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Highway Accident Report: Greyhound Lines, Inc., Intercity Bus Loss of Control and Overturn Interstate Highway 65 in Nashville, Tennessee, November 19, 1988

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

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16. Abstract

About 6 45 a m , central standard time, on November 19, 1988, an intercity bus with 45 occupants, traveling southbound through a construction zone on Interstate Highway 65 in Nashville, Tennessee, suddenly went out of control during a steering maneuver, rotated 190 degrees clockwise in the southbound lanes, overturned on its left side, and came to rest facing northbound on the southbound embankment Witness reports indicate that the bus was traveling at a high rate of speed in conditions of heavy rain The unrestrained bus driver and 38 passengers were injured in the accident Twelve passengers sustained serious injuries, and the bus driver and 26 passengers received minor injuries Six passengers were not injured Injured persons were taken to sever area hospitals for treatment

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CONTENTS

APPENDIXES

EXECUTIVE SUMMARY

About 6:45 a.m., central standard time, on November 19, 1988, an intercity bus with 45 occupants, traveling southbound through a construction zone on Interstate Highway 65 in Nashville, Tennessee, suddenly went out of control during a steering maneuver, rotated 190 degrees clockwise in the southbound lanes, overturned on its left side, and came to rest facing northbound on the southbound embankment. Witness reports indicate that the bus was traveling at a high rate of speed in conditions of heavy rain. The unrestrained bus driver and 38 passengers were injured in the accident. Twelve passengers sustained serious injuries, and the bus driver and 26 passengers received minor injuries. Six passengers were not injured. Injured persons were taken to seven area hospitals for treatment.

The National Transportation Safety Board determines that the probable cause of this accident was the operation of the bus at a speed that was above the regulatory limit and too great for existing weather conditions, which resulted in the bus driver's loss of control. Contributing to the loss of control were the variant frictional properties of the travel lanes in the construction zone.

The safety issues discussed in the report include:

- Adequacy of driver training.
- Annual reviews of driver performance records by Greyhound personnel, and Federal regulations concerning these reviews.
- Federal regulations concerning medical certification of commercial drivers.
- Skid accident reduction efforts by the Tennessee Department of Transportation.

Safety Recommendations addressing these issues were made to Greyhound Lines Inc., the Tennessee Department of Transportation, and the Federal Highway Administration.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT

GREYHOUND LINES, INC., INTERCITY BUS LOSS OF CONTROL AND OVERTURN, INTERSTATE HIGHWAY 65 IN NASHVILLE, TENNESSEE NOVEMBER 19, 1988

INVESTIGATION

The Accident

About 3:45 a.m. central standard time on Saturday, November 19, 1988, an intercity bus operated by Greyhound Lines, Inc., departed Louisville, Kentucky, heading south toward Nashville, Tennessee, with several intermediate stops en route. The bus was on a regularly scheduled run that originated in Cincinnati, Ohio, and was due to terminate in Tallahassee, Florida. There was a change of drivers in Louisville. The bus had been scheduled to leave that city's terminal at 3:15 a.m., but the departure was delayed approximately 30 minutes because of heavy rain in the area.

The bus arrived in Franklin, Kentucky, the last scheduled stop before Nashville, about 6:05 a.m. It left about 6:15 a.m. with 44 passengers and entered Interstate Highway 65 (I-65). (See figure 1.) Shortly after that, the bus driver directed the bus from the right to the left southbound lane, but he soon returned to the right and remained there. He did so, the bus driver later explained, because rain on the side mirror was limiting his rearward visibility; and also because of the rain, he was uncomfortable maintaining a speed of 55 to 60 mph, which was the speed of traffic in the left lane.

An 8.1-mile portion of I-65 in the Nashville area was under construction at the time. At the beginning of the construction zone, there was a shift in the two travel lanes, so that the normal outside lane became the temporary inside lane (lane 2, see figure 2) and the paved right shoulder became the temporary outside lane (lane 1). The shoulder was repaired and reinforced to strengthen the pavement, wherever necessary, to accommodate traffic during construction. A sign was posted about 4/10 mile before the beginning of the construction zone advising trucks to use the left lane. Although the sign did not specifically include buses, the bus driver later indicated that he believed it applied to him.

As the bus approached the construction zone, the bus driver said, he had "every intention of getting over to the left lane," but traffic in that lane prevented him from doing so. With no vehicles obstructing his path in the right lane, he decided to stay there. Once in the construction zone, he still did not find it possible to change lanes.

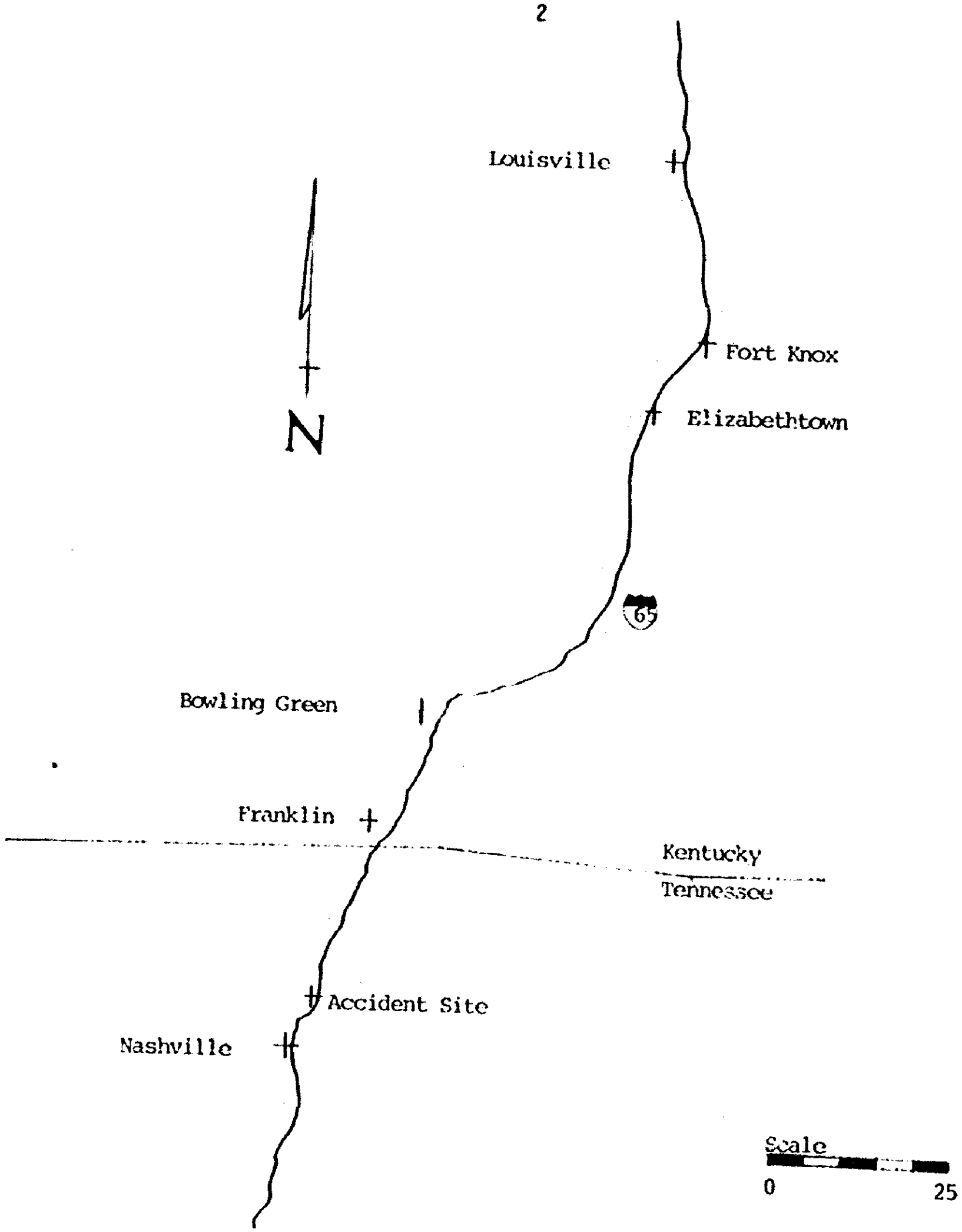

Figure 1.--Map showing bus route and accident location.

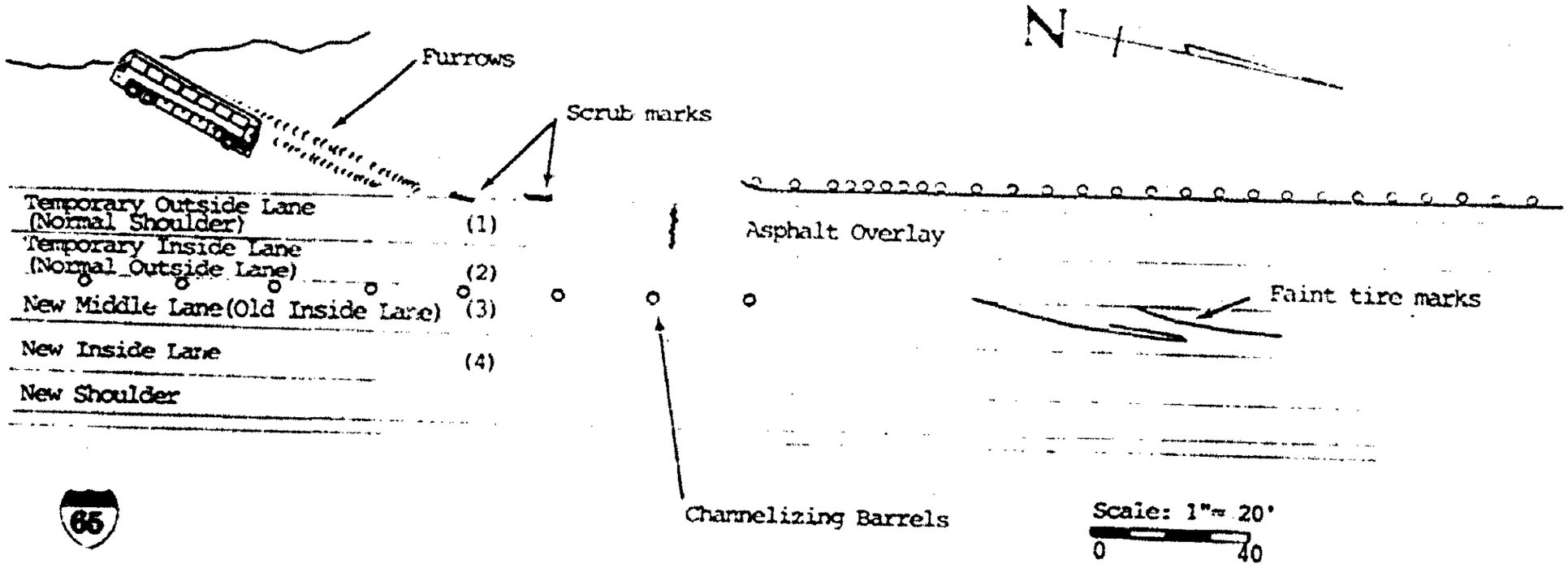

Figure 2.--Accident scene diagram.

Skies were overcast at the time, with moderate to heavy rain. Some of the passengers later indicated that the bus driver was driving too fast for conditions. One passenger commented that, during the trip, "he was passing every vehicle on the road." The driver of a car that was passed by the bus just before the accident estimated that the bus was traveling at 65 mph. The posted speed limit for the highway was 55 mph, but in the construction zone it was reduced to 45 mph. The bus driver later stated that his speed had been 55 mph, but that in the construction zone at the time of the accident he was traveling at 45 miles per hour. However, he also indicated that from the time he entered the construction zone until the accident, he did not look at his speedometer.

About 6:45 a.m., after the bus had been traveling in the construction zone for approximately four miles, it was passed on the left by two automobiles, one following closely behind the other. According to the bus driver and witnesses, the first of these moved right, in front of the bus, to allow the other to pass. As a result, the bus driver later said, the distance between the bus and the next vehicle in front was reduced from 6-8 seconds to less than 3-4 seconds.[1] The bus driver indicated that he was not comfortable with this amount of following distance and chose to steer into the adjacent left lane without braking. Instead of staying in the intended lane, the bus continued farther leftward into the next lane, which was closed to traffic because of the construction. (See figure 2.) The bus driver was able to steer back toward the right, but after returning to the inside travel lane (lane 2), the bus began to rotate clockwise. After rotating approximately 190°, the bus left the right side of the roadway and overturned on its left side. The bus struck several trees and came to rest facing north on the southbound embankment. There was no fire. (See figure 3.)

In addition to the bus driver, there were 37 adults, four children, and three infants on board. The driver, who was not wearing his lapbelt, was ejected out the front of the bus, landing on the windshield, which remained intact after detaching from the bus. None of the passengers was ejected from the bus, and, following the accident, most were able to exit the bus unassisted or with the aid of motorists who stopped to help. In the majority of cases, the passengers went out through the windshield area; some, though, crawled through an opening found in a damaged portion in the left rear of the bus, or through right side windows. By the time emergency response personnel arrived at the scene, only five passengers, all incapacitated, remained in the bus.

The Nashville Metropolitan Fire Department Communications Center was notified of the accident at 6:50 a.m. The first rescue unit arrived on the scene four minutes later, and the first ambulance one minute after that.

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[1]Under Greyhound procedures, following distance is expressed in seconds, i.e., the interval between the moment the vehicle in front passes a given point on the highway and when the bus passes the same point. At 45 mph, 6-8 seconds is equivalent to 395-527 feet, and 3-4 seconds would be 197-263 feet; at 65 mph, 6-8 seconds is equivalent to 571-762 feet, and 3-4 seconds would be 285-381 feet.

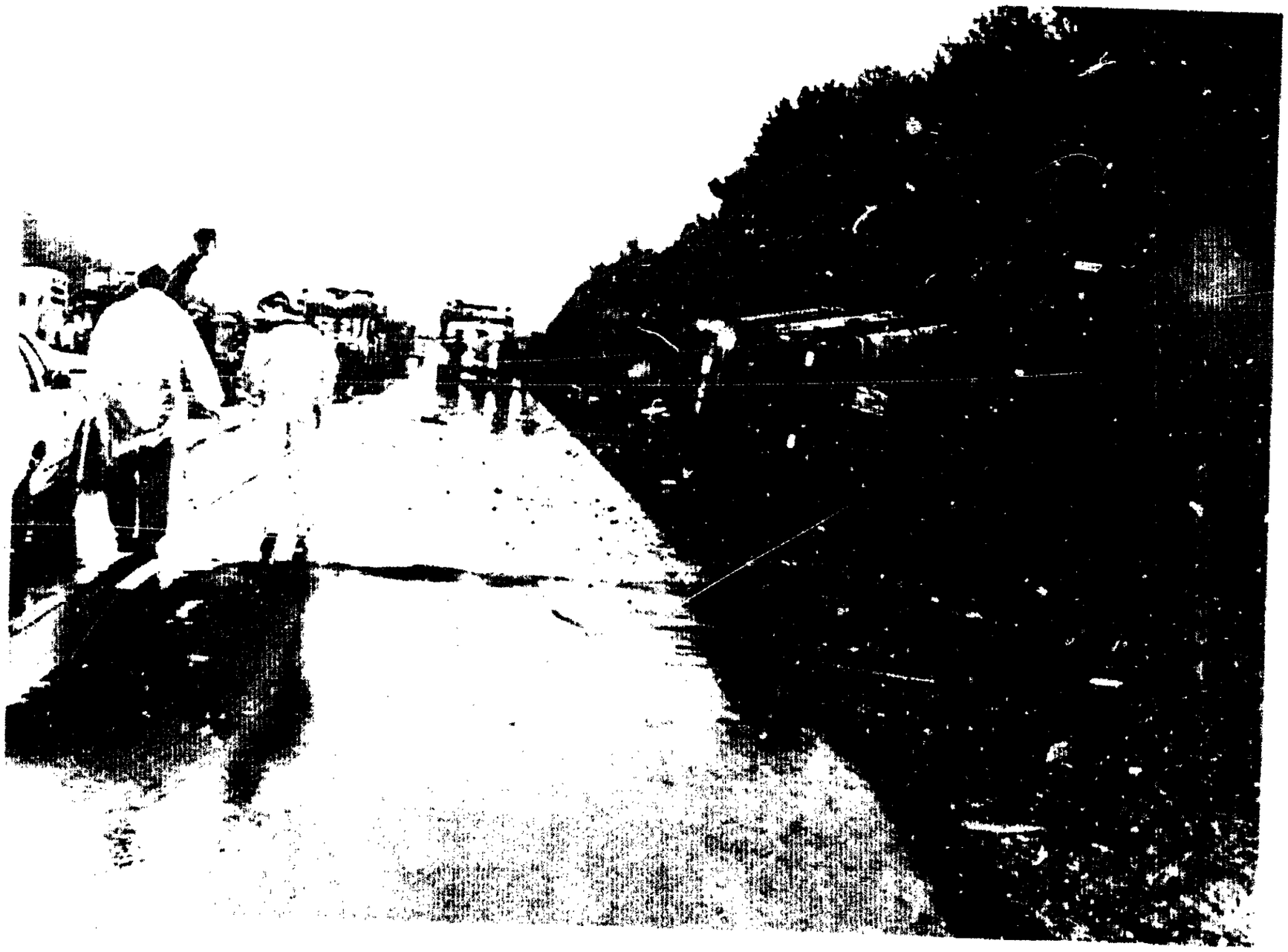

Figure 3.--General photo of accident scene.

