ENGINEERING ANALYSIS EA94-005

CHRYSLER MINIVAN LIFTGATE LATCH INVESTIGATION

ENGINEERING ANALYSIS TECHNICAL REPORT

October 25, 1995

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I. BACKGROUND

On Sept 25, 1993, the Office of Defects Investigations (ODI) received a phone call from a Fairfax County Police officer regarding a fatal accident that involved a 1992 Dodge Caravan. The minivan was traveling west at 30 mph when it was struck in the left rear (sideswipe) by a 1988 Mercury Grand Marquis traveling east at 35 mph. Upon impact, the minivan spun counter-clockwise, and the rear liftgate opened. Two children (ages 5 and 7) who were unsecured in the cargo area were ejected. One child instantly died and the other was critically injured. The police officer's judgment was that the crash force was not severe enough to justify a liftgate opening, and he requested an evaluation of the accident by ODI. On September 30, 1993, shortly after ODI's examination of the damage to the minivan and of the accompanying police accident report, a Preliminary Evaluation, (PE)93-084, was opened on 1992 Dodge Caravan, Plymouth Voyager, and Chrysler Town and Country vehicles (Chrysler minivans). The preliminary evaluation involved all liftgate latch failure or malfunction in Chrysler minivans.

PRELIMINARY EVALUATION

On October 11, 1993, ODI received a second phone call from the same police officer, regarding another fatal accident that involved a 1990 Plymouth Voyager. The Voyager was traveling north at approximately 45 mph, when it was impacted in the right rear quarter panel by a 1986 GMC van traveling west at 35 mph. The collision force threw the Voyager in a clockwise rotation (180 degrees), and the liftgate opened. A 1985 Toyota Tercel, traveling south, intruded through the open liftgate killing a 9-year old girl who was restrained in the rear seat. In both accidents, there was little damage to the liftgates. Most of the damage to the minivan was concentrated on the side of the impact. The liftgate latches were also deformed.

During the Preliminary Evaluation, ODI identified 13 additional crash-induced liftgate openings in Chrysler minivans that involved ejections, fatalities, and injuries. The accounts included reports retrieved from the ODI database as well as submissions by Chrysler, vehicle safety consultants, engineers, attorneys, police officers, etc. Upon the examination of either impacted minivans or of photographs of impacted minivans, ODI noted a common failure mode: structural deformation to the liftgate latch on the side opposite the impact point. Several of the 13 incidents involved older minivans which were equipped with liftgate latches similar in design, operation, and performance to the liftgate latches of 1991 through 1994 minivans. Consequently, ODI expanded its investigation to include all 1984 through 1994 model year Chrysler minivans.

Chrysler's response to the Preliminary Evaluation information request included reports and warranty claims of liftgate latch openings and malfunctions in non-impact situations. However, the problems coded in warranty replacement records varied from "binding, sticking or seizing," to "breaking or cracking, and improper installation." No single common failure mode was noted among those incidents of latch failure during normal vehicle operation. Hence, the investigation focused on crash-induced liftgate latch openings in Chrysler minivans.

ENGINEERING ANALYSIS

On January 31, 1994, the Preliminary Evaluation was upgraded to an Engineering Analysis (EA) 94-005. In April, 1995, the 1995 Chrysler minivans were added to the investigation. This was motivated by ODI's concern about another latch failure mode, that of inertial unlatching: a phenomenon that may occur during right side impacts when inertial forces acting on a solenoid plunger activate the latch and allow the liftgate to open with little or no structural deformation to the latch. The solenoid is an option for 1984 through 1994 model year minivans, and are installed in most 1995 minivans.

Subject Vehicles and Population

The vehicles subject to this investigation include all 1984 through 1995 Dodge Caravan, Plymouth Voyager, and Chrysler Town and Country vehicles. Table 1 lists the model years (MY) and the corresponding vehicle population estimates.

Table 1. Subject Minivans' Population

	MY '84-'89	MY '90-'94	MY '95	Total
	Base Design	Restrictor Tab Added*	Reinforced Latch*	
Non-Remote Release*	460,500	193,100	4,000	657,600
Remote Release*	1,261,800	2,067,400	385,400	3,714,600
Total	1,722,300	2,260,500	389,400	4,372,200

*Terms will be defined in the next section.

Alleged Defect

Inability of the liftgate latch to remain closed during motor vehicle crashes.

Scope of Investigation

This investigation involves a "crashworthiness" aspect of vehicle performance. The alleged defect is related to the liftgate latch mechanism design. The objective of the investigation was to evaluate the performance of the Chrysler minivan's liftgate latch in protecting against crash-induced liftgate openings, which can result in occupant ejections through the rear liftgate opening. Hence, a thorough technical evaluation of the latching system of the rear liftgate was conducted, including component and vehicle testing. In addition, ODI analyzed consumer complaints, accidents, fatalities, injuries, and lawsuits relevant to Chrysler and peer minivans' liftgate latching system failure. ODI also reviewed all manufacturer responses and conducted analyses of real world accident data files to assess whether the performance of the minivan liftgate latches in real world crashes is consistent with the results of the technical evaluation.

On March 27, 1995, after extensive discussions with NHTSA officials, Chrysler announced that it would provide all 1984 through 1994 minivan owners with a stronger, safer latch. On April 27, 1995, Chrysler announced that it would expand the campaign to cover model year 1995 minivans with a remote release, and that it would redesign the latch for all minivans with the remote release option to address inertial unlatching.

The purpose of this report is to present the technical analyses conducted by ODI and the results of those analyses.

II. FUNCTION, AND DESCRIPTION OF LIFTGATE LATCHING COMPONENTS AND SYSTEMS.

The function of a latch/striker system is to keep a vehicle door closed both during normal operation and in crash situations, minimizing the likelihood of occupant ejection or other vehicle intrusion into the passenger compartment. A vehicle door usually provides rigidity to the body of the vehicle, and is held in place by hinges and latch(es). If the hinges or latch components of the door fail, the passenger compartment loses rigidity and there is a greater risk of vehicle occupant ejection. The risk of serious injury increases when an occupant is ejected from the vehicle[1].

Rear liftgate latch and striker systems vary in design, specifications, and orientation among minivan manufacturers. ODI evaluated the characteristics of the Chrysler minivan liftgate latching system and those of other minivans' liftgate latch assemblies. This section will discuss: (A) the components and basic operation of a vehicle's door latching system; (B) NHTSA's Federal Motor Vehicle Safety Standard for vehicle door latches; (C) the Chrysler minivan's liftgate latching system; (D) Chrysler's modifications of the liftgate latching system; (E) other minivans' liftgate latch and striker assemblies; and (F) the modes of failure in liftgate latches.

A. Overview of a Door Latch/Striker System

A typical door latching system in a motor vehicle usually incorporates the following: (1) a fork bolt (rotor) that pivots to either engage or disengage a striker bolt mounted to the door frame. The fork bolt could have one or two detents corresponding to primary and secondary latching positions; (2) a detent lever (pawl) that locks the fork bolt in place when engaged to the striker; (3) a linkage system that disengages the detent lever from the fork bolt. The linkage system usually includes a release lever and is connected to the door handles (interior or exterior), or to the key cylinder. In vehicles equipped with a power door release, an electrical or electronic system may also trigger the detent lever to release. Figure 1 depicts the components of a basic latching system.

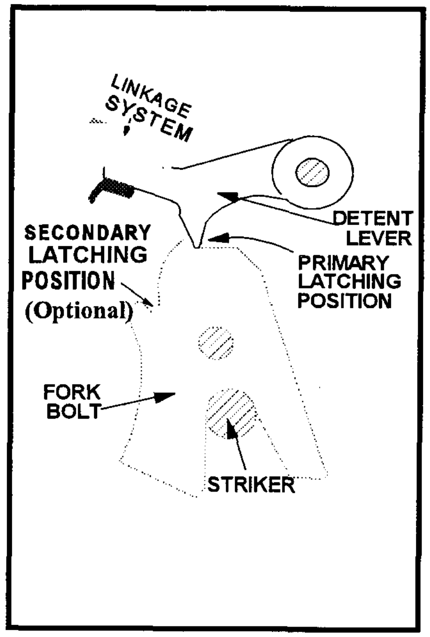

Figure 1. Typical Door Latching System

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[1] "Relative Risk of Death for Ejected Occupants in Fatal Traffic Accidents, (DOT HS 807 096), NHTSA Technical Report, November 1986.

B. NHTSA' s Standard for Motor Vehicle Door Latches

Federal Motor Vehicle Safety Standard (FMVSS) No. 206, "Door Locks and Door Retention Components," specifies performance requirements for side door locks and side door retention components, including latches, hinges, and other supporting means. The requirements are intended to minimize the likelihood of occupant ejections from the vehicle.

Under FMVSS No. 206, the requirements that apply to latch systems on side doors are: (1) A latch system must have a fully latched position and a secondary latched position. (2) Latches and striker assemblies must withstand specified load requirements. When in the fully latched position, the latch and striker must not separate when a longitudinal load of 11,100 newtons (2,500 pounds) or a transverse load of 8,900 newtons (2,000 pounds) is applied. When in the secondary latched position, the latch and striker must not separate when a longitudinal or a transverse load of 4,450 newtons (1,000 pounds) is applied. "Longitudinal" loads are perpendicular to the face of the latch. "Transverse" loads are those applied in the direction in which the door opens. (3) A door latch must not disengage from a fully latched position when a longitudinal or a transverse inertial load of 30 g is applied to the door latch system.

Until recently, liftgate latches were not governed by the same safety requirements. On June 19, 1990, NHTSA was petitioned by the Insurance Institute for Highway Safety to extend the requirements of FMVSS No. 206 to include back doors. The agency denied the petition, based on a lack of statistical evidence of real world crash data (drawn from the National Accident Sampling System (NASS), and from the Fatal Accident Reporting System (FARS)) indicating an increased risk of back door ejections.[2]

In 1994, NHTSA decided to revisit the issue of extending FMVSS No. 206 to rear hatch latches, in part because FMVSS No. 206 requirements had been effective in reducing side door ejections.[3] On August 30, 1994, NHTSA published a Notice of Proposed Rulemaking (NPRM) to extend FMVSS No. 206 to rear hatch latches. In the NPRM, NHTSA stated that such an action would contribute to the reduction of injuries and perhaps fatalities caused by rear hatch door ejections. The agency also believed

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[2] "Denial of Petition for Rulemaking to Extend FMVSS No. 206 Requirements to Hatchbacks and Other Doors." 55 Fed. Reg. 48261-48262 (November 20, 1990).

[3] "An Evaluation of Door Locks and Roof Crush Resistance of Passenger Cars- FMVSS No. 206 and No. 216" (DOT HS 806 489).

that "given the increasing popularity of vehicles with rear hatch doors, especially vans, this safety problem may become more serious unless action is taken."[4]

On September 27, 1995, NHTSA published a final rule which extended the application of FMVSS No. 206 to include rear hatch doors, effective September 1, 1997.[5] Given the differences in orientation between side doors and rear hatch doors, and given the wide variety of rear hatch door designs (including latch and hinge structure and orientation), the requirements were modified for doors that open upward (e.g., liftgates). Basically, for those doors, the test requirements are specified in terms of the latch orientation, rather than in terms of longitudinal and transverse vehicle orientation. Also, a third load requirement (2,000 lbs) in the direction orthogonal to the other two directions was added in order to account for the loading that rear hatch latches are likely to experience in the event of a side impact to the rear quarter panel. The inertia load requirement was also amended to apply to the three principal axes.

Since the new FMVSS No. 206 was published on September 27, 1995, and will become effective on September 1, 1997, its requirements do not apply to the Chrysler minivans subject to this investigation. The compliance test methods in the new standard, however, were used in comparing liftgate latch strength of Chrysler minivans and their peers.

During this investigation, ODI evaluated the loading capacity of the Chrysler minivans' rear latches in directions prescribed by the September 1995 final rule, including the new orthogonal direction (+90 degrees and -90 degrees from the centerline of the vehicle). ODI also evaluated the static strength of other minivans' rear liftgate latches in the same directions. The evaluation will be discussed in detail in the Testing Section of this Report.

C. Description of Chrysler Minivan Liftgate Latching System

The Chrysler minivan liftgate latch consists of: (1) a fork bolt or a rotor with a single detent (one latching position) that engages a striker post when the liftgate is fully latched and disengages when it is opened; (2) a detent lever that holds the fork bolt in place when its is engaged with the striker; (3) a linkage system that connects the detent lever to the key cylinder,

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[4] Docket No. 94-70; Notice 1; 59 Fed. Reg. 44691.

[5] Docket No. 94-70; Notice 3; 60 Fed. Reg. 50124.

which is the manual method of opening the liftgate. There are no internal or external rear liftgate handles; (4) a single or double-bladed electrical switch which is located beneath the detent lever. When the detent lever contacts the blades of the switch, a door 'ajar" warning indicator is illuminated on the instrument panel, or an audible chime is activated to warn the driver that the liftgate is open; (5) a steel base plate on which all the above components are mounted. Depending on the model year of the minivan, the plate may have a restrictor tab locator; (6) a striker post that is located on the liftgate sill. Depending on the model year of the minivan, the striker assembly may or may not have an upset head (a cap) and a lateral restrictor tab corresponding to the locator configuration in the latch. The latch is not enclosed in a metal case. In vehicles equipped with an optional remote release mechanism, there is an electrical solenoid with a plunger. When the solenoid is activated by an electrical signal from the dashboard, its plunger actuates the detent lever downward in order to release the fork bolt from the striker. Figure 2 represents a 1984-1989 Chrysler minivan liftgate latch equipped with the remote release (solenoid) feature.

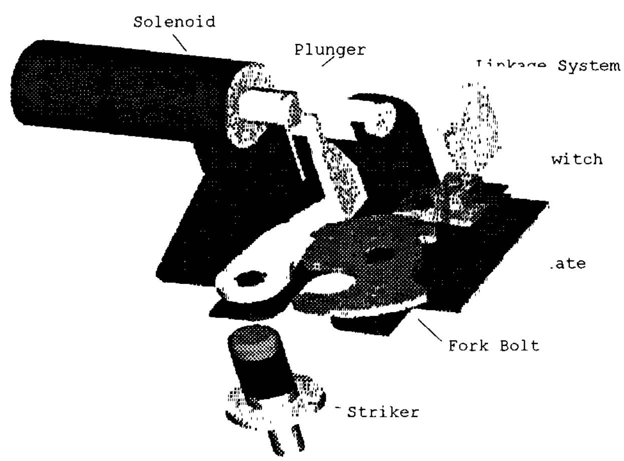

Figure 2. 1984-1989 Chrysler Minivan liftgate latch

D. Chrysler's Modifications of the Latch/Striker Assembly

Chrysler began modifying its minivan latching system in 1988. Beginning in January 1988, the striker assembly was modified by incorporating an "upset head" formation (cap) to the top of the striker post. In response to an ODI inquiry, Chrysler could find no documentation indicating the reason for the modification but speculated that it was done for "increased latch retention capability in the vertical direction." Figure 3 depicts this modification.

