15-Passenger Van Single-Vehicle Rollover Accidents, Henrietta, Texas, May 8, 2001, and Randleman, North Carolina, July 1, 2001

Highway Accident Report

NTSB/HAR-03/03

PB2003-916203
Notation 7567

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National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2003. ***15-Passenger Van Single-Vehicle Rollover Accidents, Henrietta, Texas, May 8, 2001, and Randleman, North Carolina, July 1, 2001.*** **Highway Accident Report NTSB/HAR-03/03. Washington, DC.**

Abstract: On May 8, 2001, a 1993 Dodge 15-passenger van was eastbound on U.S. Route 82 near Henrietta, Texas. The driver and 11 passengers, all members of the First Assembly of God Church in Burkburnett, Texas, occupied the van. As the vehicle approached milepost 538, the left rear tire experienced a tread separation and blowout; subsequently, the van departed the roadway and rolled over at least two times, ejecting seven passengers. The driver and three of the ejected passengers sustained fatal injuries, and eight passengers sustained serious injuries.

On July 1, 2001, a 1989 Dodge Ram 15-passenger van was northbound in the left lane on U.S. Route 220, near Randleman, North Carolina. The van, owned by Virginia Heights Baptist Church of Roanoke, Virginia, was occupied by the driver and 13 passengers. As the vehicle approached the Level Cross, North Carolina, exit, the left rear tire experienced a tread separation and blowout; subsequently, the van overturned, ejecting four passengers. One ejected passenger was fatally injured, and three sustained serious injuries; the driver and nine passengers sustained injuries ranging from none to serious.

The major safety issues discussed in this report are 15-passenger van classification, driver training, occupant protection, and tire condition, inspection, and maintenance.

As a result of its investigation of these accidents, the Safety Board made recommendations to the National Highway Traffic Safety Administration, the Federal Motor Carrier Safety Administration, the 50 States and the District of Columbia, the American Driver and Traffic Safety Education Association, the American Automobile Association, the National Safety Council, the American Association of Motor Vehicle Administrators, Ford Motor Company, and General Motors Corporation.

Contents

Acronyms and Abbreviations

AAMVA	American Association of Motor Vehicle Administrators
CFR	*Code of Federal Regulations*
DaimlerChrysler	DaimlerChrysler Corporation
EDVSM	Engineering Dynamics Corporation's Simulation Model
FMCSA	Federal Motor Carrier Safety Administration
FMVSSs	*Federal Motor Vehicle Safety Standards*
FMVSS	Federal Motor Vehicle Safety Standard
Ford	Ford Motor Company
GVWR	gross vehicle weight rating
GM	General Motors Corporation
HVE	Human Vehicle Environment
NHTSA	National Highway Traffic Safety Administration
psi	pounds per square inch
STL	Standards Testing Laboratories, Inc.
TREAD Act	Transportation Recall Enhancement, Accountability, and Documentation Act of 2000

Executive Summary

On May 8, 2001, about 8:57 a.m., central daylight time, a 1993 Dodge Ram 15-passenger van was eastbound on U.S. Route 82 near Henrietta, Texas, en route from Burkburnett, Texas, to an outlet mall in Gainesville, Texas. The driver and 11 passengers, all members of the First Assembly of God Church, occupied the van. As the vehicle approached milepost 538 in the left lane, at a calculated speed of 61 to 67 mph, the left rear tire experienced a tread separation and blowout; subsequently, the van departed the roadway and rolled over at least two times in the median, ejecting seven passengers before coming to final rest. The driver and three of the ejected passengers sustained fatal injuries, and eight passengers sustained serious injuries.

On July 1, 2001, about 2:30 p.m., eastern daylight time, a 1989 Dodge Ram 15-passenger van was northbound in the left lane on U.S. Route 220, near Randleman, North Carolina, en route from Myrtle Beach, South Carolina, to Roanoke, Virginia. The van, owned by Virginia Heights Baptist Church of Roanoke, Virginia, was occupied by the driver and 13 passengers, ages 13 to 19. As the vehicle approached the Level Cross, North Carolina, exit, at a witness-estimated speed of 65 mph, the left rear tire experienced a tread separation and blowout; subsequently, the van moved from the left lane into the right lane, then back into the left lane, where it overturned and came to rest in the travel lanes. During the accident sequence, four passengers were ejected, one of whom was fatally injured and three of whom sustained serious injuries; the driver and the other nine passengers sustained injuries ranging from none to serious.

The National Transportation Safety Board determines that the probable cause of the accidents was tire failure, the drivers' response to that failure, and the drivers' inability to maintain control of their vans. Contributing to the accidents was the deteriorated condition of the tires, as a result of the churches' lack of tire maintenance, and the handling characteristics of the vans. Contributing to the severity of the injuries was the lack of appropriate *Federal Motor Vehicle Safety Standards* applicable to 15-passenger vans in the areas of restraints and occupant protection.

The major safety issues discussed in this report are 15-passenger van classification, driver training, occupant protection, and tire condition, inspection, and maintenance.

As a result of its investigation of these accidents, the Safety Board makes recommendations to the National Highway Traffic Safety Administration, the Federal Motor Carrier Safety Administration, the 50 States and the District of Columbia, the American Driver and Traffic Safety Education Association, the American Automobile Association, the National Safety Council, the American Association of Motor Vehicle Administrators, Ford Motor Company, and General Motors Corporation.

Factual

Henrietta, Texas

Accident Narrative

On May 8, 2001, about 8:57 a.m., central daylight time, a 1993 Dodge Ram 15-passenger van was eastbound on U.S. Route 82 near Henrietta, Texas, en route from Burkburnett, Texas, to an outlet mall in Gainesville, Texas (see figure 1). Eleven passengers and a driver, all members of the First Assembly of God Church, occupied the van. As the van approached milepost 538 in the left lane, at a calculated speed[1] of 61 to 67 mph, the left rear tire experienced a tread separation and blowout; subsequently, the van departed the roadway and rolled over at least two times in the median, ejecting seven passengers before coming to final rest (see figure 2). The driver and three of the ejected passengers sustained fatal injuries, and eight passengers sustained serious injuries.

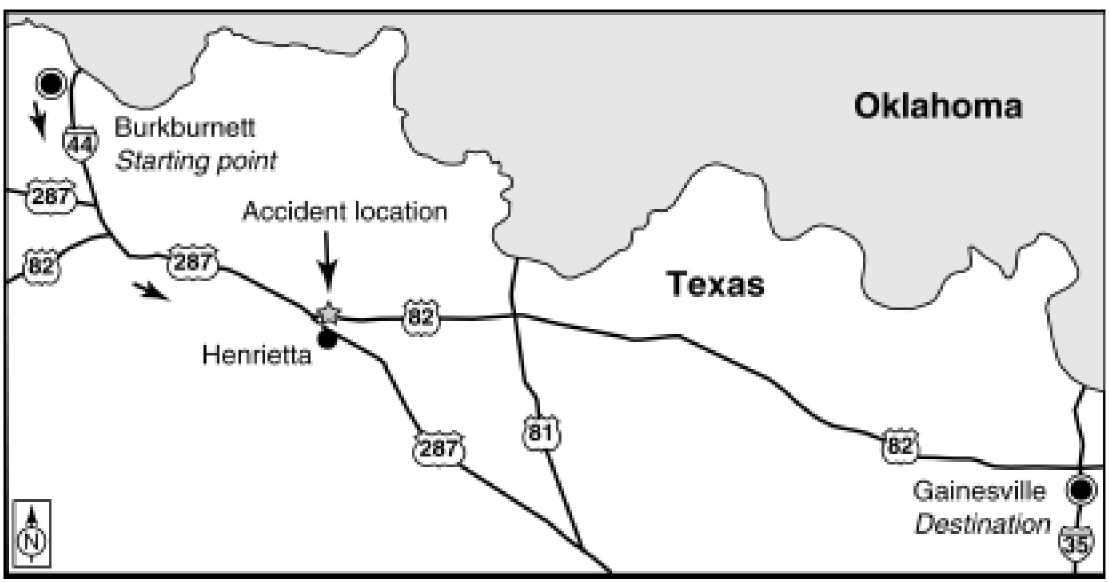

Figure 1. Henrietta accident route.

[1] The speed was calculated as part of the accident simulation. See Vehicle Dynamics Simulation section below.

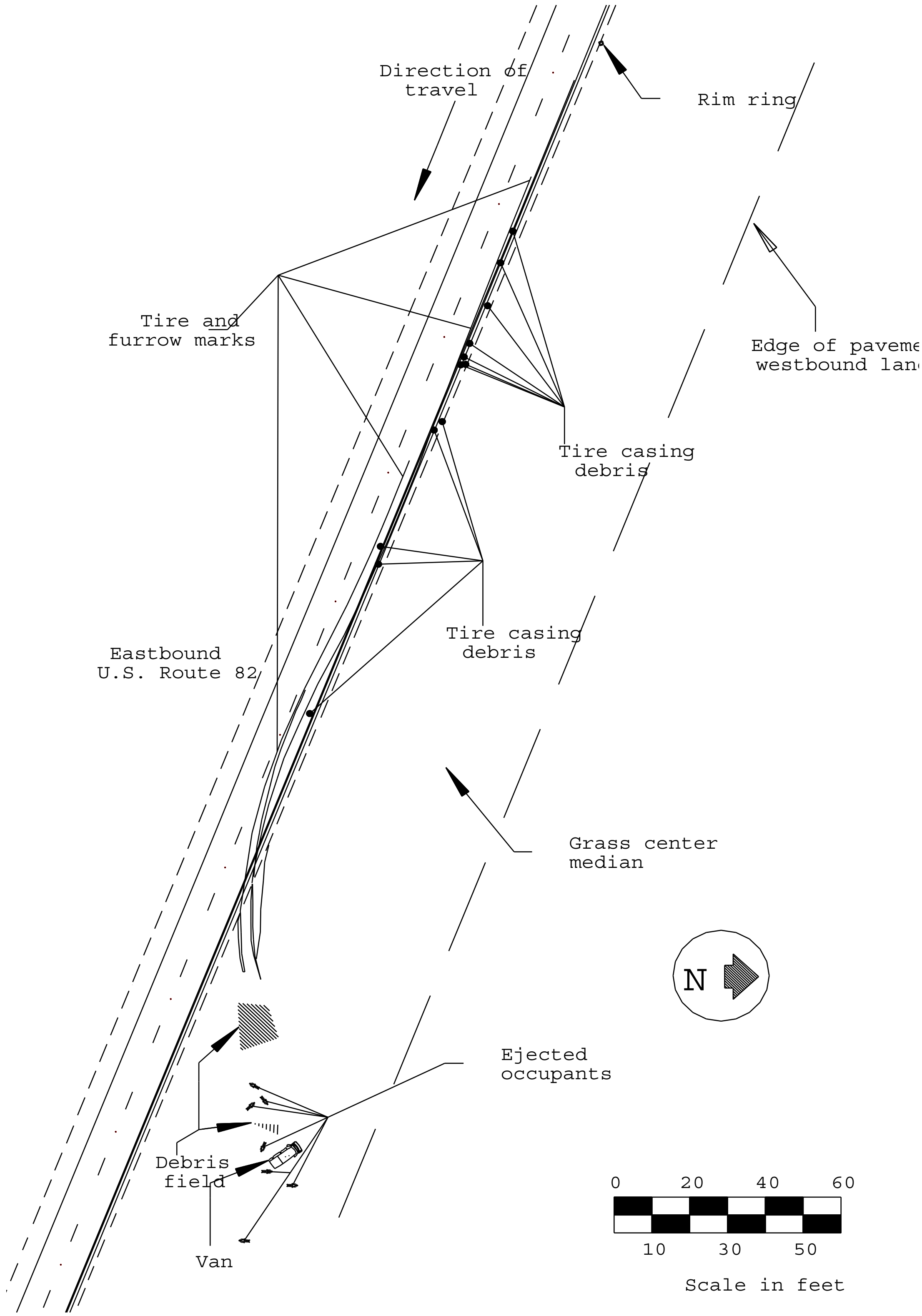

Figure 2. Henrietta accident scene.

According to the pastor of the church, a group of parishioners had scheduled a trip to the Texas Outlet Centers in Gainesville, Texas, one of about four trips the group makes each year. The church, which owned the van, provided transportation for the trips at no cost to the group members. The trip began at the church parking lot about 8:30 a.m. Gainesville is about 100 miles from Burkburnett, and the trip would have taken about 2 hours to complete. The van had traveled about 34 miles from the church when the accident occurred.

According to one passenger, she heard what she said was a sound "similar to a muffled gunshot," and she believed that it was a tire blowout. She stated that as soon as she heard the noise, the vehicle began to swerve and then departed the roadway. A witness driving in the right lane at a witness-estimated distance of about 200 yards behind the accident van said that the van swerved left off the edge of the pavement and then returned to the road, but the back end of the van slid to the right and then off the left side of the road into the median before the van began to roll. This witness thought the van rolled "four or five times at least." Another witness, traveling in the right lane approximately three vehicles behind the van, stated that he saw rubber come out from under the van when "it had a blowout." He said that he saw the van brake and then it "bobbled" back and forth a few times before sliding into the median. This witness stated that "the vehicle rolled onto its right side and over, then end-to-end once, and then rolled over on its side two more times."

Injuries

Table 1. Injuries.[2]

Injuries	Driver	Passengers	Total
Fatal	1	3	4
Serious	0	8	8
Minor	0	0	0
None	0	0	0
Total	1	11	12

Medical and Pathological Information

Four of the van passengers, including the driver, sustained fatal injuries as a result of the accident. The driver, who was wearing a lap/shoulder belt, sustained multiple skull fractures, brain avulsion,[3] bilateral lung contusions, fractured sternum, fractured right ribs

[2] 49 *Code Federal Regulations* (CFR) 830.2 defines a fatal injury as any injury that results in death within 30 days of the accident. It defines a serious injury as an injury that requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; results in a fracture of any bone (except simple fractures of the fingers, toes, or nose); causes severe hemorrhages, nerve, muscle, or tendon damage; involves any internal organ; or involves second or third degree burns, or any burns affecting more than 5 percent of the body surface.

[3] An avulsion is a separation or detachment.

1 through 7, fractured left clavicle, fractured left ribs 1 through 8, abraded contusions to the right hand and abrasions and lacerations of the left forearm and elbow. The fatally injured passenger in seat 3 (see figure 3) was ejected and sustained a large gaping laceration of the scalp; C1 and C2 vertebrae fractures with partial dislocation into the spinal canal and laceration of the spinal cord; spleen laceration; liver pulpification; laceration of the inferior vena cava; fractured right ribs 1 through 9; fractured left ribs 1 through 11; fractured right clavical, pelvis, left femur, left radius, and ulna; multiple abrasions; contusions; and lacerations. The fatally injured passenger in seat 9 was ejected and sustained a deep laceration to the right femoral region extending into the anterior right thigh and a large scalp laceration.[4] The fatally injured passenger in seat 12 was ejected and sustained a C2 vertebra fracture with partial dislocation into the spinal canal and transection of the spinal cord and medulla, liver lacerations, fractured right posterior pelvis, dislocation of the left femur head, and multiple contusions and abrasions.

Seat	Age	Belt Use	Injury
1	62	Lap/shoulder	Fatal
2	55	Lap/shoulder	Serious
3	59	None	Fatal
4	62	None	Serious
5	63	None	Serious
6	51	None	Serious
8	59	None	Serious
9	71	None	Fatal
11	71	Lap	Serious
12	62	None	Fatal
14	74	None	Serious
15	68	None	Serious

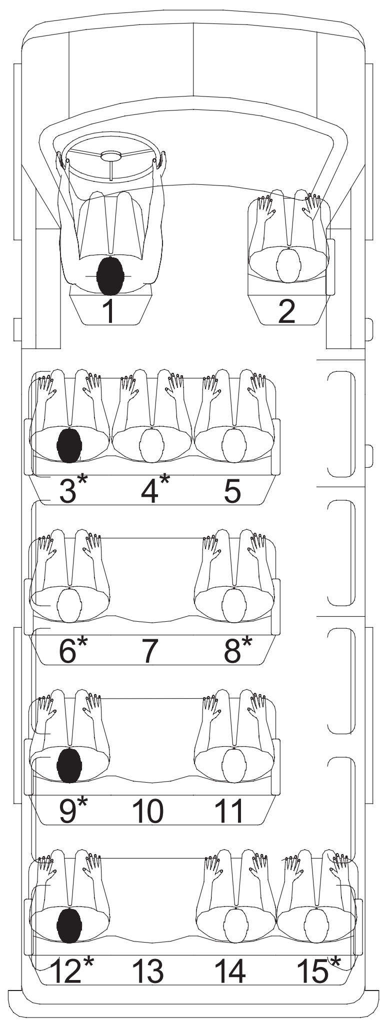

Figure 3. Henrietta seating chart. (*ejected; shading indicates fatal injuries)

4 This passenger was not autopsied, and no further information on her injuries was available.

The remaining eight passengers, four of whom were ejected, sustained serious injuries. The passenger in seat 2 was wearing a lap/shoulder belt. She sustained multiple right rib fractures with right pneumothorax[5] and multiple contusions and abrasions to the scalp, thorax, and lower frontal abdomen. The passenger in seat 4 was ejected and sustained a splenic injury, right hip fracture, brain hemorrhage, and multiple abrasions and contusions. The passenger in seat 5 remained within the vehicle and sustained a closed fracture of the acetabulum,[6] a closed fracture of the scapula, and multiple rib fractures. The passenger in seat 6 was ejected and sustained a closed C5 vertebra fracture, right rib fractures, and multiple abrasions, contusions, and lacerations. The passenger in seat 8 was ejected and sustained bilateral brain hemorrhages, multiple rib fractures, a lung contusion, radius shaft fracture, and multiple contusions and abrasions. The passenger in seat 11 was wearing a lap belt and remained within the van. She sustained a right ulna fracture, forehead and chest contusions, lacerations, and abrasions. The passenger in seat 14 remained within the vehicle and sustained a major scalp avultion, left first rib fracture with right lung contusion, laceration of the wrist, and multiple abrasions and contusions. The passenger in seat 15 was ejected and sustained liver injury, right kidney injury with hemorrhage, right rib fractures, head laceration, and right side extremity contusions.

Survival Aspects

The driver was wearing a lap/shoulder belt, as was the front seat passenger. The left outer seating positions on each of the four rows and the right outer seating position in the fourth row were equipped with lap/shoulder belts. All remaining seating positions were equipped with lap belts. Only the passenger in seat 11 was wearing the lap belt restraint. Of the nine unrestrained passengers, seven were ejected.

Emergency Response

At 8:57 a.m. the Clay County (Texas) Sheriff's Office received a 911 call reporting the accident. Within 2 minutes, the first ambulance with emergency medical personnel was dispatched from the Clay County Memorial Hospital. Two minutes later, a Clay County Sheriff's unit was dispatched and en route to the accident site. When the emergency medical personnel arrived on scene and reported the severity of the accident and the number of injured, the mutual aid plan was initiated for Clay County fire and medical response. A total of 14 medical personnel responded to the scene in eight emergency vehicles. Fire response included local departments from Henrietta, Dean, and Jolly, Texas. Law enforcement units from the Texas Department of Public Safety State Highway Patrol also responded.

An informal critique of the emergency response was held after the accident. According to a captain with the Clay County Sheriff's Office, who was also a volunteer firefighter with the Henrietta Fire Department, the issues addressed as a result of the response were minor and not documented. Overall, according to the captain, the response

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[5] Pneumothorax is a condition in which air or other gas is present in the pleural cavity; it occurs spontaneously as a result of injury to the lung tissue or puncture of the chest wall.

[6] The acetebulum is the cavity at the base of the hip bone into which the head of the femur fits.

went well and all patients were transported from the scene within 22 minutes of the dispatch call. The only issues for improvement discussed during the critique were the initial assessment of the severity of the accident and the response resources required. As a result, a review of the mutual aid plan was conducted.

Driver Information

At the time of the accident, the 62-year-old driver held a Texas class C, noncommercial driver's license, valid through July 8, 2005, with a corrective lens restriction. A review of Texas Department of Public Safety records revealed no traffic convictions or accidents.

A 72-hour history of the driver's activities was constructed based on an interview with the driver's husband and is shown in table 2.

Table 2. Henrietta van driver 72-hour history.

Date	Time	Activity	Sleep
May 4, 2001	10:00 p.m. – 10:30 p.m.	Went to bed	
May 5, 2001	5:30 a.m.	Awoke	7 – 7.5 hours
	6:15 a.m. – 8:00 a.m.	Travel/shopping	
	8:00 a.m. – 6:00 p.m.	Sales at flea market (with light lunch)	
	6:00 p.m.	Dinner	
	8:00 p.m. – 8:30 p.m.	Went to bed	
May 6, 2001	8:00 a.m.	Awoke	11.5 – 12 hours
	11:30 a.m. – 4:00 p.m.	Shopping (lunch between 2:30 p.m. and 3:00 p.m.)	
	8:00 p.m. – 9:00 p.m.	Went to bed	
May 7, 2001	8:00 a.m.– 9:00 a.m.	Awoke	11 – 13 hours
	Daytime	Shopping/worked in yard	
	6:00 p.m. – 7:00 p.m.	Dinner	
	10:00 p.m.	Went to bed	
May 8, 2001	6:30 a.m.	Awoke	8.5 hours
	7:30 a.m.	Departed home after breakfast to pick up van	
	8:00 a.m. – 8:30 a.m.	Departed in van	

According to the driver's husband, the driver was familiar with the accident van; she had driven the 15-passenger van for the church for about 15 years. Her husband stated that prior to the accident, she had been driving the van at least once a week locally and drove on longer distance highway trips about six or seven times per year.

The driver had Crohn's Disease,[7] requiring a strict diet, as well as high cholesterol and arthritis, according to her husband. He stated that she took Tylenol for the arthritis but was not taking any other medications. She wore photoreactive prescription sunglasses when she drove. Toxicological tests of the driver's blood by the Civil Aeromedical Institute were negative for alcohol or other drugs.

Vehicle and Wreckage Information

Exterior. The 1993 Dodge Ram 350 Maxi-Wagon was configured to accommodate 15 passengers, including the driver. The vehicle had a wheelbase of 127.6 inches, an overall length of 222.8 inches, and a gross vehicle weight rating (GVWR)[8] of 8,510 pounds. The van was equipped with a 5.9-liter fuel-injected V-8 gasoline engine and a four-speed automatic transmission; it had an odometer reading of 44,156 miles. Inspection of the suspension system revealed no anomalies.

The van was equipped with front disc brakes and rear antilock drum brakes. When the brakes were applied, both front wheel hubs remained locked without creep or slippage. The front brake friction surfaces were smooth and did not show excessive grooving or wear ridging. The friction surfaces of the rear brakes were smooth with slight wear ridging on the edges of the drums. Examination of the brake system revealed no hydraulic system leaks or restrictions. The brake pedal was intact and functional.

The van was equipped with a hydraulic power-assisted steering system, a 15-inch concentric two-spoke steering wheel, and tilt steering column. The steering wheel and column were pushed rearward and to the right due to accident damage. Rotating the steering wheel resulted in a correlating movement of the steering box sector shaft, as well as the associated steering system components. No excessive play or wear was observed within the steering system components. The steering wheel could be rotated from stop to stop without restriction other than resistance due to the damaged column.

All four tires were manufactured by Michelin and conformed to the size for the vehicle recommended by the manufacturer. The tread depths complied with Texas vehicle inspection criteria. Both front tires were inflated to 60 pounds per square inch (psi) and the right rear tire was inflated to 58 psi. The pressure of the left rear tire prior to the blowout could not be determined. The manufacturer recommended a tire pressure of 55 psi for the front tires and 80 psi for the rear tires. A placard containing this information was located on the inside of the driver's doorsill. The left front and both rear tires were more than 8 years old.

The left front tire exhibited extensive circumferential sidewall (see figure 4) and tread groove cracking (see figure 5). According to the manufacturer, the cracking was due to weather and is commonly referred to as weather checking, that is, surface cracks in the exterior tire rubber. Written in yellow crayon on the sidewall were the words "RE-

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[7] Crohn's disease causes chronic inflammation in the gastrointestinal tract. Symptoms are typically controlled through diet, drugs, nutritional supplements, and surgery.

[8] GVWR is the maximum weight of the vehicle plus passengers and any cargo the vehicle can carry.

INFLATE TO 60 PSI." The right front tire had sustained a circumferential cut along the outer shoulder and tread; otherwise, examination revealed no anomalies. The right rear tire exhibited circumferential scrubbing,[9] as well as soil or dirt and grass between the flange/bead seat and the tire.

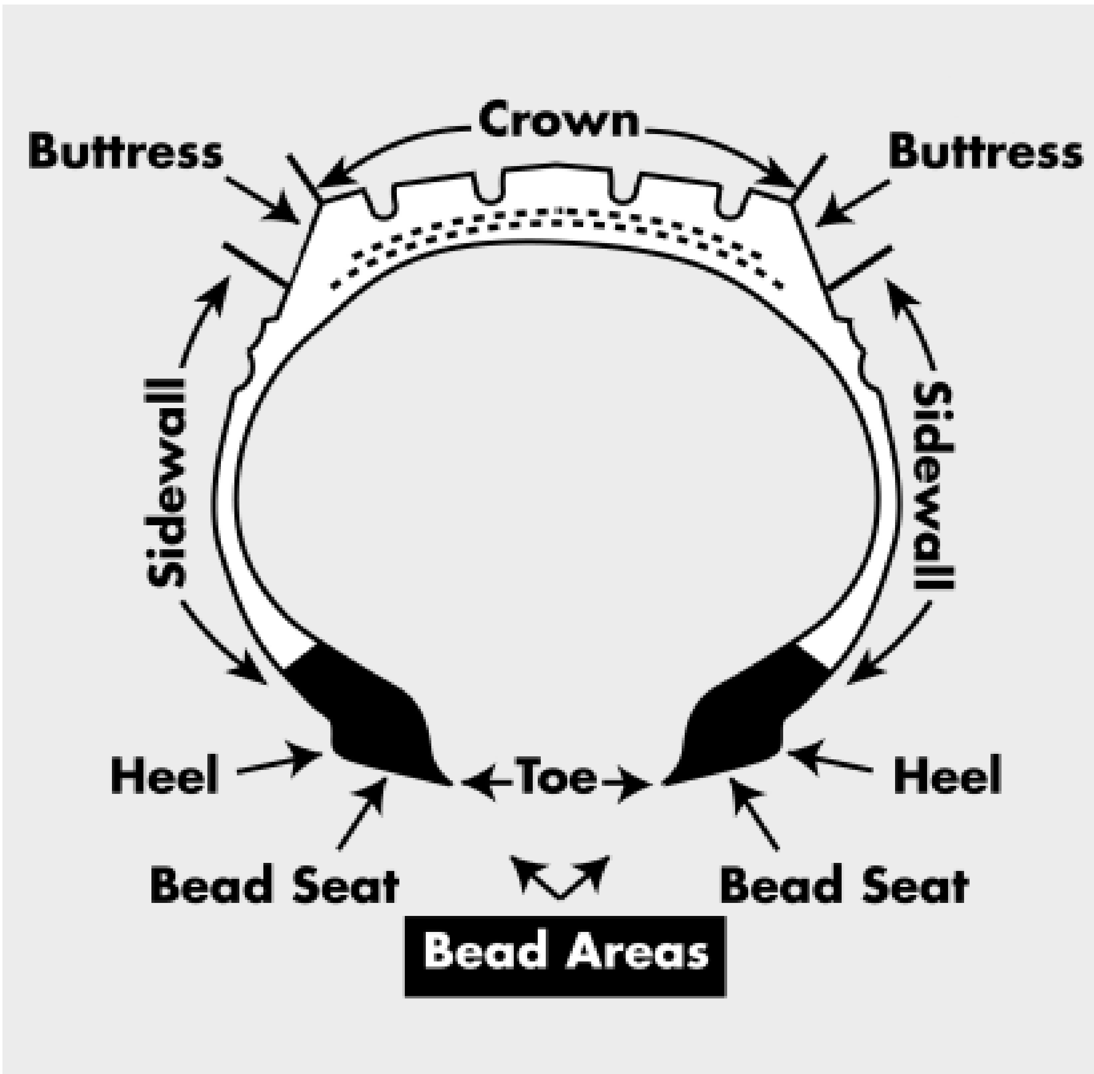

Figure 4. External tire diagram. Source: Michelin.

[9] Scrubbing is the action of rubbing the tire surface against another surface, for example, sidewall against curb or tread surface against the road.

Figure 5. Left front tire tread groove cracking.

The left rear tire (see figure 6) sustained extensive damage to the inner and outer sidewalls and tread, exposing the body plies[10] and inner liner (see figure 7). The tire exhibited extensive circumferential cracking and deterioration of the sidewall and bead areas, which the manufacturer attributed to weather. Radial splits and abrasions were noted on the sidewalls, as was severe weather checking. The tread and belt components were partially detached from the tire. Where the bottom belt remained attached, it was separated from the body ply along the interior edge. A nail found embedded in the detached tread and top belt piece had not penetrated all components. Another puncture hole, extending through all components, was found. The inner liner was split radially.

[10] Layers of fabric that make up the tire body.

Figure 6. Left rear tire.

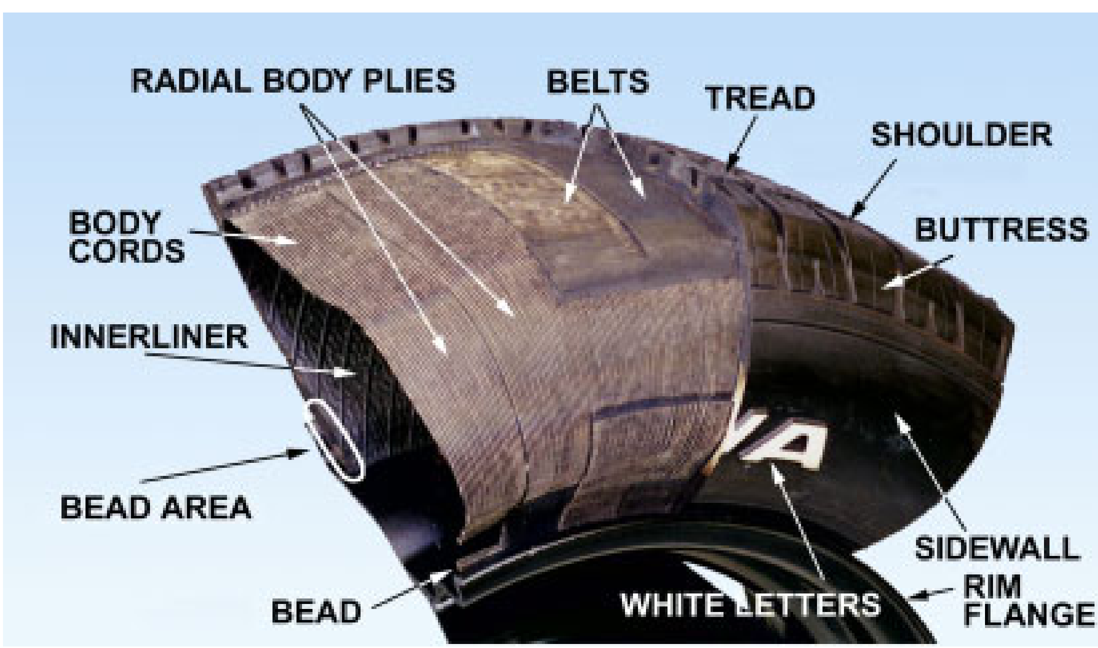

Figure 7. Inner tire diagram. Source: Michelin.

Interior. The van had driver and front passenger bucket seats, three rows with seating for three passengers each, and a fourth row with seating for four passengers. All four rows of passenger seats were intact.

Lap belts were attached to the seat frame for passengers in the middle and right aisle seats of the first three rows. Lap belts for two middle seats in the fourth row were attached to the floor behind the seat frame (see figure 8). A single bolt near the right seat frame pedestal base secured the two webbing straps with buckles to the floor for these two middle seats; the two webbing straps with latch plates were bolted to the floor near the left seat frame pedestal base. DaimlerChrysler Corporation (DaimlerChrysler) engineers stated that they were unable to determine why the anchorages had been designed in such a manner. As a result of this configuration for the fourth row lap belts, the two buckles were on the right side of the seat, and the two latch plates were on the left side of the seat (see figure 9); they had to cross one another in order to buckle the belts (see figure 10).

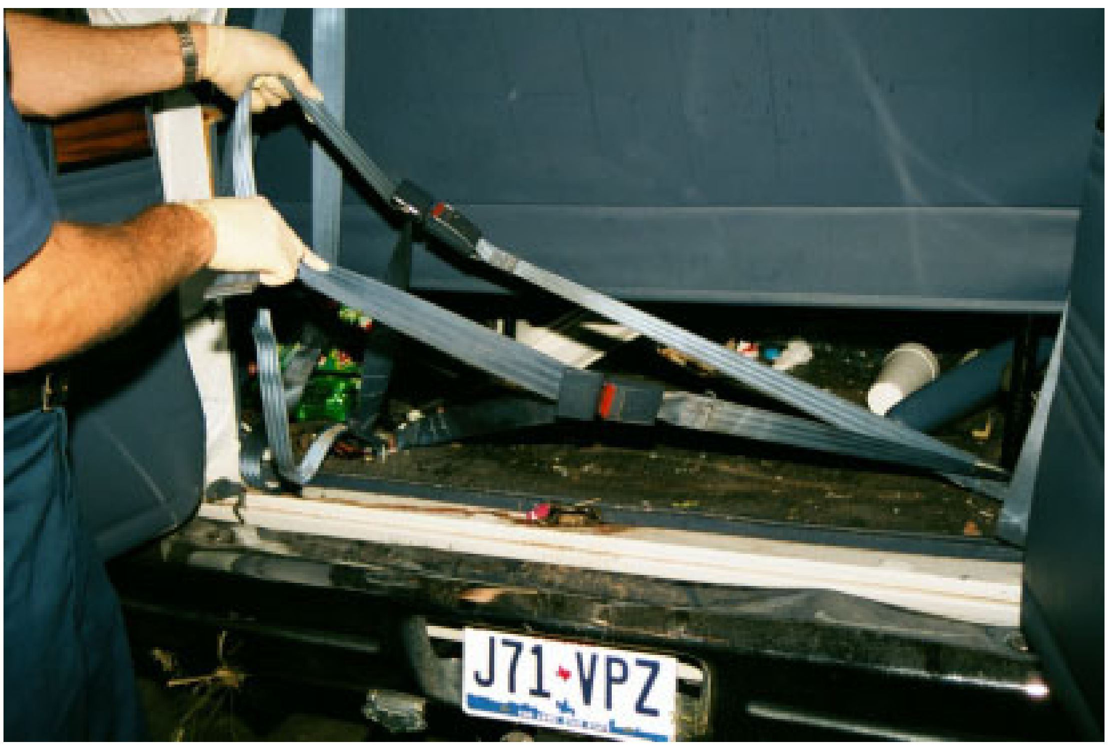

Figure 8. Fourth row lap belt attachments.

Figure 9. Fourth row center lap belt configuration.

