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Highway Accident Report: Collision of Levy County, Florida School Bus and Airdrome Tire Centers, Inc. Truck near Bronson, Florida, August 28, 1987

(U.S.) National Transportation Safety Board, Washington, DC

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16. Abstract

On August 28, 1987, a 1982 school bus carrying 21 passengers was traveling westbound on Levy County (Florida) Road C-32 when it collided with a two-axle flatbed truck traveling northbound on Levy County Road C-337 near Bronson, Florida. The school bus driver and 5 passengers died; the truckdriver sustained critical injuries and 16 school bus passengers were injured.

The safety issues discussed in the report include: the crashworthiness of the Thomas Built school bus body, particularly the floor, and deficiencies of the Federal Motor Vehicle Safety Standard applicable to the floor joints of large school buses.

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EXECUTIVE SUMMARY

On August 28, 1987, a 1982 school bus carrying 21 passengers was traveling westbound on Levy County (Florida) Road C-32 when it collided with a two-axle flatbed truck traveling northbound on Levy County Road C-337 near Bronson, Florida. The school bus driver and 5 passengers died; the truckdriver sustained critical injuries and 16 school bus passengers were injured.

The National Transportation Safety Board determines that the probable cause of this accident was the truckdriver's failure, for undetermined reasons, to stop his vehicle at the stop sign. Contributing to the severity of this accident was the loss of structural integrity of the school bus due to the collapse of the school bus floor.

The safety issues discussed in the report include:

- the crashworthiness of the Thomas Built school bus body, particularly the floor; and
- deficiencies of the Federal motor vehicle safety standard (FMVSS) applicable to the floor joints of large school buses.

As a result of its investigation, the Safety Board classified three safety recommendations to the National Highway Traffic Safety Administration as "Closed--Superseded" and issued a new safety recommendation regarding FMVSS 221. The Safety Board also issued a safety recommendation to Florida concerning the assignment of points to driving violation conviction records of Florida-licensed drivers.

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D. C. 20594

HIGHWAY ACCIDENT REPORT

COLLISION OF LEVY COUNTY, FLORIDA SCHOOL BUS AND AIRDROME TIRE CENTERS, INC., TRUCK, NEAR BRONSON, FLORIDA AUGUST 28, 1987

INVESTIGATION

The Accident

At 2:50 p.m. on August 28, 1987, a 1982 school bus owned and operated by the School Board of Levy County (Florida), transporting 2 adult aides and 19 special education students ages 4 to 18, was traveling westbound on Levy County Road (CR) 32 when it collided with an Airdrome Tire Centers, Inc., two-axle flatbed truck. The truck was traveling northbound on Levy CR 337 and had failed to stop for a stop sign at the intersection of the two county roads. The weather was clear and the pavement was dry.

After the right-angle collision, the truck rotated about 130° counterclockwise, rolled over 90° to the right, and came to rest northwest of the intersection with its rear bumper positioned above and between the longitudinal frame members of the school bus chassis. The school bus rotated clockwise and came to rest upright northwest of the intersection. (See figures 1 and 2.) At its final rest position, the right rear of the school bus body was partially off the chassis and had shifted forward about 10 1/2 feet. (See figure 3.) The front of the school bus body came to rest against an embankment northwest of the intersection with the front portion of the roof collapsed about 12 feet forward and down over the engine compartment. (See figure 4.) A small fire that had started in the school bus engine compartment after the collision was extinguished by rescuers.

The truckdriver, who was pinned in the wreckage of his vehicle, sustained critical injuries. The school bus driver and five school bus passengers were fatally injured, and the remaining 16 passengers sustained minor to critical injuries. One of the adult aides who sustained moderate (AIS-2) injuries was about 25 weeks pregnant. After the accident, it was determined that the fetus was dead and it was surgically removed on August 30, 1987.

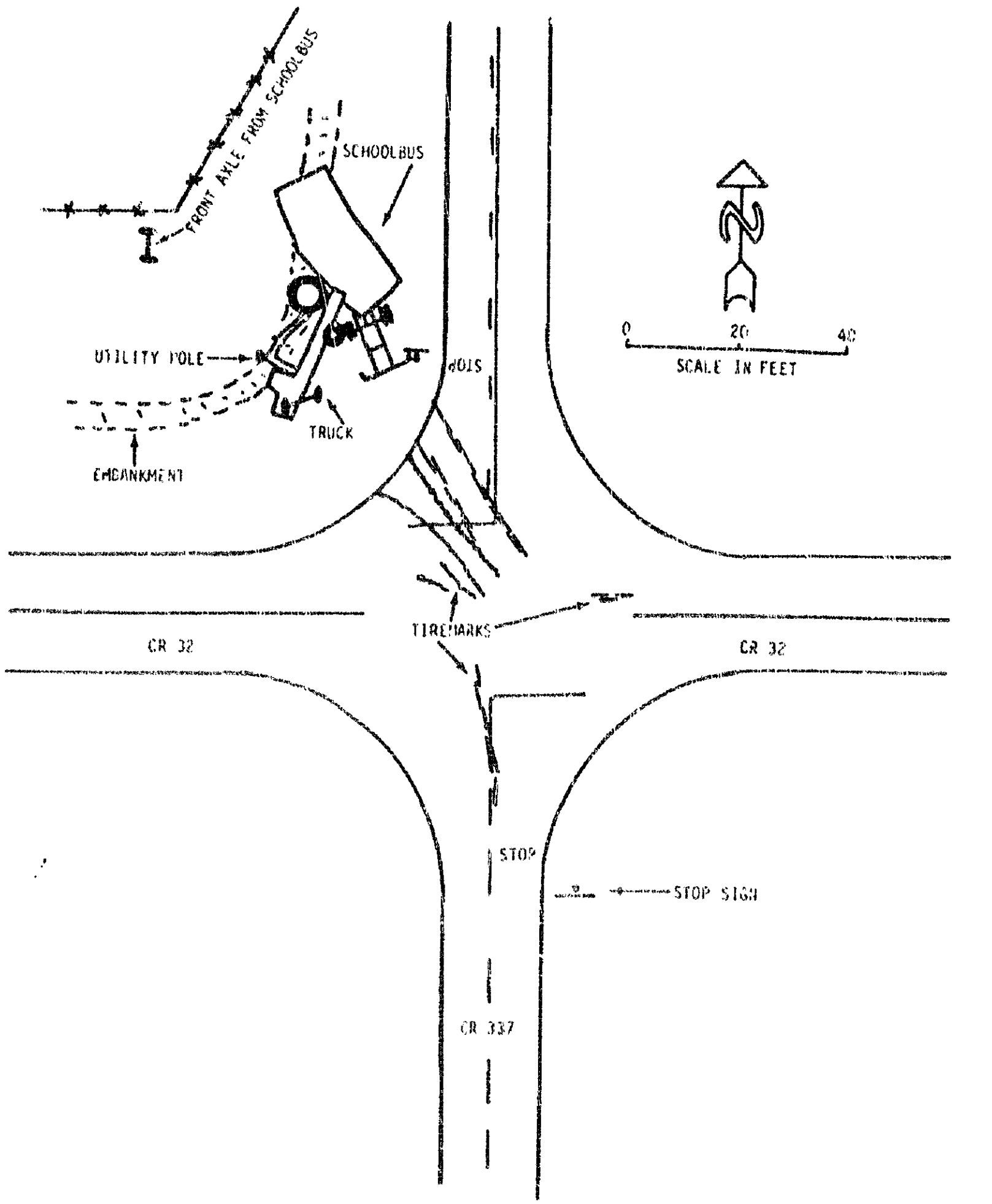


Figure 1.--Plan view of the accident site

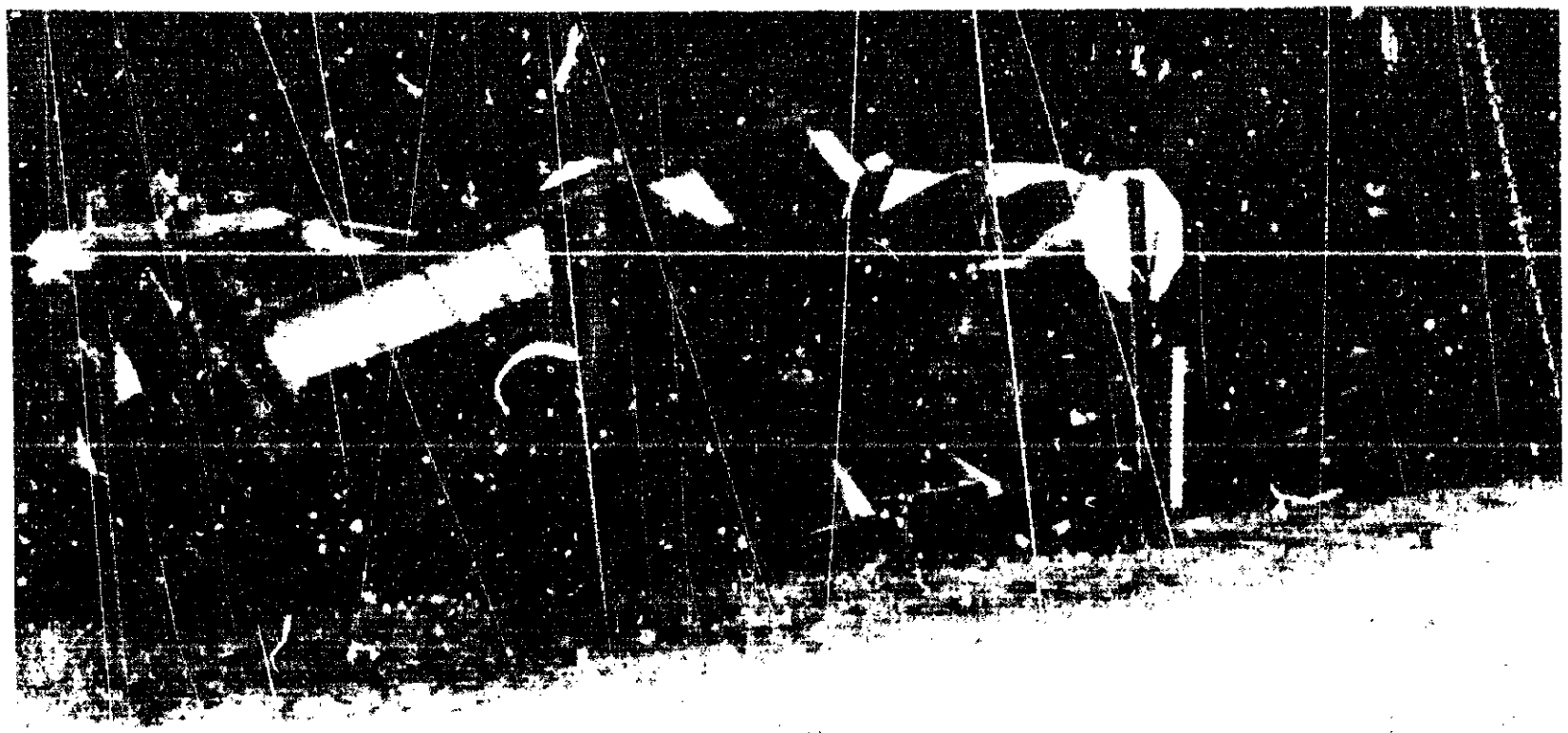


Figure 2.--Final rest positions of the school bus and the truck

Injuries

International Civil Aviation Organization Injury Criteria

	Driver	Passengers	Other	Total
Fatal	1	5	0	6
Serious	1	13	0	14
Minor	0	3	0	3
None	0	0	0	0
Total	2	21	0	23

Figure 3.--The school bus body shifted forward and off its chassis.

Abbreviated Injury Scale (AIS*)

Injuries	Drivers	Passengers	Other	Total
AIS 1 Minor	0	3	0	3
AIS-2 Moderate	0	9 (1)	0	9
AIS-3 Serious	0	3	0	3
AIS-4 Severe	0	4 (3)	0	4
AIS-5 Critical	1	1	0	2
AIS-6 Unsurvivable	1 (1)	1 (1)	0	2
AIS-9 Unknown	0	0	0	0
Total	2	21	0	23

*AIS refers to the abbreviated injury scale of the American Association for Automotive Medicine. It is a standardized system of assessing the severity of injuries. Injuries in this accident have been coded according to the revised 1985 abbreviated injury scale. The numbers in parentheses indicate the number of persons in each injury category who died.

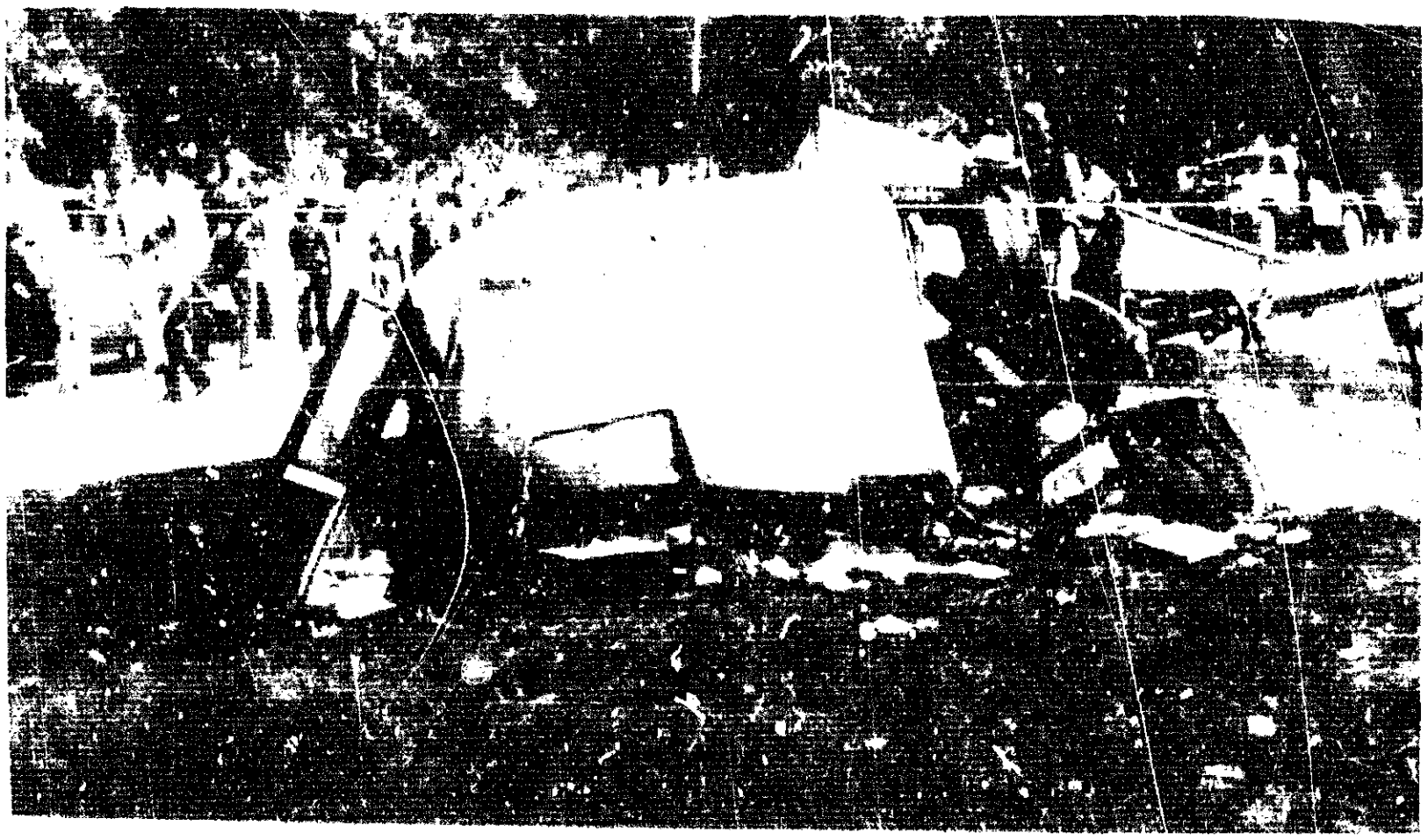


Figure 4.--The front of the school bus came to rest against an embankment.

