# Rear Seat Safety of Estate Cars - New Concepts

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## ABSTRACT

The safety of the rear seat of estate cars (station wagons) is discussed. Recent improvements to the rear seat safety systems of these cars will be explained. The customer-oriented design process, using QFD technique, of the new rear seats for estate cars, is described.

The new designs include three-point belts and head restraints on all seating positions, integrated child booster cushion, convenient seat folding mechanisms and integrated luggage restraints.

The accident experience of the rear seats in passenger cars is summarized, with special attention to estate cars.

The result is a new concept of estate car rear seats with a high level of safety, comfort and convenience.

## INTRODUCTION

Safety standards for passenger cars have been steadily improving for several decades. For Volvo cars, several safety improvements both to the interior and the structure of the car have contributed to the present high safety level.

A major step in this process for Volvo was the introduction of the three-point belt as standard equipment in the front seat, which was done gradually between 1959 and 1963 on all Volvo models. Successively, more refined belts (retractor belts in the late sixties and belt tensioners in the mid eighties) have further raised the safety standards of the front seat.

Over the same time period the safety standards of the rear seat of Volvo cars have also been improved. Three-point belts were introduced in the late sixties. Three-point retractor belts were introduced on some markets in 1972, and became standard on all markets in 1975. A further improvement to the rear seat was the anti-submarining floor ridge introduced in the Volvo model 760 in 1982 (Lundell et al 1981).

In the rear centre seat the lap-belt was the only belt available for several years. However, an improvement to the rear centre belt started in 1986, with the introduction of a three-point belt and head restraint for the centre seat as an accessory with the Volvo 700 sedan model (Karlbrink, Mellander 1987). This was followed by the introduction of three-point belts as standard equipment in the rear centre seat of the Volvo 900 sedan models in 1990. This specification was also offered for the new Volvo 850 model when it was introduced in 1991. Adjustable height head restraints were introduced together with the three-point belts. An integrated belt-positioning child booster cushion was also offered as an optional extra, for which the three-

point belt and head restraint were necessary prerequisites (Lundell et al 1991).

With these improvements of the rear centre seat in sedan cars of the 850 and 900 models, only the estate cars continued to be fitted with a lap belt for the rear centre seat. One reason for this was that it was more difficult to find a stable anchor point that was sufficiently high for the upper belt attachment. In an estate car, there was no rear shelf to support the retractor. Finding effective solutions for these problems was a clear design challenge. This challenge was overcome with the MY93 (Model Year '93) design for the Volvo 900 series estate car and the new Volvo 850 estate model, the latter being introduced in January 1993. In the following pages, the design of these rear seats will be explained more in detail.

## ACCIDENT EXPERIENCE OF THE REAR SEAT

Before explaining the design of the new rear seats, we will discuss the accident experience of the rear seat. This experience supports the improvements made to the rear seats, e.g the introduction of three-point belts in the centre seat. There are a few reports of the effect of the three-point belt in the rear seat. One estimate, based on accident experience, reports an injury-reducing effect (AIS 1+ injuries) of 52% for children and 28% for adults (Norin et al 1980 and AAAM 1980). (The injury-reducing effect is defined as the ratio between the reduction in injury rate for an improvement and the injury rate when no restraint or an inferior restraint is used). Another estimate, by Evans, for rear seat three-point belts is that they are 32% effective in reducing the risk of death (Evans 1986). When changing from lap-belt to three-point seat belt in the rear centre position of Volvo sedan models, the injury-reducing effect (compared with lap-belt) for AIS 1+ injuries was estimated to be 25% (Lundell et al 1991).

The most recent data from Volvo's accident data base will be summarized below.

### Volvo's accident data base

All new Volvo cars in Sweden are covered by a three years damage warranty in the Volvia insurance company. About 10% of these cars are involved in some kind of accident each year. Accidents in which the repair cost exceeds a certain level (today 25000 SEK, approx. 3000 USD) are investigated by Volvia's insurance claim inspectors. Technical data about the damaged cars, together with accident, occupant, and injury data is collected for each case and stored in a computer data base. The injury data are gathered from medical injury reports and analyzed by a physician associated with Volvo's Accident Research Team. The injuries are coded by body region, using AIS, Abbreviated Injury Scale (AAAM 1980). The present data base consists of about 22000 accidents involving about 38000 occupants in the Volvo cars, of which about 6700 were rear seat occupants.

### Rear seat and belt usage data

A summary of the number of accidents from different accident years and presence and seat belt use of rear seat occupants are presented in Table 1. The restraint usage is shown also in Figure 1. These data includes all types of accidents. The rear seat occupants are divided in two groups, rear outer seating position and rear centre seating position. The belted occupants in the outer seats have used three-point retractor belts and in the centre seat static lap belts. If the seat belt usage was unknown, these occupants were excluded in the table.

