

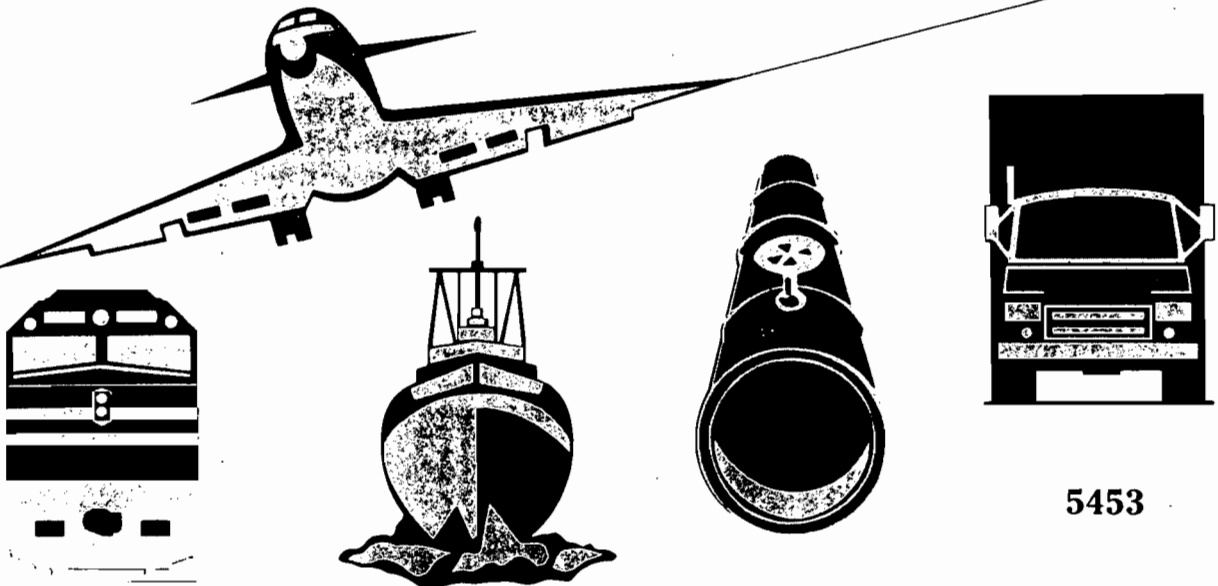
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# NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

## SPECIAL INVESTIGATION REPORT

EMERGENCY FIRE APPARATUS



5453

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### EMERGENCY FIRE APPARATUS

ADOPTED: MARCH 19, 1991

NOTATION: 5453

**Abstract:** For this report, the Safety Board examined 8 separate fire apparatus accidents and conducted an informal survey of the 50 States and the District of Columbia to determine their requirements for inspecting fire apparatus. The safety issues discussed in the report are fire department vehicle maintenance programs and State inspection programs, fire department operating procedures concerning manual brake limiting valves and engine retarders, and fire apparatus occupant seatbelt use. Recommendations concerning these issues were made to the U.S. Fire Administration of the Federal Emergency Management Agency, the International Association of Fire Chiefs, the National Fire Protection Association, and those States which do not have existing programs in place to periodically inspect fire apparatus.

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## EXECUTIVE SUMMARY

On May 10, 1990, a 1974 Hahn custom pumper fire engine responding to an emergency call in Waterbury, Connecticut, ran off the road and hit a large tree when the driver lost control on a steep downgrade. The fire engine carried five paid firefighters; two firefighters were fatally injured, one sustained moderate injuries, and the driver and remaining firefighter sustained only minor injuries. Because the Safety Board had several other fire truck (apparatus) accidents under investigation at the time of the Waterbury, Connecticut, accident, it was decided to undertake a special investigation concerning emergency fire apparatus safety.

The primary safety issues raised by these accidents are the adequacy of fire department vehicle maintenance programs and State inspection programs, fire department operating procedures concerning manual brake limiting valves and engine retarders, and fire apparatus occupant seatbelt use.

Safety recommendations addressing these issues were made to the U.S. Fire Administration of the Federal Emergency Management Agency, the International Association of Fire Chiefs, the National Fire Protection Association, and those States which do not have existing programs in place to periodically inspect fire apparatus.

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**SPECIAL INVESTIGATION REPORT**

**EMERGENCY FIRE APPARATUS**

**INTRODUCTION**

On May 10, 1990, a 1974 Hahn custom pumper fire engine operated by the Waterbury Fire Department (WFD), while responding to an emergency call in Waterbury, Connecticut, ran off the road and hit a large tree when the driver lost control on a steep downgrade. The fire engine carried five paid firefighters and 500 gallons of water. Two firefighters were fatally injured, one firefighter sustained moderate injuries, and the driver and remaining firefighter sustained only minor injuries. The pavement was wet from previous rain.

This accident and several others involving emergency fire apparatus<sup>1</sup> responding to alarms prompted the Safety Board to conduct a special investigation to determine the adequacy of fire apparatus maintenance and inspection, fire department operating procedures, and occupant seatbelt use. National Fire Protection Association (NFPA)<sup>2</sup> data indicate that between 1980 and 1989, 15 percent<sup>3</sup> of all firefighters who died in the line of duty died as a result of accidents involving fire apparatus that were en route to alarms.<sup>4</sup> As part of this special investigation, the Safety Board examined 8 separate fire apparatus accidents and conducted an informal survey of the 50 States and the District of Columbia to determine their requirements for inspecting fire apparatus.

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<sup>1</sup>For the purposes of this report, "fire apparatus" refers to the heavy fire vehicles, such as pumpers/engines, ladder trucks, heavy squad units, 10,000 pounds and over, that transport people, and specialized equipment, such as foam/crash units used at airports.

<sup>2</sup>The National Fire Protection Association (NFPA), organized in 1896, is an independent, voluntary membership, nonprofit organization that develops voluntary standards and codes which serve as guidelines for the fire services in all phases of operations.

<sup>3</sup>One hundred and seventy-nine firefighters.

<sup>4</sup>See appendix A for further information concerning NFPA accident data.

## MAINTENANCE AND INSPECTION

### Accident Information

Waterbury, Connecticut.--On May 10, 1990, at 11:19 a.m. eastern standard time, a 1974 Hahn custom pumper, Model HCP12-24, with two jumpseats<sup>5</sup> was dispatched from the WFD Highland Avenue fire house to an alarm on Thomaston Avenue in Waterbury, Connecticut. (See figure 1.) The driver stated that after the alarm sounded, he started the vehicle and observed that the brake system air pressure was 120 psi (within normal operating limits).