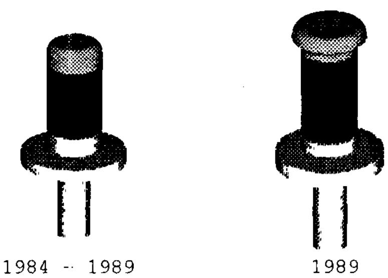

Figure 3. Striker "Upset Head" Modification

Beginning in July 1989, for the 1990 model year vehicles, a lateral restrictor tab was added to the liftgate sill. The tab fits into a corresponding restrictor locator configuration that was incorporated into the latch plate. According to Chrysler, this change was intended to address customer noise complaints. Figure 4 depicts this modification.

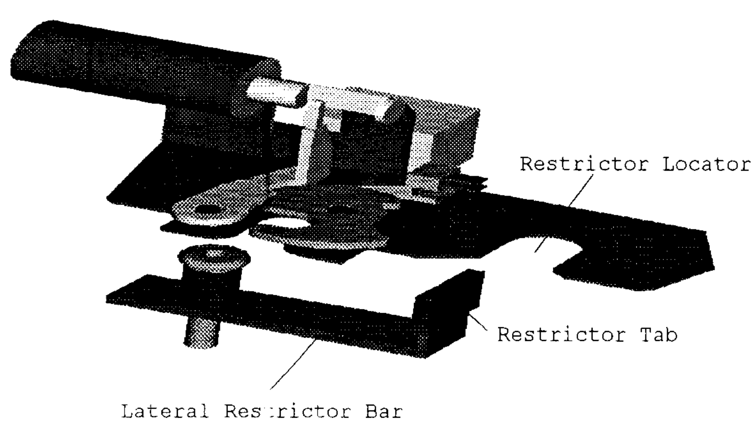

Figure 4. Lateral Restrictor Bar Modification

Also in July 1989, for 1990 model year vehicles, the striker assembly was modified by reducing the length of the striker cylinder by 5 mm. This change was made to coordinate with the 5 mm height increase in the striker's mounting position on the sill, caused by the addition of the lateral restrictor. Figure 5 depicts this modification.

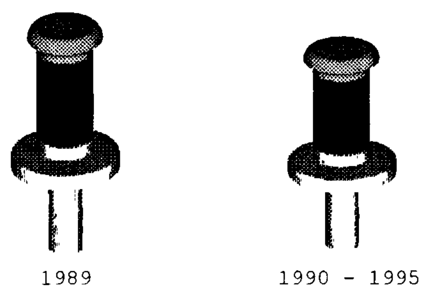

Figure 5. Striker Length Modification

Beginning in July 1994, for the 1995 model year minivans, Chrysler introduced a modified version of the 1994 latch with improved steel strength in the fork bolt and the latch base plate. Chrysler also added an L-shaped bar to reinforce the detent lever and the fork bolt in the same plane. Figure 6 depicts this modification.

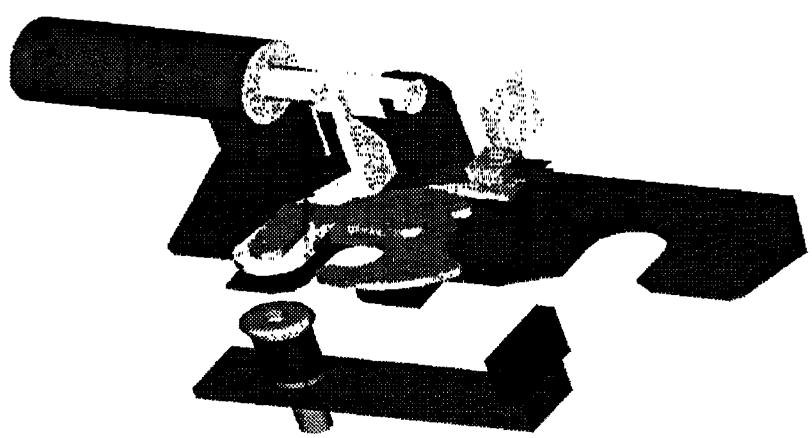

Figure 6. L-Shaped Bar Modification

E. Description of Other Minivans' Liftgate Latching Systems

During the investigation, ODI compared the design and specifications of the Chrysler minivan liftgate latching system to those of other minivans. What follows is a description of some of the latching systems employed by other minivan manufacturers.

Ford Aerostar: The Ford minivan liftgate latch assembly consists of: (1) two fork bolts, each with a primary and a secondary latching position. They engage the striker post in a wrap-around-fashion (one on each side), when the liftgate is fully latched and disengage it when the liftgate is opened; (2) a single detent lever that holds both fork bolts in place when they are engaged with the striker; (3) a linkage system that connects the detent lever to the outside liftgate handle. When the handle is pulled, the release lever, forced by the control rod, activates the detent lever to release the two fork bolts. The outside handle is the only mechanism that can open the liftgate latch; (4) a block-out lever that is part of the control assembly and that determines whether the liftgate is locked or unlocked. If the block-out lever is in the locked position, the release lever is prevented from pivoting and thus the outside handle cannot open the liftgate. If the block-out lever is in the unlocked position, the latch release lever is free to rotate. The power lock option operates a power actuator rod which in turn pivots the block-out lever. The liftgate latch cannot be opened through a direct electrical remote option; (5) a metal case; and (6) a striker post that is located on the liftgate sill and that includes an upset head formation or a cap. Figure 7 depicts a 1991 Ford Aerostar liftgate latch.

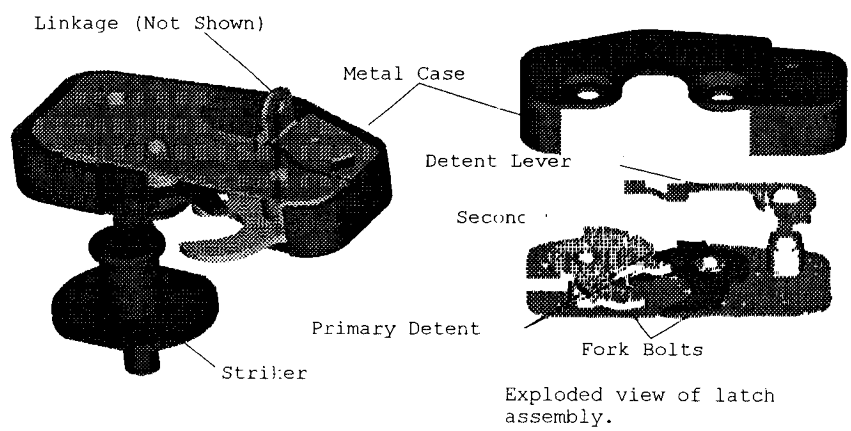

Figure 7. 1991 Aerostar Liftgate Latch and Striker Assembly

<u>GM APV</u>: The General Motors APV includes the Chevrolet Lumina, the Oldsmobile Silhouette, and the Pontiac TransSport. The liftgate in these vans incorporates dual latches (one on each side of the liftgate), each with two latching positions (two detents in the fork bolt), and each engaging a separate striker post. Each latch consists of : (1) a fork bolt with a primary and a secondary latching position that engages a striker post when the liftgate is fully latched and disengages it when the liftgate is open; (2) a detent lever that rotates in order to latch or unlatch the fork bolt; (3) a linkage system that pulls simultaneously on the left and the right detent levers and serves as a connector to the key cylinder. The key cylinder has an exterior handle (wings) that rotate clockwise in order to unlatch the liftgate; (4) door ajar switches (bolted to both right hand and left hand lock assemblies) that illuminate a gate ajar indicator; (5) remote power options that activate the lock mechanism, and are not directly linked to the latches; (6) two metal plates to which all above latch components are mounted; and (7) two strikers each bolted into threaded mounted holes in the rear body side panels. Figure 8 depicts a 1991 GM APV liftgate latch.

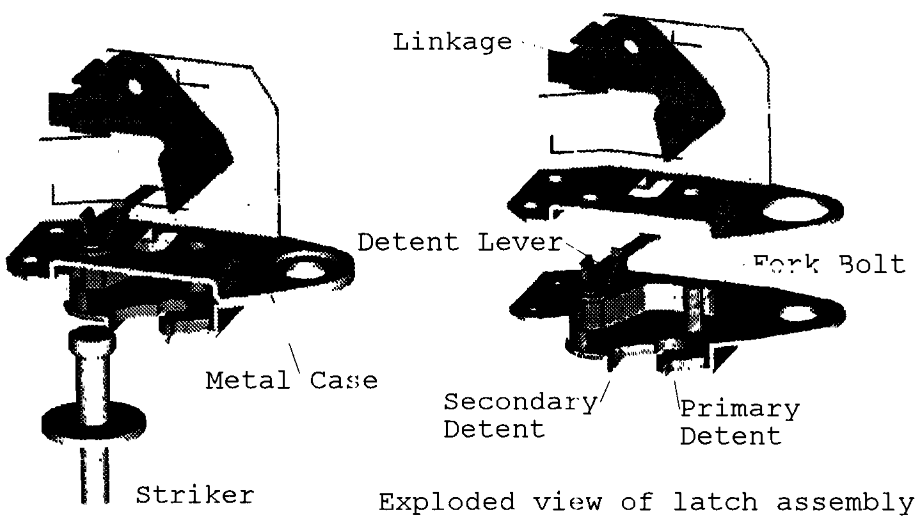

Figure 8. 1991 GM APV Liftgate Latch and Striker Assembly

__Mazda MPV__: The Mazda MPV liftgate latching system consists of: (1) a fork bolt with two detents (primary and secondary) that engages the striker when the liftgate is fully latched and disengages it when the liftgate is open; (2) a detent lever that holds the fork bolt in place when it is engaged with the striker; (3) a linkage system that connects the detent lever to an exterior liftgate handle. The exterior handle pushes the linkage system downward rotating the detent lever to release the fork bolt. The handle is the only mechanism by which the liftgate latch can be released, and the key cylinder must be unlocked; (4) a single-bladed electrical switch, mounted to the latch that detects the position of the fork bolt (half-lock and open conditions) and warns the driver through an indicator light that illuminates the instrument panel; (5) power lock options that activate the lock mechanism, with no direct linkage to the latching system; (6) a metal case that encloses all the above components; and (7) a striker wire loop that is mounted to the liftgate sill. Figure 9 depicts a 1991 Mazda MPV liftgate latching system.

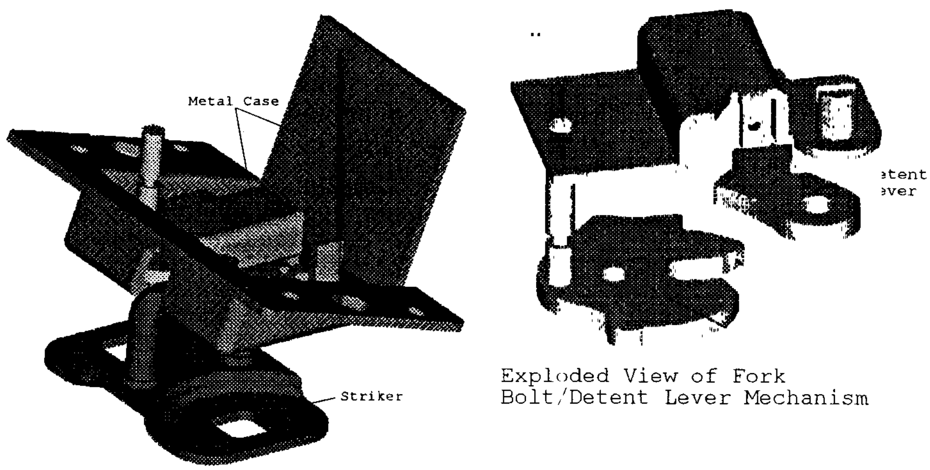

Figure 9. 1991 Mazda MPV Liftgate Latch and Striker Assembly

F. Summary of Modes of Failure in Liftgate Latches

In general, there are four distinct latch failure modes that have been identified in previous NHTSA Engineering Analyses: (1) structural failure; (2) detent lever-fork bolt bypass; (3) linkage activation; and (4) inertial loading[6].

Structural Failure: Structural failure of the door latch system occurs when the latch or the striker deforms, separates, or breaks, allowing for disengagement of the latch from the striker.

Detent lever-fork bolt bypass: Detent lever-fork bolt bypass occurs when the detent lever and fork bolt become non-coplanar. The detent lever usually locks the fork bolt in place when the fork bolt is engaged with the striker. If the detent lever gets out of plane with the fork bolt, due to a combination of longitudinal and lateral loading, the fork bolt releases and the door may open.

Linkage Activation: Linkage activation occurs if parts of the linkage system are displaced sufficiently to cause the door latch to open. The displacement is usually due to door deformation which may deflect parts of the linkage system activating the detent lever and releasing the latch.

Inertial Unlatching: High levels of acceleration produce inertial forces that may load the latch enough to allow for its activation.

During the investigation, ODI identified two modes of failure that resulted in the release of the Chrysler minivan liftgate latch: detent lever-fork bolt bypass (which also involves structural deformation) and inertial unlatching. These failure modes will be discussed in detail in the testing and in the complaint/field analysis sections of the report. In those sections, ODI evaluated the Chrysler minivan liftgate latch relative to other minivans' latches.

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[6] Howe, J.G., Leigh M., Wilke, D.T., "Door Latch Integrity Study: Evaluation of Door Latch Failure Modes," (DOT HS 808 188).

III. PEER SELECTION

When assessing an alleged defect in a vehicle or component under investigation, the Office of Defects Investigation often compares the design and performance characteristics of the components or systems at issue with those of peer vehicles. Peer comparisons can identify specific engineering (i.e., design, material) and manufacturing characteristics that may result in one component in one vehicle performing better or worse than the corresponding component in another similar vehicle (i.e., contains a defect).

ODI usually selects peer vehicles from vehicles in the same market class as the vehicle under investigation. A peer vehicle typically has a comparable configuration, weight, layout, and driver and occupant demographics to those of the vehicle under investigation. The intent is to minimize factors that may bias the comparison between the subject vehicles and peer vehicles. As will be discussed below, Chrysler's definition of "peer vehicles" for the purpose of this investigation differed from that of ODI.

A. ODI's Definition of Peer Vehicles: ODI defined the peer vehicles to the Chrysler minivan as other minivans (i.e., Ford Aerostar, Mazda MPV, GM APV, Toyota Previa, etc.). ODI based its determination of peer vehicles on all the factors discussed above in addition to the two following factors: (1) the marketing of minivans in comparison to that of hatchback vehicles; and (2) rear occupancy levels in minivans compared to other vehicles with rear openings.

Marketing of Minivans and Other Hatch-Back Vehicles: ODI reviewed various marketing brochures released by Chrysler and other manufacturers of minivans and hatchback vehicles. From the review, minivans are apparently marketed mainly to families with children. Hatchback vehicles, on the other hand, appear to be sporty cars not designed for the family market. Their marketing tends to focus on high performance rather than passenger capacity.

Chrysler, when marketing its minivan, for example, has used the following language:

- "It is a family affair. Plymouth Voyager minivans are a household name and a top choice for all kinds of families on the go. Kids, especially, love riding in a Voyager because it's lots of fun to see everything from all angles."
- "adaptable seven-passenger seating"; "integrated child-safety seats"; "converta-bed"; etc.

When marketing the hatchback Eagle Talon, on the other hand, Chrysler has said:

- "For a time, sports coupes existed sheerly for the fun of it. In our more sensible age, people expect a little more. Like the all wheel drive system on Eagle Talon TSi AWD that improves traction......"