**Table 1**
**Number of accidents, rear seat occupants, seat usage and belt usage**

| Year | 1976-80 | 1981-85 | 1986-90 | 1991-94 |
|---|---|---|---|---|
| No. of accidents | 4401 | 3692 | 10188 | 4475 |
| Seat | outer/ centre | outer/ centre | outer/ centre | outer/ centre |
| No. of rear seat occupants | 935/ 181 | 942/ 182 | 2400/ 293 | 1051/ 131 |
| Average seat usage (%) | 10.6/ 4.5 | 12.8/ 4.9 | 11.8/ 2.9 | 11.7/ 2.9 |
| Belt usage (%) | 9.3/ 5.5 | 26.6/ 18.7 | 84.1/ 72.6 | 89.7/ 82.4 |

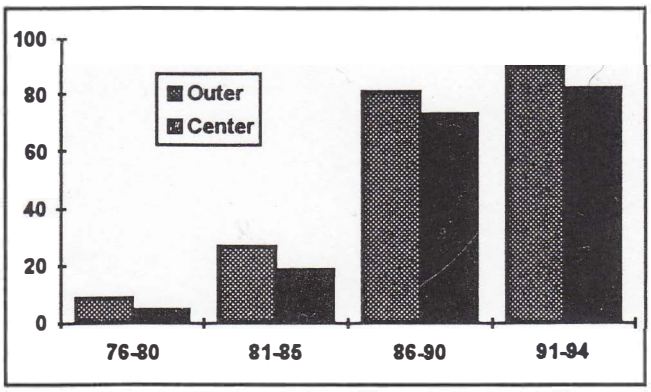


**Figure 1. Restraint usage by rear seat occupants in outer and centre position.**

It is clear from Figure 1 that the frequency of belt usage has increased markedly after the introduction of the law in Sweden in 1986 regarding mandatory rear seat belt usage. The figures after 1986 might be somewhat too high since they are based on the occupant's own information, and can be assumed to be exaggerated after the law was introduced.

Furthermore, it can be seen from Table 1 that the average seat usage is rather stable over the years. For the center seating position, however, there is a small decrease for the periods after 1986. The reason for this decrease is not known.

### Sedan and estate models usage data

Rear seat usage in sedan and estate cars is shown in Table 2. We can see that there is no significant difference concerning the restraint use for rear seat occupants in sedan and estate cars. The comparison is done for the period 1986 to 1990 and involve 4523 sedan cars and 3103 estate cars.

**Table 2**
**Restraints usage for rear seat occupants in sedan and estate cars**

| | Outer position | Centre position |
|---|---|---|
| Sedan | 85% | 75% |
| Estate | 83% | 75% |

In Table 3 the average seat usages for the rear seat is presented. This and the following tables are for the whole 1976-1994 period.

**Table 3**
**Average rear seat usage for sedan and estate cars**

| | Left outer position | Right outer position | Centre position |
|---|---|---|---|
| Sedan | 11.7% | 13.6% | 3.4% |
| Estate | 14.2% | 15.2% | 5.1% |

Table 3 shows that the average rear seat usage is higher in the estate cars. It is also shown that the usage rate for the centre seat is considerably higher in estate cars. One explanation for this might be that the estate car is often used as a family car. This motivates the efforts to provide the centre seat of also estate cars with three-point belts.

### Injury rate and restraint effectiveness

In Table 4 the injury frequencies (MAIS 1+ and MAIS 2+) in frontal impacts are presented for rear seat occupants using three point seat belts or belt positioning child booster cushion in the outer positions, lap belts in the centre position, and unrestrained occupants in all three positions. Child occupants using a booster cushion on the rear centre position are not included, as they are too few to give statistically significant results.

**Table 4**
**Injury rates for rear seat occupants**

| Injury rate | Outer seats | | Centre seat | Outer and centre seat |
|---|---|---|---|---|
| | 3-p belt | booster cushion | lap belt | no restraint |
| AIS 1-6 | 26.2% | 22.5% | 38.7% | 39.0 % |
| AIS 2-6 | 5.6% | 4.2% | 9.7% | 10.8 % |

The effectiveness of the different types of restraints in the rear seat, compared with unrestrained occupants, is presented in Table 5.

**Table 5**
**Effectiveness of rear seat belts**

| Injury rate | Outer seats | | Centre seat |
|---|---|---|---|
| | 3-p belt | Booster cushion | Lap belt |
| AIS 1-6 | 33% | 43% | 1% |
| AIS 2-6 | 52% | 64% | 10% |

The highest effectiveness can be seen for the occupants using booster cushions in the rear outer positions. The relatively high figures for the booster cushion can probably be explained by the fact that the occupants using the booster cushion are children and the unrestrained group is a mix of all ages. In earlier studies it has been seen that children have a lower injury risk compared with adults (Norin et al 1980). It can also be seen that the three point belt, (excluding occupants using booster cushion) has a high effectiveness, 33% for AIS 1+ and 52% for AIS 2+ respectively. For the occupants using lap belt only, the effectiveness is lower. This also motivates the efforts to provide the centre seat with three-point belts.

### Injury data for each body region

The data in table 4 is studied more in detail in Table 6, where the injury frequencies (MAIS 2+) for different body regions are presented for restrained and unrestrained occupants.

