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A Three-Point Belt in the Rear Center Seating Position as Accessories

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ABSTRACT

This paper describes some of the engineering situations encountered during the development of a three point belt for the rear center seating position in a sedan car. The belt will be sold as an accessory for the after market.

The reinforcement of the parcel shelf to achieve a sufficiently strong anchorage for the retractor and the geometrical locations of the belt anchorages are presented.

The conflict between the geometrical requirements, the design and the visibility will be focussed. The need for updated requirements for belt installations in the rear center seating position will be pointed out.

Data from the performed tests show that all demands from regulations and "in-house" requirements are fulfilled.

BACKGROUND

THE 1ST OF JULY, 1986, Sweden introduced a compulsory belt law for the rear seat in passenger cars. Countries as West-Germany, Norway, New Zeeland and Australia have already enforced similar laws. This will increase the use of seat belts in the rear and also increase the demand on comfort of seat belt installations.

Today most European car manufacturers have three point belts on the rear outboard positions and a lap belt in the center as standard equipment.

It is, even for the front seat occupant, important that rear seat occupants use their safety belts (1)*. In the center seating position today we have a very low usage rate, mainly because it is uncomfortable and difficult to put on and wear a non-retractor lap belt.

Children may prefer to sit in the rear center position where they can have a clear view out on the road. Families with three children may want to have all their children use the same type of three point belt.

Taking all this into account it was decided to develop a three point belt for this seating position as an accessory. The main advantages of a three point belt in the rear center position are:

- Higher safety level in frontal impacts
- Increased comfort and convenience
- Better design, compared to a non-retractor lap belt
- Children prefer this place

* Numbers in parentheses designate references at end of paper.

ENGINEERING

The requirements governing the development of this belt system came from "in-house" requirements and from regulations. The regulations were static strength testing of belt anchorages according to ECE R14 and ADR 5B, belt system testing as in FMVSS and geometrical locations of anchorage points.

The "in-house" requirements were frontal barrier crash tests in 30 and 35 mph, design and comfort requirements, such as easy handling, minimizing of the webbing pressure on the shoulder and easy installation in the car of the accessory belt.

During the development phase it became clear that the parcel shelf had to be reinforced. Special parts had to be engineered to make the parcel shelf anchorage meet the existing strength requirements.

In the engineering of the special parts (see figures 1 and 2) the following points had to be considered:

- As low weight as possible
- Low manufacturing cost
- No interference with the luggage area
- No interference with existing parts like loudspeakers, window shade and head restraints

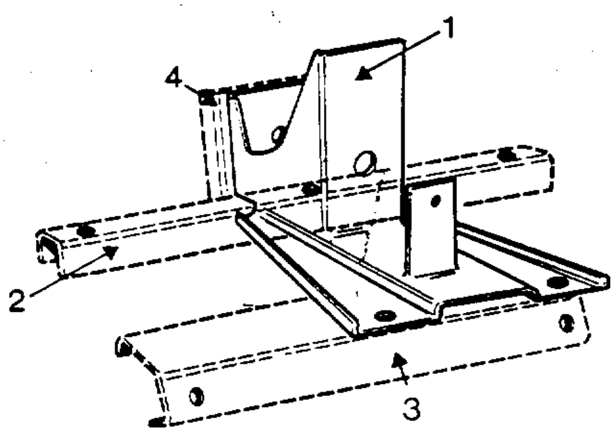

Fig. 1. Reinforcement brackets supplied in the accessory kit

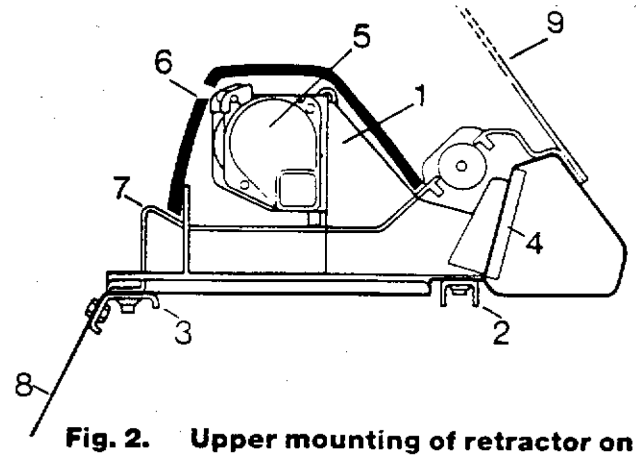

Fig. 2. Upper mounting of retractor on the parcel shelf

1. A bracket holding and keeping the retractor at the decided position
2. Profile distributing the load

3-4. Profiles preventing the tipping of the retractor due to the bending moment

5. Retractor
6. Plastic cover
7. Parcel shelf trim
8. Parcel shelf sheet-metal
9. Rear window

It was also a problem to find a retractor that was capable of withstanding a load of 15 kN directly into the reel. In this beltsystem there is no D-ring and the load comes from a different angle than in a normal loading case, as in a B-post installation (see figure 3).

