BENEFIT FROM A NECK PROTECTION SYSTEM FOR AFTERMARKET FITTING

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INTRODUCTION

Cervical spine distortion injuries (CSD) in passenger car rear impact accidents, in particular at low speeds with a Δv of 15 km/h or less, are becoming increasingly problematic. Since only few vehicle models are equipped with a CSD protection system to date, the aim of Autoliv and Winterthur Insurance Corp. was to develop a system for aftermarket vehicle installation, especially because the vehicles being sold today or being only few years old will be on the roads for many more years. The system will be available for a first car model from fall 2001.

Basically, there are by now two different systems for reduction of CSD injuries on the market: active headrest (e.g. SAHR, Saab) and yielding backrest (e.g. WHIPS, Volvo). Both of these systems reduce relative movement between the head and thorax in rear impact; the first one by increasing head acceleration, the latter one by reducing thorax acceleration. The yielding backrest has the advantage to reduce head rebound speed and to offer protection with wrongly adjusted headrest, as well. The working principle is as follows: A deformation element is located in the recliner. During rear impact, a parallel backwards movement of the seat back begins at a point of critical load, which motion is then transformed into rotation. The backwards movement is limited so that the seat back will offer sufficient protection in a high-speed impact. Our CSD protection system, AWS (Anti Whiplash System), is based on this principle. Because aftermarket installation of an energy-absorbing recliner in an existing seat design appeared unsuitable to us, we decided to integrate the deformation element in the seat rail (Fig. 1). In this solution, the entire seat moves backwards with the desired motion. This installation site is also special for another reason: Different levering rations result from the position of the seat in the longitudinal direction. The CSD protection system is more readily released when the seat is positioned at the front than at the back - a simple mechanical adaptation of the release threshold to the size of the occupant. This means optimum protection for small, lightweight persons as well as large, heavy persons. This was proved by MADYMO simulation at Δv 15 km/h using HIII 5th percentile female and 95th male. For the female dummy, the thorax acceleration is reduced by 30% to 65% depending on the seating position, for the large male by around 10% in the most rearward position. As there is no biofidelic neck for these dummy percentiles available, a benefit in terms of reducing injury risk can be assumed but not quantified.

BENEFIT FROM THE AFTERMARKET CSD SYSTEM

The benefit of our aftermarket CSD system was accessed by sled tests using a BioRID II as dummy and by MADYMO simulation. In sled tests, the seat was tested with and without AWS at Δv 15 km/h and a 6 g rectangular pulse, at Δv 9 km/h (4g), and at Δv 5 km/h (3g). The latter test was to make sure the system does not activate in minor accidents. At 9 km/h, on the other hand, release should take place, since CSD injures can be expected beginning at this speed change level. In the 15 km/h test, a drastic reduction of the neck injury criterion NIC is seen from 26.3 to 17.6 . In the 9 km/h test, the system did release but the deformation element deformed in the front section only. The NIC decreased slightly from 16.3 to 14.0. This test shows that the efficiency of the AWS begins at this speed level. With AWS within a range of Δv 9 km/h to Δv 15 km/h the NIC value increases only slightly (see Fig. 2).

To evaluate further the performance capacity of the AWS, a MADYMO model was set up. Fig. 3 shows the NIC value resulting from applying generic rectangular pulses to the simulation model. It can be seen clearly that the AWS motion threshold is at approx. Δv = 9 km/h. Up to Δv = 16 km/h the NIC value remains at a low level of about 16 and does not increase until higher impact speeds are applied, whereby the absolute improvement factor compared with the system without AWS is retained. Improvement of the NIC value by installing AWS can be demonstrated up to Δv = 20 km/h. The pulses used in a further study (Fig. 4) are from car-to-car crash tests carried out by *Winterthur Accident Research*. Some of the data are from an offset crash configuration, which result in different energy input into the system than a 100% overlap crash. Therefore the neck loading can be different even if Δv is constant. The simulation shows that an AWS can reduce the NIC value by up to 38 %, even using real crash data, within the range of Δv from 11.5 km/h to 14.5 km/h.