**Table 6**
**Injury frequencies (MAIS 2+) for restrained and unrestrained rear seat occupants**

| | Outer seat | | Centre seat | Outer and centre seat |
|---|---|---|---|---|
| | 3-p belt | Cushion | Lap belt | No belt |
| No. of occupants | 2552 | 351 | 268 | 1649 |
| Head | 1,8 | 2,9 | 3,4 | 7.0 |
| Neck | 0,4 | 0,4 | 0 | 0,6 |
| Back | 0.7 | 0.4 | 4,5 | 0.9 |
| Chest | 1.9 | 0.4 | 0.6 | 2.0 |
| Abdomen | 1.0 | 0,8 | 2,3 | 1,5 |
| Pelvis | 0.4 | 0 | 0 | 0.8 |
| Arms | 1.1 | 0.8 | 2,3 | 3.2 |
| Legs | 0,7 | 0.4 | 0 | 2.2 |

It can be seen from Table 6 that most injuries at MAIS 2+ level are reduced for the occupants using some kind of restraint. For example, the injury reducing effect for head injuries is 74%, 59% and 51% for the occupants using three-point seat belt, booster cushion on the outer seating position and occupants using lap belt on the centre position respectively. The only exceptions from the injury reduction are for the occupants in the centre position using lap belts, where a clear increase of injuries to the back and abdomen can be seen. This does however not oppose the overall injury-reducing effect of the lap-belt given in Table 5.

### Experience of the centre seat three-point belt.

The accident data for the three-point belt in the centre seat is so far limited. We have only 24 occupants who were sitting in a rear centre seat equipped with a three-point belt in an accindent. Of these 22 used the belt, some of which were children using the belt and the booster cushion. Of those belted, only four were injured, and none more severe than AIS 1.

## DEVELOPING CUSTOMER REQUIREMENTS

At an early stage in the development of the improved rear seats for estate cars, it was decided that customer requirements were of high priority. The requirements concerning safety were very important and also rather easily developed, due to Volvo's long experience in this field. Other customer requirements, e.g. comfort and convenience, were not so obvious. It was therefore decided to develop a systematic approach to identify these requirements and use them in the engineering process. The method used is termed QFD, Quality Function Deployment.

### QFD method

The QFD is a method to identify the most valuable features of a new product. By using a matrix (or a series of matrices) the customer requirements are developed into design requirements. The technique also ranks the requirements in order of their importance to the customer.

Factors suggesting that adoption of QFD might be appropriate were:

= The rear seat mechanisms are frequently used
= The high safety standards needed to be carefully balanced against other customer needs

A multi-disciplinary QFD working group was formed and conventional QFD methods were applied.

A reference group was also established to represent the customers in the process. The group was asked to evaluate existing rear seats from Volvo's models and those of Volvo's competitors. The group was also asked to express and rank general requirements on the seats.

The most fundamental conclusions to emerge from the initial study are described below.

### Results of QFD

The items given the highest priority by the reference group were safety and comfort.

A notable weak point for all rear seats (including Volvo), was the centre seat belt (i.e. the lap belt), in particular concerning:

- Operation and adjustment
- Tidiness
- Safety: as percieved by the customer.

Weak points for most rear seats (better solutions available in some cars) were the general mechanisms for folding/unfolding of the rear seat:

- Operation and adjustment of head restraints
- Operation and adjustment of safety belts
- Control levers, knobs etc. used for folding of the seats
- Safe locking of the seat backrest/cushion when in raised position

Especially strong points and features unique to Volvo:

- Sculpturing of the seat cushion, backrest and head restraints, giving good comfort
- Fold out arm rest
- Comfort and vibration isolation
- Layout and design of loading area with backrest in both upright and folded position

### Implementation of QFD results

The following areas were selected for special innovative efforts due to a combination of high customer importance and weak existing solutions:

- Increased rear centre seat safety
- User-friendly folding of rear seats, in particular easy handling of head restraints and seat belts when folding and unfolding the seat

Other conclusions were:

- Special design effort to adapt specific features from other Volvo products: e.g. integrated child booster cushions (from Volvo sedan models)
- Keep and refine Volvo strong points i.e. those Volvo features which were identified as being important to the customer and superior to the competitors' products as percieved by the customer

When prototypes for the new rear seat's subsystems were available, the reference group was again employed to verify that the design requirements were adequately met. The same screening procedure was repeated for the complete design solution prior to full production status. The results indicated that the new design met the exacting customer requirements stipulated as the basis for the project.

The QFD method was found to provide a very useful tool in developing customer requirements.

The chosen design and its details are described in the following section.

## REAR SEAT DESIGN

The major design goals for the new rear seats of the 850 and the 900 estate cars have been covered in the previous chapters.

The following section refers to the design of the 850 model unless otherwise stated. Comments on differences with the 900 model are added where relevant.

The general layout of the rear seat of the 850 estate is shown in Figure 2.

### Outboard Belts

The uppermost attachment points of the rear outboard belts for the 850 estate are mounted in the foldable seatbacks, see Figure 2.

