

The Folksam safety rating program for CRS promoting rearward facing seating

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Abstract

To increase the safety of young children in cars, studies have shown that the most effective strategy is to increase the use of rearward facing seating for children up to 4-5 years age. Since 2015, Folksam has conducted consumer tests of rearward facing child restraints aimed to guide consumers to the safest restraints. The Folksam CRS rating program 2023 includes the evaluation of three categories. First the ability to enable rearward facing to at least 4-5 years of age, second the presence of safety features that minimize injury risk in case of a crash and finally inclusion of design features known to minimize user mistakes that reduce the protective abilities of the CRS. The Folksam CRS rating program for CRSs is a contrast to other programs available as it focuses on promoting rearward facing child seats for young children up to the age of 4-5 years. The program clearly shows the need of this kind of test as it highlights large variations among the CRSs tested. The tested CRSs show differences in weight and body length approvals, seatback height (difference by 13 cm) and leg space (difference by 28 cm). Three out of thirteen tested CRSs did not have any approval from the voluntary Plus Test. Properties that affect misuse were present on two CRSs that obtained the lowest points because they were convertible increasing the risk of improper use by turning forward facing too early. A rating program that promotes rearward facing up to 4-5 years age is important and can play a significant role to the traffic safety of children. This paper aimed to introduce the development of Folksam rating program for child restraints, the scoring procedure, and the outcome of thirteen tested rearward CRSs in 2023.

Background

The current Swedish recommendation for protecting toddlers and young children in cars, is to travel rear-facing up to at least age of four to five. Promoting rearward facing child restraint systems (CRS) has been a successful strategy in Sweden to reduce the number of fatalities and injured children in cars (Carlsson et al., 2013; Jakobsson, Isaksson-Hellman, & Lundell, 2005; Kamrén et al. (1993). A total of seven children (0-6 year of age) have been fatally injured as car occupants in road traffic accidents during the last ten years in Sweden (2012-2022) (TRAFSA, 2023). The corresponding number of seriously injured is 121. To maintain the high level of child safety it is important to guide consumers to pick and use the safest CRSs on the market, and also that the CRS is used correctly during the child's growth.

In car accidents children are at higher risk than adults to sustain more severe injuries in certain body regions due to differences in anatomy (Anund et al., 2003; Bohman, Stigson, & Krafft, 2014; Janssen et al., 1991; Myers & Winkelstein, 1995; Tingvall, 1987; Yoganandan et al., 2002). To address this risk, a child needs an additional protection, preferably by a rearward facing CRS.

A rear-facing CRS provides robust protection for the child, offering synchronized support for the head and neck, and is more forgiving of minor misuse (Whyte et al., 2022). According to Turbell (1974), the neck load was three times higher in crash tests when a forward-facing CRS was used, and the risk of severe neck injuries and fatalities increases significantly. Because of the need for modern car's passenger compartment to stay intact and to avoid intrusion, newer cars tend to be stiffer in their compartments but also in their frontal structures. The increased stiffness leads to higher forces on the occupants which is an issue especially for forward facing children (Esfahani et al., 2011; Huibers & de Beer, 2001; Sahraei et al., 2014; Varat, Husher, & Kerkhoff, 1994). This suggests that it is even more important to have children rear-facing in modern cars. Despite this, parents turn their children forward-facing too early, with six out of ten four-year-olds being placed in forward-facing CRSs in Sweden (Stigson et al., 2022). Sweden has been and continues to be a pioneering country when it comes to rear-facing seating children at older ages (up to 4-5 years or longer). To promote rear-facing travel, it is important that Swedish consumers receive continuous information about what characterizes a safe rear-facing CRS that enables extended rear-facing seating up to the age of four or even longer. Therefore, a rearward-facing CRS should besides offer protection from severe head, neck, and abdominal injuries, also offer the possibility of rear-facing travel as long as possible.