Emergency Response

Before the accident, an employee of the town of Bronson was in his vehicle waiting for traffic to clear to enter westbound CR 32 when the school bus went past him. After traffic cleared, he proceeded west on CR 32. He did not witness the collision, but he did see a cloud of dust as he approached the intersection. When he arrived at the accident site, he parked his vehicle in the center of the intersection and told a passerby to call the Levy County sheriff's office.

As he ran toward the school bus, he saw smoke coming from the front near the dashboard. He retrieved a fire extinguisher from his vehicle and entered the school bus through an opening in the left side. He reported that to get to the front of the school bus he had to climb over some seats that had been displaced into the aisle. Although he could see no flames, he used his fire extinguisher to put down the smoke.

While he was in the front of the bus, he noticed the school bus driver slumped across the steering wheel and an unconscious student aide in the right front of the bus. He also saw several students pinned between some of the forward seats on the left side of the school bus. Leaving the school bus, he went to his own vehicle and got a sledge hammer and a pry bar. He gave the tools to another person at the scene to try to extricate the bus passengers. When he returned to the school bus, rescuers inside handed out

the bodies of two apparently dead male children. He placed the bodies on top of the embankment northeast of the school bus.

At 2:56 p.m., the Levy County Department of Emergency Medical Services received a call from the Levy County sheriff's office requesting that an ambulance respond to the accident site. A Levy County ambulance with two paramedics on board, which had been en route from Chiefland to Bronson for routine vehicle maintenance, was rerouted by radio to the accident site at 2:56 p.m. and arrived about 3 p.m.

The Levy County paramedics reported that when they arrived at the accident site, one sheriff's deputy and less than a dozen passersby were on scene and had already removed most of the surviving school bus passengers who were not pinned in the wreckage. These passengers had been taken east across CR 337 and placed on the ground next to a ditch.

One paramedic entered the school bus through an opening in its left front side adjacent to the driver's position. He observed that the busdriver was apparently dead and that the student aide on the right side of the school bus was conscious and sitting up.

The other Levy County paramedic assessed the injuries to the passengers who had been removed from the school bus. Climbing the embankment in front of the school bus, she observed two or three bodies which had been placed there. She warned her partner, who was still in the school bus, that the school bus was on fire.

The paramedic inside the bus noted that there was smoke and a small amount of flames in the engine area, and he instructed a rescuer to get a fire extinguisher which was used to put out the fire. The paramedic then exited the school bus and called for additional emergency response personnel on the ambulance radio.

Meanwhile, the other paramedic provided rescuers with a Hurst "Jaws of Life" tool to extricate the truckdriver from the wreckage. This paramedic then entered the school bus through an opening in the right sidewall near the front entrance door and stepwell. When she entered the school bus about 10 minutes after the collision, nine occupants were still inside. The school bus driver, one adult aide, and one student were not pinned in the wreckage; six students were pinned between the first several rows of seats at the front of the school bus.

At 3:08 p.m., Shands Hospital and Alachua General Hospital dispatched helicopters to the accident site. Baptist Medical Center and University Hospital near Jacksonville, Florida, about 25 miles from the accident site, placed helicopters on standby.

At 3:20 p.m., Levy County Emergency Services requested aid from Alachua County which dispatched two ambulances, a rapid response unit, and a district fire chief. At 3:27 p.m., the Levy County sheriff requested three additional helicopters. The helicopters at Baptist Medical Center and University Hospital launched immediately.

At 3:40 p.m., Alachua County paramedics arrived on scene, assumed command of the emergency response, and reported to the hospitals in the area that they had at least 25 injured persons which caused Shands Hospital to activate its Phase-I Disaster Plan. At 3:44 p.m., Orlando Regional Medical Center placed its "Air Care" helicopter on standby.

Alachua County paramedics reported that the six passengers who were pinned in the left front of the school bus were pinned between several of the first three or four seat rows which had collapsed. A paramedic reported that an 11-year-old male was pinned by metal which had rolled up and trapped the passenger; the paramedic thought the metal was the floor. Triage indicated that this passenger needed immediate extrication because he was having difficulty breathing. However, paramedics reported that moving the seats or the metal either forward or aft would cause additional injury to passengers pinned in front or behind.

To extricate the passengers who were pinned, paramedics used a Hurst tool to remove part of the left sidewall near the driver's position. The paramedics then removed the pinned passengers beginning at the front and moving sequentially to the rear by cutting seat legs and spreading the metal apart. A tow truck operator reported that in some cases the paramedics used a winch on a tow truck to move the seats 2 or 3 inches.

Emergency response personnel and civilian rescuers also removed windows and window support posts at the left and right sides of the school bus at the front to help evacuate the school bus occupants. This extrication process took about 2 hours. The 11-year-old male and a 4-year-old male located in front of him died before they could be extricated.

At 4:18 p.m., the Orlando Regional Medical Center was notified that its helicopter was no longer needed. By 5:19 p.m., all the survivors had been transported to hospitals. The Shands Hospital disaster plan was ended at 5:27 p.m.

Vehicle Information and Damage

School Bus.--The school bus was manufactured in 1982 with a Ford Motor Company chassis and a body constructed by Thomas Built Buses, Inc. The two-axle school bus was equipped with a gasoline engine, a four-speed automatic transmission, and air-mechanical service brakes. It weighed an estimated 16,025 pounds at the time of the accident.

Although the school bus was not required by Federal motor vehicle safety standards to be equipped with passenger lapbelts, the first bench seat on the left side behind the driver's position was equipped with two lapbelts. The school bus driver's seat was equipped with a lapbelt. The remaining bench seats were not equipped with lapbelts.

The passenger compartment was equipped with padded restraining barriers in front of the first row of passenger seats on each side of the center aisle. The school bus was configured to transport a maximum of 39 passengers

in 13 conventional bench seats (6 seats on the left side and 7 seats on the right side) and 3 passengers in wheelchairs for which restraints had been installed along the sidewall in the left rear. The passenger bench seats were attached on their outboard sides by a bracket bolted to the sidewall. The inboard sides of the passenger seats were equipped with two legs that were bolted to the floor.

In addition to the front entrance/exit door on the right side and the emergency exit door at the rear, the school bus was equipped with a wheelchair lift and door on the right sidewall at the rear. No passengers were occupying wheelchairs at the time of the accident. A postcrash mechanical inspection of the school bus disclosed no defects that may have caused the accident.

The postaccident examination revealed that the entrance vestibule and the driver's station were crushed and the roof over the driver's station was collapsed forward over the engine compartment. The driver's lapbelt was found retracted inside its reel and the belt functioned without difficulty. No defects or load marks were found on the belt webbing. The two lapbelts for the first seat behind the driver's station were found hanging through openings in the floor below the left side of the school bus.

Also, evidence of passenger contact and blood stains were found on the ceiling forward of the boarding door. No impact damage was found on the right side of the school bus body aft of the front boarding door. The rear emergency door was jammed closed and could not be opened from the inside.

The first seat on the left side separated from its floor attachment and protruded about 5 feet from the left sidewall next to the driver's position. The first seat on the right side and the second seat on the left side had been removed by emergency response personnel. The second seat on the right side, which had separated from its attachment to the right sidewall but had remained attached to the floor, was displaced aft and to the left so that it was resting on the seat cushion of the third seat on the left side.

The third seat on the right side, which remained attached to the right sidewall, separated from its floor attachment. The seat cushion for this seat was missing, and the floor panels under this seat were displaced to the left so that the ground could be seen under this seat.

Twenty-nine floor panels formed the school bus floor aft of the driver's position. The floor panels, which varied from 8 5/8 inches to 9 7/8 inches wide, were fastened to adjacent floor panels by 12 spot welds along the vertical rise of the flange about 6 5/8 inches apart, by fillet welds at the bottom flanges, and by fillet welds joining the floor panels to the floor capping on the top and bottom of the floor.

Before the accident, the distance from the extreme front of the school bus to the floor joint between the 9th and the 10th floor panels was about 14 1/2 feet. After the accident, this distance had been compressed to about 6 1/4 feet. The first nine floor panels had separated from both the left and

right sidewalls. The first seven floor panels were displaced to the left about 4 feet. (See figure 5.)

The first floor panel with the restraining barriers still attached had almost inverted. The left restraining barrier had collapsed forward against the backrest of the driver's seat, and the right barrier had inverted and crushed forward into the stepwell area.

The second floor panel had separated from the first floor panel and the third floor panel, except for about 12 inches on the left. The right ends of the second and third floor panels protruded into the interior of the school bus to about 2 1/2 feet from the interior roof liner. (See figure 6.) The left ends of the fourth, fifth, sixth, and seventh floor panels were compressed and extended under the left sidewall. The right ends of the fifth and sixth floor panels protruded through the seat cushion frame of the second bench seat on the right side. (See figure 7.)

The 8th and 9th floor panels were folded aft between the 10th and 11th floor panels and the chassis. The floor panels aft of the 10th panel sustained no remarkable damage.

When the school bus body was built, the manufacturer bolted 18 body mounting clips (9 on each side of the school bus body) at the junction of the lower flanges of 18 of the floor panels. The body mounting clips, which helped attach the school bus body to the chassis, left marks on the underside of the upper flanges on the longitudinal frame members where they were mounted before the accident.

A postaccident examination of the first eight clips on the left side of the school bus revealed no damage. (See figure 8.) The rearmost clip on the left side was bent down and away from the lower floor panel flanges on both sides of the mounting bolts. No other marks were found on the inside vertical face of the left longitudinal frame member adjacent to the mounting clip marks.

The eight body mounting clips on the right side of the school bus body were attached to the same floor panels as those on the left side with the exception that there was no body mounting clip mounted on the lower flanges of the 12th and 13th floor panels on the right side. Although the Safety Board did observe some physical evidence that the clip was installed at one time, it could not determined if this clip was removed before, during, or after the accident.

The lip portions of these clips were bent down at a 90° angle. (See figure 9.) In addition to the marks left where they were mounted, scratches about 8 inches long were found on the inside vertical face of the right longitudinal frame member going aft from where the seventh and eighth clips were mounted originally.

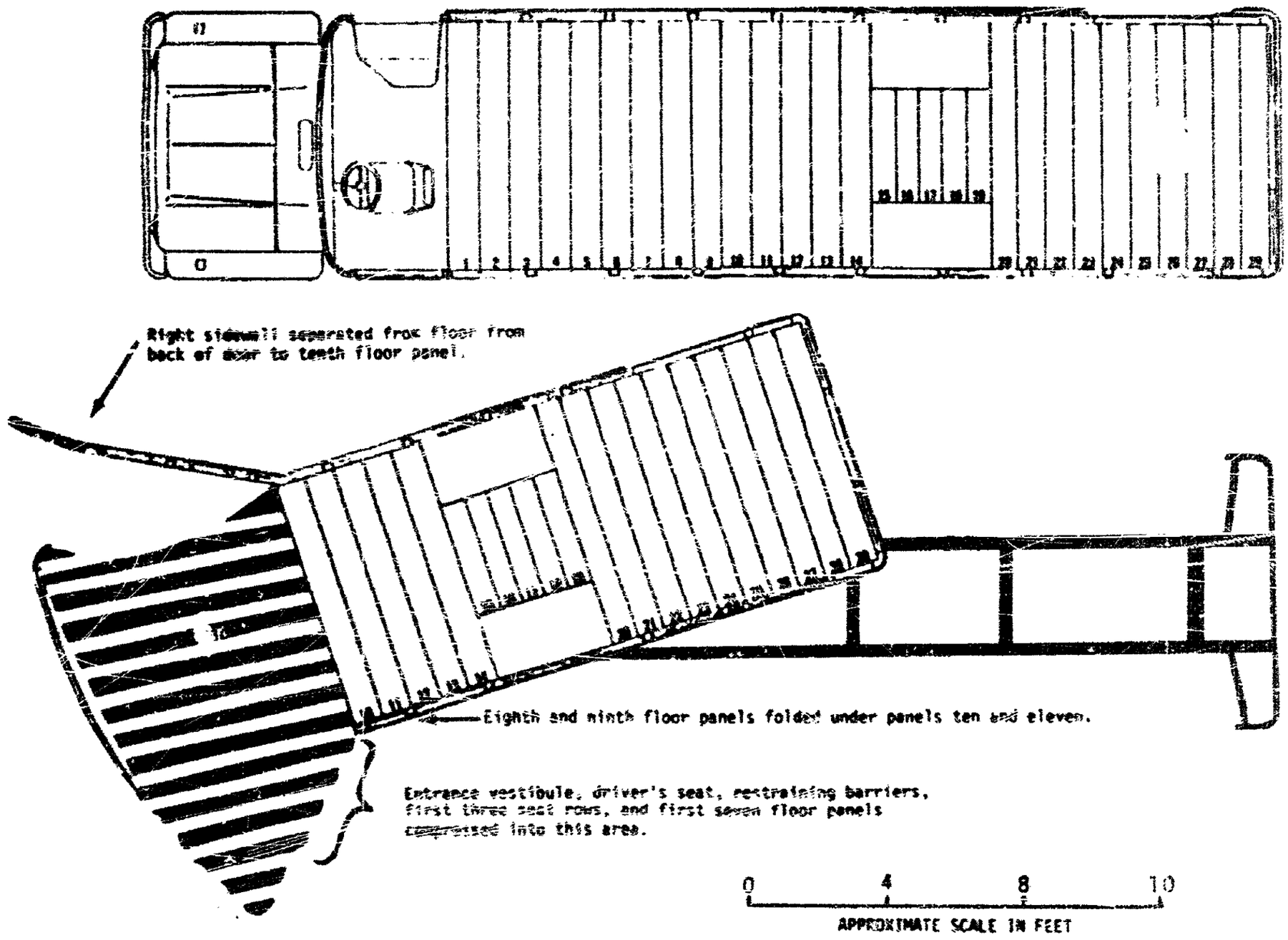


Figure 5.--Preaccident and postaccident configuration of the school bus at floor level