It appears that other manufacturers such as Ford, GM, Toyota, and Saab use a similar discourse when marketing their minivans or hatchback vehicles. Copies of the sample of marketing brochures reviewed by ODI can be found in the public file.

Based on the marketing of the minivan, ODI's expectation is that its occupancy rate behind the driver and front passenger seats should exceed that of other vehicle types. To support or substantiate this hypothesis, ODI conducted an occupancy analysis of minivans and compared it to the occupancy of other vehicles with liftgates or hatches.

Occupancy Analysis of Seat Positions by Body Type: This analysis is based on data drawn from 1991 through 1993 FARS because it provided the most complete occupancy information. ODI calculated: the ratio of non-front passengers to drivers in minivans, hatchbacks, and station wagons; and non-front seat occupancy rates. ODI reasoned that the risk of liftgate ejection is greater for occupants who sit closer to the liftgate.

Non-Front Occupant to Driver Ratio: The ratio for each body type is listed in Table 2.

Table 2. Non-front Passengers to Driver Ratio (1991-1993 FARS)

	2dr/3dr Hatch	Station Wagon	Minivan
Non-Front Occupant/Driver	0.26	0.42	0.86

Thus, on average, if a minivan, a hatchback, and a station wagon all have equal probability of liftgate latch failure, then the average minivan would have over 3.29 times the number of passengers at risk of liftgate ejection than the average 2- or 3-door hatchback vehicle and over 2 times the number of passengers at risk of liftgate ejection than the average station wagon.

Non-Front Seat Occupancy Rate: In minivans, the passenger seats behind the front seats and the cargo area are occupied far more often than in all other types of passenger vehicles. Figure 10 demonstrates this fact.

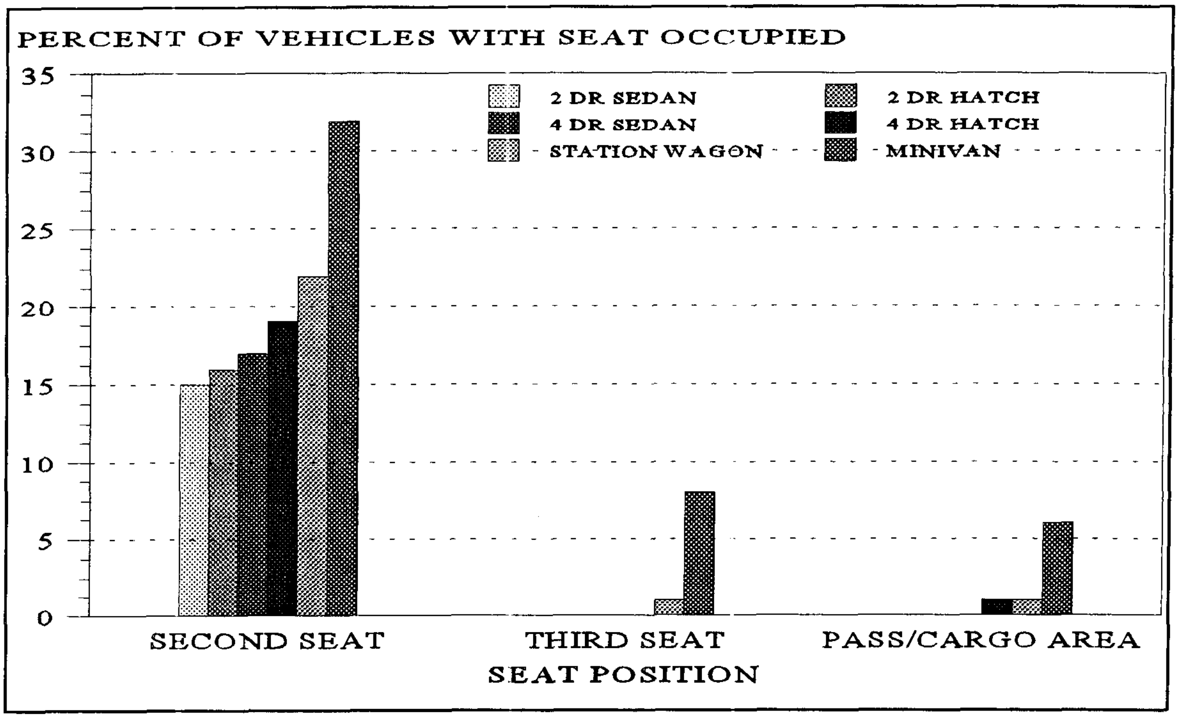

Figure 10. Occupancy Analysis of Seat Positions By Body Type of Vehicles in Fatal Accidents

B. Chrysler's Definition of Peer Vehicles: In a December 13, 1994, submission, Chrysler contended that peer vehicles should be defined as any vehicle with a liftgate, including station wagons and smaller hatchback vehicles, because all "those vehicles should be exposed to the same potential risk of post-collision liftgate opening." Chrysler also incorrectly alleged that "this is the group defined by NHTSA as appropriate peers in the 1990 and 1994 rulemaking analyses of rear hatch and door performance."

Despite the broad definition of "peer vehicles" that Chrysler would have NHTSA apply in this investigation, it appears that the company considers other minivans as peer vehicles. According to a former Chrysler employee who furnished information to ODI, Chrysler compares its minivans to other body types, such as station wagons and hatchbacks, for the purpose of competitive analysis, only if those vehicles exhibit a new, innovative option that could embellish the product.

Chrysler took a narrow approach in its evaluation of its minivan latch capability relative to FMVSS No. 206 and other manufacturers' specifications set out in a July 7, 1990 memo, where Chrysler did not evaluate the latches of hatchback vehicles. Chrysler instead compared its minivan's latch performance to that of the

Ford Aerostar, the GM APV, the Toyota Previa, and the Mazda MPV, which is consistent with ODI's approach.

NHTSA's 1990 analysis of rear hatch and door performance referred to by Chrysler was conducted in response to a petition for rulemaking that sought to extend the side door requirements of FMVSS No. 206 to hatchbacks and other back doors. The agency at that time was not comparing one type of vehicle's liftgate latch to the next, but rather was deciding whether an overall safety problem associated with rear back-door openings warranted an amendment of the standard. Similar considerations applied during the agency's 1994-1995 rulemaking that led to the recent amendment.

C. Finding

For the purpose of this investigation, the peer vehicles of the Chrysler minivan are best defined as other minivans (i.e., Ford Aerostar, Mazda MPV, GM APV, Toyota Previa, Nissan Quest, etc.). ODI used this definition in all evaluations and analyses conducted.

IV. DESIGN LOAD SPECIFICATIONS

A. Chrysler's Design Load Specifications

Table 3 provides Chrysler's design load specifications as outlined in a 1990 memo.

Table 3. Chrysler's Design Load Specifications for Minivan Latches		
Specifications	**Primary Longitudinal/Transverse**	**Secondary Longitudinal/Transverse**
FMVSS No. 206	2,500/2,000 lbs	1,000/1,000 lbs
Chrysler Specifications	None/750 lbs	No Secondary Latching Position

B. Other Manufacturers' Design Load Specifications

Table 4 provides manufacturer load specifications for the latch/striker mechanism for Ford Aerostar, GM APV, and Mazda MPV.

Table 4. Other Manufacturers' Design Load Specifications for Minivan Latches		
Specifications	**Primary Longitudinal/transverse**	**Secondary Longitudinal/transverse**
Ford Aerostar	3100/2500 lbs	1250/1250 lbs
GM APV*	2000/1350 lbs	None/1000 lbs
Mazda MPV	2,490/2,000 lbs	990/990 lbs

* GM APV has two latches located one on each side of the liftgate. Each latch has the above specifications.

C. Finding

Chrysler's design load criteria for its liftgate latch are lower than those of peer minivans.

V. TESTING

During the investigation, ODI conducted several types of tests in order to evaluate the performance of the Chrysler minivan liftgate latch relative to the performance of other minivans' liftgate latching systems. The tests included, static strength tests, sled tests, and full scale crash tests which were conducted by NHTSA's Vehicle and Research Test Center (VRTC), and by the Transportation Research Center (TRC) in East Liberty, Ohio. Copies of all VRTC and TRC test reports can be found in the public file.

Chrysler also conducted several types of tests in relation to the investigation. Chrysler's testing program included static strength tests, sled tests, and full scale crash tests. Chrysler's dynamic tests concentrated on the evaluation of the liftgate latching systems utilized in a variety of non-Chrysler vehicles with liftgates or rear hatch doors, including smaller hatchback vehicles and station wagons. After the announcement of the latch replacement campaign, Chrysler performed evaluative tests on the replacement latches that will be incorporated in the minivans during the latch replacement campaign. These tests included a crash test, a bump test, a series of sled tests, and a driving test. The results of those tests will be discussed in the Replacement Latch section of this report.

A. Static Strength Tests (ODI)

ODI conducted static strength tests on Chrysler minivan and peer liftgate latches in order to determine the load capacity of the latches. A detailed discussion of the test procedure, equipment, and results is presented in VRTC report, VRTC-74-0324A, "Tensile Tests of Liftgate Latches for 1984-95 Chrysler Minivans."

The tests were conducted in accordance with the procedures set out in the new NHTSA rule which extended the FMVSS No. 206 to rear door latches. Although the standard does not apply to Chrysler minivan latches and to peer latches tested, the test procedures are appropriate for latch strength evaluations. As discussed above, in the new rule, the requirements of FMVSS No. 206 were modified to (1) specify the two load test directions for rear hatch doors in terms of latch orientation rather than vehicle orientation; and (2) include a third load direction (orthogonal to the other two directions) to address the loading that rear hatch latches are likely to experience during a side impact to the rear quarter panel.

Hence, the three principal pull directions used by ODI during its tests were: (1) door-opening direction (called transverse in FMVSS No. 206, and called lateral by VRTC); (2) vertical direction along the striker axis (called longitudinal in FMVSS No. 206); and (3) modified lateral in the direction orthogonal to the other two. ODI also statically tested the Chrysler minivan latch in ± 45 ° directions from the centerline of the vehicle.

Door-Opening Direction: The test results for this pull direction are summarized in Table 5. Only the mean of test values is listed. Unless otherwise noted, three pull tests were performed on each model latch. Only one pull was performed on each latch assembly, however.

Table 5. Test Results for Door-Opening Direction

Make/Model	Model Year	Mean Load at Failure (lbs)
Chrysler; Dodge Caravan Plymouth Voyager Town and Country	1984-1987	1322
	1988-1989	1261
	1990-1994	1,314
	1995	2,003*
Ford Aerostar	1993	2,985
Chevrolet Lumina APV	1993	4,312
Toyota Previa	1993	2,651
Mitsubishi Expo	1993	2,541
Volkswagen EuroVan	1993	4,497
Mazda MPV	1993	2,583
Nissan Quest	1993	2,464
Mercury Villager	1993	2,956
FMVSS 206 (new)		2,000

Note: * only two latch assemblies tested

- The 1984-1994 Chrysler minivan latches had failure loads substantially below those of other minivan latches in the door opening direction. The mean failure load for the Chrysler latch was 1,165 pounds below the next highest mean failure load for a non-Chrysler minivan.

- The addition of the striker head to the 1988 model year Chrysler minivan liftgate latch did not appear to affect the strength of the latch in the door-opening direction.

- The addition of the restrictor tab and locator to the 1990 model year Chrysler minivan liftgate latch did not seem to affect the strength of the latch in the door-opening direction.

- The higher strength steel fork bolt and the L-shaped reinforcement bracket in the 1995 model year Chrysler minivan liftgate latch added strength to the latch in the door-opening direction.

Vertical Direction: The test results for this pull direction are summarized in Table 6. Only the mean of test values is listed. Unless otherwise noted, three pull tests were performed on each model latch. Only one pull was performed on each latch assembly.

Table 6. Results for Vertical Direction Test

Make/Model	Model Year	Mean Load at Failure (lbs)
Chrysler: Dodge Caravan Plymouth Voyager Town and Country	1984-1987	(No Head on Striker)
	1988-1989	2,629
	1990-1994	2,611
	1995	3,264*
Ford Aerostar	1993	4,150
Chevrolet Lumina APV	1993	4,193
Toyota Previa	1993	2,438
Mitsubishi Expo	1993	2,782
Volkswagen EuroVan	1993	4,688
Mazda MPV	1993	1,866
Nissan Quest	1993	3,888
Mercury Villager	1993	3,522
FMVSS 206 (new)		2,500

Note: *only two latch assemblies tested

- The 1984 through 1987 Chrysler minivan latch was not tested in this direction, because a headless striker would slip out of the latch as soon as a vertical load was applied to it. In other words, the failure load for the vertical direction is nearly zero.

- All other non-Chrysler minivan latches had retention in the vertical direction. The lowest mean failure load for a non-Chrysler minivan was 1,866 lbs.

- The addition of the restrictor tab and locator did not appear to affect the strength of the Chrysler minivan latch in this direction. The restrictor tab does not engage its locator while the latch and striker assemblies are pulled vertically apart.

- The addition of the L-shaped reinforcement bracket and the higher-strength-steel fork bolt for the 1995 Chrysler minivan latch appeared to increase the strength of the latch in this direction.

Modified Lateral: The test results for this pull orientation are summarized in Table 7. Unless otherwise noted, a single pull test was performed on each latch. The latches were tested along the (±90°, ±45°) directions in order to account for the loading that rear liftgate latches are likely to experience during a side impact to the rear quarter panels. The ±90° orientations are orthogonal to the vertical and door opening directions. The positive directions are equivalent to left side impacts, whereas the negative directions correspond to right side impacts.

Table 7. Results for Modified Lateral Direction Tests

Make/Model	Model Year	Load(s) at Failure (lbs.)			
		-90°	-45°	+45°	+90°
Chrysler: Dodge Caravan Plymouth Voyager Town and Country	1990-1994	4,209	2,090	1,660	2,114 1,743
	1995	4,600 4,399	2,891	2,568* 2,178	4,404 4,053
Ford Aerostar	1993	3,120	2,769	3,272	3,677
Mazda MPV	1993	3,159	3,071	2,744	2,744
Nissan Quest	1993	4,907	2,940	3,291	4,639
FMVSS 206 (new)		2,000			2,000

Note: * 1993 restrictor tab was used for this test, the 1995 tab was not available at the time of test.

- The loads at failure of 1990 through 1994 Chrysler minivan latch were lower than other peer minivans in all but the -90° direction.

- The mean failure load for the 1995 Chrysler minivan latch was 2,300 lbs above the mean failure load for the 1990 through 1994 Chrysler minivan latch in the +90° direction.

- In tests conducted in the +90° direction, the damage pattern in the latch was consistent with that found in field vehicles that had experienced post-crash latch failures. The striker loaded the latch plate, and the failure mode was a fork bolt-detent lever bypass.

- Generally, in the +90° direction, when the bypass occurred, the restrictor tab slipped out of its locator before any bending took place.

- Some bending of the tab was noted in the -90° direction. Additionally, in this direction, the striker appeared to be pushing against the mouth of the fork bolt before loading the latch plate.

B. Dynamic Tests (ODI)

ODI conducted two types of dynamic tests: (1) full scale crash tests; and (2) high acceleration sled tests.