According to the driver, the apparatus was functioning normally while heading north on Highland Avenue. As the driver approached Chase Parkway, he slowed the vehicle by downshifting the automatic transmission from drive to drive 2, applied the brakes, and came to a stop at the intersection. Highland Avenue at this location is straight and level. The driver stated that the brakes worked "okay" and that he had no trouble stopping. The driver then crossed Highland Avenue, successfully negotiated a sharp turn (with a radius of 355 feet), and proceeded down the 10-to 13-percent grade to the intersection of West Main Street. The driver stated that he slowed through the sharp turn by downshifting.

On the steep grade, he downshifted again and applied the brakes but "did not feel any braking." He then downshifted to drive 1 and applied the brakes and parking brake (spring brake), but the parking brake button kept "popping" back.<sup>6</sup> He stated that the only deceleration he could detect was from the transmission. When he reached the intersection of Highland Avenue and West Main Street, he made a right turn into the westbound lane of West Main Street. He saw traffic backed up from the light at a nearby intersection and attempted an immediate left turn into an apartment complex parking lot. The fire engine ran over a 7-inch curb, and the driver stated that he saw a tree and tried to steer away from it. The fire engine traveled about 38 feet on the grass and collided with a tree that had two trunks. (See figure 2.)

As a result of the collision with the tree, the driver and firefighter who had been seated in the left jumpseat received minor injuries. The firefighter seated in the right front seat received moderate injuries. All of these firefighters were restrained by lap belts. The firefighter in the right jumpseat was fatally injured, (the Safety Board could not determine whether this firefighter was restrained by the available lap belt). The firefighter standing behind the right jumpseat, who was unrestrained, was fatally injured. None of the occupants were ejected. The right front of the cab sustained most of the damage.

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<sup>5</sup>This fire apparatus was a spare vehicle that was in use because the first-line fire apparatus was being serviced.

<sup>6</sup>The parking brake for this fire apparatus was controlled by a push/pull control valve located on the apparatus instrument panel. The Hahn operating manual states: "To set the parking brake on the rear axle chambers, pull out the parking brake control. To release the parking brake, push control in."



Figure 1.--Hahn custom pumper, Model HCP-15.  
(similar to the accident vehicle.)

**Tarrant County, Texas.**--About 2:34 p.m., on October 24, 1990, a Spillway Volunteer Fire Department (SVFD) firefighter was dispatched in a tanker truck to transport 1,000 gallons of water to other firefighters at the scene of a house fire in rural Tarrant County, Texas. Before departing on the fire call, she had been babysitting the fire chief's 2-year-old daughter. She was unable to find another babysitter and took the infant with her. The 1963 International Loadstar 1600 firetruck was not equipped with seatbelts, and the infant was not restrained in a child safety seat.



Figure 2.--Accident vehicle at its final rest position.  
(Waterbury *Republican American* newspaper photograph; Don Cousey, staff  
photographer; Tom Kabelka, photo lab.)

The firetruck was eastbound on Farm-to-Market Road 1886 at a witness-estimated speed of 45 mph when the driver began negotiating a shallow left curve on a 6-percent downgrade. The right side tires of the firetruck dropped 5 inches off the right pavement edge, and the driver steered to the left and lost control of the vehicle. The firetruck eventually travelled off the pavement on the south side of the road, dropped 10 feet, and crashed head-on into a dirt embankment. The firetruck exploded into flames at impact, and both occupants were killed.

#### **Fire Apparatus Maintenance**

WFD vehicle maintenance was performed by the WFD Bureau of Auto Repairs (BAR) located in the Waterbury Public Works service yard. The four employees at the BAR maintained all fire apparatus, firefighting equipment, fire station power generators, lawn mowers, nonemergency vehicles, and automobiles. The WFD had 42 motorized vehicles including 21 fire apparatus. The WFD mechanics were required to pass a civil service mechanics test. They received on-the-job training and brief training seminars from truck dealers and distributors.



Generally, spare fire apparatus are used only when the first-line apparatus are out of service for maintenance or repair. In January 1990, the WFD purchased new equipment, and the accident fire apparatus was taken out of first-line service as engine 9 at the Northside fire house on January 27, 1990. The accident fire apparatus eventually became the first-line spare at the fire house on Highland Avenue. At the time of the accident, the WFD had three ladder trucks and five engines in spare service. They were under the same maintenance schedule as the regular first-line apparatus.

All the WFD fire apparatus had hour meters that recorded engine running time and were used to determine when vehicle service was needed. Under the WFD preventive maintenance program, a vehicle was to be serviced after 150 hours of operation. The 150-hour service check included changing the engine oil and filter, lubricating the chassis, checking all fluids, and inspecting all belts, hoses, batteries, tires, exhaust system, fuel system, steering, suspension, and brakes. The service manual for the 1974 Hahn pumper, which was the accident vehicle, recommends service every 50 hours.

The master mechanic stated that the BAR also performs an annual service check on each vehicle that includes the items on the 150-hour service check, changing the fuel, automatic transmission, water, and air filters, and changing the pump transfer gear case and rear axle carrier case oil. Any rebuilding of components (brakes, transmission, etc.) is normally performed at this time. A service reminder (a 4-inch by 8-inch index card) is posted in the cab of the apparatus and states the hour meter reading for the next 150-hour service check and the date of the next annual service check. It is the responsibility of the personnel where the apparatus is stationed to notify the BAR when a vehicle is due for maintenance. Additionally, the WFD accident driver stated that shift duty drivers normally inspect their vehicles (pre-trip) at the beginning of a 3-day duty shift; this inspection includes a check of all fluids and an examination of the tires for damage, low air pressure, and tread wear, but no road tests are performed.

Of the 12 request-for-repair forms filed on the accident vehicle between November 7, 1988, and May 3, 1990, 7 were requests to fix the brakes. Most of the forms had notes indicating that the brakes had been checked or adjusted. A request for repair dated May 3, 1990, stated that "the maxi brake doesn't hold on hills and the regular [brakes] have a hard time stopping the engine on emergency runs." No records or available information indicated that the brakes had been repaired. Earlier in the morning on the day of the accident, the crew took the accident vehicle to the BAR to exchange the 24-foot extension ladder. While there, the driver talked to the master mechanic about the brakes. The driver indicated that the master mechanic checked the air pressure and made several brake applications. He told the driver there were no mechanics in the shop at that time and that if the driver brought the engine back after lunch, someone would adjust the brakes. Shortly after the engine company returned to the fire station, it responded to the call that resulted in the accident.