To achieve maximum safety effectiveness by a CRS, it is also necessary to install and use it correctly. Misuse can range from less to more severe. Being unbelted or not using the support leg of the CRS or lower tether straps can be considered a serious misuse with a relatively high increase in injury risk in case of a collision. Less severe misuses may include the seatbelt or lower tether straps not being fully tightened but still leading to an elevated risk of injury. The severity of misuse is also depending of the direction of travel (Hummel et al., 1997). It can be noted that misuse occurs frequently in the use of CRS (Askell & Zheng, 2022; Klingegård & Ydenius, 2022; Koppel & Charlton, 2009; Kühn et al., 2019), which can be partially mitigated through the design of CRSs (Askell & Zheng, 2022; Klinich et al., 2014). Various installation options affect the degree of misuse, as do guides and indicators on the CRS aimed at minimizing incorrect installation and usage.

Folksam has conducted child safety research since mid-80s (Bohman et al., 2014; Kamrén et al., 1991; Kamrén et al., 1993; Klingegård et al., 2023; Tingvall, 1987). Folksam insurance data with injury details has been a valuable source of knowledge by conducting accident investigations, Folksam got the idea of starting development of a series of CRSs during the 1990s in our inhouse crash test facility. These were rent out to the insurance customers. Furthermore, Folksam has also conducting the CRS rating program since 2015. Data from cars fitted with crash recorders has also been an important source to investigate injury risks and impact severity (Ydenius, 2010).

CRS rating program

There are several CRS rating programs around the world to guide consumers in their choice of a CRS. These rating programs impose additional criteria and greater demands compared to the baseline requirement set by ECE R129. The CRS ratings programs are usually based on evaluation of crash tests, often with an impact severity above the ECE R129 regulation closer to the voluntary Swedish Plus Test conducted by The Swedish National Road and Transport Research Institute (VTI, 2023). Other criteria such as usability, comfort and chemical content are also commonly evaluated.

The International Consumer Research & Testing (ICRT) with 37 members is the main global consortium of consumer organizations that collaborate on research and testing of consumer products as CRSs. The CRSs are tested within the CRS test methodology by the European Test Consortium ETC (Van Ratingen, Vroman, & Ratzek, 2019). The tests are performed by test labs such

as ADAC, TSC, ÖAMTC, RACE, TRL, and the result are communicated in each country by consumer organizations such as Stiftung Warentest (D), Which? (UK), and Taenk (DK). The individual members are free to develop their own rating program based on the results of the performed tests. The test procedure includes typically crash tests at higher test speed than the ECE R129 regulation (64 km/h front and 50 km/h side collision), ease of installation, ergonomics, pollutants, and ease of cleaning. The three major test criteria by ETC are typically weighted according to safety (50%), operations (40%) and ergonomics (10%).

US organizations includes Consumer reports (CR, 2023) and the NHTSA (NHTSA, 2023) along with MGA Research Corporation (GearLab, 2023) that has their own programs to guide consumers to the safest CRS. Most of the tests includes a combined score including test crash data and ease of use and installation, comfort, weight, and size (apart from the NHTSA which only includes ease of use).

In Australia, the independent Child Restraint Evaluation Program (CREP) (Brown et al., 2015; CREP, 2023; Suratno et al., 2007) guide consumers on their purchases of CRSs. The test program includes frontal crash tests with higher impact severity and side impact intrusion than in the R129 regulation. Head, neck, chest, and torso loadings are measured. CRSs are ranked from crash protection as the first criterion followed by ease-of-use.

The Swedish magazine Råd&Rön is one of the ICRT consumer groups who publish child restraint testing to inform the public of the safest CRS. Also, Swedish Testfakta publish rating data from crash tests conducted by the British test laboratory TRL. The frontal test speed used is typically 50 kph with a more severe pulse corridor compared to R129. Attachment and usability are also evaluated. The three tested categories contain safety 80% and mounting and usage 20%.

Method

The Folksam child seat safety rating program

The Folksam child safety rating program was originally developed in 2015 for the Swedish market to guide customers to pick a safe CRS that could be used at least for children of an age of four. It was based on the Swedish National Recommendation ("Swedish Recommendations for Protecting Children in Cars," 2017) which claimed that children up to the age of at least 4-5 should travel in rearward facing CRSs. Starting from 2023, the testing procedure also incorporates design elements aimed at countering user errors that compromise the effectiveness of the CRS. The developed test method consists of geometric measurements, assessment of available approvals and an assessment of the CRS design features. The test method is divided into three categories (Figure 1):

1. **Rearward facing** – Focus on CRS use to the age of 4-5.
2. **Safety** – Focus on CRS features which minimize injury risk of the child in case of accident.
3. **Misuse** – Focus on CRS design features recognized for preventing misuse.