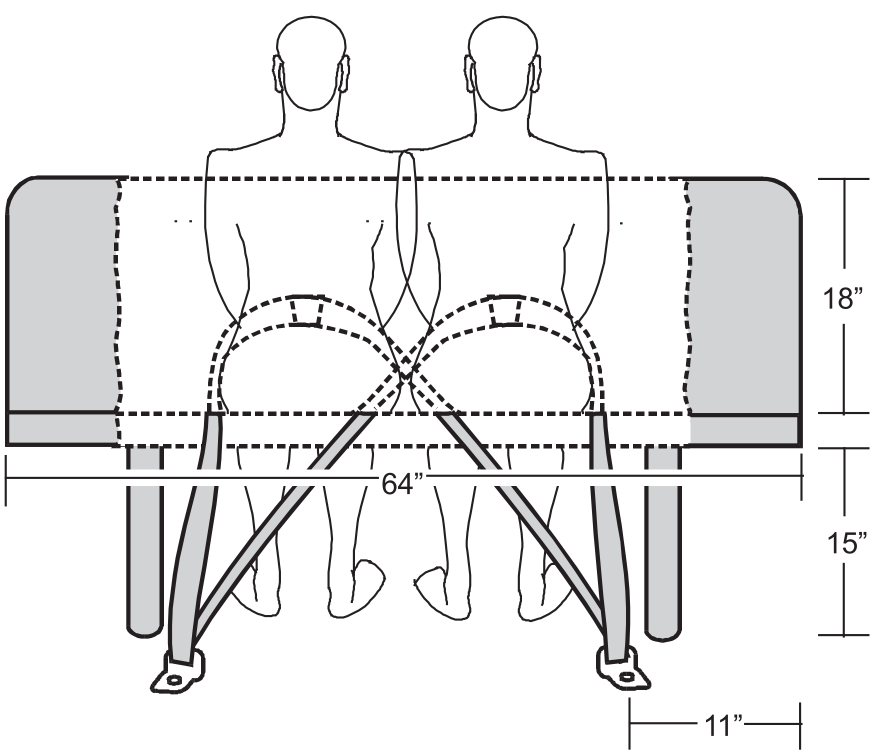

Figure 10. Fourth row center lap belts in use.

The roof of the van was deflected to the right and downward (see figures 11 and 12), damaging all the pillars that supported the roof. The pillar behind the driver was in contact with the headrest of the driver's seat and protruded 17 inches into the passenger compartment over the second row of seats. The roof shifted to the extent that the first and second rows of seats extended 16 inches beyond the edge of the roof, the third row extended 15 inches, and the fourth row extended 8 inches. The distance between the top of the seat and the roof at the point of maximum crush was 5.5 inches in the first row, 6 inches in the second row, 4 inches in the third row, and 5 inches in the fourth row. Investigators compared these measurements to those for an undamaged, exemplar 1999 Dodge Ram van, which had a distance between the seatback and the roof of 22 inches in the first row, 20 inches in the second row, 18 inches in the third row, and 18.5 inches in the fourth row.

Figure 11. Henrietta van roof crush.

The front windshield and rear door windows were found outside the van at the accident scene. The driver and passenger window glazing was missing, as was the glazing on the three passenger windows on the driver's side and the glazing on the four passenger windows on the passenger side.

Highway Information

U.S. Route 82 in Texas is primarily a four-lane divided, controlled-access highway with exit and entrance ramps and a posted speed limit of 70 mph (daytime) and 65 mph (nighttime) at the accident location. The 12-foot-wide traffic lanes were divided by 4-inch wide pavement markings consisting of reflectorized painted white lines, approximately 12

Figure 12. Front of Henrietta van.

feet long and spaced every 28 feet. Four-inch-square raised pavement markers (retroreflective delineators) were spaced 80 feet apart and were centered between every other painted white line. The lanes were separated from the shoulders by a 4-inch-wide white edgeline delineating the 10-foot-wide outside shoulder and a 4-inch-wide yellow edgeline delineating the 4-foot-wide inside shoulder. Each shoulder had milled rumble strips, 9 inches wide, 18 inches long, and 0.5 inch deep, spaced 6 inches apart and located 6 inches from the edge of the traffic lane. The eastbound and westbound traffic lanes were separated by a 120-foot-wide depressed earthen median at the accident location.

The average annual traffic volume was 18,000 vehicles in 1998 and 1999. From 1997 to 2002, the Texas Department of Transportation reported a total of 63 accidents on U.S. Route 82 in an area 2.5 miles in either direction from the accident site. Of these accidents, 39, or 62 percent, were single-vehicle accidents. According to the Texas Department of Transportation, rumble strips were installed in 2000 and single-vehicle accidents decreased thereafter to 13 (7 of which were not run-off-road accidents), or 48 percent, in 2001 and 2002.

The accident occurred near milepost 538 in the eastbound lanes of U.S. Route 82 in Clay County about 6 miles north of Henrietta. The van departed the left side of the asphaltic concrete road surface, crossed the asphalt shoulder, and rolled in the earthen median. Tire marks and pieces of tire casing were found on the roadway and shoulder leading up to the earthen median. Furrow marks and gouge marks continued in the median.

Operational Information

The van was owned and operated by the First Assembly of God Church in Burkburnett and was used exclusively for church-sponsored activities, according to church officials, who also stated that these activities took place primarily in Texas and occasionally in Arkansas and Oklahoma. When not in use, the van was parked in an unprotected area of the church parking lot. The church did not maintain a qualification file for drivers, nor was it required to. The pastor of the church told investigators that he was not aware of the National Highway Traffic Safety Administration's (NHTSA's) "Consumer Advisory" on the risks of rollover crashes in 15-passenger vans, released April 9, 2001 (see NHTSA "Consumer Advisory" below for more information). He was also unaware of the additional training that NHTSA recommends for van operators.

A review of available church records and receipts, as well as conversations with current and past pastors, did not indicate any systematic vehicle maintenance or preventive inspection activities.

Several documents pertaining to vehicle maintenance were found in the van, including a tire owner's manual and a document entitled *Tire Inflation Pressures* for 1993 Chrysler[11] vans and trucks. The tire owner's manual stated in several places the importance of maintaining proper tire inflation pressures, and both the manual and the vehicle tire information placard recommended seeking vehicle-specific information regarding inflation pressures. The tire owner's manual made several references to checking inflation pressures at least once a month and noted the consequences of operating tires while underinflated. The *Tire Inflation Pressures* manual recommended checking the pressure once a month and inflating the tires to 55 psi for the front and 80 psi for the rear when the van was fully loaded.

According to the vehicle's inspection certificate, the van had last been inspected, in accordance with the Texas Department of Public Safety's *Texas Vehicle Inspection Act*, on October 23, 2000. All passenger vehicles registered in Texas are required to be inspected annually at designated, approved, privately owned and operated garages and repair facilities. All facilities operate under the *Rules and Regulations Manual for Official Vehicle Inspection Station* issued by the Texas Department of Public Safety. Tires are observed for proper inflation (a tire gauge check is not required).[12] In addition, tires are to be inspected for physical defects and rejected if any tire is found to have "tread or sidewall cracks, cuts, or snags (such as measured on the outside of the tire) in excess of one inch in any direction and deep enough to expose the body cords."[13] No inspection criteria address the sidewall and tread groove cracking that was observed during postaccident tire inspections.

Since the accident, according to the pastor, the church has created a driver file and requires that drivers be 25 or more years old, have no accidents, and have no more than

[11] Chrysler (now DaimlerChrysler) owned Dodge in 1993.

[12] Inspection Item 04.20.28 (Tires), section I, paragraph 3.

[13] Inspection Item 04.20.28 (Tires), section II.

two moving violations in the last 5 years. He also reported that the church now limits the occupancy of its 12-passenger van to no more than 9 passengers and has decided not to purchase another 15-passenger van.

Meteorological Information

The National Weather Service observatory at the Wichita Falls, Texas, Municipal Airport, about 20 miles north of the accident site, reported clear conditions, visibility of 10 miles, and a temperature of 70° Fahrenheit with variable winds of about 4 knots (4.6 mph) at 8:52 a.m. on May 8, 2001.

Randleman, North Carolina

Accident Narrative

On July 1, 2001, about 2:30 p.m., eastern daylight time, a 1989 Dodge Ram 15-passenger van was northbound in the left lane on U.S. Route 220, near Randleman, North Carolina, en route from Myrtle Beach, South Carolina, to Roanoke, Virginia (see figure 13). The van, owned by Virginia Heights Baptist Church of Roanoke, Virginia, was occupied by the driver and 13 passengers, ages 13 to 19. As the van approached the Level Cross, North Carolina, exit, at a witness-estimated speed of 65 mph, the left rear tire experienced a tread separation and blowout; subsequently, the van moved from the left lane into the right lane, then back into the left lane, where it overturned and came to rest in the travel lanes (see figure 14). During the accident sequence, four passengers were ejected, one of whom was fatally injured and three of whom sustained serious injuries; the driver and the other nine passengers sustained injuries ranging from none to serious.

According to the driver, the church youth group had gone to Myrtle Beach for 4 days. On the day of the accident, they left Myrtle Beach about 10:15 a.m. to return to Roanoke, a distance of about 310 miles. The driver said the group stopped for lunch about 12:40 p.m. and then continued the trip. The accident occurred about 187 miles from Myrtle Beach. The church music director stated that he was traveling in a Plymouth Grand Voyager with three youths in front of the accident vehicle, and most of the luggage was in the Grand Voyager, not in the accident vehicle.

The accident van driver stated that he was "just driving" when he "heard a grinding noise and had to fight to keep the van from swerving." One passenger reported saying he thought the tire was going flat. Another passenger said she heard what sounded like an explosion immediately thereafter. According to several passengers, the van began shaking and vibrating before changing lanes. Two passengers stated that they saw debris from the tire before the van began to roll over. Three witnesses traveling southbound on U.S. Route 220 reported that the left rear tire blew out before the van began to swerve. All three witnesses stated that they thought the van rolled sideways at least three times before coming to rest.

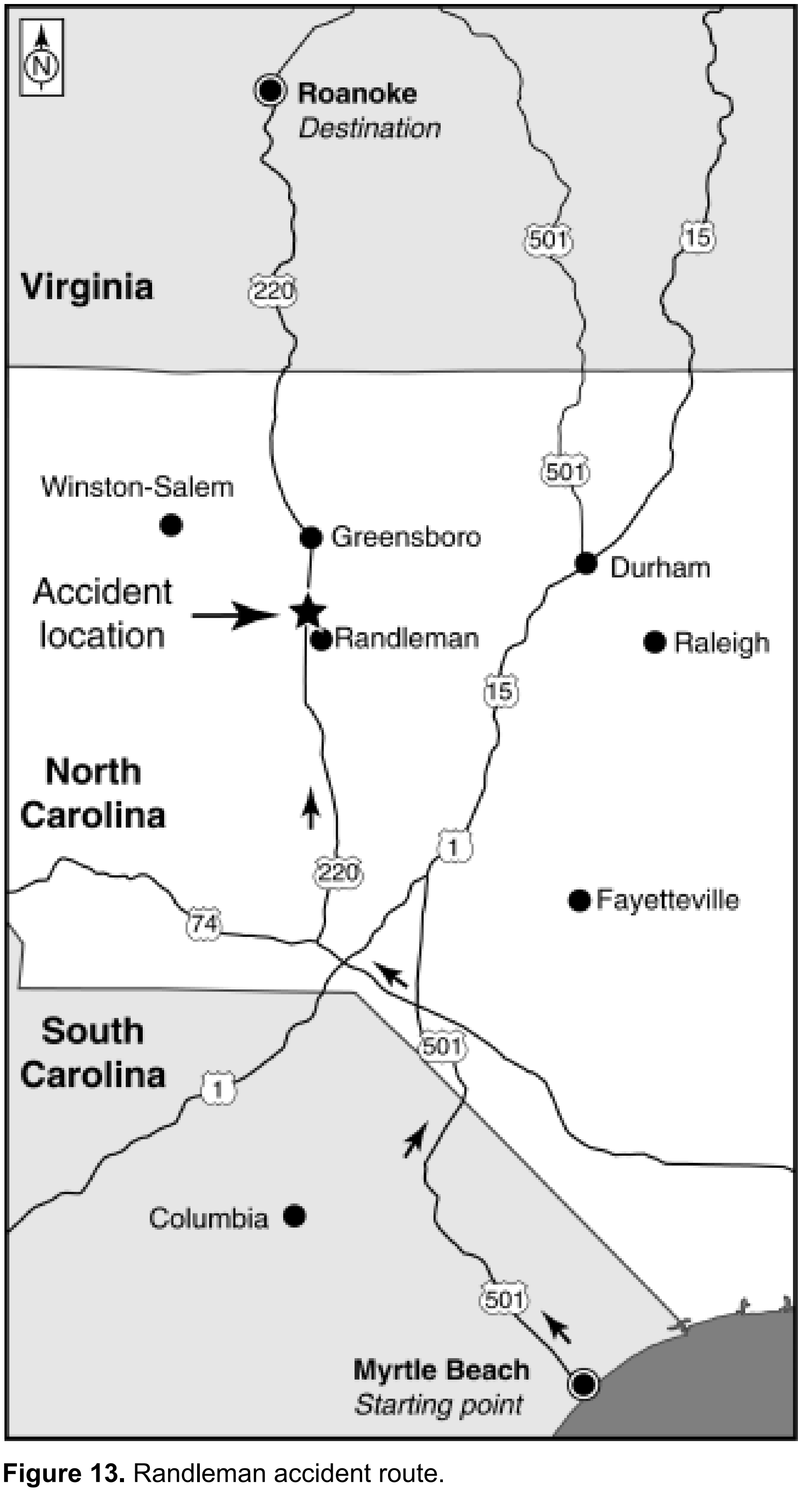

Figure 13. Randleman accident route.

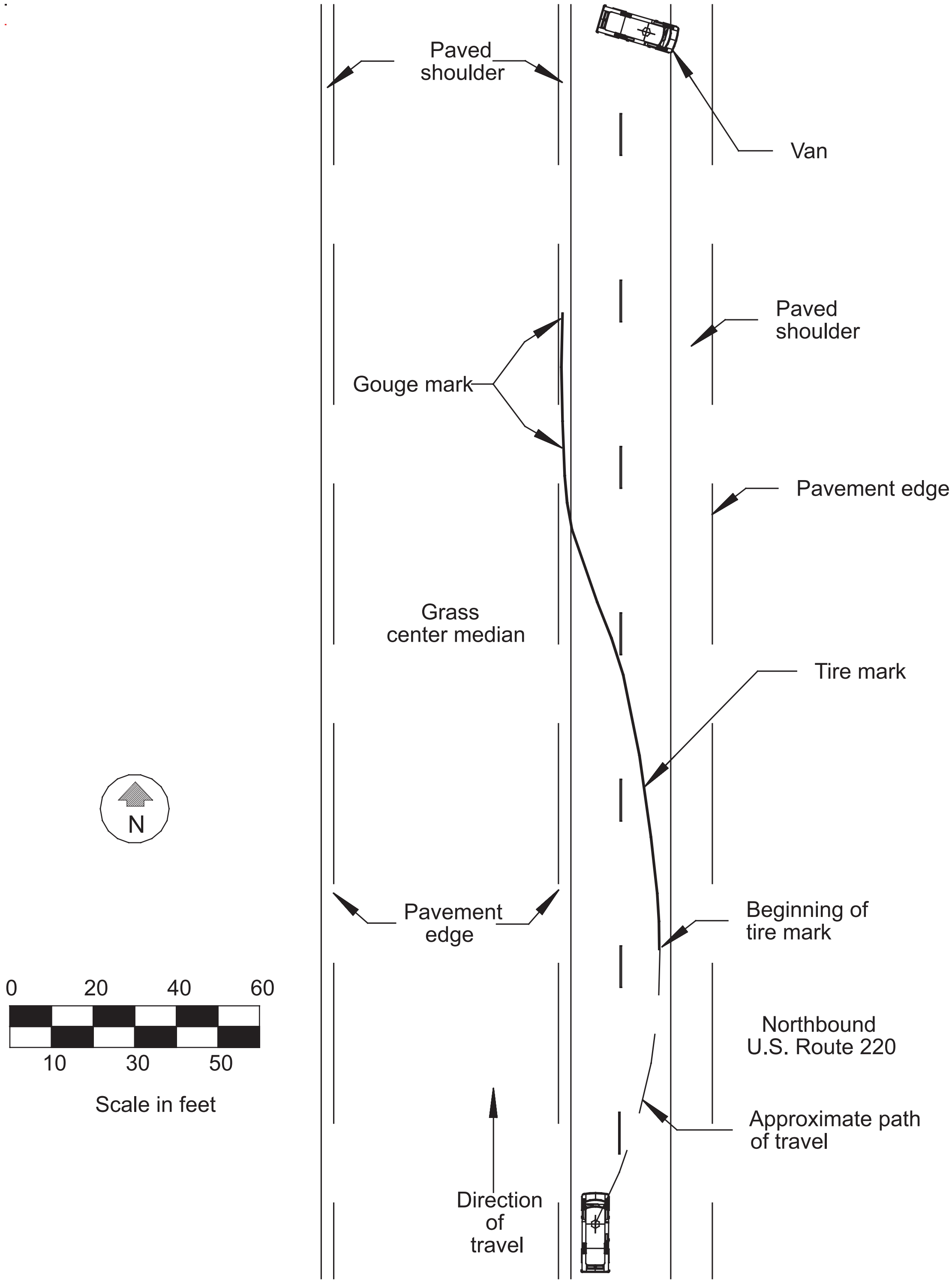

Figure 14. Randleman accident scene.

Injuries

Table 3. Injuries.

Injuries	Driver	Passengers	Total
Fatal	0	1	1
Serious	1	3	4
Minor	0	8	8
None	0	1	1
Total	1	13	14

Medical and Pathological Information

One passenger, who was in seat 5 (see figure 15) before being ejected, died in the hospital 4 days after the accident. She sustained a left front parietal[14] skin subdural hematoma, right temporal and parietal fractures, a diastic lambdoid[15] fracture, left temporal fracture, left basilar skull fracture, left petrous[16] fracture, left occipital fracture, and left orbital roof fracture.

The driver and three of the ejected passengers sustained serious injuries. The driver sustained a concussion, a left clavicle fracture, and left scalp laceration. The passenger in seat 8 sustained a brain laceration, open finger wound, open lateral abdomen wound, large deep shoulder abrasion and contusion, and multiple contusions. The passenger in seat 11 sustained a T7 vertebra compression fracture, a T12 vertebra Chance fracture,[17] an open occipital area laceration, and an elbow abrasion. The passenger in seat 15 sustained a basilar skull fracture; frontal bone fracture, including the left orbital roof into the anterior cranial fossa;[18] left maxillary fracture; diffuse axonal injury; cerebral contusion; left lower posterior calcaneal (heel bone) fracture; left periorbital contusion; and abrasions.

Eight passengers sustained minor injuries. The passenger in seat 2 sustained neck strain. The passenger in seat 3 sustained a left zygomatic contusion, left knee sprain, and knee abrasions. The passenger in seat 4 sustained left shoulder and left foot contusions. The passenger in seat 7 sustained abrasions to the right side of the face and right posterior shoulder and a small scalp laceration. The passenger in seat 9 sustained a right eye contusion and abrasions. The passenger in seat 10 sustained neck and back strains and multiple abrasions. The passenger in seat 12 sustained a right ulnar ligament sprain. The passenger in seat 13 sustained a scalp laceration. The passenger in seat 6 was uninjured.

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[14] The parietal bones form the roof of the skull.

[15] The lambdoid is the suture between the occipital and parietal bones.

[16] The petrous is the hard portion of the temporal bone that forms a protective case for the inner ear.

[17] A Chance fracture is a horizontal fracture through the vertebra.

[18] Front subdivision of the floor for the cranium.

Seat	Age	Belt Use	Injury
1	26	Lap/shoulder	Serious
2	24	Lap only of Lap/shoulder	Minor
3	27	None	Minor
4	13	None	Minor
5	13	Inaccessible	Fatal
6	12	None	None
7	14	Missing	Minor
8	14	None	Serious
9	15	Inaccessible	Minor
10	13	None	Minor
11	19	Inaccessible	Serious
12	17	None	Minor
13	17	Inaccessible	Minor
15	15	None	Serious

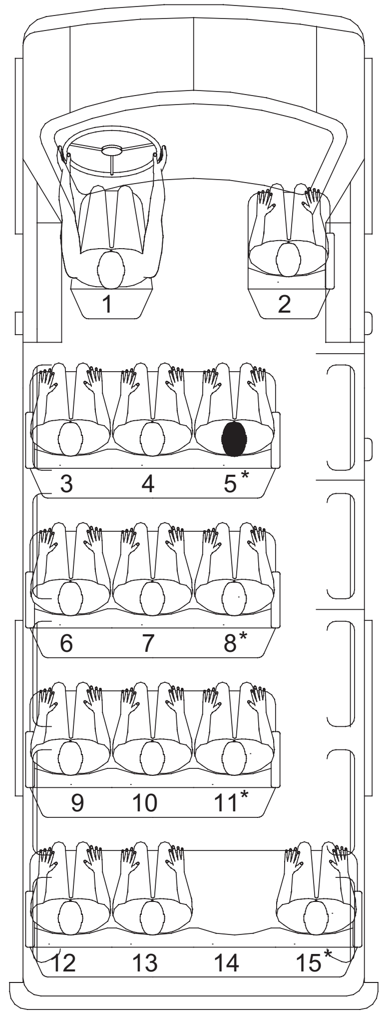

Figure 15. Randleman seating chart. (*ejected; shading indicates fatal injury)

Survival Aspects

The driver was wearing the available lap/shoulder belt. The front-seat passenger said she was wearing the lap portion of the lap/shoulder belt and had the shoulder portion behind her back. All remaining seating positions were equipped with lap belts. None of the other passengers reported wearing their lap belts.

Some of the restraints (seats 5, 7, 9, 11, and either 13 or 14) were missing or had buckles that were inaccessible because they were within the seat bights.[19]

[19] The seat bight is the point at which the lower edge of the seatback cushion and the rear edge of the seat bottom cushion meet.

Emergency Response

The Randolph County (North Carolina) Communications Center received a 911 cellular call at 2:31 p.m. Because the accident occurred outside Randleman city limits, the North Carolina Highway Patrol had jurisdiction over the investigation. The Randleman Fire Department was the first responder on scene at 2:38 p.m. Nine fire, police, and rescue departments responded to the accident scene. Six ambulances responded to transport passengers to local hospitals. One passenger was transported by air ambulance to the University of North Carolina Memorial Hospital in Chapel Hill, North Carolina; the air ambulance departed the scene at 3:24 p.m.

Driver Information

The 26-year-old driver held a Virginia driver's license valid through July 2005. A review of his driving history revealed a conviction for speeding in April 1998 and a personal injury accident in December 1998. The driver said he was familiar with the van and had about 5 years of experience driving a 15-passenger van for the church. He had driven the van on the same route about 2 weeks before the accident occurred.

The driver provided a 72-hour history (see table 4).

Table 4. Randleman van driver's 72-hour history.

Date	Time	Activity	Sleep
June 29, 2001	1:00 a.m.	Went to bed	
	7:00 a.m. – 7:30 a.m.	Awoke	6 – 6.5 hours
June 30, 2001	1:00 a.m.	Went to bed	
	7:00 a.m.	Awoke	6 hours
	12:20 p.m.	Ate lunch	
	5:20 p.m.	Ate dinner	
July 1, 2001	1:00 a.m.	Went to bed	
	6:30 a.m.	Awoke	5.5 hours
	7:00 a.m.	Attended church service	
	10:15 a.m.	Departed	
	12:40 p.m.	Ate lunch	

No toxicological tests were performed on the driver because, according to law enforcement personnel on scene, they did not have reasonable suspicion that the driver was intoxicated or under the influence of an impairing substance. In North Carolina, law enforcement personnel are required to have "an articulable and reasonable suspicion" that a driver has operated a vehicle under the influence in order to request a toxicological test.

Vehicle and Wreckage Information

Exterior. The 1989 Dodge Ram Maxi-Wagon was designed to accommodate 15 passengers, including the driver. The vehicle had a wheelbase of 127.6 inches, an overall length of 222.8 inches, and a GVWR of 8,510 pounds. The van was equipped with a 5.9-liter fuel-injected V-8 gasoline engine and a three-speed automatic transmission; it had an odometer reading of 76,465 miles.

The van was also equipped with front disc brakes and rear drum brakes. When the brakes were applied, both front wheel hubs remained locked without creep or slippage. The front brake friction surfaces were smooth with no significant wear ridges. The front left inside brake pad had worn to the fastener surface, which was in contact with the rotor surface. The friction surfaces of the rear brakes were smooth and showed slight wear ridging on the edges of the drums. The left rear shoe lining and drum friction surfaces were contaminated with axle gear case lubricant from a leaking left axle seal. Scrape marks were observed on the backing plates of both brake assemblies, consistent with brake drum contact due to axle shaft bending or flexing. Examination of the brake system revealed no hydraulic system leaks or restrictions. The brake pedal was intact and functional.

The van was equipped with a hydraulic, power-assisted steering system. Rotating the steering wheel resulted in corresponding movement to the steering box sector shaft and associated steering system components. The steering wheel could be rotated from stop to stop without restriction other than resistance from the damaged column. Inspection of the suspension system revealed extensive cracking in the front antisway/stabilizer bar link bushings.

Three of the four tires were the vehicle manufacturer-recommended Michelin tires. The right rear tire had been manufactured by Radial Medalist and was below the recommended load range E.[20] All tread depths complied with Virginia vehicle inspection criteria. The left front tire was inflated to 62.5 psi, the right front tire to 60.5 psi, and the right rear to 60 psi. The pressure of the left rear tire prior to the blowout could not be determined. The manufacturer recommended a tire pressure of 50 psi for the front tires and 80 psi for the rear tires. A tire information placard containing this information was located on the inside of the driver's doorsill. Both front tires and the left rear tire were more than 8 years old.

The left front tire exhibited extensive circumferential sidewall and tread groove cracking. Weather checking was evident circumferentially along the outer sidewall extending from 1 inch above the rim flange, through the buttress, and into the tread area. A 5-inch long, 0.125-inch deep incision was located within the inner buttress area, as was chunking.[21] Scrape marks were found along the outboard rim flange.

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[20] A load range E tire, the recommended tire for this vehicle, is rated at 2,680-pound capacity at 80 psi, whereas a load range D tire, found on the right rear wheel, is rated at 2,335-pound capacity at 65 psi.

[21] Michelin defines "chunking" as the tearing off of small pieces of tread rubber while the tire is in service.

The right front tire exhibited extensive circumferential sidewall and tread groove cracking (see figure 16). Weather checking was evident along the outer sidewall from 1.75 inches above the rim into the tread area. Scrape marks were found on the rim flange. A 0.1875-inch deep radial split was found in the buttress, and a 0.625-inch long near-radial split was 0.75 inch from the rim flange. The body plies[22] were exposed due to missing tire material that measured approximately 0.5 inch long, 0.1875 inch wide, and 0.1875 inch deep.

Figure 16. Right front tire sidewall cracking.

The left rear tire sustained extensive damage to the inner and outer sidewalls, tread, belts, and body plies (see figure 17). The tire exhibited extensive circumferential cracking and weather checking of the sidewall. The inner and outer beads were unseated from the wheel flanges and a 0.5-inch deep circumferential groove was found in the bead area. In another location, the bead area was cut or torn, exposing the body cords. Some sidewall rubber was missing and bare body cords were exposed. Multiple radial splits had breached the inner liner. A radial split was found in the sidewall rubber, and the rubber was not attached to the body cords. Radial splits were also found in the tread and buttress.

[22] Michelin defines body plies as the principal load-supporting component, usually reinforcing textile cords or steel cables encased in rubber, extending from bead to bead across the crown of the tire.

Portions of the tread and all three steel belts were partially detached. Bare body cords were visible in the tread and buttress areas.

Figure 17. Left rear tire.

The right rear tire exhibited circumferential scrubbing, as well as asphalt between the rim flange and the tire.

Interior. The driver and front passenger bucket seats were equipped with lap/shoulder belts. The first three rows could seat three passengers each. The fourth row could seat four passengers. The center of the seatbacks in all rows bowed rearward (see figure 18) due to accident damage. The outboard armrest was missing on the first row and broken on the second row. The roof deflected upward near the center of the van, extending longitudinally the entire length of the vehicle (see figure 19).

The fourth row center lap belts were configured similarly to those in the Henrietta accident van. The two center lap belt buckle webbing straps were attached to the floor with one bolt near the right seat frame pedestal base, and the two center latch plate webbing straps were attached to the floor with one bolt near the left seat frame pedestal base.

Figure 18. Bowed Randleman seatbacks.

Figure 19. Randleman van damage.

The windshield and rear left door window were missing; the windshield was found inside the vehicle. The glazing on the driver window, front passenger window, first window on the driver's side, and all passenger side windows was missing. The glazing on the third window on the driver's side was broken; that on the second window was intact.

Highway Information

U.S. Route 220 in North Carolina is primarily a four-lane divided, controlled-access highway. The posted speed limit is 65 mph. The 12-foot-wide traffic lanes were divided by 4-inch-wide pavement markings consisting of reflectorized painted white lines, approximately 12 feet long and spaced every 28 feet. The lanes were separated from the shoulders by a 4-inch-wide white edgeline, delineating the 10-foot-wide outside shoulder, and a 4-inch-wide yellow edgeline, delineating the 3-foot-wide inside shoulder. The northbound and southbound traffic lanes were separated by a 60-foot-wide depressed earthen median directly adjacent to the area where the collision occurred. In the roadway in the vicinity of the accident was an 800-foot-long, 1° left hand curve with a 0.5-percent downgrade and a 0.33° maximum superelevation.

The average annual traffic volume was 22,000 vehicles in 1998, 24,000 vehicles in 1999, and 23,000 vehicles in 2000. From 1997 to October 2002, the North Carolina Department of Transportation reported a total of 10 accidents on U.S. Route 220 in an area 1 mile in either direction from the accident site. Four of the 10, including the subject accident, were single-vehicle accidents.

The accident occurred near milepost 26.5 in the northbound lanes of U.S. Route 220 in Randolph County about 4 miles north of Randleman. The van left a series of tire marks in the right lane and across the left lane, followed by gouge marks on the left shoulder. As the van overturned, it returned to the travel lanes, where it came to rest.

Operational Information

The 15-passenger van was owned and operated by the Virginia Heights Baptist Church in Roanoke. The accident van was the only one operated by the church and, according to church officials, was used exclusively for church-sponsored activities; estimated use was once a week on a 20-mile trip. The van was typically parked in an unprotected location on church property, according to the church minister, who was not aware of NHTSA's "Consumer Advisory," or of NHTSA's recommended training for van operators.

The church did not maintain driver qualifications files, nor was it required to. It had submitted the names of van drivers to its insurance company, which required that the church do so and also required that all drivers be at least 21 years old.

The church's board of directors was responsible for operating and maintaining the van. If a driver found a problem with the van, he or she was to complete a form that was forwarded to the board for action. The board's role was primarily financial rather than safety or operational oversight.

All motor vehicles registered in Virginia must be inspected annually at an approved, privately owned and operated garage or repair facility authorized by the Virginia Department of State Police. The van had most recently been inspected in December 2000.

The Virginia inspection manual has a paragraph on inspection of vehicle tires, wheels, and rims (19VAC 30-70-130). The inspection procedures cover tread depth, cracks in wheels or rims, cut or worn tires if the fabric or steel cord is visible, and knots and bulges in the sidewalls. The manual addresses neither tire inflation pressure nor the sidewall and tread groove cracking that was found during postaccident inspection of the tire.

Meteorological Information

At 2:30 p.m. on the day of the accident, the National Weather Service Observatory at the Greensboro, North Carolina, Piedmont Triad International Airport, approximately 21 miles north of the accident site, reported clear conditions, visibility of 10 miles, and a temperature of 86° Fahrenheit; winds were out of the southwest at about 11 knots (12.7 mph).

Tests and Research

Simulation

National Transportation Safety Board staff conducted simulations of the Henrietta accident to determine general occupant motion and injury mechanisms during the rollover sequence and to evaluate the benefits of restraint use. The simulation showed that the van most likely rolled over two or more times and that the outboard occupants had greater potential for ejection due to their proximity to the windows. The simulation predicted that unbelted occupants were more prone to ejection and received more serious injuries than the belted occupants. A more detailed description of the simulations follows.

Vehicle Dynamics Simulation. The purpose of the vehicle dynamics simulation was to determine, based upon available physical evidence, the driver inputs before and after loss of control of the vehicle. Definitive physical evidence was not available to indicate the number of vehicle overturns or the contact points between the vehicle and the ground. Using Engineering Dynamics Corporation's Vehicle Simulation Model (EDVSM) software, Safety Board staff assessed several potential overturn scenarios.

To perform the simulation, the accident scene was modeled[23] using three-dimensional mapping data obtained on scene. The vehicle was modeled using

[23] The scene was built with AutoCAD Land Development Desktop release 2i.

measurements obtained from the accident van and an exemplar van,[24] as well as data from the Human Vehicle Environment (HVE) software.

The results of the vehicle dynamics simulation indicated that the initial speed of the van before the tire blowout was 67 mph. After the blowout, steering input to the right and then back to the left was required to match the physical evidence on the roadway. The steering toward the left and the resulting yaw would have caused the vehicle to depart the roadway at an angle of approximately 100° counterclockwise to the initial direction of travel prior to the tire failure. Simulations of the overturn sequence indicated that the vehicle completed at least two rolls before reaching final rest. For a depiction of the van at various stages of the overturn, see figure 20.

Figure 20. Potential path of the van during the overturn; the time is based on the beginning of the rollover.

[24] A 1990 Dodge Ram 350.

Several crash pulses[25] were developed to evaluate the rollover dynamics and occupant motion. Three of the scenarios involved the vehicle overturning twice (720°).[26] The fourth scenario involved the vehicle overturning three times before reaching final rest (1,080°). The simulation results were consistent with the location of the van when it first struck the ground and after it came to rest and with the damage it sustained.

Occupant Kinematics Simulation. Based on the results of the vehicle dynamics simulation, occupant kinematics were modeled using the Graphical Articulated Total Body[27] software program. This program calculates the unrestricted motion of a simulated occupant and the resulting forces due to occupant interaction with contact surfaces, such as the seats, roof, sidewalls, and windows.

The 10 passengers seated in the rear of the van were simulated (seats 3, 4, 5, 6, 8, 9, 11, 12, 14, and 15). Because the program can simulate a maximum of four occupants at a time, each row was simulated separately and interactions between occupants in different rows were not simulated.

The initial occupant kinematics simulation was based on the crash pulse generated from the original EDVSM physics module. Occupants were simulated in three conditions: actual,[28] all restrained by lap belts, and all restrained by lap/shoulder belts. When the enhanced EDVSM program became available, the occupant kinematics simulations were again conducted based on the three additional crash pulses. For these three crash pulses, only the unrestrained condition was simulated in an effort to understand the effects of changes in crash pulse on occupant kinematics during rollovers. Because the restraints in the initial simulation maintained the occupants within the vehicle, similar beneficial results were assumed for the three additional pulses.

In the actual restraint condition, the occupant kinematics based on the original crash pulse were evaluated for the full overturn sequence. Due to limitations in modeling the restraint systems for multiple overturns, the belted conditions were only evaluated during the first overturn and then compared to the results of the first overturn in the actual restraint condition. Similarly, only the first overturn was evaluated for the three additional crash pulses.

The occupant kinematics were similar among all four crash pulses. The main difference between the runs was the roll rate of the van, which affected the distance the

[25] Crash pulse is the vehicles' change in acceleration over time.

[26] Based on this simulation work and correspondence with the developers of HVE, enhancements were made to the EDVSM physics software module. Safety Board staff then reran the simulations to better understand how these enhancements would affect the rollover dynamics when the tire struck the ground at an angle parallel to the ground. The first simulation, involving two rollovers, was run using the original EDVSM physics module, while the other three simulations were run using the enhanced EDVSM physics module.