The fire engine was equipped with an automatic transmission and air-mechanical service brakes. A mechanical examination of the vehicle following the accident indicated that the front axle brakes had no defects and that the push-rod adjustments were within operating limits. An accumulation of rust was observed in both the left and right rear axle brakes. Three of the four rear axle brakeshoes were not making contact with the drum upon application. The lower left and both the upper and lower right brakeshoes were frozen at the anchor pins.

The rear axle brake chamber push-rod adjustments were within operating limits on the right side and at the maximum operating limit on the left side. The air chambers were misaligned, and the push rods had severe wear markings on the sides.<sup>7</sup>

If only one brakeshoe out of four makes contact with one of the two drums, the rear axle receives only 25 percent of the brake retarding force that it should. According to Safety Board calculations, which took into account the size of the air chamber (24 square inches on the front axle and 30 square inches on the rear axle) and which assumed an air pressure application of 100 psi, the rear axle brakes were in such poor condition that the apparatus had only 58 percent of its original braking capability. The driver indicated that the wet/dry switch<sup>8</sup> was in the wet position, thus providing only 50 percent of the braking capability of the front axle. (See "Fire Department Operating Procedures.") The condition of the rear axle brakes, coupled with the use of the wet/dry switch in the wet position, reduced the original braking capability of the vehicle to about 36 percent.

The accumulated rust around the anchor pins of the WFD apparatus rear axle brakes indicated that they were in need of lubrication. According to the manufacturer's service manual, the brakeshoe pins should be cleaned and lubricated after every 500 hours of use. Based on the hour-meter recorded measurements, the accident vehicle's brakeshoe pins should have been serviced in November 1989. The rust and the frozen condition of the pins indicate that the service was not performed. The Safety Board concludes that the BAR did not adequately maintain the accident vehicle's brakes and did not follow the manufacturer's recommended service guidelines.

The WFD BAR policy was that fire apparatus should receive preventive maintenance after every 150 hours of operation, as measured by the engine hour-meters. A review of the service records for the accident vehicle shows that in September 1988 it received a 150-hour service check although it had been in service for 267 hours since its last check. In November 1989, 468 hours of service later, it received its next check. The Safety Board concludes that the BAR did not adhere to its own policy of servicing a vehicle after every 150 hours of service. The manufacturer's service intervals are intended to insure that a vehicle performs as designed. Service intervals of 50 hours were recommended by the manufacturer's maintenance manual for the WFD accident vehicle. Most vehicle manufacturers recommend service based on either the amount of use or elapsed time, whichever comes first, because a vehicle can deteriorate even while it is idle. Lubricants can dry out, and rust and corrosion can develop, especially in the case of spare vehicles that may be used infrequently.

The Tarrant County, Texas, SVFD had 6 vehicles (a tanker, two engines, a rescue vehicle, and two grass trucks). The SVFD did not have a formal maintenance program or record system. It did change the oil in its vehicles every 3 or 4 months and did take the vehicles to an outside shop for repair when they were not functioning properly.

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<sup>7</sup>See appendix B for further information concerning the condition of the brake.

<sup>8</sup>Many vehicles use a manual limiting valve (commonly called a dry road/slippy road valve or wet/dry switch) that is controlled by a pneumatic switch in the cab. In the "dry road" position, the valve is a 1:1 valve. In the "slippy road" position, it reduces front brake pressure to 50 percent of control line pressure at all control line pressure levels.

The postcrash examination of the firetruck disclosed numerous deficiencies: The left front tire was underinflated; its rated inflation pressure was 95 psi; however, it was only inflated to 50 psi. The right rear dual tires were inflated to 45/44 psi; their rated inflation pressure was 85 psi. Further, the firetruck's steering components were excessively worn. The splined shaft attaching the pitman arm to the steering gear box was worn, and the ball socket joint where the steering arm attached to the drag link was excessively worn.

The firetruck's hydraulic brakes also had several deficiencies. SVFD personnel indicated that before the accident the firetruck would pull to the left during brake applications. An examination of the brakes revealed that the right front drum was rusted and the bottom shoe did not make contact with the drum.

As illustrated by the Waterbury, Connecticut, accident, some fire department maintenance programs do not ensure that fire apparatus are properly maintained. Further, as illustrated by the Tarrant County, Texas, accident some fire departments have no maintenance program. Because fire apparatus often stop suddenly, because they are frequently operated at higher speeds than are conventional vehicles, and because they are operated under hazardous conditions, it is essential that they be properly maintained. Therefore, the Safety Board believes that the U.S. Fire Administration (USFA)<sup>9</sup> of the Federal Emergency Management Agency and the International Association of Fire Chiefs (IAFC) should urge fire departments to establish vehicle maintenance programs that follow all of the manufacturers service requirements and schedules.

### Fire Apparatus Inspection

**Connecticut State Inspection.**--Following the Waterbury accident, a mechanical inspection of the WFD fire apparatus was conducted by the Connecticut Department of Motor Vehicle (CDMV) Commercial Vehicle Safety Unit. The CDMV indicated that because of the condition of the brakes, the vehicle failed the safety criteria used in the commercial vehicle roadside inspection program developed by the Commercial Motor Carrier Safety Assistance Program (MCSAP) of the Federal Highway Administration (FHWA).<sup>10</sup> After the accident, the Waterbury City Maintenance Department examined the brakes of the WFD first-line fleet of 9 engines and 5 ladder trucks; 9 of the 14 (64 percent) were withdrawn from service to be repaired.

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<sup>9</sup>The United States Fire Administration maintains offices and conducts programs in the following areas: fire policy and coordination, firefighter health and safety, fire data and analysis, and fire prevention and control. The Administration works closely with the Nation's fire service, with fire service organizations, with Federal, State, and local governments, and with the private sector in developing and implementing programs aimed at lowering the level of loss of life and property.