Full Scale Crash Tests: The objectives of the tests were: (1) to evaluate the performance of the liftgate latch system of Chrysler minivans in certain side-impact crashes; (2) to compare this performance to peer minivans; (3) to evaluate the risk of occupant ejection through the liftgate; and (4) in some cases to evaluate possible occupant injury based on dummy responses. ODI conducted a series of seven crash tests. Details of the test procedure, parameters, and results for the crash tests can be found in VRTC reports (VRTC-74-0324B), "Summary of the Crash Test Program Concerning Rear Liftgate Integrity of 1984-95 Chrysler Minivans," dated December, 1994 and (VRTC-74-0363E), "Summary of Sled and Crash Test Program Concerning Rear Liftgate Integrity of 1984-95 Chrysler Minivans," dated September 1995.

Vehicles Involved

All the Chrysler minivans tested were equipped with V-6 engines and had a short wheelbase design. The two peer vehicles tested were the Ford Aerostar, based on comparable vehicle sales volume, and the Mazda MPV, based on the performance of the MPV liftgate latch during the static strength testing (relatively low failure loads in the vertical and +90° modified lateral directions compared to other peer vehicle latches).

Test Procedures

The crash tests were conducted using the moving deformable barrier (MDB) similar to the one that is used to test for compliance with the requirements of FMVSS No. 214, "Side-Impact Protection." However, certain modifications were made.

The barrier was set up with a test weight of approximately 3,600 pounds. NHTSA's 1994 notice of proposed rulemaking to extend FMVSS No. 214 to multipurpose passenger vehicles, trucks, and busses suggested an MDB weight within the range of 3,000 to 3,800 lbs. ODI had received field reports involving impacting vehicles ranging in size from compact to full size passenger cars, minivans, and light trucks. ODI selected a barrier weight of 3,600 lbs to represent a common weight range of impacting vehicles.

ODI chose an impacting speed not to exceed 30 mph in the lateral component. This is consistent with the speed specified in most of NHTSA's safety standards that involve dynamic testing. In addition, several real world incidents of liftgate openings have occurred at impact speeds of 30 mph lateral speed or less.

The bottom of the barrier was set at 15 inches to allow the barrier bumper to impact against the floor sill of the minivan. The test vehicles were positioned at different impact angles to the barrier direction of travel, and the wheels of the MDB were straight in order to avoid the engagement of the barrier face with the liftgate.

For the first six tests, three dummies were placed in the third (rearmost) bench seat of each test vehicle. The dummies were unrestrained. Each outboard dummy was a 50th percentile adult male, the center dummy was a 33 pound, 6 year-old child dummy. All dummies were non-instrumented except for an instrumented adult side dummy (SID), used only in crash tests 4, 5, and 6. The instrumented dummy was positioned in the left outboard seating position of the third seat. In the first six crash tests, all impacts were near the left rear wheel of each test vehicle. For the seventh test, the impact point was to the right side of the minivan, a mirror image of those in Tests 3 through 6.

Test Results

Test # 1 (TRC # 940701)[7]: This test was a 243.6 ° side impact (measured between the barrier direction of travel and the longitudinal centerline of the test vehicle) with the MDB striking a 1987 Caravan with the "headless" striker/latch system. The actual impact speed was 33.6 mph, which resulted in a lateral velocity component (perpendicular to the side of the test vehicle) of about 30 mph. The impact point, the projection of the right edge of the barrier at the time of first contact with the vehicle, was 17.8 inches aft of the centerline of the rear axle.

Upon impact, the van spun counter-clockwise, and the liftgate opened. The uninstrumented 50th-percentile adult male dummy, unsecured in the right outboard seating position, was ejected through the liftgate opening. The 6-year-old child dummy, unsecured in the center seating position of the third seat, was also ejected through the liftgate opening. The latch was bent downward as it "rode" up and off the "headless" end of the striker during impact. The latch was still in the closed position following the test. The left side windows (rear and middle) were broken during impact, but the liftgate glass remained intact. The support posts for the third seat were also bent and the seat's right front support post hook disengaged from the floor. The impact caused the rear axle to break near the left wheel.

Test # 2 (TRC # 940707): This test was conducted at a lower impact speed (30.2 mph). The lateral velocity component was about 27 mph. The test vehicle was a 1991 Caravan with a latch/striker system incorporating a lateral restrictor tab and a striker with an upset head. The impact point and angle were set to be the same as the previous test.

Upon impact, the van spun counter-clockwise, but the liftgate remained latched. It was observed from the mini-camera videotape that upon impact, the liftgate latch slid up the striker stem, and was held by the head. The rear axle also broke near the left wheel, and the left side windows (rear and middle) were broken during impact. However, despite the open portals, the unsecured dummies remained in the vehicle.

Test # 3 (TRC # 940719): This test was a 285 ° side impact (measured between the barrier direction of travel and the longitudinal centerline of the test vehicle) with the MDB striking another 1991 Caravan. The actual speed was 31.1 mph (a lateral velocity component of 30 mph). The impact

[7] The TRC test numbers correspond to the test date (i.e., "940701" indicates a test date of July 1, 1994).

point (with the left, front edge of the MDB) was 14.7 inches forward of the centerline of the rear axle.

Upon impact, the van rotated counter-clockwise, and the liftgate opened. The uninstrumented 50th-percentile adult male dummy, unsecured in the right outboard seating position of the third seat, was ejected through the liftgate opening. The latch was bent downward as it "rode" up to the head of the striker during impact. The liftgate latch failure mode was a detent lever-fork bolt bypass. The left side windows (rear and middle) were broken during impact. The support posts for the third seat were bent, but both front support post hooks remained engaged. The rear axle also broke near the left wheel in a similar manner as the previous two Caravan crash tests.

Tests # (4 and 5) (TRC # 940722 and # 940729): These crash tests were conducted on a 1991 Ford Aerostar and a 1991 Mazda MPV, respectively, at the same target conditions as the third test (285 ° impact at 31.1 mph). The actual impact speeds were 31.1 for the Ford Aerostar and 31.2 for the Mazda MPV, resulting in lateral velocities of 30 and 30.1 mph respectively. The actual impact points were about 16.8 inches forward of the centerline of the rear axle.

Upon impact, the each minivan spun counter-clockwise, and liftgates remained closed during both tests. The left side dummy appeared to break the left side window in the Aerostar during impact. All three unrestrained dummies remained in each vehicle. Both side windows (rear and middle) were broken in the Mazda MPV during impact. The rear axles and wheels remained intact for both peer vehicles

Test # 6 (TRC # 940930): This test was conducted using the same target conditions as the third test. The impact point was about 10.3 inches forward of the centerline of the rear axle. The test vehicle was a 1991 Caravan with a 1995 latch/striker assembly installed.

Upon impact, the van spun counter-clockwise, and liftgate remained closed. The left side windows (rear and middle) were broken during impact, but the liftgate glass remained intact, and the rear axle broke near the left wheel. All three unrestrained dummies remained in the vehicle.

Test # 7 (950404-1): This test was conducted in April 1995, several months after the previous tests. The test conditions for this test were the same as those during the sixth test except for the impact point, which was on the right side of the vehicle and the angle of impact (75 ° measured between the barrier direction of travel and the longitudinal centerline of the test vehicle). The purpose of this test was to determine the response of the minivan's latching system to inertial loading during the crash.

Upon impact, the van rotated clockwise, and, the liftgate opened. The failure mode was inertial unlatching. The inertial forces trigger a solenoid plunger to activate the latch. The solenoid action is due to inertial effects of its mass undergoing the acceleration of the crash. A mini-camera recorded the event and depicted the solenoid shaft moving (relative to the solenoid housing) almost upon impact and triggering the release lever to open the latch. There were no dummies in this vehicle, but a ballast was added to simulate dummy loading.

A summary of the results is presented in Table 8 .

Table 8. Summary of Crash Test Conditions and Results

Test Number	Vehicle Impacted	Moving Barrier			Liftgate Status after Impact	Ejections
		Speed (mph)	Lateral speed (mph)	Direction (deg)		
1	1987 Dodge Caravan	33.6	30.0	243.6	Opened	2
2	1991 Dodge Caravan	30.2	27.0	243.6	Closed	No
3	1991 Dodge Caravan	31.1	30.0	285	Opened	1
4	1991 Ford Aerostar	31.1	30.0	285	Closed	No
5	1991 Mazda MPV	31.2	30.1	285	Closed	No
6	1991 Dodge Caravan*	31.1	30.0	285	Closed	No
7	1991 Dodge Caravan*	31.2	30.1	75	Opened	N/A

Note: The first six impacts were near the left rear wheel of each test vehicle; while Test #7 was near the right rear wheel.
*Test vehicles # 6 and # 7 were fitted with 1995 model latches.

- The above table shows that at a speed of approximately 30 mph, an impact to the left rear quarter panel of the 1987 and 1991 Caravans, which represent the latch design for all 1984 through 1994 Chrysler minivans, resulted in liftgate latch failure and ejection of unbelted dummies. Under similar test conditions, the peer minivan liftgates remained closed.

- Test No. 2, of a 1991 Chrysler minivan, did not result in a liftgate opening. The reasons may have been: (1) the decrease in speed, and/or (2) the role of the "upset" head on the newer-model striker.

- The L-shaped bracket and the increased-strength rotor improved the crashworthiness of the 1995 Chrysler minivan latch with respect to the failure mode of fork bolt-detent lever bypass. However, it did not prevent inertial unlatching in a right side impact.

- The unbelted dummies seated on the side opposite the impact point were ejected from the liftgate opening in the two tests in which the liftgate opened in left side impacts.

- Even though the liftgate glass broke in test # 3, the ejection path of the dummy was the liftgate opening.

HYGE Sled Testing: In April, 1995, prior to the seventh crash test, ODI used the TRC HYGE sled to conduct acceleration tests of the Chrysler minivan latching systems with their solenoid release devices attached. These tests were conducted to determine if the latch release device was sensitive to inertial loads. Tests were conducted at several deceleration levels and changes in velocity. In some tests, the inertial forces on the latch acted to release the latch. Some tests were also run with a spring attached to the fork bolt in order to simulate the preload force that is present on the rotor when the door is closed. This force was measured on normally operating doors of field vehicles and found to be approximately 85 pounds.

Tables 9 and 10 present a summary of the test set up and the results.

Table 9. Setup for HYGE Sled Tests	
VRTC/TRC Test No.	**Setup**
01/88	Eight latches installed on sled as follows: 1- Sensitive axis +30 deg off alignment with axis of sled travel. 2,3,4- Sensitive axis aligned with direction of sled travel. 5- Sensitive axis -30 deg off alignment with axis of sled travel. 6,7,8- Sensitive axis opposite to direction of sled travel.
02/89	One latch installed on sled as follows: Sensitive axis aligned with direction of sled travel and spring attached to rotor to simulate 85 pounds of preload between striker and rotor.
03/90 and 04/91	Three latches installed on sled as follows: 1- Sensitive axis +30 deg off alignment with axis of sled travel. 2- Sensitive axis aligned with direction of sled travel. 3- Sensitive axis aligned with direction of sled travel and spring attached to rotor to simulate 85 pounds of preload between striker and rotor.
Note: Sensitive axis is the orientation of the latch where the solenoid plunger tends to move when the latch is subjected to an acceleration.	

Table 10. Results of VRTC HYGE Sled Tests			
VRTC/TRC Test No.	**Delta-V (mph)**	**Peak g (Class 60 Filter)**	**Description of Results**
01/88	33.3	29.2	1, 2, 3, 4, & 5 opened; 6, 7, & 8 remained closed.
02/89	33.4	29.4	Latch opened with 85 pounds of preload.
03/90	22.9	13.8	All latches remained closed.
04/91	29.1	21.7	All latches opened, but # 3 flipped closed when the spring released (verified with high speed film).

- During the tests, the latching systems with no preload released at acceleration levels as low as 21.7 g's or more along the sensitive axis (right side impacts) due to inertial forces acting on the plunger portion of the solenoid. The latches did not release at 13.8 g's.

- Latches installed with an 85 pound preload also released at acceleration level as low as 22 g's along the sensitive axis (right side impacts) due to inertial forces.

C. Static Strength Tests (Chrysler)

Chrysler conducted static strength tests to evaluate minivan latches on three different occasions: (1) in a 1990 evaluation of the load carrying capacity of the Chrysler minivan's latch assembly relative to FMVSS No. 206; (2) soon after ODI opened its preliminary evaluation; and (3) during ODI's engineering analysis.

The 1990 Evaluation: Chrysler evaluated the latch/striker assembly relative to FMVSS No. 206 in two directions: transverse (door-opening) and longitudinal (vertical). The results were described in a 1990 memo that was provided to ODI. Table 11 lists the load capacities for both directions as outlined in the memo.

Table 11. Chrysler's Load Capacity For Minivan Latches

Load Capacity	Primary Longitudinal/transverse (pounds)	Secondary Longitudinal/transverse (pounds)
FMVSS No. 206 (new)	2,500/2,000	1,000/1,000
1991 Minivan	3,200/1,300	No Secondary Latching Position

During the Preliminary Evaluation: Chrysler performed static strength tests as part of its efforts to improve the strength of the liftgate latches for the 1995 model year minivans. After the development of the prototype, Chrysler compared the load capacity of the improved version with that of the existing latch. NHTSA granted Chrysler's request for confidentiality for this submission.

During the Engineering Analysis: Chrysler compared the load capacity of its minivans' liftgate latches to those of many other vehicles' liftgate latches. Chrysler tested latches from non-minivans with rear hatches (i.e., Saab 900, Hyundai Excel, Ford Escort, etc.) in addition to several competing minivan models. Their test results were provided to ODI in the December 13, 1994 submission. The pull direction for the modified lateral strength test was again ±60 °. Table 12 summarizes the results of these tests.

Table 12. Chrysler's Static Strength Test Results (Load at Failure, pounds)				
	Door Opening Direction	Vertical Direction	Modified Lateral +60	Modified Lateral -60
Chrysler Minivan 88-94	1,393	2,125	2,313	2,636
Ford Aerostar	3,100	4,550	3,250	3,100
Mercury Villager	3,900	3,525	3,600	3,950
Toyota Previa	2,600	2,375	2,675	2,560
Mazda MPV	2,450	1,876	3,550	3,700
VW Eurovan	4,600	5,675	4,200	3,200
Chrysler Minivan 1995	2,341	2,663	2,933	3,486
Ford Escort Wagon	1,885	2,690	2,080	1,800
Chevette	260	1,670	1,250	915
Saab 900	1,215	760	1,485	1,605
Hyundai Excel	625	650	1,040	985
Honda Civic Wagon	1,130	1,150	1,550	1,720
Honda Accord Wagon	900	1,430	2,320	990

- Based on the above results, Chrysler contended that although its minivan latches are not as strong as some other minivan latches, they are stronger than liftgate/hatchback latches on many vehicles other than minivans.

- The values obtained by Chrysler for the door-opening and the vertical directions were fairly close to those obtained by ODI in its tests of minivan latches.

In a later submission dated February 1, 1995, Chrysler presented static strength data for 1991 through 1994 Chrysler latches pulled in the ±90 ° directions. The values obtained by Chrysler for its minivan latches exceeded those obtained by ODI by 47 percent in the +90 direction.