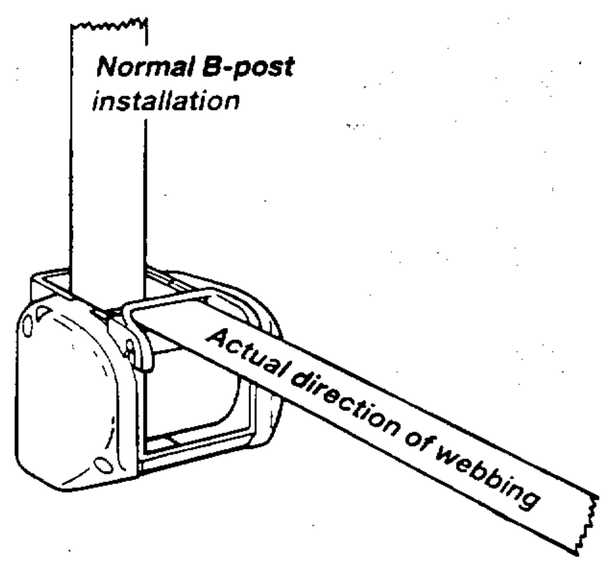

Fig. 3. Difference in loading directions for the retractor

Due to the regulations of geometrical zones the retractor had to be placed about 100 mm above the parcel shelf trim, which meant that the retractor had to be covered with a plastic cover (see figure 4).

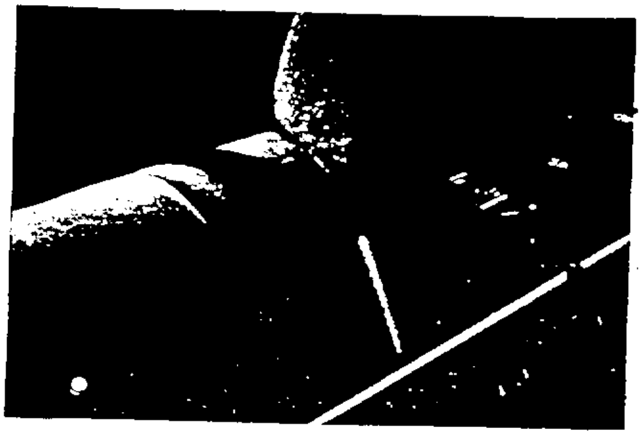

Fig. 4. View through rear window showing the installation

The installation of the new three point belt also permits the lap belt to remain in the car and be used for securing long luggage or restraining certain child- seats (see figure 5).

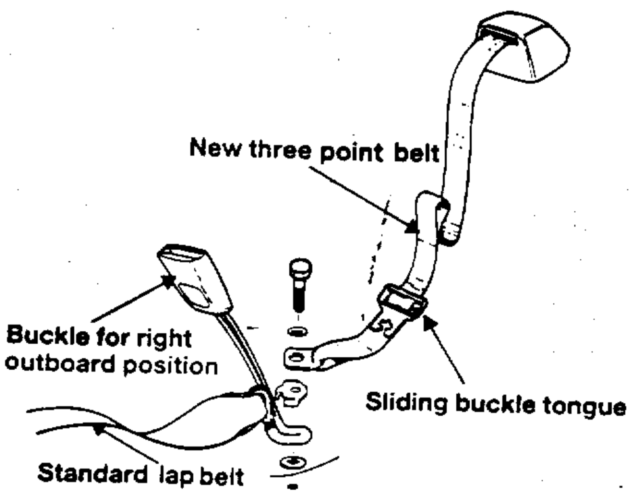

Fig. 5. Lower anchorages of rear center position

SIMULATIONS

Mathematical simulations were done to determine the effect of a lowered upper anchorage point. In the 760 sedan car there are three different belt geometries (see figure 6) and the question was what effect the lowered upper anchorage had on compression of the spine.