The total fire department response consisted of nine ambulances, two rescue units, one fire engine, and one high rise rescue unit,[2] along with the Fire Chief and three assistant chiefs. A triage area was established at the site at 7:00 a.m., and a multiple-casualty emergency plan was activated at 7:20 a.m. Under that plan, additional medical units both within and outside the county provided backup service at fire stations in the event of additional emergencies. The Nashville Metropolitan Police Department was notified of the accident at 7:03 a.m. and responded with a supervisor and seven police units to investigate the accident and control traffic. At 8:27 a.m. the last fire department unit left the scene.

Injuries

All bus occupants were transported to seven local hospitals. In addition to the emergency vehicles, a transit bus provided transportation; one passenger was flown to Vanderbilt University Hospital by helicopter. The bus driver sustained a minor back sprain; he was treated at a hospital and released. Of the 44 passengers, 13 were admitted to four hospitals, including one infant with minor injuries admitted for observation; 25 were treated and released; and 6 either refused treatment or were not injured.

International Civil Aviation Organization Injury Criteria

	Driver	Passengers	Total
Fatal	0	0	0
Serious	0	12	12
Minor	1	26	27
None	0	6	6
Total	1	44	45

Abbreviated Injury Scale (AIS)[3] Table

	Driver	Passengers	Total
Maximum Injury, Virtually Unsurvivable (AIS-6)	0	0	0
Critical (AIS-5)	0	1	1
Severe (AIS-4)	0	0	0
Serious (AIS-3)	0	4	4
Moderate (AIS-2)	0	7	7
Minor (AIS-1)	1	26	27
None (AIS-0)	0	6	6
Unknown (AIS-9)	0	0	0
Total	1	44	45

[2]An emergency response unit with equipment primarily used in operations at high rise buildings.

[3]Abbreviated injury scale of the Association for the Advancement of Automotive Medicine, revised in 1985.

The passenger with the AIS-5 injury was a 52-year-old woman, suffering from a flailed chest. The four passengers with AIS-3 injuries were listed in hospital records as: symphysis pubic separation; pneumothorax; multiple rib fractures; and fractured left femur and left tibia.

Vehicle Mechanical Description and External Damage

The accident bus was a three-axle intercity coach with seating for 47 passengers. Manufactured by the Transportation Manufacturing Corp. in November 1987, the bus, model number 102A3, was owned and operated by Greyhound Lines Inc. and bore Greyhound number 2095. The bus had a rear-mounted diesel engine, power steering, and a four-speed automatic transmission. At the time of the accident, it had an estimated gross weight of 37,300 pounds.

The bus was equipped with air-mechanical brakes on all wheels and parking brakes on the middle (drive) axle. All brake linings were found to be at least 75 percent of their original thicknesses. Pushrod travel was measured for the front (steering) axle and the rear (bogie) axle service brakes. All were adjusted within the manufacturer's recommended standard. Accurate measurements could not be made on the drive axle brakes, because they had been backed off after the accident to accommodate towing.

The bus had eight Goodyear steel-belted radial tires. All had original tread except tires on both right drive wheels and the right bogie, which were regrooved. Tread depth on the tires ranged from 7/32 inch to 18/32 inch.[4] On all but two of the tires, inflation pressures were within six pounds per square inch (psi) of the standards set by Greyhound policy.[5] In both cases where there were greater discrepancies (the left bogie tire was 40 psi under the appropriate standard, and the left outer drive tire was 30 psi underinflated), the tire had been pulled away from the rim, allowing debris to get between the tire bead and the rim. When these tires were later reinflated to 90 psi and sprayed with a soap solution, bubbles formed on both tires in the area where the debris was trapped, indicating that the seal was broken at these points during the accident. The footprint aspect ratios for all eight tires were measured. These tire footprints ranged from 9.0 inches wide by 9.4 inches long for the left front tire to 7 by 7 for the right tire on the bogie axle.

Because the bus came to rest on its left side, damage was extensive along the entire left side of the bus, including scraping and gouge marks. The left rear cargo bay door was missing. Fragments of fluorescent orange

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[4] 49 CFR 393.75 requires that any tire on a bus, truck, or truck tractor have a tread groove pattern depth of at least 2/32 of an inch, when measured in a major tread groove, except for tires on the front wheels, which must have at least 4/32 of an inch. The steel-belted radial tires on the accident bus were manufactured with 19/32-inch tread depth.

[5] The standards are: 110 psi for tires on the steering axle; 90 psi for the drive axle; and 80 psi for the bogie axle.

channelizing barrels[6] were embedded in the left front grille and bumper and at several locations along the left side of the bus.

The rest of the damage was concentrated near the left rear corner, with much of the roof displaced rightward. The top left rear corner was displaced to the right about 39 inches; at a point 12 feet forward from the left rear corner, the roof was displaced rightward about 27 inches; and at the left front, the chassis shifted 12 inches. The roof above the seventh window on the left side was crushed downward and to the right. Both roof escape hatches, which are located above the aisle, were found open. The rear hatch frame was bent and distorted, as was most of the roof area around the frame. (See figure 4.)

The windshield, bus driver's side window, and sixth and seventh windows on the left side were damaged during the accident, and they were missing when the Safety Board examined the bus. All other side windows remained intact and in their frames. Although the main entrance door was not damaged, it could not be closed because of the roof displacement.

Interior Description and Damage

In addition to one seat for the bus driver, accommodations in the bus consisted of 11 sets of double-unit reclining seats on each side of a 14-inch center aisle, plus a set of three nonreclining seats in the rearmost row, across the aisle from a restroom. The seats were produced by American Seating Inc., Model W-6682-STG. There were aluminum restraining barriers, or modesty panels, in front of the first row of seats. Six of the seat armrests along the aisle on the right side were displaced toward the aisle. Other damage included two seats that were completely destroyed and two others that had crushed backs. These damaged seats were located in the left rear of the bus.

There were overhead luggage racks above the seats on both sides of the aisle, extending the full length of the passenger compartment. These 24-inch-wide racks were similar to those found on commercial aircraft in that they were constructed of ABS, a high-impact plastic material, and were equipped with top-hinged compartment doors. According to Greyhound officials, some of the buses purchased by the company since 1987 have been equipped with this type of enclosed overhead rack, but there is no established policy calling for the feature on all newly acquired vehicles. Instead, purchasing agents at the regional offices determine whether to order buses with the enclosed racks. Approximately 700 buses out of the 4,000-bus Greyhound fleet are currently equipped with enclosed luggage racks.

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[6]Devices used to close off lanes temporarily or otherwise alter the flow of traffic, usually during highway construction and maintenance projects. At the accident site, each barrel was held in place with either one or two sandbags.

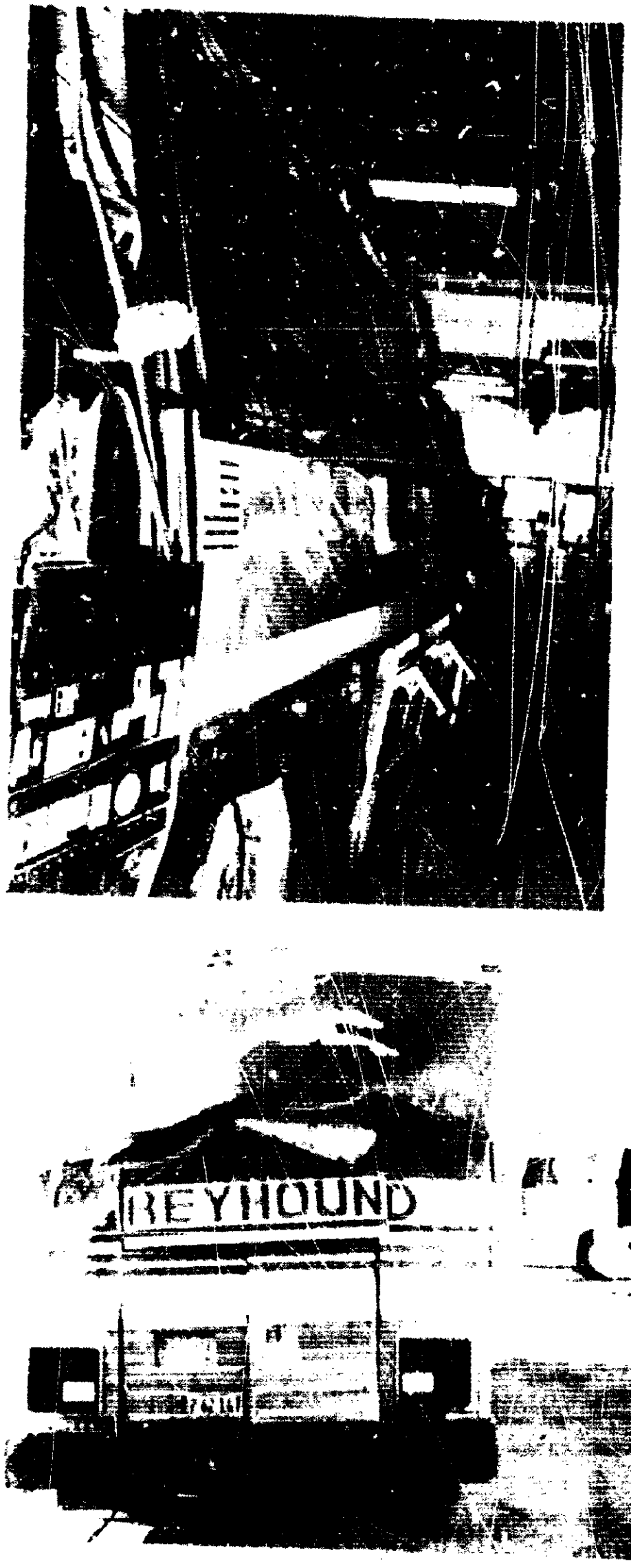

Figure 4.--Left side and rear views of the bus.

The interior damage was greatest on the left rear side of the bus; the sheet metal there intruded into the passenger compartment. Although the ceiling joints were bent and distorted, they did not separate. The rear bulkhead of the bus collapsed downward; and the luggage rack above the last two rows of seats on the left side collapsed down to the tops of the seatbacks. The entire left side luggage rack was loose, but it did not separate from the sidewall, and the overhead light panels were damaged. (See figure 5.) The doors to the racks remained closed during the accident. The passenger service units[7] were loose above the first eight rows of seats on the left and missing above the rearmost four rows.

Figure 5.--View of the bus interior.
(Overhead luggage rack doors opened by recovery personnel.)

Survival Factors

None of the passengers reported being struck with luggage from overhead. Several did state that they struck interior components or that other passengers had fallen on them during the overturn.

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[7] Fixtures above the seats containing individual reading lights and air vents for the passengers.

Additional information about the source of passenger injuries was unavailable, since none of the seriously injured passengers responded to Safety Board questionnaires, and subsequent efforts to contact them were unsuccessful.

The passenger seats were not equipped with any form of seatbelts, nor were they required to be. The bus driver's seat was equipped with a lapbelt, but he was not using it at the time of the accident.

Meteorological Information

At the time of the accident, the sky was overcast, with 2 miles visibility, and the wind was 8 knots. Sunrise was at 6:28 a.m. Based on information from the National Weather Service in Nashville, rainfall was light to moderate, about 0.17 inch per hour, with fog. However, the bus driver, passengers, and witnesses described the rainfall at the time of the accident as heavy. The temperature was about 51° F.

The Highway

General Information.-- The segment of I-65 on which the accident took place was built in the late 1960s and consisted of two 12-foot concrete travel lanes in each direction, separated by a 40-foot grass median, with 10-foot outside shoulders, constructed of asphalt, on each side. A construction project was begun in 1987 to provide an additional travel lane in each direction. The existing lanes would remain intact, becoming the outer and middle lanes when work was completed. The new lanes would be inner lanes; with inner shoulders and a concrete barrier between them, they were to replace the grass median. (See figure 2.)

While construction was in progress, southbound traffic entering the construction zone would shift to the right. The original inside lane (which would become the new middle lane -- lane 3) was closed to traffic. Plastic channelizing barrels were used to close off the lane. The outside lane remained open to traffic (lane 2). The outer shoulder was stabilized to establish a second travel lane during the construction (lane 1). Stabilization of the shoulder included application of asphalt overlays, or patches, to strengthen the pavement; the bus ran off the road approximately 50 feet past the end of a 300-foot overlay.

The accident site was near milepost 92, about 4/10 mile south of Old Hickory Boulevard. The bus came to rest approximately 30 feet off the roadway on a 3:1 crossslope embankment. The temporary southbound lanes were delineated with broken white lane lines and a solid white edgeline. At the accident site, the edgeline was obscured by the asphalt overlay.

According to the Tennessee Department of Transportation (DOT), the average daily traffic count in 1988 for the vicinity of the accident was 70,000. The speed limit at that location had been 55 mph. In May 1988, though, the contractor for the construction project requested that Tennessee DOT reduce the limit to 45 mph "as an added safety precaution for both the

traveling public and our work force."[8] In June the speed limit was reduced as requested. (See figure 6.)