ODI and Chrysler reviewed the test configurations, set up, methodologies, and samples tested to identify the source of the difference. The following points were noted:

- Significant differences existed between the Chrysler and the VRTC test fixtures. Both were found to have shortcomings when testing the Chrysler minivan latch in the ±90° directions. Chrysler's test procedure did not allow the striker to freely pivot in the lateral direction because the fixture to which the striker was attached was very stiff. VRTC's test configuration allowed the striker to pivot in the lateral direction, but also unintentionally allowed it to pivot in the longitudinal direction. The pivoting in the longitudinal direction was primarily due to the relatively lesser stiffness of the VRTC fixture.

- The problems with the VRTC fixture only occurred when testing the Chrysler minivan latch. This problem occurred due to the relatively unique design of the lateral restrictor tab in combination with the latch and striker.

- Several subsequent tests were conducted with a stiffer fixture at VRTC. It was found that the Chrysler latch failure loads in the modified lateral +90° direction were higher when using the stiffer fixture than earlier Chrysler latch values obtained by VRTC when using the less stiff fixture (from the 1,743 to 2,114 pound range up to the 2,290 to 3,252 pound range).

- During the testing with the modified fixture, variations were found to exist in the material composition of the Chrysler latch base plate from one "lot" number to the next. This variation affected the strength of the latch.

ODI believes that the original fixture used by VRTC may more closely simulate the real-world environment, because it allows the restrictor tab to slip out of its locator before major loading occurs. ODI inspected several real world failed latches in which the restrictor locator was not cracked (i.e., not loaded). This slipping action was also noted from the photographic evidence from ODI's crash tests.

D. Dynamic Tests (Chrysler)

Chrysler's original dynamic tests consisted of mechanical shock tests and full scale crash tests of vehicles in its defined "peer" group. Later, Chrysler conducted sled tests, a bump test, a driving test, and a full scale crash test in order to evaluate the replacement latches. These tests will be discussed in Section IX of this report.

<u>Mechanical Shock Tests:</u> These tests were submitted early during the engineering analysis. In general, the test was intended to measure the acceleration at which latches with and without solenoids can release when subjected to a shock test. NHTSA granted Chrysler's request for confidentiality for this submission.

Full Scale Crash Tests (Chrysler): Chrysler reported to ODI that the rear liftgate latch opened during five crash tests of Chrysler minivans. The tests were conducted for compliance purposes (i.e., FMVSS 208, FMVSS 214, FMVSS 301, and FMVSS 303) and not in relation to this investigation. According to Chrysler, however, for each test, an anomaly that existed prior to the test was present, which affected the ability of the liftgate to remain closed during the impact. A list of the tests, test reports, photographs, and a composite video can be found in the public file.

Other crash tests conducted by Chrysler in relation to this investigation included non-minivan vehicles (i.e., Saab, Hyundai Excel, station wagons, etc.). In general, Chrysler used similar test conditions and procedures to ODI's. The impact speeds and points varied however, and only one peer minivan was included in the evaluation, namely the Ford Aerostar.

Chrysler conducted four crash tests on the Aerostar. The impact speeds and points varied. In the first test, the vehicle was impacted at approximately 30 mph in the left rear with a type IV 301 barrier (4,000 lbs), and the liftgate did not open. The second test used the same impact conditions except that the speed was raised to 35 mph, and the liftgate did not open. Using a 3600 lb MDB barrier for the remaining two tests, Chrysler impacted the Aerostar in the right rear. One of the last two tests resulted in a liftgate opening. The speed of impact for this particular test was approximately 34 mph.

E. Findings

In static stength tests, the 1984-1994 Chrysler minivan latches had failure loads substantially below those of other minivan latches in the door opening direction. The mean failure load for the Chrysler latch was 1,165 pounds below the next highest mean failure load for a non-Chrysler minivan.

The 1984 through 1987 Chrysler latch has no retention capability in the vertical direction. All other non-Chrysler minivan latches had retention in the vertical direction. The lowest mean failure load for a non-Chrysler minivan was 1,866 lbs. The 1988 through 1995 latch/striker assembly was modified with a striker head. The mean failure load ranged from 2,611 pounds to 3,264 pounds, depending on the model year latch.

Of all latches tested in the modified lateral direction, the loads at failure for the Chrysler latch were lower than those of peer latches tested in all but the -90^0

direction.

In VRTC's dynamic crash tests with impact speeds of about 30 mph, only the Chrysler minivan latches released, allowing the ejection of unbelted dummies through the liftgate opening. The liftgates of peer minivans tested remained closed, as did the liftgate of the Chrysler minivan equipped with the 1995 latch when impacted on the left side..

Test # 2, (involving a 1991 Caravan) demonstrated the importance of retention in the vertical direction, as observed from the mini-camera video tape showing latch movement up the striker stem.

The fork bolt-detent lever bypass failure mode observed in field vehicles was also observed during both static and full scale crash tests conducted by VRTC.

The inertial unlatching failure mode was observed during both sled tests and the full scale right-side impact test conducted by VRTC.

VI. ENGINEERING EVALUATION

The function of any latch/striker system is to keep the door closed during normal vehicle operation and in crash situations, in order to minimize the likelihood of occupant ejections. The liftgate, similar to any other door, provides rigidity to the vehicle body, and is held in place by hinges and latch(es). If the hinges or latch components fail to maintain liftgate integrity (i.e., liftgate opens), the passenger compartment loses rigidity, and there is greater risk of occupant ejection.

During the investigation, using basic engineering principles, ODI analytically compared the design load carrying adequacy of several manufacturers' liftgate attaching systems. This approach required basic assumptions and used results obtained during: (A) vehicle crash tests, (B) static strength tests, and (C) actual physical measurements of the liftgate systems. The purpose of this analysis was to answer the following question: "During a vehicle impact, does the latch system contain sufficient strength to transfer loads (produced from acceleration) from the vehicle's body to the liftgate while maintaining latch integrity?"

Latch and Striker Acceleration Levels During Impacts

During ODI's crash tests, each minivan was instrumented with accelerometers that measured the translational acceleration of the components on which they were mounted. Accelerometers were placed near the striker and the latch, in order to record that location's acceleration-time profile during the crash. Table 13 presents the maximum acceleration observed at the latch and striker, in the vehicle's lateral direction, for each of the 4 crash tests at a 285 degrees impact angle from the centerline of the vehicle. The data was filtered with an SAE Class 60 filter based on SAE J211 OCT88, "Instrumentation for Impact Tests," recommendations.

Table 13. Peak Lateral Acceleration Measurements.

Test	Vehicle	Peak Lateral Acceleration	
		Striker	Latch
940719	1991 Chrysler	45 g	51 g
940722	1991 Aerostar	40 g	39 g
940729	1991 Mazda MPV	38 g	46 g
940930	1995 Chrysler	45 g	46 g

Static Load Capacity

As discussed in the previous section, ODI evaluated the static strength of several minivan latches. The results are listed in Table 14. The modified lateral orientation (± 90 degrees) represents load directions that account for right and left side impacts to the rear quarter panels of the minivans. The pre-1990 Chrysler minivan design was not included in this analysis since ODI did not have sufficient information to conduct the analysis, namely the static strength and door measurements.

Table 14. VRTC Static Test Results for Chrysler and Peer Minivan Latches

Model Year Vehicle	Minimum Force Required for Failure (pounds)		
	Modified Lateral		
	Left (+90)	Right (-90)	Minimum
1990-1994 Chrysler Minivan	1,743	4,209	1743
1991 Ford Aerostar	3,677	3,120	3,120
1991 Mazda MPV	2,744	3,159	2,744
1995 Chrysler	4,053	4,399	4,053

Liftgate Measurement Data

The liftgates for two Chrysler minivans, an Aerostar, and a Mazda MPV were weighed using two scales, thus allowing the calculation of total weight and the location of the center of gravity. Table 15 presents the data from the measurements, using the variables shown in Figure 11

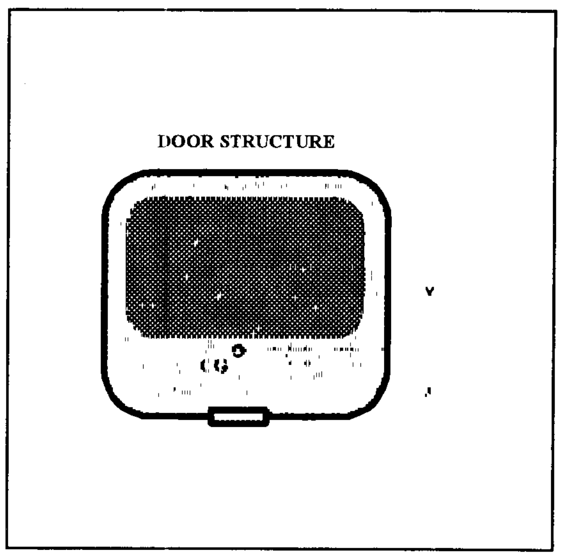

Figure 11.

Table 15. Liftgate Data.			
Vehicle	**Door wt**	**"X"**	**"Y"**
1991-1994 Chrysler	85 lb	20.9 in	27.7 in
1991 Ford Aerostar	70 lb	26.5 in	26.5 in
1991 Mazda MPV	72 lb	19.8 in	26.2 in
1995 Chrysler	85 lb	20.9 in	27.7 in

Note: Since the Chrysler minivan changed body design in 1991, the weight data for the door is not applicable to the 1990 model, although the latch in the 1990 model vehicle has the same modified lateral strength as the 1991 through 1994 models.

A. The Engineering Model

During a crash, force is transferred to the impacted vehicle through the contact zone of the crash. This force causes the impacted vehicle to accelerate away from the striking vehicle. This acceleration acts on all rigid bodies in the vehicle.

To accelerate the rear liftgate, force is required to act on the liftgate. There are three points of positive contact between the liftgate of vehicles referenced in Table 15 and the frame of the minivan: the latch/striker system and two hinges. (Note: Some other minivans have two latches, which would reduce the inertial load on each latch.) The latch/striker system is the load path for the lower portion of the liftgate, while the two hinges are the load paths for the upper portion of the liftgate. All three points act together to accelerate the door. In a side crash, the predominant crash force is in the lateral direction. Full scale crash test measurements at 30 mph impact speed showed acceleration levels of up to 50 g's near the latch and striker assemblies. Acceleration must be transferred to the liftgate through the hinges and latch. Based on the cg location and weight of the liftgate, the magnitude of the force applied to the latch can be estimated using simple physics.

<u>Dynamic Latch Strength Requirement Estimates</u>:

The dynamic force (at the striker/latch) = wt * g * [Y/(X+Y)], where wt is the door weight, g is the dynamic acceleration, and X and Y relate the proportion of the door weight acting on the latch/striker system.

Table 16 presents estimates of the dynamic force at the latch required to accelerate the door structure of each of these minivans to 50 g's. Also presented are the minimum modified lateral static test results and the ratio of the static to dynamic load estimates, which is a measurement of the capability of the latch to withstand the dynamic forces generated during a 30 mph crash.

Table 16. Striker Dynamic Forces, Static Loads, and Ratios.			
Vehicle	**Dynamic Force Estimate**	**Minimum Static Load Capacity**	**Ratio, Static over Dynamic**
1991-1994 Chrysler	2450	1743	0.71
'191 Aerostar	1750	3120	1.78
1991 Mazda MPV	2050	2744	1.34
1995 Chrysler	2450	4053	1.65

From the above data, for the 1991-1994 Chrysler minivans, the force required to accelerate the liftgate at the latch/striker in a left side impact at approximately 30 mph (2,450 lbs) is about 40% more than the lateral strength of the liftgate's latch/striker system (1,740 lbs) in that direction, resulting in a safety factor below one. (A safety factor is a number that should always be greater than one which is used to indicate the amount by which the strength of a component exceeds the stress imposed by the external loads.) For the peer minivans and the 1995 Chrysler minivan, the force required to accelerate the liftgates is less than the lateral strength of the liftgates' latch/striker assemblies, with safety factors ranging from 1.34 to 1.78.

B. Chrysler's Response to ODI's Engineering Model

Chrysler submitted information in response to the above engineering calculations. The following is a general discussion of the response:

- Chrysler argued that ODI's engineering model is too simplistic, and that the one-dimensional model used in the analysis does not account for a sufficient portion of the event to be meaningful.

- Chrysler indicated its disagreement with the filtering employed by ODI while processing the accelerometer data. Changes in the filter characteristics and cut-off frequency do have a direct effect on the peak acceleration measurements. A lower cut-off frequency results in lower acceleration readings.

- Chrysler claimed that the results of ODI's static testing in the modified lateral orientation are not accurate. Chrysler stated that ODI underestimated the strength of the Chrysler latches by a large quantity. Chrysler's test results for this direction were much higher than those obtained by ODI.

ODI agrees that its simple model is not adequate for predicting vehicle crush, exact loads of failure, etc. However, a simple model can be used as a tool to review first order events. The purpose of the model was not to quantify the exact behavior of the liftgates during a crash. The analysis simply compares the impact loads with the latch strengths for several minivan latch systems in order to provide insight on the possibility of liftgate opening during a crash.

ODI believes that the SAE J211a guideline is the correct process for data filtering. This guideline is widely used, in government and industry, when processing acceleration data. Hence, developing a special criterion for a specific application, as suggested by Chrysler, is not warranted.

The reasons for the discrepancies in static strength test results between Chrysler and VRTC were discussed in the testing section. A stiffer fixture used by Chrysler allowed the restrictor locator to be loaded, sometimes to a point of fracture. VRTC and ODI observed minimal loading of the restrictor locator during both crash tests and real world accidents. In fact, ODI observed that upon impact, there is a relative movement in the vertical direction of the liftgate door allowing the restrictor locator to slip off the tab. ODI believes that the values obtained with the less stiff fixture may more closely simulate real-world events. Nevertheless, using the results obtained in ODI tests using the stiffer fixture, ODI recalculated the ratio of static to dynamic load. The minimum lateral load capacity of the 1991-1994 Chrysler latch in these tests was 2,290 lbs, leading to a safety factor of 0.93, a value below 1.00 and below the safety factors of peer minivans' liftgate latches.

C. Findings

The engineering model shows that a 1991-1994 Chrysler latch may not have sufficient strength to accelerate the liftgate and allow it to remain closed, during a 30 mph impact to the left rear of the vehicle. Other latch designs including the 1995 Chrysler latch, have sufficient strength to do so.

VII. CONSUMER COMPLAINTS

As stated earlier, the investigation was opened based on a police report regarding a fatal accident that occurred in Fairfax County, Virginia, and that involved Chrysler minivan rear liftgate ejections. During the investigation, ODI became aware of more incidents similar in nature to the Fairfax County accident. Reports of incidents originated from various sources, including consumers, vehicle safety consultants, engineers, accident reconstructionists, attorneys, insurance companies, the Insurance Institute for Highway Safety, junkyards, and the manufacturer.

During the investigation, ODI also contacted owners of Chrysler minivans, inspected vehicles, obtained liftgates and latches, and/or photographs of liftgates and latches that were involved in crash related liftgate openings. ODI also reviewed and analyzed the corresponding police accident reports.

As of July 13, 1995, ODI was aware of 207 alleged crash related liftgate openings that resulted in a reported 134 ejections through the liftgate opening, 98 injuries, and 37 fatalities. ODI's approach to complaint count will be explained in greater detail in the ejection path portion of the Complaint/Field Analysis section.

A. Complaint/Field Analysis

During the early stages of the investigation, ODI identified one predominant failure mode, that of a fork bolt-detent lever bypass. ODI also analyzed the sequence of events which resulted in the ejection of occupants, by noting points of impact, seating positions of the ejected occupants, open portals or possible ejection paths, seatbelt usage, and resting position of the ejected occupant outside the van.

