ACCIDENTS INVOLVING SEAT BACK FAILURES

Prepared for
Transport Canada

December 1989

By
T E S Limited
Kanata, Ontario

T E S Limited
308 Legget Drive
Kanata, Ontario
Canada K2K 1Y6
Tel: (613) 592-2998
Fax: (613) 592-6893

Report No. C1322/2

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Introduction

This report involves the examination of twenty-three Canadian case studies in which passenger vehicles have experienced seat back failures. The case studies presented represent a wide range of incidents from failures during everyday use to failures during various types of crashes.

The purpose of this report is to illustrate, by means of individual, real world incidents, a variety of injury mechanisms arising out of seat back failure. Presumably it will enable persons examining seat back strength requirements to better understand the consequences of failure of the subject component.

Each case is presented in anecdotal form in Appendix 'A' and together they form the basis of discussions in the main text.

Background

In January 1967 the United States National Highway Traffic Safety Administration (NHTSA) initiated requirements for seat and seat anchorage strength for passenger vehicles. Canada followed suit in November 1970, with an equivalent standard; Canadian Motor Vehicle Safety Standard 207 (CMVSS 207) (Appendix B). Many of the requirements are based on the Society of Automotive Engineers Recommended Practice J879, which has been in place since November 1963.

For a number of years it has been observed that the existing seat back strength requirement does not prevent seat back collapse. Seat back failure during a crash can not only result in injury to rear seat occupants but provides an avenue for ejection even when the occupant is using the restraint system. It has also been observed that during CMVSS 301 rear impact tests, virtually all bucket seat backs and split bench seat backs fail.

Discussion

Types of Seat Back Failures

Seat backs can fail under various circumstances, however, the ultimate cause of these failures is the rearward loading of the seat by the occupant's body mass. Some seats fail due to the relative acceleration of this mass during a collision, whereas others fail under the weight of the occupant while the vehicle is stationary or travelling at a constant velocity.

The two most common types of failure which occur are the failure of the seat back support system to hold the seat back in an upright position and the deformation of the seat back frame itself. Less common are failures which have been attributed to deformation of the mounting system which holds the seat to the vehicle floor or to a collapse of the vehicle floor pan. Another problem is the detachment of non integral head restraints during an accident.

There are twenty-three cases of seat back failure documented in Appendix 'A'. Fifteen of these involved the failure of the seat back support system to hold the seat back in an upright position. Three of these cases (cases 15, 22 and 23) as well as the remaining eight cases, involve deformation of the seat frame or other mounting hardware. A summary of the modes of failure is given in Table 1.

In three of the cases (14, 18 and 20) which involved failure of the seat back support system, the seat back collapse occurred during normal occupant loading without excessive acceleration of the vehicle. In case 14, the driver's seat back suddenly reclined to a horizontal position while the vehicle was moving. In cases 18 and 20, the drivers's seat back reclined unexpectedly while the vehicle was stationary. In all three of these cases, the reclining mechanism had failed.

In ten cases which involved failures of the seat back support system, the failure occurred during an impact to the rear of the case vehicles. In each case the mechanism which holds the seat in an upright position was unable to withstand the forces acting upon it due to the relative acceleration of the occupant with respect to the seat during the collision.

Case Number	Mode of Failure	
	Seat Back Support System	Frame or Other Deformation
1		X
2	X	
3		X
4		X
5	X	
6	X	
7	X	
8		X
9		X
10		X
11	X	
12		X
13	X	
14	X	
15	X	X
16		X
17	X	
18	X	
19	X	
20	X	
21	X	
22	X	X
23	X	X
Total	15	11

Table 1 Summary of Modes of Failure

In the remaining two cases which involved failure of the seat back support system (cases 22 and 23), the seat back failure occurred during an impact to the side of the vehicle by another vehicle.

As a result, in all fifteen cases, the seat back collapsed rearward due to the failure of a reclining mechanism, self locking device or the brackets which mount the seat back to the base of the seat.

Eleven cases involved deformation of the back of the seat. In nine of these cases, the vehicle was involved in a collision in which the rear of the vehicle impacted another vehicle or object. In the other two cases (22 and 23), the deformation occurred as a result of side impact. The deformation was caused by rearward loading of the seat back by the occupant during the collision.

In each case the deformation to the seat frame was at least partially permanent in that the seat did not return to its original shape once the load was removed. Although the deformation of the seat back was rearward in each case, it was generally not symmetrical due to the design of the seat. Typically bucket seats are designed such that all of the loading on the seat back is transferred through the recliner mechanism located on the outboard sides. The inboard section contains a simple pivot with no ability to hold the seat upright. Because of this the seat backs are usually slanted inboard after a failure.

In addition to the failures mentioned above, in case 1, the front seats of the vehicle tilted rearwards when the vehicle impacted a guardrail backwards and the seat mounts broke through the floor. The vehicle floor was not strong enough to withstand the force applied by the seats, when loaded rearward by the occupants. The deformation of the floor pans in cases 3 and 9 contributed to the rearward tilt of the seats.

In cases 8 and 9, the driver's seat head rest was detached from the seat during collision. In both cases this could be attributed to the rapid deformation of the back of the seat and the force of the passenger's body against the head rest.

All of these incidents involve failure of components of the passenger seat. All of the seats involved in these cases met the standards currently in place for new motor vehicles.