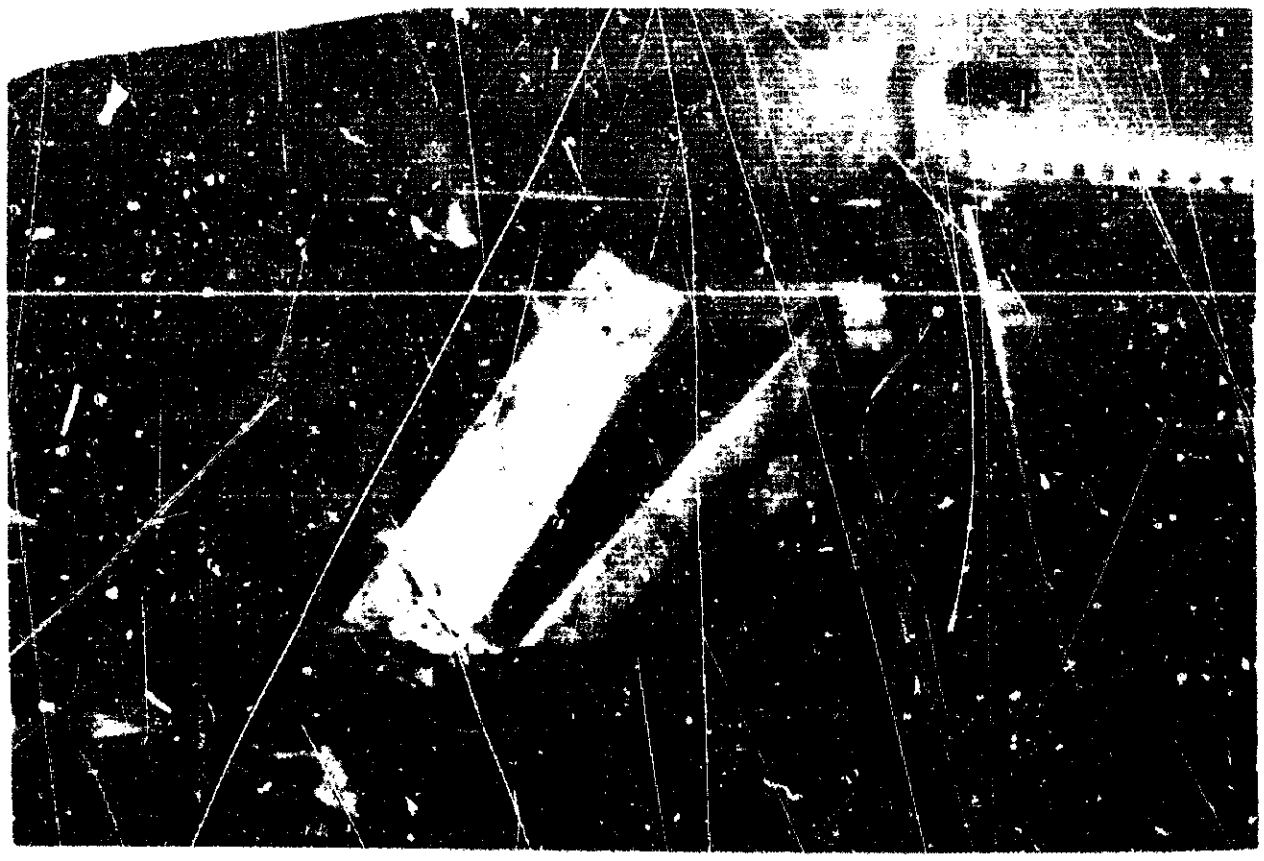


Figure 6.--Right ends of the second and third floor panels protruding into the passenger compartment of the school bus

Figure 7.--Right ends of the fifth and sixth floor panels protruding up through seat cushion frame in the school bus

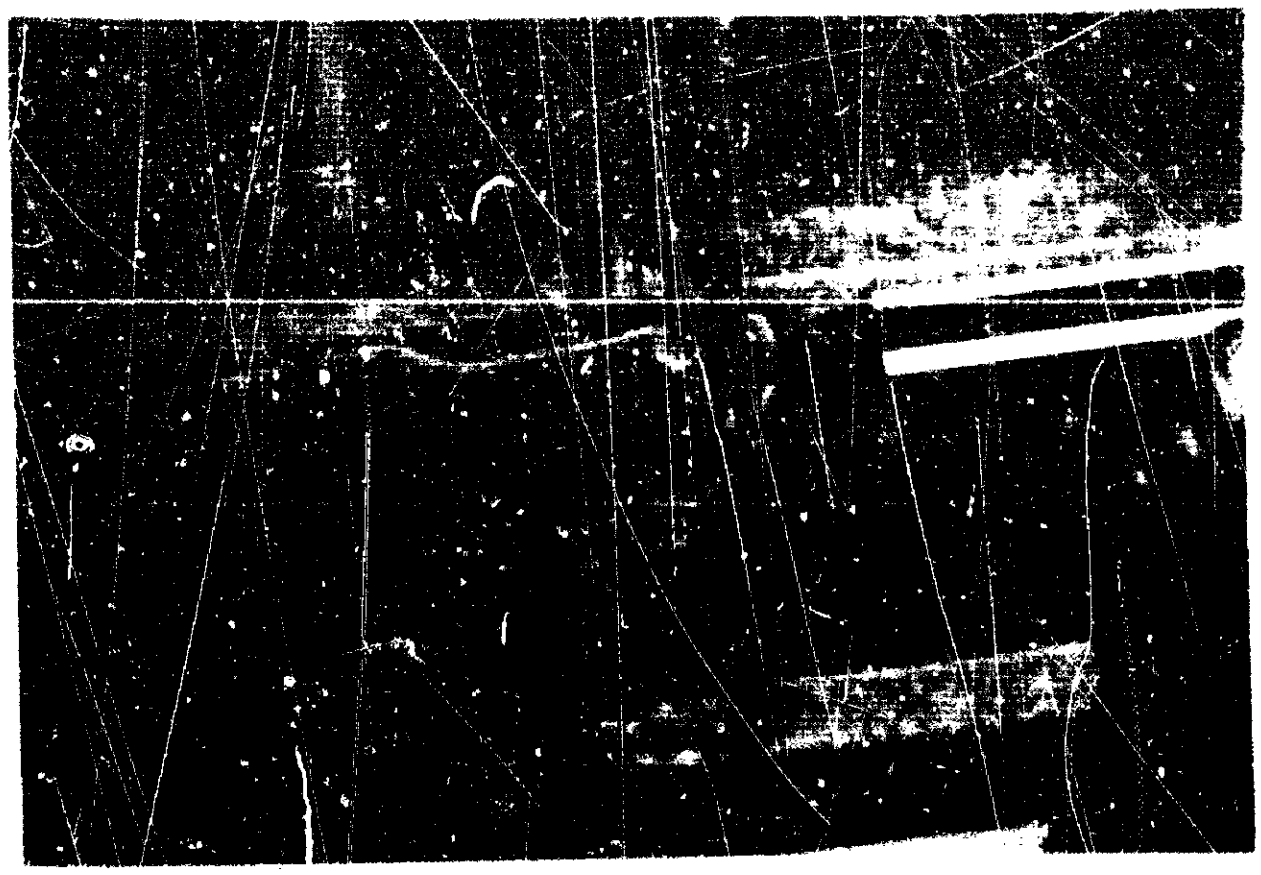


Figure 8.--An undamaged body mounting clip from the left side of the school bus

Figure 9.--A damaged body mounting clip from the right side of the school bus

The top flange of the right longitudinal frame member was bent upward at eight points along its length. Although 8-inch marks were found on the inside vertical flange of the right frame member aft of where mounting clips joined floor panels 23 and 24 and 27 and 28, the upper flange adjacent to where these clips were mounted before the accident was not bent upward when these clips separated. (See figure 10.)

Truck.--The two-axle truck chassis and conventional cab was manufactured in 1985 by the Ford Motor Company and was equipped with an aftermarket special aluminum flat bed with a hydraulic boom and claw for handling heavy equipment tires. The truck was equipped with a diesel engine, a five-speed manual transmission with a 5.43:1 rear axle ratio in fifth gear, air-mechanical service brakes, and power steering.

At the time of the accident, the truck was en route to deliver a heavy equipment tire to Newberry, Florida. The tire, which weighed 2,892 pounds, was loaded on the cargo bed behind the hydraulic boom and the boom claw was lowered into the center of the tire to secure it from falling off the bed. (See figure 11.) Imprints above the opening in the left rear sidewall of the school bus matched the general configuration of the boom from the truck. At the time of the accident, the gross weight of the truck was estimated to be 25,750 pounds.

As a result of the accident, the cab, engine, transmission, and front axle were torn off the chassis. (See figure 12.) The transmission was found to be in fifth gear.

The truck chassis was deformed to the left 28 inches at the front bumper. The right end of the front bumper was pushed rearward against the frame rail. The right fender portion of the one-piece fiberglass hood was missing.

The rear of the truck did not receive any impact damage; the boom did not receive any visual damage. The truck was equipped with 11.00 X 20 tires. The jammed tachometer indicated 1,900 rpm. A postaccident examination of the truck disclosed no defects that may have caused or contributed to the accident.

Florida Driver Licensing Information

Both drivers involved in this accident held valid Florida chauffeur's licenses at the time of the accident. The Florida Division of Driver's Licenses requires a chauffeur's license for persons driving any vehicle with a gross weight of more than 8,000 pounds, any vehicle more than 80 inches wide, any vehicle transporting passengers for hire, and any school bus. Applicants for a regular chauffeur's license must be at least 18 years old and must pass a vision test.

Applicants who are at least 16 years old may be granted a restricted chauffeur's license authorizing the operation of a single-unit vehicle with a 1 1/2-ton capacity provided the applicant has held a restricted or regular

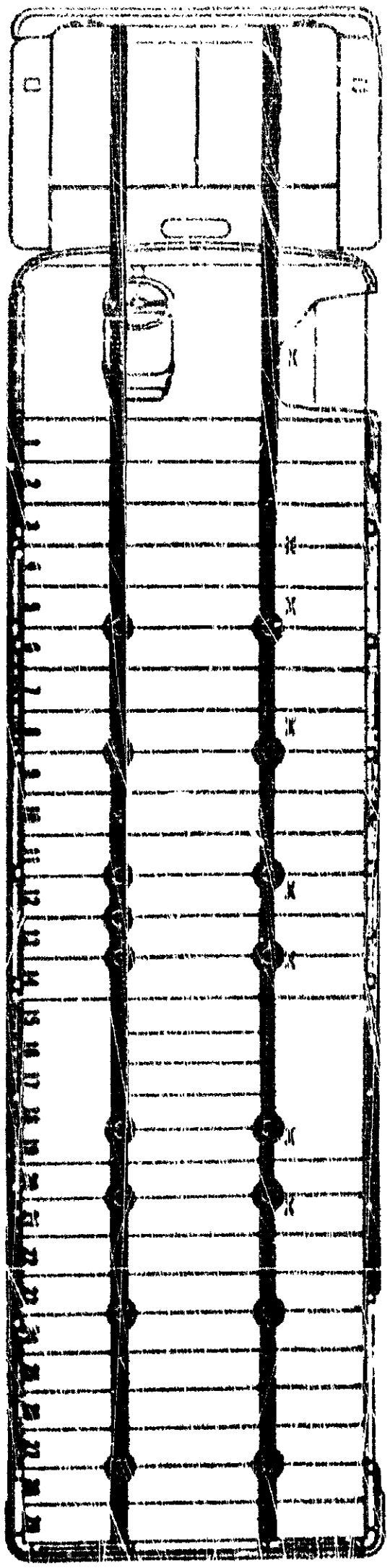


Figure 10.--Preaccident location of body mounting clips and postaccident locations where upper flange of the right frame member was bent upward.