This provides a number of advantages:

- The belt geometry suits all occupant sizes including children sitting on a booster cushion.
- The seat backrest may be easily folded as opposed to a seat where the seatbelts are fixed to the car body since the latter can hinder folding and get clamped in the seat back when unfolding the seat.
- The seat is easily installed as it is delivered from the manufacturer complete with belts after functional tests

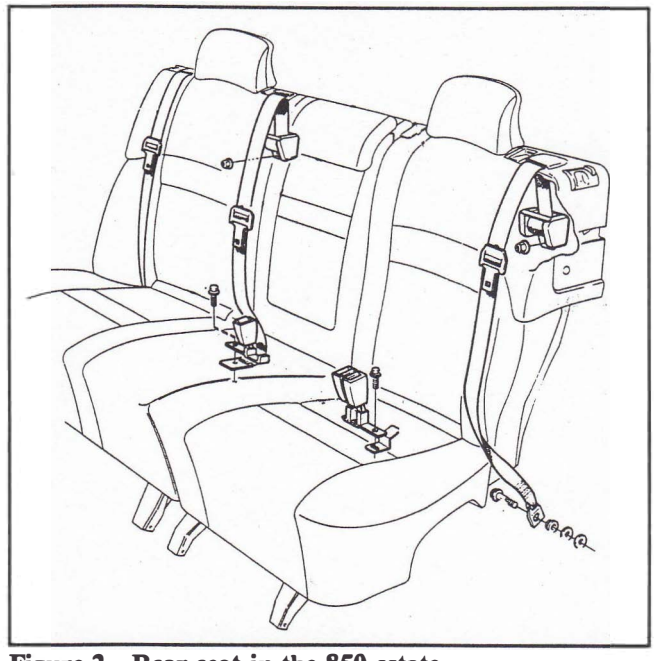

**Figure 2. Rear seat in the 850 estate**

The seat belt buckles are flexibly mounted on the floor, giving an effective lower belt geometry and buckles which fold away or get pressed down if you happen to sit in on them. They also allow one-hand buckling.

In the 900 estate, the outboard belts are traditionally fastened to the C-pillar, Figure 3. This is an effective design in this car geometry for a safe function and for an easy folding/unfolding of the seat back, without the drawbacks of some seats with this design described above, where the belts may get tangled with the seat in the folding process.

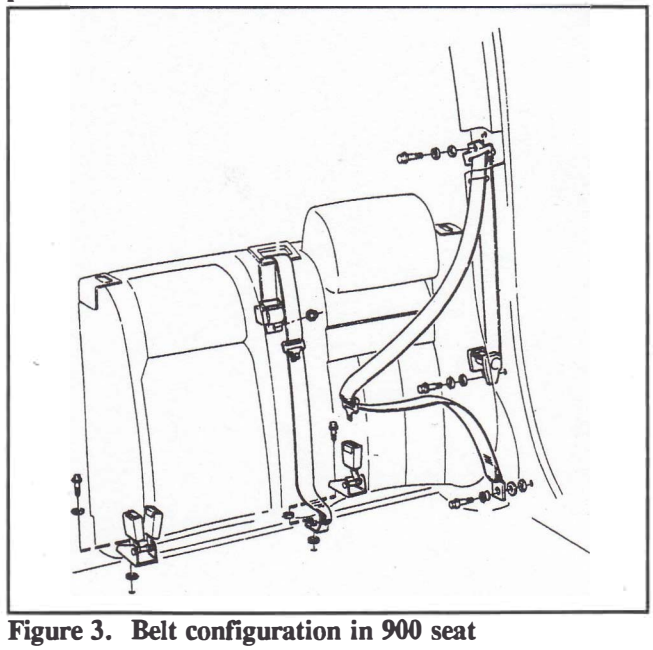

**Figure 3. Belt configuration in 900 seat**

## Centre Three-Point Belt

The three-point belt for the rear centre seat was first introduced as standard for the Volvo 900 series sedan models in August 1990 (MY91) and followed for the new 850 series in June 1991. (Lundell et al, 1991.)

The provision of a three-point belt for the rear centre seat in estate cars was first introduced in the 900 series from August 1992 (MY93), and in the 850 estate from the latter's introduction in January 1993.

The advantages with the three-point for the rear centre seat are as follows:

- High level of protection to the occupant, with an effective geometry when the belt is worn
- The use of this type of belt facilitates the use of an integrated child booster cushion, making the centre seat an attractive and well protected seating place for the child
- This belt allows the use of conventional child seats which require a three-point belt
  This system offers ease of installation during manufacture as the belt, including retractor, is pre-mounted in the seat backrest by the supplier
  The mounting of the belt in the seat backrest provides a part of the belt system's energy absorption in a crash, by controlled deformation of the backrest structure

One difficulty in mounting the uppermost attachment of the centre belt, as well as the outboard belts, in the seat backrest was to get a sufficiently high attachment point, both to fulfil legal aspects of belt geometry and to give a comfortable and safe geometry. This required the seat backrest to be higher than in previous designs. Compared with the backrest in the Volvo 700 estate model, the backrest in the 900 estate model is 60 mm higher.