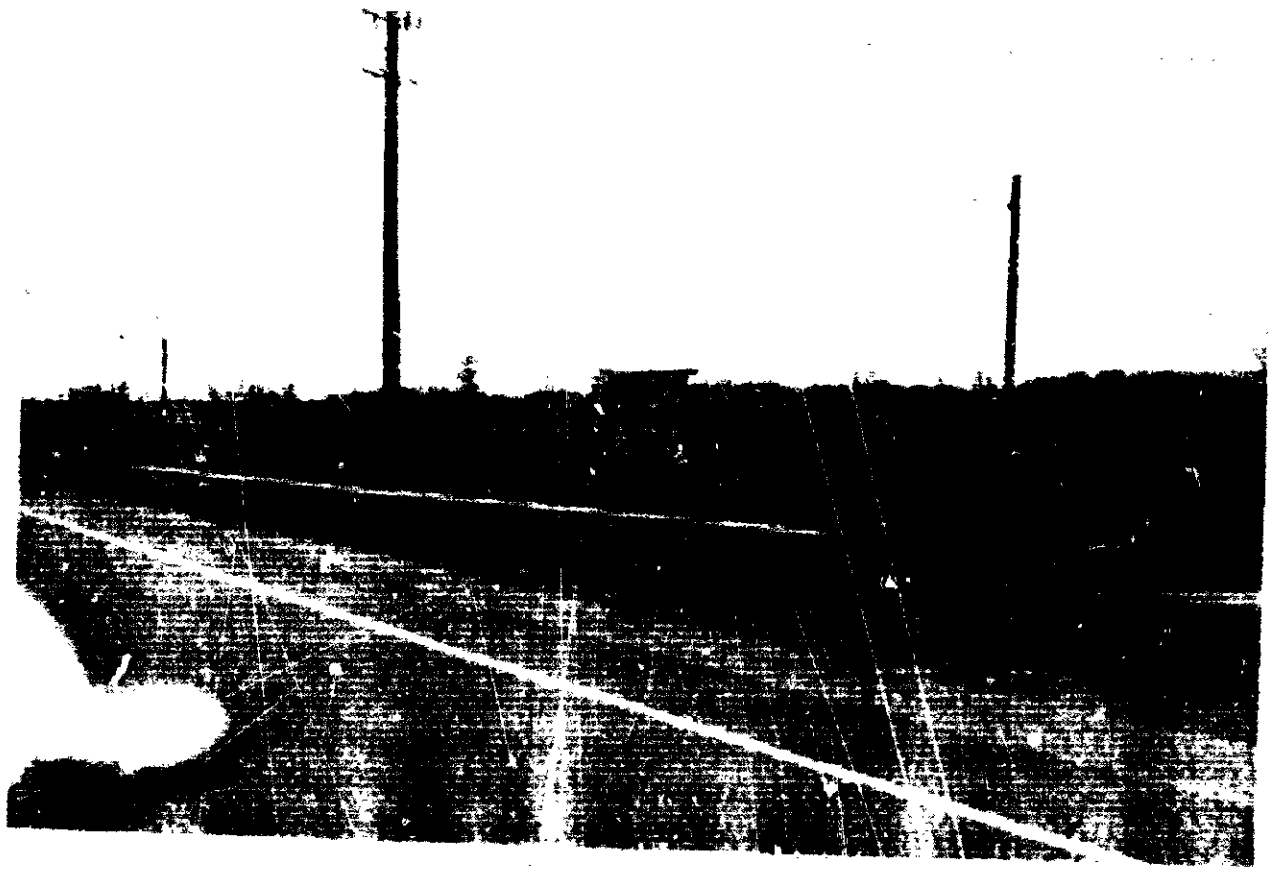

Figure 6.--Construction Zone 45 MPH Speed Limit Sign.

An accident rate was not available for this specific location; it does not appear in the State's file of hazardous or high-accident locations. Accident rates calculated using 1984-1986 data for two locations within a mile of the accident site averaged 0.20 accidents per million vehicles, compared with the statewide spot location average of 0.16 for rural freeways and 0.13 for urban freeways.

Road Surface Rehabilitation and Skid Resistance.--The construction project was federally funded and therefore subject to oversight by the Federal Highway Administration (FHWA). The total length of the project was 8.106 miles. Among other things, the construction plans called for adding the new travel lanes, stabilizing the outside shoulder, and rehabilitation of the existing concrete roadway. The FHWA had noted, in its Intermediate Inspection Report for the project, dated April 14, 1988, that "significant rutting exists in both the northbound and southbound right lanes." The Safety Board did find evidence of this deterioration about 4/10 mile north of the accident site, though not in the immediate vicinity of the site. Further, the Safety Board found no evidence of surface water ponding in the temporary outside lane (lane 1) at the accident site.

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[8]Letter from Michael L. Agee, Area Vice President, Rogers Group Inc., to Robert Williams, Resident Engineer, Tennessee Department of Transportation, May 5, 1988.

Under the original plans, the concrete pavement rehabilitation would entail, at the minimum: "A) Partial or full replacement of all damaged concrete slabs; B) 'Diamond' type grinding[9] of all concrete surfaces; C) Cleaning and sealing of all cracks and spalled areas; and D) Resealing of all transverse and longitudinal joints."

There are several reasons for performing diamond grinding in a highway rehabilitation project, one of which is to improve skid resistance. An FHWA training manual explained:

> Because grinding restores the cross slope and provides rougher macrotexture, it also improves skid resistance. Proper cross slope facilitates transverse drainage and reduces the potential for hydroplaning. The rough macrotexture initially provides high skid numbers. However, this improvement in macrotexture may be temporary, and the skid number may decline rapidly to pre-grinding levels if the pavement contains polishing aggregate.[10]

Before the construction plans were authorized by the FHWA, Tennessee DOT deleted the provision for diamond grinding from the Scope of Work section of the contract. When FHWA officials authorized the plans, they were unaware that the deletion had occurred. However, after construction began, the FHWA area engineer learned that diamond grinding had been eliminated.[11] In response to inquiries on the subject from the Safety Board, Tennessee DOT explained:

> ... the Tennessee Department of Transportation has had a varying history of results with the grinding of concrete pavements. However, it has now been decided to grind a short section of the old pavement on this project for further evaluation. If it can be determined that substantial improvement can be made to the riding quality and skid resistance to warrant further work, the

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[9] Diamond grinding is performed with closely spaced diamond saw blades, which cut a pattern and remove surface material from concrete pavement to provide a uniform traveling surface.

[10] Federal Highway Administration Pavement Management Course, Module 3F, "Diamond Grinding, Grooving, and Cold Milling," Section 4.6, "Surface Friction," page 350.

[11] Telephone conversations between Safety Board investigators and the FHWA Regional Administrator in Nashville, Tennessee, July 6, 1989.

Department will then determine how it should proceed with the remainder of this project.[12]

The Tennessee DOT also indicated that there may be a project within the next five years to overlay concrete lanes with asphalt. However, no schedule or scope of any potential project has yet been determined. Most interstate highways in Tennessee currently have asphalt pavement, except in urban areas, where concrete pavement still predominates on the interstate highways.

Four days after the accident, the Tennessee Department of Transportation conducted skid tests in the vicinity of the accident site, in accordance with standards established by the American Society for Testing and Materials. The tests were conducted on wet pavement at 40 mph. Skid numbers[13] were determined for the point at which the bus left the road and for a point within the section covered by the asphalt overlay. In addition, tests were performed at two locations north of the overlay: at milepost 92 (approximately 2,075 feet north of the end of the overlay) and at a position north of milepost 92. The tests were performed in both of the lanes that were open to traffic during the construction project, once in the concrete lane (lane 2) and twice in the asphalt lane (lane 1), in all cases in the right wheel path. The test results are as follows:

Location	Lane 2 (Left, Concrete)	Lane 1 (Right, Asphalt) First Run	Lane 1 (Right, Asphalt) Second Run
North of Milepost 92	27	28	30
Milepost 92	27	27	26
Area of Asphalt Overlay	27	49	42
Point Where Bus Left the Road	27	30	30

The new inside lane (lane 4) is composed of newly tined[14] concrete. Tennessee DOT indicated that, based on past experience, such new pavement could develop skid numbers approaching 60.

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[12] Letter from the Regional Engineering Director, Tennessee Department of Transportation, to National Transportation Safety Board investigator, March 16, 1989.

[13] Skid number is the tire-to-pavement friction coefficient X 100, for a specified set of test conditions. Although there is no consensus of opinion on appropriate skid numbers for wet pavement surface, the Commonwealth of Kentucky, a leader in skid resistance research, has developed the following criteria:

Above 39 - Good Skid Resistance
33 to 39 - Marginal
26 to 32 - Slippery
Below 26 - Very Slippery

[14] Tined concrete is mechanically grooved as it is cured.

Physical Evidence of the Accident.--Three faint, rightward curving tire marks were found in the new middle lane (lane 3, previously the left concrete lane, which was closed to traffic) beginning 158 feet north of the south end of the asphalt overlay. Additional tire marks were located at the right edgeline of the asphalt lane (lane 1), about 60 feet south of the south end of the overlay. There was a nine inch gouge mark just east of the edgeline, about 55 feet south of the south end of the overlay. Furrows in the grass roadside extended diagonally from the edgeline tire marks to the final rest position of the bus. Several of the channelizing barrels used to close lanes on the left to traffic were damaged and displaced in the vicinity of the accident site.

Federal and State Oversight

Motor Carrier Operations.--All commercial interstate bus operations are subject to the Federal Motor Carrier Safety Regulations[15] (FMCSR), which govern: safety equipment; vehicle maintenance and inspection; driver qualifications; and motor carrier operations. The FMCSR are established by the FHWA's Office of Motor Carrier Safety (OMCS), which also conducts periodic safety audits and reviews to monitor compliance with these regulations. One such review of Greyhound Lines was conducted on May 5, 1987; and on October 15, 1987, OMCS issued a satisfactory rating to the corporation.

Highway Conditions.--Highways are constructed and maintained in Tennessee by the State's Department of Transportation (DOT). The FHWA requirements for pavement skid resistance are contained in several documents, including Highway Safety Program Standard 12 (HSPS No. 12).[16] HSPS No. 12 calls for every State to have a program that addresses highway design, construction, and maintenance to improve highway safety and one that provides "standards for pavement design and construction with specific provisions for high skid resistance qualities." The standard also stipulates that each State have a "program for resurfacing or other surface treatment with emphasis on correction of locations or sections of streets and highways with low skid resistance and high or potentially high accident rates susceptible to reduction by providing improved surfaces."

FHWA encourages each State highway agency to develop and manage a skid accident reduction program that will reflect the individual needs and conditions within the State.[17] The purpose of a skid accident reduction program is to minimize wet weather skidding accidents by:

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[15] 49 CFR Parts 325, 350, 383, and 385-399.

[16] 23 CFR 1204.

[17] Instructional Memorandum 21-2-73, "Skid Accident Reduction Program," Federal Highway Administration, July 19, 1973.

-- Incorporating skid prevention principles into pavement design, construction, and maintenance. For example, establishing skid resistance criteria for the mixes used in the construction of new pavement.

-- Identifying locations with high or potentially high rates of skid accidents, and implementing corrective action.

-- Conducting skid resistance testing.

In a program manual dated March 6, 1989, the FHWA established a policy that every State highway agency must have a Pavement Management System (PMS). While many States have long maintained their own pavement management programs, according to FHWA officials, one of the purposes of the recently announced program is to provide guidance for these individual efforts.

Regulations have been promulgated and guidelines issued under the PMS program. In the policy section of the program manual, the section titled Safety requires the following:

> Each project involving construction of a pavement shall have a skid resistant surface. Pavement rehabilitation and reconstruction projects shall also incorporate other cost-effective opportunities to enhance safety as required by 23 CFR 625.2.[18]

The guidelines in the FHWA policy recommend, among other things, that each State highway agency conduct a condition survey, defined as a "measurement of the condition of the PMS roadway network from which the change over time can be determined."[19] Four major measurements are to be included in the survey, and one of them is "surface friction."

The PMS guidelines also include the following:

> Each SHA's [State highway agency] skid accident reduction program should include a systematic process to identify, analyze, and correct hazardous skid locations. The same procedures and quality standards used in construction should be used in maintenance operations.[20]

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[18]Federal-Aid Highway Program Manual, Transmittal 428, Federal Highway Administration, March 6, 1989, p. 16.

[19]Ibid., p. 4.

[20]Ibid., p. 17.

In 1986 the FHWA conducted a review of Tennessee's skid accident reduction program. Pavement skid resistance testing was one of the functions to be examined. The report on the review noted that in Tennessee skid data are collected for the interstate highway system every two years and at lesser frequency for other systems. The report went on to observe, "At present, considerable effort is devoted to obtaining skid data but utilization of this information is limited."[21] Therefore, one of the report's recommendations was:

> It is suggested that skid data be included in the annual or periodic pavement condition surveys and also be used to establish a historic background for aggregate types and sources, asphalt pavement mixes and comparison of pavement types in regard to skid problems. This could be incorporated into the overall pavement management program and provided to appropriate engineers.[22]

In response, the Tennessee DOT pointed out that it had been conducting pavement skid testing in cooperation with two universities in the State since 1951, but it also observed, "It is agreed that better use of skid test data could be made by the Department. The incorporation of this data into the pavement management program is a valid suggestion and one that the Department plans to pursue."[23]

The FHWA also recommended:[24]

> A specific policy should be established for skid resistance of rigid and flexible pavements both new and old noting acceptable parameters and action to be taken when values drop below specified values. This should also include interim measures such as warning signs.

The Tennessee DOT responded to this recommendation with the following:[25]

> Field and laboratory testing procedures and standard specifications are designed to provide acceptable skid resistance qualities on all new pavements. There is a

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[21] "Review of the Tennessee Department of Transportation Skid Accident Review Program," unpublished report, Federal Highway Administration, cover memorandum March 17, 1986, p. 10.

[22] Ibid., p. 10.

[23] Personal communication from Lewis Evans, State Transportation Engineer, Tennessee Department of Transportation, to Thomas J. Ptak, Division Administrator, Federal Highway Administration, September 16, 1986.

[24] Federal Highway Administration, memorandum March 17, 1986, p. 10.

[25] Evans to Ptak, September 16, 1986.

> need to develop guidelines for actions to be taken on old pavements that are near or below acceptable test values and exhibit evidence of other distress. If skid data is incorporated into the pavement management program, guidelines could be developed within that program.

Although the Tennessee DOT stated that it planned to pursue the FHWA suggestion of incorporating skid test data into its pavement management program, the Department has not provided evidence to the Safety Board of any efforts to make systematic use of the data developed through skid testing, i.e., to improve the frictional properties of those older pavements found through testing to have deficient skid resistance.

The Bus Driver

The bus driver was 44 years old at the time of the accident. He is a resident of Louisville, Kentucky, and has lived there most of his life. He holds a valid Kentucky chauffeur's license. His commercial driving career began when he was hired by Greyhound Lines Inc. in 1971, and, with the exception of three short furloughs and two times when he was discharged and later reinstated, he has worked for the Greyhound corporation ever since.[26] (One of these discharges and subsequent reinstatements resulted from this accident.)

The bus driver had been off duty during the two days prior to the accident. He returned to duty on Saturday, November 19, 1988, when he arrived at the Louisville Greyhound terminal at 2:55 a.m. for a scheduled 3:15 a.m. departure. However, operations were delayed because of the heavy rain, and the bus did not actually leave Louisville until 3:45 a.m. The bus driver later told investigators that, because of the adverse weather conditions, "there was no interest or concern about keeping the schedule." He cited the company rule on the subject. That rule states:

> It is expected that Drivers will operate late under abnormal conditions. When departure and/or enroute delays develop, such delay time need not be made up on regular schedule operations. When late, stay late![27]

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[26] In March 1987, Greyhound Lines Inc., a Delaware corporation and the bus driver's current employer, purchased substantially all the assets of Greyhound Lines Inc., a California corporation. Until March 1987, the driver's employer was Greyhound Lines (California) and since then, it has been Greyhound Lines (Delaware). Throughout his career, the driver has remained domiciled in Louisville, Kentucky.

[27] "Drivers Rule Book," Greyhound Lines, Inc., reissued April 1988, Rule S-12, page 19.

At the last scheduled stop prior to the accident, in Franklin, Kentucky, the bus was more than 55 minutes behind schedule. At that stop, the bus driver called the Nashville terminal, notifying company personnel about the delay and the connections his passengers needed.