[27] W.D. Grimes, "Using ATB Under the HVE Environment," SAE 970967 (Warrendale, PA: Society of Automotive Engineers, 1997).

[28] In the accident, all passengers were unrestrained except the passenger in seat 11, who was restrained by the available lap belt.

occupants traveled inside the van during each segment of the overturn. The series of still images in appendix B shows the path of motion for the simulated occupants in each crash pulse. Occupants in the original simulation (run one) traveled farther toward the right side of the van as the vehicle initially began to roll toward its right side. Occupants in runs three and four experienced the least travel toward the right side of the van. In all runs, occupants seated in the van's outboard positions were more likely to be ejected as the vehicle overturned because of their proximity to the windows.

These simulations revealed the potential for head, neck, and chest injuries in the actual restraint condition; one chest injury in the lap-belted condition; and no injuries in the lap/shoulder-belted condition. These results must be considered in the context that only the first overturn was simulated for the restrained conditions and intrusion was not modeled. In the actual restraint condition, simulated occupants were potentially ejected at various points during the overturn sequence. Some were predicted to be ejected during the first overturn as the van rotated from the roof onto its left side. Ejection was not predicted for others until the second overturn sequence, when the right side struck the ground. For others, ejection was not predicted until the end of the second overturn sequence. In both the lap- and lap/shoulder-belted conditions, the simulation did not predict full ejection for the passengers; the belts provided an additional level of protection that was not fully reflected in the predicted injury levels.

Independent Tire Examination

Standards Testing Laboratories, Inc., (STL)[29] examined the failed left rear tires of both vehicles on October 24, 2001. STL staff concluded that the Henrietta tire was:

> …9 years old, [and] exhibits severe heat/UV aging. Evidence of run low, generating severe heat buildup causing belt/tread separation, sidewall splits and rapid air loss.

STL staff concluded that the Randleman tire was:

> …heat/ozone/time aged. Tire exhibits prolonged run low evidence which caused excessive heat/stress resulting in belt tread separation and resulting sidewall splits and rapid air out.

Dynamic Vehicle Handling Tests

Tests. On November 14, 2001, STL staff and Safety Board investigators conducted a series of dynamic vehicle stability and handling tests on a 1990 Dodge Ram 350 15-passenger van at the Transportation Research Center in East Liberty, Ohio. The tests focused on the handling characteristics of a 15-passenger van in circumstances similar to those of the Henrietta accident. The test vehicle had the same dimensions as the Henrietta accident van. Safety Board investigators installed an accelerometer and monitored road speed using radar equipment. In all seven tests, the van was ballasted with

[29] STL's TransTech Division, which conducted the testing, is an independent research and testing facility specializing in product performance needs of the transportation industry.

sandbags to correlate with the known occupant weights and seating positions in the Henrietta accident. Measurements of the exemplar van showed that loading the van moved the center of gravity approximately 11 inches rearward, placing it about 10 inches behind of the centerline of the wheelbase. The professional driver was experienced in driving during tire blowouts. STL and Michelin determined that braking after the blowout would be dangerous, and the driver stated that he would be uncomfortable conducting the tests if he were required to brake. Table 5 summarizes the test scenarios.

Table 5. Dynamic testing scenarios.

Test	Tire pressure	Test scenario	Driver instruction
1a	55 psi front and 80 psi rear *	50 mph, double lane change***	
1b	60 psi front and 58 psi rear **	50 mph, double lane change	
2	60 psi front and 58 psi rear	40 mph, rapid air loss	
3	60 psi front and 58 psi rear	75 mph, rapid air loss and tread/belt detachment	Maintain speed after blowout (the driver was unable to accelerate because the accelerator was already fully depressed to maintain 75 mph)
4	55 psi front and 80 psi rear	75 mph, rapid air loss and tread/belt detachment	Maintain speed after blowout
5	55 psi front and 80 psi rear	75 mph, rapid air loss and tread/belt detachment	Decelerate by removing foot from accelerator, no braking
6	60 psi front and 58 psi rear	75 mph, rapid air loss and tread/belt detachment	Decelerate by removing foot from accelerator, no braking

*Factory-recommended.
**Henrietta accident van.
***The course was based on International Standards Organization standard 3888-1.

For the rapid air loss scenarios, the left rear tire (was the same tire that blew out in the Henrietta accident) was prepared with a driver-controlled explosive charge to simulate a blowout. For the tread/belt detachment, the left rear tire was prepared to facilitate a tread/belt separation near 75 mph. The driver was instructed to trigger the blowout when he heard the tread and belt begin to detach.

Results. Safety Board investigators determined the maximum lateral acceleration and peak speed attained during the testing. Table 6 shows these values.

Table 6. Peak lateral forces and speed for each test.

Test number	Lateral acceleration left (G's*)	Lateral acceleration right (G's)	Peak speed (mph)
1a	0.49	0.44	51.67
1b	0.38	0.55	51.73
2	0.03	0.18	41.80
3	0.30	0.26	71.29
4	0.20	0.23	73.08
5	0.17	0.25	75.18
6	0.09	0.21	74.88

*One G equals 32.2 feet per second squared (9.8 meters per second squared).

The professional driver stated that he did not have a problem controlling the van when executing either lane change maneuver during testing; he commented that the van seemed to "wallow" (behave in an ungainly manner) during the lane change maneuver when the tire pressures were low. During test 2, the blowout at 40 mph, the driver rated his ability to control the vehicle after the blowout as a 9 on a scale of 1 (completely out of control) to 10 (completely in control). During test 3 at 75 mph with underinflated tires, the van did not stay in its lane after the blowout, initially veering left until the driver countered by steering to the right. Safety Board staff observed side-to-side motion of the van body after the tire failure. The driver stated that "the rear of the van became loose" and said the key issue was not to oversteer, since any steering input was magnified. On a controllability scale of 1 to 10, the driver rated this test as a 5.

In test 4, with the tires inflated to the recommended pressures, the van veered to the left before the driver could counter by steering to the right, but the driver was able to maintain the van within its lane. The driver stated that the handling was better than during the previous test, but the vehicle remained sensitive to steering input, and tire pressure was a "significant" factor during the tests. The driver rated this run as a 7 for controllability. In tests 5 and 6, the van also veered left initially, but the driver was able to take corrective action and maintain the lane. He stated that tests 5 and 6 were comparable to the previous tests, except that the van pulled more toward the left when he took his foot off the gas. The driver said he preferred to keep his foot on the gas, but was comfortable taking it off, even though the vehicle tended to go left. Overall, the driver stated that steering input was key and that "any time you add steering, you lose some control."

Other Information

Federal Regulations

Federal Motor Vehicle Safety Standards (FMVSSs) (49 CFR 571.3) define *bus* as a motor vehicle designed to carry more than 10 passengers. Based on this definition, a 12- or 15-passenger van is a bus and has to meet the FMVSSs applicable to buses.

Some FMVSSs apply only to vehicles with a GVWR less than 8,500 pounds and thus do not apply to 15-passenger vans, which have a GVWR exceeding that criterion. Federal Motor Vehicle Safety Standard (FMVSS) 201, Section 6, "Requirements for Upper Interior Components," specifically excludes buses with a GVWR greater than 8,500 pounds. FMVSS 216, "Roof Crush Resistance" does not apply to buses with a GVWR greater than 6,000 pounds. All these sections apply to passenger cars.

Title 49 CFR Part 390.5 defines a commercial motor vehicle as any self-propelled vehicle used on a highway in interstate commerce to transport passengers when the vehicle is designed or used to transport more than 8 passengers, including the driver, for compensation or is designed or used to transport more than 15 passengers, including the driver, and is not used to transport passengers for compensation.

If a motor carrier operates a commercial motor vehicle designed or used to transport 9 to 15 passengers, including the driver, for compensation, the carrier must file a motor carrier identification report, mark its vehicles with a U.S. Department of Transportation identification number, and maintain an accident registry.

NHTSA "Consumer Advisory"

On April 9, 2001, and again on April 15, 2002, NHTSA issued a "Consumer Advisory" warning the public that "research has shown that 15-passenger vans have a rollover risk that increases dramatically as the number of occupants increases from fewer than five to more than ten." The rollover rate for vans loaded with more than 10 passengers is three times greater than that for a van loaded with fewer than 10 passengers. NHTSA recommended that 15-passenger vans be operated by trained, experienced drivers familiar with the handling of such vehicles and that all passengers wear seat belts at all times. According to the NHTSA contact listed on the advisory, the advisory was issued to NHTSA news media contacts, newsletter subscribers, and about 40 to 50 umbrella groups[30] that typically use these vehicles. The advisory was also posted on the NHTSA website (www.nhtsa.dot.gov). The advisory is not listed on NHTSA's home page and can only be found by conducting a search for it.

Seat Belt Laws

Texas law requires that every person sitting in the front seat of a passenger vehicle wear a seat belt. "Passenger vehicle" includes passenger cars, light trucks, sport utility vehicles, trucks, and truck tractors. It does not include 15-passenger vans.

In North Carolina, all drivers and front-seat passengers ages 16 and older must have a seat belt properly fastened about their bodies at all times when the vehicle is on a street or highway. Children under 16 must use age-appropriate child restraints or wear seat belts in all seating positions of any vehicle (including 15-passenger vans) required by Federal law to be equipped with seat belts.

[30] Religious groups, Boy Scouts, Girl Scouts, senior centers, and so forth.

State Vehicle Safety Inspections

Currently, 18 States[31] and the District of Columbia conduct annual or biannual vehicle safety inspections of passenger vehicles. The States generally base their inspection criteria on guidelines found in the *Passenger Vehicle and Light Truck Inspection Handbook* published by the American Association of Motor Vehicle Administrators (AAMVA). The handbook sets forth recommended procedures for conducting safety inspections of vehicles weighing less than 10,000 pounds GVWR. In the chapter on tires, the AAMVA handbook recommends that inspectors measure tire pressure; check for tire condition and wear, including cuts, snags, or cracks that exceed 1 inch and are deep enough to expose cords or visible bumps, bulges or knots; measure tread depth; and inspect for tire size or type mismatching.

Previous Recommendations

The Safety Board has investigated several accidents and addressed the issue of passenger vehicle safety in previous reports. Below is a summary of the safety recommendations that have been issued as a result of these reports and their status.

On September 20, 1996, the Safety Board adopted a safety study on *The Performance and Use of Child Restraint Systems, Seat Belts, and Air Bags for Children in Passenger Vehicles* (NTSB/SS-96/01). In that report, the Safety Board concluded that occupants seated in the center rear seat position should be afforded the same level of protection as other occupants of the back seat, who had lap/shoulder belts available to them since January 1, 1990. The Safety Board recommended that NHTSA:

> Require installation of center rear lap/shoulder belts in all newly manufactured passenger vehicles for sale in the United States. (H-96-28)

NHTSA replied on August 27, 2002, that it had initiated rulemaking for lap/shoulder belts for nonoutboard seats and expected to publish a proposal to require these belts by late summer 2003. The Safety Board classified the recommendation "Open—Acceptable Response" on February 5, 2003.

As a result of the same study, the Safety Board urged automobile manufacturers to:

> Voluntarily install center rear lap/shoulder belts in all newly manufactured passenger vehicles for sale in the United States. (H-96-33)

Ford Motor Company (Ford) responded on February 3, 1999, that nearly half of the 1998 model year vehicles were equipped with rear lap/shoulder belts and they planned to expand installation to newly designed passenger vehicles and light trucks. The Safety Board classified the recommendation "Closed—Acceptable Action" on May 11, 1999. General Motors Corporation (GM) responded to this recommendation on November 20, 2002, stating that it currently offers center rear lap/shoulder belts on 60 percent of its

[31] Delaware, Hawaii, Louisiana, Maine, Massachusetts, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Texas, Utah, Vermont, Virginia, and West Virginia.

vehicles and would install them on the balance of the fleet by 2007. The Safety Board classified the recommendation to GM "Closed—Acceptable Action" on February 27, 2003. DaimlerChrysler responded to this recommendation on June 21, 1999, stating that all passenger cars would be equipped with center lap/shoulder belts by 2002 and that light truck vehicles (including sport utility vehicles, pick-up trucks, and vans) would be equipped with center lap/shoulder belts as they are redesigned over the next several years. The Safety Board classified the recommendation to DaimlerChrysler "Closed—Acceptable Action" on October 27, 1999.

On March 17 to 20, 1997, the Safety Board convened a public hearing to discuss concerns related to the effectiveness of air bags, passenger vulnerability to injuries from air bag deployment, other countries' experience with air bags, and ways to increase seat belt and child restraint use. As a result of issues identified in the hearing, the Safety Board recommended that the States, the U.S. territories, and the District of Columbia:

> Enact legislation that provides for primary enforcement of mandatory seat belt use laws, including provisions such as the imposition of driver license penalty points and appropriate fines. Existing legal provisions that insulate people from the financial consequences of not wearing a seat belt should be repealed. (H-97-2)

The intent of the recommendation is that seat belt laws should apply to all motor vehicle occupants, not just those in the front seat. The recommendation was classified "Open—Acceptable Response" for Texas on December 30, 2002, since Texas has a primary enforcement law, although it only requires those in the front seat to be restrained. The Safety Board has not received a written response from North Carolina, but is aware North Carolina has a primary enforcement law that only requires those in the front seat to be restrained.

In 1998 and 1999, the Safety Board investigated four accidents involving vehicles used to transport children to or from school that were not built to school bus occupant protection standards. Three of these accidents involved 15-passenger vans. The Safety Board adopted a report and issued recommendations in 1999.[32] Most of the recommendations pertained to the transportation of children to or from school or school-related activities, including day care and Head Start. The Safety Board recommended that the States, U.S. Territories, and the District of Columbia:

> Review your State and local laws and, if applicable, revise to eliminate any exclusions or exemptions pertaining to the use of age appropriate restraints in all seat belt-equipped vehicles carrying more than 10 passengers (buses) and transporting school children. (H-99-23)

The Safety Board sent a letter to the Governor of North Carolina on November 16, 2000, requesting action on this recommendation, since at the time North Carolina exempted vehicles carrying more than 10 passengers from child restraint laws. In that same letter, the Board classified this recommendation "Open—Await Response." North

[32] National Transportation Safety Board, *Pupil Transportation in Vehicles Not Meeting Federal School Bus Standards*, Special Investigation Report NTSB/SIR-99/02 (Washington, DC: NTSB, 1999).

Carolina now requires that all passengers under the age of 16 be properly secured in a child passenger seat or a seat belt in any vehicle required by Federal law to be equipped with seat belts.

The Safety Board also recommended that various associations and churches:

> Inform their members about the circumstances of the accidents discussed in this special investigation report and urge that they use school buses or buses having equivalent occupant protection to school buses to transport children. (H-99-25)

The Safety Board has not received a response from the Southern Baptist Convention, of which Virginia Heights Baptist Church is a member. The First Assembly of God church in Burkburnett was not a member of a national organization. The Safety Board received few responses to this recommendation, and on March 11, 2003, prepared an article about the circumstances of these accidents, urging the use of school buses or the equivalent to transport children; the Board asked that the associations and churches distribute the article in their newsletters or by other means of communication.

In 2002, the Safety Board issued a safety report, *Evaluation of the Rollover Propensity of Fifteen Passenger Vans* (NTSB/SR-02/03), based on rollover accidents the Safety Board had investigated to date and fatality data involving 15-passenger vans. In it, the Safety Board recommended that NHTSA:

> Include 15-passenger vans in the National Highway Traffic Safety Administration dynamic testing program. The dynamic testing should test the performance of 15-passenger vans under various load conditions. (H-02-26)

> Extend the New Car Assessment Program rollover resistance program to 15-passenger vans, especially for various load conditions, and use the dynamic testing results of 15-passenger vans, as described in Safety Recommendation H-02-26, to supplement the static measures of stability in the New Car Assessment Program rollover resistance program. (H-02-27)

> Evaluate, in conjunction with the manufacturers of 15-passenger vans, and test, as appropriate, the potential of technological systems, particularly electronic stability control systems, to assist drivers in maintaining control of 15-passenger vans. (H-02-28)

The Safety Board received a response from NHTSA on December 23, 2002, stating that the agency will consider how best to accomplish these recommendations. While the New Car Assessment Program (NCAP) rating system remains under review, NHTSA indicated that it cannot state whether 15-passenger vans will be part of this testing and rating system. The Safety Board classified these recommendations “Open—Acceptable Response” on June 30, 2003.

The Safety Board issued a companion recommendation to Ford and GM (H-02-29). Dodge no longer manufactures 15-passenger vans effective model year 2002. Ford responded on February 21, 2003, that it is researching electronic stability systems on various Ford products and evaluating the feasibility of adapting the technology for different vehicle lines. The Safety Board classified the recommendation to Ford "Open—Acceptable Response" on June 30, 2003. GM responded on February 14, 2003, that it will implement an electronic stability system, called a Vehicle Stability Enhancement System, in the near future for its 15-passenger vans. Because GM had evaluated the potential of Vehicle Stability Enhancement System before the Board issued its recommendation, the Safety Board classified Safety Recommendation H-02-29 to GM "Closed—Reconsidered" on May 6, 2003.

Analysis

Accident Discussion

In both the Henrietta and Randleman accidents, a tire blowout precipitated the events leading to the rollover. The Safety Board, which addressed the propensity of 15-passenger vans to roll over in its 2002 safety report, *Evaluation of the Rollover Propensity of Fifteen Passenger Vans*, found that 15-passenger vans with 10 or more occupants had a rollover ratio[33] of 85 percent compared with a ratio of 28.3 percent for vans with fewer than 5 occupants. In other words, 15-passenger vans that were loaded with 10 or more occupants were three times more likely to roll over in single-vehicle accidents than lightly loaded vans. NHTSA conducted simulations of the effects that loading can have on the handling of 15-passenger vans and concluded that the computer simulations illustrated the adverse effects that a fully loaded passenger van can have on its handling properties.[34]

Manufacturers of electronic stability control systems maintain that the systems will activate in a blowout situation. Given the extreme nature of the Henrietta and Randleman accidents and the drivers' steering and braking reactions to the blowouts, the Safety Board cannot definitively state that an electronic stability control system would have prevented the accidents. Nonetheless, such a system would probably have provided the drivers with greater opportunity to regain control of their vehicles. Because the Safety Board has already considered and made recommendations on dynamic rollover testing and electronic stability control for 15-passenger vans, the rollover propensity of these vehicles will not be the subject of further discussion in this analysis.

The issues identified as a result of the Henrietta and Randleman accident investigations are similar. Throughout the report, the vehicles discussed are 15-passenger vans; the same issues also apply to 12-passenger vans. Following a discussion of each accident scenario, the analysis will present issues related to vehicle classification, driver training, occupant protection, and tire condition, inspection, and maintenance, which are relevant to both accidents.

Henrietta, Texas

The failure of the left rear tire initiated the Henrietta accident sequence. The tire experienced a separation of the tread and belt and rapid air loss, causing a change in the vehicle's handling characteristics. The failed tire created more rolling resistance on the roadway than the other tires did, and the driver would have felt the van begin to rotate counterclockwise. When a driver feels his or her vehicle start to rotate, the instinctual

[33] Rollover ratio is the number of single-vehicle rollover accidents divided by the number of all single-vehicle accidents.

[34] W.R. Garrott, B. Rhea, R. Subramanian, and G.J. Heydinger, *The Rollover Propensity of Fifteen-Passenger Vans*, Research Note (Washington, DC: NHTSA, April 2001).

reaction is to turn the vehicle in the opposite direction to stop the rotation and then to brake. Physical evidence and witness statements indicate that the Henrietta driver did try to correct the van's orientation by steering toward the right and braking.

Application of the brakes would have increased the lateral force created by the left rear tire, requiring more driver input. Physical evidence indicated that as greater steering force was applied, the van started rotating toward the right. In an effort to correct the clockwise rotation, the driver probably steered left; that input, coupled with the drag of the left rear tire, would have caused further vehicle instability as the van rotated back toward the left. The van departed the roadway, rolling over twice toward the right, and seven passengers were ejected during the rollover sequence.

Compensatory steering and braking are natural driver reactions when a vehicle begins to lose control. In an automobile, the effects of such steering and braking are not necessarily disabling, but because a loaded 15-passenger van has a high, rearward center of gravity, driver input is magnified and quickly leads to instability. During the dynamic stability testing with underinflated tires, the test driver reported that he experienced reduced steering control following the blowout.

Neither the highway design, nor pavement conditions, nor the weather contributed to the Henrietta accident. The driver had not used alcohol or other performance-degrading drugs before the accident, and she had no known health problems that would have affected her ability to drive a vehicle. The driver had obtained sufficient rest in the 72 hours prior to the accident. On the day of the accident, she did get at least 2.5 hours less sleep than on the previous 2 days, and small reductions in sleep (as little as 2 hours) can result in measurable changes in vigilance.[35] However, the circumstances of the accident do not indicate that the driver's performance was degraded due to lack of sleep nor do they suggest that she was less than vigilant in her driving behavior and reaction to the tire blowout. The emergency response to the accident was timely and adequate.

Randleman, North Carolina

The failure of the left rear tire also initiated the Randleman accident sequence. Again, the tire experienced separation of the tread and belt and rapid air loss, causing a change in the vehicle's handling characteristics. The failed tire created more rolling resistance on the roadway than the other tires did, and the driver, as in the case of the Henrietta accident, would have felt the van rotating counterclockwise. The van was in the left lane when the tire blew out. Physical evidence indicated that the driver quite likely steered to the right to counteract the counterclockwise rotation, causing the van to move into the right lane. The driver then probably overcorrected back to the left and possibly applied the brakes as the van returned to the left lane in an arc and toward the median, hitting the shoulder. At this point, the driver may have steered back to the right to return to the roadway, when the van rotated clockwise and then overturned toward the driver's side.

[35] R.T. Wilkinson, R.S. Edwards, and E. Haines, "Performance Following a Night of Reduced Sleep," *Psychonomic Science* Vol. 5 (1966): 471-472.

Neither the highway design, nor pavement conditions, nor the weather contributed to the accident. Law enforcement personnel on scene stated that they did not believe that the van driver was under the influence of alcohol or other drugs, and they did not request a test of the driver for these substances. Although a toxicology test was not available, the driver's performance during the accident and his behavior afterward do not indicate that he was under the influence of alcohol or other drugs. The driver stated that he did not have any chronic medical conditions. While the driver had only obtained an average of 6 hours of sleep per night in the previous 72 hours, he was not necessarily sleep-deprived at the time of the accident. The average sleep requirement is about 7.5 to 8 hours per night; given the variability and individual differences in sleep needs, 6 hours of uninterrupted sleep may have been sufficient for this driver. Furthermore, the driver's performance and reaction to the tire blowout do not indicate that he was operating in a fatigued state. The emergency response in this accident was timely and adequate.

The Safety Board concludes that following the tire blowouts, both accident drivers instinctively, but inappropriately, applied the brakes and oversteered in an attempt to regain control of their vans; however, these actions led to further vehicle instability, resulting in loss of control and subsequent rollover. The Safety Board further concludes that there is no evidence of alcohol use, other drug use, or fatigue on the part of either driver. Weather and roadway conditions did not contribute to the Henrietta and Randleman accidents, and the emergency response to both was adequate.

Vehicle Classification

According to NHTSA's FMVSSs, 12- and 15- passenger vans, which can carry more than 10 passengers, are buses and therefore not required to meet the same safety and occupant protection requirements as passenger vehicles. Yet these vans are built neither to the standards for school buses nor to the industry standards for motorcoaches. Moreover, vans are often used in the same manner as passenger vehicles, even though they have different safety requirements and are required to meet different safety standards in some areas. Vans have a higher center of gravity and can accommodate more occupants than passenger vehicles, but are currently held to less stringent occupant protection and roof crush requirements than passenger vehicles (see occupant protection section below). Even though these vans are used in a manner similar to passenger cars, the occupants are not afforded the same level of safety as those occupants riding in passenger cars.

Although NHTSA classifies 12- and 15-passenger vans as buses, the Federal Motor Carrier Safety Administration (FMCSA) considers them commercial vehicles only if they are used for compensation, in which case a van designed to carry 8 or more passengers is considered a commercial vehicle. Therefore, any individual who has a driver's license and is not operating the vehicle for compensation can operate a 12- or 15-passenger van without additional training, despite NHTSA's statement in its consumer advisory that they have different operating characteristics from passenger cars. Because the vans in the Henrietta and Randleman accidents were not used for compensation, the FMCSA did not consider them commercial vehicles; therefore, the operators were not required to have a commercial driver's license. The FMCSA regards 12- and 15-passenger vans as commercial vehicles based solely on their intended use (for compensation), not on their handling characteristics. Yet the van's handling characteristics are the same, regardless of whether the driver is being paid. These vans are the only type of vehicle that may or may not be classified as commercial, depending on use; all other vehicles, such as trucks over 26,000 pounds or buses carrying more than 15 passengers, are always defined as commercial vehicles.

Despite NHTSA's consumer advisory, the general public may not be aware that 12- and 15-passenger vans, which are not sold or used differently from passenger vehicles, have unique operating characteristics. Church officials in the Henrietta and Randleman accidents did not know that the vans differed from passenger cars in any way except size, even though the accident vans were not required to meet the same safety standards as passenger vehicles. Additionally, the vans may or may not be defined as commercial vehicles, depending on their use, leading to further confusion on the part of the public and a lack of consistent requirements for training and licensure.

The Safety Board concludes that NHTSA's and the FMCSA's inadequate and inconsistent vehicle classification of 12- and 15-passenger vans leaves a gap that adversely affects regulations pertaining to the manufacture and safe operation of these vehicles. The Safety Board believes that NHTSA and the FMCSA should revise their definitions of buses and commercial motor vehicles to apply consistently to 12- and 15-passenger vans, taking into account the unique operating characteristics and multiple functions of these vans.

Training

NHTSA's study on *The Rollover Propensity of Fifteen-passenger Vans* demonstrated that 15-passenger vans are inherently unstable when loaded to the level for which they are designed—carrying more than 10 passengers. NHTSA therefore advises all van drivers to obtain specific training on the handling and operation of these vehicles. However, as investigators found during the Henrietta and Randleman accident investigations, the van owners were not aware of the information provided by NHTSA in its consumer advisory. The advisory has not reached all 15-passenger van operators, even those within the target group, such as churches, and the Henrietta and Randleman operators did not know that they should have specific training to operate the vans safely. Both accident drivers had experience operating 15-passenger vans, but no specialized training on the handling and driving characteristics of these vehicles; neither driver was able to control the van in an emergency.

As shown in testing, the van was controllable during an anticipated blowout, and the test driver thought that the effort required to control the vehicle was within the range of an unimpaired driver. However, even the professional test driver was unable to maintain the lane of travel in test 3 when the tires were inflated below the manufacturer's recommended inflation pressures, which were similar to those in the Henrietta accident;

the van swayed from side to side as the test driver brought it under control. The professional test driver also stated that the van was more difficult to control at higher speeds, particularly with lower tire inflation pressures, and that steering inputs were magnified after the blowout. The test driver had experience operating unloaded 15-passenger vans during a blowout, and he triggered the tire blowout himself, so the situation was not unexpected, as it was during the accidents. Further, an experiment on driver reaction to tread separation that was conducted in the National Advanced Driving Simulator found that

> findings from test track studies in which test drivers were aware of an imminent tread separation may underestimate the extent to which tread separation occurring in the real world leads to instability and loss of vehicle control.[36]

Thus, even though the test van was configured similarly to the Henrietta van, the test did not replicate either accident in the critical area of operator behavior.

While both accident drivers were familiar with their respective vans and had driven them previously, investigators did not find evidence that either driver had experienced an emergency situation, such as tire failure, while operating the van. Both drivers are likely to have overcorrected and braked following the blowout because they did not know how to respond appropriately to the vehicle dynamics that occurred after the blowout and did not understand the potential instability problems associated with 15-passenger vans. The drivers are likely to have reacted instinctively by attempting to correct the rotation of the van while braking to slow it. Had the two drivers maintained their speed, not applied the brakes, and exerted more controlled steering, as the professional driver did during the tests, they may have been able to control their vans. Braking, the likely response on the part of both drivers, can lead to further vehicle instability during a tire failure, particularly in a fully loaded 15-passenger van with a high, rearward center of gravity. The drivers' lack of training on their vehicles' operating and handling characteristics, particularly in emergency situations, put them at a disadvantage in reacting to the blowout.

As the National Safety Council, the American Automobile Association, and most driver education programs recognize, acceleration is the appropriate response to a blowout, but that response is counterintuitive to the general public. Therefore, such groups emphasize that drivers need to refrain from braking and to decelerate slowly in the event of a tire blowout. This strategy requires that the driver provide steering input to counteract the lateral dragging force created by the blown tire. If a driver brakes, the lateral steering force experienced by the vehicle is greater and the driver must provide more steering input to maintain control of the vehicle. If the driver provides too much steering input, he or she will have to try to correct the direction of the vehicle and may oversteer. When the vehicle has a high, rearward center of gravity, as a loaded 15-passenger van does, the rapid changes in steering direction can lead to instability and rollover. A similar driver reaction

[36] T.A. Ranney, G. Heydinger, G. Watson, K Salaani, E.N. Mazzae, and P. Grygier, *Investigation of Driver Reactions to Tread Separation Scenarios in the National Advanced Driving Simulator (NADS)*, DOT HS 809 523 (Washington, DC: National Highway Traffic Safety Administration, 2002).

to a blowout in a passenger car is unlikely to have such severe consequences because the passenger car's lower center of gravity makes it more forgiving of inappropriate driver inputs.

Impressing upon 15-passenger van drivers the inherent dangers of operating these vehicles, particularly when fully loaded, and educating them about proper handling and control, particularly during emergency situations, can reduce the risk of rollover. Such training can also help dispel the expectation that these vans operate like large passenger cars. While the accident drivers had experience operating the vans, they did not have experience with how the vehicles would respond in this type of emergency situation or other emergency situations or the consequences of their instinctive reactions to such situations. Educating drivers on how such vehicles respond to, and on the consequences of, different driver input could help operators approach 15-passenger van driving more cautiously.

In addition, training would provide a forum for educating drivers about the tire pressures and maintenance required for 15-passenger vans. The rear tires on a fully loaded van, for instance, must be inflated to 80 psi, which is much higher than the rear tire pressure for most passenger cars. Stressing the importance of proper tire inflation during training will help drivers avoid potential problems. Drivers should also be taught to check the tires and tire pressure before driving the vehicle. In both these accidents, the tires were in very poor condition, which should have been readily apparent to someone who knew to look for cracks and rotting rubber.

Although NHTSA recommends that 15-passenger van drivers be trained to operate the vehicles, the agency does not provide information on the source of such training. The National Safety Council offers computer-based training, "Coaching the Van Driver," and many colleges and universities use this program to train their employees who drive vans. But this course does not educate drivers about emergency handling of the vans, nor does it discuss tire pressure and maintenance.

To ensure that drivers have the necessary skills to operate vehicles other than passenger vehicles, States have established classes of driver's licenses, for example, a commercial driver's license, a motorcycle license, or a chauffeur's endorsement, that require specialized training and testing. No such class of license exists for 15-passenger vans. Yet, as NHTSA has acknowledged, 15-passenger van operators need training in the handling of those vehicles, and testing has demonstrated that controlling 15-passenger vans in a blowout is possible, albeit difficult, for a trained driver. The Safety Board concludes that safe operation of 15-passenger vans requires a knowledge and skill level different from and above that for passenger vehicles, particularly when the vans are fully loaded or drivers experience an emergency situation. Therefore, the Safety Board believes that the American Driver and Traffic Safety Education Association,[37] in conjunction with NHTSA, the National Safety Council, the American Automobile Association, GM, and Ford, should develop a training program that incorporates the skills required for safe

[37] The American Driver and Traffic Safety Education Association establishes and publishes policies and guidelines for traffic safety education.

operation of 12- and 15-passenger vans and addresses the consequences of unsafe operation, including, but not limited to, operating in a fully loaded condition, emergency braking, high-speed lane changes, tire blowouts, and tire pressure and maintenance. The Safety Board further believes that the States and the District of Columbia should establish a driver's license endorsement for 12- and 15-passenger vans that adopts the standards established by the American Driver and Traffic Safety Education Association; to obtain the endorsement, drivers should have to complete a training program on the operation of 12- and 15-passenger vans and pass a written and skills test.

While training will help 15-passenger van drivers understand the vehicles' unique handling and operating characteristics, it will not prevent all accidents involving such vehicles. The Safety Board realizes that tire blowouts require split-second, instinctual reactions that are not easily trained. For this reason, the Safety Board has recommended that 15-passenger vans be equipped with electronic stability control systems to assist drivers in maintaining control of the vehicle during emergencies (Safety Recommendations H-02-28 and -29).

Occupant Protection

Research into rollover crashes shows that a systems approach to occupant protection, involving seat belts, seats, the roof, and interior structures, is necessary to minimize occupant exposure to injury-causing mechanisms.[38] While much of this research was performed on passenger cars, it applies equally to 15-passenger vans, whose occupants also need to be protected during accidents.

In a rollover accident, the accelerations experienced by occupants at the vehicle's center of gravity can be low compared to the accelerations experienced by occupants in frontal or side impact collisions. Nonetheless, the severity of rollovers can still be significant. Researchers have found that the acceleration at a roof rail can be three times that at the center of gravity,[39] posing risks for occupants located near the accelerating roof rail. In the Henrietta simulation, the unbelted occupants sustained severe injuries, even though maximum accelerations experienced by the passengers at the van's center of gravity were less than 10 times the acceleration of gravity in the first rollover.

The Henrietta, Randleman, and other accidents, as well as the simulations conducted for this investigation, demonstrate that when a 15-passenger van is involved in a rollover accident, occupant protection needs to be improved in order to save lives and reduce injuries. Specifically, changes are needed in interior surfaces, seat belts, and roof crush protection.

[38] M.W. Arndt, G.A. Mowry, C.P. Dickerson, and S.M. Arndt, "Evaluation of Experimental Restraints in Rollover Conditions," SAE Paper 95712 (Warrendale, PA: Society of Automotive Engineers, 1995).

[39] J.W. Carter, J.L. Habberstad, and J. Croteau, "A Comparison of the Controller Rollover Impact System (CRIS) with the J2114 Rollover Dolly," SAE Paper 2002-01-0694 (Warrendale, PA: Society of Automotive Engineers, 2002).

Interior Surfaces

FMVSS 201, "Occupant Protection in Interior Impact," specifies requirements for protecting occupants inside passenger cars, multipurpose vehicles, trucks, and buses that have a GVWR less than 4,536 kg (10,000 pounds); the requirements for upper interior components do not apply to buses, including 15-passenger vans, that have a GVWR greater than 3,860 kg (8,510 pounds). The requirements that apply to 15-passenger vans include those for instrument panels, seatbacks, interior compartment doors, sun visors, and armrests. Fifteen-passenger vans do not have to meet the phased-in requirement for upper interior components in passenger vehicles manufactured after September 1, 1998, which mandates that vehicles meet head injury criteria for impacts with the front header, rear header, side rails, sliding door track, all pillars, roof braces or stiffeners, and seat belt anchorages.