Fork Bolt-Detent Lever Failure Mode: As mentioned earlier, ODI examined several impacted minivans, and many photographs of impacted minivans, in order to identify the mode of failure of the latch. During its evaluation, ODI inspected latches for signs of deformation (that is, bending or fracture of the latch or the striker). ODI also noted all damage to the liftgate, as well as to the entire structure of the van. In the majority of crashes reviewed by ODI, the minivan's liftgate incurred little or no damage. The damage was concentrated on the side of the vehicle which was impacted, and in the liftgate latch. ODI also noticed that the deformation of the latch plate was always on the side opposite to the principal impact point, and that it resulted in a fork bolt-detent lever bypass.

As discussed earlier, the detent lever locks the fork bolt in place when it is engaged with the striker. The fork bolt and the detent lever function together by rotating around pivot points that lie in the same plane, parallel to the plane of the latch plate. When the latch plate bends during impact, the fork bolt and the detent lever that are mounted on the latch plate become non-coplanar and allow for the disengagement of the fork bolt from the striker post.' Figure 12 illustrates this failure mode.

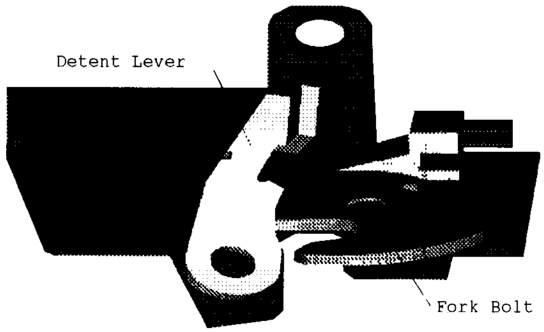

Figure 12. Fork bolt-detent lever bypass

The bending of the latch housing suggests striker loading of the latch plate. When a minivan is struck in the rear quarter panel, the forces are transmitted through the most rigid part of the van: the floor to which the striker is mounted. The van typically spins clockwise or counterclockwise depending on the point of impact. The top structure of the van that holds the liftgate, including the latch plate, is not rigid and deforms relative to the floor of the van, which holds the striker. Hence, the striker loads the latch plate and bends it enough to make the fork bolt and the detent lever non-coplanar. ODI observed contortion (racking) in the top structure of the van in almost every Chrysler minivan crash it analyzed.

Occupant Ejection Path and Sequence of Events: In addition to the ejection portal that the rear liftgate latch failure creates, other open portals may be created in crashes (i.e., broken back, side, and front windows; open side and front doors; etc.), from which occupants could be ejected. This is especially true during rollover accidents. ODI needed to determine the sequence of events that resulted in the ejection of occupants in order to quantify rear liftgate ejections and assess the impact with respect to injuries and fatalities of the liftgate latch failure in the real world.

To do so, ODI analyzed the various parameters in crashes where the ejection path could be disputed and compared them to those in accidents where the ejection path was verified and to the kinematic motion of the dummies during crash tests. The following parameters were analyzed: (1) point of impact; (2) open portals, or possible ejection paths; (3) physical evidence on the open portals (i.e., clothing, hair, blood, etc.); (4) location of the ejected occupants outside the van; (5) seating positions of the ejected and non-ejected occupants; and (6) seatbelt usage of ejected and non-ejected occupants.

If an ejection occurred during a minivan crash, and the only open portal was created by the liftgate, then ODI concluded that the ejection was a liftgate ejection. If there were additional open portals, such as rear side windows, and the minivan was impacted in the left rear, for example, ODI concluded that an occupant seated in the right center or right rear was most likely to have been ejected through the rear liftgate opening. An occupant seated in the left middle or left rear, on the other hand, was more likely to have been ejected through the side window nearest to the impact point. This was demonstrated during ODI crash tests. In cases where ODI noted physical evidence on a specific open portal (i.e., clothing remnants, hair, blood, etc.), then that specific portal was determined to be the ejection path. For rollover incidents, the resting position of the ejected occupants outside of the van was also used to assess the ejection path.

ODI observed that most ejected occupants were not wearing seatbelts except in the few instances where the entire seat came out with the occupants belted in it, or where the seat belt assembly failed. ODI noted seat bending in some complaint vehicles, and in ODI crash tests. ODI also noted a few reports where the entire seat was ejected during low and moderate speed impacts.

Based on the above parameters, ODI made its best determination of ejection path in all incidents that it collected. As of March 1, 1995, ODI found 80 crash-induced liftgate latch openings, which resulted in an apparent 90 ejections through the liftgate opening in Chrysler minivans, leading to 62 injuries and 29 fatalities.

On March 2, 1995, NHTSA issued a press release asking owners of all vehicles to report liftgate and rear hatch opening incidents that they experienced or witnessed. Following the press release, ODI received 127 additional reports of crash-related liftgate openings in Chrysler minivans, which resulted in a reported 44 liftgate opening ejections, 36 injuries, and 8 fatalities.

Inertial Unlatching Failure Mode: During this stage of complaint and field analysis, ODI received owner reports of rear liftgate openings during low and moderate right rear side impacts. From the submissions and from telephone interviews, ODI noted allegations that the liftgate opened, but the latch remained operational and did not exhibit any structural damage. As a result, ODI became concerned about yet another latch failure mode, that of "inertial unlatching," which leaves the latch with no visible structural damage. Figure 13 illustrates this failure mode.

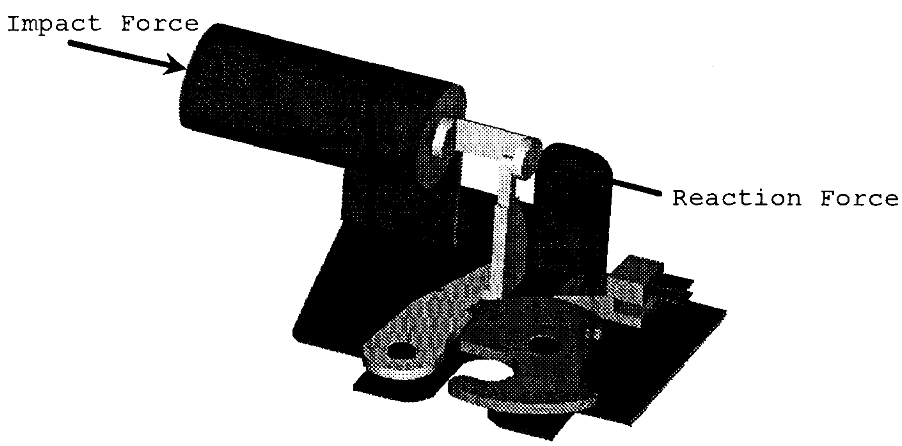

Figure 13. "Inertial Unlatching" Failure Mode

Also, following the press release, ODI received over a hundred complaints alleging liftgate latch release during ordinary vehicle operation. ODI conducted a survey of these owners, inspected vehicles, and performed tests in attempt to duplicate the latch release. Details of these activities can be found in VRTC-75-0363A, "Summary of Inspections and Tests of "Complaint" Vehicles (Non-Impact) Concerning Rear Liftgate Integrity." The following are the major findings of that analysis:

- The rear liftgate latch did not release during tests under relatively severe driving conditions. These conditions included rough roads, railroad crossings, a "bumps" course, and a cobblestone road.

- Three of the five complaint vehicles inspected were found to have corroded, broken electrical contacts for the "gate open" indicator light. Due to this failure, the drivers of the vehicles had no warning indicator telling them when the liftgate was not properly closed. Although this is a possible explanation for some liftgate openings, ODI cannot conclude that all reported unintended openings were caused because the door was not closed properly.

- For 1994 model year minivans with the key fob (remote release located on the key chain), it is relatively easy to unintentionally open the rear liftgate latch. Although there is an audible click of the solenoid when the button is pushed, under noisy or distracting conditions, the owners many not recognize that they have inadvertently opened the liftgate latch.

B. Accident Severity

Throughout the investigation, Chrysler contended that the liftgate latch failure did not pose an unreasonable risk to highway safety because the accidents are unique in nature and represent severe impacts. Hence, Chrysler argued that "since all door latching systems can fail under certain crash conditions, the fact that the latch assembly in the subject vehicles has not withstood certain severe crash conditions is not evidence of a defect in the design or performance of the latch assembly." However, ODI is aware of several accidents that were of relatively low or moderate severity. The following selected cases are examples of incidents that ODI classified as low or moderate damage impacts:

Case #1 (North Carolina, VIN: 1C4GH54R2PX646462)

A 1987 Honda Sedan traveling west did not yield at an intersection and impacted a 1993 Chrysler Town and Country minivan in the left rear. The minivan was traveling south at approximately 5 mph (just pulling out of the intersection). Upon impact, the minivan spun counterclockwise, and the liftgate opened. A 4-year old boy belted in the center of the rear seat was ejected along with the seat through the liftgate. The seat landed upright and the boy suffered only minor scratches.

Upon inspection of the van, ODI noted little damage to the rear liftgate and to the left rear side of the van at the impact point. The upper structure of the van racked, suggesting relative loading of the striker against the latch; the latch exhibited a detent lever-fork bolt bypass. The legs of the ejected seat were bent (racked) in the same manner as the upper structure of the van, suggesting relative movement of the floor against the seat. Photographs depicting the damage can be found in the public file.

Case #2 (Pennsylvania, VIN: 2P4FH4131HR300551)

A 1990 Isuzu Truck traveling south impacted a 1987 Plymouth Voyager in the left rear quarter panel. The minivan was traveling east at approximately 29 mph and failed to see a stop sign. Upon impact, the minivan spun counterclockwise, lost control, flipped, and landed on its left side. The rear seat back collapsed. Two children belted in the rear seat were not ejected and sustained minor injuries. The grandmother, however, who was seated in the middle bench on the right side without a seatbelt, was ejected through the liftgate opening and died.

Upon inspection of the van, ODI noted that the liftgate did not sustain any damage, and the rear window did not shatter. The side of the van exhibited moderate damage, and there was contortion in the top structure of the van, suggesting relative movement of the striker against the latch. The failure mode was a detent lever-fork bolt bypass. Photographs depicting the damage can be found in the public file.

Case #3 (Washington, VIN: 1B4GK54R9NX106246)

A 1992 Dodge Caravan was traveling during an ice storm, lost control, and slid into a barrier. It struck the barrier with its front end first, then with its left rear side. Upon the second impact, the rear liftgate latch opened, and all cargo (luggage and grocery) were thrown out on the highway. All occupants were belted and remained in the van. No injuries were reported.

A review of the post impact photographs revealed that the van sustained little or no damage to the liftgate and minor damage to its left rear quarter panel including the rear tail light. The rear liftgate window did not shatter, and the damage sustained by the front of the van was also minor. Photographs depicting the damage can be found in the public file.

C. Peer Complaint Analysis

During the investigation, ODI requested information from Ford Motor Company (Ford), General Motors Corporation (GM), Nissan Motors (Nissan), Toyota Motor Corporation (Toyota), Mazda (North America) Inc. (Mazda), and VolkswagenWerke, A.G. (VW) to assist in assessing the Chrysler minivan's liftgate latch integrity performance in comparison to that of peer vehicles with liftgates.

Toyota, Mazda, Nissan, VW, and GM reported no similar incidents. Ford reported one lawsuit which involved an Aerostar in which the entire liftgate became detached. Since the beginning of March, ODI received an additional Ford Aerostar report and a Mazda MPV report that alleged rear liftgate openings and ejections.

Because of the low number of complaint reports received, ODI's analysis of complaints could not reveal a common liftgate latch failure mode in peer minivans.

D. Findings

In several crashes, the Chrysler minivan liftgate latches released during low and moderate speed impacts, resulting in liftgate opening ejections, injuries, and fatalities.

Field reports reveal that the Chrysler minivan liftgate latches exhibit a common failure mode, fork bolt-detent lever bypass. There were also unconfirmed consumer reports consistent with the inertial unlatching failure mode.

There is no evidence from the complaint and field analyses conducted on peer vehicles that those vehicles exhibit similar trends with respect to liftgate latch failure.

VIII. CRASH DATA ANALYSIS

During the Engineering Analysis, ODI searched NHTSA's data bases for evidence of crash-induced liftgate openings and of occupant ejection in real-world accidents involving Chrysler and peer minivans. ODI and contractors then conducted analyses of the gathered data. The intent was to identify trends consistent with those found in other areas of the investigation.

NHTSA reviewed the following NHTSA data bases: (A) the Fatal Accident Reporting System (FARS) and (B) the National Accident Sampling System (NASS) Crashworthiness Data System (CDS). FARS provides a census of all fatal crashes in the United States, while NASS is a nationally representative sample of passenger vehicle towaway crashes of all severities. Chrysler also conducted analyses of the FARS and NASS data bases in relation to this investigation.

A. FARS Analysis

FARS has records of all fatal traffic crashes involving Chrysler minivans since 1983, when the minivan was introduced as a model year 1984 vehicle. FARS records the number of ejections that occur in each fatal accident. Also, since calendar year 1991, FARS records the path of occupant ejection, when it is known.

FARS reports 431 occupant ejections (including all ejections, partial and full ejections, and fatal and non-fatal ejections) from the subject minivans for calendar years 1991 through 1994. Of these, the path is known for 92, or 21 percent. The remainder of the ejections are coded "path unknown." The analyses of FARS conducted by ODI in relation to this investigation involved accidents with occupant ejections through the liftgate opening and where the ejection path was unknown. Impact points in the crashes were also considered in an attempt to understand ejection patterns in relation to the point of contact.

In conducting an analysis of the FARS data, ODI performed certain checks to ensure the validity of the analysis. FARS data were analyzed using a statistical significance test at the 0.05 level. Second, the findings from FARS data were viewed in the context of observed real world crash vehicles and laboratory crash and bench test data. And third, surrogate measures for examining the performance of the liftgate latch system were used with the FARS data. Each of these checks is discussed in detail in the following analysis. .

<u>**FARS Limitations**</u>: FARS analysis can measure the risk of rear liftgate opening ejections or compare the risk between various models of vehicles only if the FARS database contains an adequate number of records to conduct analysis that could

yield meaningful findings. In this investigation, the ejection path was important to as an indicator of a failure of the rear liftgate latch system. The ability of FARS to quantify this risk is limited by the years that FARS coders have recorded the ejection path (only since 1991) and the frequency with which the ejection path is known and reported (about 21% of the time for the Chrysler minivans). Moreover, even when the ejection path is coded, the validity of the coding is dependant upon the interpretation of the police officer on the scene. For example, if there is more than one open portal in a crash that involved ejections, the coded ejection path is based on the officer's understanding of the accident parameters.

<u>Rear Liftgate Ejections</u>: ODI examined the 1991 through 1994 FARS files for minivans to provide a count of vehicles in which there was a fatality (referred to as Fatal Vehicles), occupant ejections (fatal and non-fatal), and back-door (liftgate or panel door) ejections. Table 17 provides data for Chrysler minivans and non-Chrysler minivans.