The bus driver's scheduled run, which was to begin with the 3:15 a.m. departure from Louisville, was to end at Nashville; after a 2-1/2 hour layover in Nashville, the bus driver would operate another bus back to Louisville. This route, performed during these hours, was very familiar to the bus driver. He had driven it frequently during his career with Greyhound, including a period of several weeks leading up to the accident. During those trips, he repeatedly encountered the construction zone where the accident took place. He also had extensive experience with Greyhound commercial buses, equipped with automatic transmissions, of the type he was driving the day of the accident.

On Friday morning, November 18, 1988, the bus driver slept until 9 or 10 a.m. That night (prior to the accident), he had 4-5 hours of sleep. He said in testimony that he felt well rested on that day, and, since most of his commercial driving is performed between midnight and early morning, he is able to adjust his sleep cycle accordingly.

The bus driver did not eat after arising for the 3:15 a.m. run. The last time he had eaten was at 5 or 6 p.m. the evening before. From then until the accident, a period of 13-14 hours, his only nourishment consisted of iced tea and soft drinks. According to his testimony, these are his customary eating habits when on the job. He rarely eats breakfast before driving and often does not eat until returning home after work.

The bus driver indicated that he was not wearing his lapbelt at the time of the accident. He was required to wear his lapbelt by both the Federal Motor Carrier Safety Regulations (FMCSR) and Greyhound's rule book for bus drivers.

Driving Record.--A full review of Greyhound's files on the bus driver indicated that between 1971 and the time of the accident, the driver had been convicted of six moving traffic violations, five of which were for speeding. He had been involved in 10 accidents, 5 of which were determined by Greyhound to have been preventable. He had also been cited by Greyhound for company rule infractions on three occasions and had been discharged for driving performance on one occasion, but was reinstated one month later. (See appendix B.) Greyhound determined that the accident in Nashville was preventable and discharged the bus driver on December 13, 1988, but reinstated him on January 13, 1989. In addition, prior to his service with the company, the bus driver's 1971 Greyhound employment application indicates two accidents and convictions on two speeding violations.

Medical History.--Under Federal regulation,[28] commercial drivers must be medically examined at least every two years (and more frequently when there has been injury or disease that could impair job performance). Greyhound provided records of the last two examinations of the bus driver conducted by company-designated physicians. These records, of examinations performed in 1984 and 1986, indicate mild lower back pain, headaches, hay fever, and participation in a weight loss program. The driver was scheduled for another required physical examination on November 29, 1988.

The Safety Board obtained additional medical records on the bus driver from his personal physicians. In 1984 the driver's blood pressure was recorded as 160/120. To be physically qualified, under Federal regulation,[29] a driver must have "no current clinical diagnosis of high blood pressure likely to interfere with his ability to operate a motor vehicle safely." The Federal Highway Administration (FHWA) interprets the regulation as follows:

> Initial blood pressure of greater than 180 systolic and/or greater than 104 diastolic is considered moderate to severe. The driver may not be qualified, even temporarily, until his or her blood pressure has been reduced to less than 191/105. (Emphasis in the original.)[30]

The FHWA explains in the same interpretation that the safety risk posed by hypertension is the possibility of "sudden collapse." Such collapse is not likely to result from hypertension alone, but hypertension can help foster organ damage, particularly cerebral vascular disease, which does pose the threat of sudden collapse.

An examination in 1987 indicated the bus driver's blood pressure was 148/116, and the examining physician prescribed medication to lower it. In 1988, the bus driver's blood pressure was recorded as 158/106. The continued hypertension was partially due, according to the physician's notes at the time, to the bus driver's failure to follow the prescribed course of medication.

Other conditions in the bus driver's medical history include hypothyroidism (low thyroid level) and depressive neurosis with anxiety reaction, both diagnosed in 1984, as well as hyperuricemia (elevated blood concentrations of uric acid), diagnosed in 1986. In May 1988 the bus driver complained to his physician of allergy symptoms and fatigue, both of which he had been experiencing for several months. Because of the allergy symptoms,

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[28] 49 CFR 391.45(b and c).

[29] 49 CFR 391.41(b)(6)

[30] "Medical Regulatory Criteria for Evaluation under Section 391.41(b)(6)," Federal Highway Administration, Revised September 1988. (Also established in earlier FHWA publications.)

the bus driver had been taking an over-the-counter drug which he said provided no relief but did increase his drowsiness. However, the bus driver indicated that he was not taking this medication at the time of the accident.

The form that was filled out as a record of the examination conducted by a Greyhound-designated physician in 1984 contains no indication that the bus driver reported his hypertension or any other of the above conditions; in that examination, the bus driver's blood pressure was recorded as 120/88. There is also no indication of hypertension or the other conditions in the record of the examination in 1986, in which blood pressure of 126/86 was reported. Also, there is no indication on either form that the bus driver reported the medications he was prescribed for the hypertension and other conditions. The Greyhound physical examination form required the bus driver to:

1. Explain fully any physical disabilities.

2. Indicate whether he had an examination by a private physician in the last year.

3. If yes, indicate the doctor's name, diagnosis, and treatment.

4. Indicate whether he has been under any medications during the past year.

5. Indicate whether he is currently taking prescribed medication.

There was a place on the company's physical examination forms for the bus driver to sign, authorizing that the report be sent to Greyhound, but there was no requirement for the bus driver to certify that the information he provided was complete and accurate. Further, there was no requirement for the bus driver to authorize disclosure of his medical records by his personal physicians to the company physician during these federally mandated examinations. However, Federal regulation[31] does require the examining physician to consider the bus driver's medical history in determining his or her qualifications for certification and to certify the bus driver as medically qualified.

Drug and Alcohol Ingestion.--The bus driver's medical records since 1984 indicate the following drug therapies and their initial prescription dates:

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[31] 49 CFR 391.43(c).

Hypertension:	Maxzide(9/87), Corgard(6/88)
Anxiety Neurosis:	Sinequan(10/84)
Hypothyroidism:	Synthroid(11/84)
Hyperuricemia:	Lopurin(10/84)
Allergies:	Naldecon(11/87),Seldane(5/88)
Lower Back Pain:	Indocin (2/87),Dolobid (8/86)

According to the Physicians' Desk Reference,[32] all of these drugs except Synthroid can produce adverse reactions affecting mental alertness, such as drowsiness, lightheadedness, dizziness, vertigo, and fatigue. The book's profiles of four of the drugs include warnings about their use in conjunction with driving or other activities requiring alertness or motor coordination. The bus driver told investigators he never experienced lightheadedness or dizziness while driving.

When interviewed by Greyhound officials six days after the accident, the bus driver stated he had taken no medication the week preceding the accident. However, in testimony before Safety Board investigators, the bus driver said he had taken his blood pressure medicine the day before, but not the day of the accident. Subsequent telephone conversations to clarify this point revealed the bus driver had been taking his wife's blood pressure medicine (Maxzide) during the week preceding the accident because he had run out of his own; he had taken this drug previously at the direction of his physician.

On June 28, 1988, the bus driver's physician switched his medication from Maxzide to Corgard. At that time, the physician warned the bus driver he may experience increased drowsiness until he developed a tolerance to the new drug, and, should this occur, to contact him for a medical excuse from work. The physician's records also indicate the most recent renewal for Corgard was on September 15, 1988, for 30 tablets to be taken one each day. The bus driver was scheduled for a follow-up appointment with this physician in October 1988, but the records indicate the bus driver did not keep that appointment.

Following the accident, a blood specimen was taken from the bus driver by the Nashville Metropolitan Police Department and sent to the Tennessee Bureau of Investigation Forensic Services - Crime Laboratory. Toxicological analysis was negative for alcohol and also for all selected illicit drugs, stimulants, tranquilizers, narcotics, antidepressants, and hallucinogens. A portion of the remaining specimen was sent to the Center for Human Toxicology, in Salt Lake City, Utah, which tested for chlorothiazide (Maxzide). The Center was able to rule out high concentrations of the drug,

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[32] Physicians' Desk Reference, Edition 42, Medical Economics Co., Inc., 1988.

but because of the limited quantity of the blood specimen, it was not possible to determine whether the drug was present in smaller amounts.[33]

Vision.--In testimony, the bus driver characterized his forward visibility prior to the accident as good, despite the heavy rain. However, he stated that one reason he remained in the right lane prior to the accident was rain hitting his side mirror, as well as glare from headlights. Also because of the rain, according to the bus driver, as well as heavy spray on his windshield from the automobile in front, it was impossible for him to determine whether that vehicle's lights were tail lights or brake lights. He indicated that this limited visibility contributed to his decision to change lanes at the beginning of the accident sequence.

The bus driver has corrective lenses, but he stated he was not wearing them at the time of the accident. He told Safety Board investigators he wore these lenses only for reading and was not required to wear them for driving.

The bus driver's current optometrist provided the following information to the Safety Board, based on an examination conducted on February 11, 1989:

	Uncorrected Distant Vision	Uncorrected Near Vision
Right Eye	20/60	20/40
Left Eye	20/15	20/40

Federal regulations stipulate, in part, the following vision qualifications for commercial drivers:

> ... distant visual acuity of at least 20/40 (Snellen) in each eye without corrective lenses or visual acuity separately corrected to 20/40 (Snellen) or better with corrective lenses, distant binocular acuity of at least 20/40 (Snellen) in both eyes with or without corrective lenses ...[34]

An examination by a different optometrist in 1986 indicated the bus driver's uncorrected distant vision was 20/200 in the right eye and 20/25 in the left. The records of that examination also indicate the bus driver was experiencing blurred vision, trouble with night vision, and sensitivity to sunlight or bright lights, and it was noted that he did not like wearing glasses.

Following the bus driver's company physical examination, conducted in compliance with Federal regulation in 1984, the Greyhound-designated

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[33]Report by Douglas E. Rollins, Director, and Dennis J. Crouch, Assistant Director, Center for Human Toxicology, University of Utah, to National Transportation Safety Board, May 11, 1989.

[34]49 CFR 391.41(b)(10).

physician indicated that the bus driver was qualified to drive only when wearing corrective lenses. However, the records of the 1986 examination, conducted by a different physician, indicate the bus driver had 20/20 uncorrected vision in each eye, and he was therefore certified to drive without corrective lenses.

The Motor Carrier

Greyhound Lines Inc. provides passenger and package freight bus service in all 48 contiguous states. The corporation operates approximately 3500 buses and employs approximately 7000 drivers. The Vice President of Safety/Security and the Director of Safety have offices at corporate headquarters in Dallas, Texas. Each of Greyhound's four regional operating companies has a Safety Manager who reports to the Director of the individual company but also coordinates safety activities through the corporate Safety Director. Each Safety Manager has a staff of safety supervisors who perform safety checks and driver ride-along evaluations, as well as conduct and coordinate driver training. The regional operating companies are subdivided into areas that are each supervised by a Sales and Transportation Manager. Each of these managers supervises the drivers dispatched out of his or her terminal; the manager is also responsible for marketing operations at the individual area level.

The Louisville Area Sales and Transportation Manager is the supervisor of approximately 60 bus drivers, including the bus driver involved in this accident. The manager's duties include: monitoring, documenting, and evaluating driver performance; recommending training; certifying eligibility for continued service; and administering disciplinary action when warranted. The manager has been employed by Greyhound since 1978, but has never worked as a driver. In Safety Board depositions, the Manager indicated that the majority of his duties were in the area of marketing. He had not received formal training in transportation safety. Like others who hold comparable positions in the company, he does not participate in the recruitment and hiring of the drivers who come under his direction. In testimony, the manager described the accident bus driver's job performance as average to below-average. The manager said he had received no passenger complaints about this employee's driving.

Employment Qualifications.--Greyhound maintains separate teams that interview and screen driver applicants. These teams are also responsible for hiring decisions. According to testimony by a Regional Safety Manager for Greyhound, the company's requirements for new drivers include the following:

-- No more than two moving violations and/or accidents in the preceding three years and no more than four within the preceding five years.

-- During the previous three years, no license suspensions due to accumulation of traffic violations and no drug-related offenses, and no

more than one such suspension or drug-related offense in the previous five years.

-- At least 21 years old.

-- Successfully pass a DOT-specified physical examination, which indicates no use of illicit drugs.

-- Successfully pass a background check conducted by an independent firm.

The Safety Manager said that most of these requirements, including those concerning previous accidents and violations, had been in place for many years, at least 10 to 15. Greyhound records indicate that before the accident bus driver was hired in 1971, he had applied unsuccessfully twice before. In the three years prior to his date of hire in 1971, the bus driver had two accidents and two speeding violations. The manager testified that an applicant with such a record would not be hired today, since that exceeds the two-accidents-and/or-violations-in-three-years-rule. Further, referring to 1971, the manager said, "He probably would not meet the basic criteria at that time. So obviously, in fairness, whoever looked at it must not have been correct."

Training.--According to the Safety Manager, initial training for new Greyhound drivers consists of a six-week program of classroom and behind-the-wheel instruction. The first three weeks of training are spent at a Greyhound driving school, where the driver receives approximately 70 hours of classroom instruction and about 20-25 hours of behind-the-wheel training. The next two weeks of training are spent with an instructor learning the specific routes in the driver's local area. The final week of training is then spent with an experienced driver who has been assigned by the company to take the new driver on a scheduled route, so the new driver becomes familiar with company operations. The accident bus driver told Safety Board investigators that he attended this program, but Greyhound could not produce any records documenting his performance during the training.

At the conclusion of the training course, there is a written examination and a road test administered by Greyhound staff. A new hire must pass both before he or she can be certified to drive for the company. Personnel records indicate the accident bus driver did pass both; his score on the written examination was 98 percent.

Recurrent training is provided to drivers in the form of seminars, safety films, classroom sessions, and behind-the-wheel instruction. According to the accident bus driver, films and seminars are available as often as once a month, and participation is voluntary. However, the Safety Manager described the company's recurrent instruction as "a regularly scheduled in-service driver training program that has been pretty much mandatory ..." He also said the focus of this program has been on the newer drivers.

From the beginning of his career with Greyhound until the time of the accident, records supplied by the company indicate 10 instances in which the bus driver received in-service training. Three of these were one-day refresher courses following the bus driver's involvement in preventable accidents. The other instances consisted of: three safety films; two classroom sessions; one simulator session; and one orientation session on the Eagle brand bus and driving with a standard-shift transmission. In November 1981 the bus driver viewed a film titled "Adverse Weather." There is no record that he received any other training in this subject. The bus driver did recall some classroom instruction on the effects of hazardous weather on visibility and traction, but there is no documentation of any such sessions. The bus driver also said he received no behind-the-wheel training on the procedures to follow in bad weather.

Evaluation of Driver Performance.--Greyhound management policy calls for documentation of all rule infractions, traffic citations, and accidents in which its drivers are involved. A separate form is filled out for each occurrence, such as a "Discipline Report" or "Notice of Personnel Record Entry," and a corresponding entry is made in the driver's master personnel record. An accident is first investigated, and then the Sales and Transportation Manager, with the advice of safety department personnel, determines whether it was preventable or nonpreventable. The decision about disciplinary action or other remedial measures is then based on that assessment.

The Safety Manager testified that during a driver's probationary period, "if a new driver has a preventable accident, they are also given in-service training, like we call it, a refresher course, remedial type training." However, the accident bus driver's first preventable accident while a Greyhound employee took place during his initial 90-day probationary period, but his personnel record indicates that it was not followed by remedial training or disciplinary action.

Driver supervisors and safety department personnel are required to monitor bus driver performance through periodic bus rides and road checks from a trailing vehicle. This surveillance can be initiated as a result of accidents, complaints, or violations, or on a random basis. In most cases, the bus driver is notified before the surveillance. Thirteen bus rides and road checks are recorded in the accident bus driver's personnel file, and in the reports on two of them there are notes indicating some unsatisfactory performance. One of the reports included the following: "Consistently maintained speed of approximately 65 mph in 55 zone. Finally dropped down to 35 mph in construction area." This speeding violation was noted in the bus driver's personnel record, and he received a written warning "that a similar infraction may result in more severe discipline."