## Seat Design

The rear seat is divided in two foldable sections, the larger accommodating the right outboard seat and the centre seat, and the smaller section the left outboard seat, Figure 2. The orientation of the centre belt is such that the upper belt guide is on the outboard side of the backrest (i.e. over the right shoulder of the occupant) to decrease the loads on the backrest. Nevertheless, having the centre belt as well as the outboard belt in the backrest creates high forces on the backrest in a crash, thereby necessitating particular attention to the design of this backrest. The forces on this backrest in a frontal crash may be summarised as follows:

- The two seat belt loads i.e. centre and outboard belts
- Inertia of the seat backrest itself
  Distributed load from luggage/cargo pressing against the seat backrest or load net or from an extra seat fitted in the cargo area

For impacts to the rear end of the car the forces on the backrest are restricted to the inertial forces associated with the two passsengers and the backrest itself.

The structure of the seat's backrest in the Volvo 850 is shown in Figure 4.

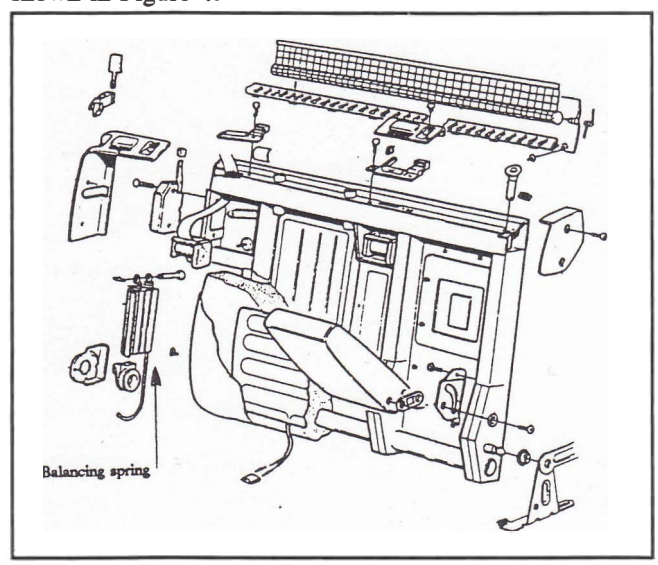


**Figure 4. Structure of 850 backrest (right section).**

The backrest's structure is a welded framework of closed profiles, both vertical and horizontal. Closed profiles offer high stiffness in torsion and bending.

The loads on the backrest frame are transmitted to the car body through the seat's three attachment points namely the two floor hinges (on which the backrest pivots when folded) and the unsymmetrically placed upper outboard lock. The asymmetry gives rise to torsional moments in the backrest frame in a crash and it is therefore essential that the backrest frame be designed with a high torsional strength.

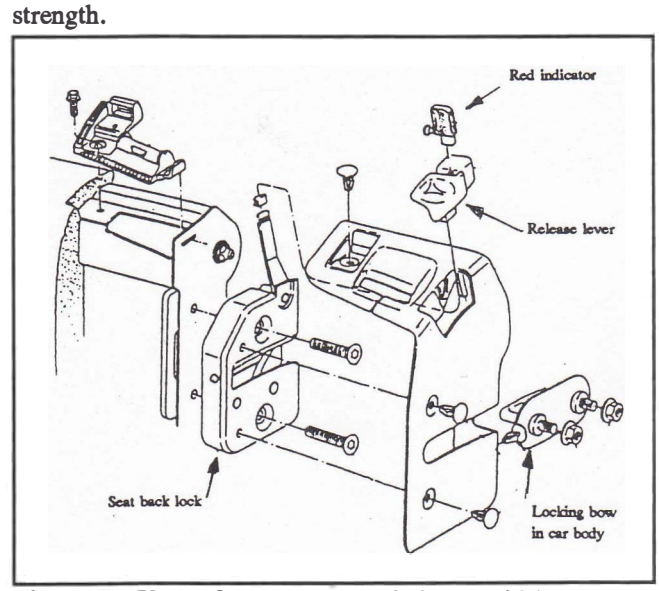


**Figure 5. Upper backrest lock (850, left side).**

The unsymmetrically placed upper locking catch also takes high loads in a crash. It is made of high tensile steel and engages a U-shaped, forged locking eye monted on the

car body, Figure 5. Great attention was paid to the safety of the locking mechanism. A red indicator warns when the lock is not engaged.