Each parameter in Figure 1 was given a point based either on presence of specific features, various approvals, or metric measurements (see Appendix). Specific features and various approvals were given fixed points while the points from metric measurements were distributed from measurement intervals.

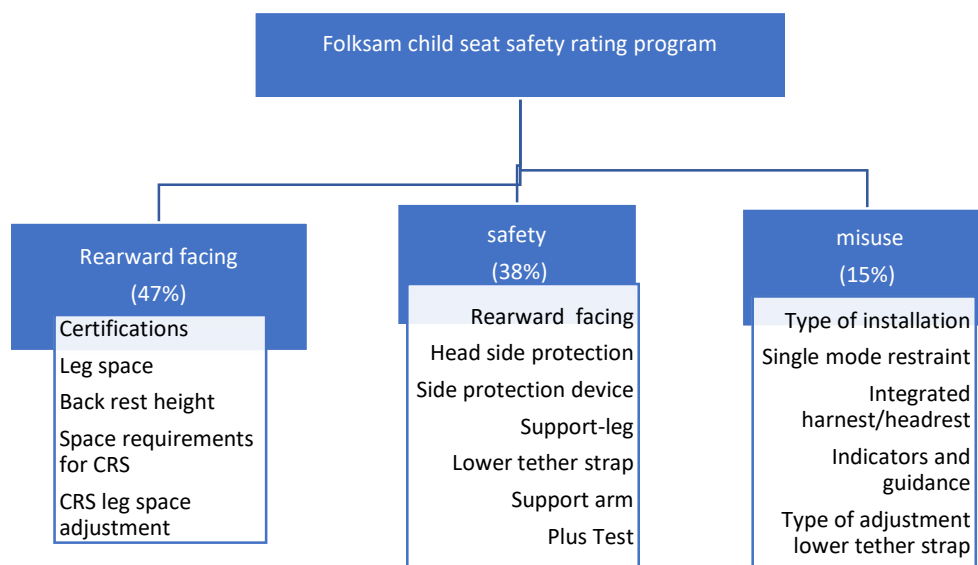


Figure 1. Overview of Folksam test protocol (see appendix for details). A total point and sub-points were calculated for each of the included seats with a weighting for each category based on importance.

The category “**Rearward facing**” contains parameters that affect parents’ decision to turn the child forward facing (see appendix). Seats that accommodate children of higher ages are awarded. The test procedure identified the size of the CRS with five test parameters that include the certification of the CRS as well as measurements of available space for the child. CRSs with approvals up to 125 cm and 36 kg were given at highest 3 points, while CRSs with 105 cm/ 18 kg approval got zero points. The points evaluated from measured leg space and back rest height, were based on calculations of sitting height for various ages (Fredriks et al., 2005) and the size of male children in the age group 2 to 7 year (Wikland et al., 2002). The highest point in this category was given CRSs with leg space and back rest height corresponding to the age above five. The space needed for the CRS in the car was measured to encourage a spacious CRS interior, without taking up too much space in the car. The presence of CRS leg space adjustment and the ability to make the CRS more compact, was awarded as it allows the CRS to be used in smaller cars.

The category “**Safety**” contains seven parameters which reduce the injury risk in case of an accident. The investigated parameters include the CRS direction of travel, side impact protection, and features that keeps the CRS firmly in place in the car. Furthermore, CRSs with an approval in the Plus Test that verifies a neck load below specified limits were given one point. The rearward-facing CRS with its high safety performance, were given 3 points while a forward-facing CRS got zero. The headrest wing depth was measured and given points according to a sliding scale from zero to two. The additional side protection device gave 0,5 point.