<sup>10</sup>North American Uniform Service Criteria, Commercial Vehicle Safety Alliance, February, 1990, **Out-of-Service Condition:** When any motor vehicle(s) by reason of its mechanical condition or loading, is determined to be so imminently hazardous as to likely cause an accident or breakdown, or when such condition(s) would likely contribute to loss of control of the vehicle(s) by the driver, said vehicle(s) shall be placed out of service. No motor carrier shall require nor shall any person operate any motor vehicle declared and marked "out-of-service" until all required repairs have been satisfactorily completed.

At the time of the Waterbury accident, the State did not require the inspection of emergency vehicles. After the accident, the CDMV initiated a voluntary non-fee inspection program for fire service vehicles. From July 1, 1990, to January 3, 1991, the CDMV inspected 559 fire apparatus from 64 cities and towns. During this period, 193, or 35 percent, of the fire apparatus failed the CDMV roadside inspection. Fifty percent of the deficiencies involved brakes, 18 percent involved steering systems, and the remaining deficiencies involved tires, suspension systems, and fuel leaks.

**Texas State Inspection.**--The postaccident examination of the Tarrant County, Texas, fire apparatus disclosed numerous mechanical deficiencies, including under-inflated tires, worn steering components, worn brake drums, and a rusted brake drum, all of which indicate inadequate maintenance. The apparatus had been inspected at an inspection station designated by the Texas Department of Public Safety (DPS) and had received an Annual Vehicle Inspection Certificate dated October 5, 1990, which was 19 days before the accident.<sup>11</sup> The requirements of the Texas inspection for this apparatus consisted of 22 elements that included emissions testing; examinations of the lights, horn, windshield wipers, and tires, and a brake test that required the vehicle to stop within 20 feet at a speed of 10 mph. This inspection did not include a visual or mechanical examination of the brakes.

**State Vehicle Inspection Programs.**--The Safety Board conducted a limited survey of the 50 States and the District of Columbia to determine whether the States require vehicle inspections for fire emergency vehicles. Currently, 19 States require fire apparatus to be inspected periodically by the State or by designated fleet inspection stations.<sup>12</sup>

Table 1--States Requiring Periodic State Fire Apparatus Inspections

Arkansas	New York
California	North Carolina
Connecticut <sup>13</sup>	Oklahoma
District of Columbia	Pennsylvania
Hawaii	Rhode Island
Louisiana	South Carolina
Maine	Texas
Massachusetts	Utah
Mississippi	Vermont
New Hampshire	Washington <sup>14</sup>
New Mexico <sup>15</sup>	

<sup>11</sup>In July 1990, the DPS Motor Vehicle Inspection Unit cited the designated inspection station that had issued the certificate for issuing certificates of inspection without completing the required safety inspections.

<sup>12</sup>See appendix C for further information concerning State motor vehicle and commercial vehicle inspection programs.

<sup>13</sup>Voluntary program.

<sup>14</sup>Voluntary program.

<sup>15</sup>Fire apparatus inspection is required by the State Fire Marshall's Office.

Among the 18 highway safety program standards issued by the Department of Transportation were the periodic motor vehicle inspection (PMVI) standards. The Highway Safety Act of 1966 gave the Secretary of Transportation the authority to withhold highway construction funds if highway safety program standards were not met. By 1975, 31 States and the District of Columbia had periodic inspection programs. However, according to a report<sup>1</sup> by the U.S. General Accounting Office (GAO), the Highway Safety Act of 1976 removed the Secretary's authority to withhold highway construction funds and provided that State safety programs could be approved without meeting all of the 18 program standards. Ten States repealed the program as a result of the 1976 Act.<sup>2</sup>

The GAO report states that a 1989 National Highway Traffic Safety Administration (NHTSA) study<sup>3</sup> and other data show that periodic vehicle inspection programs reduce accident rates. The NHTSA study concluded that periodic inspection programs reduce the number of poorly maintained vehicles on the highways, but that available data do not conclusively demonstrate that inspection programs significantly reduce accident rates. The GAO took exception to this conclusion and reexamined the eight studies quoted in the NHTSA study. The GAO found that:

Taken together, the studies discussed in NHTSA's report as well as several other studies identified by GAO indicated that inspection programs reduce accident rates. These studies included estimates of accident reduction ranging from less than 1 percent to as high as 27 percent. The actual magnitude of the reduction is unknown. GAO agrees with NHTSA that all of the studies had limitations either of scope, age, or methodological completeness. Thus, while the large majority of studies point to a safety benefit from inspection programs, they do not provide a reliable basis for judging how much effect the programs have on accident rates.<sup>4</sup>

As a result of the 1990 report, the GAO recommended that:

...the Secretary of Transportation direct NHTSA to support state periodic motor vehicle inspection programs through such actions as (1) sponsoring research, (2) assisting inspection states to share their experiences and adapt to changing automotive technology, and (3) promoting public awareness of the need to properly maintain the safety-critical components of vehicles.

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<sup>1</sup>Motor Vehicle Safety, "NHTSA [National Highway Traffic Safety Administration] Should Resume Its Support of State Periodic Inspection Programs," Report to the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, United States General Accounting Office, (GAO/RCED-90-175), July 1990.

<sup>2</sup>Those States that repealed PMVI programs after the 1976 legislation are listed with the dates of start and repeal: Colorado (1937-1981), New Mexico (1953-1977), Georgia (1965-1982), Wyoming (1967-1977), Florida (1968-1981), Idaho (1968-1976), Kentucky (1968-1978), South Dakota (1968-1979), Indiana (1969-1980), Nebraska (1969-1982)

<sup>3</sup>"Study of the Effectiveness of State Motor Vehicle Inspection Programs," NHTSA, (Washington, D.C., August 1989).

<sup>4</sup>GAO, executive summary, p.5.

After the implementation of a MCSAP random roadside inspection program in Connecticut in 1986, the percentage of vehicles that had to be removed from service because of out-of-service violations declined,<sup>20</sup> indicating an improvement in the general condition of the commercial vehicles on the road. Fire apparatus are equipped with many of the same mechanical features as other heavy trucks and can do fully as much damage in the event of an accident. However, most States do not have an oversight program for these vehicles that is comparable to the MCSAP inspections for heavy trucks. For example, although the Tarrant County, Texas, fire apparatus was inspected shortly before the accident, the vehicle was not taken out of service even though the apparatus was in poor condition. The Texas inspection did not provide the level of scrutiny that an inspection under MCSAP (mechanical) criteria would have provided. Additionally, the voluntary inspections of fire apparatus in Connecticut indicate that many of these vehicles are not maintained properly.