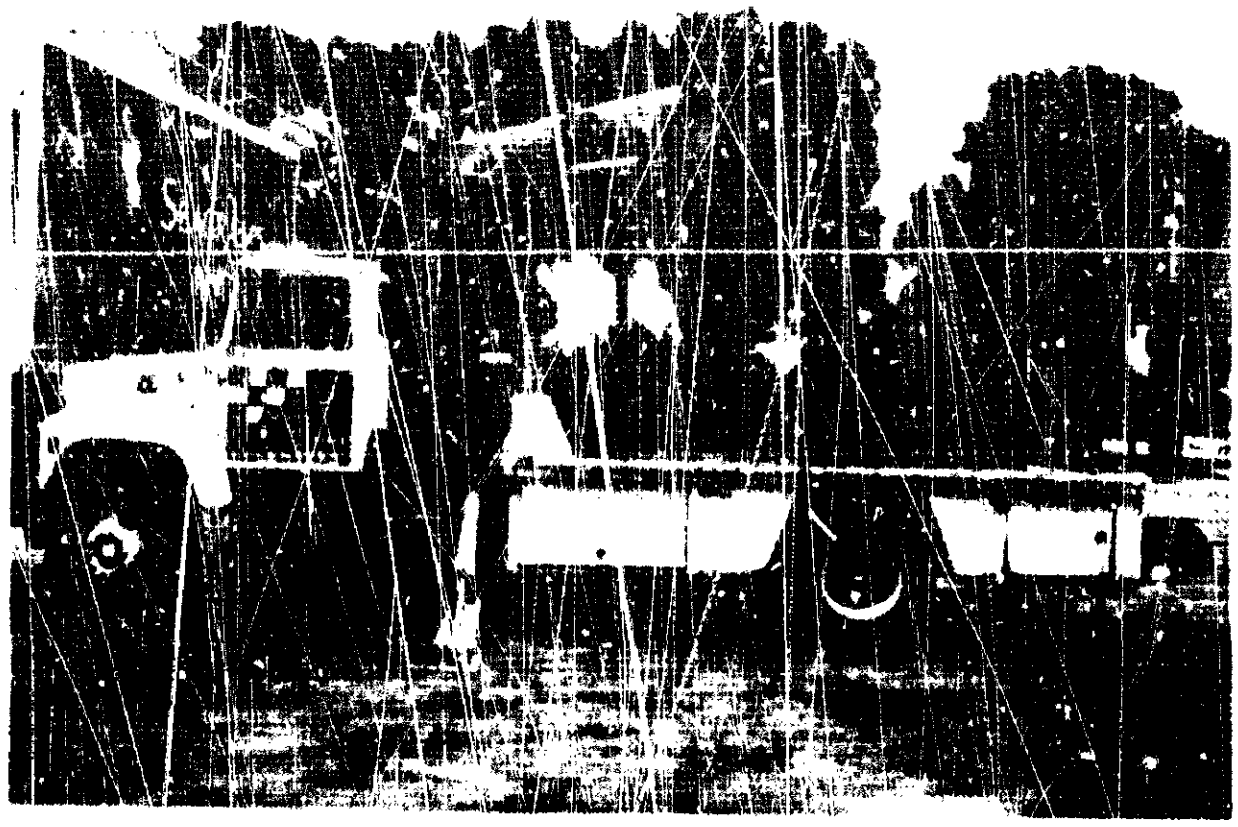


Figure 11.--Truck similar to accident truck loaded with a similar tire

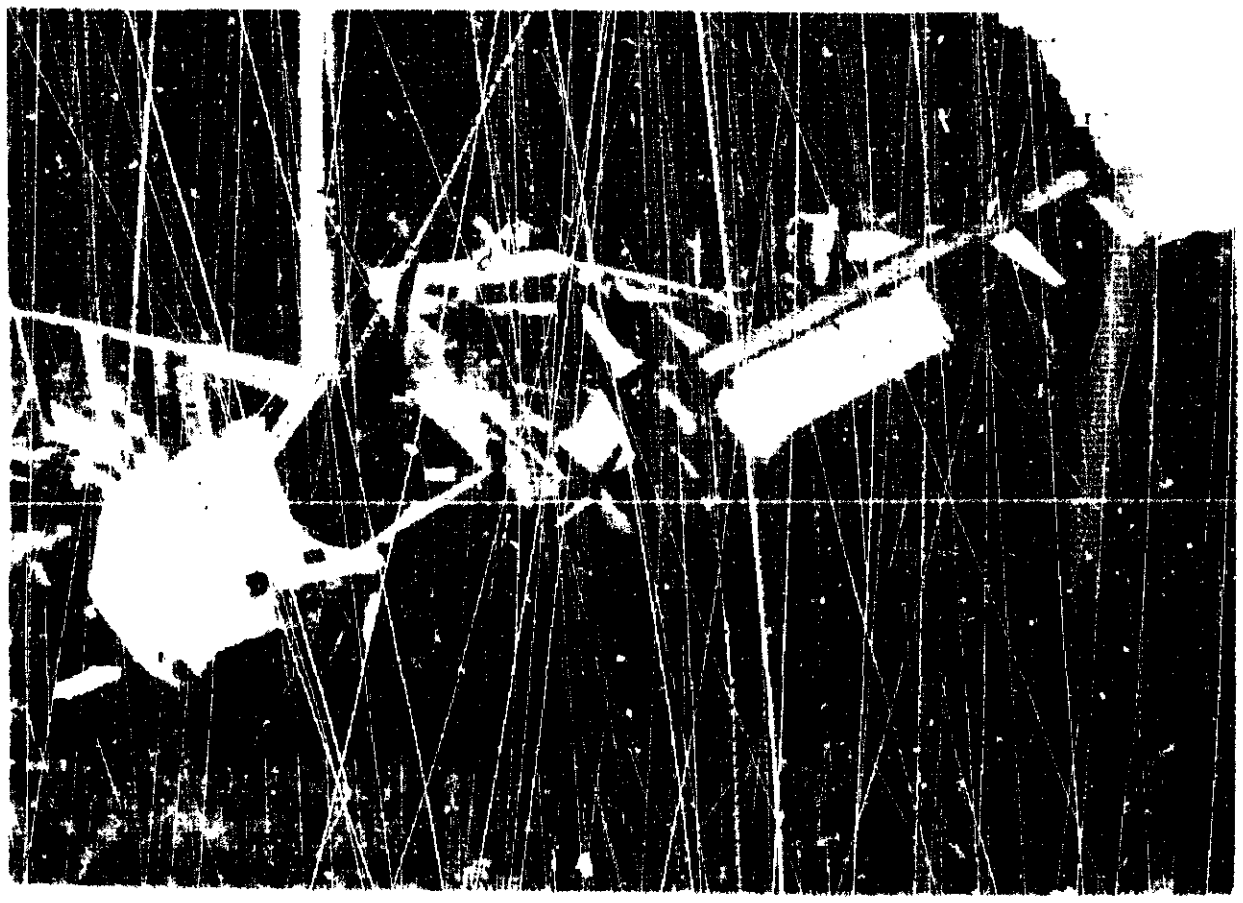


Figure 12.--Accident tire truck at the accident site

operators's license for 90 days; has the signature of at least one parent and an employer on the consent form; and has passed the vision, road sign, road rules, and driving tests. If during testing, it is noticed that an applicant is hard of hearing, a hearing aid restriction may be prescribed.

In addition, applicants must take a special knowledge test for the operation of larger vehicles. Florida currently does not require that an applicant for a chauffeur's license pass a road test in the type of vehicle or school bus which the applicant intends to operate.

Florida uses a "point" system to determine when and for how long a driver's license should be suspended:

Table 1.--Florida's point system

Violation	Points
Leaving the scene of an accident resulting in property damage of more than $50	6
Unlawful speed resulting in an accident	6
Reckless driving	4
Any moving violation resulting in an accident	4
Passing a stopped school bus	4
Unlawful speed--16 mph or more over lawful or posted speed	4
Unlawful speed--15 mph or less over lawful or posted speed	3
All other moving violations (including parking on highway outside municipalities)	3
Improper equipment--brakes, lights, steering	2

In Florida, operators' licenses are suspended for 30 days if 12 points are accumulated within a 12-month period. Licenses are suspended for 3 months if a total of 18 points are accumulated within an 18-month period and for 1 year if a total of 24 points are accumulated within a 36-month period. The total points for the first suspension will be reduced by three points after the driver has attended an appropriate driver improvement school and has the license returned.

In accordance with Section 322.27 of the Florida statutes, a driver receives 1/2 the number of points listed if the conviction occurs out-of-state or in a Federal court. A representative for the Division of Driver Licenses of the Florida Department of Highway Safety and Motor Vehicles reported that this provisions of the Florida statutes was lobbied by the trucking industry when the Florida point system was adopted because of the large number of miles Florida-licensed commercial drivers operated in other States and because of the existence of "speed traps" in an adjoining State.

In Florida, a conviction of a more serious vehicle-related crime, such as driving while drunk or under the influence of narcotic drugs, a felony in which a motor vehicle is used, or three convictions of reckless driving in 1 year, will result in the revocation of a drivers or chauffeur's license. In some cases, a revoked license may be reinstated after a period of time and

may contain restrictions, such as limiting a restored driver's driving privilege to driving only to and from his place of employment.

Driver Information

School Bus Driver.--The 59-year-old driver had been employed as a school bus driver by the School Board of Levy County for 12 years. Her last physical examination performed on June 6, 1987, indicated that she was qualified physically to operate a school bus. She possessed a valid Florida chauffeur's license restricted to corrective lenses; she had no moving violations on her Florida driving record. During her employment, she had received 88 hours of in-service training on such subjects as first aid, critical situations, accident procedures, bus handling, pretrip inspections, and paperwork requirements.

Truckdriver.--The 26-year-old truckdriver had been employed by Airdrome Tire Centers, Inc. since August 1986. From April to August 1986, he had been employed by another tire company, and before that, he had been employed previously by Airdrome for 2 years. In the year between his re-employment by Airdrome and this accident, he had received two pay raises from his employer. He reported that he had been driving trucks since he was 16 years old.

He possessed a valid Florida chauffeur's license with no restrictions. His privilege to drive a motor vehicle in Florida had been suspended for 30 days in August 1981 for accumulating excessive driving violation points. From October 1980 to August 1986, the truckdriver had been convicted of the following traffic violations:

Offense Date	Violation	Points Assessed	Commercial or Private Vehicle
10/9/80	speeding (67/55)	3	unknown
11/29/80	reckless driving	4*	unknown
2/28/81	careless or improper driving	4*	unknown
6/13/81	careless or improper driving	3	unknown
3/8/82	failure to wear helmet	0*	private
3/8/82	registration violation	0*	private
3/8/82	careless or improper driving	4*	private
1/28/83	speeding (65/55)	3	commercial
6/12/84	speeding (51/30)	4	private
6/19/84	improper tag	0	private
8/5/86	speeding (60/45)	3	commercial

* Involved in an accident

In addition to these convictions, the truckdriver was charged with speeding 70 mph in a 55-mph zone on December 31, 1985. This alleged violation was not adjudicated because the truckdriver attended a driver improvement school under a forgiveness program for reduction of points. None of the more recent violations caused the truckdriver to accumulate sufficient

driving violation points to result in another suspension of his driving privileges. All of the above violations occurred in Florida.

The truckdriver reported that his workday usually began about 6 a.m. and ended about 6 or 7 p.m. each week day, and that he occasionally worked on Saturdays. He reported that the evening before the accident he arrived home between 5:30 and 6 p.m. and relaxed before he started mowing his lawn. He had a beer, ate dinner, and watched television until 10 or 11 p.m. when he went to bed.

On the day of the accident, he was awakened by his alarm clock at 6 a.m. He had no breakfast and left for work about 6:15 a.m. At 10 a.m., he was given afternoon work assignments in Gulf Hammock and Newberry. After he left for Gulf Hammock at 1 p.m., he ate a "hoagie" sandwich for lunch.

He spent 30 to 45 minutes in Gulf Hammock servicing tires, then at 2 p.m. he began driving to his last work assignment of the day in Newberry. He stopped in Bronson to ask directions to Newberry because he had never driven the route before, and then he proceeded north from Bronson on CR 337 toward the accident site about 2:40 p.m.

He reported that he was traveling between 35 and 40 mph as he approached the intersection, that there was no traffic in front of him, and that he did not see the stop sign. He stated that when he first saw the school bus about one or two truck lengths from the intersection he started an evasive steering maneuver to the left and applied his brakes in an attempt to avoid a collision. He reported he was not wearing the available lapbelt in his truck.

As a result of the accident, the truckdriver was convicted of one count of vehicular homicide on May 2, 1988. He was placed in community control (supervision by a parole officer) for 6 months, followed by 18 months probation. He also was required to perform 200 hours of community service. Also as a result of the accident, on June 30, 1988, the truckdriver was found guilty of violation of the right of way, was required to pay a fine of $52, and was required to attend an advanced defensive driving school by September 30, 1988.

Effective the day of his conviction for vehicular homicide, the truckdriver's Florida chauffeurs' license was revoked for 3 years. On January 13, 1989, he was issued a restricted license authorizing the operation of a vehicle for business purposes only.

Motor Carrier Information

Airdrome Tire Centers, Inc., is an intrastate private motor carrier that has been in the commercial tire business for 45 years. The company has 60 employees in five stores, and its principal office is located in Tampa, Florida. The truck involved in the accident was based at Airdrome's facility in Brooksville, Florida.

The company operates 25 trucks, including five boom service trucks similar to the one involved in the accident. Each vehicle is given a brief pretrip inspection by the assigned driver to determine if these are any obvious defects (lights, tires, etc.). A monthly inspection is performed by a supervisor, and a form denoting the findings is completed. Engine oil change and chassis lubrication is performed at 4,000-mile intervals, and reminder stickers are used on every vehicle to maintain this schedule.

The company president reported that at the time of the accident, each driver completed an employment application and provided previous employment, driving experience, and violation record. In addition each applicant's driving violation conviction record for the previous 3 years was obtained from the State that issued the applicant's license. The truckdriver involved in the accident reported his two most recent speeding violations on the Airdrome employment application on August 20, 1986.

In addition to the preemployment driving record check, the company obtained each driver's driving conviction record every 6 months. If a driver had accumulated a sufficient number of points to have his license suspended or revoked, he was not permitted to operate company equipment. The company did not routinely screen driver applicants for drugs, and, although a self-certified health history was obtained, no medical examination was required. The company president reported that when hiring employees, the company considered driving skills and tire handling of equal importance and that the company was not merely a delivery service.

Every boom truckdriver is placed in a training program which consists of working with an experienced driver for 6 weeks performing the duties required to operate the truck. Boom truckdrivers receive more pay per hour than other company truckdrivers.

After the accident, the company established more stringent qualification criteria for drivers. For example a driving-under-the-influence conviction disqualifies a driver from driving company equipment even if the driver still holds a valid license. The company also routinely screens new applicants for drugs and requires a medical examination.

Highway Information

The accident occurred at the intersection of rural Levy CR 337 and CR 32. CR 337 is 18 feet wide and CR 32 is 20 feet wide. The right-angle intersection is controlled by stop signs on the CR 337 approaches. The surfaces of both two-lane roads were in good condition. The westbound CR 32 approach to the intersection is straight and level, and the northbound CR 337 approach to the intersection is straight and has a +0.48 percent grade. (See figure 13.)

The speed limit for vehicles westbound on CR 32 is 55 mph, and the speed limit for vehicles northbound on CR 337 is 35 mph. A sign posting the 35 mph speed limit for CR 337 is located 8/10 mile south of the intersection, and the stop sign at the intersection for vehicles northbound on CR 337 is visible for almost a mile.

Figure 13.--View of northbound CR 337 approach to CR 32

There were 9 feet of tire marks attributed to a brake application by the school bus and 26 feet of tire marks attributed to a brake application by the truck on the roadway surfaces leading up to the point of the collision near the center of the intersection. Measurement of the truck's tire marks at the scene indicated that the truck steered 10^{0} left of its preaccident path and the postcollision departure angle for the school bus was 57^{0} to the right of its precollision path. Postaccident measurements also indicated that the school bus traveled about 79 feet, 46 feet of which was off the pavement, and the truck traveled 65 feet after the accident.

Medical and Pathological Information

Tests performed to determine the presence of alcohol or other illegal drugs in the school bus driver's system were negative. Tests performed on a blood specimen taken from the truckdriver at 6:05 p.m. the day of the accident were negative for alcohol. The truckdriver's blood was found to contain 8 nanograms/milliliter of the carboxylic acid metabolite of delta-9 tetrahydrocannabinol (THC).

Postmortem examinations of the six school bus occupants determined that they had sustained multiple blunt traumatic injuries including lacerations of

vital organs, multiple fractures, scalpine and subarachnoid hemorrhages, pulmonary contusions and edema, exterior lacerations, and ecchymoses of th lung spaces. The surviving school bus occupants sustained fractures, lacerations, internal injuries, abrasions, and contusions. (See figure 14.)

Federal Motor Vehicle Safety Standards

The school bus involved in this accident was manufactured after April 1, 1977 and, therefore, was required to meet several Federal motor vehicle safety standards (FMVSS) promulgated by the National Highway Traffic Safety Administration (NHTSA), including FMVSS 221, School Bus Body Joint Strength, and FMVSS 222, School Bus Passenger Seating and Occupant Protection.

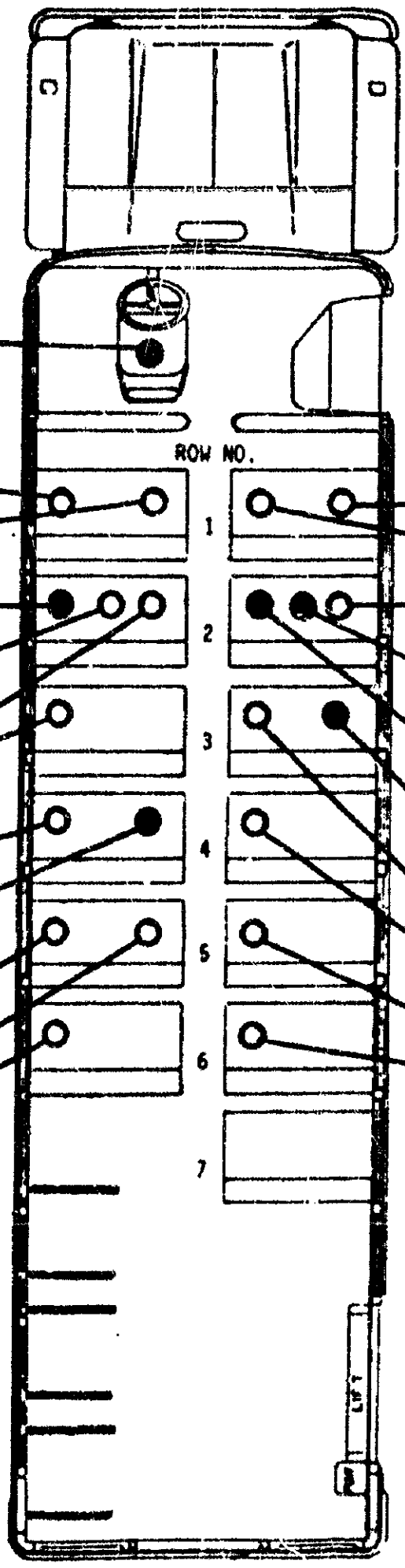
FMVSS 221 requires that a body panel joint of a school bus be fastened so that it is capable of holding the body panel to the member to which it is joined when subjected to a force equal to 60 percent of the tensile strength of the weakest joined body panel. The standard states that its purpose is to reduce deaths and injuries resulting from the structural collapse of school bus bodies during crashes.