The category “**Misuse**” contains design parameters which mitigate misuse during installation and daily use. A total of five parameters were considered such as type of installation, single mode restraint and adjustable internal seat belt integrated with headrest adjustment. All test parameters that were included were based on scientific findings and the available knowledge of crash severity, and misuse (Albanese et al., 2022; Askeff & Zheng, 2022; Bilston, Yuen, & Brown, 2007; Brown et al., 2010; Greenwall, 2015; Kühn et al., 2019; Whyte et al., 2022).

A total point and sub-points were calculated for each of the included seats with the largest emphasis on category Rearward facing, Safety and Misuse with a weighting for each category of 47%, 37% and 15% respectively (see Appendix). Each of the included parameters were assigned a weighted point. The weighting of each parameter was done to ensure that the most critical aspects in a collision was prioritized. The weighting was based on knowledge from real crashes, crash tests, and scientific studies. Specific features and various approvals were given fixed points while the points from metric measurements were distributed from measurement intervals. A CRS could receive a maximum of 26.5 points. The total point was converted into a four-point rating grade based on the percentage deviation from the median value of points received by the tested CRSs. Rating grade three and four qualified to be rated "Good". The Best award was given the CRS with the highest point for seat belt attachment and Isofix respectively. To be rated as Best, a CRS must receive at least a rating of four. However, convertible CRSs cannot qualify for these awards.

Results

Thirteen rearward facing CRSs (from 9 months to at least 4-5 years old) available on the Swedish market were evaluated in 2023. The Best award was given one CRS with seatbelt attachment and one with Isofix respectively. Both child restraints stand out by allowing large weight and great length of the child. Five CRSs were rated "Good" (Table 1).

In the **Rearward** category, the maximum available point was 12.5 and varied between the CRSs from 2 up to 10.5 points. The drawbacks with the CRSs with the lowest score (2-4 points) in this category, was mainly due to low ECE approval limit up to 18 kg/105 cm, less leg space and back rest height, which together corresponded to 10 points. The tested CRSs revealed that there was a variation among the CRSs in terms of the sizes of children they accommodate. The maximum weight limit for which the tested CRSs were approved ranged from 18 to 36 kg or between 105 and 125 cm. The height of the seatbacks differed by 13 cm between the tallest and shortest, and the leg space differed by 28 cm between the CRS that provided the shortest and largest leg space. The CRS with the highest seatback (49 cm) was Axxkid Minikid 3 and 4, and the shortest (36 cm) was BeSafe iZi Twist i-Size, Britax Römer Swingfix M I-Size, and Bugaboo Owl by Nuna. The largest leg space in its most extended position (63 cm) was offered by BeSafe Stretch, and the smallest leg space (35 cm) was provided by Beemoo Reverse I-Size. Eight out of thirteen CRSs did miss 1 point due to the absence of leg space adjustment.

In the **Safety** category the maximum point was 10,5 and the tested CRSs received points between 6,5 to 10,5 points. Three out of the thirteen tested CRSs did not have any approval from the Plus Test certification (Beemoo Reverse I-Size, Bugaboo Owl by Nuna, and Maxi-Cosi Emerald i-Size), which resulted in one lost point. Five CRSs sustained 7,5 points or less due to lack of either side protection device or wing depth of the headrest. The depth of the headrest's side wings varied by 8 cm between the best and worst CRS. The shallowest headrest (10 cm) was found in the Britax Römer Swingfix M I-Size, and the deepest headrest (18 cm) was in the Beemoo Reverse I-Size.

In the **Misuse** category the maximum point was 4. The two CRSs that obtained the lowest points were Bugaboo Owl by Nuna and Maxi-Cosi Emerald i-Size. They lost 2 points because they were convertible. Convertible seats that can be turned forward-facing, increase the risk of improper use by turning forward too early. All CRSs except one (Klippan Opti 129) have synchronized height adjustment for the headrest and chest strap, which helps the user ensure that the shoulder straps are at the correct height. Eleven out of thirteen CRSs have indicators showing that the support leg has sufficient floor support, reducing misuse. Among the four belt-mounted CRSs, three (Axxkid

Minikid 3&4 and BeSafe Stretch) have self-tightening lower tether straps, which facilitate improved tensioning of the strap.