Currently, MCSAP programs do not include fire apparatus, and because of the random nature of MCSAP inspections, the Safety Board believes that it would be inappropriate to include them in MCSAP. However, the Safety Board believes that an improvement in the condition of fire apparatus could be expected if these vehicles were subjected to the level of inspections that commercial vehicles receive through MCSAP. Therefore, the Safety Board believes that States should require the inspection of fire apparatus and that these inspections should be performed by commercial vehicle inspectors in accordance with MCSAP (mechanical) criterion to ensure continuity in the depth and level of the inspections.

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<sup>20</sup>In 1986 70 percent of the heavy commercial vehicles inspected during CDMV MCSAP random roadside inspections failed or were put out of service because of safety violations; in 1990, 40 percent failed.

## FIRE DEPARTMENT OPERATING PROCEDURES

### Accident Information

About 6:50 p.m., on June 9, 1990, engine 381, a 1979 Oren pumper-tanker of the Long Green Volunteer Fire Company (LGVFC) in Baltimore County, Maryland, was traveling north on Manor Road responding to an emergency call when the driver lost control of the vehicle while turning at an intersection. The fire apparatus rotated 180 degrees and overturned in a ditch. The driver and four firefighters received minor to no injuries. All of the firefighters were restrained by seatbelts. The pavement was wet from a previous rain. The driver stated that as he entered the curve, he was traveling 25 to 30 miles per hour. He took his foot off the gas to slow the truck, and he "counted on the engaged engine retarder<sup>21</sup> to slow him down." He also stated that "the rear end went very fast, slipped around 180 degrees till I hit a ditch and flopped over." He indicated that the engine retarder was always left on and that none of the drivers turned it off.

The driver indicated that he had been driving fire apparatus for 26 years. He had participated in obstacle course driver training sponsored by the Baltimore County Fire Department. The LGVFC Chief indicated that the company periodically received driver training from the Baltimore County Fire Department in which participants were taught to leave engine retarders on all the time. It was the LGVFC practice to have engine retarders on at all times. Additionally, the training officer of the Baltimore County Fire Department indicated that its drivers were taught to leave engine retarders on all the time.

### Engine Retarders

The Jacobs Manufacturing Company, one of several manufacturers of engine retarders, warns drivers in its "Professional Driver Techniques and Owner's Manual" about the dangers of using retarders when they are driving on slippery or wet roads. The manual states that the driver should not use the retarder until he is sure that his truck is maintaining traction without its use. Then he can use the lower power settings on the retarder. Progressively higher power settings should not be used until it is established that the vehicle is maintaining traction in the lower settings. "If the tractor drive wheels lock or if there is a fishtail motion, immediately turn off the master switch and don't turn the Jake Brake [engine retarder] on until road conditions improve."

In the NHTSA booklet entitled "A Professional Truck Driver's Guide on the Use of Retarders,"<sup>22</sup> truck drivers are warned to turn engine retarders off when they are driving empty trucks or pulling empty trailers on wet pavement or when they are driving tractors without trailers.

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<sup>21</sup>An engine retarder uses the engine itself to aid in slowing and controlling the vehicle. When activated, the engine retarder alters the operation of the engine's exhaust so that the engine works as a power-absorbing air compressor; however, this provides a retarding action only to the drive axle.

<sup>22</sup>DOT HS 806 675, January 1985.



The "Model Driver's Manual for Commercial Vehicle Driver Licensing"<sup>23</sup> also addresses engine retarders and states:

Some vehicles have "retarders." Retarders help slow a vehicle, reducing the need for using your brakes. They reduce brake wear and give you another way to slow down. There are many types of retarders (exhaust, engine, hydraulic, electric). All retarders can be turned on or off by the driver. On some the retarding power can be adjusted. When turned "on" retarders apply their braking power (to the drive wheels only) whenever you let up on the accelerator pedal all the way.

**Caution:** When your drive wheels have poor traction, the retarder may cause them to skid. Therefore you should turn the retarder off whenever the road is wet, icy or snow covered.

In 1982 and 1983, the NHTSA sponsored research that was done by the Transportation Research Institute of the University of Michigan.<sup>24</sup> The research explored the influence of retarder torque on directional control on slippery pavements. In summary, the study indicates that drivers of retarder-equipped vehicles should be informed that they may avoid potential control problems by turning off their retarders when they are operating either empty or lightly loaded vehicles on roads that are either icy or slippery. The experimental portion of the research was performed by a test driver who had experience in heavy-truck braking experiments on slippery surfaces. In the experiment, this driver could not recover from the rapid jackknives that occurred on slippery surfaces when he was turning an empty vehicle while decelerating with the engine retarder.

In 1985 and 1986, the Safety Board investigated accidents in Texas and Colorado<sup>25</sup> in which heavy trucks lost directional control due to the misuse of engine retarders. The drivers of the trucks did not have manufacturers' operating manuals, and the motor carriers had not established operating procedures that were consistent with the manufacturers' warnings about the proper use of engine retarders.

As a result of these investigations, the Safety Board recommended that the National Highway Traffic Safety Administration (NHTSA):

H-89-38

Require the installation of a permanently affixed placard in the interior of new truck tractors equipped with an engine retarder to warn against using the retarder on slippery/wet surfaces when the

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<sup>23</sup>U.S. DOT, Federal Highway Administration Publication No. FHWA-MC-89-051, dated January 31, 1989.

<sup>24</sup>"Retarders for Heavy Vehicles: Phase III Experimentation and Analysis; Performance, Brake Savings, and Vehicle Stability" (DOT HS 8006 672).

<sup>25</sup>Highway Field Report--"1981 GMC Astro Jackknife and Loss of Control, near Decatur, Texas," August 13, 1985 (NTSB-FTW-85-H-TR38), and Highway Field Report--"1981 Freightliner Jackknife and Overturn, near Mineral Wells, Texas," April 3, 1986 (NTSB-FTW-86-H-TR09).



vehicle is empty or lightly loaded. The placard should also warn against using the engine retarder to shift gears in these conditions.

The NHTSA responded that the warnings in the booklet "A Professional Truck Driver's Guide on the Use of Retarders" and in the commercial drivers license (CDL) "Model Driver's Manual" should reach the truck driving population and eliminate the need for placarding. The NHTSA was concerned about "driver-compartment clutter and information overload from an excessive number of lights, buzzers, and warnings." The NHTSA is investigating the "driver overload issue." Safety Recommendation (H-89-38) has been classified as "Open--Acceptable Action."