FMVSS 222 establishes occupant protection requirements for seats and restraining barriers for large school buses. The purpose of this standard is to reduce the number of deaths and injuries resulting from the impact of school bus occupants against structures within the vehicle during crashes and sudden driving maneuvers. FMVSS 222 provides for school bus occupant crash protection through the use of strengthened, closely spaced, and padded seatbacks and padded restraining barriers installed in front of the first row of seats in large school buses.

NHTSA Tests of School Bus Floor Joints

In response to a Blue Bird Body Company request for clarification of FMVSS 221 test procedures for cases in which the two body components which form the joint in question are not flat surfaces in the same or parallel planes, on April 26, 1976, the NHTSA advised that it intended to test such configurations by determining the nature of the two body components and test identical materials joined by the same means after modification of the joint into a configuration in which the two body components are flat surfaces in the same or parallel planes. This interpretation of the standard resulted in these "surrogate" test specimens being placed primarily in a shear failure mode.

Section S6.2(a) of FMVSS 221 provides that if the mechanical properties of a material are specified by the American Society for Testing and Materials (ASTM), the relative tensile strength for such a material is the minimum tensile strength specified for that material in the 1973 edition of the Annual Book of ASTM Standards. (See appendix B.) Based upon the ASTM specifications, the NHTSA determined that the minimum strength for an 8-inch floor joint specimen for four manufacturers--Blue Bird Body Company, Carpenter Body Works, Inc., Thomas Built Buses, Inc., and Ward School Bus, Inc.--was 15,228 pounds in shear.



F-55; AIS-6; FATAL; Fragmentation of Upper Cervical Spinal Cord, Transected Aorta, Brain Disruption, Fractured Neck, Ribs, and Legs.

M-8; AIS-2; Fractured Left Clavicle, Head Lacerations.

F-34; AIS-3; Fracture of 6th Vertebrae, Head Injury.

M-4; AIS-4; FATAL; Fractured right Hip, Tibia, Fibula, Head Lacerations. (Died During Rescue Procedures.)

M-6; AIS-2; Fractured Left Clavicle, Head Lacerations.

M-10; AIS-4; Fractured Skull, Pelvis, Left Ankle, Head Laceration.

M-15; AIS-5; Torn Esophagus, Lacerated Left Thigh.

M-12; AIS-3; Fractured Left Femur.

M-11; AIS-2; FATAL; Multiple Petechial and Ecchymoses of Lung Spaces, Pulmonary Edema, Lacerated Right Ear. (Died During Rescue Procedures.)

M-18; AIS-2; Fractured Right Pelvis, Clavicle, Head Lacerations.

M-17; AIS-1; Contusion of Right Eye, Head Laceration.

M-16; AIS-2; Fractured Clavicle, Head Laceration.

M-4; AIS-1; Fractured Clavicle.

F-28; AIS-2; Fracture of Right Clavicle, Head Laceration.

M-11; AIS-2; Fractured 11th and 12th Ribs, Lacerations on Right Thumb and Head.

M-8; AIS-6; FATAL; Transected Thoratic Aorta, Lacerated Lungs, Fractured Clavicle.

M-9; AIS-4; FATAL; Diffuse Cerebral Hemorrhage, Pulmonary Contusions, Multiple Lacerations of Spleen.

F-6; AIS-4; FATAL; Subarachoid Hemorrhage, Fractured Left Humerus and Femur.

M-10; AIS-3; Closed Head Injury.

F-16; AIS-1; Hematoma of Right Forehead and Knee.

M-17; AIS-1; Lacerated Left Forehead.

M-12; AIS-2; Fractured Right Scapula.

LEGEND

AIS* SEVERITY CODE

AIS-0	NO INJURY
AIS-1	MINOR
AIS-2	MODERATE
AIS-3	SERIOUS
AIS-4	SEVERE
AIS-5	CRITICAL
AIS-6	MAXIMUM INJURY; VIRTUALLY UNSURVIVABLE

M-10; AIS-X

SEX AGE SEVERITY

*AMERICAN ASSOCIATION FOR AUTOMOTIVE MEDICINE: ABBREVIATED INJURY SCALE

(AIS CODE DETERMINED BY MAXIMUM INJURY)

● = FATALLY INJURED

○ = SURVIVED

Figure 14.--School bus occupant seating and injury chart

From April 1977 to August 1982, the NHTSA obtained and had a contractor examine or test floor joint specimens of 13 large school buses manufactured by eight different school bus body manufacturers for compliance with the joint strength requirement of FMVSS 221. Five of the specimens the NHTSA had tested or examined "passed" the joint strength requirement. Eight specimens were found to be in apparent noncompliance. (See appendix C.)

When the NHTSA acquires data indicating that a manufacturer may not be complying with a Federal safety standard, it NHTSA sends a Certified Information Request (CIR) to the manufacturer requesting data supporting the certification the manufacturer made that the vehicle is complying with applicable Federal safety standards.

The NHTSA sent eight CIRs to six manufacturers whose floor joints apparently did not meet the joint strength requirement of FMVSS 221. The CIR issued to Carpenter Body Works, Inc., resulted in a recall of 19 school buses.

The CIR issued to Ward School Bus, Inc., which is not the same company presently manufacturing school buses under the Ward name, was closed by the NHTSA Office of Vehicle Safety Compliance (OVSC) after examination of the test bus disclosed poor quality control of the application of the adhesive joints in the bus. The new owner of the company, American Transportation Corporation (AmTran), advised that it had replaced the Ward adhesive process with rivets for which a visual quality control method could be used.

In December 1978, a NHTSA contractor tested a 1978 school bus manufactured by Crown Coach Corporation (Crown). The Crown school bus, which used plywood in the floor construction, was determined to need a floor joint strength of 1,980 pounds in shear to meet the joint strength requirement of FMVSS 221. In January 1979, a NHTSA contractor tested a 1978 school bus manufactured by the Gillig Corporation (Gillig). The Gillig school bus, which also used plywood in the floor construction, was determined to need a floor joint strength of 1,680 pounds in shear to meet the joint strength requirement of FMVSS 221. During tests, the Crown floor joint failed at 270 pounds in shear, and the Gillig joint failed at 1,138 pounds in shear. The NHTSA sent CIRs to both manufacturers.

According to the NHTSA these two CIRs were closed with respect to the floor joints' apparent noncompliance after it was determined that the floor joint specimens tested may have been prestressed during other tests previously performed on the same buses.

The NHTSA Office of the Chief Counsel (OCC) closed the remaining four CIRs pertaining to floor joints. One of these CIRs had been issued to Sheller-Globe Corporation (Superior school buses), which discontinued manufacturing large school bus bodies in March 1981. Three CIRs which the OCC closed without explanation in June 1985 had been issued to Thomas Built Buses, Inc.

In 1986, the OVSC advised the Safety Board that in August 1982, the NHTSA discontinued its program of testing large school bus floor joints for

compliance with the joint strength requirement of FMVSS 221. An attorney for the OCC advised the Safety Board in a 1986 meeting that, in the opinion of the OCC, FMVSS 221 was "anomalous" and unenforceable with respect to school bus floor joints because the standard permitted manufacturers to use materials of varying strengths. The attorney for the OCC stated that the standard, in effect, penalized a manufacturer using stronger materials because of the resulting higher joint tensile strengths required.

In July 1987 the NHTSA Chief Counsel stated that the NHTSA has never made a determination that any motor vehicle manufactured by Thomas Built Buses, L.P., either failed to comply with an applicable FMVSS or contained a defect related to motor vehicle safety within the meaning of the National Traffic and Motor Vehicle Safety Act of 1966. However, in January 1989 the NHTSA's Associate Administrator for Enforcement advised the Safety Board, "Investigation cases involving compliance of Thomas floor panel joints were closed by NHTSA's Office of Chief Counsel based upon an inadequate legal basis to proceed rather than on questions related to the technical merits of the test failures."

Previous Safety Board Findings and Recommendations

About 3:20 p.m. on May 31, 1985, near Snow Hill, North Carolina, a 1982 48-passenger school bus with a body manufactured by Thomas Built Buses, Inc., traveling southbound about 32 mph was struck and sideswiped on the left side by a northbound tractor-semitrailer traveling at a speed estimated to be between 44 and 60 mph.[1] The collision split the school bus floor, creating a V-shaped opening which was 45 inches wide on the left side across the entire width of the school bus in front of the fourth row of seats. (See figure 15.)

Six school bus passengers who were all sitting in the first four seats on the left side of the school bus and the truckdriver sustained fatal injuries. The school bus driver and the remaining 21 passengers sustained minor to serious injuries.

In its analysis of the Snow Hill accident, the Safety Board determined:

> The occupants in the fourth bench seat on the left side probably also were ejected, either through the opening in the left sidewall or through the opening in the floor.
>
> . . . the occupant in the fourth row (on the right side) may have been ejected either through the opening in the left sidewall or possibly even through the opening in the school bus floor.

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[1] Highway Accident Report--"Multiple Vehicle Collision and Fire, U.S. 13 near Snow Hill, North Carolina, May 31, 1985" (NTSB/HAR-86/02).

Figure 15.--Opening in the Snow Hill school bus floor
(Photograph courtesy of the Goldsboro News-Argus)

The Safety Board's investigation of the Snow Hill accident disclosed that three NHTSA-sponsored tests or examinations of the Thomas floor joint indicated that the OSVC had found that the Thomas floor joint was in apparent noncompliance with the joint strength requirement of FMVSS 221. The Board also found that the primary failure mode of the floor joint of the Snow Hill school bus was in peel or tension rather than shear as was used by the NHTSA to determine compliance with FMVSS 221; that Thomas Built Buses, Inc., maintained that the floor joint was body structure joining not subject to FMVSS 221; that the NHTSA Office of Chief Counsel maintained that FMVSS 221 was legally insufficient; and that the NHTSA had discontinued testing school bus floor joints for compliance with FMVSS 221 in August 1982.

As a result of these findings, on October 2, 1986, the Safety Board recommended that the NHTSA:

H-86-54

Amend or clarify Federal Motor Vehicle Safety Standard 221 to require that body panel joints for school bus body structures be tested in tension or peel unless they can only be tested in shear.

H-86-55

Amend or clarify Federal Motor Vehicle Safety Standard 221 to include all body panel joints that enclose the occupant space.

H-86-56

Resume testing of school bus floor joints to ensure compliance with Federal Motor Vehicle Safety Standard 221.

In addition, on October 2, 1986, the Safety Board recommended that Thomas Built Buses, L.P.:

H-86-57

Strengthen the floor panel joints of all newly-manufactured school buses to ensure that they comply with the requirements of Federal Motor Vehicle Safety Standard 221.

The NHTSA and Thomas Built Buses, Inc., responses to these recommendations are discussed later in this report.

In March 1987, the Safety Board adopted its safety study of the crashworthiness of large (over 10,000 pounds gross vehicle weight rating)

poststandard school buses.[2] In addition to reiterating Safety Recommendation H-86-57 to Thomas, on May 1, 1987, the Board recommended that 10 manufacturers of large school bus bodies:

H-87-12

Apply the performance requirements of FMVSS 221 to floor panels and interior maintenance access panels.

In letters dated June 15 and July 1, 1987, Thomas Built Buses, Inc., filed a petition for reconsideration and withdrawal of the Safety Board's findings, conclusions, and recommendations relating to Thomas in its report of the Snow Hill, North Carolina accident and the safety study of the crashworthiness of large poststandard school buses. However, after reviewing the petition, on April 11, 1989, the Board denied Thomas' request.

Two other manufacturers of large school bus bodies have responded and seven manufacturers have not yet responded to Safety Recommendation H-87-12. On May 26, 1987, the Wayne Corporation advised the Safety Board that Wayne bus body floor joints fully comply with FMVSS 221 and that Wayne has not had any reports of floor joint failures in an accident. On June 10, 1987, Blue Bird Body Company reported that Blue Bird developed, tested, and certified floor-panel-to-floor-panel joint designs to meet and exceed the 60 percent joint strength requirement of FMVSS 221, and has used these joint designs in all school buses manufactured since the effective date of the standard.

On October 27, 1988, Thomas Built Buses, Inc., reported to the Safety Board that, effective the first quarter of calendar year 1989, Thomas intends to modify the method of fastening its floor joint. This modification will result in the inclusion of spot welds on approximately 2-inch centers, resulting in the placement of 45 to 48 spot welds on each Thomas floor joint. The former floor joint design utilized 12 spot welds across the entire width of the floor. This modification will serve as the standard floor configuration on all large Thomas school bus bodies being produced.

Thomas also submitted preliminary (and proprietary) test data which indicate that this modification of the fastening increases the strength of the floor joint and exceeds, on average, the 15,228-pound strength the NHTSA required in the shear failure mode for the floor joint to be considered in compliance with FMVSS 221. Thomas reported that it modified the floor joint fastening because several States have indicated to Thomas that they intend to change the wording of their school bus specifications such that they "will speak to the specific structural joint in question in the Thomas floor." Thomas also reported that this change was not intended to convey the impression that floor modifications were made to bring the floor into compliance with FMVSS 221. Thomas stated, "It is and has been our contention that the Thomas floor is in compliance with that Standard."

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[2] Safety Study--"Crashworthiness of Large Poststandard Schoolbuses" (NTSB/SS-87/01).

NHTSA Rulemaking Activities

On June 19, 1987, in response to Safety Recommendations H-85-54 through -56, the NHTSA published an Advance Notice of Proposed Rulemaking (ANPRM) in the Federal Register requesting comments on floor joint strength requirements and several changes to the test procedures currently required by the NHTSA's interpretations of FMVSS 221. In its August 1987 comments concerning the ANPRM, the Safety Board reiterated its recommendations to the NHTSA that FMVSS 221 should be amended or clarified to make it clear that all floor joints are subject to the standard, to specify the failure mode for testing, and to resume testing for compliance with the standard. (See appendix D.)

According to the NHTSA, the comments to the ANPRM indicated that floor joint strength would require a separate research project. The NHTSA has initiated a school bus crash testing program to evaluate floor joint strength in a number of buses through dynamic rather than static tests. A decision on rulemaking concerning floor joints is currently scheduled for the third quarter of calendar year 1989.

