial to specify this for each mode of use. It is important to consider the essential attributes (age, weight, stature), for each type of CRS. While maximum weight limit is relevant from a CRS strength perspective, minimum weight limit might be counterproductive as it could encourage late transfer into the next type of CRS. This is further elaborated below.

Rearward facing recommendations

Volvo Cars strongly supports the Agency's recommendation that rearward facing CRS should be utilized for children as long as possible, given the manufacturer recommended upper limit for use. While the ambition of 3 years old is a positive step, Volvo Cars' experience is that even longer is preferable. This can be achieved by the appropriate CRS, which are available today in Sweden and other countries. In Sweden rearward facing usage is at 98% for children from new-born up to when they turn 2 years-old, and 77% always and 4 % sometimes among 2- and 3-year olds (Volvia 2020).

As stated in the NPRM, the protection principles for infants and toddlers are to travel rearward facing, thereby distributing the load over the back and head and thus preventing the relatively large head from moving independently of the proportionately weaker neck. The development of the cervical spine includes the vertebral ossification, facet joint orientations and ligament laxity. These developments are mainly driven by age, stature and weight (in that order).

Therefore, Volvo Cars strongly encourages the Agency to use age limits instead of weight limits, as the main determining factor for a transition from rearward facing. The ECE R129 contains a usage limit of 15 months (minimum age) for the forward-facing seat approval. Volvo Cars appreciates the inclusion of such age limit; however, we believe it is too low. Volvo Cars' global recommendation is that children should be transported rearward facing up to at least 4 years old. This is also consistent with the American Academy of Pediatrics recommendation that children should be rearward facing as long as possible and at least through 4 years of age (Durbin et al., 2018).

Although we prefer an age limit instead of weight, we see the proposal from the Agency of moving from 9 kg to 12 kg for introduction of forward-facing use as an important step in the right direction. It is in-line with Volvo Cars' central goal to increase the use of rearward facing CRS, although a larger step is preferred from our side.

In addition, Volvo Cars is concerned about how the 12kg limit is communicated to caregivers. This limit is dependent on available CRS and their designs. Therefore, there is a risk that a child will remain in the infant CRS longer and thus might not transfer to a rearward facing toddler CRS (e.g. a convertible seat in rearward facing mode) at all. Therefore, to help mitigate this risk Volvo Cars recommends additional factors be communicated rather than solely a weight limit.

When to transfer to booster seat?

NHTSA recommends children 4-7 years old ride forward-facing in CRS with internal harness if they are within the height and the weight limits allowed by the CRS manufacturer. Volvo Cars agrees that children should not be transferred too early to booster seats. However, Volvo Cars strongly recommends forward-facing children use a booster seat in order to benefit from using the vehicle restraints. Use of a booster should be determined by the child's development; from a biomechanical and size perspective, as well as the child's ability to sit still.

Age is important for the child's tolerance as well as maturity. Stature is important for the child to fit comfortably into a booster seat and seatbelt, and this will encourage a child to sit in a good position in relation to the seatbelt. Our experience is that 5 years old is an appropriate age to transfer to a booster seat. However, some 4-year-olds, who have graduated from the large rearward facing CRS available in Sweden, are able to achieve good protection in booster seats as well. We do not recommend average-sized 6 and 7-year-olds to use CRS with internal harness.

A child in a CRS with harness will not have any benefit from advanced seatbelt functions (e.g. pretensioners and load limiters). For this reason, Volvo Cars recommends that children should use booster seats as soon as they are mature enough to use them. The pretensioner is particularly critical as it helps to tighten up slack for the child using a booster seat, but it will not have any impact on slack in the harness for a child in the CRS with harness. As noted earlier, the availability of advanced seatbelt technologies in the rear seat, will increase rapidly with the introduction of rear seat rating programs, as planned by IIHS in 2023.

Weight is not a determining factor for transferring a child from CRS with harness to booster seat. For several reasons, it is not preferable for a lightweight, but tall, child to remain in a CRS with harness. If weight is chosen, Volvo Cars strongly encourages the Agency to also add an age limit, preferably 5 years old.

Use of ATDs

Volvo Cars supports the Agency's proposal of the anthropomorphic test devices (or ATDs) for the different CRS and weight limits. Consistent with what we have stated above, ATDs should be utilized and communicated with optimal protection for all children. As an example, we would like to raise the awareness of not recommending the use of infant CRS by larger children. As soon as it is not relevant to carry the child in an infant CRS, the focus should be on recommending a transfer to a rearward facing CRS for toddlers. A larger ATD can be used for type-approval. However, this must be communicated clearly in order to prevent parents from utilizing an infant seat too long, and thus, parents would then skip the rearward facing toddler seat.