In both the Henrietta and Randleman accidents, occupants contacted and sustained injuries from one or more interior surfaces that are required to be protected in passenger vehicles but not in 15-passenger vans. The front passenger in the Henrietta accident was restrained by a lap/shoulder belt but sustained injuries due to contact with the interior roof and B-pillar during the rollover sequence. Four passengers in the Henrietta accident were seated on the left side of the vehicle (seats 3, 6, 9, and 12). A possible source of their injuries prior to ejection was deceleration into the noncrash-protected interior surfaces, including the roof, exposed window frame, and collapsed sidewalls, during the initial rollover and subsequent roof crush. Two passengers in the Henrietta van (seats 5 and 14) were unbelted but remained inside the vehicle, and both sustained serious injuries. The passenger in seat 14, for example, sustained a first rib fracture, which is rare unless extreme force is applied to the upper torso.[40] The injuries to these passengers most likely resulted from contact with interior vehicle components, roof crush deformation into the survivable space of the vehicle compartment, or striking or being struck by other occupants during the rollover.

While restraint use in rollovers increases an occupant's chance of survival by preventing ejections, seat belts cannot prevent head contact with the adjacent roof or window.[41] The most frequent harmful contact points for nonejected occupants are the roof, pillars, rails, and headers (28.1 percent combined).[42] Therefore, vehicles need to be designed with impact protection to minimize injuries when an individual's head strikes the roof or windows.

The Henrietta and Randleman accident vans did not afford passengers the occupant-protected surfaces that passenger cars would have provided. The Safety Board concludes that during the rollover sequences in the Henrietta and Randleman accidents,

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[40] David Viano, *Chest: Anatomy, Types and Mechanisms of Injury, Tolerance Criteria and Limits, and Injury Factors*, AAM and IRCOBI Biomechanics of Trauma Course Book, October 1997, p. 9.

[41] G.S. Bahling, R.T. Bundorf, G.S. Kaspzyk, E.A. Moffatt, K.O. Orlowski, and J.E. Stocke, "Rollover and Drop Tests – The Influence of Roof Strength on Injury Mechanics Using Belted Dummies," *Stapp Car Crash Conference 34th Proceedings, Orlando, Florida* (Warrendale, PA: Society of Automotive Engineers, 1990) 101-112.

[42] M.W. Arndt, G.A., Mowry, C.P. Dickerson, and S.M. Arndt.

passengers remaining inside the vehicles, as well as some ejected occupants, sustained injuries as a result of contact with interior surfaces, which were not required to be protected from occupant impact. Even if these accidents had occurred in vans manufactured today, those passengers who remained within the vehicles or struck surfaces before being ejected may still have sustained injuries, since parts of FMVSS 201 do not apply to 15-passenger vans. FMVSS 201 reduces fatal injuries because it mandates use of technologies such as side airbags, curtain airbags, or energy-absorbing materials. Passenger cars today incorporate these technologies, but occupants of 15-passenger vans do not benefit from such protection. The Safety Board believes that NHTSA should include 12- and 15-passenger vans in Federal Motor Vehicle Safety Standard 201, Section 6, "Requirements for Upper Interior Component Protection." Further, the Safety Board believes that Ford and GM should voluntarily develop and install technologies, to provide upper interior component protection within 12- and 15-passenger vans by model year 2006. DaimlerChrysler no longer manufactures 15-passenger vans.

Seat Belt Usage

Lap/Shoulder Belts. In the Henrietta accident, 7 of the 12 occupants were ejected from the van during the rollover, and 3 of the 7 ejected occupants sustained fatal injuries; none of the 3 belted occupants were ejected. In the Randleman accident, 4 of 14 occupants were ejected from the van during the rollover, 1 of whom sustained fatal injuries. None of the ejected Randleman occupants was wearing his or her seat belt, and at least five of the vehicle's lap belts were unusable.

When a passenger is ejected from a vehicle during an accident, he or she is exposed to rapid deceleration into injury-causing surfaces outside the vehicle. The orientation and speed of the passenger and the kind of surface struck are important factors in determining the nature and extent of the injuries sustained.

In the Henrietta accident, the ejected passengers' injuries included traumatic head injuries, spinal injury, skeletal fractures, blunt force trauma to the internal organs, and severe lacerations. Seven passengers were ejected during the accident sequence, five of whom had lap/shoulder belts available, although none wore the restraint. Had they been restrained, the vehicle would have given them some protection during the overturn sequence; instead they struck the ground at the same speed at which they were ejected from the vehicle, exacerbating the injuries they sustained inside the vehicle. The accident simulation showed that during the first overturn, head, neck, and thorax injuries were not predicted for simulated occupants wearing lap/shoulder belts.

In the Randleman accident, the three ejected passengers experienced traumatic head injuries, spinal injury, and lacerations. The injuries sustained by those who remained in the van were minor because these passengers did not experience rapid decelerations into injury-causing surfaces outside the vehicle. The ejected passengers were seated on the right side of the van and were unrestrained. Thus, during the accident sequence, they did not remain within their seating area, but moved about the compartment before being ejected. Had they been wearing their lap belts, as two of them were required to do by

North Carolina law (because they were less than 16 years old), they may have benefited from the protection provided by the vehicle.

In both accidents, the ejected passengers' injuries were significantly more severe than those sustained by passengers who remained in the vehicles. The one exception was the Henrietta driver, whose injuries were due to roof crush and the loss of survivable space (see roof crush section below). One of the five occupants who remained within the vehicle (seat 11) in the Henrietta accident was restrained by a lap belt only and sustained injuries when her upper body struck the interior surfaces or when she contacted other unrestrained passengers during the accident sequence. A lap belt does not prevent movement of the upper body and acts as a fulcrum for flailing of the upper body and lower extremities.[43] However, the lap belt did prevent ejection, giving the passenger some protection as the van overturned and deformed. She did not experience the rapid deceleration into injury-causing surfaces inside or outside the vehicle that the ejected passengers did. Additionally, this passenger's injuries were not as severe as those of the unbelted passengers seated around her who also remained within the van, probably because she did not strike injury-causing surfaces within the vehicle or other passengers at as great a velocity. The simulation of lap-belted occupants within the van predicted a thorax injury for the simulated occupant in seat 15 during the first rollover sequence, further indicating that lap belts alone are not the most effective restraint.

The Henrietta simulations showed that the amount of movement for unrestrained occupants was significantly greater than that of their restrained counterparts, resulting in far more serious predicted injuries and exposing them to the serious injuries associated with ejection. These predicted injuries occurred because the simulated occupants struck parts of the van during the accident sequence. Additionally, several simulated occupants in the unrestrained conditions were either partially or fully ejected, whereas neither of the restrained conditions resulted in predicted ejections during the first overturn. The Safety Board concludes that had the passengers in the accident vans been wearing lap/shoulder belts, their injuries may have been less severe because of fewer and less forceful impacts with nonoccupant-protected interior components and other occupants and because those who were ejected would have remained in the vehicles.

The Safety Board has advocated use of lap/shoulder belts for many years because they greatly reduce a passenger's risk of injury during a collision. Restrained by lap belts only, passengers sometimes sustain abdominal injuries as a result of pivoting about the lap belt or as the upper body flails about. Yet the Ford and GM vans being manufactured today are equipped with lap/shoulder belts only at the outboard locations, rather than at all seating locations. NHTSA is developing a rulemaking to require that all center seats be equipped with lap/shoulder belts but has not disclosed whether the rulemaking will apply to 15-passenger vans. Ford and GM have begun to equip the passenger vehicles in their fleets with center lap/shoulder belts but have not indicated whether they will so equip their 15-passenger vans, which are not classified as passenger vehicles. The Safety Board believes that NHTSA should include 12- and 15-passenger vans in its upcoming

[43] J.K. Mason, *The Pathology of Violent Injury* (London: Edward Arnold, 1978) 28.

rulemaking that will require lap/shoulder belts at all center seats. The Safety Board also believes that Ford and GM should voluntarily install lap/shoulder belts at all center seating positions in 12- and 15-passenger vans and make all lap/shoulder belts in outboard and center seating positions adjustable by model year 2006.

The fatally injured occupant in the Randleman accident was seated in a position that had a seat belt that was completely unusable; the buckle was wedged so tightly inside the seat bight that investigators could not even remove the buckle for inspection. In four other seats in the van, the seat belts were unusable either because of missing components or because the seat belt was stuck in the seat bight or under the seat frame. Children, who are required to be restrained by North Carolina law, occupied four of the five seating positions with unusable belts. Thus, even if these passengers had wanted to wear their seat belts, they would have been unable to do so. In an informal survey of other 15-passenger vans, investigators found that the vehicles lacked any mechanism to ensure that seat belt latches and buckles remain accessible in the seat bight. The Safety Board believes that Ford and GM should redesign the seat belts in their 12- and 15-passenger vans to ensure that the buckle and latch components remain readily accessible to occupants at all times by model year 2006. The Safety Board plans to inform 12- and 15-passenger van owners and operators about the importance of maintaining seat belt accessibility.

Lap Belt Configuration. The purpose of seat belts is to reduce the likelihood of injury in the event of a crash. The two lap belts in the center of row 4 in both accident vehicles were configured so that one of the webbing straps for each passenger would have to pass behind the adjacent passenger if both occupants were to be lap belted at the same time. In the event of a forward deceleration, the webbing of the belt passing behind a passenger would compress his or her abdomen, potentially causing abdominal injuries. In the event of a lateral collision, because one webbing strap for each passenger (the buckle for one and the latch plate for the other) would have to extend quite far from its anchor position, the lack of a properly fitting restraint at the two positions would permit lateral movement of the passengers, thereby increasing the risk of injury to all four passengers in the fourth row.

Also, because of the distance between the two anchorages, two people could conceivably share one lap belt, leaving the other latch and buckle unused. FMVSS 209, “Seat Belt Assemblies,” requires that such assemblies be designed for use by one, and only one, person at a time. Thus, the current configuration of the lap belt anchorages does not conform to FMVSS 209 and provides users with an opportunity to use the seat belts in an unsafe manner. The Safety Board concludes that the lap belt assemblies and anchorages in the center of the fourth row of both accident vans were configured in a manner that had potential to increase the risk of injury to passengers in the event of an accident. On July 10, 2003, staff met with DaimlerChrysler representatives, who demonstrated that, even though a potential hazard exists, no actual occurrence has been reported in more that 30 years of fleet operations. Although Dodge no longer manufactures these vans, DaimlerChrysler committed to monitoring the issue of the fourth row center lap belts through its defect investigation system and will report to the Safety Board any relevant complaints identified.

Roof Crush

One of the impact points between the Henrietta van and the ground during the rollover was the left front corner of the roof; the resulting roof crush at that location was so severe that it brought the roof in contact with the top of the driver's seatback. The driver was belted but sustained fatal head injuries as a result of the roof intrusion.

After the Henrietta accident, roof crush left 4 to 6 inches of space above each row of passenger seats; originally, the vehicle had 18 to 21 inches of space between the roof and the seats. Passengers probably sustained more serious injuries due to contact with the roof during the rollover and the resulting lack of interior space. The Safety Board concludes that roof crush to the Henrietta accident van contributed to the severity of the driver's injuries and diminished survivable space for the passengers. The roof in the Randleman accident did not sustain similar crush damage, probably due to the vehicle dynamics during the rollover sequence. The lack of roof crush damage may be one reason the injuries to those passengers who remained within the vehicle were less severe than in the case of the Henrietta accident. Other factors that may have contributed to the differing severity of injuries in these two accidents were the age of the occupants, the points of impact during the rolls, and the crash pulse experienced as the vehicles rolled over.

The Safety Board investigated another accident involving roof crush in a 15-passenger van that occurred on March 12, 2000, near San Antonio, Texas.[44] The driver, who had attempted to change lanes, left the roadway; when she tried to correct her path of travel, the vehicle rolled over, landed on a guardrail, and the rear of the vehicle straddled the guardrail on its roof. A lap/shoulder-belted 15-year-old female passenger was fatally injured; a lap/shoulder-belted 15-year-old male passenger and an unrestrained 15-year-old female passenger were seriously injured. All three were seated in the area of roof crush damage. The driver and the other 10 passengers, also belted, were outside the roof crush area and did not sustain serious injuries.

Studies have shown that the initial roof crush usually does not increase injuries to unrestrained occupants; passengers generally sustain serious injuries during contact with the roof and upper door window areas and when the head is adjacent to these areas during contact the ground.[45] However, the reduction in survivable space due to roof crush for those who remain within the vehicle can lead to injuries, particularly during subsequent rollovers. NHTSA, which evaluated 1988-1999 National Automotive Sampling System and Fatality Analysis Reporting System data, found that, on average, 26,376 occupants sustain serious or fatal injuries in light-vehicle rollovers annually. Roof crush intrusion is estimated to occur and possibly contribute to serious or fatal injury in about 26 percent of rollover crashes.[46] If the roof does not crush, belted occupants may benefit because they

[44] Docket No. HWY-00-IH-032.

[45] K.F. Orlowski, R.T. Bundorf, and E.A. Moffatt, "Rollover Crash Tests—The Influence of Roof Strength on Injury Mechanics," SAE Paper 851734 (Warrendale, PA: Society of Automotive Engineers, 1985).

[46] National Highway Traffic Safety Administration, *Federal Motor Vehicle Safety Standards; Roof Crush Resistance*, NHTSA-1999-5572; Notice 2 (Washington, DC: NHTSA, October 2001).

have less chance of contacting the roof and being subjected to the forces of roof-to-ground contact during the rollover sequence.[47]

The purpose of FMVSS 216, "Roof Crush Resistance," which establishes strength requirements for passenger compartment roofs, is to reduce death and injury due to roof crush in rollover crashes. The standard applies only to passenger cars, multipurpose vehicles, and buses with a GVWR of 2,722 kilograms (6,000 pounds) or less. The GVWRs of 15-passenger vans exceed 8,500 pounds and, therefore, the vans are not required to meet FMVSS 216. Yet statistics show that 15-passenger vans are involved in a higher percentage of rollover accidents than are passenger cars and smaller vans. About 52 percent of the 15-passenger vans involved in fatal single-vehicle accidents experience a rollover, while 33 percent of passenger cars involved in such accidents do.[48]

NHTSA requested comments on its proposed amendments to FMVSS 216 on October 22, 2001. In the request, NHTSA stated that it is considering whether to extend FMVSS 216 to vehicles weighing up to 10,000 pounds, because the composition of the vehicle fleet has changed since the previous rulemaking was issued; in particular, the number of vehicles weighing more than 6,000 pounds has increased.

The Safety Board believes that NHTSA should include 12- and 15-passenger vans in FMVSS 216, "Roof Crush Resistance," to minimize the extent to which survivable space is compromised in the event of a rollover accident. Further, the Safety Board believes that Ford and GM should voluntarily redesign 12- and 15-passenger vans to minimize the extent to which survivable space is compromised in the event of a rollover accident by model year 2006.

Tires

Two of the Henrietta van's four tires, including the tire that suffered the tread/belt separation, were original tires (8 years old). Three of the four tires on the Randleman van were more than 8 years old. When not in use, both vans had been parked in the unprotected parking lots of their respective churches since purchase. The tires were subject to the ozone and ultraviolet light present outdoors, which can degrade the tire rubber, leading to dry rot and weather checking. These phenomena are typical of a sedentary vehicle; during normal use, anti-degradants introduced during the tire manufacturing process are released and brought to the surface of the tire. When a vehicle is not driven extensively (the Henrietta van averaged 5,500 miles per year and the Randleman van averaged about 7,000 miles per year), this release does not occur. Visual inspection of the two original tires on the Henrietta van and all the tires on the Randleman van revealed that the tires were drying out and that the rubber was rotting and cracking.

[47] G.S. Bahling, R.T. Bundorf, G.S. Kaspzyk, E.A. Moffatt, K.O. Orlowski, and J.E. Stocke.

[48] National Transportation Safety Board, *Evaluation of the Rollover Propensity of 15-passenger Vans*, Safety Report NTSB/SR-02/03 (Washington, DC: NTSB, 2002).

These conditions can lead to tire failure. The sidewall and tread groove cracking on the tires of both vans was evidence of this degradation due to weather.

None of the Henrietta or Randleman tires were inflated to the recommended pressure, even though the manufacturer-recommended pressures were specified on a label inside the driver's doorsill. The two front tires on the Henrietta van were inflated to 60 psi; the recommended pressure was 55 psi. The right rear tire on the Henrietta van was inflated to 58 psi; the preaccident pressure of the left rear tire could not be determined. However, given that three of the four tires on the Henrietta van were inflated to or near 60 psi and the words "reinflate to 60 psi" were written on the right front tire in yellow crayon, the left rear tire was also probably inflated to about 60 psi. Thus, the two rear tires were significantly under the manufacturer's recommended pressure of 80 psi. On the Randleman van, the left and right front tires were inflated to 62.5 psi and 60.5 psi, respectively, and the right rear tire was inflated to 60 psi. Again, the preaccident pressure on the left rear tire could not be determined but is likely to have been about 60 psi, as was true of the other three tires. The manufacturer-recommended tire pressures for the Randleman van were 50 psi[49] for the front tires and 80 psi for the rear tires.

Overinflated tires can result in excessive tire wear to the center of the tread. Underinflation can shorten a tire's life and lead to premature tire failure. According to NHTSA, "When a tire is used while significantly underinflated, its sidewalls flex more and the air temperature inside the tire increases, increasing stress and the risk of failure. In addition, a significantly underinflated tire loses lateral traction, making handling more difficult."[50]

Underinflated tires are also able to carry less weight. In the case of the tires on the accident vehicles, when inflated to a pressure of 60 psi, each rear tire could carry almost 500 pounds less than it was designed to carry had it been inflated to the manufacturer's recommended pressure of 80 psi.

Neither the degradation of the tires from weather nor the underinflated pressure of the left rear tire by itself is likely to have caused the tire failure on either van. Nonetheless, they were contributory factors. Also, a small hole extending through all the tire components of the Henrietta tire may have allowed air to penetrate the tire, thereby degrading its structural integrity. The Safety Board concludes that a combination of underinflation, degradation from weather, and, in the case of the Henrietta van tire, a possible infiltration of air through a small puncture, is likely to have led to the rapid air loss and tread/belt separation on both the Henrietta and the Randleman left rear tires.

In addition, the right rear tire on the Randleman van was underrated for the accident vehicle, that is, the tire could not carry the maximum load required for the vehicle. An underrated tire flexes too much and can lead to failure. The required tire rating is printed in the owner's manual and can also be found on the tire. A replacement tire

[49] The recommended front tire pressures for the two vans were probably different because of a 1992 design change to the van.

[50] Docket No. NHTSA 2000-8572.

should always have the same or greater load rating as the original. The owner could provide no information on why an underrated tire had been placed on the Randleman van.

Tires may be not be inflated to the proper pressure or an underrated tire may be placed on a vehicle because drivers are unaware of the proper pressure or load rating. As part of the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act of 2000, NHTSA issued a final rulemaking that requires manufacturers to place a prominent label stating the manufacturer-recommended tire pressures and tire load ratings on all vehicles weighing less than 10,000 pounds; the label is to be printed in yellow, red, black, and white and is to be affixed to the vehicle's B-pillar (the pillar behind the driver). By requiring placement of the label in a prominent location and providing consistent information, NHTSA seeks to ensure that consumers have the necessary information to maintain their tires.

As required by the TREAD Act, NHTSA also issued a rulemaking on June 5, 2002, directing that all vehicles be equipped with a tire pressure monitoring system that will alert the driver when a tire is significantly underinflated. During the period from November 1, 2003, through October 31, 2006, manufacturers must begin phasing in tire pressuring monitoring systems on their vehicles. To allow itself sufficient time to consider additional data on the effect and performance of tire pressure monitoring systems, NHTSA plans to defer a decision on long-term performance requirements for such systems on vehicles manufactured after October 31, 2006. It intends to publish these requirements by March 1, 2005, to give manufacturers sufficient lead time to comply with the final rule.

In its rulemaking, NHTSA requires manufacturers to employ a system that alerts drivers if the tire pressure of one or more tires is at least 25 or 30 percent[51] below the vehicle manufacturer's recommended cold inflation pressure for the tires. Based on this criterion, a tire pressure monitoring system on the accident vans would only have been required to warn the drivers when the pressure in the rear tires reached 25 or 30 percent of the recommended pressure of 80 psi, that is, 56 or 60 psi. At the time of the accidents, the rear tires of the vans were quite likely inflated to 58 or 60 psi and thus may not have been beyond the threshold that today's tire pressure monitoring systems were designed to detect. The Safety Board concludes that because low tire pressure in fully loaded 15-passenger vans contributes to vehicle instability, the current tire pressure monitoring standard of 25 or 30 percent below manufacturer's recommended pressure is insufficient to warn van drivers of potentially unsafe low pressures.

As was seen during the vehicle dynamics testing, the van became more unstable and difficult to control when the tire pressures were inflated to 58 psi for the rear tires. The test driver stated that in the lane change maneuver, the vehicle "wallowed" when the tire pressures were low. During the blowout testing, the driver reported that the van handled better when the tires were inflated to their recommended pressure and that tire pressure significantly affected the handling of the van.

[51] Manufacturers have two options, 25 percent or 30 percent, based on the capabilities of currently available technologies.

The Safety Board understands that tire pressure monitoring systems are a new technology and that detecting pressure differentials below 20 percent is currently difficult. However, as these accidents and the dynamic testing demonstrate, tire pressures that are 25 or 30 percent below the manufacturer's recommended pressure can have significant negative effects on the handling of 15-passenger vans. Therefore, the Safety Board believes that NHTSA, in developing long-term performance requirements for tire pressure monitoring systems, should adopt more stringent detection standards than 25 or 30 percent below manufacturer-recommended levels, since pressures at those levels can have an adverse effect on safe handling of vehicles, such as 12- and 15-passenger vans.

Both accident vehicles had undergone recent State safety inspections; the Henrietta van passed a Texas inspection on October 23, 2000, and the Randleman van passed a Virginia inspection in December 2000. The Texas criteria included visual inspection of tire pressure, as well as identification of tread or sidewall cracks and cuts or snags of more than 1 inch that were deep enough to expose the body cords. The Virginia criteria included checking for cuts in tire fabric, for wear so extensive that the fabric or steel cord is visible, and for knots or bulges in the sidewalls, broken belts, or tread separation from the fabric. Neither State's criteria included excessive cracking and weather checking, a defect on five of the eight tires on the two accident vehicles. Nor did either State require inspectors to make sure that proper load-rated tires were on the vehicle or that tires were inflated to the manufacturer-recommended pressure. While none of these conditions alone was responsible for the tire failures in these accidents, the weather checking and underinflation were contributory factors, and the improperly rated tire on the Randleman accident van could have created an unsafe condition.

The AAMVA inspection handbook recommends that vehicle inspections include measuring tire pressure and, as necessary, correcting deficiencies if the owner agrees. The guidelines do not address weather checking and cracking as criteria for rejection during an inspection. The Safety Board concludes that the Texas and Virginia safety inspection criteria, which do not adequately address tire pressure, overlook an important factor in vehicle safety inspection and that the Texas, Virginia, and AAMVA guidelines for vehicle safety inspections are not thorough enough because they exclude factors such as weather checking and tire rating. The Safety Board believes that Texas and Virginia should require that all passenger vehicle inspections include (1) tire pressure measurement and correction of any inflation deficiencies detected and (2) identification and failure of those tires that exhibit extensive weather checking and deterioration or that are not properly load-rated. The Safety Board believes that AAMVA should revise its *Passenger Vehicles and Light Trucks Inspection Handbook* to provide guidance on inspecting and failing tires for extensive weather checking or deterioration and on examining tires to ensure that they have the proper load rating.

The tires on both accident vans were in poor condition because neither church had a comprehensive maintenance program for its vehicle. No one was responsible for making sure the tires were in sound condition and inflated properly. The Safety Board will inform various users of 12- and 15-passenger vans about the need to inspect the tires frequently and to maintain proper tire pressure.

Conclusions

Findings

1. Following the tire blowouts, both accident drivers instinctively, but inappropriately, applied the brakes and oversteered in an attempt to regain control of their vans; however, these actions led to further vehicle instability, resulting in loss of control and subsequent rollover.

2. There is no evidence of alcohol use, other drug use, or fatigue on the part of either driver. Weather and roadway conditions did not contribute to either the Henrietta, Texas, or Randleman, North Carolina, accidents and the emergency response to both was adequate.

3. The National Highway Traffic Safety Administration's and the Federal Motor Carrier Safety Administration's inadequate and inconsistent vehicle classification of 12- and 15-passenger vans leaves a gap that adversely affects regulations pertaining to the manufacture and safe operation of these vehicles.

4. Safe operation of 15-passenger vans requires a knowledge and skill level different from and above that for passenger vehicles, particularly when the vans are fully loaded or drivers experience an emergency situation.

5. During the rollover sequences in the Henrietta, Texas, and Randleman, North Carolina, accidents, passengers remaining inside the vehicles, as well as some ejected occupants, sustained injuries as a result of contact with interior surfaces, which were not required to be protected from occupant impact.

6. Had the passengers in the accident vans been wearing lap/shoulder belts, their injuries may have been less severe because of fewer and less forceful impacts with nonoccupant-protected interior components and other occupants and because those who were ejected would have remained in the vehicles.

7. The lap belt assemblies and anchorages in the center of the fourth row of both accident vans were configured in a manner that had potential to increase the risk of injury to passengers in the event of an accident.

8. The roof crush to the Henrietta, Texas, accident van contributed to the severity of the driver's injuries and diminished survivable space for the passengers.

9. A combination of underinflation, degradation from weather, and, in the case of the Henrietta, Texas, van tire, a possible infiltration of air through a small puncture, is likely to have led to the rapid air loss and tread/belt separation on both the Henrietta, Texas, and the Randleman, North Carolina, left rear tires.

10. Because low tire pressure in fully loaded 15-passenger vans contributes to vehicle instability, the current tire pressure monitoring standard of 25 or 30 percent below manufacturer's recommended pressure is insufficient to warn van drivers of potentially unsafe low pressures.

11. The Texas and Virginia safety inspection criteria, which do not adequately address tire pressure, overlook an important factor in vehicle safety inspection and that the Texas, Virginia, and American Association of Motor Vehicle Administrators guidelines for vehicle safety inspections are not thorough enough because they exclude factors such as weather checking and tire rating.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accidents was tire failure, the drivers' response to that failure, and the drivers' inability to maintain control of their vans. Contributing to the accidents was the deteriorated condition of the tires, as a result of the churches' lack of tire maintenance, and the handling characteristics of the vans. Contributing to the severity of the injuries was the lack of appropriate *Federal Motor Vehicle Safety Standards* applicable to 15-passenger vans in the areas of restraints and occupant protection.

Recommendations

To the National Highway Traffic Safety Administration:

In cooperation with the Federal Motor Carrier Safety Administration, revise your definitions of buses and commercial motor vehicles to apply consistently to 12- and 15-passenger vans, taking into account the unique operating characteristics and multiple functions of these vans. (H-03-12)

In cooperation with the American Driver and Traffic Safety Education Association, the National Safety Council, the American Automobile Association, General Motors Corporation, and Ford Motor Company, develop a training program that incorporates the skills required for safe operation of 12- and 15-passenger vans and addresses the consequences of unsafe operation, including, but not limited to, operating in a fully loaded condition, emergency braking, high-speed lane changes, tire blowouts, and tire pressure and maintenance. (H-03-13)

Include 12- and 15-passenger vans in Federal Motor Vehicle Safety Standard 201, Section 6, "Requirements for Upper Interior Component Protection." (H-03-14)

Include 12- and 15-passenger vans in your upcoming rulemaking that will require lap/shoulder belts at all center seats. (H-03-15)

Include 12- and 15-passenger vans in Federal Motor Vehicle Safety Standard 216, "Roof Crush Resistance," to minimize the extent to which survivable space is compromised in the event of a rollover accident. (H-03-16)

In developing long-term performance requirements for tire pressure monitoring systems, adopt more stringent detection standards than 25 or 30 percent below manufacturer-recommended levels, since pressures at those levels can have an adverse effect on the handling of vehicles, such as 12- and 15-passenger vans. (H-03-17)

To Federal Motor Carrier Safety Administration:

In cooperation with the National Highway Traffic Safety Administration, revise your definitions of buses and commercial motor vehicles to apply consistently to 12- and 15-passenger vans, taking into account the unique operating characteristics and multiple functions of these vans. (H-03-18)

To the 50 States and the District of Columbia:

Establish a driver's license endorsement for 12- and 15-passenger vans that adopts the standards established by the American Driver and Traffic Safety Education Association; to obtain the endorsement, drivers should have to complete a training program on the operation of 12- and 15-passenger vans and pass a written and skills test. (H-03-19)

To Texas and Virginia:

Require that all passenger vehicle inspections include (1) tire pressure measurement and correction of any inflation deficiencies detected and (2) identification and failure of those tires that exhibit extensive weather checking and deterioration or that are not properly load-rated. (H-03-20)

To the American Driver and Traffic Safety Education Association:

In cooperation with the National Highway Traffic Safety Administration, the National Safety Council, the American Automobile Association, General Motors Corporation, and Ford Motor Company, develop a training program that incorporates the skills required for safe operation of 12- and 15-passenger vans and addresses the consequences of unsafe operation, including, but not limited to, operating in a fully loaded condition, emergency braking, high-speed lane changes, tire blowouts, and tire pressure and maintenance. (H-03-21)

To the American Automobile Association and the National Safety Council:

In cooperation with the American Driver and Traffic Safety Association, the National Highway Traffic Safety Administration, General Motors Corporation, Ford Motor Company, and each other, develop a training program that incorporates the skills required for safe operation of 12- and 15-passenger vans and addresses the consequences of unsafe operation, including, but not limited to, operating in a fully loaded condition, emergency braking, high-speed lane changes, tire blowouts, and tire pressure and maintenance. (H-03-22)

To American Association of Motor Vehicle Administrators:

Revise your *Passenger Vehicles and Light Trucks Inspection Handbook* to provide guidance on inspecting and failing tires for extensive weather checking or deterioration and on examining tires to ensure that they have the proper load rating. (H-03-23)

To Ford Motor Company and General Motors Corporation:

In cooperation with the American Driver and Traffic Safety Association, the National Highway Traffic Safety Administration, the National Safety Council, the American Automobile Association, and each other, develop a training program that incorporates the skills required for safe operation of 12- and 15-passenger vans and addresses the consequences of unsafe operation, including, but not limited to, operating in a fully loaded condition, emergency braking, high-speed lane changes, tire blowouts, and tire pressure and maintenance. (H-03-22)

Voluntarily develop and install technologies to provide upper interior component protection within 12- and 15-passenger vans by model year 2006. (H-03-24)

Voluntarily install lap/shoulder belts at all center seating positions in 12- and 15-passenger vans and make all lap/shoulder belts in outboard and center seating positions adjustable by model year 2006. (H-03-25)

Redesign the seat belts in your 12- and 15-passenger vans to ensure that the buckle and latch components remain readily accessible to occupants at all times by model year 2006. (H-03-26)

Voluntarily redesign 12- and 15-passenger vans to minimize the extent to which survivable space is compromised in the event of a rollover accident by model year 2006. (H-03-27)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Adopted: July 15, 2003

Appendix A

Henrietta, Texas, Investigation

The National Transportation Safety Board was notified of the Henrietta, Texas, accident on May 8, 2001. The Safety Board dispatched an investigative team consisting of members from the Washington, D.C.; Atlanta, Georgia; Fort Worth, Texas; and Parsippany, New Jersey, offices. Groups were established to investigate human performance; motor carrier operations; and highway, vehicle, and survival factors and to conduct on-scene documentation.

Representatives of Michelin, North America, Inc., participated in the investigation.

No public hearing was held; no depositions were taken.

Randleman, North Carolina, Investigation

The National Transportation Safety Board was notified of the Randleman, North Carolina, accident on July 1, 2001. The Safety Board dispatched an investigative team consisting of members from the Washington, D.C.; Atlanta, Georgia; Fort Worth, Texas; and Parsippany, New Jersey, offices. Groups were established to investigate human performance; motor carrier operations; and highway, vehicle, and survival factors.

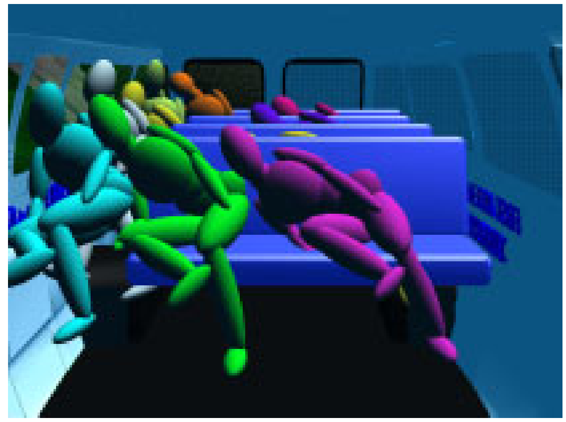
Representatives of Michelin, North America, Inc., participated in the investigation.

No public hearing was held; no depositions were taken.

Appendix B

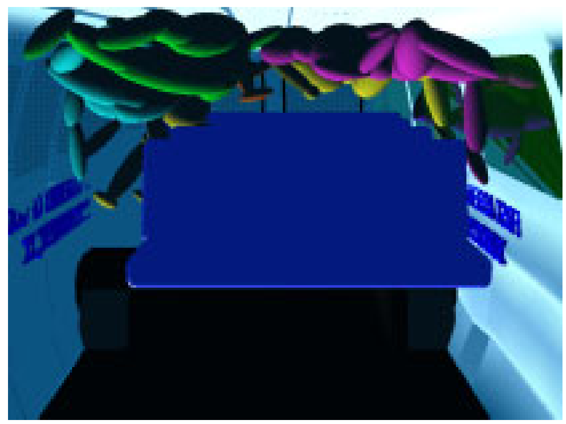
Potential Occupant Motion in Simulations

Time = 0.0 seconds (~13° rotation)



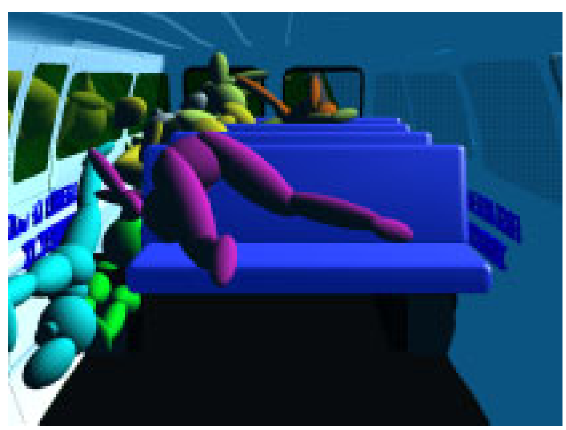
Time = 0.4 seconds (~40° rotation)

Time = 0.8 seconds (~110° rotation)



Time = 1.3 seconds (~220° rotation)

Time = 2.0 seconds (~380° rotation)

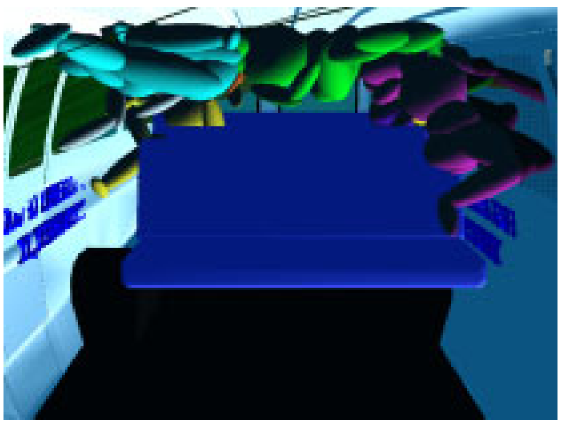


Time = 3.05 seconds (~420° rotation)

Figure 1. A series of still images illustrating the occupant kinematics for Run One in the actual restraint condition at various stages of the rollover.