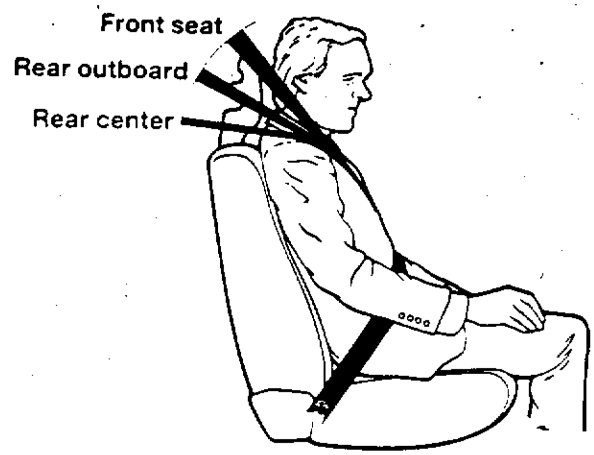

Fig. 6. Belt geometries for the different seating positions in a 760 sedan car

A two-dimensional lumped mass computerprogram developed by Volvo (2) was used to study this situation.

According to the simulations the compression force in the spine is greater with a lower upper anchorage point but still at an acceptable level compared with the outboard higher point (3). The simulation showed 2.8 kN in compression of the lower spine in a 30 mph crash. This value was also later confirmed in sledtests as described below.

TESTING

All regulation tests, the strength testing of belt anchorages and the belt system testing, were conducted with satisfactory results. The in-house demands of the system included dynamic crash tests. Frontal barrier tests at 35 mph and Hy-Ge sledtests at 30 mph have been performed with the belt.

SLED TESTS - The sled tests were conducted with a Hy-Ge crash simulator that simulated a 30 mph crash. The dummies used were a P572 dummy and child dummies : TNO P3, US3year, US6year, TNO P10.

The 50 perc. dummy was also equipped with a special axial force transducer in the lower spine to measure the compression load in the spine. (See figure 7).

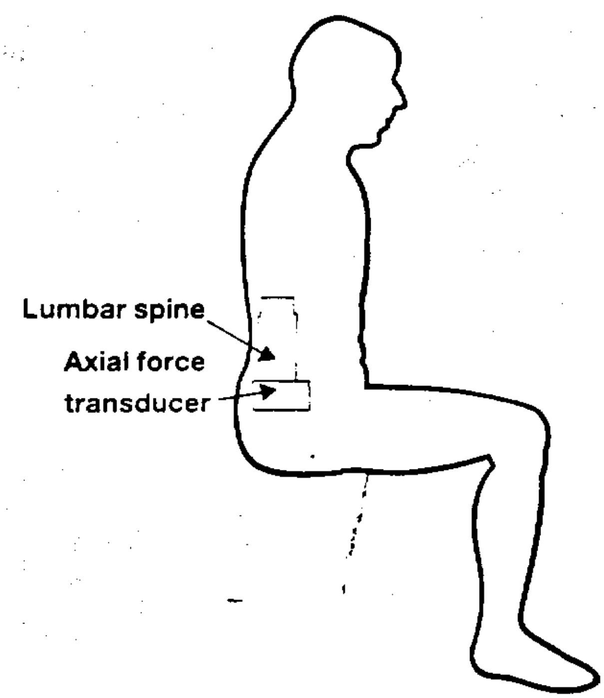

Fig. 7. Position of special axial force transducer in the P572 dummy

An advantage with this new belt geometry compared with the outboard geometry was a reduced forward displacement of the head and lower HIC- values.

The tests conducted with child dummies were done with Volvo's child cushion. There was no significant difference of child dummy response restrained with three point belt on center place compared to outboard places.

The dummy responses in average from 30 mph sledtests were as follows:

	HIC	Chest resultant, cr G	Upper anchorage belt force, kN
50 perc.	770	41	7
3 years	560	46	not measured
6 years	430	48	"
10 years	450	51	"

The loads from the load cell in the lower spine showed 2-4 kN. This is somewhat higher compared with the outboard places and confirmed the results from the simulation. The outboard places showed 1.5 - 3.0 kN.

FRONTAL BARRIER TEST - The frontal barrier test were run at 35 mph with a 760 sedan car. The rear center position was equipped with a three point belt and occupied by a P572-dummy.

The dummy responses were:

HIC = 780
Chest resultant, Cr = 41 G
Femure forces = 2.5 kN

The maximum force in the diagonal belt was 6.4 kN.