Effect of Seat Back Failure on Passenger Ejection

Seat back collapse during a vehicle crash may result in occupant ejection. Of the twenty-three cases examined, eleven of these resulted in one or more of the passengers being ejected from the vehicle. These are shown in Appendix 'A'.

In cases 4, 9 and 10, the ejection was due to vehicle rotation induced by a collision. In all three cases the vehicle had been rear impacted prior to rotation causing the seat back to fail or deform such that the occupant could not be retained during rotation. In each case, the vehicle rotation was caused by a secondary impact.

Seven cases (1, 3, 8, 11, 12, 13 and 21) involved a direct ejection from the vehicle when impacted in the rear. In all cases, the ejection would probably have been avoided if the seat back had remained in an upright position when loaded by the occupant during the collision.

In case 1, the front seats had not failed but the floor pan of the vehicle collapsed. However, this case also illustrates how the seat back, when in a reclined position, can not stop an occupant from being ejected from the vehicle even when the restraint system is used.

There were also four partial ejections in which an occupant of the vehicle was not fully retained in their seat during a collision but did not exit the vehicle (cases 2, 16, 22 and 23). In case 2, the passenger came to rest in the back seat during the accident and in case 16, the driver was found lying face up on the floor of the vehicle with his lower legs over the seat bottom and the lap belt around his shins. In case 22 and 23, the driver's were both partially ejected through the rear window of their vehicles.

In fourteen of these cases, the occupant was forced out of the seat in a rearward direction because the seat was unable to withstand the force exerted on it by the occupant.

Effect of Passenger Restraints When the Seat Back Fails

The passenger seat and restraint system in a vehicle act together to retain the occupant during the accelerations a vehicle experiences in the course of an accident. When one of these fails, it is not always possible for the other to fully restrain the occupant.

As outlined in the previous section, eleven of the twenty-three cases examined resulted in one or more persons being ejected from the automobile as a result of an accident in which there was seat back failure.

A total of thirteen people were ejected from the vehicles due to seat back failure. Of these people, six were using their restraint system, six were unrestrained and for one person it is unknown whether or not they were using the restraint system. It is, therefore, apparent that if seat back failure occurs, the use of the restraint system may not prevent the occupant from being ejected from the vehicle.

The cases in which partial ejection occurred showed a similar result. Only four people were ejected from their seat without exiting the vehicle but all four were wearing a seat belt at the time.

Six of the remaining cases involved accidents in which there were no ejections and in all but case 18 the passengers were using restraints. In case 18, it is not clear whether or not a restraint was used. In these accidents, the accelerations were relatively low and ejection would probably not have occurred even if the occupants were not using restraints.

Contribution of Seat Back Failure to Injuries Sustained

In the twenty-three cases examined, there were a total of thirty-one seat back failures. These failures and the severity of injuries sustained by the thirty-two occupants are summarized in Appendix 'C'.

Eighteen of the thirty-two occupants suffered minor injuries and twelve suffered major injuries, with ten of these twelve being fatal. For one of the occupants, the severity of injury is unknown and one was uninjured.

In examining the circumstances in which each of these passengers was injured, it was determined that of the eighteen occupants who suffered minor injuries, the seat back failure was a contributing factor in fourteen. For the other four of these eighteen occupants, there is not sufficient evidence to state whether or not the seat back failure contributed to their injuries.

In nine of the twelve cases in which major injuries were sustained, the seat back failure was a contributing factor. Seven of these occupants were ejected from their vehicle and the other two partially ejected. In Case 12, a right front passenger was ejected and fatally injured when the seat back failed, however in this case there was a single person seat occupied by two people. In cases 22 and 23, the right front passenger was fatally injured, however, there is insufficient evidence to conclude that the seat back failure contributed to their injuries.

In three cases in which major injuries were sustained (3,4 and 13), there were two occupants in the vehicle in which one seat back failed but the other did not. In all three cases the occupant of the failed seat suffered major or fatal injuries, while the occupant of the other seat suffered only minor injuries or no injuries at all.

There are also three passengers whose seat backs did not fail but who were injured as a result of a seat back failure. In Case 9, the left rear passenger was fatally injured by the head restraint of the driver's seat which became detached during the collision. In Case 19, the right rear passenger suffered minor injuries when the right front passenger's seat back failed. In case 23, the right rear passenger was fatally injured and was probably impacted by the driver during his ejection from the driver's seat.

Effects of Seat Back Failure on Rear Seat Occupants

Five of the twenty-three cases examined involved rear seat occupants and four of the passengers are known to have sustained injuries as a result of seat back failure. For the other passenger, it is not known whether or not injuries were sustained.

Three of these four cases were described in the previous section and involved injury to a rear seat passenger due to failure of the back of one of the front seats. Case 14 involved a child in the seat behind that which failed, however no injuries were sustained.

In the remaining case (case 1), the left rear passenger was ejected from the vehicle through the rear hatch and suffered minor injuries. This passenger's seat back deformed as well, and it is likely some contact was made between the driver and the rear seat passenger which contributed to the injuries.

In Case 5, there was no occupant in the rear seat, however, a baby seat which occupied the left rear seat was damaged when the seat back of the driver's seat collapsed. Had a child been occupying the seat, injury to the child would also have resulted.

These six cases indicate the danger to rear seat passengers as a result of seat back failure whether it happens to their own seat or a seat in front of them.