Also as a result of the Texas and Colorado accidents, the Safety Board issued recommendations to the Professional Truck Drivers Institute of America, Inc., the International Brotherhood of Teamsters, the American Trucking Associations, Inc., the manufacturers of engine retarders, and the Federal Highway Administration, recommending that they inform their members of the potential hazards of misusing engine retarders and develop training on the proper use of engine retarders. (See appendix D.) However, no recommendations were issued to the fire service community.

Some of the newer fire apparatus are equipped with engine retarders and these vehicles have operating characteristics that are similar to those of heavy commercial trucks. The use of engine retarders on wet pavement can lead to loss of control. As the Baltimore County, Maryland, accident shows, some fire departments have policies that directly conflict with the written warnings issued by the manufacturers of engine retarders. Therefore, the Safety Board believes that the USFA and the IAFC should inform fire departments nationwide of the potential hazards of misusing engine retarders and encourage fire departments to establish operating procedures that are consistent with manufacturers warnings about the proper use of engine retarders.

### Limiting Valves

Following the Waterbury, Connecticut, accident, the front axle limiting valve was found in the "wet or "slippery-road" position. The driver stated that it had been raining on and off on the morning of the accident and that the streets were wet. He had set the valve to the "wet" position earlier that morning before driving the apparatus. It was WFD practice that when the roads were wet, the brake limiting valve was to be switched to the slippery road position.

Hahn "Maintenance-Operating Manual" states that "Putting the lever in the 'slippery road' position reduces pressure on the front brakes to half of that on the rear brakes. The front wheels will have less tendency to slide and steering control is maintained. Keep the lever in the 'dry road' position under all normal operating conditions." The "Model Driver's Manual for Commercial Vehicle Driver Licensing" states:

Some older vehicles (made before 1975) have a front brake limiting valve and control in the cab. The control is usually marked "normal" and "slippery." When you put the control in the "slippery" position, the limiting valve cuts "normal" air pressure to the front brakes by half. Limiting valves were used to reduce the chance of the front wheels skidding on slippery surfaces. However, they actually reduce the stopping power of the vehicle. Front wheel

braking is good under all conditions. Tests have shown front wheel skids from braking are not likely even on ice. Make sure the control is in the "normal" position to have normal stopping power.

According to a published NHTSA report,<sup>26</sup> a two-axle vehicle that weighs 27,300 pounds consistently performs better with the front axle limiting valve in the "dry road" position, even on a wet road surface. "Use of a limiting valve on this [type of] vehicle appears unwise; it degrades performance." This research program was completed in 1985.

Currently, the Safety Board is conducting a nationwide study of heavy-vehicle brake performance that evaluates nationwide data on inspections and accidents involving commercial vehicles. The results of the study will be used as a basis for making more definitive recommendations concerning the use of brake limiting valves on other types of highway vehicles. Many of the older fire service apparatus are equipped with a dry road/slippery road brake limiting valve. Because fire apparatus often stop suddenly, because they are frequently operated at higher speeds than are conventional vehicles, and because they are operated under hazardous conditions, the Safety Board concludes that the use of manual brake limiting valves can diminish the apparatus stopping capability and, therefore, their use should be discontinued.

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<sup>26</sup>U.S. DOT, NHTSA DOT HS 806 738, Interim Report "NHTSA Heavy Duty Brake Research Program, Report No. 1--Stopping Capability of Air Brake Vehicles. Volume I: Technical Report."

**OCCUPANT SEATBELT USE****Accident Information**

**Catlett, Virginia.**--About 7:38 p.m. on September 28, 1989, wagon 7 of the Catlett Volunteer Fire Company was struck on its left side by a southbound National Railroad Passenger Corporation (AMTRAK) train. The accident occurred at a private-driveway grade crossing off Virginia Route 28 about 1 mile south of Catlett, Virginia.<sup>27</sup> The cab and chassis of the apparatus rotated counterclockwise 450 degrees during the collision and came to rest facing north about 80 feet southeast of the crossing. Most of the apparatus was destroyed; however, the passenger compartment of the canopy cab remained intact. The unrestrained driver and the other firefighter seated in the cab were ejected and fatally injured, and two unrestrained firefighters riding in the rear-facing canopied jumpseat behind the cab were ejected and sustained moderate to severe injuries. A fifth firefighter riding in the rear-facing jumpseat remained within the apparatus following the collision. He received serious injuries.

**Eugene, Oregon.**--About 6:09 a.m., on January 30, 1990, a Crow Valley Fire Protection District 1989 Pierce pumper fire engine responding to a house fire overturned while traversing a residential driveway which collapsed. The engine-pumper overturned 1.5 times down a 20-foot incline and came to rest on its roof. The apparatus was occupied by three firefighters, who were restrained by seatbelts. All of the firefighters remained within the apparatus during the overturn. Following the accident all of the firefighters were treated for minor injuries and released from the hospital.

**Los Angeles, California.**--On March 1, 1990, engine 91, a Seagrave firetruck of the Los Angeles City Fire Department, left the station house on a nonemergency run (no lights or siren) and was struck broadside at the intersection of Borden Avenue and Polk Street in the Sylmar section of Los Angeles by an automobile that failed to stop for a red light.

The fire apparatus was hit on the right side behind the rear axle. The police estimated that the automobile's speed was "well in excess of 55 mph." As a result of the collision, the apparatus rotated approximately 90 degrees and overturned onto its roof. The driver and an officer were seated in the forward cab section, and the two firefighters were seated facing rearward in the jumpseat in the enclosed rear cab section. The firetruck cab remained intact during the crash, and all of the firefighters were wearing their seatbelts. The firefighters received only minor injuries. The driver of the automobile was fatally injured.

**Gallitzin Township, Pennsylvania.**--About 2:45 p.m., on May 17, 1990, the Cresson Volunteer Fire Company responded to an emergency call about a motor vehicle accident. As the 1968 Chevrolet firetruck was traveling northbound downhill on State Route 53, the driver lost control of the vehicle. The rear of the vehicle struck and rode up on a guardrail, and the vehicle overturned more than 360 degrees. The vehicle then struck a bridge abutment, traveled over the side of the bridge, and came to rest on its left side in a creek bed. Both occupants were ejected onto the roadway and were fatally injured.

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<sup>27</sup>See docket HY-514-89 for further information concerning this accident.