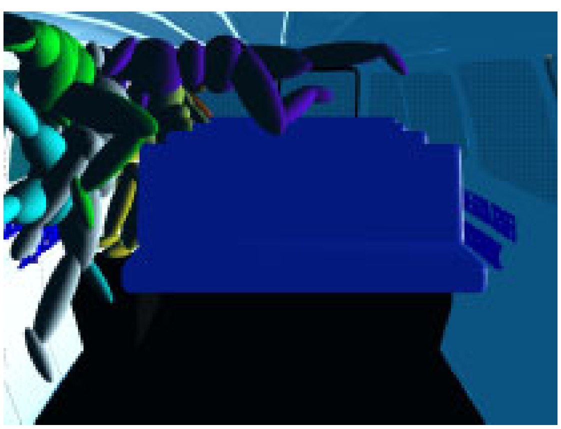
Time = 0.0 seconds (13° rotation)

Time = 0.4 seconds (46° rotation)



Time = 0.8 seconds (146° rotation)

Time = 1.3 seconds (327° rotation)

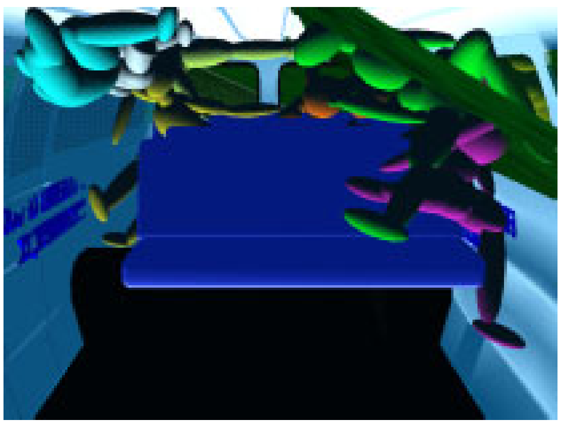


Time = 2.0 seconds (463° rotation)

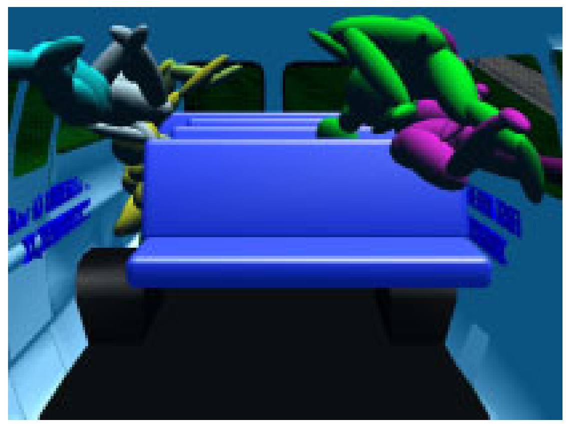
Figure 2. A series of still images illustrating the occupant kinematics for Run Two in the actual restraint condition at various stages of the rollover.

Time = 0.0 seconds (13° rotation)

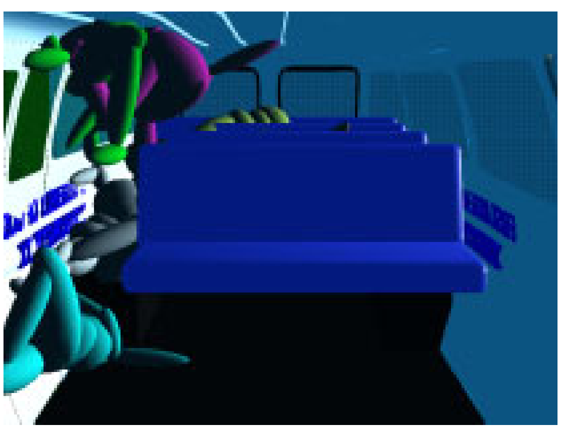
Time = 0.4 seconds (82° rotation)



Time = 0.8 seconds (203° rotation)



Time = 1.3 seconds (382° rotation)

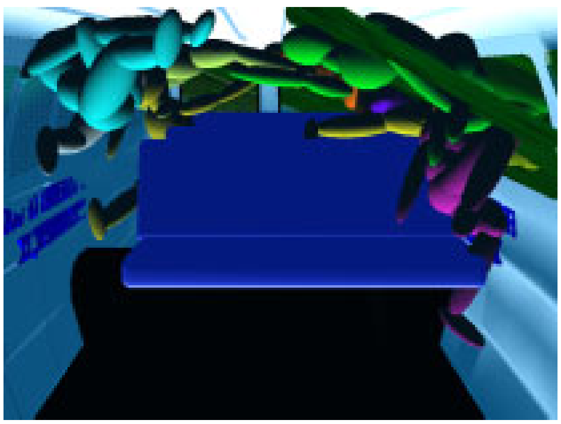


Time = 2.0 seconds (450° rotation)

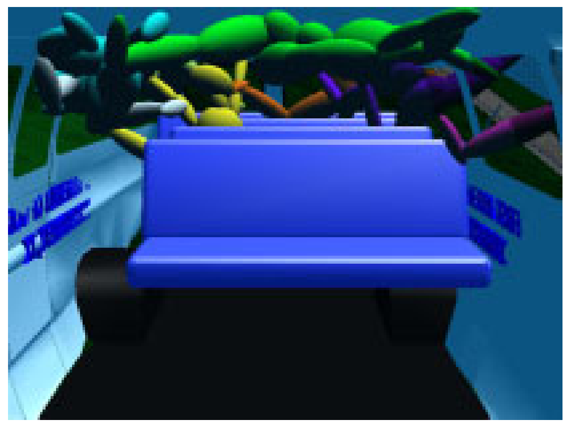
Figure 3. A series of still images illustrating the occupant kinematics for Run Three in the actual restraint condition at various stages of the rollover.

Time = 0.0 seconds (13° rotation)

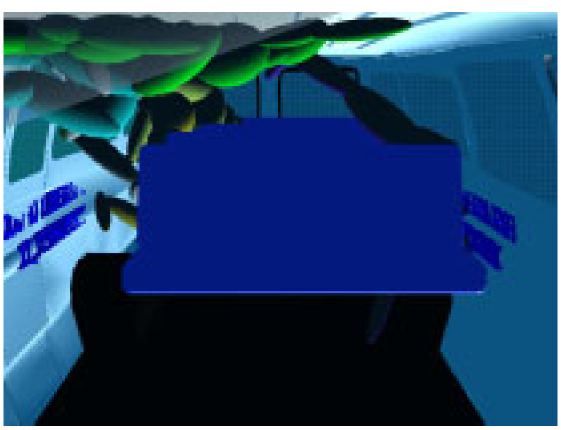
Time = 0.4 seconds (84° rotation)



Time = 0.8 seconds (205° rotation)



Time = 1.3 seconds (390° rotation)



Time = 2.0 seconds (529° rotation)

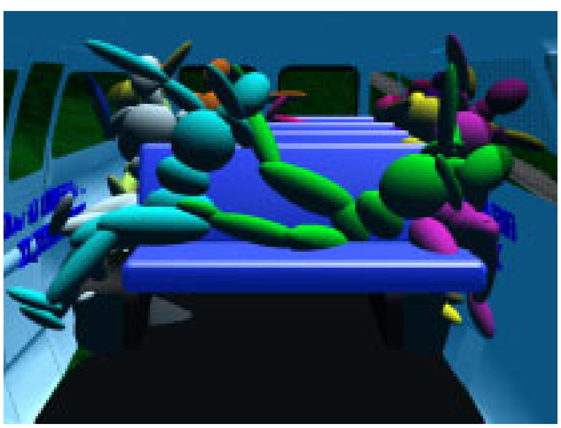
Figure 4. A series of still images illustrating the occupant kinematics for Run Four in the actual restraint condition at various stages of the rollover.

Time = 0.0 seconds (~13° rotation)

Time = 0.4 seconds (~40° rotation)

Time = 0.8 seconds (~110° rotation)

Time = 1.3 seconds (~220° rotation)

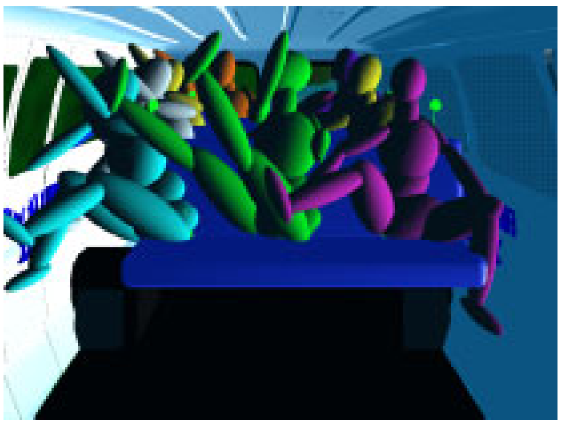


Time = 2.0 seconds (~380° rotation)

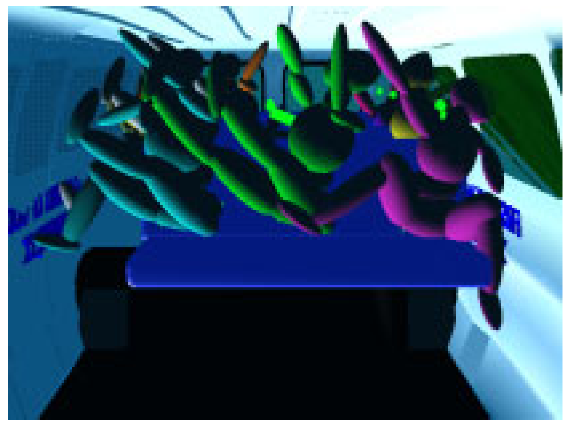
Figure 5. A series of still images illustrating the occupant kinematics in the lap-belted condition at various stages of the rollover.

Time = 0.0 seconds (~13° rotation)

Time = 0.4 seconds (~40° rotation)



Time = 0.8 seconds (~110° rotation)



Time = 1.3 seconds (~220° rotation)

Time = 2.0 seconds (~380° rotation)

Figure 6. A series of still images illustrating the occupant kinematics in the lap/shoulder-belted condition at various stages of the rollover.

Appendix C

Federal Motor Vehicle Safety Standards 201, 209, and 216

[67 FR 38746, June 5, 2002]

§ 571.201 Standard No. 201; Occupant protection in interior impact.

S1. *Purpose and scope.* This standard specifies requirements to afford impact protection for occupants.

S2. *Application.* This standard applies to passenger cars and to multipurpose passenger vehicles, trucks, and buses with a GVWR of 4,536 kilograms or less, except that the requirements of S6 do not apply to buses with a GVWR of more than 3,860 kilograms.

S3. *Definitions.*

A-pillar means any pillar that is entirely forward of a transverse vertical plane passing through the seating reference point of the driver's seat.

Ambulance means a motor vehicle designed exclusively for the purpose of emergency medical care, as evidenced by the presence of a passenger compartment to accommodate emergency medical personnel, one or more patients on litters or cots, and equipment and supplies for emergency care at a location or during transport.

B-pillar means the forwardmost pillar on each side of the vehicle that is, in whole or part, rearward of a transverse vertical plane passing through the seating reference point of the driver's seat, unless there is only one pillar rearward of that plane and it is also a rearmost pillar.

Brace means a fixed diagonal structural member in an open body vehicle that is used to brace the roll-bar and that connects the roll-bar to the main body of the vehicle structure.

Convertible means a vehicle whose A-pillars are not joined with the B-pillars (or rearmost pillars) by a fixed, rigid structural member.

Convertible roof frame means the frame of a convertible roof.

Convertible roof linkage mechanism means any anchorage, fastener, or device necessary to deploy a convertible roof frame.

Daylight opening means, for openings on the side of the vehicle, other than a door opening, the locus of all points where a horizontal line, perpendicular to the vehicle longitudinal centerline, is tangent to the periphery of the opening. For openings on the front and rear of the vehicle, other than a door opening, *daylight opening* means the locus of all points where a horizontal line, parallel to the vehicle longitudinal centerline, is tangent to the periphery of the opening. If the horizontal line is tangent to the periphery at more than one point at any location, the most inboard point is used to determine the daylight opening.

Door opening means, for door openings on the side of the vehicle, the locus of all points where a horizontal line, perpendicular to the vehicle longitudinal centerline, is tangent to the periphery of the side door opening. For door openings on the back end of the vehicle, *door opening* means the locus of all points where a horizontal line, parallel to the vehicle longitudinal centerline, is tangent to the periphery of the back door opening. If the horizontal line is tangent to the periphery at more than one point at any location, the most inboard point is the door opening.

Dynamically deployed upper interior head protection system means a protective device or devices which are integrated into a vehicle and which, when activated by an impact, provide, through means requiring no action from occupants, protection against head impacts with upper interior structures and components of the vehicle in crashes.

Forehead impact zone means the part of the free motion headform surface area that is determined in accordance with the procedure set forth in S8.10.

Free motion headform means a test device which conforms to the specifications of part 572, subpart L of this chapter.

Mid-sagittal plane of a dummy means a longitudinal vertical plane passing through the seating reference point of a designated seating position.

Motor Home means a motor vehicle with motive power that is designed to provide temporary residential accommodations, as evidenced by the presence of at least four of the following facilities: Cooking; refrigeration or ice box; self-contained toilet; heating and/or air conditioning; a potable water supply system including a faucet and a sink; and a separate 110–125 volt electrical power supply and/or an LP gas supply.

Other pillar means any pillar which is not an A-pillar, a B-pillar, or a rearmost pillar.

Pillar means any structure, excluding glazing and the vertical portion of door window frames, but including accompanying moldings, attached components such as safety belt anchorages and coat hooks, which:

(1) Supports either a roof or any other structure (such as a roll-bar) that is above the driver's head, or

(2) Is located along the side edge of a window.

Roll-bar means a fixed overhead structural member, including its vertical support structure, that extends from the left to the right side of the passenger compartment of any open body vehicles and convertibles. It does not include a header.

Seat belt anchorage means any component involved in transferring seat belt loads to the vehicle structure, including, but not limited to, the attachment hardware, but excluding webbing or straps, seat frames, seat pedestals, and the vehicle structure itself, whose failure causes separation of the belt from the vehicle structure.

Sliding door track means a track structure along the upper edge of a side door opening that secures the door in the closed position and guides the door when moving to and from the open position.

Stiffener means a fixed overhead structural member that connects one roll-bar to another roll-bar or to a header of any open body vehicle or convertible.

Upper roof means the area of the vehicle interior that is determined in accordance with the procedure set forth in S8.15.

Windshield trim means molding of any material between the windshield glazing and the exterior roof surface, including material that covers a part of either the windshield glazing or exterior roof surface.

S4 *Requirements*

S4.1 Except as provided in S4.2, each vehicle shall comply with either:

(a) The requirements specified in S5, or,

(b) The requirements specified in S5 and S6.

S4.2 Vehicles manufactured on or after September 1, 1998 shall comply with the requirements of S5 and S6.

S5 *Requirements for instrument panels, seat backs, interior compartment doors, sun visors, and armrests.* Each vehicle shall comply with the requirements specified in S5.1 through S5.5.2.

S5.1 *Instrument panels.* Except as provided in S5.1.1, when that area of the instrument panel that is within the head impact area is impacted in accordance with S5.1.2 by a 6.8 kilogram, 165 mm diameter head form at—

(a) A relative velocity of 24 kilometers per hour for all vehicles except those specified in paragraph (b) of this section,

(b) A relative velocity of 19 kilometers per hour for vehicles that meet the occupant crash protection requirements of S5.1 of 49 CFR 571.208 by means of inflatable restraint systems and meet the requirements of S4.1.5.1(a)(3) by means of a Type 2 seat belt assembly at the right front designated seating position, the deceleration of the head form shall not exceed 80 g continuously for more than 3 milliseconds.

S5.1.1 The requirements of S5.1 do not apply to:

(a) Console assemblies;

(b) Areas less than 125 mm inboard from the juncture of the instrument panel attachment to the body side inner structure;

(c) Areas closer to the windshield juncture than those statically contactable by the head form with the windshield in place;

(d) Areas outboard of any point of tangency on the instrument panel of a 165 mm diameter head form tangent to and inboard of a vertical longitudinal plane tangent to the inboard edge of the steering wheel; or

(e) Areas below any point at which a vertical line is tangent to the rearmost surface of the panel.

S5.1.2 *Demonstration procedures.* Tests shall be performed as described in Society of Automotive Engineers Recommended Practice J921, ''Instrument Panel Laboratory Impact Test Procedure,'' June 1965, using the specified instrumentation or instrumentation that meets the performance requirements specified in Society of

Automotive Engineers Recommended Practice J977, ''Instrumentation for Laboratory Impact Tests,'' November 1966, except that:

(a) The origin of the line tangent to the instrument panel surface shall be a point on a transverse horizontal line through a point 125 mm horizontally forward of the seating reference point of the front outboard passenger designated seating position, displaced vertically an amount equal to the rise which results from a 125 mm forward adjustment of the seat or 19 mm; and

(b) Direction of impact shall be either:

(1) In a vertical plane parallel to the vehicle longitudinal axis; or

(2) In a plane normal to the surface at the point of contact.

S5.2 *Seat Backs.* Except as provided in S5.2.1, when that area of the seat back that is within the head impact area is impacted in accordance with S5.2.2 by a 6.8 kilogram, 165 mm diameter head form at a relative velocity of 24 kilometers per hour, the deceleration of the head form shall not exceed 80g continuously for more than 3 milliseconds.

S5.2.1 The requirements of S5.2 do not apply to seats installed in school buses which comply with the requirements of Standard No. 222, *School Bus Passenger Seating and Occupant Protection* (49 CFR 571.222) or to rearmost side-facing, back-to-back, folding auxiliary jump, and temporary seats.

S5.2.2 *Demonstration procedures.* Tests shall be performed as described in Society of Automotive Engineers Recommended Practice J921, ''Instrument Panel Laboratory Impact Test Procedure,'' June 1965, using the specified instrumentation or instrumentation that meets the performance requirements specified in Society of Automotive Engineers Recommended Practice J977, ''Instrumentation for Laboratory Impact Tests,'' November 1966, except that:

(a) The origin of the line tangent to the uppermost seat back frame component shall be a point on a transverse horizontal line through the seating reference point of the right rear designated seating position, with adjustable forward seats in their rearmost design driving position and reclinable forward seat backs in their nominal design driving position;

(b) Direction of impact shall be either:

(1) In a vertical plane parallel to the vehicle longitudinal axis; or

(2) In a plane normal to the surface at the point of contact.

(c) For seats without head restraints installed, tests shall be performed for each individual split or bucket seat back at points within 100 mm left and right of its centerline, and for each bench seat back between points 100 mm outboard of the centerline of each outboard designated seating position;

(d) For seats having head restraints installed, each test shall be conducted with the head restraints in place at its lowest adjusted position, at a point on the head restraint centerline; and

(e) For a seat that is installed in more than one body style, tests conducted at the fore and aft extremes identified by application of subparagraph (a) shall be deemed to have demonstrated all intermediate conditions.

S5.3 *Interior compartment doors.* Each interior compartment door assembly located in an instrument panel, console assembly, seat back, or side panel adjacent to a designated seating position shall remain closed when tested in accordance with either S5.3.1(a) and S5.3.1(b) or S5.3.1(a) and S5.3.1(c). Additionally, any interior compartment door located in an instrument panel or seat back shall remain closed when the instrument panel or seat back is tested in accordance with S5.1 and S5.2. All interior compartment door assemblies with a locking device must be tested with the locking device in an unlocked position.

S5.3.1 *Demonstration procedures.*

(a) Subject the interior compartment door latch system to an inertia load of 10g in a horizontal transverse direction and an inertia load of 10g in a vertical direction in accordance with the procedure described in section 5 of SAE Recommended Practice J839b, ''Passenger Car Side Door Latch Systems,'' May 1965, or an approved equivalent.

(b) Impact the vehicle perpendicularly into a fixed collision barrier at a forward longitudinal velocity of 48 kilometers per hour.

(c) Subject the interior compartment door latch system to a horizontal inertia load of 30g in a longitudinal direction in accordance with the procedure described in section 5 of SAE Recommended Practice J839b, ''Passenger Car Side Door Latch Systems,'' May 1965, or an approved equivalent.

S5.4 *Sun visors.*

S5.4.1 A sun visor that is constructed of or covered with energy-absorbing material shall be provided for each front outboard designated seating position.

S5.4.2 Each sun visor mounting shall present no rigid material edge radius of less than 3.2 mm that is statically contactable by a spherical 165 mm diameter head form.

S5.5 *Armrests.*

S5.5.1 *General.* Each installed armrest shall conform to at least one of the following:

(a) It shall be constructed with energy-absorbing material and shall deflect or collapse laterally at least 50 mm without permitting contact with any underlying rigid material.

(b) It shall be constructed with energy-absorbing material that deflects or collapses to within 32 mm of a rigid test panel surface without permitting contact with any rigid material. Any rigid material between 13 and 32 mm from the panel surface shall have a minimum vertical height of not less than 25 mm.

(c) Along not less than 50 continuous mm of its length, the armrest shall, when measured vertically in side elevation, provide at least 50 mm of coverage within the pelvic impact area.

S5.5.2 *Folding armrests.* Each armrest that folds into the seat back or between two seat backs shall either:

(a) Meet the requirements of S5.5.1; or

(b) Be constructed of or covered with energy-absorbing material.

S6 *Requirements for upper interior components.*

S6.1 *Vehicles manufactured on or after September 1, 1998 and before September 1, 2002.* Except as provided in S6.3, for vehicles manufactured on or after September 1, 1998 and before September 1, 2002, a percentage of the manufacturer's production, as specified in S6.1.1, S6.1.2, S6.1.3, or S6.1.4, shall conform, at the manufacturer's option, to either S6.1(a) or S6.1(b). The manufacturer shall select the option by the time it certifies the vehicle and may not thereafter select a different option for the vehicle.

(a) When tested under the conditions of S8, comply with the requirements specified in S7 at the target locations specified in S10 when impacted by the free motion headform specified in S8.9 at any speed up to and including 24 km/h (15 mph). The requirements do not apply to any target that cannot be located using the procedures of S10.

(b) When equipped with a dynamically deployed upper interior head protection system and tested under the conditions of S8, comply with the requirements specified in S7 at the target locations specified in S10 as follows:

(1) Targets that are not located over any point inside the area measured along the contour of the vehicle surface within 50 mm (2.0 inch) of the periphery of the stowed system projected perpendicularly onto the vehicle interior surface, including mounting and inflation components but exclusive of any cover or covers, shall be impacted by the free motion headform specified in S8.9 at any speed up to and including 24 km/h (15 mph). The requirements do not apply to any targets that can not be located by using the procedures of S10.

(2) Targets that are over any point inside the area measured along the contour of the vehicle interior within 50 mm (2.0 inch) of the periphery of the stowed system projected perpendicularly onto the vehicle interior surface, including mounting and inflation components but exclusive of any cover or covers, when the dynamically deployed upper interior head protection system is not deployed, shall be impacted by the free motion headform specified in S8.9 at any speed up to and including 19 km/h (12 mph) with the system undeployed. The requirements do not apply to any target that can not be located using the procedures of S10.

(3) Each vehicle shall, when equipped with a dummy test device specified in Part 572, Subpart M, and tested as specified in S8.16 through S8.28, comply with the requirements specified in S7 when crashed into a fixed, rigid pole of

254 mm in diameter, at any velocity between 24 kilometers per hour (15 mph) and 29 kilometers per hour (18 mph).

S6.1.1 *Phase-in Schedule #1*

S6.1.1.1 *Vehicles manufactured on or after September 1, 1998 and before September 1, 1999*. Subject to S6.1.5(a), for vehicles manufactured by a manufacturer on or after September 1, 1998 and before September 1, 1999, the amount of vehicles complying with S7 shall be not less than 10 percent of:

(a) The manufacturer's average annual production of vehicles manufactured on or after September 1, 1996 and before September 1, 1999, or

(b) The manufacturer's production on or after September 1, 1998 and before September 1, 1999.

S6.1.1.2 *Vehicles manufactured on or after September 1, 1999 and before September 1, 2000*. Subject to S6.1.5(b), for vehicles manufactured by a manufacturer on or after September 1, 1999 and before September 1, 2000, the amount of vehicles complying with S7 shall be not less than 25 percent of:

(a) The manufacturer's average annual production of vehicles manufactured on or after September 1, 1997 and before September 1, 2000, or

(b) The manufacturer's production on or after September 1, 1999 and before September 1, 2000.

S6.1.1.3 *Vehicles manufactured on or after September 1, 2000 and before September 1, 2001*. Subject to S6.1.5(c), for vehicles manufactured by a manufacturer on or after September 1, 2000 and before September 1, 2001, the amount of vehicles complying with S7 shall be not less than 40 percent of:

(a) The manufacturer's average annual production of vehicles manufactured on or after September 1, 1998 and before September 1, 2001, or

(b) The manufacturer's production on or after September 1, 2000 and before September 1, 2001.

S6.1.1.4 *Vehicles manufactured on or after September 1, 2001 and before September 1, 2002*. Subject to S6.1.5(d), for vehicles manufactured by a manufacturer on or after September 1, 2001 and before September 1, 2002, the amount of vehicles complying with S7 shall be not less than 70 percent of:

(a) The manufacturer's average annual production of vehicles manufactured on or after September 1, 1999 and before September 1, 2002, or

(b) The manufacturer's production on or after September 1, 2001 and before September 1, 2002.

S6.1.2 *Phase-in Schedule #2*

S6.1.2.1 *Vehicles manufactured on or after September 1, 1998 and before September 1, 1999*. Subject to S6.1.5(a), for vehicles manufactured by a manufacturer on or after September 1, 1998 and before September 1, 1999, the amount of vehicles complying with S7 shall be not less than seven percent of:

(a) The manufacturer's average annual production of vehicles manufactured on or after September 1, 1996 and before September 1, 1999, or

(b) The manufacturer's production on or after September 1, 1998 and before September 1, 1999.

S6.1.2.2 *Vehicles manufactured on or after September 1, 1999 and before September 1, 2000*. Subject to S6.1.5(b), for vehicles manufactured by a manufacturer on or after September 1, 1999 and before September 1, 2000, the amount of vehicles complying with S7 shall be not less than 31 percent of:

(a) The manufacturer's average annual production of vehicles manufactured on or after September 1, 1997 and before September 1, 2000, or

(b) The manufacturer's production on or after September 1, 1999 and before September 1, 2000.

S6.1.2.3 *Vehicles manufactured on or after September 1, 2000 and before September 1, 2001*. Subject to S6.1.5(c), for vehicles manufactured by a manufacturer on or after September 1, 2000 and before September 1, 2001, the amount of vehicles complying with S7 shall be not less than 40 percent of:

(a) The manufacturer's average annual production of vehicles manufactured on or after September 1, 1998 and before September 1, 2001, or

(b) The manufacturer's production on or after September 1, 2000 and before September 1, 2001.

S6.1.2.4 *Vehicles manufactured on or after September 1, 2001 and before September 1, 2002*. Subject to S6.1.5(d), for vehicles manufactured by a manufacturer on or after September 1, 2001 and before September 1, 2002, the amount of vehicles complying with S7 shall be not less than 70 percent of:

(a) The manufacturer's average annual production of vehicles manufactured on or after September 1, 1999 and before September 1, 2002, or

(b) The manufacturer's production on or after September 1, 2001 and before September 1, 2002.

S6.1.3 *Phase-in Schedule #3*

S6.1.3.1 Vehicles manufactured on or after September 1, 1998 and before September 1, 1999 are not required to comply with the requirements specified in S7.

S6.1.3.2 Vehicles manufactured on or after September 1, 1999 shall comply with the requirements specified in S7.

S6.1.4 *Phase-in Schedule #4* A final stage manufacturer or alterer may, at its option, comply with the requirements set forth in S6.1.4.1 and S6.1.4.2.

S6.1.4.1 Vehicles manufactured on or after September 1, 1998 and before September 1, 2003 are not required to comply with the requirements specified in S7.

S6.1.4.2 Vehicles manufactured on or after September 1, 2003 shall comply with the requirements specified in S7.

S6.1.5 *Calculation of complying vehicles.*

(a) For the purposes of complying with S6.1.1.1 or S6.1.2.1, a manufacturer may count a vehicle if it is manufactured on or after May 8, 1997, but before September 1, 1999.

(b) For the purposes of complying with S6.1.1.2 or S6.1.2.2, a manufacturer may count a vehicle if it:

(1) Is manufactured on or after May 8, 1997, but before September 1, 2000, and

(2) Is not counted toward compliance with S6.1.1.1 or S6.1.2.1, as appropriate.

(c) For the purposes of complying with S6.1.1.3 or S6.1.2.3, a manufacturer may count a vehicle if it:

(1) Is manufactured on or after May 8, 1997, but before September 1, 2001, and

(2) Is not counted toward compliance with S6.1.1.1, S6.1.1.2, S6.1.2.1, or S6.1.2.2, as appropriate.

(d) For the purposes of complying with S6.1.1.4 or S6.1.2.4, a manufacturer may count a vehicle if it:

(1) Is manufactured on or after May 8, 1997, but before September 1, 2002, and

(2) Is not counted toward compliance with S6.1.1.1, S6.1.1.2, S6.1.1.3, S6.1.2.1, S6.1.2.2, or S6.1.2.3, as appropriate.

S6.1.6 *Vehicles produced by more than one manufacturer.*

S6.1.6.1 For the purpose of calculating average annual production of vehicles for each manufacturer and the number of vehicles manufactured by each manufacturer under S6.1.1 through S6.1.4, a vehicle produced by more than one manufacturer shall be attributed to a single manufacturer as follows, subject to S6.1.6.2.

(a) A vehicle which is imported shall be attributed to the importer.

(b) A vehicle manufactured in the United States by more than one manufacturer, one of which also markets the vehicle, shall be attributed to the manufacturer which markets the vehicle.

S6.1.6.2 A vehicle produced by more than one manufacturer shall be attributed to any one of the vehicle's manufacturers specified by an express written contract, reported to the National Highway Traffic Safety Administration under 49 CFR part 589, between the manufacturer so specified and the manufacturer to which the vehicle would otherwise be attributed under S6.1.6.1.

S6.2 *Vehicles manufactured on or after September 1, 2002.* Except as provided in S6.3, vehicles manufactured on or after September 1, 2002 shall, when tested under the conditions of S8, conform, at the manufacturer's option, to either S6.2(a) or S6.2(b). The manufacturer shall select the option by the time it certifies the vehicle and may not thereafter select a different option for the vehicle.

(a) When tested under the conditions of S8, comply with the requirements specified in S7 at the target locations specified in S10 when impacted by the free motion headform specified in S8.9 at any speed up to and including 24 km/h (15 mph). The requirements do not apply to any target that cannot be located using the procedures of S10.

(b) When equipped with a dynamically deployed upper interior head protection system and tested under the conditions of S8, comply with the requirements specified in S7 at the target locations specified in S10 as follows:

(1) Targets that are not located over any point inside the area measured

along the contour of the vehicle surface within 50 mm (2.0 inch) of the periphery of the stowed system projected perpendicularly onto the vehicle interior surface, including mounting and inflation components but exclusive of any cover or covers, shall be impacted by the free motion headform specified in S8.9 at any speed up to and including 24 km/h (15 mph). The requirements do not apply to any targets that cannot be located by using the procedures of S10.

(2) Targets that are over any point inside the area measured along the contour of the vehicle interior within 50 mm (2.0 inch) of the periphery of the stowed system projected perpendicularly onto the vehicle interior surface, including mounting and inflation components but exclusive of any cover or covers, when the dynamically deployed upper interior head protection system is not deployed, shall be impacted by the free motion headform specified in S8.9 at any speed up to and including 19 km/h (12 mph) with the system undeployed. The requirements do not apply to any target that cannot be located using the procedures of S10.

(3) Each vehicle shall, when equipped with a dummy test device specified in Part 572, Subpart M, and tested as specified in S8.16 through S8.28, comply with the requirements specified in S7 when crashed into a fixed, rigid pole of 254 mm in diameter, at any velocity between 24 kilometers per hour (15 mph) and 29 kilometers per hour (18 mph).

S6.3 A vehicle need not meet the requirements of S6.1 through S6.2 for:

(a) Any target located on a convertible roof frame or a convertible roof linkage mechanism.

(b) Any target located rearward of a vertical plane 600 mm behind the seating reference point of the rearmost designated seating position.

(c) Any target located rearward of a vertical plane 600 mm behind the seating reference point of the driver's seating position in an ambulance or a motor home.

(d) Any target in a walk-in van-type vehicles.

S7 *Performance Criterion.* The HIC(d) shall not exceed 1000 when calculated in accordance with the following formula:

$$HIC = \left[\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a\,dt \right]^{2.5} (t_2 - t_1)$$

Where the term *a* is the resultant head acceleration expressed as a multiple of *g* (the acceleration of gravity), and t1 and t2 are any two points in time during the impact which are separated by not more than a 36 millisecond time interval.

(a) For the free motion headform; HIC(d)=0.75446 (free motion headform HIC)+166.4.

(b) For the part 572, subpart M, anthropomorphic test dummy; HIC(d)=HIC.

S8 *Target location and test conditions.* The vehicle shall be tested and the targets specified in S10 located under the following conditions.

S8.1 *Vehicle test attitude.*

(a) The vehicle is supported off its suspension at an attitude determined in accordance with S8.1(b).

(b) Directly above each wheel opening, determine the vertical distance between a level surface and a standard reference point on the test vehicle's body under the conditions of S8.1(b)(1) through S8.1(b)(3).

(1) The vehicle is loaded to its unloaded vehicle weight, plus its rated cargo and luggage capacity or 136 kg, whichever is less, secured in the luggage area. The load placed in the cargo area is centered over the longitudinal centerline of the vehicle.

(2) The vehicle is filled to 100 percent of all fluid capacities.

(3) All tires are inflated to the manufacturer's specifications listed on the vehicle's tire placard.

S8.2 *Windows and Sunroofs.*

(a) Movable vehicle windows are placed in the fully open position.

(b) For testing, any window on the opposite side of the longitudinal centerline of the vehicle from the target to be impacted may be removed.

(c) For testing, movable sunroofs are placed in the fully open position.

S8.3 *Convertible tops.* The top, if any, of convertibles and open-body type vehicles is in the closed passenger compartment configuration.

S8.4 *Doors.*

(a) Except as provided in S8.4(b) or S8.4(c), doors, including any rear hatchback or tailgate, are fully closed and latched but not locked.

(b) During testing, any side door on the opposite side of the longitudinal centerline of the vehicle from the target to be impacted may be open or removed.

(c) During testing, any rear hatchback or tailgate may be open or removed for testing any target except targets on the rear header, rearmost pillars, or the rearmost other side rail on either side of the vehicle.

S8.5 *Sun visors.* Each sun visor shall be placed in any position where one side of the visor is in contact with the vehicle interior surface (windshield, side rail, front header, roof, etc.).

S8.6 *Steering wheel and seats.*

(a) During targeting, the steering wheel and seats may be placed in any position intended for use while the vehicle is in motion.

(b) During testing, the steering wheel and seats may be removed from the vehicle.

S8.7 *Seat belt anchorages.* If a target is on a seat belt anchorage, and if the seat belt anchorage is adjustable, tests are conducted with the anchorage adjusted to a point midway between the two extreme adjustment positions. If the anchorage has distinct adjustment positions, none of which is midway between the two extreme positions, tests are conducted with the anchorage adjusted to the nearest position above the midpoint of the two extreme positions.

S8.8 *Temperature and humidity.*

(a) The ambient temperature is between 19 degrees C. and 26 degrees C., at any relative humidity between 10 percent and 70 percent.