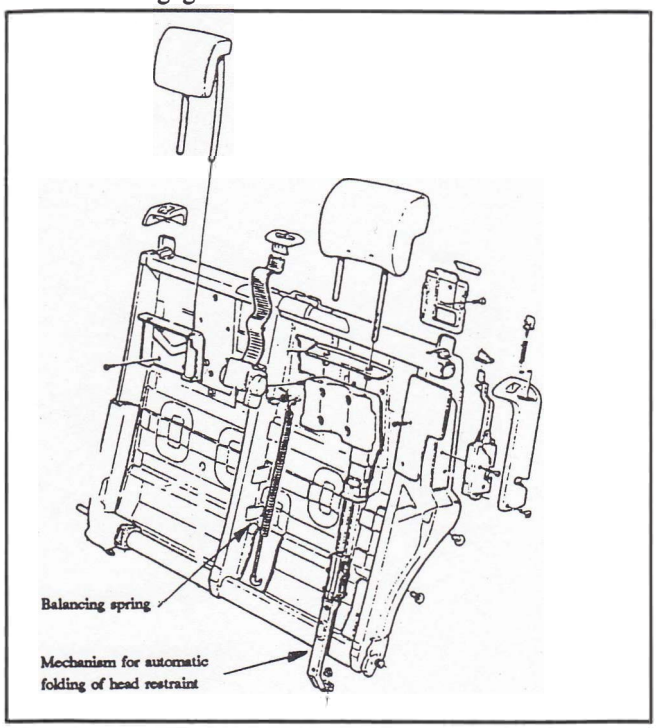


**Figure 6. Backrest design of 900 model.**

The Volvo 900 estate has a similar rear seat design, Figure 6. One difference is that the upper anchoring points for the outboard belts are mounted on the C-pillar and not on the seat backrest as in the 850. Nevertheless, the backrest has to take the loads from the centre belt, so it has a very strong construction also in the 900.

To summarize, both the 850 and 900 seats are of a very strong design, to withstand the loads from the occupants as well as from luggage in the cargo area.

The added strength as well as the new items included in the seat did of course increase the weight of the seat. Since the new rear seat in the 900 model is a development of the seat in the 700 model, with a lap belt only for the rear centre seat, it is possible to compare the weight of the two seats. The rear seat is approximately 10 kg heavier in the 900 than in the 700 model.

A difference between the 850 and 900 is the relative positions of the large and small seat and backrests sections. The larger of the two sections is fitted on the right hand side in the 850 and on the left hand side in the 900. This change in seating geometry was adopted for a number of practical reasons, though in terms of safety there is no difference between the two solutions. One reason for having the wide part on the right hand side in the 850 is that 850 is fitted with a forward folding passenger seat. Thus, when the front passenger seat and right rear hand seats are both folded down, long and wide cargos may be loaded. For example a stretcher may be carried while another passenger sits on the narrower, rear left hand seat, to tend to the srtetcher patient.

## Integrated Child Booster Cushion

The introduction of the three-point belt and the adjustable head restraint for the rear centre seat were necessary prerequisites for the development of an integral belt positioning child booster cushion for this seating position. An integral child seat was first introduced simultaneously with the introduction of the three-point belt as standard in the rear centre seat of the 900 and 850 sedan models. (Lundell et al 1991)

An integral booster cushion is now available also with all new Volvo estate models. The cushions are in principle the same as those fitted in sedan models and are integrated into the foldable armrests in the same way. They are intended for children between 3 and 10 years of age, i.e. ECE Regulation 44 groups 2 and 3.

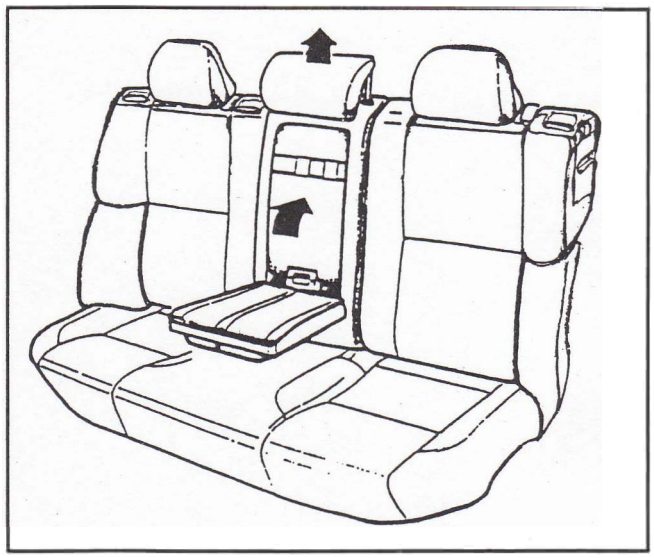

**Figure 7. Integrated booster cushion (850).**

The cushions used in the 850 and 900 are largely the same. The 850's child cushion is illustrated in Figure 7. It has an expanding mechanism such that its seat cushion widens when it is folded down. When folding up, its width contracts to the original armrest width and is stowed in the armrest recess. When the cushion is unfolded without operating the widening mechanism the cushion functions as an ordinary armrest.

In comparison the 900 series child cushion is of constant width whether used as a child cushion or as an armrest.

## Head Restraints

The head restraints of rear outboard seats in the 850 estate are of a unique, patented construction, Figure 8. The overriding design consideration was, of course, to provide maximal protection from injury, especially in rear end crashes, but passenger comfort and sound ergonomics when folding the rear seat forward to give a larger load carrying area were also important, as a result of the QFD study.

When folding the seat backrest, the head restraints need not be removed. Instead, the head restraint is easily lifted and folded forward. When the backrest is then folded forwards, the head restraint fits into a hidden and well protected position between the raised seat cushion and the anti-submarining ridge on the floor. In this way the head restraint does not reduce the cargo loading volume and is well protected from dirt and soiling by goods loaded.