As explained previously, Federal regulation requires Greyhound to obtain from its bus drivers an annual list of traffic violations. In addition, the company uses a private firm to screen state records for violations committed by its bus drivers. However, with the exception of the initial check performed when the accident bus driver was applying for employment, Greyhound

has provided no documentation of any state record checks performed concerning this bus driver.

Using information obtained through these lists and checks, as well as other data in the bus driver's record, Greyhound is required to ascertain at least once a year whether each bus driver continues to meet the Federal minimum standards for safe driving.[35] These reviews do not include participation by the safety department, unless the Sales and Transportation Manager specifically requests it. Greyhound has provided documents showing annual reviews were conducted on the accident bus driver in 1986 through 1988. In 1986 and 1987, however, the review, which includes a subjective evaluation of the bus driver's performance, was not conducted by any of the bus driver's supervisors, but instead by the Sales and Transportation Manager's secretary.

Other Information

Part 392.14 of Title 49, Code of Federal Regulations, states that:

> Extreme caution in the operation of a motor vehicle shall be exercised when hazardous conditions, such as those caused by snow, ice, sleet, fog, mist, rain, dust, or smoke, adversely affect visibility or traction. Speed shall be reduced when such conditions exist.[36]

Greyhound's bus drivers rule book states that:

> Buses are not to be operated in excess of the posted speed limit. Under no circumstances is a bus to be driven at a speed greater than is reasonable and prudent under the existing weather, road and traffic conditions.

ANALYSIS

The Accident Sequence

The Safety Board's assessment of the accident dynamics is based on the pattern of tire marks and other physical evidence on the highway, the final resting position of the bus, and statements by the bus driver and witnesses. The accident sequence began when two cars passed the Greyhound bus on the left, and one of them moved in front of the bus to let the other go by. The following distance between the bus and the next vehicle in front was therefore diminished. The bus driver indicated that he was uncomfortable with this situation and chose to steer into the left lane (lane 2). The bus driver was unable to complete the lane change before the bus slid into the closed new middle lane (lane 3), knocking over several channelizing barrels. Both the rear and the front of the bus entered that lane, as evidenced by

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[35] 49 CFR 391.25.

[36] 49 CFR 392.14.

barrel fragments found embedded in the left front grille and bumper and along the left side of the bus. At that point, though, the bus was still under enough control so that the bus driver was able to introduce a rightward steering maneuver and direct the bus back toward the outermost concrete lane (lane 2). However, while the front of the bus moved rightward, its rear began to track leftward. As a result, the bus began to rotate clockwise. During the approximately 190° rotation, the bus began tilting so that it was riding on its left wheels alone. When it left the right side of the highway, the bus overturned onto its left side, sliding into an embankment and striking several trees.

When the bus shifted from the asphalt lane (lane 1) to the concrete lane (lane 2), it encountered a pavement surface with sharply reduced coefficient of friction. The bus driver may have been late with his steering input to correct the leftward movement of the bus, or the input to move the bus back to the right may not have been sufficient to develop the cornering forces to turn the front of the bus rightward before the bus moved into the closed new middle lane (lane 3), given the lower coefficient of friction of the concrete lane. Thus, the lower coefficient of friction of the concrete lane (lane 2) adjacent to the asphalt overlay contributed to the encroachment of the bus into the closed new middle lane (lane 3).

The bus driver testified that he was traveling at 45 mph at the time of the accident; however, he also indicated that he had not looked at his speedometer since entering the construction zone. Because of the rain, limited visibility, and wet road conditions, even that speed may have been too high for the prevailing conditions. However, passenger and witness statements indicated that the speed was actually significantly greater than 45 mph, with one witness placing it at 65 mph. The Safety Board therefore performed hydroplane and critical speed calculations to develop estimates of the speed of the bus prior to the accident.

Because the pavement of I-65 was wet from the rain, the potential existed for hydroplaning. Hydroplaning occurs when a vehicle traveling on wet pavement reaches a speed at which water pressure builds up under the tires. As contact diminishes between the tires and pavement, it becomes increasingly difficult for a driver to maintain directional stability. Ultimately, the ability of the tires to develop braking and turning forces can be completely eliminated.

Since there were no reported indications of control problems before the accident sequence, it is likely that most, if not all, of the bus's tires were maintaining contact with the pavement surface until then. When the bus moved into the new middle lane (lane 3, closed at that time), the bus driver was able to steer the bus back toward the right. Therefore, the front tires were not hydroplaning. However, the rear of the bus began to move leftward, initiating a clockwise rotation of the bus. Because it was raining heavily at the time, the road surface was wet, and there were no marks left on the pavement surface by the rear tires as a result of the clockwise rotation of the bus. The Safety Board concludes that the clockwise rotation probably occurred as a result of hydroplaning by the rear tires.

Hydroplaning calculations, based on the pressures and footprint aspect ratios of the Greyhound bus's tires, indicated that the speed of the bus, when traveling straight, would have had to be greater than 65 mph before hydroplaning would take place. (See appendix C.) However, the bus was not going straight when the tires hydroplaned. This would have reduced the speed at which the hydroplaning could have occurred, because of the yaw angle of the rear tires with respect to the forward movement of the bus.

Critical speed calculations, based on measurements of tire marks from the bus and estimated skid resistance of the concrete pavement in the new middle lane (lane 3), indicated an estimated speed of 57 to 67 mph. When the bus moved left and then went out of control, it would have lost some forward speed in the process. Since the tire marks on which this set of calculations was based were made well into the accident sequence, the speed of the bus at the beginning of the accident sequence was probably greater than the lower end of the 57-67 mph range.

Considering the calculations based on tire marks, the calculations based on hydroplaning, and the witness estimate that the bus had been traveling about 65 mph, the Safety Board concludes that the speed of the bus prior to the accident was 60 to 65 mph. It was this excessive speed that led the bus to go out of control and overturn. Furthermore, high speed exacerbated the effects of decreased coefficient of friction, which the bus encountered in the move to the left, and the high speed resulted in hydroplaning as the bus moved back toward the right. Thus, if the bus driver had been operating the bus at a speed appropriate for conditions, instead of nearly 20 mph over the posted speed limit, the sequence of events that comprise this accident would not have occurred.

The Safety Board also believes that the bus driver demonstrated poor judgment when he decided to change lanes instead of slowing down. If he had slowly decelerated the bus without attempting to change lanes, it is likely the accident could have been avoided. The Safety Board examined the factors that may have led to the bus driver's failure to slow his bus rather than to change lanes at such a high speed in adverse conditions.

Bus Driver Performance

The Safety Board could find no evidence that the bus driver's speeding was the result of pressure from the company to make up time or meet a schedule. In fact, driving a Greyhound bus 60-65 mph in conditions of steady rainfall and in a construction zone where the speed limit is 45 mph is not only contrary to State law and Federal regulation, it is also contrary to specific company rules. The failure to wear a lapbelt while driving a Greyhound bus is contrary to both Federal regulation and company rules. This disregard for rules is consistent with a pattern of disregard for rules and regulations the bus driver established even before he was hired by Greyhound. The bus driver reported two accidents and two speeding violations on his Greyhound employment application in 1971.

Less than 90 days after he was hired by the bus line, during his initial probationary period, he was involved in an on-duty accident. Prior to this accident in Nashville, the bus driver had been involved in 10 other accidents while operating buses for Greyhound. Although five of these accidents were classified as nonpreventable, five were classified as preventable by Greyhound officials. The bus driver's record also includes six traffic citations, five for speeding and one for failure to yield, according to Greyhound's files. In addition, he was charged on three occasions with infractions of company rules. The bus driver had been suspended four times by the company and discharged (but later reinstated) once.

On the day of the accident, the bus driver was operating a type of vehicle whose handling characteristics were very familiar to him. The route was one he had driven frequently during his career, and he had encountered the construction zone repeatedly for several weeks preceding the accident. After 17 years with Greyhound, the bus driver was not lacking in experience, but rather, a proper regard for the rules of safe driving.

Factors Affecting the Bus Driver's Alertness

The Safety Board believes that the bus driver exercised questionable judgment in his decision to switch lanes instead of slowing the bus when he was confronted with the car in front. The Safety Board sought to determine whether fatigue, insufficient nourishment, or the effects of medication could have been factors in this decision.

Fatigue.--Highway driving, particularly at night, can be a monotonous task. Also, the human circadian rhythm produces a strong tendency to sleep during the hours from 1:00 a.m. to 8:00 a.m., regardless of whether the individual is well rested. The time of this accident falls within the time of day in which statistics show human performance errors are most likely to occur.[37] In light of these factors, the four to five hours of sleep the bus driver said he received the night before the accident may not have been enough to avoid subsequent drowsiness or degraded judgment. Furthermore, there are reasons to question whether the bus driver did in fact receive as much as four to five hours of sleep. He may have been in bed for that amount of time or longer, prior to arising at 1:45 a.m. But it is possible that he had difficulty falling asleep. The bus driver had been off duty during the two days preceding the accident. In that time he had been at home, integrating into his family's daily routine, which included sleeping during the nighttime hours. Prior to those days off, he had worked for six consecutive nights. Therefore, at the beginning of his time off he had imposed a shift in his sleep pattern, and at the end (the night prior to the accident), he reverted once again to working at night. Those transitions in

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[37]Mitler, M. M., et al., Catastrophes, Sleep, and Public Policy: Consensus Report, Raven Press Ltd., 1988.

rapid succession could have created disharmony in his circadian rhythm.[38] That disharmony, in turn, could have made it difficult to fall asleep as needed the evening before the accident. This variable sleep pattern could have made the bus driver drowsy at the time of the accident. However, there are no indications that the bus driver was in fact drowsy or that he exhibited driving behavior indicative of fatigue. Further, the bus driver stated that he was alert at the time of the accident.

The Safety Board believes that in all transportation modes it is important for vehicle operators who work nights and those with fluctuating schedules to understand the impact their sleep/work patterns can have on their job performance. Companies such as Greyhound should provide education and counseling to these employees and also their families about the nature of the problem and steps that can be taken to minimize it.

Nutrition.--At the time of the accident, the bus driver had been without nourishment, other than iced tea and soft drinks, for 13-14 hours. Research suggests that an individual begins feeling the effects of hypoglycemia (low blood glucose) approximately five hours after eating a balanced meal. After 10 hours, the symptoms are likely to be very strong. Hypoglycemia can manifest itself with fatigue, dizziness, blurred vision, and diminished decision-making ability.[39] Therefore, the bus driver could have been subject to the effects of hypoglycemia. He stated that this was his customary eating pattern.

As with the effects of night work and fluctuating sleep patterns, the effects of nutrition on job performance should be explained thoroughly to bus drivers and other vehicle operators. The Safety Board believes Greyhound should undertake an appropriate ongoing education program on this subject for its bus drivers.

In a letter to the Secretary of Transportation, dated May 12, 1989, which discussed the role of fatigue and inadequate diet in transportation accidents, the Safety Board made the following recommendations:

I-89-1

Expedite a coordinated research program on the effects of fatigue, sleepiness, sleep disorders, and circadian factors on transportation system safety.

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[38]Mackie, R. R., and Miller, J. C., Effects of Hours of Service, Regularity of Schedules, and Cargo Loading on Truck and Bus Driver Fatigue, Human Factors Research, Inc., October 1978.

[39]Cowart, Elgin C. Jr., Director, Armed Forces Institute of Pathology, personal communication to Martyn V. Clarke, Director, Bureau of Technology, National Transportation Safety Board, December 14, 1976.

I-89-2

Develop and disseminate educational material for transportation industry personnel and management regarding shift work; work and rest schedules; and proper regimens of health, diet, and rest.

I-89-3

Review and upgrade regulations governing hours of service for all transportation modes to assure that they are consistent and that they incorporate the results of the latest research on fatigue and sleep issues.

Responses have not yet been received to these recommendations.

Effects of Prescription Drug Therapy.--Toxicological testing indicated that the bus driver was not subject to the effects of alcohol or any of the illicit drugs that were selected for screening. However, according to the bus driver's testimony, he was taking some form of hypertension medication at the time of the accident.

The bus driver had most recently been prescribed Corgard. However, the 30 tablets prescribed on September 15, 1988 would have been used up at mid-October if the tablets were taken as prescribed. Since the bus driver did not keep the appointment at which he could have obtained a renewed prescription, he may have gone without medication from that point until a week prior to the accident, when he began taking the Maxzide prescribed for his wife.

Although the bus driver had in the past been prescribed both Maxzide and Corgard, the tolerance he had built up first to one and then the other probably dissipated during the periods without either drug. Therefore, when he began taking Maxzide without a physician's supervision during the week prior to the accident, he may have been subject to any of the potential side effects of first-time use, which can include drowsiness and fatigue. There was no evidence, however, that the bus driver was experiencing any of these side effects.

As the result of any of these conditions affecting alertness, the bus driver could have slipped into a brief episode of overwhelming drowsiness or "microsleep." There is laboratory evidence that such episodes can produce inattention, forgetfulness, and performance lapses.[40] However, there were no witness statements or other evidence indicating that the bus driver was suffering from microsleep or fatigue at the time of the accident.

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[40] Dinges, D. F., The Nature of Sleepiness: Causes, Contexts, and Consequences, Perspectives in Behavioral Medicine, 1988.

Although the quantity and quality of the bus driver's sleep, his lack of nourishment for 13 to 14 hours prior to the accident, and the possible side effects of medication taken for hypertension are factors that could degrade driving performance, the Safety Board did not find sufficient evidence to conclude that these factors did exert such an effect. Further, the accident sequence can be fully explained by the bus driver's propensity to speed and the differential in coefficient of friction between the travel lanes.

Greyhound Management Policies

A company that employs commercial drivers has three general means of ensuring safe performance by those drivers: employment screening; training; and inservice monitoring and discipline. The fact that the bus driver in this case was able to gain employment and then continue working despite an ongoing history of speeding suggests that there have been shortcomings in the programs through which Greyhound manages its driver workforce.

When the bus driver applied for employment with Greyhound in 1971, he presented a record that would have barred him from the company if he were applying today, according to the testimony of the Regional Safety Manager. That record also may not have met the standards used in 1971, the Manager indicated as well, in which case the bus driver joined the company through an error by a hiring official.

According to Greyhound, its standards and practices for pre-employment screening have improved since the time this bus driver was hired. Certainly when a company's employment standards are upgraded, it should not be expected to dismiss those of its employees who were hired under a lower standard. However, when public safety is involved, it is a responsibility of the company to bring the performance of such employees up to the higher standard. If such efforts, through training and other means, prove unsuccessful for some employees, those individuals should not be allowed to remain in safety-sensitive positions. In the years since he was hired, the record of the bus driver in this case suggests either that insufficient effort was given to improving his performance or that he is one of those individuals for whom routine efforts at improving performance are insufficient. In either case, his continuing pattern of disregard for speed regulations should have been identified, and steps should have been taken to prevent that behavior from putting the lives of bus passengers and others on the highway at risk.

The bus driver's job performance is generally well documented in Greyhound's records, but these records are nevertheless deficient in a number of ways. The files on the bus driver indicate not only his accidents, traffic citations,[41] and company rule infractions, but also the results of on-the-job performance evaluations, annual record reviews, and other details. But Greyhound officials, including the bus driver's supervisor, could not adequately explain why the bus driver was reinstated in 1983 after being

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[41] Some citations are noted by the driver in the annual traffic record review all drivers are required to fill out, but missing from his central Greyhound driving record.

discharged from the company following his involvement in an accident, or why he was similarly reinstated in 1989 after being discharged following the accident in Nashville. Missing from the files were: documentation of the bus driver's initial training at Greyhound; results of screening by an outside firm of the bus driver's state traffic records; and detailed accounts of disciplinary action and recurrent training for the driver.