(b) Tests are not conducted unless the headform specified in S8.9 is exposed to the conditions specified in S8.8(a) for a period not less than four hours.

S8.9 *Headform.* The headform used for testing conforms to the specifications of part 572, subpart L of this chapter.

S8.10 *Forehead impact zone.* The forehead impact zone of the headform is determined according to the procedure specified in (a) through (f).

(a) Position the headform so that the baseplate of the skull is horizontal. The midsagittal plane of the headform is designated as Plane S.

(b) From the center of the threaded hole on top of the headform, draw a 69 mm line forward toward the forehead, coincident with Plane S, along the contour of the outer skin of the headform. The front end of the line is designated as Point P. From Point P, draw a 100 mm line forward toward the forehead, coincident with Plane S, along the contour of the outer skin of the headform. The front end of the line is designated as Point O.

(c) Draw a 125 mm line which is coincident with a horizontal plane along the contour of the outer skin of the forehead from left to right through Point O so that the line is bisected at Point O. The end of the line on the left side of the headform is designated as Point a and the end on the right as Point b.

(d) Draw another 125 mm line which is coincident with a vertical plane along the contour of the outer skin of the forehead through Point P so that the line is bisected at Point P. The end of the line on the left side of the headform is designated as Point c and the end on the right as Point d.

(e) Draw a line from Point a to Point c along the contour of the outer skin of the headform using a flexible steel tape. Using the same method, draw a line from Point b to Point d.

(f) The forehead impact zone is the surface area on the FMH forehead bounded by lines a-O-b and c-P-d, and a-c and b-d.

S8.11 *Target circle.* The area of the vehicle to be impacted by the headform is marked with a solid circle 12.7 mm in diameter, centered on the targets specified in S10, using any transferable opaque coloring medium.

S8.12 *Location of head center of gravity.*

(a) *Location of head center of gravity for front outboard designated seating positions (CG–F).* For determination of head center of gravity, all directions are in reference to the seat orientation.

(1) *Location of rearmost CG–F (CG–F2).* For front outboard designated seating positions, the head center of gravity with the seat in its rearmost normal

design driving or riding position (CG–F2) is located 160 mm rearward and 660 mm upward from the seating reference point.

(2) *Location of forwardmost CG–F (CG–F1)*. For front outboard designated seating positions, the head center of gravity with the seat in its forwardmost adjustment position (CG–F1) is located horizontally forward of CG–F2 by the distance equal to the fore-aft distance of the seat track.

(b) *Location of head center of gravity for rear outboard designated seating positions (CG–R)*. For rear outboard designated seating positions, the head center of gravity (CG–R) is located 160 mm rearward, relative to the seat orientation, and 660 mm upward from the seating reference point.

S8.13 *Impact configuration*.

S8.13.1 The headform is launched from any location inside the vehicle which meets the conditions of S8.13.4. At the time of launch, the midsagittal plane of the headform is vertical and the headform is upright.

S8.13.2 The headform travels freely through the air, along a velocity vector that is perpendicular to the headform's skull cap plate, not less than 25 mm before making any contact with the vehicle.

S8.13.3 At the time of initial contact between the headform and the vehicle interior surface, some portion of the forehead impact zone of the headform must contact some portion of the target circle.

S8.13.4 *Approach Angles*. The headform launching angle is as specified in Table 1. For components for which Table 1 specifies a range of angles, the headform launching angle is within the limits determined using the procedures specified in S8.13.4.1 and S8.13.4.2, and within the range specified in Table I, using the orthogonal reference system specified in S9.

TABLE 1.—APPROACH ANGLE LIMITS

[In degrees]

Target component	Horizontal angle	Vertical angle
Front Header	180	0–50
Rear Header	0 or 360	0–50
Left Side Rail	270	0–50
Right Side Rail	90	0–50
Left Sliding Door Track	270	0–50
Right Sliding Door Track	90	0–50
Left A-Pillar	195–255	−5–50
Right A-Pillar	105–165	−5–50
Left B-Pillar	195–345	−10–50
Right B-Pillar	15–165	−10–50
Other Left Pillars	270	−10–50
Other Right Pillars	90	−10–50
Left Rearmost Pillar	270–345	−10–50
Right Rearmost Pillar	15–90	−10–50
Upper Roof	Any	0–50
Overhead Rollbar	0 or 180	0–50
Brace or Stiffener	90 or 270	0–50
Seat Belt Anchorages	Any	0–50

S8.13.4.1 *Horizontal Approach Angles for Headform Impacts*.

(a) *Left A-Pillar Horizontal Approach Angles*.

(1) Locate a line formed by the shortest horizontal distance between CG–F1 for the left seat and the right A-pillar. The maximum horizontal approach angle for the left A-pillar equals 360 degrees minus the angle formed by that line and the X-axis of the vehicle, measured counterclockwise.

(2) Locate a line formed by the shortest horizontal distance between CG–F2 for the left seat and the left A-pillar. The minimum horizontal approach angle for the left A-pillar impact equals the angle formed by that line and the X-axis of the vehicle, measured counterclockwise.

(b) *Right A-Pillar Horizontal Approach Angles*.

(1) Locate a line formed by the shortest horizontal distance between CG–F1 for the right seat and the left A-pillar. The minimum horizontal approach angle for the right A-pillar equals 360 degrees minus the angle formed by that line and the X-axis of the vehicle, measured counterclockwise.

(2) Locate a line formed by the shortest horizontal distance between CG–F2 for the right seat and the right A-pillar. The maximum horizontal approach angle for the right A-pillar impact equals the angle formed by that line and the X-axis of the vehicle measured counterclockwise.

(c) *Left B-Pillar Horizontal Approach Angles*.

(1) Locate a line formed by the shortest horizontal distance between CG–F2 for the left seat and the left B-pillar.

The maximum horizontal approach angle for the left B-pillar equals the angle formed by that line and the X-axis of the vehicle measured counterclockwise, or 270 degrees, whichever is greater.

(2) Locate a line formed by the shortest horizontal distance between CG–R for the left seat and the left B-pillar. The minimum horizontal approach angle for the left B-pillar equals the angle formed by that line and the X-axis of the vehicle measured counterclockwise.

(d) *Right B-Pillar Horizontal Approach Angles*.

(1) Locate a line formed by the shortest horizontal distance between CG–F2 for the right seat and the right B-pillar. The minimum horizontal approach angle for the right B-pillar equals the angle formed by that line and the X-axis of the vehicle measured counterclockwise, or 90 degrees, whichever is less.

(2) Locate a line formed by the shortest horizontal distance between CG–R for the right seat and the right B-pillar. The maximum horizontal approach angle for the right B-pillar equals the angle between that line and the X-axis of the vehicle measured counterclockwise.

S8.13.4.2 *Vertical Approach Angles*

(a) Position the forehead impact zone in contact with the selected target at the prescribed horizontal approach angle. If a range of horizontal approach angles is prescribed, position the forehead impact zone in contact with the selected target at any horizontal approach angle within the range which may be used for testing.

(b) Keeping the forehead impact zone in contact with the target, rotate the FMH upward until the lip, chin or other part of the FMH contacts the component or other portion of the vehicle interior.

(1) Except as provided in S8.13.4.2(b)(2), keeping the forehead impact zone in contact with the target, rotate the FMH downward by 5 degrees for each target to determine the maximum vertical angle.

(2) For all pillars except A-Pillars, keeping the forehead impact zone in contact with the target, rotate the FMH downward by 10 degrees for each target to determine the maximum vertical angle.

S8.14 *Multiple impacts*.

(a) A vehicle being tested may be impacted multiple times, subject to the limitations in S8.14 (b) and (c).

(b) As measured as provided in S8.14(d), impacts within 300 mm of each other may not occur less than 30 minutes apart.

(c) As measured as provided in S8.14(d), no impact may occur within 150 mm of any other impact.

(d) For S8.14(b) and S8.14(c), the distance between impacts is the distance between the centers of the target circle specified in S8.11 for each impact, measured along the vehicle interior.

S8.15 *Upper Roof*. The upper roof of a vehicle is determined according to the procedure specified in S8.15 (a) through (h).

(a) Locate the transverse vertical plane A at the forwardmost point where it contacts the interior roof (including trim) at the vehicle centerline.

(b) Locate the transverse vertical plane B at the rearmost point where it contacts the interior roof (including trim) at the vehicle centerline.

(c) Measure the horizontal distance (D1) between Plane A and Plane B.

(d) Locate the vertical longitudinal plane C at the leftmost point at which a vertical transverse plane, located 300 mm rearward of the A-pillar reference point described in S10.1(a), contacts the interior roof (including trim).

(e) Locate the vertical longitudinal plane D at the rightmost point at which a vertical transverse plane, located 300 mm rearward of the A-pillar reference point described in S10.1(a), contacts the interior roof (including trim).

(f) Measure the horizontal distance (D2) between Plane C and Plane D.

(g) Locate a point (Point M) on the interior roof surface, midway between Plane A and Plane B along the vehicle longitudinal centerline.

(h) The upper roof zone is the area of the vehicle upper interior surface bounded by the four planes described in S8.15(h)(1) and S8.15(h)(2):

(1) A transverse vertical plane E located at a distance of (.35 D1) forward of Point M and a transverse vertical

plane F located at a distance of (.35 D1) rearward of Point M, measured horizontally.

(2) A longitudinal vertical plane G located at a distance of (.35 D2) to the left of Point M and a longitudinal vertical plane H located at a distance of (.35 D2) to the right of Point M, measured horizontally.

S8.16 *Test weight—vehicle to pole test.* Each vehicle shall be loaded to its unloaded vehicle weight, plus 136 kilograms (300 pounds) or its rated cargo and luggage capacity (whichever is less), secured in the luggage or load-carrying area, plus the weight of the necessary anthropomorphic test dummy. Any added test equipment shall be located away from impact areas in secure places in the vehicle.

S8.17 *Vehicle test attitude—vehicle to pole test.* Determine the distance between a level surface and a standard reference point on the test vehicle's body, directly above each wheel opening, when the vehicle is in its ''as delivered'' condition. The ''as delivered'' condition is the vehicle as received at the test site, filled to 100 percent of all fluid capacities and with all tires inflated to the manufacturer's specifications listed on the vehicle's tire placard. Determine the distance between the same level surface and the same standard reference points in the vehicle's ''fully loaded condition.'' The ''fully loaded condition'' is the test vehicle loaded in accordance with S8.16. The load placed in the cargo area shall be centered over the longitudinal centerline of the vehicle. The pretest vehicle attitude shall be the same as either the ''as delivered'' or ''fully loaded'' attitude or is between the ''as delivered'' attitude and the ''fully loaded'' attitude. If the test configuration requires that the vehicle be elevated off the ground, the pretest vehicle attitude must be maintained.

S8.18 *Adjustable seats—vehicle to pole test.* Initially, adjustable seats shall be adjusted as specified in S6.3 of Standard 214 (49 CFR 571.214).

S8.19 *Adjustable seat back placement—vehicle to pole test.* Initially, position adjustable seat backs in the manner specified in S6.4 of Standard 214 (49 CFR 571.214).

S8.20 *Adjustable steering wheels—vehicle to pole test.* Adjustable steering controls shall be adjusted so that the steering wheel hub is at the geometric center of the locus it describes when it is moved through its full range of driving positions.

S8.21 *Windows and sunroof—vehicle to pole test.* Movable windows and vents shall be placed in the fully open position. Any sunroof shall be placed in the fully closed position.

S8.22 *Convertible tops—vehicle to pole test.* The top, if any, of convertibles and open-body type vehicles shall be in the closed passenger compartment configuration.

S8.23 *Doors—vehicle to pole test.* Doors, including any rear hatchback or tailgate, shall be fully closed and latched but not locked.

S8.24 *Impact reference line—vehicle to pole test.* On the striking side of the vehicle, place an impact reference line at the intersection of the vehicle exterior and a transverse vertical plane passing through the center of gravity of the head of the dummy seated in accordance with S8.28, in the front outboard designated seating position.

S8.25 *Rigid Pole—vehicle to pole test.* The rigid pole is a vertical metal structure beginning no more than 102 millimeters (4 inches) above the lowest point of the tires on the striking side of the test vehicle when the vehicle is loaded as specified in S8.16 and extending above the highest point of the roof of the test vehicle. The pole is 254 mm ±3 mm (10 inches) in diameter and set off from any mounting surface, such as a barrier or other structure, so that the test vehicle will not contact such a mount or support at any time within 100 milliseconds of the initiation of vehicle to pole contact.

S8.26 *Impact configuration—vehicle to pole test.* The rigid pole shall be stationary. The test vehicle shall be propelled sideways so that its line of forward motion forms an angle of 90 degrees (±3 degrees) with the vehicle's longitudinal center line. The impact reference line shall be aligned with the center line of the rigid pole so that, when the vehicle-to-pole contact occurs, the center line of the pole contacts the vehicle area bounded by two transverse vertical planes 38 mm (1.5

inches) forward and aft of the impact reference line.

S8.27 *Anthropomorphic test dummy—vehicle to pole test.*

S8.27.1 The anthropomorphic test dummy used for evaluation of a vehicle's head impact protection shall conform to the requirements of subpart M of part 572 of this chapter (49 CFR part 572, subpart M). In a test in which the test vehicle is striking its left side, the dummy is to be configured and instrumented to strike on its left side, in accordance with subpart M of part 572. In a test in which the test vehicle is striking its right side, the dummy is to be configured and instrumented to strike its right side, in accordance with subpart M of part 572.

S8.27.2 The part 572, subpart M, test dummy specified is clothed in form fitting cotton stretch garments with short sleeves and midcalf length pants. Each foot of the test dummy is equipped with a size 11EEE shoe, which meets the configuration size, sole, and heel thickness specifications of MIL–S–13192 (1976) and weighs 0.57 ±0.09 kilograms (1.25 ±0.2 pounds).

S8.27.3 Limb joints shall be set at between 1 and 2 g's. Leg joints are adjusted with the torso in the supine position.

S8.27.4 The stabilized temperature of the test dummy at the time of the side impact test shall be at any temperature between 20.6 degrees C. and 22.2 degrees C.

S8.27.5 The acceleration data from the accelerometers installed inside the skull cavity of the test dummy are processed according to the practices set forth in SAE Recommended Practice J211, March 1995, ''Instrumentation for Impact Tests,'' Class 1000.

S8.28 *Positioning procedure for the Part 572 Subpart M Test Dummy—vehicle to pole test.* The part 572, subpart M, test dummy shall be initially positioned in the front outboard seating position on the struck side of the vehicle in accordance with the provisions of S7 of Standard 214, 49 CFR 571.214, and the vehicle seat shall be positioned as specified in S6.3 and S6.4 of that standard. The position of the dummy shall then be measured as follows. Locate the horizontal plane passing through the dummy head center of gravity. Identify the rearmost point on the dummy head in that plane. Construct a line in the plane that contains the rearward point of the front door daylight opening and is perpendicular to the longitudinal vehicle centerline. Measure the longitudinal distance between the rearmost point on the dummy head and this line. If this distance is less than 50 mm (2 inches) or the point is not forward of the line, then the seat and/or dummy positions shall be adjusted as follows. First, the seat back angle is adjusted, a maximum of 5 degrees, until a 50 mm (2 inches) distance is achieved. If this is not sufficient to produce the 50 mm (2 inches) distance, the seat is moved forward until the 50 mm (2 inches) distance is achieved or until the knees of the dummy contact the dashboard or knee bolster, whichever comes first. If the required distance cannot be achieved through movement of the seat, the seat back angle shall be adjusted even further forward until the 50mm (2 inches) distance is obtained or until the seat back is in its full upright locking position.

S9. *Orthogonal Reference System.* The approach angles specified in S8.13.4 are determined using the reference system specified in S9.1 through S9.4.

S9.1 An orthogonal reference system consisting of a longitudinal X axis and a transverse Y axis in the same horizontal plane and a vertical Z axis through the intersection of X and Y is used to define the horizontal direction of approach of the headform. The X–Z plane is the vertical longitudinal zero plane and is parallel to the longitudinal centerline of the vehicle. The X–Y plane is the horizontal zero plane parallel to the ground. The Y–Z plane is the vertical transverse zero plane that is perpendicular to the X–Y and X–Z planes. The X coordinate is negative forward of the Y–Z plane and positive to the rear. The Y coordinate is negative to the left of the X–Z plane and positive to the right. The Z coordinate is negative below the X–Y plane and positive above it. (See Figure 1.)

S9.2 The origin of the reference system is the center of gravity of the headform at the time immediately prior to launch for each test.

S9.3 The horizontal approach angle is the angle between the X axis and the headform impact velocity vector projected onto the horizontal zero plane, measured in the horizontal zero plane in the counter-clockwise direction. A 0 degree horizontal vector and a 360 degree horizontal vector point in the positive X direction; a 90 degree horizontal vector points in the positive Y direction; a 180 degree horizontal vector points in the negative X direction; and a 270 horizontal degree vector points in the negative Y direction. (See Figure 2.)

S9.4 The vertical approach angle is the angle between the horizontal plane and the velocity vector, measured in the midsagittal plane of the headform. A 0 degree vertical vector in Table I coincides with the horizontal plane and a vertical vector of greater than 0 degrees in Table I makes a upward angle of the same number of degrees with that plane.

S10 *Target Locations.*

(a) The target locations specified in S10.1 through S10.13 are located on both sides of the vehicle and, except as specified in S10(b), are determined using the procedures specified in those paragraphs.

(b) Except as specified in S10(c), in instances in which there is no combination of horizontal and vertical angles specified in S8.13.4 at which the forehead impact zone of the free motion headform can contact one of the targets located using the procedures in S10.1 through S10.13, the center of that target is moved to any location that is within a sphere with a radius of 25 mm, centered on the center of the original target, and that can be contacted by the forehead impact zone at one or more combination of angles.

(c) If there is no point within the sphere specified in S10(b) which the forehead impact zone of the free motion headform can contact at one or more combination of horizontal and vertical angles specified in S8.13.4, the radius of the sphere is increased by 25 mm increments until the sphere contains at least one point that can be contacted at one or more combination of angles.

S10.1 *A-pillar targets*

(a) *A-pillar reference point and target AP1.* On the vehicle exterior, locate a transverse vertical plane (Plane 1) which contacts the rearmost point of the windshield trim. The intersection of Plane 1 and the vehicle exterior surface is Line 1. Measuring along the vehicle exterior surface, locate a point (Point 1) on Line 1 that is 125 mm inboard of the intersection of Line 1 and a vertical plane tangent to the vehicle at the outboardmost point on Line 1 with the vehicle side door open. Measuring along the vehicle exterior surface in a longitudinal vertical plane (Plane 2) passing through Point 1, locate a point (Point 2) 50 mm rearward of Point 1. Locate the A-pillar reference point (Point APR) at the intersection of the interior roof surface and a line that is perpendicular to the vehicle exterior surface at Point 2. Target AP1 is located at point APR.

(b) *Target AP2.* Locate the horizontal plane (Plane 3) which intersects point APR. Locate the horizontal plane (Plane 4) which is 88 mm below Plane 3. Target AP2 is the point in Plane 4 and on the A-pillar which is closest to CG–F2 for the nearest seating position.

(c) *Target AP3.* Locate the horizontal plane (Plane 5) containing the highest point at the intersection of the dashboard and the A-pillar. Locate a horizontal plane (Plane 6) half-way between Plane 3 and Plane 5. Target AP3 is the point on Plane 6 and the A-pillar which is closest to CG–F1 for the nearest seating position.

S10.2 *B-pillar targets.*

(a) *B-pillar reference point and target BP1.* Locate the point (Point 3) on the vehicle interior at the intersection of the horizontal plane passing through the highest point of the forwardmost door opening and the centerline of the width of the B-pillar, as viewed laterally. Locate a transverse vertical plane (Plane 7) which passes through Point 3. Locate the point (Point 4) at the intersection of the interior roof surface, Plane 7, and the plane, described in S8.15(h), defining the nearest edge of the upper roof. The B-pillar reference point (Point BPR) is the point located at the middle of the line from Point 3 to Point 4 in Plane 7, measured along the vehicle interior surface. Target BP1 is located at Point BPR.

(b) *Target BP2*. If a seat belt anchorage is located on the B-pillar, Target BP2 is located at any point on the anchorage.

(c) *Target BP3*. Target BP3 is located in accordance with this paragraph. Locate a horizontal plane (Plane 8) which intersects Point BPR. Locate a horizontal plane (Plane 9) which passes through the lowest point of the daylight opening forward of the pillar. Locate a horizontal plane (Plane 10) halfway between Plane 8 and Plane 9. Target BP3 is the point located in Plane 10 and on the interior surface of the B-pillar, which is closest to CG–F(2) for the nearest seating position.

(d) *Target BP4*. Locate a horizontal plane (Plane 11) half-way between Plane 9 and Plane 10. Target BP4 is the point located in Plane 11 and on the interior surface of the B-pillar which is closest to CG–R for the nearest seating position.

S10.3 *Other pillar targets*.

(a) *Target OP1*.

(1) Except as provided in S10.3(a)(2), target OP1 is located in accordance with this paragraph. Locate the point (Point 5), on the vehicle interior, at the intersection of the horizontal plane through the highest point of the highest adjacent door opening or daylight opening (if no adjacent door opening) and the centerline of the width of the other pillar, as viewed laterally. Locate a transverse vertical plane (Plane 12) passing through Point 5. Locate the point (Point 6) at the intersection of the interior roof surface, Plane 12 and the plane, described in S8.15(h), defining the nearest edge of the upper roof. The other pillar reference point (Point OPR) is the point located at the middle of the line between Point 5 and Point 6 in Plane 12, measured along the vehicle interior surface. Target OP1 is located at Point OPR.

(2) If a seat belt anchorage is located on the pillar, Target OP1 is any point on the anchorage.

(b) *Target OP2*. Locate the horizontal plane (Plane 13) intersecting Point OPR. Locate a horizontal plane (Plane 14) passing through the lowest point of the daylight opening forward of the pillar. Locate a horizontal plane (Plane 15) half-way between Plane 13 and Plane 14. Target OP2 is the point located on the interior surface of the pillar at the intersection of Plane 15 and the centerline of the width of the pillar, as viewed laterally.

S10.4 *Rearmost pillar targets*

(a) *Rearmost pillar reference point and target RP1*. Locate the point (Point 7) at the corner of the upper roof nearest to the pillar. The distance between Point M, as described in S8.15(g), and Point 7, as measured along the vehicle interior surface, is D. Extend the line from Point M to Point 7 along the vehicle interior surface in the same vertical plane by (3*D/7) beyond Point 7 or until the edge of a daylight opening, whichever comes first, to locate Point 8. The rearmost pillar reference point (Point RPR) is at the midpoint of the line between Point 7 and Point 8, measured along the vehicle interior. Target RP1 is located at Point RPR.

(b) *Target RP2*.

(1) Except as provided in S10.4(b)(2), target RP2 is located in accordance with this paragraph. Locate the horizontal plane (Plane 16) through Point RPR. Locate the horizontal plane (Plane 17) 150 mm below Plane 16. Target RP2 is located in Plane 17 and on the pillar at the location closest to CG–R for the nearest designated seating position.

(2) If a seat belt anchorage is located on the pillar, Target RP2 is any point on the anchorage.

S10.5 *Front header targets*.

(a) *Target FH1*. Locate the contour line (Line 2) on the vehicle interior trim which passes through the APR and is parallel to the contour line (Line 3) at the upper edge of the windshield on the vehicle interior. Locate the point (Point 9) on Line 2 that is 125 mm inboard of the APR, measured along that line. Locate a longitudinal vertical plane (Plane 18) that passes through Point 9. Target FH1 is located at the intersection of Plane 18 and the upper vehicle interior, halfway between a transverse vertical plane (Plane 19) through Point 9 and a transverse vertical plane (Plane 20) through the intersection of Plane 18 and Line 3.

(b) *Target FH2*.

(1) Except as provided in S10.5(b)(2), target FH2 is located in accordance with this paragraph. Locate a point (Point 10) 275 mm inboard of Point

APR, along Line 2. Locate a longitudinal vertical plane (Plane 21) that passes through Point 10. Target FH2 is located at the intersection of Plane 21 and the upper vehicle interior, halfway between a transverse vertical plane (Plane 22) through Point 10 and a transverse vertical plane (Plane 23) through the intersection of Plane 21 and Line 3.

(2) If a sun roof opening is located forward of the front edge of the upper roof and intersects the mid-sagittal plane of a dummy seated in either front outboard seating position, target FH2 is the nearest point that is forward of a transverse vertical plane (Plane 24) through CG–F(2) and on the intersection of the mid-sagittal plane and the interior sunroof opening.

S10.6 *Targets on the side rail between the A-pillar and the B-pillar or rearmost pillar in vehicles with only two pillars on each side of the vehicle.*

(a) *Target SR1.* Locate a transverse vertical plane (Plane 25) 150 mm rearward of Point APR. Locate the point (Point 11) at the intersection of Plane 25 and the upper edge of the forwardmost door opening. Locate the point (Point 12) at the intersection of the interior roof surface, Plane 25 and the plane, described in S8.15(h), defining the nearest edge of the upper roof. Target SR1 is located at the middle of the line between Point 11 and Point 12 in Plane 25, measured along the vehicle interior.

(b) *Target SR2.* Locate a transverse vertical plane (Plane 26) 300 mm rearward of the APR or 300 mm forward of the BPR (or the RPR in vehicles with no B-pillar). Locate the point (Point 13) at the intersection of Plane 26 and the upper edge of the forwardmost door opening. Locate the point (Point 14) at the intersection of the interior roof surface, Plane 26 and the plane, described in S8.15(h), defining the nearest edge of the upper roof. Target SR2 is located at the middle of the line between Point 13 and Point 14 in Plane 26, measured along the vehicle interior.

S10.7 *Other side rail target (target SR3).*

(a) Except as provided in S10.7(b), target SR3 is located in accordance with this paragraph. Locate a transverse vertical plane (Plane 27) 150 mm rearward of either Point BPR or Point OPR. Locate the point (Point 15) as provided in either S10.7(a)(1) or S10.7(a)(2), as appropriate. Locate the point (Point 16) at the intersection of the interior roof surface, Plane 27 and the plane, described in S8.15(h), defining the nearest edge of the upper roof. Target SR3 is located at the middle of the line between Point 15 and Point 16 in Plane 27, measured along the vehicle interior surface.

(1) If Plane 27 intersects a door or daylight opening, the Point 15 is located at the intersection of Plane 27 and the upper edge of the door opening or daylight opening.

(2) If Plane 27 does not intersect a door or daylight opening, the Point 15 is located on the vehicle interior at the intersection of Plane 27 and the horizontal plane through the highest point of the door or daylight opening nearest Plane 27. If the adjacent door(s) or daylight opening(s) are equidistant to Plane 27, Point 15 is located on the vehicle interior at the intersection of Plane 27 and either horizontal plane through the highest point of each door or daylight opening.

(b) Except as provided in S10.7(c), if a grab handle is located on the side rail, target SR3 is located at any point on the anchorage of the grab-handle. Folding grab-handles are in their stowed position for testing.

(c) If a seat belt anchorage is located on the side rail, target SR3 is located at any point on the anchorage.

S10.8 *Rear header target (target RH).* Locate the point (Point 17) at the intersection of the surface of the upper vehicle interior, the mid-sagittal plane (Plane 28) of the outboard rearmost dummy and the plane, described in S8.15(h), defining the rear edge of the upper roof. Locate the point (Point 18) as provided in S10.8(a) or S10.8(b), as appropriate. Except as provided in S10.8(c), Target RH is located at the mid-point of the line that is between Point 17 and Point 18 and is in Plane 28, as measured along the surface of the vehicle interior.

(a) If Plane 28 intersects a rear door opening or daylight opening, then Point 18 is located at the intersection of Plane 28 and the upper edge of the door opening or the daylight opening (if no door opening).

(b) If Plane 28 does not intersect a rear door opening or daylight opening, then Point 18 is located on the vehicle interior at the intersection of Plane 28 and a horizontal plane through the highest point of the door or daylight opening nearest to Plane 28. If the adjacent door(s) or daylight opening(s) are equidistant to Plane 28, Point 18 is located on the vehicle interior at the intersection of Plane 28 and either horizontal plane through the highest point of each door or daylight opening.

(c) If Target RH is more than 112 mm from Point 18 on the line that is between Point 17 and Point 18 and is in Plane 28, as measured along the surface of the vehicle interior, then Target RH is the point on that line which is 112 mm from Point 18.

S10.9 *Upper roof target (target UR).* Target UR is any point on the upper roof.

S10.10 *Sliding door track target (target SD).* Locate the transverse vertical plane (Plane 29) passing through the middle of the widest opening of the sliding door, measured horizontally and parallel to the vehicle longitudinal centerline. Locate the point (Point 19) at the intersection of the surface of the upper vehicle interior, Plane 29 and the plane, described in S8.15(h), defining the nearest edge of the upper roof. Locate the point (Point 20) at the intersection of Plane 29 and the upper edge of the sliding door opening. Target SD is located at the middle of the line between Point 19 and Point 20 in Plane 29, measured along the vehicle interior.

S10.11 *Roll-bar targets.*

(a) *Target RB1.* Locate a longitudinal vertical plane (Plane 30) at the midsagittal plane of a dummy seated in any outboard designated seating position. Target RB1 is located on the rollbar and in Plane 30 at the location closest to either CG–F2 or CG–R, as appropriate, for the same dummy.

(b) *Target RB2.* If a seat belt anchorage is located on the roll-bar, Target RB2 is any point on the anchorage.

S10.12 *Stiffener targets.*

(a) *Target ST1.* Locate a transverse vertical plane (Plane 31) containing either CG–F2 or CG–R, as appropriate, for any outboard designated seating position. Target ST1 is located on the stiffener and in Plane 31 at the location closest to either CG–F2 or CG–R, as appropriate.

(b) *Target ST2.* If a seat belt anchorage is located on the stiffener, Target ST2 is any point on the anchorage.

S10.13 *Brace target (target BT)* Target BT is any point on the width of the brace as viewed laterally from inside the passenger compartment.

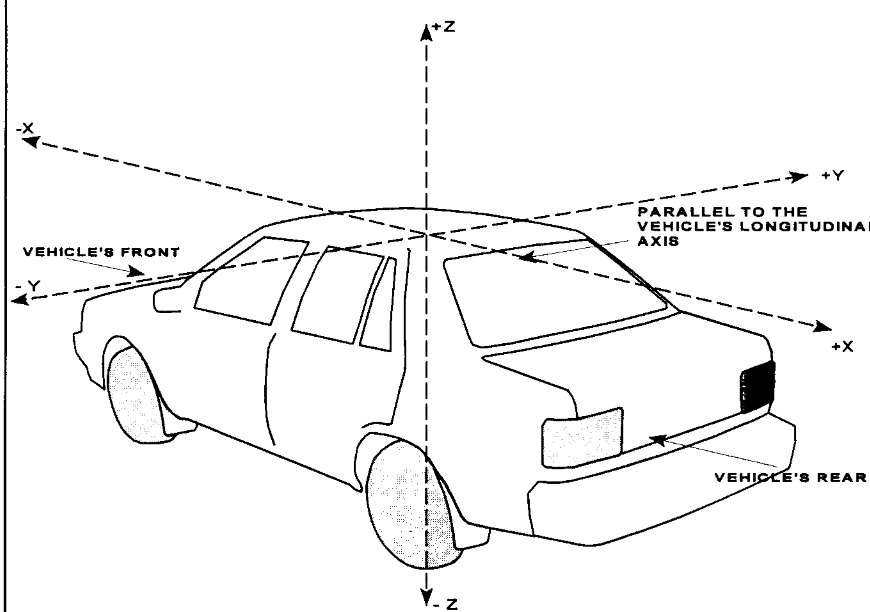
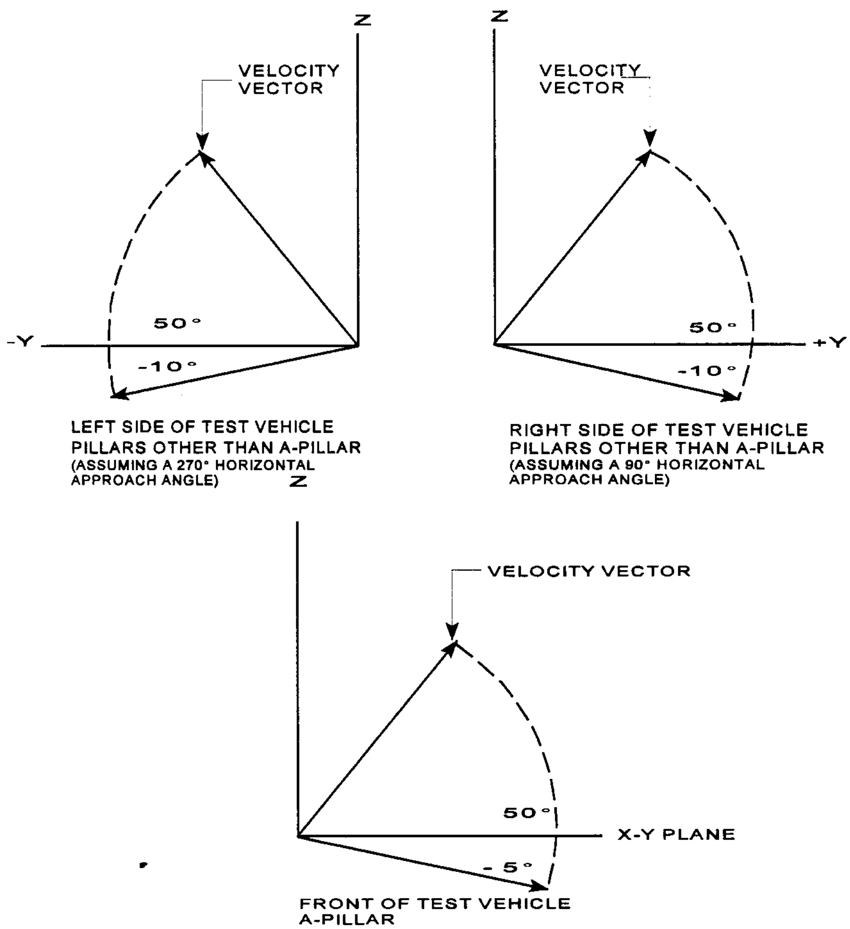


FIGURE 1 - ORTHOGONAL REFERENCE SYSTEM



VERTICAL AND HORIZONTAL APPROACH ANGLE PLANE
FIGURE 2

[62 FR 16725, Apr. 8, 1997; 63 FR 28, Jan. 2, 1998; 63 FR 41464, Aug. 4, 1998; 63 FR 45965, Aug. 28, 1998; 64 FR 7140, Feb. 12, 1999; 64 FR 69671, Dec. 14, 1999; 67 FR 41354, June 18, 2002]

§571.202 Standard No. 202; Head restraints.

S1. *Purpose and scope.* This standard specifies requirements for head restraints to reduce the frequency and severity of neck injury in rear-end and other collisions.

S2. *Application.* This standard applies to passenger cars, and to multipurpose passenger vehicles, trucks and buses with a GVWR of 4,536 kg or less.

S3. *Definitions. Head restraint* means a device that limits rearward angular displacement of the occupant's head relative to his torso line.

S4. *Requirements.*

S4.1 Each passenger car shall comply with S4.3.

December 1, 1999, may be used by the National Highway Traffic Safety Administration to test the suppression system of a vehicle that has been certified as being in compliance with 49 CFR 571.208 S19. When the restraint system comes equipped with a removable base, the test may be run either with the base attached or without the base.