The police report indicated that the occupants were not wearing seatbelts. Following the crash, the State Police Motor Carrier Inspection Division officer inspected the accident vehicle. The only problem noted was that the "female ends of both seatbelts were found tucked under the seat, rendering them unusable." The cab was intact after the accident.

Dallas, Texas--About 1:54 p.m., on August 5, 1990, Dallas Fire Department engine 9, a 1990 Quality firetruck with four occupants, was responding to a medical emergency and was traveling south on South Beltline Road. The driver released the accelerator while he was traveling down a hill that curved to the left; the rear of the apparatus began to skid to the right. The apparatus skidded sideways down the road until the right front tires hit the soft dirt shoulder on the left side of the road and the apparatus rolled over and came to rest 30 feet from the road facing north. (See figure 3.) It was drizzling rain, and the pavement was wet. The driver and officer in the cab and the two firefighters in the jumpseat were wearing their seatbelts. Although the damage to the apparatus was extensive, there were no injuries.



Figure 3.--Dallas, Texas, Fire Department engine 9.  
(photograph courtesy of Dallas Fire Department.)

## National Fire Protection Association Standards

The NFPA is an independent, voluntary-membership, nonprofit organization. More than 200 NFPA committees develop voluntary standards and codes that serve as guidelines for the fire services in all phases of operations. These standards are updated every 3 to 5 years; however, they are not mandatory.

The 1987 NFPA Standard 1500, "Fire Department Occupational Safety and Health Program," Chapter 4, "Vehicles and Equipment," Section 3, "Persons Riding on Fire Apparatus," states:

4-3.1 All persons riding on fire apparatus shall be seated and secured to the vehicle by seat belts or safety harnesses at any time the vehicle is in motion. Riding on tailsteps or in any other exposed positions shall be specifically prohibited. Standing while riding shall be specifically prohibited.

### Fire Apparatus Occupant Seatbelt Use

In the Catlett, Virginia, accident four unrestrained firefighters were ejected from the apparatus, and two of these firefighters were fatally injured. Even though the fire apparatus was heavily damaged, the cab section remained intact. In the Gallitzin Township, Pennsylvania, accident, both unrestrained occupants were ejected. However, the apparatus passenger compartment remained intact. The NHTSA Fatal Accident Reporting System (FARS) 1988 data concerning fatal accidents indicate that 17.4 percent of the unrestrained passenger-car occupants were ejected from the vehicle; of those ejected, 73.5 percent were fatally injured. Although there is no similar data concerning occupant ejection as a result of accidents involving fire apparatus, it is clear that ejection from a vehicle during a collision is likely to cause a serious or fatal injury.

In contrast, several accidents in which fire apparatus overturned and the restrained occupants remained within the apparatus and were not injured illustrate the benefits of using seatbelts. In the Los Angeles, California, accident and in the Eugene, Oregon, accident, the vehicles overturned, yet the firefighters, who had used their seatbelts, received only minor injuries. In the Dallas, Texas, accident the fire apparatus rolled over and came to rest 30 feet from the road; however, the four firefighters were uninjured. Accordingly, it is likely that had the occupants of the Catlett, Virginia, and Gallitzin Township, Pennsylvania, accident vehicles been restrained, they might not have been ejected and might have been less severely injured.

NFPA voluntary standard 1500 clearly states that all persons shall be seated and restrained while riding on fire apparatus, and most departments have policies requiring the use of seatbelts. Yet, firefighters continue to be injured and killed because they are not restrained. Fire apparatus are frequently operated at higher speeds than conventional vehicles are and, therefore, are prone to overturn and high-speed accidents. It is essential for firefighters to wear available seatbelts to prevent ejection and injury. Although there are voluntary standards that encourage seatbelt use, there is no nationwide program to educate the firefighting community concerning the benefits of seatbelts. Thus, the Safety Board believes that the USFA, in cooperation with the IAFC and the NFPA, should encourage fire departments to establish and enforce mandatory seatbelt policies and to develop programs that promote the use of seatbelts in fire apparatus.

**CONCLUSIONS**

1. The condition of the rear axle brakes coupled with the use of the wet/dry switch in the wet position reduced the original braking capability of the Waterbury, Connecticut, accident vehicle to about 36 percent.
2. The Waterbury Fire Department Bureau of Auto Repairs did not maintain the accident vehicle's brakes adequately and did not follow the manufacturer's recommended service guidelines.
3. The Waterbury Fire Department Bureau of Auto Repairs did not adhere to its own policy of servicing a vehicle after 150 hours of service.
4. The condition of fire apparatus can be improved if these vehicles are subjected to the level of inspections that commercial vehicles receive through MCSAP.
5. The use of manual brake limiting valves can diminish fire apparatus stopping capability.
6. The use of engine retarders on wet pavement can lead to loss of control.
7. Firefighters are more likely to avoid ejection and injury if they are restrained.

## RECOMMENDATIONS

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

--to the U.S. Fire Administration of the Federal Emergency Management Agency:

Urge fire departments to establish vehicle maintenance programs that follow all of the manufacturers service requirements and schedules. (Class II, Priority Action) (H-91-3)

Inform fire departments nationwide of the potential hazards of misusing engine retarders, and encourage fire departments to establish operating procedures that are consistent with manufacturers warnings about the proper use of engine retarders. (Class II, Priority Action) (H-91-4)

Notify fire departments of the hazards of using fire apparatus manual brake limiting valves, and urge them to discontinue the use of these devices. (Class II, Priority Action) (H-91-5)

In cooperation with the National Fire Protection Association and the International Association of Fire Chiefs, encourage fire departments to establish and enforce mandatory seatbelt policies and to develop programs that promote the use of seatbelts in fire apparatus. (Class II, Priority Action) (H-91-6)

--to the International Association of Fire Chiefs:

Urge fire departments to establish vehicle maintenance programs that follow all of the manufacturers service requirements and schedules. (Class II, Priority Action) (H-91-7)

Inform fire departments nationwide of the potential hazards of misusing engine retarders, and encourage fire departments to establish operating procedures that are consistent with manufacturers warnings about the proper use of engine retarders. (Class II, Priority Action) (H-91-8)

Notify fire departments of the hazards of using fire apparatus manual brake limiting valves, and urge them to discontinue the use of these devices. (Class II, Priority Action) (H-91-9)