As mentioned previously, Volvo Cars strongly supports inclusion of large rearward facing toddler CRS. This type of seat, usually with a support leg, is not included in the standard today. This would entail some test set-up modifications (like positioning of the ATD) as well as a review of the performance criteria. An investigation of the ATD performance criteria is encouraged to ensure that the upright seat position and reduced forward tilting do not result in unreasonable head and chest acceleration values. In the real-world context, neck injuries are the primary concern for children of this size and age and these are not reflected in the acceleration-based criteria. Volvo Cars can support a further investigation on this.

Volvo Cars supports the modification of the knee joints of the HIII-3YOs as this will accommodate their use for rearward facing CRS when the child seat is placed close to the seat backrest (as shown in Figure 2b). This modification is likely not needed for a rearward facing CRS with support leg, which enables a distance between the child seat and the seat backrest, as shown in Figures 2a and 3b.

Recent research findings (Section XI)

Addressing the developments in child passenger safety that have arisen in the research context, Volvo Cars would like to provide comments on the recent developments in child passenger safety raised by the Agency. In addition, Volvo Cars would like to share some concerns on the topic of belt-positioning devices.

New developments of child restraint ambitions

As shared mobility has increased, there is a need for more portable CRS, to ensure that children continue to travel safely on every trip. This is an important area of development of CRS. With this ambition, several new products have been developed to address this issue. This include inflatable booster seats and belt-positioning devices, e.g. so called "height-less boosters" and also different types of "belt straps"-restraints.

To ensure their protective effect, Volvo Cars strongly emphasizes that it is critical that these products serve the role of a CRS only when used in a vehicle and that they do not negatively interfere with the vehicle protection (e.g. the seatbelt).

When using the vehicle seatbelt as the primary restraint, the fundamental protection principles of a booster seat are essential. As stated above, this is done by elevating the child in order to position the lap and shoulder belt across the strong body parts (pelvis, chest and shoulder). A tight coupling of the child to the seatbelt is preferred. Furthermore, the booster seat is essential to shorten the seat surface for the child, which enables a child to bend their legs comfortably and thereby reduce the risk of a slouched sitting posture. The booster seat design must be stable during a crash, so that the booster cushion deformation is controlled to avoid the lap belt sliding off the pelvis.

Inflatable boosters

The dynamic stability of a booster seat is essential, and this will influence its performance in a real-world crash. Using a human body model and an ATD in a vehicle environment, we compared different types of conventional backless booster seats. These booster seats had a varied degree of stiffness and design. The finding was that although there were similarities in initial belt fit, there were alarming differences that were obtained dynamically (Bohman et al., 2020). Specifically, one of the booster seats deformed substantially and this in turn caused unfavorable kinematics and seatbelt interaction. Transport Canada conducted tests on inflatable boosters and submarining occurred which highlights the importance of a stable dynamic booster seat design (Tylko et al., 2016, and reports available in docket NHTSA-2020-0093). It is important to note that these tests were performed in vehicles which indicates that the consequences of excessive deformation of the booster is not recognized in the test bench to the same extent.

Given the differences in the test bench and vehicle environment and the limitations of today's ATD and performance criteria to detect submarining and risk of abdominal injury, Volvo Cars supports the introduction of a quasi-static compression test requirements, as a complement. The Canadian requirement of maximum deformation of 25 mm when subjected to 2250 N quasi-static compression force has shown to be an effective complement. Currently, no inflatable boosters have been introduced in the Canadian market since they have not met this requirement.

In addition, Volvo Cars would like to emphasize that it is important that the specification of the quasi-static test is written so that the booster seat will not be sub-optimized for one specific position of the pressure plate. It is especially important that the booster seat does not deform excessively on the front edge of the booster as this is the most critical area in order to prevent submarining.

Belt- positioning devices

Unless the belt-positioning devices elevate the child and shorten the seat cushion length, Volvo Cars believes they should not be categorized as booster seats nor used as child restraints in cars. However, due to limitations in the test bench (replicating vehicle environment and limitations in ATD sensitivity), some of these devices have passed the dynamic test requirements. “Foldable devices” that do not boost, but have passed FMVSS 213 certification, resulted in submarining when in vehicle crash tests (Tylko et al., 2016).

The “foldable devices” as included in Tylko et al. (2016) are examples of so called “height-less boosters”, which offer a surface to sit on and belt-routing guides. These products are available on the market and so are different types of “belt straps” that do not include a surface to sit on but are attached to the seatbelt in order to attempt to route the belt into a position relative to the child. The common concern for all these types of devices is that they interfere with the seatbelt function and do not reposition the child into the seatbelt.

Since they do not adhere to the protection principles of a CRS, Volvo Cars argues that these devices are not booster seats nor CRS. They could even have an unintended impact on seatbelt performance during a crash and this is deceptive as the initial seatbelt position placement looks in-line with the intention of a booster.