Britax Handle with Care 191
Century Assura 4553
Century Avanta SE 41530
Century Smart Fit 4543
Cosco Arriva 02727
Cosco Opus 35 02603
Evenflo Discovery Adjust Right 212
Evenflo First Choice 204
Evenflo On My Way Position Right V 282
Graco Infant 8457

C. Any of the following forward-facing convertible child restraint systems, manufactured on or after December 1, 1999, may be used by the National Highway Traffic Safety Administration to test the suppression system of a vehicle that has been certified as being in compliance with 49 CFR 571.208 S19, or S21:

Britax Roundabout 161
Century Encore 4612
Century STE 1000 4416
Cosco Olympian 02803
Cosco Touriva 02519
Evenflo Horizon V 425
Evenflo Medallion 254

D. Any of the following forward-facing toddler/belt positioning booster systems, manufactured on or after December 1, 1999, may be used by the National Highway Traffic Safety Administration as test devices to test the suppression system of a vehicle that has been certified as being in compliance with 49 CFR 571.208 S21 or S23:

Britax Roadster 9004
Century Next Step 4920
Cosco High Back Booster 02–442
Evenflo Right Fit 245

[36 FR 22902, Dec. 2, 1971]

EDITORIAL NOTE: For FEDERAL REGISTER citations affecting §571.208, see the List of CFR Sections Affected, which appears in the Finding Aids section of the printed volume and on GPO Access.

§571.209 Standard No. 209; Seat belt assemblies.

S1. *Purpose and scope.* This standard specifies requirements for seat belt assemblies.

S2. *Application.* This standard applies to seat belt assemblies for use in passenger cars, multipurpose passenger vehicles, trucks, and buses.

S3. *Definitions. Adjustment hardware* means any or all hardware designed for adjusting the size of a seat belt assembly to fit the user, including such hardware that may be integral with a buckle, attachment hardware, or retractor.

Attachment hardware means any or all hardware designed for securing the webbing of a seat belt assembly to a motor vehicle.

Automatic-locking retractor means a retractor incorporating adjustment hardware by means of a positive self-locking mechanism which is capable when locked of withstanding restraint forces.

Buckle means a quick release connector which fastens a person in a seat belt assembly.

Emergency-locking retractor means a retractor incorporating adjustment hardware by means of a locking mechanism that is activated by vehicle acceleration, webbing movement relative to the vehicle, or other automatic action during an emergency and is capable when locked of withstanding restraint forces.

Hardware means any metal or rigid plastic part of a seat belt assembly.

Load-limiter means a seat belt assembly component or feature that controls tension on the seat belt to modulate the forces that are imparted to occupants restrained by the belt assembly during a crash.

Nonlocking retractor means a retractor from which the webbing is extended to essentially its full length by a small external force, which provides no adjustment for assembly length, and which may or may not be capable of sustaining restraint forces at maximum webbing extension.

Pelvic restraint means a seat belt assembly or portion thereof intended to restrain movement of the pelvis.

Retractor means a device for storing part or all of the webbing in a seat belt assembly.

Seat back retainer means the portion of some seat belt assemblies designed to restrict forward movement of a seat back.

Seat belt assembly means any strap, webbing, or similar device designed to secure a person in a motor vehicle in order to mitigate the results of any accident, including all necessary buckles and other fasteners, and all hardware designed for installing such seat belt assembly in a motor vehicle.

Strap means a narrow nonwoven material used in a seat belt assembly in place of webbing.

Type 1 seat belt assembly is a lap belt for pelvic restraint.

Type 2 seat belt assembly is a combination of pelvic and upper torso restraints.

Type 2a shoulder belt is an upper torso restraint for use only in conjunction with a lap belt as a Type 2 seat belt assembly.

Upper torso restraint means a portion of a seat belt assembly intended to restrain movement of the chest and shoulder regions.

Webbing means a narrow fabric woven with continuous filling yarns and finished selvages.

S4. *Requirements.*

S4.1 (a) *Single occupancy.* A seat belt assembly shall be designed for use by one, and only one, person at any one time.

(b) [Reserved]

(c) *Upper torso restraint.* A Type 2 seat belt assembly shall provide upper torso restraint without shifting the pelvic restraint into the abdominal region. An upper torso restraint shall be designed to minimize vertical forces on the shoulders and spine. Hardware for upper torso restraint shall be so designed and located in the seat belt assembly that the possibility of injury to the occupant is minimized.

A Type 2a shoulder belt shall comply with applicable requirements for a Type 2 seat belt assembly in S4.1 to S4.4, inclusive.

(d) *Hardware.* All hardware parts which contact under normal usage a person, clothing, or webbing shall be free from burrs and sharp edges.

(e) *Release.* A Type 1 or Type 2 seat belt assembly shall be provided with a buckle or buckles readily accessible to the occupant to permit his easy and rapid removal from the assembly. Buckle release mechanism shall be designed to minimize the possibility of accidental release. A buckle with release mechanism in the latched position shall have only one opening in which the tongue can be inserted on the end of the buckle designed to receive and latch the tongue.

(f) *Attachment hardware.* A seat belt assembly shall include all hardware necessary for installation in a motor vehicle in accordance with Society of Automotive Engineers Recommended Practice J800c, ''Motor Vehicle Seat Belt Installation,'' November 1973. However, seat belt assemblies designed for installation in motor vehicles equipped with seat belt assembly anchorages that do not require anchorage nuts, plates, or washers, need not have such hardware, but shall have 7⁄16–20 UNF–2A or 1⁄2–13UNC–2A attachment bolts or equivalent metric hardware. The hardware shall be designed to prevent attachment bolts and other parts from becoming disengaged from the vehicle while in service. Reinforcing plates or washers furnished for universal floor, installations shall be of steel, free from burrs and sharp edges on the peripheral edges adjacent to the vehicle, at least 1.5 mm in thickness and at least 2580 mm^2 in projected area. The distance between any edge of the plate and the edge of the bolt hole shall be at least 15 mm. Any corner shall be rounded to a radius of not less than 6 mm or cut so that no corner angle is less than 135° and no side is less than 6 mm in length.

(g) *Adjustment.* (1) A Type 1 or Type 2 seat belt assembly shall be capable of adjustment to fit occupants whose dimensions and weight range from those of a 5th-percentile adult female to those of a 95th-percentile adult male. The seat belt assembly shall have either an automatic-locking retractor, an emergency-locking retractor, or an adjusting device that is within the reach of the occupant.

(2) A Type 1 or Type 2 seat belt assembly for use in a vehicle having seats that are adjustable shall conform to the requirements of S4.1(g)(1) regardless of seat position. However, if a seat has a back that is separately adjustable, the requirements of S4.1(g)(1) need be met only with the seat back in the manufacturer's nominal design riding position.

(3) The adult occupants referred to in S4.1(g)(1) shall have the following measurements:

	5th percen- tile adult female	95th percentile adult male
Weight	46.3 kg	97.5 kg.
Erect sitting height	785 mm	965 mm.
Hip breadth (sitting)	325 mm	419 mm.
Hip circumference (sitting).	925 mm	1199 mm.
Waist circumference (sitting).	599 mm	1080 mm.
Chest depth	190 mm	267 mm.
Chest circumference:		
Nipple	775 mm	1130 mm.
Upper	757 mm	1130 mm.
Lower	676 mm	1130 mm.

(h) *Webbing.* The ends of webbing in a seat belt assembly shall be protected or treated to prevent raveling. The end of webbing in a seat belt assembly having a metal-to-metal buckle that is used by the occupant to adjust the size of the assembly shall not pull out of the adjustment hardware at maximum size adjustment. Provision shall be made for essentially unimpeded movement of webbing routed between a seat back and seat cushion and attached to a retractor located behind the seat.

(i) *Strap.* A strap used in a seat belt assembly to sustain restraint forces shall comply with the requirements for webbing in S4.2, and if the strap is made from a rigid material, it shall comply with applicable requirements in S4.2, S4.3, and S4.4.

(j) *Marking.* Each seat belt assembly shall be permanently and legibly marked or labeled with year of manufacture, model, and name or trademark of manufacturer or distributor, or of importer if manufactured outside the United States. A model shall consist of a single combination of webbing having a specific type of fiber weave and construction, and hardware having a specific design. Webbings of various colors may be included under the same model, but webbing of each color shall comply with the requirements for webbing in S4.2.

(k) *Installation instructions.* A seat belt assembly, other than a seat belt assembly installed in a motor vehicle by an automobile manufacturer, shall be accompanied by an instruction sheet providing sufficient information for installing the assembly in a motor vehicle. The installation instructions shall state whether the assembly is for universal installation or for installation only in specifically stated motor vehicles, and shall include at least those items specified in SAE Recommended Practice J800c, ''Motor Vehicle Seat Belt Installations,'' November 1973. If the assembly is for use only in specifically stated motor vehicles, the assembly shall either be permanently and legibly marked or labeled with the following statement, or the instruction sheet shall include the following statement:

This seat belt assembly is for use only in [insert specific seating position(s), e.g., ''front right''] in [insert specific vehicle make(s) and model(s)].

(l) *Usage and maintenance instructions.* A seat belt assembly or retractor shall be accompanied by written instructions for the proper use of the assembly, stressing particularly the importance of wearing the assembly snugly and properly located on the body, and on the maintenance f the assembly and periodic inspection of all components. The instructions shall show the proper manner of threading webbing in the hardware of seat belt assemblies in which the webbing is not permanently fastened. Instructions for a nonlocking retractor shall include a caution that the webbing must be fully extended from the retractor during use of the seat belt assembly unless the retractor is attached to the free end of webbing which is not subjected to any tension during restraint of an occupant by the assembly. Instructions for Type 2a shoulder belt shall include a warning that the shoulder belt is not to be used without a lap belt.

(m) *Workmanship.* Seat belt assemblies shall have good workmanship in accordance with good commercial practice.

S4.2 *Requirements for webbing.*

(a) *Width.* The width of the webbing in a seat belt assembly shall be not less than 46 mm, except for portions that do not touch a 95th percentile adult male with the seat in any adjustment position and the seat back in the manufacturer's nominal design riding position when measured under the conditions prescribed in S5.1(a).

(b) *Breaking strength.* The webbing in a seat belt assembly shall have not less than the following breaking strength when tested by the procedures specified in S5.1(b): Type 1 seat belt assembly—26,689 N; Type 2 seat belt assembly—

22,241 N for webbing in pelvic restraint and 17,793 N for webbing in upper torso restraint.

(c) *Elongation.* Except as provided in S4.5, the webbing in a seat belt assembly shall not extend to more than the following elongation when subjected to the specified forces in accordance with the procedure specified in S5.1(c): Type 1 seat belt assembly—20 percent at 11,120 N; Type 2 seat belt assembly 30 percent at 11,120 N for webbing in pelvic restraint and 40 percent at 11,120 N for webbing in upper torso restraint.

(d) *Resistance to abrasion.* The webbing of a seat belt assembly, after being subjected to abrasion as specified in S5.1(d) or S5.3(c), shall have a breaking strength of not less than 75 percent of the breaking strength listed in S4.2(b) for that type of belt assembly.

(e) *Resistance to light.* The webbing in a seat belt assembly after exposure to the light of a carbon arc and tested by the procedure specified in S5.1(e) shall have a breaking strength not less than 60 percent of the strength before exposure to the carbon arc and shall have a color retention not less than No. 2 on the Geometric Gray Scale published by the American Association of Textile Chemists and Colorists, Post Office Box 886, Durham, NC.

(f) *Resistance to micro-organisms.* The webbing in a seat belt assembly after being subjected to micro-organisms and tested by the procedures specified in S5.1(f) shall have a breaking strength not less than 85 percent of the strength before subjection to micro-organisms.

S4.3 *Requirements for hardware.*

(a) *Corrosion resistance.* (1) Attachment hardware of a seat belt assembly after being subjected to the conditions specified in S5.2(a) shall be free of ferrous corrosion on significant surfaces except for permissible ferrous corrosion at peripheral edges or edges of holes on underfloor reinforcing plates and washers. Alternatively, such hardware at or near the floor shall be protected against corrosion by at least an electrodeposited coating of nickel, or copper and nickel with at least a service condition number of SC2, and other attachment hardware shall be protected by an electrodeposited coating of nickel, or copper and nickel with a service condition number of SC1, in accordance with American Society for Testing and Materials B456–79, ‘‘Standard Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium,’’ but such hardware shall not be racked for electroplating in locations subjected to maximum stress.

(2) Surfaces of buckles, retractors and metallic parts, other than attachment hardware, of a seat belt assembly after subjection to the conditions specified in S5.2(a) shall be free of ferrous or nonferrous corrosion which may be transferred, either directly or by means of the webbing, to the occupant or his clothing when the assembly is worn. After test, buckles shall conform to applicable requirements in paragraphs (d) to (g) of this section.

(b) *Temperature resistance.* Plastic or other nonmetallic hardware parts of a seat belt assembly when subjected to the conditions specified in S5.2(b) shall not warp or otherwise deteriorate to cause the assembly to operate improperly or fail to comply with applicable requirements in this section and S4.4.

(c) *Attachment hardware.* (1) Eye bolts, shoulder bolts, or other bolt used to secure the pelvic restraint of seat belt assembly to a motor vehicle shall withstand a force of 40,034 N when tested by the procedure specified in S5.2(c)(1), except that attachment bolts of a seat belt assembly designed for installation in specific models of motor vehicles in which the ends of two or more seat belt assemblies cannot be attached to the vehicle by a single bolt shall have breaking strength of not less than 22,241 N.

(2) Other attachment hardware designed to receive the ends of two seat belt assemblies shall withstand a tensile force of at least 26,689 N without fracture of a section when tested by the procedure specified in S5.2(c)(2).

(3) A seat belt assembly having single attachment hooks of the quick-disconnect type for connecting webbing to an eye bolt shall be provided with a retaining latch or keeper which shall not move more than 2 mm in either the vertical or horizontal direction when tested by the procedure specified in S5.2(c)(3).

(d) *Buckle release.* (1) The buckle of a Type 1 or Type 2 seat belt assembly shall release when a force of not more than 133 N is applied.

(2) A buckle designed for pushbutton application of buckle release force shall have a minimum area of 452 mm^2 with a minimum linear dimension of 10 mm for applying the release force, or a buckle designed for lever application of buckle release force shall permit the insertion of a cylinder 10 mm in diameter and 38 mm in length to at least the midpoint of the cylinder along the cylinder's entire length in the actuation portion of the buckle release. A buckle having other design for release shall have adequate access for two or more fingers to actuate release.

(3) The buckle of a Type 1 or Type 2 seat belt assembly shall not release under a compressive force of 1779 N applied as prescribed in paragraph S5.2(d)(3). The buckle shall be operable and shall meet the applicable requirement of paragraph S4.4 after the compressive force has been removed.

(e) *Adjustment force.* The force required to decrease the size of a seat belt assembly shall not exceed 49 N when measured by the procedure specified in S5.2(e).

(f) *Tilt-lock adjustment.* The buckle of a seat belt assembly having tilt-lock adjustment shall lock the webbing when tested by the procedure specified in S5.2(f) at an angle of not less than 30 degrees between the base of the buckle and the anchor webbing.

(g) *Buckle latch.* The buckle latch of a seat belt assembly when tested by the procedure specified in S5.2(g) shall not fail, nor gall or wear to an extent that normal latching and unlatching is impaired, and a metal-to-metal buckle shall separate when in any position of partial engagement by a force of not more than 22 N.

(h) *Nonlocking retractor.* The webbing of a seat belt assembly shall extend from a nonlocking retractor within 6 mm of maximum length when a tension is applied as prescribed in S5.2(h). A nonlocking retractor on upper torso restraint shall be attached to the nonadjustable end of the assembly, the reel of the retractor shall be easily visible to an occupant while wearing the assembly, and the maximum retraction force shall not exceed 5 N in any strap or webbing that contacts the shoulder when measured by the procedure specified in S5.2(h), unless the retractor is attached to the free end of webbing which is not subjected to any tension during restraint of an occupant by the assembly.

(i) *Automatic-locking retractor.* The webbing of a seat belt assembly equipped with an automatic locking retractor, when tested by the procedure specified in S5.2(i), shall not move more than 25 mm between locking positions of the retractor, and shall be retracted with a force under zero acceleration of not less than 3 N when attached to pelvic restraint, and not less that 2 N nor more than 5 N in any strap or webbing that contacts the shoulders of an occupant when the retractor is attached to upper torso restraint. An automatic locking retractor attached to upper torso restraint shall not increase the restraint on the occupant of the seat belt assembly during use in a vehicle traveling over rough roads as prescribed in S5.2(i).

(j) *Emergency-locking retractor.* An emergency-locking retractor of a Type 1 or Type 2 seat belt assembly, when tested in accordance with the procedures specified in paragraph S5.2(j)—

(1) Shall lock before the webbing extends 25 mm when the retractor is subjected to an acceleration of 7 m/s^2 (0.7 g);

(2) Shall not lock, if the retractor is sensitive to webbing withdrawal, before the webbing extends 51 mm when the retractor is subjected to an acceleration of 3 m/s^2 (0.3 g) or less.

(3) Shall not lock, if the retractor is sensitive to vehicle acceleration, when the retractor is rotated in any direction to any angle of 15° or less from its orientation in the vehicle;

(4) Shall exert a retractive force of at least 3 N under zero acceleration when attached only to the pelvic restraint;

(5) Shall exert a retractive force of not less than 1 N and not more than 5 N under zero acceleration when attached only to an upper torso restraint;

(6) Shall exert a retractive force of not less than 1 N and not more than 7

N under zero acceleration when attached to a strap or webbing that restrains both the upper torso and the pelvis.

(k) *Performance of retractor*. A retractor used on a seat belt assembly after subjection to the tests specified in S5.2(k) shall comply with applicable requirements in paragraphs (h) to (j) of this section and S4.4, except that the retraction force shall be not less than 50 percent of its original retraction force.

S4.4 *Requirements for assembly performance*.

(a) *Type I seat belt assembly*. Except as provided in S4.5, the complete seat belt assembly including webbing, straps, buckles, adjustment and attachment hardware, and retractors shall comply with the following requirements when tested by the procedures specified in S5.3(a):

(1) The assembly loop shall withstand a force of not less than 22,241 N; that is, each structural component of the assembly shall withstand a force of not less than 11,120 N.

(2) The assembly loop shall extend not more than 7 inches or 178 mm when subjected to a force of 22,241 N; that is, the length of the assembly between anchorages shall not increase more than 356 mm.

(3) Any webbing cut by the hardware during test shall have a breaking strength at the cut of not less than 18,683 N.

(4) Complete fracture through any solid section of metal attachment hardware shall not occur during test.

(b) *Type 2 seat belt assembly*. Except as provided in S4.5, the components of a Type 2 seat belt assembly including webbing, straps, buckles, adjustment and attachment hardware, and retractors shall comply with the following requirements when tested by the procedure specified in S5.3(b):

(1) The structural components in the pelvic restraint shall withstand a force of not less than 11,120 N.

(2) The structural components in the upper torso restraint shall withstand a force of not less than 6,672 N.

(3) The structural components in the assembly that are common to pelvic and upper torso restraints shall withstand a force of not less than 13,345 N.

(4) The length of the pelvic restraint between anchorages shall not increase more than 508 mm when subjected to a force of 11,120 N.

(5) The length of the upper torso restraint between anchorages shall not increase more than 508 mm when subjected to a force of 6,672 N.

(6) Any webbing cut by the hardware during test shall have a breaking strength of not less than 15,569 N at a cut in webbing of the pelvic restraint, or not less than 12,455 N at a cut in webbing of the upper torso restraint.

(7) Complete fracture through any solid section of metal attachment hardware shall not occur during test.

S4.5 *Load-limiter*. (a) A Type 1 or Type 2 seat belt assembly that includes a load-limiter is not required to comply with the elongation requirements of S4.2(c), S4.4(a)(2), S4.4(b)(4) or S4.4(b)(5).

(b) A seat belt assembly that includes a load limiter and that does not comply with the elongation requirements of this standard may be installed in motor vehicles at any designated seating position that is subject to the requirements of S5.1 of Standard No. 208 (§ 571.208).

S4.6 *Manual belts subject to crash protection requirements of Standard No. 208*.

(a)(1) A manual seat belt assembly, which is subject to the requirements of S5.1 of Standard No. 208 (49 CFR 571.208) by virtue of any provision of Standard No. 208 other than S4.1.2.1(c)(2) of that standard, does not have to meet the requirements of S4.2(a)–(f) and S4.4 of this standard.

(2) A manual seat belt assembly subject to the requirements of S5.1 of Standard No. 208 (49 CFR 571.208) by virtue of S4.1.2.1(c)(2) of Standard No. 208 does not have to meet the elongation requirements of S4.2(c), S4.4(a)(2), S4.4(b)(4), and S4.4(b)(5) of this standard.

S5. *Demonstration procedures*.

S5.1 *Webbing*—(a) *Width*. The width of webbing from three seat belt assemblies shall be measured after conditioning for at least 24 hours in an atmosphere having relative humidity between 48 and 67 percent and a temperature of 23° ±2 °C. The tension during measurement of width shall be not more than 22 N on webbing from a Type

1 seat belt assembly, and 9786 N ± 450 N on webbing from a Type 2 seat belt assembly. The width of webbing from a Type 2 seat belt assembly may be measured during the breaking strength test described in paragraph (b) of this section.

(b) *Breaking strength.* Webbing from three seat belt assemblies shall be conditioned in accordance with paragraph (a) of this section and tested for breaking strength in a testing machine of capacity verified to have an error of not more than one percent in the range of the breaking strength of the webbing in accordance with American Society for Testing and Materials E4–79 "Standard Methods of Load Verification of Testing Machines." The machine shall be equipped with split drum grips illustrated in Figure 1, having a diameter between 51 and 102 mm. The rate of grip separation shall be between 51 and 102 mm per minute. The distance between the centers of the grips at the start of the test shall be between 102 and 254 mm. After placing the specimen in the grips, the webbing shall be stretched continuously at a uniform rate to failure. Each value shall be not less than the applicable breaking strength requirement in S4.2(b), but the median value shall be used for determining the retention of breaking strength in paragraphs (d), (e) and (f) of this section.

(c) *Elongation.* Elongation shall be measured during the breaking strength test described in paragraph (b) of this section by the following procedure: A preload between 196 N and 245 N shall be placed on the webbing mounted in the grips of the testing machine and the needle points of an extensometer, in which the points remain parallel during test, are inserted in the center of the specimen. Initially the points shall be set at a known distance apart between 102 and 203 mm. When the force on the webbing reaches the value specified in S4.2(c), the increase in separation of the points of the extensometer shall be measured and the percent elongation shall be calculated to the nearest 0.5 percent. Each value shall be not more than the appropriate elongation requirement in S4.2(c).

(d) *Resistance to abrasion.* The webbing from three seat belt assemblies shall be tested for resistance to abrasion by rubbing over the hexagon bar prescribed in Figure 2 in the following manner: The webbing shall be mounted in the apparatus shown schematically in Figure 2. One end of the webbing (A) shall be attached to a mass (B) of 2.35 kg ± .05 kg, except that a mass of 1.5 kg ± .05 kg shall be used for webbing in pelvic and upper torso restraints of a belt assembly used in a child restraint system. The webbing shall be passed over the two new abrading edges of the hexagon bar (C) and the other end attached to an oscillating drum (D) which has a stroke of 330 mm. Suitable guides shall be used to prevent movement of the webbing along the axis of hexagonal bar C. Drum D shall be oscillated for 5,000 strokes or 2,500 cycles at a rate of 60 ± 2 strokes per minute or 30 ± 1 cycles per minute. The abraded webbing shall be conditioned as prescribed in paragraph (a) of this section and tested for breaking strength by the procedure described in paragraph (b) of this section. The median values for the breaking strengths determined on abraded and unabraded specimens shall be used to calculate the percentage of breaking strength retained.

(e) *Resistance to light.* Webbing at least 508 mm in length from three seat belt assemblies shall be suspended vertically on the inside of the specimen track in a Type E carbon-arc light exposure apparatus described in Standard Practice for Generating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials, ASTM Designation: G23 81, published by the American Society for Testing and Materials, except that the filter used for 100 percent polyester yarns shall be chemically strengthened soda-lime glass with a transmittance of less than 5 percent for wave lengths equal to or less than 305 nanometers and 90 percent or greater transmittance for wave lengths of 375 to 800 nanometers. The apparatus shall be operated without water spray at an air temperature of 60° ± 2 °Celsius (°C) measured at a point 25 ± 5 mm outside the specimen rack and midway in height. The temperature sensing element shall be shielded from radiation. The specimens shall be exposed to light from the carbon-arc for 100 hours and then conditioned as prescribed in paragraph (a) of this section. The colorfastness of the exposed and conditioned specimens shall be determined on the Geometric Gray Scale issued by the American Association of Textile Chemists and Colorists. The breaking strength of the specimens shall be determined by the procedure prescribed in paragraph (b) of this section. The median values for the breaking strengths determined on exposed and unexposed specimens shall be used to calculate the percentage of breaking strength retained.

(f) *Resistance to micro-organisms*. Webbing at least 508 millimeters (mm) in length from three seat belt assemblies shall first be preconditioned in accordance with Appendix A(1) and (2) of American Association of Textile Chemists and Colorists Test Method 381, ''Fungicides Evaluation on Textiles; Mildew and Rot Resistance of Textiles,'' and then subjected to Test I, ''Soil Burial Test'' of that test method. After soil-burial for a period of 2 weeks, the specimen shall be washed in water, dried and conditioned as prescribed in paragraph (a) of this section. The breaking strengths of the specimens shall be determined by the procedure prescribed in paragraph (b) of this section. The median values for the breaking strengths determined on exposed and unexposed specimens shall be used to calculate the percentage of breaking strength retained.

NOTE: This test shall not be required on webbing made from material which is inherently resistant to micro-organisms.

S5.2 *Hardware*.

(a) *Corrosion resistance*. Three seat belt assemblies shall be tested in accordance with American Society for Testing and Materials B11773, ''Standard Method of Salt Spray (Fog) Testing.'' Any surface coating or material not intended for permanent retention on the metal parts during service life shall be removed prior to preparation of the test specimens for testing. The period of test shall be 50 hours for all attachment hardware at or near the floor, consisting of two periods of 24 hours exposure to salt spray followed by 1 hour drying and 25 hours for all other hardware, consisting of one period of 24 hours exposure to salt spray followed by 1 hour drying. In the salt spray test chamber, the parts from the three assemblies shall be oriented differently, selecting those orientations most likely to develop corrosion on the larger areas. At the end of test, the seat belt assembly shall be washed thoroughly with water to remove the salt. After drying for at least 24 hours under standard laboratory conditions specified in S5.1(a) attachment hardware shall be examined for ferrous corrosion on significant surfaces, that is, all surfaces that can be contacted by a sphere 19 mm in diameter, and other hardware shall be examined for ferrous and nonferrous corrosion which may be transferred, either directly or by means of the webbing, to a person or his clothing during use of a seat belt assembly incorporating the hardware.

NOTE: When attachment and other hardware are permanently fastened, by sewing or other means, to the same piece of webbing, separate assemblies shall be used to test the two types of hardware. The test for corrosion resistance shall not be required for attachment hardware made from corrosion-resistant steel containing at least 11.5 percent chromium or for attachment hardware protected with an electrodeposited coating of nickel, or copper and nickel, as prescribed in S4.3(a). The assembly that has been used to test the corrosion resistance of the buckle shall be used to measure adjustment force, tilt-lock adjustment, and buckle latch in paragraphs (e), (f), and (g), respectively, of this section, assembly performance in S5.3 and buckle release force in paragraph (d) of this section.

(b) *Temperature resistance*. Three seat belt assemblies having plastic or nonmetallic hardware or having retractors shall be subjected to the conditions prescribed in Procedure D of American Society for Testing and Materials D756–78, ''Standard Practice for Determination of Weight and Shape Changes of Plastics under Accelerated Service Conditions.'' The dimension and weight measurement shall be omitted. Buckles shall be unlatched and retractors shall be fully retracted during conditioning. The hardware parts after conditioning shall be used for all applicable tests in S4.3 and S4.4.

(c) *Attachment hardware*. (1) Attachment bolts used to secure the pelvic restraint of a seat belt assembly to a motor vehicle shall be tested in a manner similar to that shown in Figure 3. The load shall be applied at an angle of 45° to the axis of the bolt through attachment hardware from the seat belt assembly, or through a special fixture which simulates the loading applied by the attachment hardware. The attachment hardware or simulated fixture shall be fastened by the bolt to the anchorage shown in Figure 3, which has a standard 7⁄16–20UNF–2B or ½-UNF–2B or metric equivalent threaded hole in a hardened steel plate at least 10 mm in thickness. The bolt shall be installed with two full threads exposed from the fully seated position. The appropriate force required by S4.3(c) shall be applied. A bolt from each of three seat belt assemblies shall be tested.

(2) Attachment hardware, other than bolts, designed to receive the ends of two seat belt assemblies shall be subjected to a tensile force of 26,689 N in a manner simulating use. The hardware shall be examined for fracture after the force is released. Attachment hardware from three seat belt assemblies shall be tested.

(3) Single attachment hook for connecting webbing to any eye bolt shall be tested in the following manner: The hook shall be held rigidly so that the retainer latch or keeper, with cotter pin or other locking device in place, is in a horizontal position as shown in Figure 4. A force of 667 N ± 9 N shall be applied vertically as near as possible to the free end of the retainer latch, and the movement of the latch by this force at the point of application shall be measured. The vertical force shall be released, and a force of 667 N ± 9 N shall be applied horizontally as near as possible to the free end of the retainer latch. The movement of the latch by this force at the point of load application shall be measured. Alternatively, the hook may be held in other positions, provided the forces are applied and the movements of the latch are measured at the points indicated in Figure 4. A single attachment hook from each of three seat belt assemblies shall be tested.

(d) *Buckle release*. (1) Three seat belt assemblies shall be tested to determine compliance with the maximum buckle release force requirements, following the assembly test in S5.3. After subjection to the force applicable for the assembly being tested, the force shall be reduced and maintained at 667 N on the assembly loop of a Type 1 seat belt assembly, 334 N on the components of a Type 2 seat belt assembly. The buckle release force shall be measured by applying a force on the buckle in a manner and direction typical of those which would be employed by a seat belt occupant. For push button-release buckles, the force shall be applied at least 3 mm from the edge of the push button access opening of the buckle in a direction that produces maximum releasing effect. For lever-release buckles, the force shall be applied on the centerline of the buckle lever or finger tab in a direction that produces maximum releasing effect.

(2) The area for application of release force on pushbutton actuated buckle shall be measured to the nearest 30 mm^2. The cylinder specified in S4.3(d) shall be inserted in the actuation portion of a lever released buckle for determination of compliance with the requirement. A buckle with other release actuation shall be examined for access of release by fingers.

(3) The buckle of a Type 1 or Type 2 seat belt assembly shall be subjected to a compressive force of 1779 N applied anywhere on a test line that is coincident with the center line of the belt extended through the buckle or on any line that extends over the center of the release mechanism and intersects the extended centerline of the belt at an angle of 60°. The load shall be applied by using a curved cylindrical bar having a cross section diameter of 19 mm and a radius of curvature of 152 mm, placed with its longitudinal center line along the test line and its center directly above the point or the buckle to which the load will be applied. The buckle shall be latched, and a tensile force of 334 N shall be applied to the connected webbing during the application of the compressive force. Buckles from three seat belt assemblies shall be tested to determine compliance with paragraph S4.3(d)(3).

(e) *Adjustment Force*. Three seat belt assemblies shall be tested for adjustment force on the webbing at the buckle, or other manual adjusting device normally used to adjust the size of the assembly. With no load on the anchor end, the webbing shall be drawn through the adjusting device at a rate of 508 mm ±50 mm per minute and the maximum force shall be measured to the nearest 1 N after the first 25 mm of webbing movement. The webbing shall be precycled 10 times prior to measurement.

(f) *Tilt-lock adjustment.* This test shall be made on buckles or other manual adjusting devices having tilt-lock adjustment normally used to adjust the size of the assembly. Three buckles or devices shall be tested. The base of the adjustment mechanism and the anchor end of the webbing shall be oriented in planes normal to each other. The webbing shall be drawn through the adjustment mechanism in a direction to increase belt length at a rate of 508 mm ±50 mm per minute while the plane of the base is slowly rotated in a direction to lock the webbing. Rotation shall be stopped when the webbing locks, but the pull on the webbing shall be continued until there is a resistance of at least 89 N. The locking angle between the anchor end of the webbing and the base of the adjustment mechanism shall be measured to the nearest degree. The webbing shall be precycled 10 times prior to measurement.

(g) *Buckle latch.* The buckles from three seat belt assemblies shall be opened fully and closed at least 10 times. Then the buckles shall be clamped or firmly held against a flat surface so as to permit normal movement of buckle part, but with the metal mating plate (metal-to-metal buckles) or of webbing end (metal-to-webbing buckles) withdrawn from the buckle. The release mechanism shall be moved 200 times through the maximum possible travel against its stop with a force of 133 N ±13 N at a rate not to exceed 30 cycles per minute. The buckle shall be examined to determine compliance with the performance requirements of S4.3(g). A metal-to-metal buckle shall be examined to determine whether partial engagement is possible by means of any technique representative of actual use. If partial engagement is possible, the maximum force of separation when in such partial engagement shall be determined.

(h) *Nonlocking retractor.* After the retractor is cycled 10 times by full extension and retraction of the webbing, the retractor and webbing shall be suspended vertically and a force of 18 N shall be applied to extend the webbing from the retractor. The force shall be reduced to 13 N when attached to a pelvic restraint, or to 5 N per strap or webbing that contacts the shoulder of an occupant when retractor is attached to an upper torso restraint. The residual extension of the webbing shall be measured by manual rotation of the retractor drum or by disengaging the retraction mechanism. Measurements shall be made on three retractors. The location of the retractor attached to upper torso restraint shall be examined for visibility of reel during use of seat belt assembly in a vehicle.

NOTE: This test shall not be required on a nonlocking retractor attached to the free end of webbing which is not subjected to any tension during restraint of an occupant by the assembly.

(i) *Automatic-locking retractor.* Three retractors shall be tested in a manner to permit the retraction force to be determined exclusive of the gravitational forces on hardware or webbing being retracted. The webbing shall be fully extended from the retractor. While the webbing is being retracted, the average force or retraction within plus or minus 51 mm of 75 percent extension (25 percent retraction) shall be determined and the webbing movement between adjacent locking segments shall be measured in the same region of extension. A seat belt assembly with automatic locking retractor in upper torso restraint shall be tested in a vehicle in a manner prescribed by the installation and usage instructions. The retraction force on the occupant of the seat belt assembly shall be determined before and after traveling for 10 minutes at a speed of 24 kilometers per hour (km/h) or more over a rough road (e.g., Belgian block road) where the occupant is subjected to displacement with respect to the vehicle in both horizontal and vertical directions. Measurements shall be made with the vehicle stopped and the occupant in the normal seated position.