Tests and Research

Accident Site.--Sight-distance tests conducted after the accident indicated that the school bus and truck were first visible to each other when the school bus was 187 feet and the truck was 201 feet from the center of the intersection. During the tests, it was determined that the school bus driver's view of the approaching truck may have been blocked partially for some undetermined time by the left rear-view mirror on the school bus. Visibility was also limited by trees and shrubs at the southeast corner of the intersection. Skid tests conducted after the accident indicated that the skid number[3] for the roadway surface the school bus was traveling, adjusted for the type of tires in use on the school bus, was 54.

Floor Joint Strength Tests.--The Safety Board obtained specimens of the floor joints from five school bus body manufacturers: Blue Bird Body Company (Blue Bird); Carpenter Body Works, Inc. (Carpenter); Thomas Built Buses, Inc. (Thomas); American Transportation Corporation (AmTran), which currently manufacturers school buses using the Ward brand name; and the Wayne Corporation (Wayne). These five school bus body manufacturers were selected for testing, and other manufacturers were excluded, because the Safety Board had recent crash data concerning the performance of these manufacturers' floor joints from its 1987 school bus crashworthiness safety study, and because these five are currently manufacturing large school bus bodies.

Undamaged floor joint specimens of the current Blue Bird, Thomas, and Wayne floor joints were obtained from school buses that had been involved in accidents. Specimens of the current Carpenter and AmTran (Ward) floor joints could not be obtained from accident-involved school buses, so these two

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[3] A skid number is the coefficient of friction times 100 of a standard tire sliding on wet pavement when tested at 40 mph with a two-wheel skid trailer or equivalent device following the procedures outlined in ASTM E274-79.

manufacturers supplied specimens from the production line at the Safety Board's request.

The Safety Board fabricated the floor joints into 8-inch specimens as specified in section S6.1.1 of FMVSS 221. Although FMVSS 221 provides that 8-inch specimens may be selected at random, in the case of the Carpenter, Thomas, and AmTran (Ward) specimens, the maximum amount of fastening available was included in the 8-inch specimens selected. In the case of Blue Bird and Wayne, which use rivets that are spaced closer together at the floor joint near the sidewall, the Board selected 8-inch specimens with one rivet, simulating the floor joint near the centerline of a school bus. Blue Bird and Wayne also performed their own tests on specimens using two rivets, simulating a floor joint adjacent to the sidewall; they reported the findings (see below) of these tests to the Safety Board.

These specimens, with the exception of the AmTran specimen which could not be tested in peel[4] because of the overlapping panel design, were tested statically in both the peel and shear failure modes by the National Institute of Standards and Technology (NIST-formerly the National Bureau of Standards) at the request of the Safety Board.

Peel Tests.--The strengths of the strongest 8-inch specimen tested by the NIST in peel for each of the manufacturers tested are listed below:

Manufacturer	Strength of Strongest Specimen (lbs.)
Blue Bird (1 rivet)	1,873
Carpenter	2,932
Thomas	1,609
Wayne (1 rivet)	1,058*

*The test was not valid because the Wayne specimen was corroded.

Carpenter did not report any additional peel tests. Three manufacturers, Blue Bird, Thomas, and Wayne, also performed their own testing in the peel failure mode. These results are reported below:

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[4]Peel: A test that subjects the specimen to a combination of static pull (tension) and bending loads.

Manufacturer	Strength of Strongest Specimen (lbs.)
Blue Bird (2 rivets)	4,120
Thomas	2,325
Wayne (2 rivets)	3,950

*The results of the peel tests of the Blue Bird, Thomas, and Wayne specimens performed by the NIST differ considerably from the results of the tests performed and reported by these manufacturers, in large part, because Blue Bird and Wayne tested specimens using additional fastening, simulating their floor joint configuration near the sidewall, while the NIST tested specimens with only one rivet in an 8-inch specimen, simulating the Blue Bird and Wayne floor joint near the center of the floor. The NIST-tested specimens also may have been prestressed due to accident involvement, other in-use stresses, and corrosion. Variations may also be due to differences in material thickness, weld penetration, and the use of different testing machines.

Shear Tests.--Shear is the failure mode used by the NHTSA to determine compliance with FMVSS 221. Three manufacturers, Blue Bird, Thomas, and Wayne, fabricated "surrogate" floor joint specimens using the same materials and means of fastening, but configured so that when these specimens were placed in a tensile testing machine, the specimens were subjected primarily to shearing forces. AmTran fabricated floor joint specimens using the same materials and joint configuration that presently is used in a typical school bus.

The NIST modified one Carpenter peel specimen into a shear specimen by bending, and the Safety Board modified a piece of an undamaged floor joint from the Thomas school bus involved in the Bronson, Florida, accident into a shear specimen, also by bending. The results of the NIST tests in shear are reported below:

Manufacturer	Strength of Strongest Specimen (lbs.)
Blue Bird	exceeded 15,228
Carpenter	13,514*
Thomas	9,303
AmTran (Ward)	exceeded 15,228
Wayne	exceeded 15,228

*Only one Carpenter floor joint specimen was tested in shear. This specimen was tested twice. The first test was invalid. The result of the second test is given in the table.

Testing of the shear specimens of the Blue Bird, AmTran, and Wayne floor joints was stopped when the strength of the joint exceeded 15,228 pounds, which was the strength the NHTSA determined was necessary to meet the strength requirement of FMVSS 221.

ANALYSIS

The Accident

The weather and the condition of the highway did not contribute to this accident. A postcrash inspection of both the school bus and the truck disclosed no preaccident defects, and the Safety Board concludes that there was no mechanical defect in either of the involved vehicles that caused the accident. The Board believes that the absence of the missing body mounting clip (assuming it was not in place at the time of the accident) had no effect on the outcome of the accident since it had been mounted aft of the area of the floor collapse.

An examination of the truck tachometer indicated that the engine was operating at 1,900 rpm at the time of the collision. Using 1,900 as the rpm of the truck engine at the moment of the collision and the truck tire size and transmission ratio, the Safety Board calculated that the speed of the truck at impact was about 42 mph.

The 29 feet of preimpact skid marks left by the truck indicate that the truckdriver applied his brakes and therefore, the truck began to decelerate over this distance. Assuming a constant rate of deceleration, the Safety Board estimates that the speed of the truck before the brakes were applied was about 45 mph, 10 mph over the 35-mph posted speed limit. Using a speed of 42 mph at impact for the truck, the angles of approach and departure, and the estimated weights of the two vehicles, the Board calculates that the speed of the school bus at impact was about 31 mph. The Board also calculates that the school bus decelerated and subsequently struck the embankment at a speed between 14 and 19 mph, not including any additional speed the school bus may have been accelerated as the truck rotated and struck the left side of the school bus.

The initial collision of the left front of the school bus with the right front of the truck redirected both vehicles 57^{0} northwest from the precollision path of the school bus. After both vehicles were redirected, the right side of the truck collided with the left side of the school bus as the truck began its counterclockwise rotation and 90^{0} overturn to the right.

When this secondary side-to-side collision occurred, the floor panels aft of the school bus driver's position were subjected to side-shearing forces. At this point in the collision sequence, several, if not all, of the first seven floor panels separated from their attachment to the left and right sidewalls and at least partially from each other.

As the truck continued its counterclockwise rotation, its degree of rollover also increased; as the cargo bed was rolling over onto the left sidewall of the school bus, the left ends of floor panels one through seven

were compressed downward, causing their right ends to begin to rise up into the passenger compartment. Because there were no body mounting clips installed forward of the joint between the fifth and sixth floor panel (see figure 10), the right ends of panels one through four, which probably had separated due to shearing forces in the initial phase of the collision sequence, were free to turn up as their left ends were deflected downward by the truck's cargo bed.

Although the ends of floor panels five through seven were also separated from their attachment to the left and right sidewalls of the school bus at this phase of the collision, the mounting clips joining the fifth and sixth floor panels probably prevented the right ends of these panels from turning up into the passenger compartment as far as the first four panels. At this point, the truck probably pushed the left ends of panels four through seven down under the left sidewall and compressed the left ends of these panels.

As the truck continued to rotate counterclockwise, the right front of the truck disengaged from the left front of the school bus, and the rear right side of the truck's cargo bed engaged the left side of the school bus near the floor joint between the seventh and eighth floor panels. The 8-inch marks on the inside vertical face of the right longitudinal frame member of the school bus is evidence that the body mounting clips between floor panels 11 and 21 were pushed about 8 inches aft before the rear of the school bus body separated from the chassis. This aft movement was induced by the slamming of the 2,892-pound heavy equipment tire on the truck into the left sidewall of the school bus. This impact separated the aft portion of the school bus body from its chassis and displaced the school bus body to the right.

The final phase of the collision sequence occurred when the front of the school bus struck the dirt embankment at the northwest corner of the intersection. This final collision caused the rear of the school bus body, which was now separated from the chassis, to slide forward, to compress the first seven floor panels and the first four rows of seats, and to invert the first floor panel with the restraining barriers still attached.

When the school bus body compressed, it caused the left sidewall and the first seat on the left side to bulge, while the right sidewall aft of the entrance door slid forward. The roof support pillars outboard of the windshield glass remained attached and caused the roof to be pulled down and over the engine compartment.

Medical and Pathological Factors

Analysis of the truckdriver's blood after the accident revealed the presence of 8 ng/ml of the carboxylic acid metabolite of delta-9 tetrahydrocannabinol (THC). The carboxylic acid metabolite is not psychoactive. THC, the psychoactive compound in marijuana, was not detected.

Based only on the test showing the presence of 8 ng/ml of the carboxylic metabolite of THC in the blood sample, the truckdriver may have used

marijuana as little as a few hours or as long as 5 or more days before the accident depending on how frequently he used the drug. If the driver was an infrequent user, he may have used marijuana a few hours before the accident, while he was on duty. Although it is not very likely that an infrequent user would use the drug while on duty, this cannot be eliminated as a possibility. Further, had the driver been an infrequent user and nevertheless used marijuana while on duty it is possible that the driver could have been impaired at the time of the accident and still had no detectable level of THC in the blood sample that was tested. Because the Safety Board has no information on the extent of use of marijuana by the driver, and no urine sample was available for additional tests, the Board could not determine if marijuana was or was not a factor in the accident.

Driver Performance

Both the truckdriver and the school bus driver held valid licenses and met Florida's requirements to operate their respective vehicles. Sight-distance tests indicated that the approaching truck was visible from the school bus driver's position when the school bus was 187 feet from the center of the intersection about where the vehicles first collided. At a speed of 31 mph, the school bus driver had a maximum of 4 seconds before impact to see the truck approaching, to perceive that the truck was not going to stop, to decide on a course of action to attempt to avoid the collision, and to take that action. The time available to the school bus driver actually may have been less because of the possibility that the approaching truck was masked partially or completely by the left rear-view mirror on the school bus.

The 9 feet of skid marks attributed to a brake application by the school bus driver indicates that the school bus driver did perceive a danger and did attempt to avoid the collision. However, the school bus driver did not have time to take any effective action to avoid the collision. The available evidence leads the Safety Board to conclude that the accident cannot be attributed to any performance errors on the part of the school bus driver.

At an estimated speed of 45 mph with 201 feet of sight distance, the truckdriver would have had only 3 to 5 seconds to recognize the danger presented by the bus and to initiate action to avoid the collision. The available evidence indicates that when the truckdriver recognized the danger, he applied his brakes, leaving 26 feet of skid marks, and initiated a 10^{0} turn to the left in an attempt to avoid the collision. The Safety Board believes that once the driver recognized and reacted to the danger, there was insufficient time available for the truckdriver to execute effective evasive action.

The truckdriver had no restrictions on his Florida license requiring the use of corrective lenses while driving, and there is no other evidence available to the Safety Board to indicate that his vision or some other medical condition may have caused or contributed to his failure to stop at the intersection. There also is no evidence indicating that the truckdriver may have been distracted temporarily by some condition on his vehicle or by some other factor in the truckdriver's sight or hearing.

According to his statement made after the accident, the truckdriver had obtained about 7 to 8 hours sleep the night before the accident, which apparently closely approximated the truckdriver's normal work/sleep cycle during the work week. There is no evidence that the truckdriver was working at a part-time job, and although it cannot be completely ruled out, the Safety Board does not believe that inattention due to fatigue was a contributing factor.

The truckdriver reported that he stopped and asked directions to get to his next work assignment a few minutes before the accident. Although the truckdriver may have become drowsy while driving, the act of stopping and asking directions probably would have dispelled any lack of vigilance, at least temporarily.

The fact that the truckdriver had four convictions on his record for reckless and/or careless driving between 1980 and 1982 indicates to the Safety Board that he had exhibited a disregard for safe vehicle operations in the past. Because of this disregard, as well as the evidence indicating that the truckdriver was operating his vehicle at a speed estimated to be about 10 mph above the posted speed limit, it is possible that the truckdriver may have chosen to ignore the stop sign. However, there is no previous record of the truckdriver deliberately disobeying stop signs or other traffic signals. It is just as possible that the truckdriver simply was inattentive to his duties and failed to see the stop sign or the school bus until it was too late. This would be consistent with impairment from marijuana use. However, there is insufficient evidence to conclude that the driver was or was not impaired. Thus, the Board is unable to determine from the available evidence why the truckdriver failed to stop before entering the intersection.

Survival Factors

The school bus driver probably sustained her fatal injuries during the initial collision with the truck. This collision crushed the driver's area and did not provide for survivable space. Although the available evidence indicates that the lapbelt installed at the driver's position in the school bus was not in use at the time of the accident, use of this lapbelt would not have prevented the school bus driver from sustaining her fatal injuries.

The initial impact probably caused all of the school bus passengers to be thrown forward and to the left, where they contacted restraining barriers, the left sidewall of the school bus, the seatbacks in front of them, and possibly other passengers during the initial phase of the collision sequence. Some of the passengers seated on the right side on the aisle may have been ejected from their seats. As a result of the second collision in the accident sequence, the right sides of the first seven floor panels were lifted up, ejecting forward and to the left any passengers who had remained in the first several rows of seats.

In the final phase of the collision sequence, the front of the school bus struck the dirt embankment northwest of the intersection. Blood stains

on the ceiling forward of the boarding door indicate that passenger(s) were ejected forward into this area.

The Safety Board believes that the passengers of the first seat row were probably ejected forward and made contact with the roof forward of the boarding door during the initial phase of the collision sequence. Three of the four passengers in the first seat row sustained moderate injuries, and the remaining passenger sustained serious injuries. The available evidence indicates that none of the passengers of the first seat row was pinned in the wreckage. If the passengers seated in the first seat on the left side had been using the available lapbelts, they might have been pinned or crushed in the wreckage of the collapsing school bus body when the school bus struck the embankment and possibly would have sustained more serious or fatal injuries.

The two passengers seated in the second row on the right side closest to the aisle, the one passenger seated in the second seat row on the left side who died during rescue procedures, and the one passenger seated in the third row on the right side sustained fatal blunt force traumatic injuries. These fatally-injured passengers received injuries at the AIS-4 (severe) or AIS-6 (virtually unsurvivable) levels on the abbreviated injury scale. (See figure 14.)