CRS no	Child seat (CRS)	Attachment	Rearward points	Safety points	Misuse points	Total points	Total grade
1	Avionaut Sky 2.0	Seat belt	6	8.5	3	17,5	3/Good
2	Axxid Minikid 3	Seat belt	10.5	10	2.5	23	4/Good
3	Axxid Minikid 4	Seat belt	10.5	9	2.5	22	4/Good
4	Axxid One 2	Isofix	9.5	9	3.5	22	4/Best
5	Beemoo Reverse I-Size	Isofix	4	7.5	3.5	15	2
6	BeSafe iZi Twist i-Size	Isofix	2	9	3.5	14.5	2
7	BeSafe Stretch	Seat belt	10.5	10.5	3	24	4/Best
8	Britax Römer Swingfix M I-Size	Isofix	2	6.5	3.5	12	2
9	Bugaboo Owl by Nuna	Isofix	2	7	1.5	10.5	2
10	Joie i-Prodigi i-Size	Isofix	6.5	8	3.5	18	3/Good
11	Joie i-Spin Safe	Isofix	4	8	3.5	15.5	2
12	Klippan Opti 129	Seat belt	8	8	2	18	3/Good
13	Maxi-Cosi Emerald i-Size	Isofix	6	7.5	1.5	15	2

Table 1. Rating results 2023

Discussion

The Folksam CRS rating program started due to the lack of safety programs promoting rearward facing travel for young children. The commonly used CRS in Sweden for children up to 4-5 years of age is rearward facing, whereas the rest of Europe and the USA tend to turn children forward-facing considerably earlier than recommended in Sweden. The tendency to forward-face children relatively early in Europe partly influences the availability of CRSs, especially convertible CRSs that can be used both rear-facing and forward-facing. In consumer tests conducted by organizations like the German testing institute Stiftung Warentest (Warentest, 2023), CRSs for children in the age group of 1 to 4-5 years are evaluated. Out of the 70 CRSs tested by Stiftung Warentest between 2020 and 2022, only ten CRSs were entirely intended for rear-facing use, 40 were convertible CRSs, and 20 were entirely intended for forward-facing. This does not reflect the situation in Sweden, since 74% of children 0-4 year of age have been reported to sit rear-facing (Stigson et al., 2022).

The ECE R129 regulation does not consider the orientation of the CRS for children above the age of 15 months. ECE R129 does not include assessment of neck loads, which is one of the most critical for young children up to at least 4 years of age. In addition to ECE R129, Sweden uses a voluntary Plus Test, which is a frontal crash test in 56.5 kph with a more severe acceleration corridor (30-38 g) compared to the ECE R129 corridor (20-28 g). The Plus Test is conducted by the Swedish National Road and Transport Research Institute VTI (VTI, 2023). This test is difficult to pass for forward facing CRSs due to the limits regarding neck load. The two main purposes with the Plus Test are to focus on neck protection and overall robust protection in a frontal crash. The Folksam test method do not contain any crash tests. One reason for that is the existence of the Swedish Plus Test that ensure acceptable dummy loadings at a higher impact severity than the ECE R129. In Sweden, it is common that CRS manufactures approve their CRSs for the additional voluntary Plus Test. Data from 578 real

life crashes (Ydenius, 2010) shows that the most severe cases did not exceed a mean acceleration above 23 g. The approximate mean acceleration in the Plus Test is 20-25 g, calculated from the range of duration and impact speed within the pulse corridor.

The Folksam CRS rating program show a positive development of CRSs safety level over time. The Folksam CRS rating program highlights that rearward facing seats are becoming more spacious with higher weight limits and larger leg space. This is a positive development for young children that improves their safety in cars. The increased number of good performing CRSs over time is also confirmed in test within the ETC test method (Van Ratingen et al., 2019) and the CREP program (Brown et al., 2015).

Safe transport of children in cars is the joint responsibility of parents, child restraint suppliers and vehicle manufacturers (Van Ratingen et al., 2019). Consumer rating programs such as the Folksam CRS rating program is important to guide consumers, and provide direction to vehicle manufacturers, CRS child restraint suppliers, and legal institutions to make sure safe travel for young children in cars.