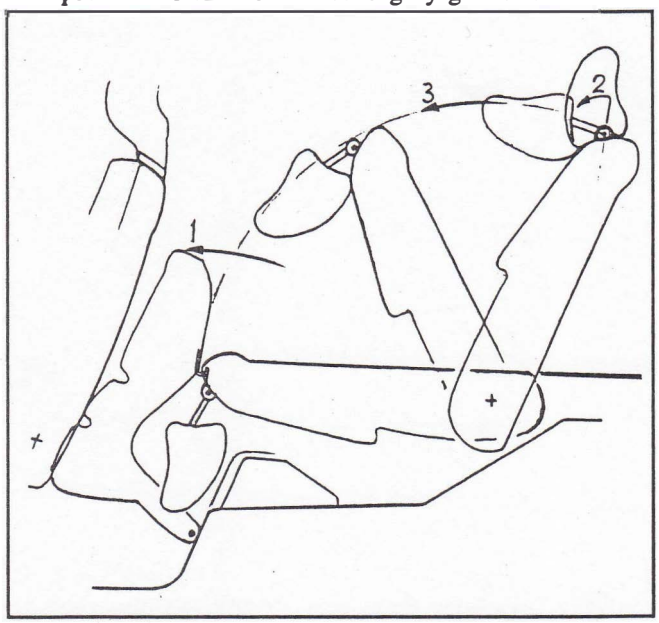


**Figure 8. Folding of seat and head restraint (850).**

When the seat backrest is folded upright again the head restraint is easily erected by a pulling and lifting motion. A spring then pulls the head restraint down and locks it in the upright position.

The head restraint can also be left in the forward-folded (horizontal) mode so long as no passenger is sitting in that position. In this mode it presents no restriction to the rearwards visibility for the driver or for a car behind. It is however, due to bad comfort, not possible to sit in the seat without raising the head restraint to the upright position.

The 900 estate is fitted with outboard rear head restraints of another unique and patented construction, already shown in Figure 6. The head restraint has an automatic folding mechanism. Further its height is adjustable. The head restraint is retracted automatically when the seat backrest is folded forwards, even when the head restraint is adjusted to its maximum height. It folds into a recess in the foam of the seat backrest such that it is completely out-of-the-way and protected from any luggage or cargo loaded, in the same way as in the 850 model. When raising the seat backrest again, the head restraint extends to its lowest protective position and may then be manually adjusted to a higher position.

Head restraints that do not need any action from the user when folding the rear seat was one of the most strongly expressed customer requirements in the QFD conducted before design work commenced. This requirement was completely satisfied by the 900 design and to a large extent in the 850. Completely automatic folding was not possible together with the integrated load net in the 850 model.

In summary Volvo estate's rear outboard head restraints have the following common features:

- High level of crash safety, concerning both strength and geometry
- The head restraints do not need to be removed in order to fold down the rear seats
- When the seat backrest is folded, the head restraints are protected from the load and do not impinge upon the effextive load bearing area
- The head restraints are always raised when the seat is occupied, to ensure maximum protection in a collision
- Visibility may be increased by folding down (850) or pushing to a low position (900)

The centre seat of both the 850 and 900 series have head restraints. These may be raised or lowered manually, to adjust to the height of the occupant. They have to be pushed down before the seat backrest may be folded down, although this operation is very simple. This manual operation is justified by the low usage frequency of the centre seat compared with the outer seats. The head restraint is adjusted to a higher position simply by pulling upwards, and it is automatically locked against being pushed downwards. To lower again, the head restraint is first pulled slightly forward without the need for a release button which might be difficult to reach.

### Integrated Load Net

The 850 estate has a unique, patented, split load protective net in the top of the two seat backrest sections (see Figures 4 and 9-11. This loadnet is retracted in a housing when not in use, forming part of a closed profile in the top of the seat back, Figure 9.

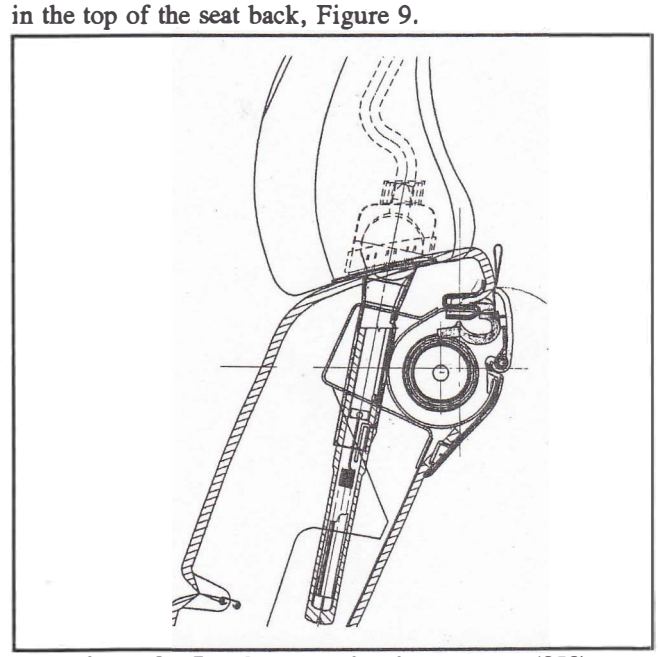

**Figure 9. Loadnet housing in backrest (850).**

The load net can be used both when the seat backrests are up i.e. to carry passengers (Figure 10) or when the backrests are folded down to carry large loads (Figure 11). The section of the loadnet covering the larger section of the seat may be used separately, regardless of the position of the smaller section of the seat.