GEOMETRICAL BELT ANCHORAGE ZONES

Three different regulations of belt anchorage zones apply to this belt system. The US (FMVSS 210), Australian (ADR 5B) and the European (EG 76/115, 82/318, R14/02) zones. (See figure 8).

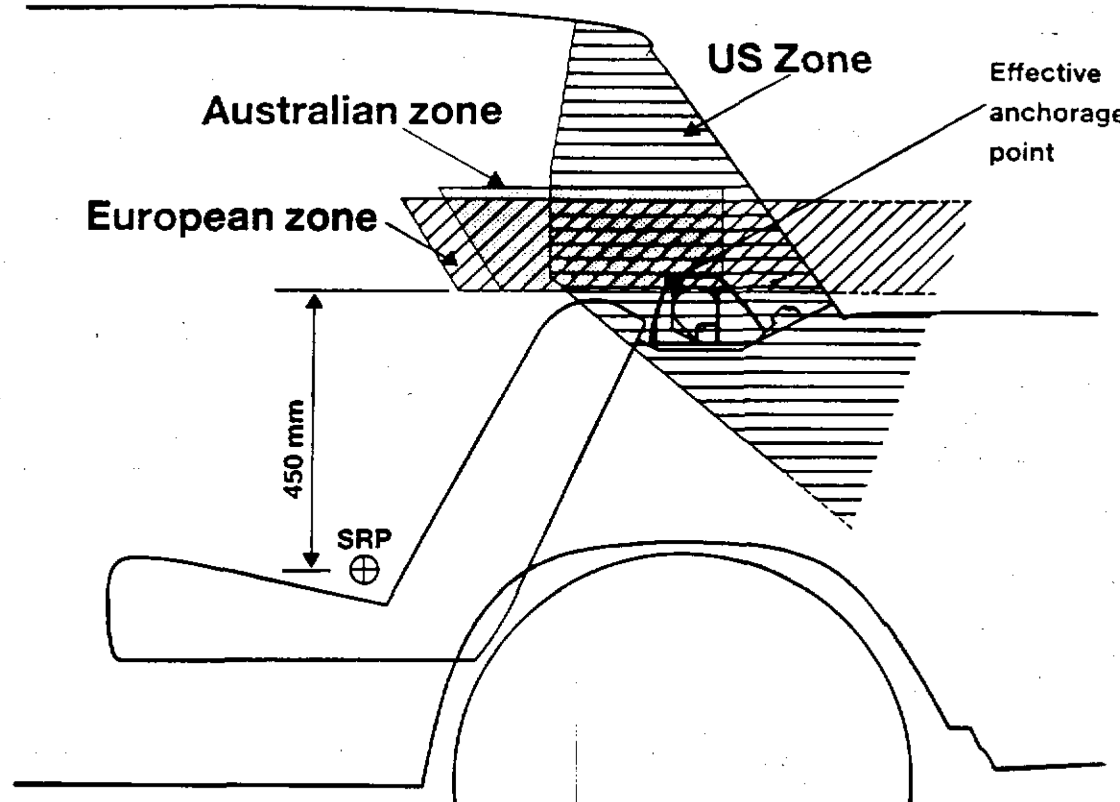

Fig. 8. Upper belt anchorage zones in different regulations

Today the European regulations state certain zones for three point belts anchorages in the outboard positions and zones for a lap belt in the center position. The zones for the upper anchorage point also apply for the center position, if equipped with a three point belt..

In order not to interfere with the sight out through the rear window, the retractor was put close to the lower limits of the European and Australian zones. An additional European requirement is that even after a static pull test of 13.5 kN the retractor has to be inside the zone. (See figure 9).

This project has shown that the installation of a three point belt in the center position would benefit from not having the same geometrical zones as for the outboard places. Due to lack of high body structure, design and conflicts with rear sight, the middle place ought to have a lower zone if equipped with a three point belt. Note that the US-zone already allows a lower position.

During the development phase of this project, the differences of the national regulations became very obvious. A harmonization between the different regulations would be beneficial. The geometrical zones and the static strength testing are areas where there are possibilities to have the same regulations. Since today's regulations are not intended for the rear center position, specific regulations for this position ought to be founded.