Table 17. FARS 1991 Through 1994 Minivan Data

	Chrysler	Non-Chrysler
Total Fatal Vehicles (FV)	882	1342
Occupant Ejections	431	1152
Ejection FV	247	628
Path Known Ejections	92	240
Path Known Ejection FV	65	166
Back-door Ejections	16	15
Back-door Ejection FV	10	9
Back-door Ejections/ Path Known Ejection	17.39%	6.25%
Back-door Ejection FV/ Path Known Ejection FV	15.38%	5.42%
Back-door Ejection FV/ Total Fatal Vehicles	1.13%	0.67%

Chrysler minivans exhibit higher back-door ejection rates than non-Chrysler minivans, as measured by the ratios in the last three rows of Table 17. The shaded rows indicate a significant difference between Chrysler and non-Chrysler minivans, at the 0.05 significance level.

NHTSA requested DeBlois Associates to perform an analysis of the FARS data to assess the real-world occurrence of rear liftgate openings and rear ejections in

Chrysler minivans and all other minivans. At the time the analysis was performed, only FARS data for 1991 through 1993 calendar years were available. The results of the analysis are described in the report, "Rear Hatch Openings in Highway Crashes," September 1994, available in the public file.

In general, the analysis reported liftgate opening ejection rates per 100 FARS ejectees and liftgate opening ejection rates per 1,000 FARS occupants. Selected results from the study are shown in Tables 18 and 19.

Table 18. Occupant Ejections From Minivans; FARS 1991 through 1993

Occupants by Restraint Use	Makes	Rear Hatch Ejectees per 100 FARS Ejectees
		Rate
Irrespective of Belt Use	Chrysler	14.9
	Non-Chrysler	6.3
Unrestrained	Chrysler	14.3
	Non-Chrysler	5.6

Table 19. Occupant Ejections From Minivans; FARS 1991 through 1993

Occupants by Restraint Use	Makes	Rear Hatch Ejectees per 1000 FARS Occupants
		Rate
Irrespective of Belt Use	Chrysler	15.8
	Non-Chrysler	10.5
Unrestrained	Chrysler	39.3
	Non-Chrysler	21.7

Based on the 1991 through 1993 calendar year data, the subject minivans present a higher reported liftgate ejection rate per 100 FARS ejectees and a higher liftgate ejection rate per 1,000 FARS occupants than the non-Chrysler minivan group.

Analysis of Unknown Ejection Path Crashes: As noted above, about 79% of the ejections from Chrysler minivans reported in 1991 through 1994 FARS are not coded for ejection path (ejection path is unknown). Since FARS is skewed toward very severe accidents, where the vehicles involved may exhibit many open portals, police officers often cannot determine with certainty that an ejection is a liftgate opening ejection or no notation was made in the police report. Hence, ODI conducted an analysis of many of the reported unknown ejection path accidents in an attempt to determine the most likely ejection path. To do this, ODI obtained, from the FARS files, the identification of the police departments reporting specific fatal accidents and requested photographs and any update to the police reports. The criteria for including an accident for this analysis was:

- The ejection path was unknown.
- The date of the accident was 1991 or later.
- The vehicle was a Chrysler minivan or Ford Aerostar (peer vehicle).
- One or more ejected occupants were sitting in the middle or rear seats or in the cargo area behind the seats.
- The accident was not a high severity accident, but single vehicle rollovers were included.

ODI reviewed photographs and, in some cases, other additional information on 29 accidents involving 80 ejections. Eleven of these accidents (30 ejections) involved Aerostars and 18 accidents (50 ejections) involved Chrysler minivans.

The ejection path was reported by the police as unknown for these cases. But the photographs provided additional information that, when evaluated with other details contained in the file of each accident (such as impact location, vehicle motion during accident, the seating position of the ejected person, damage to the vehicle, and final resting position of the victim), enabled ODI to identify the likely ejection path of the occupant from the vehicle. The results are shown in Table 20. The front ejection paths include the front windshield, the front driver and passenger windows and doors; the middle ejection paths include middle windows and side sliding door; and the rear ejection paths include the rear side windows, the rear back windows or liftgate opening. The results of this analysis indicate that both the Aerostar and Chrysler minivans represented in this sample had roughly the same percentage of occupants ejected through the rear of the minivan. Due to the small number of crashes examined, no statistically valid conclusion can be developed from the data.

Table 20. ODI Identification of Likely Ejection Path in Certain Minivan Crashes FARS Coded "Unknown" Ejection Path				
	Ford		Chrysler	
Front Ejection Paths	4	13.3%	6	12.0%
Middle Ejection Paths	4	13.3%	0	0%
Rear Ejection Paths	22	73.3%	40	80.0%
Indeterminant Ejection Path	0	0%	4	8.0%

The seating position for each ejectee in these 29 crashes was recorded in FARS and is shown in Table 21.

Table 21. Seating Position in Certain Crashes FARS Coded "Unknown" Ejection Path				
	Ford		Chrysler	
Front Seat	8	27%	7	14%
Middle Seat	5	17%	13	26%
Rear Seat	4	13%	15	30%
Trunk/Other*	9	30%	12	24%
Unknown	4	13%	3	6%
Total	30		50	

* The area behind the rearmost seat of the minivan

The data show a higher percentage of ejectees occupying the area behind the front seat in Chrysler minivans (80%) compared to Aerostar minivans (60%).

The condition (status) of the liftgate after the accident was evaluated by ODI using the accident photographs. Photographs of the minivan in most of the crashes showed the door to be either detached, fully open, partially open, or closed. In a few cases the condition of the liftgate could not be ascertained. Table 22 presents the results of this analysis.

Table 22. ODI Identification Liftgate Status of Vehicles in Certain Minivan Crashes. FARS Coded "Unknown" Ejection Path.				
	Ford		Chrysler	
Detached	3	27%	3	17%
Fully Open	1	9%	10	56%
Partially Open	7	64%	1	6%
Closed	0	0%	1	6%
Unknown	0	0%	3	17%
Total	11		18	

Typically, the Aerostar liftgates that were classified as partially open showed a gap above one of the taillights while the latch appeared to keep the bottom of the liftgate mostly closed. Based on the photographs, the gaps range from 6 inches to 2 feet. In contrast, a majority of the Chrysler minivans showed a fully open liftgate, while in only one case was the Aerostar liftgate fully open.

Point of Impact on Vehicle: A review of the complaints and field reports reveals a trend of liftgate openings when the Chrysler minivan is impacted on its left-side. This is consistent with ODI's testing of the latch, i.e., the Chrysler latch does not resist force from left-side impacts as well as peer minivan latches. ODI attempted to ascertain whether this trend was evident in the FARS data using the "impact 1" (initial impact) parameter. For all crashes, the FARS analyst records the initial impact point. The impact point is expressed by the numbers 1 through 12, representing the positions on a clock, with 12 o'clock depicting the center front of the vehicle.

For this analysis, ODI obtained data on two-vehicle crashes in which an occupant in a minivan seated behind the front row seat (i.e, in the middle or rear seat) was a fatality. Individuals in those seating positions are most likely to be at risk of ejection through an open liftgate. ODI obtained the number of FARS fatal complete ejections from minivans involved in two-vehicle crashes by initial impact clock position, and compared this to the total number of fatalities that were in those seating positions. The ejection rate is the number of middle/rear seat fatal ejections divided by the total number of middle/rear seat fatalities.

The data are grouped by impact point: front (11, 12, and 1 o'clock), right-side (2, 3, and 4 o'clock), rear (5, 6, and 7 o'clock), left-side (8, 9, and 10 o'clock), and other (under-ride and unknown). The results are shown in Table 23.

The Chrysler minivans show an overall middle/rear seat fatal ejection rate (complete fatal ejections/total fatalities) very similar to the non-Chrysler minivans, 35.4% compared to 36.7%. However, left-side impacts result in a significantly greater percentage of fatal ejections, 37% from the Chrysler minivans compared to 15 % from non-Chrysler minivans. Impacts to the front, right-side and rear do not show a significant difference in the percentage of fatal ejections.

Table 23. Middle/Rear Seat Fatal Ejections Per Middle/Rear Seat Fatalities
Two Vehicle Crashes
Minivans; Model Years 1984 Through 1993
FARS Years 1983 Through 1993

Impact Point	Middle/Rear Seat* Fatal Ejections		Middle/Rear Seat Total Fatalities		Ejectees/Total (Percent)	
	Chrysler	Other	Chrysler	Other	Chrysler	Other
Front	15	24	84	100	17.9	24
Right-side	27	28	59	49	45.8	57.1
Rear	16	21	31	28	51.7	75
Left-Side	15	5	41	34	36.6 **	14.7**
Other	5	1	5	4	100	25
All	78	79	220	215	35.4	36.7

* second and third seat
** significant at the 0.05 significance level

<u>**Chrysler's FARS Analysis**</u>: Chrysler submitted two reports to NHTSA containing its analyses of FARS data. The first was, "Study of Crashworthiness and Risk of Ejection," October 28, 1994. The second was titled "Chrysler Minivan Liftgate Latches," December 13, 1994.

The October 28, 1994 report provides a series of charts and tables showing: 1) the fatality risk for minivans compared to other types of vehicles (station wagons and passenger cars); 2) the fatal ejection risk for minivans and other vehicle types; and 3) the fatal ejection risk through back door opening for minivans.

In its October 28, 1994 report, Chrysler uses many different metrics utilizing FARS data to analyze the safety risk of Chrysler minivans compared to other vehicles. The report indicates that Chrysler minivans are overall safer vehicles than other minivans and many other vehicles based on total fatal vehicles (fatalities for all causes, not just ejections through the liftgate) per million registered vehicle years. Chrysler's analysis further states that FARS data show Chrysler minivans to have a lower fatal occupant ejection rate than most other minivans, as measured by fatal ejected occupants per million registered vehicle years. Similarly, Chrysler reports a lower fatal ejection rate for its minivans than for other vehicles based on fatal ejected occupants per 100 fatal occupants and based on fatal ejected occupants per 100 fatal vehicles. Its analysis of side-impacts using the FARS data shows the rate of fatal ejected occupants per 100 fatal occupants for the Chrysler minivans to be near the average for non-Chrysler minivans. Finally, its estimate of the rate of back door ejections per million registered vehicle years shows Aerostar minivans to have a higher rate than the Chrysler minivans.

In the December 13, 1994 report, Chrysler remarks:

> A review of the FARS data demonstrates that occupants of Chrysler minivans are not overrepresented in ejections in collisions reported in this data base.
>
> The FARS file shows that Chrysler minivans have a lower rate of rearward ejections per collision than the Ford Aerostar. Even when the collisions are limited to those involving an initial or main impact at the 5-6-or 7-o'clock position (the rear of the vehicle), Chrysler's post-collision rearward ejection rate is approximately the same as (actually, slightly lower than) the Ford Aerostar's post-collision rearward ejection rate.

While its December 13, 1994, analysis reports a Chrysler minivan back-door opening ejection risk lower than the Aerostar, it also shows a higher ejection rate compared to all other non-Chrysler minivans. However, the small number of crashes in FARS limit the statistical validity of the differences identified by Chrysler. Its back-door ejection count is based on 1991 through 1993 FARS data, and Chrysler reports finding in FARS only 11 Chrysler vehicle back-door ejections compared with 6 Aerostar and 11 all non-Chrysler back-door ejections. Its analysis shows the lower bound of estimated ejections through the back door per 100 occupants is same for the Chrysler, Aerostar, and all non-Chrysler minivans.

Difference Between Chrysler and ODI FARS Analysis: Chrysler's approach to FARS analysis is to show that the minivans are overall a safe vehicle compared to other vehicles and that back-door ejections are a very small part of the total fatal occupant count. Chrysler provided risk assessment based on total fatal vehicles and total ejections per million registered vehicle years. However, the data counts for back door ejections are small, based on 1991 through 1993 calendar years. As a result, Chrysler's back door ejection comparisons are not statistically significant. Moreover, gross risk measures such as total fatal vehicles or total ejections divided by million registered vehicle years have limitations due to confounding effects such as driver and vehicle characteristics.

ODI used a different approach that examined the data in FARS to identify any trend of ejections through a vehicle's open liftgate that relates to the alleged defect, that of liftgate latch failure. This trend was then evaluated to see if it was consistent with the information acquired through other areas of the investigation, such as field reports, bench testing and full scale vehicle crash testing. Consequently, ODI's analysis was concerned not with the overall fatality rate of the subject vehicles but instead with evidence provided by FARS analysis that would indicate a pattern of ejections through an open liftgate that may relate to a latch defect and its comparison to any pattern or lack of pattern in other minivans.

B. NASS Analysis

ODI requested DeBlois Associates to perform an analysis of the NASS data in order to (1) estimate the number of crash-induced liftgate openings in Chrysler and peer minivans, and (2) classify the failure modes associated with liftgate openings in such vehicles. At the time the analysis was performed, only NASS data for 1988 through 1992 calendar years were available. The results of the analysis are described in the report, "Rear Hatch Opening in Highway Crashes," September 1994, which is in the public file for this investigation.

ODI verified and updated the data through the National Center for Statistics and Analysis (NCSA). The NASS data may be analyzed on a crash-weighted basis. Each case is assigned a weight factor to estimate the national number of towaway crashes of this type for these vehicles.

This section provides a summary of the analyses which include: A) crash mode analysis of Chrysler minivans, non-Chrysler minivans, and other light vehicles, B) crash-induced liftgate opening rates and associated failure modes, and C) ODI analysis of each individual minivan accident with a liftgate opening reported in NASS. .

Crash Mode Analysis: This analysis was performed by DeBlois Associates in order to determine the type of crash that Chrysler minivans experience in comparison to other minivans and other light vehicles, irrespective of rear hatch opening and with rear hatch opening. Table 24 presents the crash mode distribution of all light vehicles.

Table 24. Percentage Distribution of Light Vehicle Crash Modes Irrespective of and with Hatch Opening		
Crash Mode	Crashes Irrespective of Rear Hatch Opening	Crashes with Rear Hatch Opening
Frontal	54.7	3.6
Side	27.7	22.2
Rear	7.7	36.0
Rollover	9.9	38.2

Table 24 demonstrates that vehicles with rear hatch openings exhibit a different percentage distribution among crash modes from those without rear hatch openings. The data indicate that vehicles involved in non-frontal crashes (i.e. , side impacts, rear impacts, and rollover accidents) had a greater percentage of rear hatch openings than vehicles involved in frontal crashes.

Tables 25 and 26 present crash distribution information specific to minivans.

Table 25. Percentage Distribution of Minivan Crash Modes, by Make		
Crash Mode	Chrysler Minivans	Non-Chrysler Minivans
Rollover	4.8	17.9
Side Impact, No Rollover	15.9	22.3
Non-Side, No Rollover	79.3	59.8

Table 26. Percentage Distribution of Minivan Rollover Severity, by Make		
Number of Quarter Turns in rollover	Chrysler Minivans	Non-Chrysler Minivans
1	53.4	23.4
2 to 3	24.2	33.3
4 or more	22.4	43.3

Since rear hatch openings occur at higher rates in non-frontal crashes than in frontal crashes, the non-frontal crash modes were analyzed to examine possible differences between Chrysler minivans and other minivans. The results indicate that (1) Chrysler minivans are under-represented in rollover accidents and side impacts, and (2) when there is a rollover, Chrysler minivans rollover accidents tend to be less severe than those of other minivans as a group, involving mostly one-quarter roll.