In 1986 and 1987 the annual review of the accident bus driver's record may have been conducted in accordance with the letter but certainly not with the intent of 49 CFR 391.25. In part, that Federal regulation stipulates:

> In reviewing a driving record, the motor carrier must consider any evidence that the driver has violated applicable provisions of the Federal Motor Carrier Safety Regulations and the Hazardous Materials Regulations. The motor carrier must also consider the driver's accident record and any evidence that the driver has violated laws governing the operation of motor vehicles, and must give great weight to violations, such as speeding, reckless driving, and operating while under the influence of alcohol or drugs, that indicate that the driver has exhibited a disregard for the safety of the public.

To be accomplished properly, such subjective assessments must be made by someone who is familiar with all aspects of the driver's record. In addition, that person should be qualified to interpret the information and have the authority to impose measures based on the findings, such as training, disciplinary action, reassignment, or discharge. A supervisor conversant with safe bus-operating practices would be more qualified to serve this function than a secretary (or any other person) who was not specifically trained for this function. However, Greyhound was not in violation of Federal regulation when the Sales and Transportation Manager's secretary conducted the annual review of the bus driver, because 49 CFR 391.25 does not specify the qualifications required of the reviewing official. Certainly, a review of the bus driver's violation record could be performed by a nonsupervisory person if provided adequate guidelines with which to base an assessment of the bus driver's record. However, the determination of whether the bus driver is fit to continue driving or is in need of additional training should be made by a supervisor knowledgeable about driving operations. The Safety Board believes the regulation should be amended to clarify those qualifications.

Greyhound's practice of directly observing and assessing the performance of its bus drivers on duty could help maintain a high level of safety in the company's operations. But the effectiveness of this practice is undermined by giving the bus drivers notice when they are to undergo surveillance. Most drivers prone to unsafe behavior are unlikely to display that behavior when they know they are under scrutiny. That point is illustrated by the contrast between the accident bus driver's list of accrued accidents and citations and the record of his performance in supervisory bus rides and road checks. In only two of the 13 reports on those rides and checks were there notes indicating any unsatisfactory performance. The

Safety Board believes that Greyhound should conduct at least a substantial portion of its supervisory bus rides and road checks without notice to the driver.

Training.--Greyhound's eight-week initial training program for bus drivers, as described by company officials in testimony, appears to provide adequate preparation for new hires. Although Greyhound could not provide records of the accident bus driver's participation in this program, he did testify that he received the training, and there is documentation that he successfully passed the written examination and road test given at the conclusion of the course.

According to the Regional Safety Manager, the recurrent training provided by Greyhound is directed primarily toward the recently hired bus drivers. Beyond that, the purpose of the company's recurrent training appears to be one of correcting demonstrated shortcomings rather than preventing them. Involvement in an accident can be grounds for attending a remedial training session, as the bus driver in this case did on four occasions. Under current Greyhound procedures, a pattern of citations or rule infractions can also prompt the requirement that a bus driver receive recurrent training. The Regional Safety Manager did indicate in testimony that recurrent training is "pretty much mandatory." However, the accident bus driver registered his impression that participation is left to the discretion of the individual employee.

Company records document the bus driver's attendance in 10 training sessions during 17 years of employment. The only recorded instance in which hazardous weather operations were addressed in this training was in November 1981, when the bus driver viewed the film titled "Adverse Weather." He indicated that he received no behind-the-wheel recurrent training on safe practice in bad weather.

The Safety Board believes that recurrent training such as films, seminars, or behind-the-wheel sessions should be used to keep bus drivers generally well educated about the standards of safe practice, in addition to specific remediation of demonstrated unsatisfactory performance. In order for that approach to be successful, participation in recurrent training should be regularly scheduled and mandatory for all bus drivers.

The bus driver's performance and attendance in this mandatory training should be well documented in the bus driver's record. Furthermore, recurrent training should prepare a bus driver for the physical and mental demands placed on him or her when driving in hazardous weather or road conditions. Emphasis should be placed on, but not limited to, issues such as speeding, driving during periods of reduced visibility, hydroplaning, road construction hazards, highway surface frictional properties, and proper rest and nutrition.

The Safety Board believes that the limited recurrent training that this bus driver received did not prepare him for the conditions he encountered the morning of the accident. If the experience of the bus driver in this case is at all representative, it is possible that many Greyhound bus drivers are in

need of an enhanced recurrent training program, one that specifically addresses bus operations during periods of adverse weather.

Company Evaluation of Driver's Medical Condition and Vision.--As required by federal regulation, the bus driver was periodically examined by physicians, and Greyhound used the results of these examinations to determine his continuing fitness for service. He has also been under the care of personal physicians and optometrists. Concerning both general health and vision, there have been significant discrepancies between the findings of the company-designated physicians and those of the personal practitioners.

In the two examinations for which Greyhound was able to provide records, the bus driver's blood pressure was measured and reported to have been at levels that are within the standards established by the FHWA. The bus driver, though, had a clinical history of hypertension. Similarly, following the bus driver's 1986 company physical examination, he was certified to drive without corrective lenses; but examinations by personal optometrists in 1986 and 1989 indicated not only visual acuity that would require the use of corrective lenses under FHWA standards, but also other vision problems such as blurred vision and problems with bright lights and night vision. The Safety Board could not determine the reasons for these sharply differing results in objective medical and vision tests.

The bus driver knew that he had vision problems and that he was being treated for high blood pressure (though he may not have recognized the term hypertension). In addition, even though he may not have known the clinical terms for his other conditions, such as hypothyroidism and depressive neurosis with anxiety reaction, he probably did recognize that there were additional conditions in his medical history that might adversely affect his driving ability. Yet the bus driver did not notify the company physician about the diagnosis and treatment of these conditions. And the bus driver also did not disclose them when he filled out the written medical history forms as part of his biennial physical examinations.

The purpose of the federally required biennial examination is explained in the instructions given to examining physicians:

> In the interest of public safety, the examining physician is required to certify that the driver does not have any physical, mental, or organic defect of such a nature as to affect the driver's ability to operate safely a commercial motor vehicle.[42]

Such an authoritative finding was not made for this bus driver, and one reason may have been his failure to disclose his full medical history, or to direct the examining physician to the personal physicians who could do so. There was nothing compelling the bus driver to make such a full disclosure. Greyhound does require that medical history forms be completed at each physical examination, but there is no explicit requirement, in either

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[42] 49 CFR 391.43(e).

Greyhound policy or Federal regulation, that the forms be filled out in a manner that is not only accurate but also complete.

One means of encouraging bus drivers to give a full accounting is to require them to vouch for the information they are providing. At present there is a place on the physical examination form for the bus driver to sign, permitting the report on the examination to be sent to Greyhound. If a bus driver were also required to certify by that signature that he or she has made a full and truthful disclosure, this might ensure greater vigilance in filling out the form.

Such certification already exists in the aviation industry. The following statement is from the Federal Aviation Administration's Form 8500-9 for medical certification of pilots:

> I hereby certify that all statements and answers provided by me in this examination form are complete and true to the best of my knowledge, and I agree that they are to be considered part of the basis for issuance of any FAA certificate to me. I have also read and understand the Privacy Act statement that accompanies this form.
>
> NOTICE: Whoever in any matter within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or who makes any false, fictitious or fraudulent statements or representations, or makes or uses any false writing or document knowing the same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than 5 years, or both. (U.S. Code, Title 18, Sec. 1001.)

In addition to the foregoing, the Safety Board believes the signed statement should also give the examining physician the authority to obtain additional information on the bus driver if such information is necessary. Further, the statement should prohibit significant omissions and require the bus driver to notify the certifying physician if his medical condition changes following the examination. The Safety Board believes that Greyhound should incorporate such a statement into the medical history form its bus drivers fill out when they receive the federally required biennial physical examination. Additionally, Greyhound medical examination forms require the bus driver to provide information on any illness or injury in the preceding year, although the medical examinations are performed on a biennial basis. The Safety Board believes that to compile a complete medical history for the bus driver, this section should be modified to cover the full two-year period between examinations.

The Safety Board believes the medical history information specified in 49 CFR 391.43 could be misunderstood by drivers. It is possible that the bus driver in this accident did not understand that his high blood pressure was a "cardiovascular disease" or that depressive neurosis with anxiety reaction is

considered a "psychiatric disorder," both of which are terms used in the Greyhound form, as stipulated by the federal regulation. The Safety Board believes that the section establishing the bus driver's medical history should be more comprehensive, utilizing commonly understandable terminology. An example would be to include "high blood pressure" and "heart condition" under the heading "cardiovascular disease."

In 1983 the Safety Board made the following recommendation to the FHWA:

> H-83-68
>
> Revise Federal Motor Carrier Safety Regulation 49 CFR 391.43 to incorporate a provision, similar to that specified in 14 CFR 67.20(a) for airmen medical certification, which will prohibit the falsification or omission of medical information in connection with a medical certification physical examination.

In 1988 the FHWA issued a final rule that prohibits falsification of information on an employment application, certificate, or record required by Federal regulation.[43] The Safety Board subsequently classified Safety Recommendation H-83-68 as "Closed-Acceptable Action." However, the rule does not prohibit omission of information, and a driver can simply choose, as the individual in this case did, not to answer completely a question that might reveal a medically disqualifying condition. The Safety Board believes that revisions to the FHWA's rules were generally responsive to the Board's recommendation. However, as a result of this accident, the Safety Board recognizes that further revisions are needed to ensure that adequate medical history information is available to physicians during biennial physical examinations.

Pavement Conditions

As discussed earlier, in this accident the different frictional properties of the lanes in the construction zone exacerbated the leftward slide and the subsequent loss of control of the bus. Application of a vehicle's brakes under such circumstances can worsen the situation. If a vehicle's brakes are applied when its left wheels are on pavement with one coefficient of friction and the right wheels are on pavement with different frictional properties, a turning moment can be introduced that can cause the vehicle to spin out of control.[44] This occurred in 1985 when an intercity bus near Frederick, Maryland, traveling too fast for the wet highway conditions, straddled two lanes during a braking maneuver. The bus went out

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[43] The rule, published May 19, 1988, was included in the Federal Motor Carrier Safety Regulations as 49 CFR 390.35.

[44] J. C. Burnes, "Differential Friction: A Potential Skid Hazard," Transportation Research Record No. 602, 1976.

of control and struck a concrete bridge rail. Six of the occupants were killed, and the other 11 received injuries.[45]

In the Nashville accident, although the friction differential was a result of the temporary use of asphalt overlays, the more general problem of low skid resistance on the existing travel lanes was not a result of the construction project. Testing of the traffic-polished surface of one lane produced a consistent skid number of 27, which indicates it is "slippery," according to the widely accepted criteria developed in Kentucky.[46] Although skid testing was not performed in the adjacent lane, it is of the same composition, and the concrete was poured at the same time, so it is likely that the two had similar frictional properties.

Therefore, even before the construction project was begun, vehicles traveling on this section of highway, particularly when it was wet, would encounter potentially severe difficulties in braking and steering that would not be present on pavement with better skid resistance. These difficulties would be most severe for large vehicles and those traveling at high speed.

The construction work at the accident site is now near completion. The three concrete lanes have been opened to traffic, and the asphalt lane is no longer being used as a travel lane. Based on the reported past experience of the Tennessee DOT with concrete pavements, the newly constructed inside lane (lane 4) will likely have skid resistance numbers close to 60, which is "good skid resistance," according to the Kentucky criteria. But if the pavement surface of the two older lanes remains unchanged, a new instance of friction differential will exist, as one lane with high skid resistance adjoins two with substantially different properties.

Tennessee DOT has the responsibility to prevent friction differential, which may occur during and after construction projects, and also under other circumstances. The Department also has the responsibility to provide for adequate highway skid resistance overall. Testing performed in conjunction with the investigation of the bus accident indicates that both friction differential and low skid resistance conditions existed at this particular site on I-65. The Safety Board believes the Tennessee DOT should take the measures necessary to provide adequate skid resistance for all roadways within the State and to ensure that these roadways are free from significant friction differential.

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[45] Highway Accident Report--"Intercity Bus Loss of Control and Collision with Bridge Rail on Interstate 70 Near Frederick, Maryland, August 25, 1985" (NTSB/HAR-87-01).

[46] The same study that produced those criteria also said, "Any highway section with an ADT (average daily traffic) above 1,000 should be desticked if the SN (skid number) of the pavement is 28 or less." (Rizenbergs, Rolands L., Burchett, James L., and Warren, Larry A., "Accidents on Rural, Two-Lane Roads and Their Relation to Pavement Friction," Commonwealth of Kentucky Department of Transportation, Bureau of Highways, Division of Research, April 1976.)

FHWA has previously made findings and recommendations that would help Tennessee DOT reach those goals. The review of Tennessee's skid accident reduction program that was conducted by FHWA in 1986 indicated that ample skid data are collected, but sufficient use is not made of the data. Despite its announced intentions to do so, Tennessee DOT has yet to implement fully the recommendations FHWA made in 1986. The State was urged at that time to incorporate into highway design and construction the knowledge gained through skid testing. Another recommendation awaiting action called for establishment of criteria for acceptable skid resistance in both old and new pavements, along with a program to make sure the State's highways meet those criteria. The Safety Board urges Tennessee DOT to carry out these recommendations without further delay.

By doing so, the State would be incorporating skid accident reduction principles into its pavement management system, as called for in the FHWA's policy on PMS announced in 1989. To be in compliance with the policy guidelines on this point, the Tennessee program for both highway construction and maintenance "should include a systematic process to identify, analyze, and correct hazardous skid locations."[47]

The Construction Project on I-65.--Since I-65 is a Federal-aid highway, construction projects on that highway require prior approval from FHWA. FHWA did approve the original design plans for the project on I-65. However, the decision during the construction phase of the project to eliminate the provision for "'diamond' type grinding of all concrete surfaces" was initially made without approval from, or consultation with, the appropriate FHWA division office.

Diamond grinding is one technique for raising the coefficient of friction in a pavement surface. If sufficient improvement had been accomplished in the existing concrete lanes at the site in question, there would have been little if any friction differential between the asphalt overlay and concrete travel lanes during construction or between the old and new concrete lanes after construction was completed.

According to the Tennessee DOT, the decision to eliminate the provision for diamond grinding was based on the "varying history of results" with the procedure, as well as the possibility of a future project to overlay the concrete lanes with asphalt. There are various alternatives to diamond grinding, such as tining, application of surface-roughening chemicals, and a variety of overlay methods, but Tennessee DOT did not pursue any of them when it abandoned the plans for diamond grinding.

It was only after the Safety Board made inquiries that Tennessee DOT undertook a diamond grinding test project. The results of that project have proved favorable, and Tennessee DOT has indicated diamond grinding of the existing concrete lanes within the construction zone will continue. There are no stated intentions to try other methods for improving the skid

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[47] See footnote 18.

resistance of the existing concrete surface, and there has been no timetable or other definitive word about repaving the highway with asphalt.

The Safety Board believes that friction differential is an avoidable highway hazard. The first step in preventing its development in conjunction with construction and maintenance is to evaluate each element that could bring on this condition in a project, at both the planning and implementation stages; countermeasures should then be instituted as needed. The Safety Board does not endorse one method of pavement rehabilitation over another, but it does urge Tennessee DOT to make a determination about which one is most appropriate for the highway section in question and to implement the selected method as soon as possible.

Enclosed Overhead Luggage Racks

When a vehicle overturns, particularly a large one such as a bus, unsecured items are likely to be set into motion within the structure. These items, such as falling luggage, can injure vehicle occupants and block or inhibit egress. Injuries can result as well when the occupants themselves collide with each other or with parts of the vehicle interior. When the Greyhound bus overturned on I-65, there were injuries that passengers attributed to collisions with interior components or other passengers. However, no injuries from falling luggage were reported.