(j) *Emergency-locking retractor.* A retractor shall be tested in a manner that permits the retraction force to be determined exclusive of the gravitational forces on hardware or webbing being retracted. The webbing shall be fully extended from the retractor, passing over or through any hardware or other material specified in the installation instructions. While the webbing is being retracted, the lowest force of retraction within plus or minus 51 mm of 75 percent extension shall be determined. A retractor that is sensitive to webbing withdrawal shall be subjected to an acceleration of 3 m/s^2 (0.3 g) within a period of 50 milliseconds (ms) while the webbing is at 75 percent extension, to determine compliance with S4.3(j)(2). The retractor shall be subjected to an acceleration of 7 m/s^2 (0.7 g) within a period of 50 milliseconds (ms), while the webbing is at 75 percent extension, and the webbing movement before locking shall be measured under the following conditions: For a retractor sensitive to webbing withdrawal, the retractor shall be accelerated in the direction of webbing retraction while the retractor drum's central axis is oriented horizontally and at angles of 45°, 90°, 135°, and 180° to the horizontal plane. For a retractor sensitive to vehicle acceleration, the retractor shall be:

(1) Accelerated in the horizontal plane in two directions normal to each other, while the retractor drum's central axis is oriented at the angle at which it is installed in the vehicle; and,

(2) Accelerated in three directions normal to each other while the retractor drum's central axis is oriented at angles of 45°, 90°, 135°, and 180° from the angle at which it is installed in the vehicle, unless the retractor locks by gravitational force when tilted in any direction to any angle greater than 45° from the angle at which it is installed in the vehicle.

(k) *Performance of retractor*. After completion of the corrosion-resistance test described in paragraph (a) of this section, the webbing shall be fully extended and allowed to dry for at least 24 hours under standard laboratory conditions specified in S5.1(a). The retractor shall be examined for ferrous and nonferrous corrosion which may be transferred, either directly or by means of the webbing, to a person or his clothing during use of a seat belt assembly incorporating the retractor, and for ferrous corrosion on significant surfaces if the retractor is part of the attachment hardware. The webbing shall be withdrawn manually and allowed to retract for 25 cycles. The retractor shall be mounted in an apparatus capable of extending the webbing fully, applying a force of 89 N at full extension, and allowing the webbing to retract freely and completely. The webbing shall be withdrawn from the retractor and allowed to retract repeatedly in this apparatus until 2,500 cycles are completed. The retractor and webbing shall then be subjected to the temperature resistance test prescribed in paragraph (b) of this section. The retractor shall be subjected to 2,500 additional cycles of webbing withdrawal and retraction. Then, the retractor and webbing shall be subjected to dust in a chamber similar to one illustrated in Figure 8 containing about 0.9 kg of coarse grade dust conforming to the specification given in Society of Automotive Engineering Recommended Practice J726, ''Air Cleaner Test Code'' Sept. 1979. The dust shall be agitated every 20 minutes for 5 seconds by compressed air, free of oil and moisture, at a gage pressure of 550 ±55 kPa entering through an orifice 1.5 ± 0.1 mm in diameter. The webbing shall be extended to the top of the chamber and kept extended at all times except that the webbing shall be subjected to 10 cycles of complete retraction and extension within 1 to 2 minutes after each agitation of the dust. At the end of 5 hours, the assembly shall be removed from the chamber. The webbing shall be fully withdrawn from the retractor manually and allowed to retract completely for 25 cycles. An automatic-locking retractor or a nonlocking retractor attached to pelvic restraint shall be subjected to 5,000 additional cycles of webbing withdrawal and retraction. An emergency locking retractor or a nonlocking retractor attached to upper torso restraint shall be subjected to 45,000 additional cycles of webbing withdrawal and retraction between 50 and 100 per cent extension. The locking mechanism of an emergency locking retractor shall be actuated at least 10,000 times within 50 to

100 percent extension of webbing during the 50,000 cycles. At the end of test, compliance of the retractors with applicable requirements in S4.3 (h), (i), and (j) shall be determined. Three retractors shall be tested for performance.

S5.3 *Assembly performance—(a) Type 1 seat belt assembly*. Three complete seat belt assemblies, including webbing, straps, buckles, adjustment and attachment hardware, and retractors, arranged in the form of a loop as shown in Figure 5, shall be tested in the following manner:

(1) The testing machine shall conform to the requirements specified in S5.1(b). A double-roller block shall be attached to one head of the testing machine. This block shall consist of two rollers 102 mm in diameter and sufficiently long so that no part of the seat belt assembly touches parts of the block other than the rollers during test. The rollers shall be mounted on antifriction bearings and spaced 305 mm between centers, and shall have sufficient capacity so that there is no brinelling, bending or other distortion of parts which may affect the results. An anchorage bar shall be fastened to the other head of the testing machine.

(2) The attachment hardware furnished with the seat belt assembly shall be attached to the anchorage bar. The anchor points shall be spaced so that the webbing is parallel in the two sides of the loop. The attaching bolts shall be parallel to, or at an angle of 45° or 90° to the webbing, whichever results in an angle nearest to 90° between webbing and attachment hardware except that eye bolts shall be vertical, and attaching bolts or nonthreaded anchorages of a seat belt assembly designed for use in specific models of motor vehicles shall be installed to produce the maximum angle in use indicated by the installation instructions, utilizing special fixtures if necessary to simulate installation in the motor vehicle. Rigid adapters between anchorage bar and attachment hardware shall be used if necessary to locate and orient the adjustment hardware. The adapters shall have a flat support face perpendicular to the threaded hole for the attaching bolt and adequate in area to provide full support for the base of the attachment hardware connected to the webbing. If necessary, a washer shall be used under a swivel plate or other attachment hardware to prevent the webbing from being damaged as the attaching bolt is tightened.

(3) The length of the assembly loop from attaching bolt to attaching bolt shall be adjusted to about 1295 mm, or as near thereto as possible. A force of 245 N shall be applied to the loop to remove any slack in webbing at hardware. The force shall be removed and the heads of the testing machine shall be adjusted for an assembly loop between 1220 and 1270 mm in length. The length of the assembly loop shall then be adjusted by applying a force between 89 and 98 N to the free end of the webbing at the buckle, or by the retraction force of an automatic-locking or emergency-locking retractor. A seat belt assembly that cannot be adjusted to this length shall be adjusted as closely as possible. An automatic-locking or emergency locking retractor when included in a seat belt assembly shall be locked at the start of the test with a tension on the webbing slightly in excess of the retractive force in order to keep the retractor locked. The buckle shall be in a location so that it does not touch the rollers during test, but to facilitate making the buckle release test in S5.2(d) the buckle should be between the rollers or near a roller in one leg.

(4) The heads of the testing machine shall be separated at a rate between 51 and 102 mm per minute until a force of 22,241 ± 222 N is applied to the assembly loop. The extension of the loop shall be determined from measurements of head separation before and after the force is applied. The force shall be decreased to 667 ± 45 N and the buckle release force measured as prescribed in S5.2(d).

(5) After the buckle is released, the webbing shall be examined for cutting by the hardware. If the yarns are partially or completely severed in a line for a distance of 10 percent or more of the webbing width, the cut webbing shall be tested for breaking strength as specified in S5.1(b) locating the cut in the free length between grips. If there is insufficient webbing on either side of

the cut to make such a test for breaking strength, another seat belt assembly shall be used with the webbing repositioned in the hardware. A tensile force of 11,120 ± 111 N shall be applied to the components or a force of 22,241 ± 222 N shall be applied to the assembly loop. After the force is removed, the breaking strength of the cut webbing shall be determined as prescribed above.

(6) If a Type 1 seat belt assembly includes an automatic-locking retractor or an emergency-locking retractor, the webbing and retractor shall be subjected to a tensile force of 11,120 ± 111 N with the webbing fully extended from the retractor.

(7) If a seat belt assembly has a buckle in which the tongue is capable of inverted insertion, one of the three assemblies shall be tested with the tongue inverted.

(b) *Type 2 seat belt assembly*. Components of three seat belt assemblies shall be tested in the following manner:

(1) The pelvic restraint between anchorages shall be adjusted to a length between 1220 and 1270 mm, or as near this length as possible if the design of the pelvic restraint does not permit its adjustment to this length. An automatic-locking or emergency-locking retractor when included in a seat belt assembly shall be locked at the start of the test with a tension on the webbing slightly in excess of the retractive force in order to keep the retractor locked. The attachment hardware shall be oriented to the webbing as specified in paragraph (a)(2) of this section and illustrated in Figure 5. A tensile force 11,120 ± 111 N shall be applied on the components in any convenient manner and the extension between anchorages under this force shall be measured. The force shall be reduced to 334 ± 22 N and the buckle release force measured as prescribed in S5.2(d).

(2) The components of the upper torso restraint shall be subjected to a tensile force of 6,672 ± 67 N following the procedure prescribed above for testing pelvic restraint and the extension between anchorages under this force shall be measured. If the testing apparatus permits, the pelvic and upper torso restraints may be tested simultaneously. The force shall be reduced to 334 ± 22 N and the buckle release force measured as prescribed in S5.2(d).

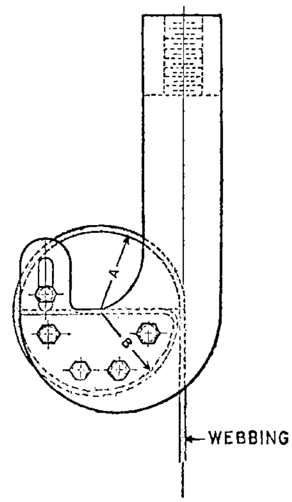
(3) Any component of the seat belt assembly common to both pelvic and upper torso restraint shall be subjected to a tensile force of 13,344 ± 134 N.

(4) After the buckle is released in tests of pelvic and upper torso restraints, the webbing shall be examined for cutting by the hardware. If the yarns are partially or completely severed in a line for a distance of 10 percent or more of the webbing width, the cut webbing shall be tested for breaking strength as specified in S5.1(b) locating the cut in the free length between grips. If there is insufficient webbing on either side of the cut to make such a test for breaking strength, another seat belt assembly shall be used with the webbing repositioned in the hardware. The force applied shall be 11,120 ± 111 N for components of pelvic restraint, and 6,672 ± 67 N for components of upper torso restraint. After the force is removed, the breaking strength of the cut webbing shall be determined as prescribed above.

(5) If a Type 2 seat belt assembly includes an automatic-locking retractor or an emergency-locking retractor the webbing and retractor shall be subjected to a tensile force of 11,120 ± 111 N with the webbing fully extended from the retractor, or to a tensile force of 6,672 ± 67 N with the webbing fully extended from the retractor if the design of the assembly permits only upper torso restraint forces on the retractor.

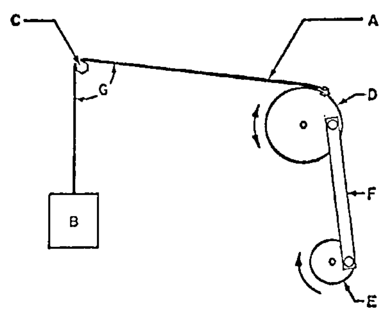
(6) If a seat belt assembly has a buckle in which the tongue is capable of inverted insertion, one of the three assemblies shall be tested with the tongue inverted.

(c) *Resistance to buckle abrasion*. Seat belt assemblies shall be tested for resistance to abrasion by each buckle or manual adjusting device normally used to adjust the size of the assembly. The webbing of the assembly to be used in this test shall be exposed for 4 hours to an atmosphere having relative humidity of 65 per cent and temperature of 18 °C. The webbing shall be pulled back and forth through the buckle or manual adjusting device as shown schematically in Figure 7. The anchor end of the webbing (A) shall be attached to a mass (B) of 1.4 kg. The webbing shall pass through the buckle (C), and the other end (D) shall be attached to a reciprocating device so that the webbing forms an angle of 8° with the hinge stop (E). The reciprocating device shall be operated for 2,500 cycles at a rate of 18 cycles per minute with a stroke length of 203 mm. The abraded webbing shall be tested for breaking strength by the procedure described in paragraph S5.1(b).



A 1 TO 2 INCHES OR 2.5 TO 5 CENTIMETERS
B A MINUS 0.06 INCH OR 0.15 CENTIMETER

FIGURE 1



A – WEBBING
B – WEIGHT
C – HEXAGONAL ROD
STEEL— SAE 51416
ROCKWELL HARDNESS – B-97 TO B-101
SURFACE – COLD DRAWN FINISH
SIZE – 0.250 ± 0.001 INCH OR
6.35 ± 0.03 MILLIMETER
RADIUS ON EDGES – 0.020 ± 0.004 INCH OR
0.5 ± 0.1 MILLIMETER
D – DRUM DIAMETER – 16 INCHES OR
40 CENTIMETERS
E – CRANK
F – CRANK ARM
G – ANGLE BETWEEN WEBBING – 85 ± 2 DEGS.

FIGURE 2

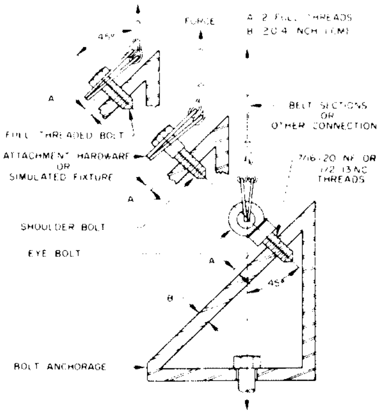


FIGURE 3

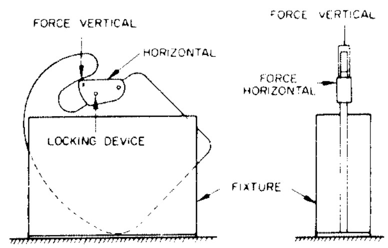


FIGURE 4
SINGLE ATTACHMENT HOOK

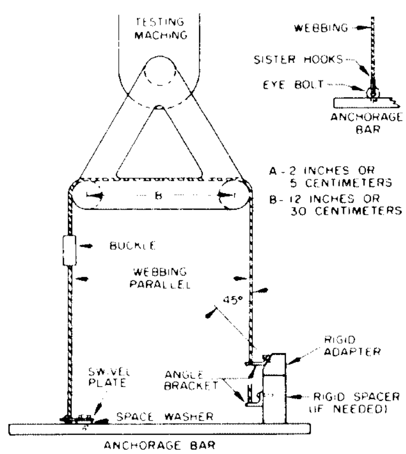


FIGURE 5

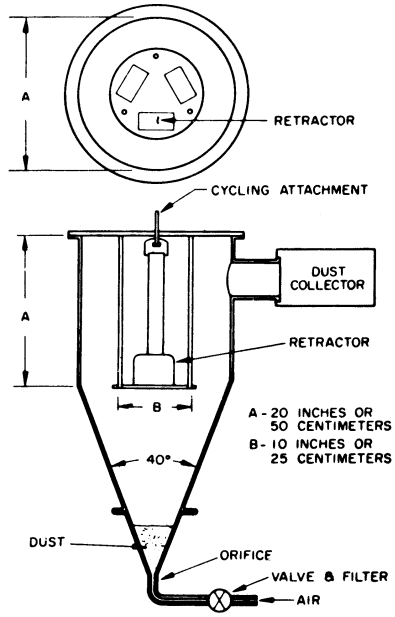


FIGURE 6

[34 F.R. 115 January 4, 1969]

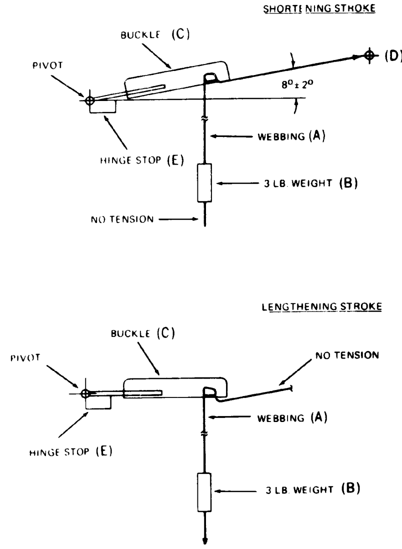


FIGURE 7

[44 FR 72139, Dec. 13, 1979, as amended at 45 FR 29048, May 1, 1980; 46 FR 2620, Jan. 12, 1981; 48 FR 30140, June 30, 1983; 49 FR 36508, Sept. 18, 1984; 51 FR 9813, Mar. 21, 1986; 51 FR 31774, Sept. 5, 1986; 52 FR 44912, Nov. 23, 1987; 56 FR 15299, Apr. 16, 1991; 56 FR 56325, Nov. 4, 1991; 59

FR 17994, Apr. 15, 1994; 61 FR 20171, May 6, 1996; 63 FR 28936, May 27, 1998; 63 FR 51003, Sept. 24, 1998; 64 FR 27206, May 19, 1999]

§ 571.210 Standard No. 210; Seat belt assembly anchorages.

S1. *Purpose and scope.* This standard establishes requirements for seat belt assembly anchorages to insure their proper location for effective occupant restraint and to reduce the likelihood of their failure.

S2. *Application.* This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses.

S3. Definition. *Seat belt anchorage* means any component, other than the webbing or straps, involved in transferring seat belt loads to the vehicle structure, including, but not limited to, the attachment hardware, seat frames, seat pedestals, the vehicle structure itself, and any part of the vehicle whose failure causes separation of the belt from the vehicle structure.

S4. *Requirements.*

S4.1 *Type.*

S4.1.1 Seat belt anchorages for a Type 1 or a Type 2 seat belt assembly shall be installed for each designated seating position for which a Type 1 or a Type 2 seat belt assembly is required by Standard No. 208 (49 CFR 571.208). Seat belt anchorages for a Type 2 seat belt assembly shall be installed for each designated seating position for which a Type 2 seat belt assembly is required by Standard No. 208 (49 CFR 571.208).

S4.1.2 (a) Notwithstanding the requirement of S4.1.1, each vehicle manufactured on or after September 1, 1987 that is equipped with an automatic restraint at the front right outboard designated seating position, which automatic restraint cannot be used for securing a child restraint system or cannot be adjusted by the vehicle owner to secure a child restraint system solely through the use of attachment hardware installed as an item of original equipment by the vehicle manufacturer, shall have, at the manufacturer's option, either anchorages for a Type 1 seat belt assembly installed at that position or a Type 1 or Type 2 seat belt assembly installed at that position. If a manufacturer elects to install anchorages for a Type 1 seat belt assembly to comply with this requirement, those anchorages shall consist of, at a minimum, holes threaded to accept bolts that comply with S4.1(f) of Standard No. 209 (49 CFR 571.209).

(b) The requirement in S4.1.1 of this standard that seat belt anchorages for a Type 1 or a Type 2 seat belt assembly shall be installed for certain designated seating positions does not apply to any such seating positions that are equipped with a seat belt assembly that meets the frontal crash protection requirements of S5.1 of Standard No. 208 (49 CFR 571.208).

S4.2 *Strength.*

S4.2.1 Except as provided in S4.2.5, and except for side-facing seats, the anchorages, attachment hardware, and attachment bolts for any of the following seat belt assemblies shall withstand a 5,000 pound force when tested in accordance with S5.1 of this standard:

(a) Type 1 seat belt assembly; and

(b) Lap belt portion of either a Type 2 or automatic seat belt assembly, if such seat belt assembly is equipped with a detachable upper torso belt.

S4.2.2 Except as provided in S4.2.5, and except for side facing seats, the anchorages, attachment hardware, and attachment bolts for any of the following seat belt assemblies shall withstand a 3,000 pound force applied to the lap belt portion of the seat belt assembly simultaneously with a 3,000 pound force applied to the shoulder belt portion of the seat belt assembly, when tested in accordance with S5.2 of this standard:

(a) Type 2 and automatic seat belt assemblies that are installed to comply with Standard No. 208 (49 CFR 571.208); and

(b) Type 2 and automatic seat belt assemblies that are installed at a seating position required to have a Type 1 or Type 2 seat belt assembly by Standard No. 208 (49 CFR 571.208).

S4.2.3 Permanent deformation or rupture of a seat belt anchorage or its surrounding area is not considered to be a failure, if the required force is sustained for the specified time.

S4.2.4 Anchorages, attachment hardware, and attachment bolts shall plane is six inches. To the extent practicable, the left leg of the test dummy is in a vertical longitudinal plane.

S7.3.2 *For a test dummy in the outboard passenger positions.* The upper legs of each test dummy rest against the seat cushion to the extent permitted by placement of the feet. The initial distance between the outboard knee clevis flange surfaces is 11.5 inches. To the extent practicable, both legs of the test dummies in outboard passenger positions are in vertical longitudinal planes. Final adjustment to accommodate placement of feet in accordance with S7.4 for various passenger compartment configurations is permitted.

S7.4 *Feet.*

S7.4.1 *For a test dummy in the driver position.* The right foot of the test dummy rests on the undepressed accelerator with the heel resting as far forward as possible on the floorpan. The left foot is set perpendicular to the lower leg with the heel resting on the floorpan in the same lateral line as the right heel.

S7.4.2 *For a test dummy in the front outboard passenger position.* The feet of the test dummy are placed on the vehicle's toeboard with the heels resting on the floorpan as close as possible to the intersection of the toeboard and floorpan. If the feet cannot be placed flat on the toeboard, they are set perpendicular to the lower legs and placed as far forward as possible so that the heels rest on the floorpan.

S7.4.3 *For a test dummy in either of the rear outboard passenger positions.* The feet of the test dummy are placed flat on the floorpan and beneath the front seat as far as possible without front seat interference. If necessary, the distance between the knees can be changed in order to place the feet beneath the seat.

S8. *Phase-in of dynamic test and performance requirements.*

S8.1–S8.2 [Reserved]

S8.3 *Passenger cars manufactured on or after September 1, 1995 and before September 1, 1996.*

S8.3.1 The number of passenger cars complying with the requirements of S3(c) shall be not less than 40 percent of:

(a) The average annual production of passenger cars manufactured on or after September 1, 1992, and before September 1, 1995, by each manufacturer, or

(b) The manufacturer's annual production of passenger cars during the period specified in S8.3.

S8.4 *Passenger cars produced by more than one manufacturer.*

S8.4.1 For the purposes of calculating average annual production of passenger cars for each manufacturer and the number of passenger cars manufactured by each manufacturer under S8.1, S8.2, and S8.3, a passenger car produced by more than one manufacturer shall be attributed to a single manufacturer as follows, subject to S8.4.2:

(a) A passenger car which is imported shall be attributed to the importer.

(b) A passenger car manufactured in the United States by more than one manufacturer, one of which also markets the vehicle, shall be attributed to the manufacturer which markets the vehicle.

S8.4.2 A passenger car produced by more than one manufacturer shall be attributed to any one of the vehicle's manufacturers specified by an express written contract, reported to the National Highway Traffic Safety Administration under 49 CFR part 586, between the manufacturer so specified and the manufacturer to which the vehicle would otherwise be attributed under S8.4.1.

[36 FR 22902, Dec. 2, 1971, as amended at 45 FR 17018, Mar. 17, 1980; 55 FR 45752, Oct. 30, 1990; 56 FR 27437, June 14, 1991; 56 FR 47011, Sept. 17, 1991; 57 FR 21615, May 21, 1992; 57 FR 30921 and 30922, July 13, 1992; 58 FR 14169, Mar. 16, 1993; 60 FR 38761, July 28, 1995; 60 FR 57839, Nov. 22, 1995; 63 FR 16140, Apr. 2, 1998]

§ 571.215 [Reserved]

§ 571.216 Standard No. 216; Roof crush resistance.

S1. *Scope.* This standard establishes strength requirements for the passenger compartment roof.

S2. *Purpose.* The purpose of this standard is to reduce deaths and injuries due to the crushing of the roof into the occupant compartment in rollover crashes.

S3. *Application.* This standard applies to passenger cars, and to multipurpose passenger vehicles, trucks and buses with a GVWR of 2722 kilograms or less. However, it does not apply to—

(a) School buses;

(b) Vehicles that conform to the rollover test requirements (S5.3) of Standard No. 208 (§571.208) by means that require no action by vehicle occupants; or

(c) Convertibles, except for optional compliance with the standard as an alternative to the rollover test requirements in S5.3 of Standard No. 208.

S4. *Definitions.*

Altered roof means the replacement roof on a motor vehicle whose original roof has been removed, in part or in total, and replaced by a roof that is higher than the original roof. The replacement roof on a motor vehicle whose original roof has been replaced, in whole or in part, by a roof that consists of glazing materials, such as those in T-tops and sunroofs, and is located at the level of the original roof, is not considered to be an altered roof.

Raised roof means, with respect to a roof which includes an area that protrudes above the surrounding exterior roof structure, that protruding area of the roof.

Roof over the front seat area means the portion of the roof, including windshield trim, forward of a transverse vertical plane passing through a point 162 mm rearward of the SgRP of the rearmost front outboard seating position.

Windshield trim means molding of any material between the windshield glazing and the exterior roof surface, including material that covers a part of either the windshield glazing or exterior roof surface.

S5. *Requirements.* Subject to S5.1, when the test device described in S6 is used to apply a force to either side of the forward edge of a vehicle's roof in accordance with the procedures of S7, the lower surface of the test device must not move more than 127 millimeters. The applied force in Newtons is equal to 1.5 times the unloaded vehicle weight of the vehicle, measured in kilograms and multiplied by 9.8, but does not exceed 22,240 Newtons for passenger cars. Both the left and right front portions of the vehicle's roof structure must be capable of meeting the requirements. A particular vehicle need not meet further requirements after being tested at one location.

S5.1 For multipurpose passenger vehicles, trucks and buses that have a raised roof or altered roof, manufacturers have the option of using the test procedures of S8 instead of the procedures of S7 until October 25, 2000. The option of using the test procedures of S8 ceases to be available on that date.

S6. *Test device.* The test device is a rigid unyielding block whose lower surface is a flat rectangle measuring 762 millimeters by 1,829 millimeters.

S7. *Test procedure.* Each vehicle must be capable of meeting the requirements of S5 when tested in accordance with the procedure in S7.1 through 7.6.

S7.1 Place the sills or the chassis frame of the vehicle on a rigid horizontal surface, fix the vehicle rigidly in position, close all windows, close and lock all doors, and secure any convertible top or removable roof structure in place over the occupant compartment. Remove roof racks or other non-structural components.

S7.2 Orient the test device as shown in Figure 1 of this section, so that—

(a) Its longitudinal axis is at a forward angle (in side view) of 5 degrees below the horizontal, and is parallel to the vertical plane through the vehicle's longitudinal centerline;

(b) Its transverse axis is at an outboard angle, in the front view projection, of 25 degrees below the horizontal.

S7.3 Maintaining the orientation specified in S7.2—

(a) Lower the test device until it initially makes contact with the roof of the vehicle.

(b) Position the test device so that—

(1) The longitudinal centerline on its lower surface is on the initial point of contact, or on the center of the initial contact area, with the roof; and

(2) Except as specified in S7.4, the midpoint of the forward edge of the lower surface of the test device is within 10 mm of the transverse vertical plane 254 mm forward of the forwardmost point on the exterior surface of the roof, including windshield trim, that lies in the longitudinal vertical plane passing through the vehicle's longitudinal centerline.

S7.4 If the vehicle being tested is a multipurpose passenger vehicle, truck, or bus that has a raised roof or altered roof, and the initial contact point of the test device is on the raised roof or altered roof to the rear of the roof over the front seat area, the plate is positioned so that the midpoint of the rearward edge of the lower surface of the test device is within 10 mm of the transverse vertical plane located at the rear of the roof over the front seat area.

S7.5 Apply force so that the test device moves in a downward direction perpendicular to the lower surface of the test device at a rate of not more than 13 millimeters per second until reaching the force level specified in S5. Guide the test device so that throughout the test it moves, without rotation, in a straight line with its lower surface oriented as specified in S7.2(a) and S7.2(b). Complete the test within 120 seconds.

S7.6 Measure the distance that the test device moved, i.e., the distance between the original location of the lower surface of the test device and its location as the force level specified in S5 is reached.

S8 *Alternate test procedure for multipurpose passenger vehicles, trucks and buses that have a raised roof or altered roof manufactured until October 25, 2000 (see S5.1).* Each vehicle shall be capable of meeting the requirements of S5 when tested in accordance with the following procedure.

S8.1 Place the sills or the chassis frame of the vehicle on a rigid horizontal surface, fix the vehicle rigidly in position, close all windows, close and lock all doors, and secure any convertible top or removable roof structure in place over the passenger compartment.

S8.2 Orient the test device as shown in Figure 2, so that—

(a) Its longitudinal axis is at a forward angle (side view) of 5° below the horizontal, and is parallel to the vertical plane through the vehicle's longitudinal centerline;

(b) Its lateral axis is at a lateral outboard angle, in the front view projection, of 25° below the horizontal;

(c) Its lower surface is tangent to the surface of the vehicle; and

(d) The initial contact point, or center of the initial contact area, is on the longitudinal centerline of the lower surface of the test device and 254 millimeters from the forwardmost point of that centerline.

S8.3 Apply force in a downward direction perpendicular to the lower surface of the test device at a rate of not more than 13 millimeters per second until reaching a force in Newtons of 1½ times the unloaded vehicle weight of the tested vehicle, measured in kilograms and multiplied by 9.8. Complete the test within 120 seconds. Guide the test device so that throughout the test it moves, without rotation, in a straight line with its lower surface oriented as specified in S8.2(a) through S8.2(d).

S8.4 Measure the distance that the test device moves, *i.e.*, the distance between the original location of the lower surface of the test device and its location as the force level specified in S8.3 is reached.

FIGURE 1 TO § 571.216

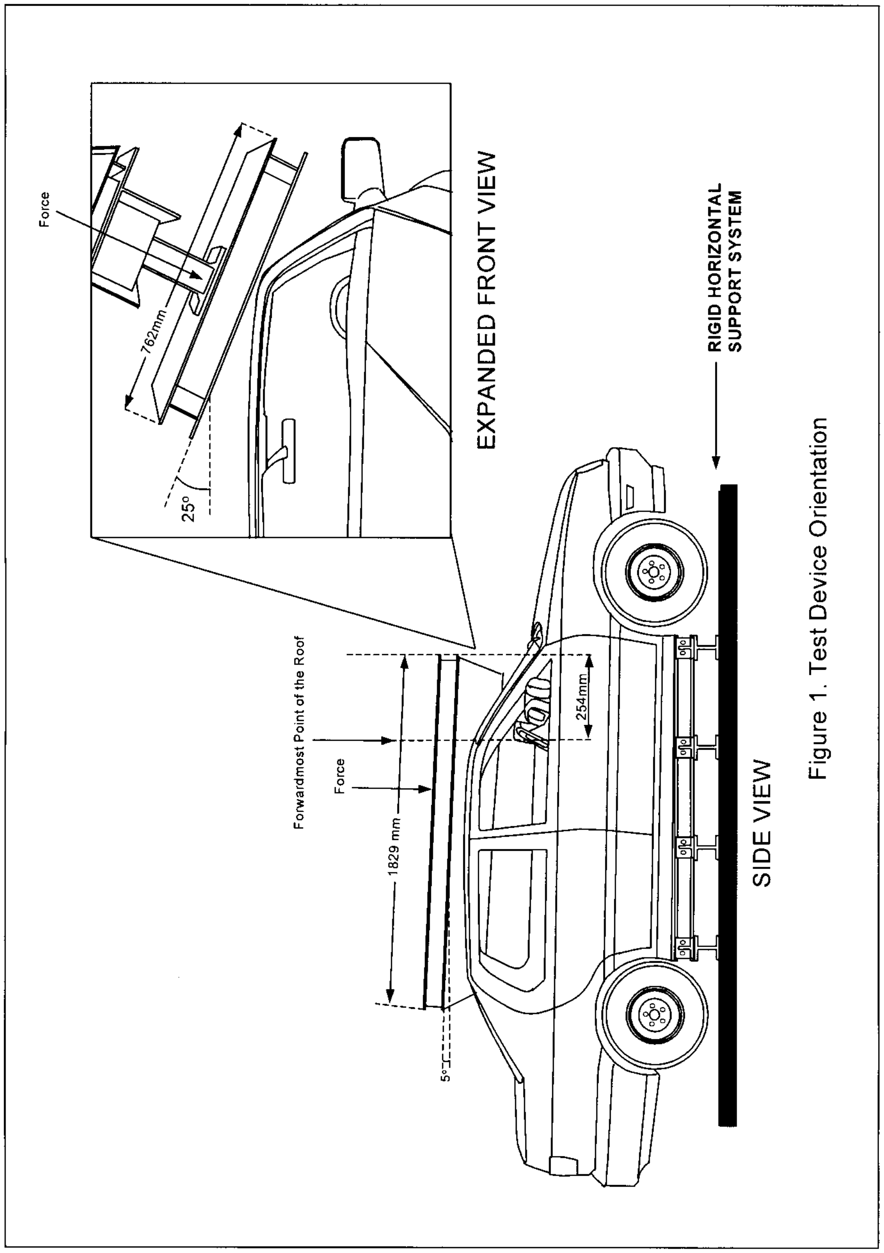


FIGURE 2 TO §571.216

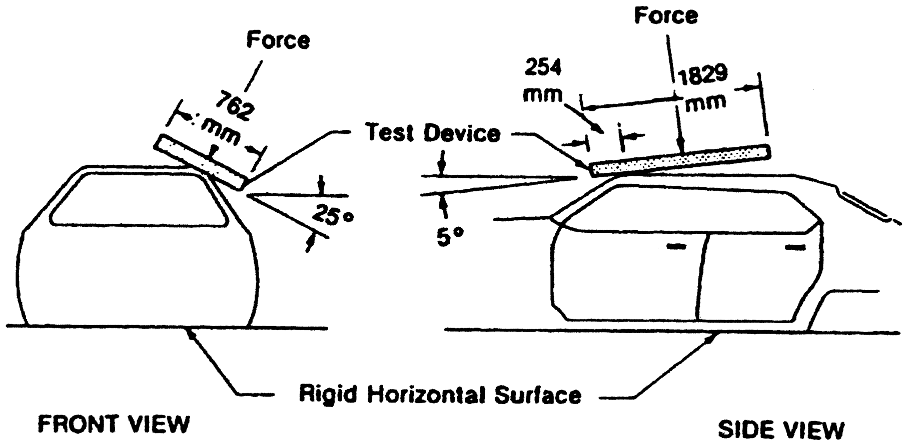


Figure 2.- Test Device Location And Application To The Roof

[36 FR 23300, Dec. 8, 1971, as amended at 38 FR 21930, Aug. 14, 1973; 56 FR 15517, Apr. 17, 1991; 58 FR 5633, Jan. 22, 1993; 60 FR 13647, Mar. 14, 1995; 64 FR 22578, Apr. 27, 1999; 65 FR 4581, Jan. 31, 2000]

§ 571.217 Standard No. 217; Bus emergency exits and window retention and release.

S1. *Scope.* This standard establishes requirements for the retention of windows other than windshields in buses, and establishes operating forces, opening dimensions, and markings for bus emergency exits.

S2. *Purpose.* The purpose of this standard is to minimize the likelihood of occupants being thrown from the bus and to provide a means of readily accessible emergency egress.

S3. *Application.* This standard applies to buses, except buses manufactured for the purpose of transporting persons under physical restraint.

S4. *Definitions. Adjacent seat* means a designated seating position located so that some portion of its occupant space is not more than 10 inches from an emergency exit, for a distance of at least 15 inches measured horizontally and parallel to the exit.

Daylight opening means the maximum unobstructed opening of an emergency exit when viewed from a direction perpendicular to the plane of the opening.

Mid-point of the passenger compartment means any point on a vertical transverse plane bisecting the vehicle longitudinal centerline that extends between the two vertical transverse planes which define the foremost and rearmost limits of the passenger compartment.

Occupant space means the space directly above the seat and footwell, bounded vertically by the ceiling and horizontally by the normally positioned seat back and the nearest obstruction of occupant motion in the direction the seat faces.

Passenger compartment means space within the school bus interior that is between a vertical transverse plane located 76 centimeters in front of the forwardmost passenger seating reference point and a vertical transverse plane tangent to the rear interior wall of the bus at the vehicle centerline.

Post and roof bow panel space means the area between two adjacent post and roof bows.

Push-out window means a vehicle window designed to open outward to provide for emergency egress.