The Safety Board could not determine if the collapse of the school bus floor in the area where these passengers were seated caused their fatal injuries to the exclusion of all other possible injury sources. However, the collapse of the floor negated any passenger crash protection that may have been afforded by the padded, high-backed restraining barriers and seats installed in the school bus as required by FMVSS 222, School Bus Passenger Seating and Occupant Protection. Therefore, the Board believes that the collapse of the school bus floor under the first three seat rows may have exacerbated most of the injuries sustained by the passengers of the second, third, and fourth seat rows of the school bus.

The 11-year-old male passenger who was seated in the fourth seat on the left side before the crash died during rescue procedures. The available evidence indicates that this passenger was pinned between the floor panels that had collapsed in the left front of the school bus. Although this passenger sustained only moderate (AIS-2) injuries which are considered to be usually survivable in most circumstances, he died before he could be extricated from the wreckage. The available evidence indicates and the Safety Board concludes that the collapse of the school bus floor contributed to his death because he could not be promptly extricated.

The Safety Board has found in several severe accidents in which the school bus body and chassis separated, that the separation produced a positive safety benefit.[5] Crash forces which normally would have been

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[5] Highway Accident Reports--"Collision of G & D Auto Sales Inc., Tow Truck Towing Automobile, Branch Motor Express Company Tractor-Semitrailer, Town of Rehoboth Schoolbus, Rehoboth, Massachusetts, January 10, 1984" (NTSB/HAR-84/05); "Collision of Isle of Wight County, Virginia, Schoolbus

transmitted to the school bus body were reduced because of the body/chassis separations. However, the body/chassis separation in this accident did not benefit the school bus occupants because the school bus floor collapsed after the separation, negating many of the passenger crash protection features required by FMVSS 222, School Bus Passenger Seating and Occupant Protection.

Commercial Driver Licensing in Florida

Currently, Florida and several other States do not require a commercial vehicle driver applicant to pass a driving test in the type of commercial motor vehicle (CMV) they intend to operate before issuing a license to operate that type of vehicle.

The Commercial Motor Vehicle Safety Act of 1966 (Public Law 99-570) directs the States to issue minimum testing standards for drivers of CMVs which must include a written test to determine the driver applicant's knowledge concerning the safe operation of CMVs and a driving test in a vehicle representative of the type of vehicle that each applicant operates or intends to operate to determine the applicant's skill in operating that type of CMV. Beginning in fiscal year 1994, the act provides for withholding Federal aid highway funds from those States that do not issue testing standards in compliance with the act.

A representative of the Florida Department of Highway Safety and Motor Vehicles advised the Safety Board that in the April 1989 assembly of the Florida legislature proposed standards to ensure compliance with the provisions of the act will be submitted to the legislature for its consideration. The Board encourages Florida and other States that have not done so to issue testing standards to ensure compliance with the act as soon as possible.

The Safety Board is concerned that the Florida statutes permit a Florida-licensed drivers, including drivers of a CMV, to have only one-half the driving points assessed against their license that they would receive for a Florida conviction if the conviction actually occurs out of state or in a Federal court for a similar violation of motor vehicle traffic laws. This provision of the Florida statutes allows Florida-licensed drivers who drive extensively in other States to accumulate, in the Board's view, an excessive number of driving violation convictions before any action will be taken to revoke their Florida driver's or chauffeur's license. This provision of the Florida statutes should be eliminated.

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with Chesapeake and Ohio Railway Company Freight Train, State Route 615 near Carrsville, Virginia, April 12, 1984" (NTSB/HAR-85-02); "Schoolbus Loss of Control and Collision with Guard Rail and Sign Piller, U.S. Highway 70 near Lucas and Hunt Road, St. Louis County, Missouri, November 11, 1985" (NTSB/HAR-87/02).

NHTSA Floor Joint Test Procedures

By using the provisions of Section S6.2(a) of FMVSS 221, the NHTSA in effect established a minimum floor joint specimen strength of 15,228 pounds in shear for Blue Bird, Carpenter, Thomas, and Ward School Bus, Inc. However, the NHTSA calculated that floor joint strengths for school bus floors using plywood in floor construction was considerably less than 15,228 pounds. The plywood floor of the Crown school bus the NHTSA tested in 1978 was determined to need a floor joint strength of 1,980 pounds in shear, and the plywood floor of the Gillig school bus was determined to need a floor joint strength of 1,680 pounds in shear in order to meet the floor joint strength requirement of FMVSS 221.

The Safety Board has no data concerning the crashworthiness of post-FMVSS 221 school bus floors that use plywood in their floor construction; therefore, it cannot determine if such floor joints need to be strengthened. However, the Board believes that the varying floor joint strength requirements that resulted from basing the requirements upon the type(s) of parent material used (steel vs. plywood) may have been the anomaly that caused the NHTSA to believe the standard was unenforceable. This needs to be addressed in the NHTSA rulemaking presently in progress.

Analysis of Floor Joint Strength Tests

Peel Test Results.--Peel was not the failure mode used by the NHTSA to determine floor joint compliance with FMVSS 221, and the Safety Board is aware that school bus body manufacturers do not presently design their school bus floor joints to meet the joint strength requirements of FMVSS 221 when floor joint specimens are subjected to peeling forces. However, the Board believes that peeling forces were the primary loading mode on the floor joint in the Thomas school bus body that separated in the accident near Snow Hill, North Carolina in 1985, and that the peel failure mode is therefore a relevant method of determining floor joint strength.

Review of the peel test data obtained from both the NIST and the school bus body manufacturers who submitted their own test data indicates, and the Safety Board concludes, that the Thomas floor joint specimens were the weakest of those specimens tested in the peel failure mode.

Shear Test Results.--Tests of the Blue Bird, AmTran, and Wayne floor joint shear specimens were discontinued when it was determined that the 8-inch specimens met or exceeded the 15,228-pound strength the NHTSA determined was necessary for the floor joint to meet the joint strength requirement of FMVSS 221. The Carpenter shear specimen separated at 13,514 pounds, some 1,714 pounds less than the 15,228 pounds required to meet the standard.

Although the shear specimen of the Carpenter floor joint did not meet the 15,228-pound strength requirement, the Safety Board believes the specimen may have been prestressed because it was tested twice. In addition, real-

world crash data available thus far indicates that the current Carpenter school bus floor joint design has performed well in severe crashes.[6]

The strongest Thomas shear specimen tested separated at 9,303 pounds. This strength is 61 percent of the strength the NHTSA determined was required to meet the joint strength requirement of FMVSS 221. These test results, together with the Thomas floor joint separations noted in this and other accidents, support the Safety Board's finding made as a result of its investigation of the Snow Hill, North Carolina, accident that the floor joint manufactured by Thomas Built Buses, Inc., needed to be strengthened.

FMVSS 221 and Real World Crash Performance

The Blue Bird floor joint was found by the NHTSA to be in compliance with FMVSS 221, and the Safety Board has thus far found no instance of a floor joint separation in accidents involving a post-FMVSS 221 Blue Bird school bus.

The Carpenter floor joint, with the exception of the floor joints on the 19 school buses that were recalled, was found by the NHTSA to be in compliance with FMVSS 221, and the Safety Board has thus far discovered no instance of a floor joint separation involving a post-FMVSS 221 Carpenter school bus.

Although the present Wayne and AmTran floor joint configurations were never tested by the NHTSA, tests performed by the NIST in accordance with NHTSA-approved procedures indicated that the Wayne and AmTran (Ward) floor joint specimens exceeded the 15,228-pound strength the NHTSA determined was necessary for floor joint specimens using similar materials to be in compliance with FMVSS 221. The Safety Board thus far has noted no separations of the post-FMVSS 221 Wayne and AmTran floor joint designs in accidents.

The NHTSA determined in 1981 that the floor joint manufactured by Ward School Bus, Inc., was in apparent noncompliance with the joint strength requirement of FMVSS 221. On November 11, 1985, a school bus with a 1980 Ward School Bus, Inc., body collided with a guard rail and sign pillar in St. Louis, Missouri.[7] The Safety Board determined that a joint in the school bus floor was separated laterally for about 20 inches between the second and third seat rows. However, Ward is no longer manufacturing school buses and the method of fastening the floor joint in the school buses manufactured by AmTran (which bought out the Ward assets) has been redesigned.

Before they were closed in 1985, three outstanding NHTSA investigations concerning the strength of floor joints manufactured by Thomas were being

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[6] "Crashworthiness of Large Poststandard Schoolbuses," Case 39, pp. 219-222.

[7] Highway Accident Report--St. Louis County, Missouri, November 11, 1985" (NTSB/HAR-87/02).

conducted, and the Safety Board discovered floor joint separations in the Thomas school bus bodies involved in the Snow Hill, North Carolina, and Bronson, Florida, school bus crashes.

In addition to the Thomas school buses involved in the Bronson and Snow Hill accidents, the Safety Board is aware of three additional floor joint separations involving post-1977 school buses manufactured by Thomas; a February 1980 school bus/train collision near Two Harbors, Minnesota; a May 1986 school bus/train collision in Greenville, North Carolina, where an occupant who sustained moderate injuries was apparently ejected through an opening in the school bus floor; and a September 1987 school bus/dump truck collision near Franklin, New Jersey.

This review indicates that floor joints that failed NHTSA-sponsored tests for compliance with the joint strength requirement of FMVSS 221 in several cases also failed to maintain their structural integrity during crashes, and that floor joints that have been determined by the NHTSA to be in compliance with FMVSS 221 have thus far performed well in even severe crashes.

NHTSA Rulemaking Activities

The NHTSA perceived problems with enforcement and interpretation of FMVSS 221 as it applied to floor joints and discontinued testing floor joints for compliance with the standard in August 1982. The NHTSA Associate Administrator for Enforcement advised the Safety Board that the investigation cases involving compliance of Thomas floor panel joints were closed by the NHTSA's Office of Chief Counsel based on an "inadequate legal basis to proceed rather than on questions related to the technical merits of the test failures." Since August 1982, the NHTSA has not tested floor joints for compliance and has not attempted to enforce the existing standard in the case of school bus floor joints. In 1987, the NHTSA published an ANPRM concerning school bus floor joint strength, and has initiated a research program involving the dynamic testing of school bus floor joints. Current research is scheduled for completion the second quarter of calendar year 1989, and a decision on whether to institute additional rulemaking is scheduled for the third quarter of calendar year 1989.

The Safety Board believes it is important that the NHTSA resume testing of school bus floor joints. However, the Safety Board also recognizes that the NHTSA will not resume testing until it amends FMVSS 221. In amending FMVSS 221, the NHTSA must make it clear that all body panel and floor joints are subject to the standard. It also must delete the provision in subsection S5 that permits the strength of the floor joint be 60 percent of the strength of the weakest material being joined to eliminate the apparent anomaly which exists in the present standard. Further, any tests specified in any revised standards must reflect the loadings experienced in actual crashes (often tensile or peel rather than shear); and static testing of the entire floor system should be considered in conjunction with dynamic tests. Accordingly, the Safety Board is superseding Safety Recommendations H-86-54, H-86-55, and H-86-56 with a new recommendation urging the NHTSA to expedite the process of revising FMVSS 221.

Revision of Thomas Floor Joint Fastening

In October 1988, Thomas notified the Safety Board that it is revising the method used to fasten its floor joints. Thomas submitted test data indicating that the revised method of fastening exceeds on average the 15,228-pound strength the NHTSA required for compliance with FMVSS 221. Based on Thomas' notification, the Safety Board classified Safety Recommendation H-86-57 "Open--Acceptable Action" until Thomas notifies the Safety Board that the floor joint modification has been implemented.

CONCLUSIONS

Findings

1. The truckdriver and the school bus driver were properly licensed to drive in Florida.

2. The weather and the condition of the highway did not contribute to this accident.

3. There was no mechanical defect in either of the accident-involved vehicles which contributed to the cause of the accident.

4. The accident cannot be attributed to any performance errors of the school bus driver.

5. The truckdriver was operating his vehicle about 10 mph over the posted speed limit before he applied his brakes; the truck's speed at impact was about 42 mph.

6. Sufficient information was not available to determine if the truckdriver's performance in this accident was affected by marijuana.

7. The Safety Board is unable to determine why the truckdriver failed to stop his vehicle at the stop sign.

8. Use of the available lapbelt would not have prevented the school bus driver's fatal injuries because the amount of crush at the school bus driver's position did not provide for survivable space.

9. The schoolbus occupants in the first row of seats were ejected forward and made contact with the roof; had these occupants been using lapbelts, they might have been pinned or crushed in the wreckage and possibly sustained more serious or even fatal injuries.

10. The collapse of the school bus floor under the first three seat rows probably exacerbated most of the injuries sustained by the occupants of the second and third seat rows in the school bus.

11. The collapse of the school bus floor contributed to the death of the 11-year-old male passenger who was seated in the fourth seat on the left side of the school bus before the collision.

12. When statically tested in both peel and shear the floor joint manufactured by Thomas Built Buses was the weakest of the floor joints tested by the Safety Board.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the truckdriver's failure, for undetermined reasons, to stop his vehicle at the stop sign. Contributing to the severity of this accident was the speed of the truck and the loss of structural integrity of the school bus because of the collapse of the school bus floor.

RECOMMENDATIONS

As a result of its investigation, the National Transportation Safety Board made the following safety recommendations:

--to the National Highway Traffic Safety Administration:

Expedite the process of amending Federal Motor Vehicle Safety Standard (FMVSS) 221 to make clear that all floor joints are subject to FMVSS 221, to remove the apparent anomaly caused by subsection S5 (Strength Requirements), and to make tests for compliance with the standard more reflective of the type of loadings experienced by the floor joints in actual crashes. (Class II, Priority Action)(H-89-20)

--to the governor and the legislative leaders of the Florida General Assembly:

Amend the Florida Statutes to assess the full number of driving points when a Florida-licensed driver is convicted of a driving violation out of state or in a Federal court. (Class II, Priority Action)(H-89-21)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
Acting Chairman

/s/ Jim Burnett
Member

/s/ John K. Lauber
Member

/s/ Lenoine V. Dickinson, Jr.
Member

Joseph T. Hall, Member, did not participate.

May 1, 1989

APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

Investigation

The National Transportation Safety Board was notified of this accident at 4 p.m. on August 28, 1987, by the news media.

Highway accident investigators were dispatched from the Safety Board's headquarters office in Washington, D.C., and arrived on scene at 10:30 a.m. on August 29, 1987. Participating in the investigation were representatives of the Florida Highway Patrol, the School Board of Levy County (Florida), Airdrome Tire Centers, Inc., Blue Bird Body Company, Carpenter Body Works, Inc., Thomas Built Buses, Inc., American Transportation Corporation, Wayne Corporation, and the National Highway Traffic Safety Administration.

Deposition and Hearing

On February 17, 1988, Safety Board investigators took depositions from representatives of the Alachua County (Florida) Department of Emergency Services in Gainesville, Florida.