In the accident bus, luggage in the overhead racks was enclosed by top-hinged compartment doors. These doors remained closed during the overturn. If the bus had not been equipped with these enclosed racks, it is likely that some luggage would have fallen from above. There is no Greyhound policy calling for purchase of buses with the racks, and only about 18 percent of the company's buses have them. The Safety Board urges Greyhound to consider the potential safety benefits of this feature. In the Board's view, the inclusion of enclosed racks on all new buses would increase the overall level of occupant crash protection provided in the Greyhound fleet. Since Greyhound and Trailways International Bus lines became parts of the same corporate structure in 1988, the adoption of such a policy by Greyhound/Trailways -- on a permanent basis, not just until the current bus purchase contracts expire -- would directly benefit the great majority of those who ride commercial intercity buses in the U.S.

CONCLUSIONS

Findings

1. The mechanical condition of the bus was not a factor in this accident.

2. The bus was traveling 60 to 65 mph when it went out of control; the posted regulatory speed limit in the construction zone was 45 mph.

3. The accident sequence began when the bus driver steered to the left without braking to avoid a car that had pulled in front; the bus then continued into the middle lane (lane 3) that was closed to traffic, then

returned to the rightmost concrete lane (lane 2) before going out of control.

4. The rear wheels of the bus hydroplaned on wet pavement during the accident sequence.

5. The concrete lane that was open to traffic in the construction zone (lane 2) had a consistently low coefficient of friction; on the adjacent shoulder that was being used as a travel lane (lane 1), at the point where the bus went out of control, there was an asphalt overlay that had a significantly higher coefficient of friction.

6. The differential coefficient of friction between the lanes served to magnify the bus driver's initial steering maneuver as he moved from the right lane (lane 1) to the left lane (lane 2).

7. Improvements are needed in the Tennessee Department of Transportation program to provide for sufficient skid resistance on the State's highways, and also to prevent conditions of differential coefficient of friction from developing.

8. Improvements are needed in the Tennessee Department of Transportation pavement management system to meet both the standards and guidelines set by the Federal Highway Administration.

9. The bus driver's record revealed a pattern of accidents, traffic citations, and company rule violations indicating a tendency to speed that was consistent with his speeding in this accident.

10. Corrective action by Greyhound, such as training, discipline, reassignment, or discharge, was not sufficient to modify the bus driver's propensity to drive at excessive speed.

11. Greyhound s recurrent training program is primarily reactive in emphasis, serving as a response to demonstrated bus driver performance problems, rather than as a means of preventing them.

12. On at least two occasions, the annual review of the bus driver's record, required by Federal regulation, was performed by Greyhound personnel who were not qualified to evaluate the results and take action as needed.

13. The Federal regulation that requires the annual review by motor carriers of commercial drivers' records does not establish the qualifications needed in the reviewing officials.

14. The bus driver was operating the bus without adequate rest and nourishment, and both circumstances could have contributed to inattentiveness and performance lapses at the time of the accident; however, there are no indications that the driver was in fact drowsy or that he exhibited driving behavior indicative of fatigue.

15. A program is needed at Greyhound to educate bus drivers and their families about the stresses imposed by night work and shift work and the impact these stresses can have on safe job performance; education is needed as well about the need for proper nourishment while on duty.

16. Toxicological tests on a blood specimen taken from the bus driver after the accident did not reveal the presence of alcohol, illicit drugs, or high concentrations of chlorothiazide, a prescription drug used in the treatment of hypertension.

17. While submitting to federally required biennial physical examinations, the bus driver, on at least two occasions, failed to provide pertinent information about his medical history, which prevented accurate assessments by company physicians of his qualifications to drive a bus in commercial service.

18. After filling out the medical history questionnaire as part of the federally required biennial physical examination, Greyhound bus drivers are not required to certify that the information is accurate and complete, or to give Greyhound the authority to obtain information on their medical history from their personal health care providers.

19. In the Federal regulation governing periodic medical certification of commercial drivers, the terms used to describe the required medical history information may not be fully understood by those drivers.

20. The accident vehicle was equipped with enclosed overhead luggage racks, the doors of which remained closed during the overturn. There were no passenger injuries from luggage falling from overhead, nor was egress from the bus hindered.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the operation of the bus at a speed that was above the regulatory limit and too great for existing weather conditions, which resulted in the bus driver's loss of control. Contributing to the loss of control were the variant frictional properties of the travel lanes in the construction zone.

RECOMMENDATIONS

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

-- to Greyhound Lines, Inc.:

Review and modify, as needed, company policies and procedures to identify bus drivers with unsafe performance records and then prevent them from continuing to operate buses in a manner hazardous to public safety. (Class II, Priority Action) (H-89-26)

Develop a structured recurrent training program, encompassing classroom instruction as well as simulator and/or behind-the-wheel instruction, designed to help maintain the performance of company bus drivers at high standards, and require all bus drivers to participate on a regular basis; include in this program instruction on safe bus operations in adverse weather conditions. (Class II, Priority Action) (H-89-27)

Revise the form bus drivers are required to complete as part of their biennial physical examinations so that by signing the document they certify that the medical history they have provided is both complete and accurate and that Greyhound has the authority to obtain information on the bus drivers' medical history from their personal health care providers; and revise the form to require bus drivers to provide information on any illness or injury incurred during the previous two years or since the last certification examination. (Class II, Priority Action) (H-89-28)

Establish and enforce a policy that each individual conducting the federally required annual review of a bus driver's traffic record be a supervisor who is familiar with that record, qualified to interpret it, and authorized to impose appropriate measures in response to findings from the review. (Class II, Priority Action) (H-89-29)

Institute a program to educate company bus drivers about the need for proper nourishment while on duty and also to educate both bus drivers and their families about the stresses imposed by night work and shift work, as well as the adverse effect these stresses can have on safe job performance. (Class II, Priority Action) (H-89-30)

-- to the Federal Highway Administration:

Revise Section 391.43 of the Federal Motor Carrier Safety Regulations to: incorporate a provision that will prohibit the omission of medical information in connection with a medical certification physical examination; require that when commercial drivers are examined, they sign a statement certifying that the medical history they have provided is both complete and accurate and that the motor carrier has the authority to obtain information on the bus drivers' medical history from their personal health care providers; and require that the medical history form elicit more complete information on drivers, using commonly understandable terminology. (Class II, Priority Action) (H-89-31)

Revise Section 391.25 of the Federal Motor Carrier Safety Regulations to specify the qualifications of the individuals conducting the reviews of commercial drivers' performance records, required annually of motor carriers. (Class II, Priority Action) (H-89-32)

-- to the Tennessee Department of Transportation:

Modify Tennessee's skid accident reduction program in accordance with the recommendations issued by FHWA in its 1986 review of the State's skid accident reduction activities, and with the standards and guidelines issued by the FHWA for pavement management systems. (Class II, Priority Action) (H-89-33)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
Acting Chairman

/s/ John K. Lauber
Member

/s/ Joseph T. Nall
Member

/s/ Lemoine V. Dickinson, Jr.
Member

Jim Burnett, Member, concurred in the recommendations and did not participate in the adoption of the report and the probable cause.

August 8, 1989

APPENDIXES

APPENDIX A

INVESTIGATION

Investigation

The National Transportation Safety Board was notified of the accident at 10:00 a.m. on November 19, 1988, by the news media. Highway accident investigators were dispatched from the Safety Board's headquarters in Washington, D.C. and from the Kansas City Field Office. Investigators arrived on the scene at about 8:00 p.m., November 19, 1988. Participating in the investigation were representatives of the Tennessee Department of Transportation, Greyhound Bus Lines, Inc., and the Metropolitan Nashville Police Department.

Depositions

On January 30, 1989, Safety Board investigators took depositions from the accident bus driver and representatives of Greyhound Lines, Inc.

APPENDIX B

BJS DRIVER'S RECORD

DATE	ACCIDENTS/TRAFFIC CITATIONS/RULES INFRACTIONS
08-20-71	Preventable Accident
07-28-75	Non-Preventable Accident
10-24-77	Company Rule Infraction (2-day suspension)
01-07-78	Traffic Citation (speeding)
03-08-78	Non-Preventable Accident
01-22-79	Non-Preventable Accident
06-25-80	Traffic Citation (speeding)
10-11-80	Traffic Citation (speeding/3-day suspension)
03-20-82	Non-Preventable Accident
12-27-82	Preventable Accident
01-25-83	Discharged (cause: driving performance)
02-24-83	Reinstated
04-26-83	Traffic Citation (speeding)
05-04-84	Preventable Accident
05-09-84	Company Rule Infraction
05-11-84	Company Rule Infraction
06-04-84	Preventable Accident (10-day suspension)
08-18-84	Non-Preventable Accident
*05-31-87	Traffic Citation (speeding)
*02-24-88	Traffic Citation (failure to yield)
04-18-88	Preventable Accident (2-day suspension)
11-19-88	Preventable Accident (Nashville)
12-13-88	Discharged (cause: driving performance)
01-13-89	Reinstated

All of the above notations were found in Greyhound's central driving record maintained on the bus driver, except for the two marked with asterisks. Those citations were reported by the bus driver on forms now held in the company files. Under Federal regulation, an interstate motor carrier is required to obtain from each of its drivers a list of all traffic violations committed by that driver during the preceding 12 months.

APPENDIX C

HYDROPLANING SPEED CALCULATIONS

Utilizing measured tire pressures and tire footprint aspect ratios, the hydroplaning speed for each bus tire was calculated using the following formula: $V_p = 7.95\ p(w/l)$

p = tire inflation pressure (lbs./inches^2)
w/l = tire footprint aspect ratio
V_p = minimum tire hydroplaning speed in MPH

Individual tire hydroplaning speeds:

Left Front: 84.43 mph
Outside Left Rear: 51.06 mph
Inside Left Rear: 69.46 mph
Left Bogie: 47.07 mph
Right Front: 81.89 mph
Outside Right Rear: 65.45 mph
Inside Right Rear: 64.38 mph
Right Bogie: 73.70 mph

The outside left rear and left bogie tires were deflated during the accident. Their inflation pressures could not be determined. Therefore, hydroplaning speeds for these tires are not representative of accident conditions.

APPENDIX D

GREYHOUND LINES INC.
MEDICAL EXAMINATION FORM

GREYHOUND LINES INC.

DRIVERS MEDICAL EXAMINATION

GREYHOUND LINES INC.
Physical Examination Form

SEE INSTRUCTIONS REVERSE SIDE

☐ New Employee ☒ Periodic ☐ Return to Work ☐ Special

Name Lightsy, Ronald, W. (Last) (First) (Initial) Birth 12-20-'43 (Month Day Year)

Present Address 6201 Tabor DR. Louisville, Ky. 40418 · 407-56-7208 (Number and Street) (City) (State) (Zip) (Social Security No.)

HEALTH HISTORY

Yes	No		Yes	No		Yes	No	
☐	☒	Asthma	☐	☒	Nervous Stomach	☐	☐	Head or spinal injuries
☐	☒	Kidney disease	☐	☒	Rheumatic Fever	☐	☐	Seizures, fits, convulsions or fainting
☐	☒	Tuberculosis	☐	☒	Muscular disease	☐	☐	Extensive confinement by illness or injury
☐	☒	Syphilis	☐	☒	Psychiatric disorder	☐	☐	Any other nervous disorder
☐	☒	Gonorrhea	☐	☒	Cardiovascular disease	☐	☐	Suffering from any other disease
☐	☒	Diabetes	☐	☒	Gastrointestinal ulcer	☐	☐	Permanent defect from illness, disease or injury

If answer to any of the above is yes, explain.
Please explain fully any physical disabilities.

Have you lost time from work in the last year due to illness or injury? ☒ Yes ☐ No If Yes explain Lo back pain

Have you been under medication during past year? ☐ Yes ☐ No Are you now taking prescribed medication? ☒ Yes ☐ No

If Yes explain Mild low back pain. on Indocin 25 mg. PRN

Have you had an examination by private physician during past year? ☒ Yes ☐ No Date Last Visit July or Aug.

Doctor's Name DR. Kolliers City Louisville, Ky. Diagnosis back pain

Treatment Indocin 25 mg. Electrocardiogram ☐ Yes ☒ No Results —

PHYSICAL EXAMINATION

General Appearance and Development ☒ Good ☐ Fair ☐ Poor Height 5'11 1/2" Weight 222 1/2

Vision ☒ Without corrective lenses Right 20/20 Left 20/20 Evidence of disease or injury Right None Left No

☐ With corrective lenses Right 20/ ___ Left 20/ ___ Horizontal Field of Vision Right 90° Left 90° Color Test NERWA.

Driver may use corrective lenses when driving ___

Hearing Right Ear 20-20 Left Ear 20-20 Disease or Injury None

Throat OK

Thorax Heart RSR If organic disease is present, is it fully compensated? ___ Lungs Clear

Blood Pressure Systolic 126 Diastolic 96 Pulse Before exercise 92 Immediately after exercise 102

Abdomen Scars OK Abnormal masses OK Tenderness OK

Hernia ☐ Yes ☒ No If Yes where ___ Is truss worn ___

Gastrointestinal Ulceration or other disease ☐ Yes ☒ No

Genito-Urinary Scars OK Urethral Discharge OK

Reflexes Romberg Negative

Pupillary OK Light R. OK L. OK Accommodation R. OK L. OK

Knee Jerks Right Normal OK Increased ___ Absent ___

Left Normal OK Increased ___ Absent ___

Extremities Upper OK Lower OK Spine OK

Laboratory Urine Spec. Gr. 1.026 Alb. Neg. Sugar Neg. Blood Serology ___

Chest X-Ray ___ Cardiograph (To be made only when findings indicate desirability) ___

Other Lab Test ___

I certify that I have carefully examined Ronald W. Lightsy and that the physical condition as described is correct.

I hereby ☐ Do ☐ Do not recommend him/her for employment/continued employment. Reason for not approving/limitations ___

Doctor's Signature [signature]

MEDICAL EXAMINER'S CERTIFICATE-DRIVERS ONLY

I certify that I have examined Ronald W. Lightsy (Please Print) in accordance with the motor carrier safety regulations (49 C.F.R. Par. 391.41 - 391.49) and with knowledge of his duties, I find him/her qualified under regulations. ☐ Qualified only when wearing ☐ Corrective lenses ☐ Hearing Aid ☐ Qualified only until 11-29-98. A completed examination form for this person is on file in my office at

10401 Taylorsville Rd. Date Examined 11-29-98 Doctor's Name C.K. Peterson, M.D. (Print)

[signature] Doctor's Signature [signature]

Signature of Applicant/Employee – Authorized Person Representing Employer

§ 391.25 Annual review of driving record.

Except as provided in Subpart G of this part, each motor carrier shall, at least once every 12 months, review the driving record of each driver it employs to determine whether that driver meets minimum requirements for safe driving or is disqualified to drive a motor vehicle pursuant to § 391.15. In reviewing a driving record, the motor carrier must consider any evidence that the driver has violated applicable provisions of the Federal Motor Carrier Safety Regulations and the Hazardous Materials Regulations. The motor carrier must also consider the driver's accident record and any evidence that the driver has violated laws governing the operation of motor vehicles, and must give great weight to violations, such as speeding, reckless driving, and operating while under the influence of alcohol or drugs, that indicate that the driver has exhibited a disregard for the safety of the public. A note, setting forth the date upon which the review was performed and the name of the person who reviewed the driving record, shall be included in the driver's qualification file.

[35 FR 6460, Apr. 22, 1970, as amended at 35 FR 17420, Nov. 13, 1970]

§ 391.27 Record of violations.

(a) Except as provided in Subpart G of this part, each motor carrier shall, at least once every 12 months, require each driver it employs to prepare and furnish it with a list of all violations of motor vehicle traffic laws and ordinances (other than violations involving only parking) of which the driver has been convicted or on account of which he has forfeited bond or collateral during the preceding 12 months.