DISCUSSION

AWS ensures nearly constant NIC in the Δv range from 9 km/h to 16 km/h, i.e. in the speed range in which CSD injuries occur most frequently. The NIC value in the standard test configuration at Δv 15km/h is 17.6. Comparison testing of 13 different seat designs with the BioRID shows, that NIC values of current seats with CSD protection systems are between 9 and 19, and from 15 to 33 without such systems (Zellmer et al., to be published). This means that AWS is well in the range of current CSD protection systems on the market, although the backrest of the seat under investigation is not optimised for such impact conditions..

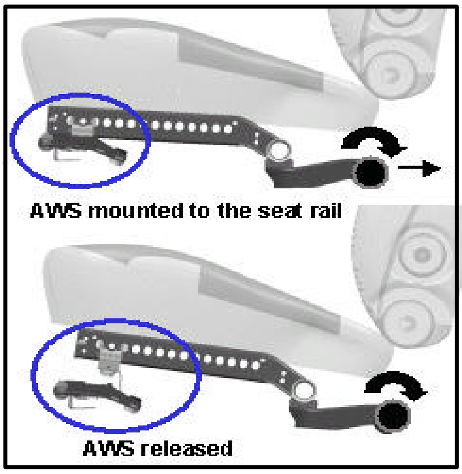

Fig. 1: AWS mounted to seat rail

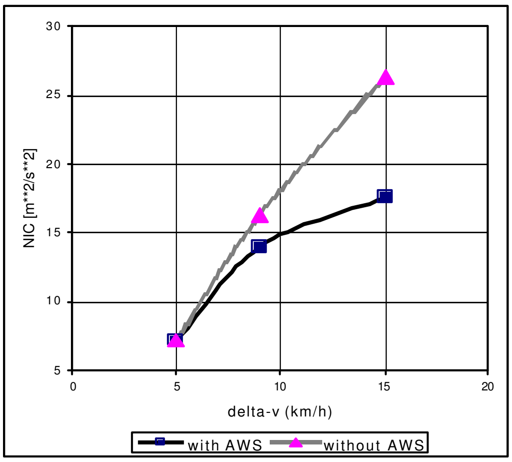

Fig. 2: Sled tests with and without AWS

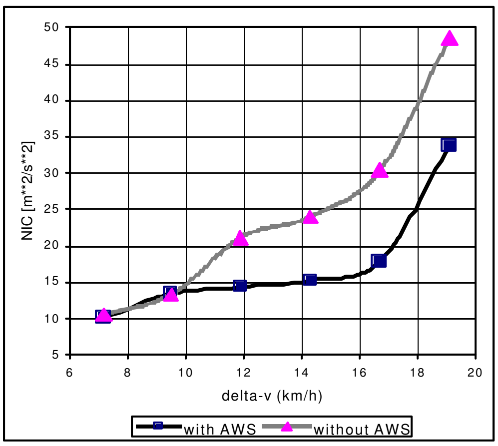

Fig. 3: NIC value vs. Δv (generic pulses)

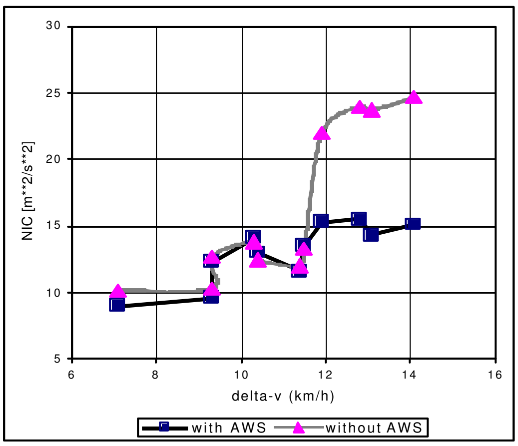

Fig. 4: NIC value vs. Δv (real crash pulses)