Thus, the Chrysler minivans are under-represented in rollover crashes and experience a lower severity of rollover crashes. Rollover crashes, particularly severe rollover crashes in which the vehicle suffers one or more complete turns, tend to produce damage to the vehicle that could be expected to result in liftgate openings. Given the crash distribution described above, Chrysler minivans would be expected to have a lower rate of liftgate opening than other minivans if other things were equal.

Crash-Induced Liftgate Opening Rates: The NASS data were used to estimate the number of liftgate openings in crashes as well as the total estimate of crashes. The ratio of these two estimates was used to determine the number of liftgate openings per 1,000 crashes. Table 27 presents the results for Chrysler minivans and other minivans.

Table 27. Weighted Crash Data from NASS years 1988 through 1994 for Minivans

Vehicle type	Total number of crashes	Total crashes with liftgate opening	Number of openings per 1,000 crashes
Chrysler Minivans	114,619	1,972	17.2
Non-Chrysler Minivans	151,846	1,725	11.4

Based on the weighted samples of crashes involving minivans reported in the 1988 through 1994 NASS files, the liftgate opened in 1.7 percent of Chrysler minivan crashes and 1.1 percent of other minivans. The direction of this difference is contrary to what would have been expected based on the crash mode analysis discussed above.

Liftgate openings may result from one of many component failures in the liftgate retention system. NASS codes failure modes to better define a reason for the opening of the liftgate. Table 28 shows the NASS coded failure mode for Chrysler minivans vs. non-Chrysler minivans.

Table 28. Weighted Failure Mode for Minivan Liftgate Induced Openings; NASS 1988-1994		
Failure Mode	Chrysler minivans	Non-Chrysler minivans
Latch/Striker	1,715	323
Hinge	16	0
Door Structure	29	1,193
Other	212	209

Detailed examination of photographic information included with these cases indicate that many of the door structure failures resulted in partial openings, of which several were near the hinges. Additionally, of the incidents in which "door structure" was the failure mode, most involved rollovers which resulted in structural damage to the liftgate and door structure. Occupant ejection through partial openings which are the result of door structure failure is less likely than ejection through a fully open door. Conversely, based on photographic review, latch failure permits the liftgate to fully open, which increases the likelihood of ejection.

The above data can also be expressed in crash-weighted terms in order to examine the estimated latch/striker related failures as a function of the number of crashes. The results are presented in Table 29.

Table 29. Weighted Number of Latch/striker Related Liftgate Openings for Minivans in Crashes; NASS; 1988-1994			
Vehicle type	Total number of crashes	Total crashes with liftgate opening from LATCH failure mode	Number of LATCH related openings per 1,000 crashes
Chrysler Minivans	114,619	1,715	15.0
Other Minivans	151,846	323	2.1

The above data demonstrate that the latch failure rates for Chrysler minivans is higher than those of other minivans. This is consistent with field data and with ODI's FARS analysis of unknown ejection paths.

ODI also reviewed the pertinent NASS files, which include photographs, in order to better understand the nature of the liftgate opening crashes, the failure mode associated with the openings, and the crash severity. Table 30 lists minivan cases with liftgate openings in the 1988 through 1994 NASS files.

Table 30. NASS Cases of Crash-Induced Rear Liftgate Openings in Minivans

No.	Year	PSU #	Case #	Delta V*, Rollover	Failure Mode	Vehicle
1	88	1	62	Rollover	Door Structure	Aerostar
2	88	9	199	Unk,No Roll	Latch/Striker	Caravan
3	88	43	122	11 mph	Latch/Striker	Voyager
4	88	49	61	Rollover	Other	GMC Safari
5	88	71	163	Rollover	Latch/Striker	Aerostar
6	88	82	140	7 mph	Door Structure	Caravan
7	89	7	81	34 mph	Hinge Failure	Voyager
8	89	48	86	Rollover	Other	Aerostar
9	89	82	71	17 mph	Latch/Striker	Voyager
10	90	9	98	Rollover	Door Structure	Aerostar
11	90	11	209	Rollover	Door Structure	Aerostar
12	91	2	111	Rollover	Other	TranSport
13	91	13	156	Rollover	Latch/Striker	Caravan
14	91	13	242	Rollover	Latch/Striker	Caravan
15	91	78	46	Rollover	Door Structure	Aerostar
16	91	78	118	Rollover	Latch/Striker	Voyager
17	93	3	28	9 mph	Other	Voyager
18	93	5	95	16 mph	Door Structure	Aerostar
19	93	43	68	29 mph	Latch/Striker	Voyager
20	93	75	23	Rollover	Latch/Striker	Mazda MPV
21	94	2	55	Rollover	Latch/Striker	Voyager
22	94	.3	49	Unk,No Roll	Other	Caravan
23	94	13	285	Rollover	Door Structure	Lumina
24	94	43	135	Unk,No Roll	Latch/Striker	Caravan
25	94	75	200	Rollover	Door Structure	Aerostar

* No Delta-V for rollover crashes

The NASS reported delta-V is an indicator of the severity of certain accidents. Generally, ODI considers a lower delta-V value indicates a lower severity accident. For this analysis, delta-V in the range from 0 to 9 mph to be a low severity accident, from 10 to 19 to be a moderate severity accident, from 20 to 29 to be a high severity, accident and at 30 and above to be a critical severity accident.

Delta-V is not an appropriate measure of crash severity for rollover crashes.

Table 30 above reports the delta-V for most of the NASS non-rollover cases involving minivan rear liftgate opening crashes. Several accidents involving Chrysler minivans show low (7 and 9 mph) and moderate (11 and 17 mph) accident severity.

Table 30 also indicates the following:

- The majority of Chrysler minivans with liftgate openings were in non-rollover accidents.
- Some of the Chrysler minivan liftgates opened during low and moderate severity crashes.
- The liftgate latches were the predominant failing components in Chrysler minivans.
- Most of the Aerostar liftgate openings occurred in rollover crashes and most of those liftgate openings were due to failure of the door structure.

Chrysler's Analysis of NASS data: Chrysler contracted with Failure Analysis Associates (FaAA) to conduct several analyses of the 1988 through 1992 NASS data in relation to the investigation. Chrysler reported in its December 13, 1994, submission to NHTSA, which can be found in the public file, that Chrysler minivans had a lower rate of rear liftgate opening than that observed by ODI. A detailed review of the data by NCSA, ODI, and FaAA staff located a case that was not included by FaAA's analysis. FaAA did not include the case because the staff believed that although the accident was a tow-away, the minivan was not towed, hence, did not belong to the NASS data.

ODI's and NCSA's review of the data and NASS coding and operational manuals revealed that this case should be included. The case (shown in Table 30 as Case 2) had a high weight factor, partly due to its low crash severity.

In a February 1, 1995 submission, Chrysler provided ODI with an updated list of vehicles for which it calculated liftgate/rear hatch opening rates per 100 crashes based on NASS data. Chrysler argued that there are 66 other vehicles (revised later to 44) that have liftgate/hatch opening rates in tow-away crashes greater than the rate for Chrysler minivans. The vehicles listed by Chrysler are mostly non-minivans.

C. Findings

Generally, comparisons of vehicle performance in this investigation using FARS and NASS data do not yield statistically significant results. Only 4 years of FARS data have the ejection path coded (years 1991 though 1994). During those years, about 79% of the ejection paths are coded as "unknown path."

Specific accident information in FARS and NASS tends to support observations and findings from the technical areas of this investigation. For example, latch failure of the Chrysler minivans reported in NASS cases appears to be consistent with latch failures observed by ODI and the testing conducted by VRTC. Many of the unknown ejection path incidents in FARS for the Chrysler minivans show evidence of liftgate opening that is consistent with latch failure.

Although the overall ejection rate for Chrysler minivans is lower than its peers, ejection rates through the liftgate opening are higher. Among unrestrained occupants, the 1991-1993 FARS data show Chrysler minivans present a significantly higher rate of liftgate ejectees (39 per 1000 FARS unrestrained occupants) compared to non-Chrysler minivans (22 per 1000 FARS unrestrained occupants).

ODI's review of police reports and photographs for the FARS coded "unknown" ejection path accident cases (involving Chrysler and Aerostar minivans) indicate a higher percentage of the Chrysler minivans had a fully open liftgate and a higher percentage of the ejectees from the Chrysler minivans occupied the area behind the front seats. It would not be unreasonable to expect that of these "unknown" ejectees, a higher percentage were ejected through a liftgate opening in the Chrysler minivans compared to the Aerostar minivans.

The significantly greater ejection rate from Chrysler minivans due to left-side impacts is consistent with the results of VRTC latch bench tests and left-side crash tests conducted on the Chrysler and peer minivans. Chrysler minivans do not show a significantly different right-side impact ejection rate compared to non-Chrysler minivans.

Some of the liftgate openings of Chrysler minivans reported in NASS indicate a low and moderate impact severity as measured by delta-V calculations and as indicated in photographs of those vehicles, which demonstrate very little body damage.

Review of the NASS incidents with liftgate openings reveals that most of the Aerostars were involved in a rollover crash while most of the Chrysler minivans were not. Additionally, the liftgate latches were the predominant failing component in the Chrysler minivan liftgate openings, while most of the Aerostar openings were due to failure of the door structure, which usually results in a partial liftgate opening.

IX. CHRYSLER'S LATCH REPLACEMENT CAMPAIGN

On March 27, 1995, after extensive discussions with NHTSA officials, Chrysler announced that it would replace all latches on 1984 through 1994 minivans to address the fork bolt-detent lever bypass failure mode. On April 27, 1995, Chrysler agreed to address the inertial unlatching issue and expanded its campaign to include all 1995 model year minivans. The campaign will provide all owners with a replacement latch free of charge.

A. Replacement Latch

There are 8 variations of the replacement latch, depending on the model year, the type of switch used to operate the "door open" indicator, and whether the vehicle is equipped with the remote release option. The application for each was discussed in Chrysler's submissions to ODI dated June 2, 1995 and July 21, 1995. Basically, all the replacement latches are based on the 1995 model year latch. The latch with the remote release option has additional improvements to address inertial unlatching.

The improvements include: relocating the solenoid release device from its horizontal axis to a nearly vertical axis; increasing the spring tension in the release spring; redesigning the detent lever to remove some of its inertial mass; and changing the lever action between the solenoid and the detent lever. Figure 15 illustrates the improvements of the replacement latch.

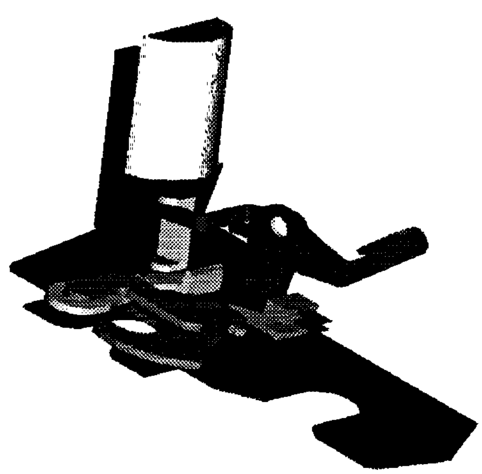

Figure 15. Replacement Latch with the Remote Release Option (1991 through 1995)

B. Testing of the Replacement Latch

Chrysler first developed a prototype latch system. The prototype was subjected to various tests including an "inertial unlatching" evaluation. Upon completion of the prototype testing, Chrysler developed a "production intent" latch, simulating the planned replacement latch. Since the tooling for the production latch was in the process of development, in order to accelerate the implementation schedule of the campaign, Chrysler conducted a series of tests to demonstrate the performance of the "production intent" latch. On August 10, 1995, ODI observed the following tests:

Full Scale Testing: Chrysler conducted a full scale right side impact similar to the test conducted by VRTC for ODI (Test 7, # 950404-1). This test was performed with the "production intent" latch. The impact speed was approximately 31 mph (lateral impact speed was 30 mph), the impact device was a movable deformable barrier, the impact point was just ahead of the right rear wheel, and the impact angle was 75 degrees (i.e., 15 degrees forward of the perpendicular to the vehicle's centerline). Three dummies were restrained in the rear (third) seat of the vehicle. Upon impact, the vehicle rotated clockwise, almost 180 degrees, and the rear liftgate latch remained closed.

ODI observed the installation of the latch, and the removal of the latch. ODI also took possession of the latch for a later metallurgical analysis.

Dynamic Tests: Chrysler demonstrated that new latch is not susceptible to inertial unlatching during a crash by accelerating it on a HYGEE sled. Eight latches, mounted in pairs, were installed on the sled in four different orientations, representing the direction of the force acting on the vehicle when impacted from the front, right side, left side, and rear. The sled was accelerated with a sine-shaped pulse. The peak acceleration was 30.5 gs, and the change in velocity was 29.3 mph. None of the latches opened due to the inertial loading of the sled.

ODI observed the installation of the latches and took possession of all eight latches for a later analysis.

Vertical Stimulation Tests: The new orientation of the solenoid could make the latch sensitive to accelerations in the downward direction. Downward acceleration occurs when a vehicle rebounds after hitting a bump (i.e., pot hole, curb, etc.). During the sled test, the latches were not oriented in a direction that simulates vertical acceleration. Instead, to test the performance of the latches in response to inertial effects in the vertical direction, especially the downward direction, Chrysler conducted two evaluations: 1) a bump test , and 2) rough road driving tests.

Bump Test: During this test, a Chrysler minivan was impacted into a vertical bump at 30.2 mph. The bump was approximately 6 inches tall and 4 feet long. The vehicle was equipped with accelerometers to document the acceleration of the latch in the vertical direction. Upon impacting the bump, both front wheels bent and flattened. The rear wheels were also bent, but not sufficiently to allow the air in the tires to escape. The liftgate latch did not open during the test. The acceleration value in the vicinity of the latch was approximately 10 g's.

Driving test: To evaluate the reorientation of the solenoid during normal vehicle operation, Chrysler drove the minivan with the replacement latch installed over a collection of rough road surfaces. The liftgate latch remained closed.

ODI also requested latch acceleration data for two courses which appeared to cause the highest acceleration levels (vertical direction) in the vicinity of the latch/striker assembly: the Cobble Stone surface and the Transverse Trough surface. The intent was to compare the acceleration data of the latch during rough surface driving with those collected during the bump impact.

The data was processed to determine the peak vertical accelerations in the downward direction near the latch. The values were 1.5 g's for the Cobble Stone surface and 1.2 g's for the diagonal trough. These values are about 7 times less than those obtained during the bump test. The bump test, which appears to be more severe than the worst case rough road driving condition, did not result in a liftgate opening.

Except for the latch used during the driving test, all test latches were collected by ODI. ODI compared the design, layout, and material composition of the "production intent" latches to those of the production latches that would be installed as replacement latches in owners' minivans.

ODI staff randomly selected the production latches from the assembly line for the purpose of this evaluation. The details of the comparative tests and results can be found in VRTC reports: "Hardness Testing of 1984-89 Chrysler Minivan Replacement Latch Plates," (VRTC-75-0363F), and "Tests to Compare New Liftgate Latches for Chrysler Minivans (EA94-005)," (VRTC-75-0363C). In general, the "production intent" latches tested by Chrysler in August 1995 appear to have the same design and material composition as the production latches.

C. Finding

The replacement latch will address the safety concerns raised during the investigation.

Safety Defects Engineer — Date: 10-25-95

I concur:

Chief, Vehicle Integrity Branch — Date: 10-25-95

Director, Office of Defects Investigation — Date: 10-25-95