When retracted, the net is nicely covered by a springloaded folding lid along the seatback.

When used, the net is prevented from extending further in the case of a crash.

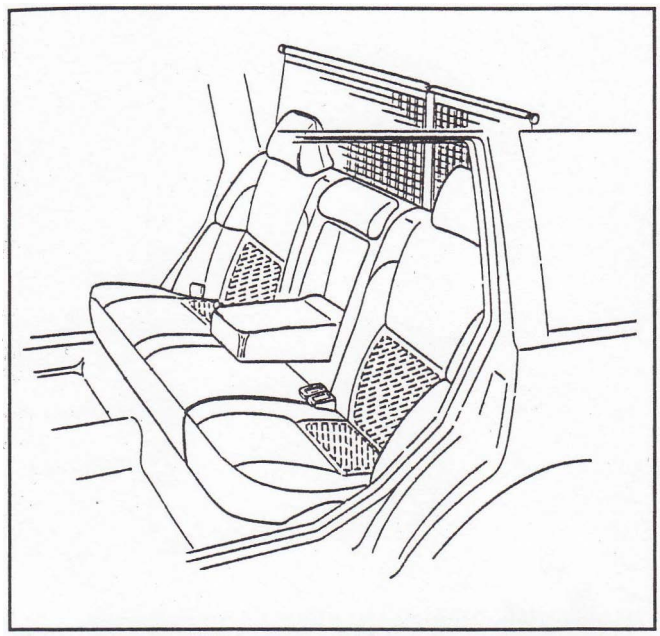

**Figure 10. Loadnet shown with rear seat in passenger configuration (850).**

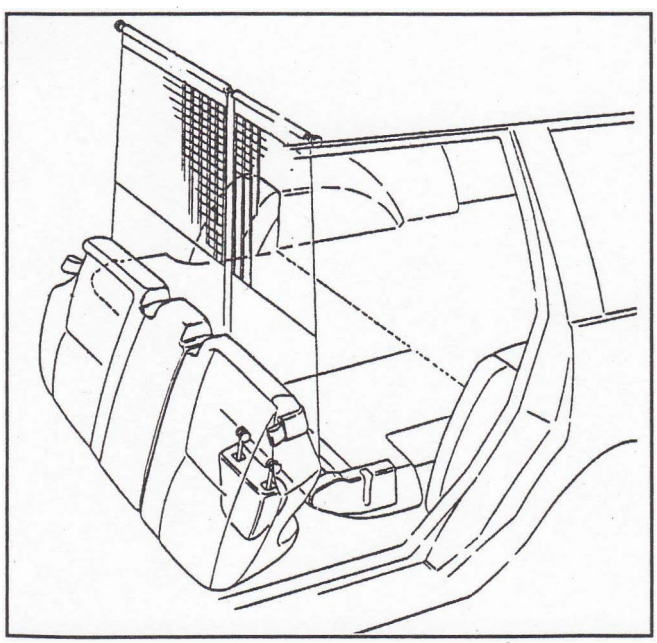

**Figure 11. Loadnet shown with rear seat folded forward in load configuration (850).**

The integral load net gives the following advantages:

- High protection from goods in the luggage area in case of a crash
- The net is always available
- There is minimal reduction of effective load carrying length (only 8 mm)
- There are no stowage problems for the net when it is not needed

  The load net may be used whether the two rear seat sections are up or down, and separately in the larger section regardless of the position of the smaller section
- The seat back is manufactured to facilitate installation of the load net as an accessory

### Rear Seat Folding Ergonomy

As stated earlier above, a high priority was given to the fulfilment of customer demands from the very start of the project. Accordingly it was important that the new rear seats should be not only safe and comfortable but also very easy to operate when folding and unfolding.

Folding down the seat backrest to maximize the load carrying area is facilitated by the following innovations:

- The seat cushion is folded forwards by pulling a strap on the outboard side, which simultaneously releases the cushion lock
- As explained above, the head restraints need not be removed in order to fold down the seat.
- The seat backrest has in the upper outboard corner a release lever that may be operated with one hand. The lever is ergonomically designed such that it is easy to see, reach and operate.
- Balancing springs are used to ensure that folding the backrests up or down is almost effortless.
- The load nets do not need to be removed when they are not in use but are instead rolled up in a specially designed resess.
- The child cushion does not have to be removed when not in use but folds away in the same way as the folding armrest.
- The seat belts need not be handled at all when folding or unfolding the seat.
- A wide, folding armrest is provided as standard.

## CONCLUSIONS

The new rear seats in the estate models of the 850 and 900 series have raised safety standards of the Volvo estate models. This result has been achieved by the combination of a new three-point belt for the rear centre seat, new head restraints and the fitting of an integrated child booster cushion for the rear centre seat. The load-carrying capability of the seat back, and the integral load net fitted in the 850 also contribute to the high safety level. Furthermore, the ergonomics of the seats have been developed to simplify the use of the seat functions. Taking

these improvements as a whole, the new rear seats of the Volvo 850 and 900 estate models have excellent safety, versatility and handling comfort.

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