APPENDIX B

FMVSS 221, SCHOOL BUS BODY JOINT STRENGTH (49 CFR 571.221)

§ 571.221 Standard No. 221; School bus body joint strength.

S1. *Scope.* This standard establishes requirements for the strength of the body panel joints in school bus bodies.

S2. *Purpose.* The purpose of this standard is to reduce deaths and injuries resulting from the structural collapse of school bus bodies during crashes.

S3. *Application.* This standard applies to school buses with gross vehicle weight ratings of more than 10,000 pounds.

S4. *Definitions.* "Body component" means a part of a bus body made from a single piece of homogeneous material or from a single piece of composite material such as plywood.

"Body panel" means a body component used on the exterior or interior surface to enclose the bus' occupant space.

"Body panel joint" means the area of contact or close proximity between the edges of a body panel and another body component, excluding spaces designed for ventilation or another functional purpose, and excluding doors, windows, and maintenance access panels.

"Bus body" means the portion of a bus that encloses the bus's occupant space, exclusive of the bumpers, the chassis frame, and any structure forward of the forwardmost point of the windshield mounting.

S5. *Requirement.* When tested in accordance with the procedure of S6., each body panel joint shall be capable of holding the body panel to the member to which it is joined when subjected to a force of 60% of the tensile strength of the weakest joined body panel determined pursuant to S6.2.

S6. *Procedure.*

S6.1 *Preparation of the test specimen.*

S6.1.1 If a body panel joint is 8 inches long or longer, cut a test specimen that consists of any randomly selected 8-inch segment of the joint, together with a portion of the bus body whose dimensions, to the extent permitted by the size of the joined parts, are those specified in Figure 1, so that the specimen's centerline is perpendicular to the joint at the midpoint of the joint segment. Where the body panel joint is not fastened continuously, select the segment so that it does not bisect a spot weld or a discrete fastener.

S6.1.2 If a joint is less than 8 inches long, cut a test specimen with enough of the adjacent material to permit it to be held in the tension testing machine specified in S6.3.

S6.1.3 Prepare the test specimen in accordance with the preparation procedures specified in the 1973 edition of the Annual Book of ASTM Standards, published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

S6.2 *Determination of minimum allowable strength.* For purposes of determining the minimum allowable joint strength, determine the tensile strengths of the joined body components as follows:

(a) If the mechanical properties of a material are specified by the American Society for Testing and Materials, the relative tensile strength for such a material is the minimum tensile strength specified for that material in the 1973 edition of the Annual Book of ASTM Standards.

(b) If the mechanical properties of a material are not specified by the American Society for Testing and Materials, determine its tensile strength by cutting a specimen from the bus body outside the area of the joint and by testing it in accordance with S6.3.

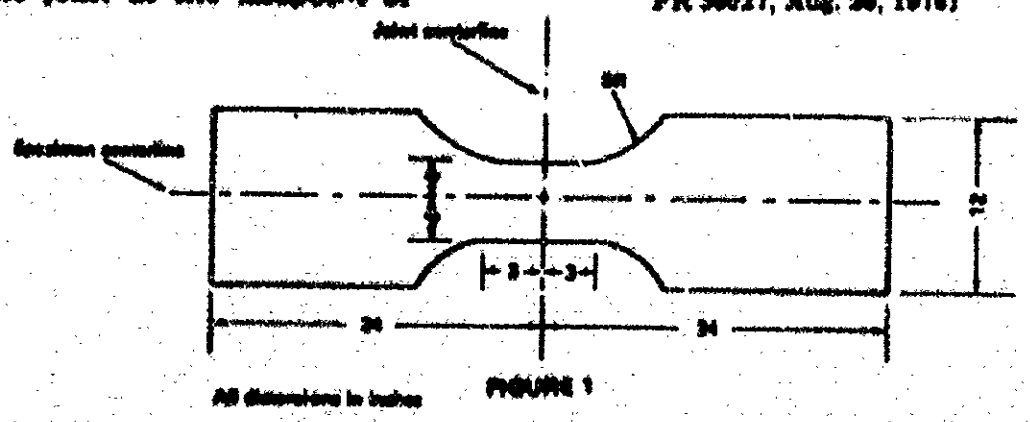
S6.3 *Strength test.*

S6.3.1 Grip the joint specimen on opposite sides of the joint in a tension testing machine calibrated in accordance with Method E4, Verification of Testing Machines, of the American Society for Testing and Materials (1973 Annual Book of ASTM Standards).

S6.3.2 Adjust the testing machine grips so that the joint, under load, will be in stress approximately perpendicular to the joint.

S6.3.3 Apply a tensile force to the specimen by separating the heads of the testing machine at any uniform rate not less than ⅛ inch and not more than ½-inch per minute until the specimen separates.

[41 FR 3972, Jan. 27, 1976, as amended at 41 FR 36027, Aug. 26, 1976]



All dimensions in inches

FIGURE 1

APPENDIX C

SUMMARY OF NHTSA FLOOR JOINT TEST RESULTS

Manufacturer	Year of bus	Pass/ Fail	CIR Number	Final Disposition
Sheller-Globe (Superior)	1977	Fail	2005	closed by OCC*
Crown Coach Corp.	1978	Fail	2084	closed by OVSC**
Gillig Corp.	1978	Fail	2088	closed by OVSC
Northern	1978	Pass	N/A	N/A
Thomas Built Buses, Inc.	1979	Fail	2262	closed by OCC
Carpenter Body Works, Inc.	1980	Pass	N/A	N/A
Sheller-Globe (Superior)	1980	Pass	N/A	N/A
Blue Bird Body Company	1980	Pass	N/A	N/A
Thomas Built Buses, Inc.	1980	Fail	2416	closed by OCC
Sheller-Globe (Superior)	1980	Pass	N/A	N/A
Thomas Built Buses, Inc.	1981	Fail	2527	closed by OCC
Carpenter Body Works, Inc.	1981	Fail	2494	recalled
Ward School Bus, Inc.	1981	Fail	2497	went bankrupt; closed by OVSC

OCC--National Highway Traffic Safety Administration, Office of the Chief Counsel
OVSC--National Highway Traffic Safety Administration, Office of Vehicle Safety Compliance

APPENDIX D

NTSB COMMENTS ON ANPRM CONCERNING FLOOR JOINT STRENGTH AND FMVSS 221

AUG 2 5 1987

COPY

Docket Section
Room 5109
National Highway Traffic Safety Administration
400 Seventh Street S.W.
Washington, D. C. 20590

Dear Sirs:

The following are the National Transportation Safety Board's comments to the Advance Notice of Proposed Rulemaking (ANPRM) published at 52 FR 23314-23316 on June 19, 1987, 49 CFR Part 571; Docket No. 73-34; Notice 08. The ANPRM requests comments on whether the National Highway Traffic Safety Administration (NHTSA) should amend Federal Motor Vehicle Safety Standard (FMVSS) 221 as it relates to schoolbus floors and maintenance access panels, and requests comments on testing procedures to determine compliance with FMVSS 221.

Schoolbus Floor Joints and FMVSS 221

As a result of its investigations of accidents involving large post-FMVSS 221 schoolbuses, the Safety Board has concluded that FMVSS 221 has generally improved the crashworthiness of large schoolbuses. However, as a result of its investigation of an accident involving a post-standard schoolbus manufactured by Thomas Built Buses, Inc. which occurred near Snow Hill, North Carolina, on May 31, 1985, and which involved a floor panel separation, the Safety Board on October 2, 1986, sent the following Safety Recommendations to the NHTSA:

H-86-54

Amend or clarify Federal Motor Vehicle Safety Standard 221 to require that body panel joints for schoolbus body structures be tested in tension or peel unless they can only be tested in shear.

H-86-55

Amend or clarify Federal Motor Vehicle Safety Standard 221 to include all body panel joints that enclose the occupant space.

H-86-56

Resume testing of schoolbus floor joints to ensure compliance with Federal Motor Vehicle Safety Standard 221.

Safety Recommendation H-86-54 was based upon the Safety Board's finding that FMVSS 221 is unclear as to whether body panel joints should be tested in tension, peel, or shear. In tests performed for the NHTSA in February 1981 and March 1982, shear forces only were applied after a modification of the floor joint was done before testing. The Safety Board believes that the methodology used in the NHTSA tests was not as representative of the forces experienced in the Snow Hill accident as floor joint tests performed by the Safety Board where tension or peel forces were applied.

Safety Recommendation H-86-55 was based upon the Safety Board's finding that FMVSS 221 should be clarified to include all body panel joints that enclose the occupant space even if they are structural. This finding was based upon examination of correspondence between the NHTSA and Thomas Built Buses, Inc., during 1980, 1981, and 1982, which indicated that Thomas disagreed with NHTSA's position concerning the applicability of the floor joint strength requirement to the floor joints of schoolbuses built by Thomas, and that the NHTSA failed to require Thomas to comply with the standard.

Safety Recommendation H-86-56 was made after the investigation of the Snow Hill accident and disclosed that the NHTSA had discontinued testing of all schoolbus floor joints for compliance with the FMVSS 221 joint strength requirement in 1982.

As a result of its investigation of the Snow Hill accident, the Safety Board also recommended that Thomas Built Buses should strengthen the floor panel joints of all newly-manufactured schoolbuses to ensure that they comply with the requirements of FMVSS 221. Safety Board tests of undamaged floor joints from the Snow Hill schoolbus disclosed that the strength of the strongest floor joint tested was 7% of the strength required for the joint to be in compliance with FMVSS 221.

The Safety Board believes that the floor of a schoolbus is an integral part of the passenger envelope and, as such, should be required to meet at least the same performance requirements for joint strength as the joints in the sidewalls, the roof, and the front and rear walls. The Safety Board also believes that a separate joint strength test or requirement for floors, as opposed to other schoolbus body components as mentioned in the ANPRM, is not justified by the present record, and the Safety Board opposes any such separate test or requirement unless it imposes a higher joint strength requirement than is specified in the present standard.

The Safety Board also opposes the dynamic testing of schoolbus floors that have been separated from their adjacent body components before testing. Although the Safety Board agrees that, in theory, dynamic testing under carefully controlled and repeatable conditions may more closely approximate real-world crash situations, testing of floor components which have been separated from their adjacent body components in the Safety Board's view defeats the attempt to simulate real-world crashes.

Additionally, in practice, dynamic testing as discussed in the ANPRM is far more complicated than static testing and may introduce variables which experience may show to be uncontrollable and nonrepeatable, thereby invalidating the results of the test(s). Even if the NHTSA believed that all the pertinent variables were identified and controlled, dynamic testing may permit a noncompliant manufacturer to allege the presence of other uncontrolled variables and thereby cloud the issue sufficiently to effectively prevent the NHTSA from successfully pursuing any enforcement action.

On the other hand, static testing as required by the present standard has fewer uncontrollable variables, can be repeatedly performed relatively inexpensively on component samples by manufacturers during design or production operations, and appears to be a generally objective test to determine joint strength which has been accepted by at least the majority of the manufacturers of large schoolbuses. Furthermore, compliance with the present standard seems to be effective in accomplishing the standard's intended objective. In the 10 years it has been in effect, the present standard has, in the Safety Board's view, made a positive contribution to the improved crashworthiness of large schoolbuses.

Although the ANPRM mentions that dynamic testing may "be more readily enforceable" than the current static test, for the above reasons, the Safety Board does not believe that dynamic testing would automatically enhance the "enforceability" of the standard.

From a conceptual standpoint, the Safety Board does not oppose repeatable dynamic testing as a means for determining the crashworthiness of schoolbuses. However, validation of any dynamic test may take years to accomplish, if ever. The Safety Board is concerned that the NHTSA, in the interim, may further discontinue testing for compliance with, and enforcement of, a joint strength standard substantially in its present form.

It is true that FMVSS 221 permits the joining of materials with greatly differing strengths, and which therefore could result in comparatively weak body joints which still are in

technical compliance with the present standard. The Safety Board does not believe that the existence of this "loophole" is adequate justification or makes a persuasive argument for any extensive revision of the present standard. The information available to the Safety Board thus far indicates that no manufacturer of large schoolbuses has attempted to utilize this "loophole" to circumvent the intent of the standard.

The Safety Board seriously doubts that any manufacturer will ever attempt to join materials of greatly differing strengths in constructing a schoolbus floor. Such a poor engineering practice would be easily recognizable by any informed potential buyer, would subject the manufacturer to pressures in the marketplace which could not be ignored, and would provide the NHTSA with more than adequate justification to promulgate rules specifying absolute minimum schoolbus body joint strength(s).

Thus far it has been the Safety Board's experience that the problem of relatively weak floor joints is not attributable to the juncture of materials with greatly differing strengths, but rather to the lack of a sufficient number or type of fastening devices or welds between adjoining metal floor panels which were in fact fabricated of the same material.

The Safety Board does not believe that any extensive revisions of FMVSS 221 as the standard applies to schoolbus floor joints is necessary or justified by the record, and that any perceived problems concerning applicability and enforcement of the standard as it applies to schoolbus floor joints can be accomplished by minor amendments or interpretations of the present rule, followed by vigorous enforcement by the NHTSA.

Maintenance Access Panels

As a result of its investigation of an accident involving a post-standard schoolbus which occurred on April 29, 1985, near Tuba City, Arizona, and two other accidents which occurred on December 11, 1984, near Durango, Colorado, and September 11, 1985, in Woodside, Delaware, the Safety Board on February 6, 1986, recommended that the NHTSA:

H-85-51

Revise Federal Motor Vehicle Safety Standard 221, School Bus Body Joint Strength, to require that the joints of interior body maintenance access panels within a defined occupant contactable zone meet the joint strength performance requirement of the standard.

In its March 31, 1986, response to this recommendation, the NHTSA advised the Safety Board that it did not believe rulemaking to amend FMVSS 221 was justified at the time because the NHTSA was concerned that "requiring additional fasteners on maintenance access panels might increase poor or inadequate maintenance of schoolbuses and result in a negative effect on safety," because "the added time and effort needed to unfasten these panels might result in necessary schoolbus maintenance being deferred or entirely ignored by maintenance personnel under scheduling pressures," and that "the integrity of the panels would be dependent on replacement of the fasteners."

Because of the NHTSA's failure to take more positive action, on July 1, 1985, Safety Recommendation H-85-51 was placed in a "Closed--Unacceptable Action" status.

As a result of its investigation of a schoolbus crash which occurred in St. Louis County, Missouri, on November 11, 1985, the Safety Board concluded that one of the schoolbus passengers sustained a head injury due to contact with an interior body panel joint which was exposed when the maintenance access panel covering the joint's edges separated. As a result of its investigation of the St. Louis accident and 42 other crashes involving large post-standard schoolbuses, five of which resulted in maintenance access panel separations, on May 1, 1987, the Safety Board recommended that the NHTSA:

H-87-11

Amend FMVSS 221, Schoolbus Body Joint Strength, to include interior maintenance access panels in the standard's performance requirements.

The Safety Board believes that exemption of interior maintenance access panels from the joint strength requirement of FMVSS 221 poses an unnecessary hazard for the occupants of large schoolbuses. The standard should be amended to remove this exemption.

Respectfully yours,

ORIGINAL SIGNED BY
JIM BURNETT

Jim Burnett
Chairman