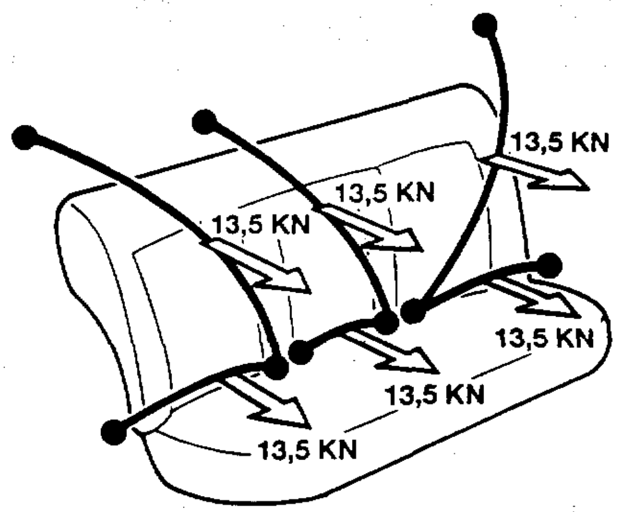

Fig. 9. Schematic figure of required European static pull test if the rear seat is equipped with three three point belts.

CONCLUSIONS

This project has shown that it is possible to install a three point retractor belt for the rear centre seating position in a sedan car.

This paper describes the development of an accessory belt where effort has been spent on reinforcing the parcel shelf with bolt-on brackets to achieve sufficient strength of the upper mounting. It is fairly easy to engineer the body structure, during the design of a new car, so that these special parts would be integrated in the body.

The variety of regulations applicable to belt systems has obstructed the work and it has to be stressed that amendment to existing regulations in Europe and Australia is needed to cover the specific problem of the three point belt installation in non-outboard places.

There is definitely a need for harmonization of regulations and also possibilities to certify restraint systems by performing dynamic system tests.

REFERENCES

1. H Norin, A Nilsson-Ehle, E Saretok, C Tingvall
"Injury-Reducing Effect of Seat belts on rear seat occupants" -8th ESV Conf., October 21-24, 1980.
2. Jernström, C (1983) "Computer simulation of a motor vehicle crash dummy and use of simulation in the design/analysis process".
Int. J. of Vehicle Design, vol. 4, no 2, PP. 136-149.
3. J.P. Stapp "Review of Air Force research on biodynamics of collision injury". Proc. of 10th Stapp Car Conf. November 8-9, 1966.
4. J.D. Horsch, P.C. Schneider, C.K. Kroell, F.D. Raasch "Response of belt restrained subjects in simulated lateral impact".
Proc. of 23rd Stapp Car Conf. October 17-19, 1979.
5. J.D. Horsch "Occupant dynamics as a function of impact angle and belt restraint". Proc. of 24th Stapp Car Conf. October 15-17, 1980.
6. B Lundell, H Mellander, I Carlsson "Safety performance of a rear seat belt system with optimized seat cushion design". Pass. car meeting, June 8-12, 1981.

APPENDIX

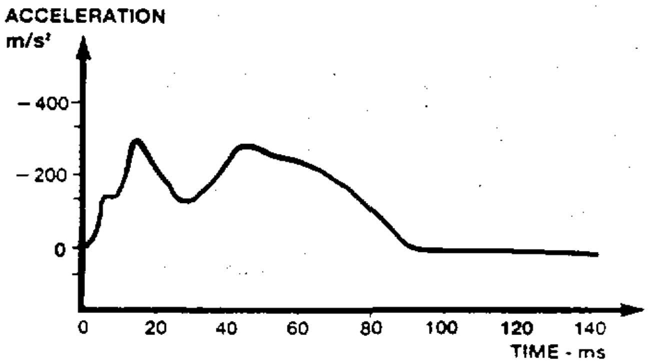

Diagram 1. Sled acceleration pulse 30 mph (simulation of a frontal barrier test)

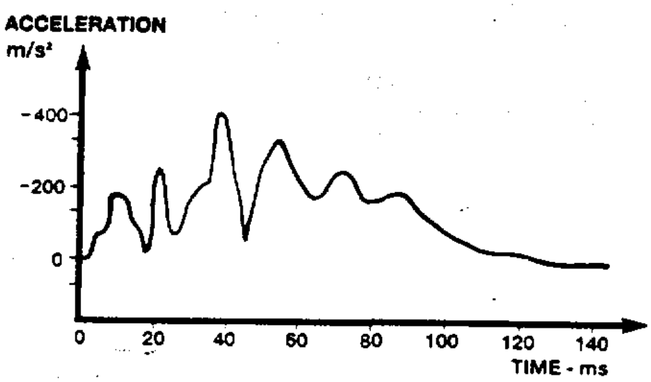

Diagram 2. Frontal barrier test acceleration pulse 35 mph