(b) Each driver shall furnish the list required in accordance with paragraph (a) of this section. If the driver has not been convicted of, or forfeited bond or collateral on account of, any violation which must be listed, he shall so certify.

(c) The form of the driver's list or certification shall be prescribed by the motor carrier. The following form may be used to comply with this section:

MOTOR VEHICLE DRIVER'S CERTIFICATION

[I certify that the following is a true and complete list of traffic violations (other than parking violations) for which I have been convicted or forfeited bond or collateral during the past 12 months]

Date of conviction	Offense	Location	Type of vehicle operated

[If no violations are listed above, I certify that I have not been convicted or forfeited bond or collateral on account of any violation required to be listed during the past 12 months.

(Date of certification) (Driver's signature)

(Motor carrier's name) (Motor carrier's address)

(Reviewed by Signature) (Title)

(d) The motor carrier shall retain the list or certificate required by this section, or a copy of it, in its files as part of the driver's qualification file.

(e) Drivers who have provided information required by § 383.31 of this subchapter need not repeat that information in the annual list of violations required by this section.

[35 FR 6460, Apr. 22, 1970, as amended at 35 FR 17420, Nov. 13, 1970, 52 FR 20589, June 1, 1987]

APPENDIX E

(b) A person is physically qualified to drive a motor vehicle if that person—

(1) Has no loss of a foot, a leg, a hand, or an arm, or has been granted a waiver pursuant to § 391.49;

(2) Has no impairment of:

(i) A hand or finger which interferes with prehension or power grasping; or

(ii) An arm, foot, or leg which interferes with the ability to perform normal tasks associated with operating a motor vehicle; or any other significant limb defect or limitation which interferes with the ability to perform normal tasks associated with operating a motor vehicle; or has been granted a waiver pursuant to § 391.49.

(3) Has no established medical history or clinical diagnosis of diabetes mellitus currently requiring insulin for control;

(4) Has no current clinical diagnosis of myocardial infarction, angina pectoris, coronary insufficiency, thrombosis, or any other cardiovascular disease of a variety known to be accompanied by syncope, dyspnea, collapse, or congestive cardiac failure.

(5) Has no established medical history or clinical diagnosis of a respiratory dysfunction likely to interfere with his ability to control and drive a motor vehicle safely;

(6) Has no current clinical diagnosis of high blood pressure likely to interfere with his ability to operate a motor vehicle safely;

(7) Has no established medical history or clinical diagnosis of rheumatic, arthritic, orthopedic, muscular, neuromuscular, or vascular disease which interferes with his ability to control and operate a motor vehicle safely;

(8) Has no established medical history or clinical diagnosis of epilepsy or any other condition which is likely to cause loss of consciousness or any loss of ability to control a motor vehicle;

(9) Has no mental, nervous, organic, or functional disease or psychiatric disorder likely to interfere with his ability to drive a motor vehicle safely;

(10) Has distant visual acuity of at least 20/40 (Snellen) in each eye without corrective lenses or visual acuity separately corrected to 20/40 (Snellen) or better with corrective lenses, distant binocular acuity of at least 20/40

Subpart E—Physical Qualifications and Examinations

(a) A person shall not drive a motor vehicle unless he is physically qualified to do so and, except as provided in § 391.67, has on his person the original, or a photographic copy, of a medical examiner's certificate that he is physically qualified to drive a motor vehicle.

(Snellen) in both eyes with or without corrective lenses, field of vision of at least 70° in the horizontal Meridian in each eye, and the ability to recognize the colors of traffic signals and devices showing standard red, green, and amber;

(11) First perceives a forced whispered voice in the better ear at not less than 5 feet with or without the use of a hearing aid or, if tested by use of an audiometric device, does not have an average hearing loss in the better ear greater than 40 decibels at 500 Hz, 1,000 Hz, and 2,000 Hz with or without a hearing aid when the audiometric device is calibrated to American National Standard (formerly ASA Standard) Z24.5—1951.

(12) Does not use a Schedule I drug or other substance identified in Appendix D to this subchapter,[1] an amphetamine, a narcotic, or any other habit-forming drug; and

(13) Has no current clinical diagnosis of alcoholism.

[35 FR 6460, Apr. 22, 1970, as amended at 35 FR 17420, Nov. 13, 1970; 36 FR 223, Jan. 7, 1971; 36 FR 12857, July 8, 1971; 43 FR 56900, Dec. 5, 1978; 51 FR 17571, May 13, 1986]

§ 391.43 Medical examination; certificate of physical examination.

(a) Except as provided in paragraph (b) of this section, the medical examination shall be performed by a licensed doctor of medicine or osteopathy.

(b) A licensed optometrist may perform so much of the medical examination as pertains to visual acuity, field of vision, and the ability to recognize colors as specified in paragraph (10) of § 391.41(b).

(c) The medical examination shall be performed, and its results shall be recorded, substantially in accordance with the following instructions and examination form:

[1] A copy of the Schedule I drugs and other substances may be obtained by writing to the Director, Bureau of Motor Carrier Safety, Washington, DC 20590, or to any Regional Office of Motor Carrier and Highway Safety of the Federal Highway Administration at the address given in Part 390 of this subchapter.

INSTRUCTIONS FOR PERFORMING AND RECORDING PHYSICAL EXAMINATIONS

The examining physician should review these instructions before performing the physical examination. Answer each question yes or no where appropriate.

The examining physician should be aware of the rigorous physical demands and mental and emotional responsibilities placed on the driver of a commercial motor vehicle. In the interest of public safety the examining physician is required to certify that the driver does not have any physical, mental, or organic defect of such a nature as to affect the driver's ability to operate safely a commercial motor vehicle.

General information. The purpose of this history and physical examination is to detect the presence of physical, mental, or organic defects of such a character and extent as to affect the applicant's ability to operate a motor vehicle safely. The examination should be made carefully and at least as complete as indicated by the attached form. History of certain defects may be cause for rejection or indicate the need for making certain laboratory tests or a further, and more stringent, examination. Defects may be recorded which do not, because of their character or degree, indicate that certification of physical fitness should be denied. However, these defects should be discussed with the applicant and he should be advised to take the necessary steps to insure correction, particularly of those which, if neglected, might lead to a condition likely to affect his ability to drive safely.

General appearance and development. Note marked overweight. Note any posture defect, perceptible limp, tremor, or other defects that might be caused by alcoholism, thyroid intoxication, or other illnesses. The Federal Motor Carrier Safety Regulations provide that no driver shall use a narcotic or other habit-forming drugs.

Head-eyes. When other than the Snellen chart is used, the results of such test must be expressed in values comparable to the standard Snellen test. If the applicant wears corrective lenses, these should be worn while applicant's visual acuity is being tested. If appropriate, indicate on the Medical Examiner's Certificate by checking the box, "Qualified only when wearing corrective lenses." In recording distance vision use 20 feet as normal. Report all vision as a fraction with 20 as numerator and the smallest type read at 20 feet as denominator. Note ptosis, discharge, visual fields, ocular muscle imbalance, color blindness, corneal scar, exophthalmos, or strabismus uncorrected by corrective lenses. Monocular drivers are not qualified to operate commercial motor vehicles under existing Federal

APPENDIX E

Motor Carrier Safety Regulations. If the driver habitually wears contact lenses, or intends to do so while driving, there should be sufficient evidence to indicate that he has good tolerance is well adapted to their use. The use of contact lenses should be noted on the record.

Ears. Note evidence of mastoid or middle ear disease, discharge, symptoms of aural vertigo, or Meniere's Syndrome. When recording hearing, record distance from patient at which a forced whispered voice can first be heard. If audiometer is used to test hearing, record decibel loss at 500 Hz, 1,000 Hz, and 2,000 Hz.

Throat. Note evidence of disease, irremediable deformities of the throat likely to interfere with eating or breathing, or any laryngeal condition which could interfere with the safe operation of a motor vehicle.

Thorax-heart. Stethoscopic examination is required. Note murmurs and arrhythmias, and any past or present history of cardiovascular disease, of a variety known to be accompanied by syncope, dyspnea, collapse, enlarged heart, or congestive heart failures. Electrocardiogram is required when findings so indicate.

Blood pressure. Record with either spring or mercury column type of sphygmomanometer. If the blood pressure is consistently above 160/90 mm Hg., further tests may be necessary to determine whether the driver is qualified to operate a motor vehicle.

Lungs. If any lung disease is detected, state whether active or arrested. If arrested, your opinion as to how long it has been quiescent.

Gastrointestinal system. Note any diseases of the gastrointestinal system.

Abdomen. Note wounds, injuries, scars, or weakness of muscles of abdominal walls sufficient to interfere with normal function. Any hernia should be noted if present. State how long and if adequately contained by truss.

Abnormal masses. If present, note location, if tender, and whether or not applicant knows how long they have been present. If the diagnosis suggests that the condition might interfere with the control and safe operation of a motor vehicle, more stringent tests must be made before the applicant can be certified.

Tenderness. When noted, state where most pronounced, and suspected cause. If the diagnosis suggests that the condition might interfere with the control and safe operation of a motor vehicle, more stringent tests must be made before the applicant can be certified.

Genito-urinary. Urinalysis is required. Acute infections of the genito-urinary tract, as defined by local and State public health laws, indications from urinalysis of uncontrolled diabetes, symptomatic albumin-urea in the urine, or other findings indicative of health conditions likely to interfere with the control and safe operation of a motor vehicle, will disqualify an applicant from operating a motor vehicle.

Neurological. If positive Romberg is reported, indicate degrees of impairment. Pupillary reflexes should be reported for both light and accommodation. Knee jerks are to be reported absent only when not obtainable upon reinforcement and as increased when foot is actually lifted from the floor following a light blow on the patella. sensory vibratory and positional abnormalities should be noted.

Extremities. Carefully examine upper and lower extremities. Record the loss of impairment of a leg, foot, toe, arm, hand, or fingers. Note any and all deformities, the presence of atrophy, semiparalysis or paralysis, or varicose veins. If a hand or finger deformity exists, determine whether sufficient grasp is present to enable the driver to secure and maintain a grip on the steering wheel. If a leg deformity exists, determine whether sufficient mobility and strength exist to enable the driver to operate pedals properly. Particular attention should be given to and a record should be made of, any impairment or structural defect which may interfere with the driver's ability to operate a motor vehicle safely.

Spine. Note deformities, limitation of motion, or any history of pain, injuries, or disease, past or presently experienced in the cervical or lumbar spine region. If findings so dictate, radiologic and other examinations should be used to diagnose congenital or acquired defects, or spondylolisthesis and scoliosis.

Recto-genital studies. Diseases or conditions causing discomfort should be evaluated carefully to determine the extent to which the condition might be handicapping while lifting, pulling, or during periods of prolonged driving that might be necessary as part of the driver's duties.

Laboratory and other special findings. Urinalysis is required, as well as such other tests as the medical history or findings upon physical examination may indicate are necessary. A serological test is required if the applicant has a history of luetic infection or present physical findings indicate the possibility of latent syphilis. Other studies deemed advisable may be ordered by the examining physician.

Diabetes. If insulin is necessary to control a diabetic condition, the driver is not qualified to operate a motor vehicle. If mild diabetes is noted at the time of examination and it is stabilized by use of a hypoglycemic drug and a diet that can be obtained while the driver is on duty, it should not be considered disqualifying. However, the driver must remain under adequate medical supervision.

The physician must date and sign his findings upon completion of the examination.

EXAMINATION TO DETERMINE PHYSICAL CONDITION OF DRIVERS

Driver's name ——— ☐ New Certification
Address ——— ☐ Recertification
Social Security No. ———
Date of birth ——— Age ———

Yes	No	Health History
☐	☐	Head or spinal injuries
☐	☐	Seizures, fits, convulsions, or fainting
☐	☐	Extensive confinement by illness or injury
☐	☐	Cardiovascular disease
☐	☐	Tuberculosis
☐	☐	Syphilis
☐	☐	Gonorrhea
☐	☐	Diabetes
☐	☐	Gastrointestinal ulcer
☐	☐	Nervous stomach
☐	☐	Rheumatic fever
☐	☐	Asthma
☐	☐	Kidney disease
☐	☐	Muscular disease
☐	☐	Suffering from any other disease
☐	☐	Permanent defect from illness, disease or injury
☐	☐	Psychiatric disorder
☐	☐	Any other nervous disorder

If answer to any of the above is yes, explain.

PHYSICAL EXAMINATION

General appearance and development:
Good — Fair — Poor —
Vision: For distance
Right 20/— Left 20/—
☐ Without corrective lenses
☐ With corrective lenses if worn.
Evidence of disease or injury:
Right — Left —
Color Test ———
Horizontal field of vision:
Right —° Left —°
Hearing:
Right ear — Left ear —
Disease or injury ———
Audiometric Test (complete only if audiometer is used to test hearing) decibel loss at 500 Hz —, at 1,000 Hz —, at 2,000 Hz —
Throat ———
Thorax:
Heart ———
If organic disease is present, is it fully compensated? ———
Blood pressure:
Systolic — Diastolic —
Pulse: Before exercise ———
Immediately after exercise ———
Lungs ———
Abdomen:
Scars — Abnormal masses —
Tenderness —
Hernia: Yes — No —
If so, where? ———
Is truss worn? ———
Gastrointestinal:
Ulceration or other disease:
Yes — No —
Genito-Urinary:
Scars ———
Urethral discharge ———
Reflexes:
Romberg ———
Pupillary — Light R — L —
Accommodation Right — Left —
Knee Jerks:
Right:
Normal — Increased — Absent —
Left:
Normal — Increased — Absent —
Remarks ———
Extremities:
Upper ———
Lower ———
Spine ———
Laboratory and other Special Findings
Urine Spec Gr. — Alb. —
Sugar —
Other laboratory data (Serology, etc.)
Radiological data ———
Electrocardiograph ———
General comments ———

(Date of examination)

(Address of examining doctor)

(Name of examining doctor (Print))

(Signature of examining doctor)

NOTE: This section to be completed only when visual test is conducted by a licensed ophthalmologist or optometrist.

(Date of examination)

(Address of ophthalmologist or optometrist)

(Name of ophthalmologist or optometrist (Print))

APPENDIX E

(Signature of ophthalmologist or optometrist)

(d) If the medical examiner finds that the person he examined is physically qualified to drive a motor vehicle in accordance with § 391.41(b), he shall complete a certificate in the form prescribed in paragraph (e) of this section and furnish one copy to the person who was examined and one copy to the motor carrier that employs him.

(e) The medical examiner's certificate shall be in accordance with the following form:

MEDICAL EXAMINER'S CERTIFICATE

I certify that I have examined _____ (driver's name (print)) in accordance with the Federal Motor Carrier Safety Regulations (49 CFR 391.41 through 391.49) and with knowledge of his duties, I find him qualified under the regulations

☐ Qualified only when wearing corrective lenses

A completed examination form for this person is on file in my office at _____ (Address)

_____
(Date of examination)

_____
(Name of examining doctor (Print))

_____
(Signature of examining doctor)

_____
(Signature of driver)

_____
(Address of driver)

If the driver is qualified only when wearing a hearing aid, the following statement must appear on the medical examiner's certificate: "Qualified only when wearing a hearing aid." If a medical examiner determines a waiver is necessary under § 391.49, the following statement shall appear on the medical examiner's certificate; "medically unqualified unless accompanied by a waiver.

[35 FR 6460, Apr. 22, 1970, as amended at 35 FR 17420, Nov. 13, 1970, 36 FR 8452, May 6, 1971; 36 FR 12857, July 8, 1971; 43 FR 56900, Dec. 5, 1978; 46 FR 53418, Oct. 29, 1981]

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