In a crash, the seatbelt will straighten out between the seatbelt anchorage points. So a child might not be restrained over the strong parts of the body, since the child is not raised in the correct position and this in turn leads to seatbelt slack which influences the kinematics. If the rerouting is extensive, slack will be introduced as the belt is straightened out, resulting in delayed coupling of the child to the seatbelt. In addition, belt-positioning devices lack the possibility for the children to bend their legs and this may mean the child is in a slouching position.

ECE R129 addresses the height of the booster by requiring a certain angle of the lap belt, and the lap belt position by specifying that “the lap belt shall pass over the top of the thigh, just touching the fold with the pelvis” (ECE R129-03 § 6.2.1.5.). Belt-positioning devices that place the lap belt further forward on the thighs, with no direct contact with the pelvis, will result in delayed restraint of the pelvis. This results in poor kinematics and increased loadings. This is the fundamental principle of protection by a seatbelt and cannot be forgotten in the context of children using CRS.

Volvo Cars proposes the Agency add requirements addressing the short-comings of belt-positioning devices. The requirement should include directives on the preferred location of the lap belt position (on top of the thigh and in contact with the pelvis). In addition, a requirement, is also necessary to address the need of a child to bend their legs to avoid slouching.

Shield-only CRSs

A shield-only CRS does not restrain a child according to the fundamental principles of protection. Volvo Cars’ opinion is that these types of CRS should not be used. A harness is needed to restrain the child over the strong parts of the body and to ensure that the child will not be ejected from the restraint. Several studies provide evidence supporting our position.

Crash testing, field studies and misuse observation studies have been conducted. All provide evidence that shield-only CRS do not address the fundamental principles of protection and result in reduced occupant protection. Tests performed by Transport Canada showed partial ejection out of the child seat in a rollover test, with all the tested ATDs including Q1.5y, CRABI 18months, HIII3y and Q3 (Tylko et al., 2013). Johannsen et al., (2013) conducted crash tests using the ECE R44 test bench, evaluating four different shield-only CRSs. The study showed increased loading to the abdomen in frontal impacts due to the shield interaction with the abdomen compared to CRS with harness.

In a field study by Edgerton et al., (2004), the injury severity and outcomes for children restrained in shield-only CRS and forward-facing CRS with harness were compared. An increased risk of injury to the head, chest and abdomen was found, for children restrained in shield-only CRS. Furthermore, a study conducted at child safety seat clinics, observed misuse in 68% of the shield-only CRS. Misuse included improper use of necessary locking clip, failing to install the seat tightly and failing to fasten the shield close to the child’s body (Morris et al., 2000)

The fundamental principles of protection include an early coupling between the occupant and restraint, which leads to reduced loading (Kent and Forman, 2015). In the misuse study of shield-only CRSs by Morris et al. (2000), 20% of the cases included shields not fastened tight enough to the child’s body. This was likely done for the child’s comfort. Utilizing a shield-only CRS inherently is likely to have a higher risk of slack as compared to a CRS with harness, due to comfort.

The NPRM proposes to add an internal harness together with the shield. An internal harness is needed to ensure that the strong body parts are engaged and ensures early coupling, and thus also reduces risk of ejection. However, by adding attachment devices there is an increased risk of misuse as well as the negative impact on ease-of-use. Hence, once the harness has been added to the child seat, the shield can be completely removed.

Infant CRS

As state above, it is essential to ensure that the optimal CRS is used for the child (age and size). The child must fit in the infant CRS, for it to serve as a good protection. An appropriate clearance between the top of the head and the top of the CRS shell is essential. This is because in the real-world environment, there is likely a vehicle seat in front, whereby risk for head impacts could occur if positioned too close. In addition, Volvo Cars encourages transfer to a larger rearward facing CRS as soon as the infant is not carried easily in the infant CRS. From this perspective, the CRABI-18MO is not representative.

The study by UMTRI shows that the infant CRS vary in size. Therefore, it is essential to provide clear and relevant customer information on what size child the CRS is designed for. Volvo Cars supports the proposal by the Agency that infant CRS height and weight recommendations should better align with the children for whom the CRS is recommended. Inclusion of a height recommendation will help ensure the child’s head is well supported and the child has not reached above the limit of the CRS.

Computer models of children – to assist CRS design

Computer models of children to assist CRS design are valuable tools and Volvo Cars appreciates the development of such CAE models of children. These tools are especially valuable in the development of real-world relevant CRS and also can account for the variation in population sizes and postures.

Volvo Cars has not yet been able to utilize the models. However, to get full advantage of such models, it is necessary to be able to change their postures, which currently does not seem possible. Therefore, we encourage some further developments, including features making it possible to change the posture of the models to fit the specific CRS or vehicle seats.

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