Future development of the Folksam CRS safety rating program

The Folksam CRS rating program for child restraints was launched since 2015 and has been developed over time, and in 2023 misuse was added as a part of the test. The final scoring used within the test procedure is based on Folksam research, scientific findings, anthropomorphic data, legal requirements and discussions within the Swedish standardization group for child safety in cars (SIS/TK242, 2015) as well as other experts in child safety. In its current state, each CRS received an overall point for each of the three categories with largest emphasis on category "Rearward facing" (47%), "Safety" (37%) and "Misuse" (15%). This is in line with other test methods such as the ETC (Van Ratingen et al., 2019). The choice of parameters may be developed in the future if other types of misuse need to be considered. Further usability testing of CRS seats within the program will verify chosen misuse parameters. However, with any changes, the comparability over time decreases. Today the rating scale is relative compared with the median point value of the 12 tested CRSs 2023. Coming series of CRSs will be compared in a similar way using the median value of all tested seats including the 2023 test series. However, since the performance of CRSs hopefully will improve over time, the process sooner or later needs to be revised. A consequence of that is that older results will not be comparable with the new results.

Summary

Conditions that reduce injury risk for young children such as rearward facing travel or minimizing misuse of CRSs, are not considered in the R129 requirement. Those aspects are besides from crash test evaluations important to include in the safety assessments of CRSs together with the fact that most safety rating program does not promote rearward facing seating. Consumer rating programs such as Folksam's could play a significant role in drive this progress forward. The test method identified large variations in the results among the tested CRSs, all approved by R129, which shows the importance of consumer tests. Besides legal requirements it is difficult for consumers to identify features and characteristics that are of most importance from a safety perspective. The Folksam CRS rating program based on visual observations and measurements, may play an important role in guiding consumers as it focusses on promoting the most important safety features.

Appendix

Category	Test parameters	Measure	Description	Maximum point
Rearward facing	Certification (R44/R129)	Binary assessment	Based on available approvals (weight (18/36)/length (105/125))	3
	Leg space	Geometric measurements	Distance between CRS backrest and passenger seat. Point based on Swedish population data of average male 0-7 years and leg range ratio	3
	Back rest height	Geometric measurements	Distance between seating and headrest. Point based on Swedish population data of average male 0-7 and sitting height ratio (back, neck, head)	4
	Space requirements for CRS	Geometric measurements	CRS in its tightest position. Longitudinal position of front passenger seat measured in cm	2
	CRS leg space adjustment	Binary assessment	Based on the possible positions of the CRS on seat (one/many)	0,5
	Subtotal Rearward			12,5 (47%)
Safety	Rearward facing	Binary assessment	Based on direction of travel (forward/rearward)	3
	Head side protection	Geometric measurements	Based on the depth of headrest wing. Distance between back of headrest to the front centre position.	2
	Side protection device	Binary assessment	Based on the presence of feature (yes/no)	0,5
	Support-leg	Binary assessment	Based on the presence of feature (yes/no)	2
	Lower tether strap	Binary assessment	Based on the presence of feature (yes/no)	1
	Rebound bar	Binary assessment	Based on the presence of feature (yes/no)	0,5
	Plus Test	Binary assessment	Based on test approval (yes/no)	1
	Subtotal Safety			10 (38%)
Misuse	Type of installation (Isofix/seat belt)	Binary assessment	Based on the presence of feature (Isofix/seat belt)	0,5
	Single mode restraint (only rearward)	Binary assessment	Based on approvals (single mode (rearward)/(rotatable)forward)	2
	Integrated harness/headrest adjustment	Binary assessment	Based on the presence of feature (integrated/manual)	0,5
	Indicators and guidance	Binary assessment	Based on the presence of feature (yes/no)	0,5
	Type of adjustment lower tether straps	Binary assessment	Based on the presence of feature (lacking/manual/semi-automatic/automatic tightening)	0,5
	Subtotal Misuse			4 (15%)
	SUM			26,5

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