Cooperate with the U.S. Fire Administration and the National Fire Protection Association to encourage fire departments to establish and enforce mandatory seatbelt policies and to develop programs that promote the use of seatbelts in fire apparatus. (Class II, Priority Action) (H-91-10)

--to the National Fire Protection Association:

Cooperate with the U.S. Fire Administration and the International Association of Fire Chiefs to encourage fire departments to establish and enforce mandatory seatbelt policies and to develop programs that promote the use of seatbelts in fire apparatus. (Class II, Priority Action) (H-91-11)

--to the Governors and legislative bodies of those States without fire apparatus inspection programs:

Develop and implement a fire-apparatus inspection program that requires periodic inspections performed by commercial vehicle inspectors in accordance with the Federal Highway Administration Motor Carrier Assistance Program vehicle (mechanical) inspection criterion. (Class II, Priority Action) (H-91-12)

**BY THE NATIONAL TRANSPORTATION SAFETY BOARD**

/s/ James L. Kolstad  
Chairman

/s/ Susan M. Coughlin  
Vice Chairman

/s/ Jim Burnett  
Member

/s/ John K. Lauber  
Member

/s/ Christopher A. Hart  
Member

March 19, 1991



## APPENDIXES

## APPENDIX A

## ACCIDENT DATA

The Safety Board examined published NFPA accident data from 1980 through 1989 (summarized in the table below). In this 10-year period there were 1,191 firefighter fatalities; 262 fatalities, or 22 percent, occurred in apparatus or motor vehicle accidents. Of the 262, 179 (15 percent of the 1,191 fatalities) occurred in fire department vehicles, and 59 (5 percent of the 1,191 fatalities) occurred in personal vehicles.

**National Fire Protection Association  
Accident Data  
1980-1989**

Year	Total fire-fighter fatalities	Career/volunteer	Apparatus or motor vehicle accident	Fire department vehicle	Personal vehicle
1980	134	67/67	21 (21%)	19	6
1981	123	64/59	20 (16%)	11	4
1982	117	49/68	23 (19%)	16	2
1983	106	58/48	21 (20%)	15	6
1984	116	47/69	32 (27%)	25	5
1985	119	57/62	23 (19%)	17	5
1986	113	60/53	27 (23%)	24	7
1987	124	52/72	33 (27%)	20	10
1988	129	48/81	33 (26%)	17	9
1989	110	46/64	21 (19%)	10	5
Total	1,191		262 (22%)	179 (15%)	59 (5%)

## APPENDIX B

## WATERBURY, CONNECTICUT, ACCIDENT APPARATUS BRAKE CONDITION

Air chamber size	Slack adjuster	Measured push rod stroke (inches)	Recommended maximum stroke before readjustment (inches)
Front axle	Manual	1 1/8	1 3/4
Left 24	Manual	1	1 3/4
Right 24			
Rear axle			
Left 30/30	Manual	2	2
Right 30/30	Manual	1 3/4	2

## APPENDIX C

## INSPECTION REQUIREMENTS FOR FIRE APPARATUS

State	PMVI <sup>a</sup>	Commercial PMVI	Fire Apparatus
Alabama	-	- <sup>b</sup>	-
Alaska	-	-	-
Arizona	-	-	-
Arkansas	X	X	X
California	-	- <sup>c</sup>	-
Colorado	-	-	-
Connecticut	-	-	- <sup>d</sup>
Delaware	X	-	-
District of Columbia	X	X	X
Florida	-	X	-
Georgia	-	X	-
Hawaii	X	X	X
Idaho	-	-	-
Illinois	-	X	- <sup>e</sup>
Indiana	-	-	-
Iowa	-	-	-
Kansas	-	X	-
Kentucky	-	-	-
Louisiana	X	X	X
Maine	X	X	X
Maryland	-	X	X
Massachusetts	X	X	X
Michigan	-	X	-
Minnesota	-	X <sup>f</sup>	-
Mississippi	X	-	X
Missouri	X	-	X
Montana	-	-	-
Nebraska	-	-	-
Nevada	-	-	-
New Hampshire	X	X	X
New Jersey	X	X	X
New Mexico	-	-	X <sup>g</sup>
New York	X	X	X
North Carolina	X	-	X
North Dakota	-	-	-
Ohio	-	-	-

<sup>a</sup>Periodic motor vehicle inspection.

<sup>b</sup>PMVI for commercial vehicles is currently limited to liquid propane gas (LPG) carriers.

<sup>c</sup>Since 1989 California has required all commercial carriers to be inspected every 90 days.

<sup>d</sup>Voluntary program.

<sup>e</sup>Ambulances are required to be inspected. Fire apparatus are not.

<sup>f</sup>Minnesota started a PWI program for commercial vehicles in April 1991.

<sup>g</sup>Fire apparatus inspection is required by the State Fire Marshall's Office.

APPENDIX C

Oklahoma	X	X	X
Oregon	-	-	-
Pennsylvania	X	X	X
Rhode Island	X	X	X
South Carolina	X	-	X
South Dakota	-	-	-
Tennessee	-	-	-
Texas	X	X	X
Utah	X	X	X
Virginia	X	X	X
Washington	-	X	-d
West Virginia	X	X	-e
Wisconsin	-	-	-
Wyoming	-	-	-

## APPENDIX D

STATUS OF PREVIOUS RECOMMENDATIONS  
ABOUT ENGINE RETARDERS

As a result of the Texas and Colorado directional control accidents,<sup>a</sup> the Safety Board issued the following safety recommendations:

--to the Professional Truck Drivers Institute of America, Inc.:

H-89-39

Inform your members of the potential hazards of misusing the engine retarder and urge your accreditation committee to require member schools to include training on the proper use of the engine retarder in their curricula. (Closed --Acceptable Action)

--to the International Brotherhood of Teamsters:

H-89-40

Inform your members of the potential hazards of misusing the engine retarder and ensure that drivers are adequately trained in the proper use of the engine and other types of retarders. (Open--Acceptable Action)

H-89-41

Urge your members to comply with the advisory placards provided by the engine retarder manufacturers that warn against using the engine retarder on slippery/wet surfaces when the vehicle is empty or lightly loaded or that warn against using the engine retarder to shift gears in these conditions. (Open--Acceptable Action)

--to the American Trucking Associations, Inc.:

H-89-42

Inform your members of the potential hazards of misusing the engine retarder and urge them to formulate written policies for the operation of engine retarders and to ensure drivers are trained in their use. (Closed--Acceptable Action)

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<sup>a</sup>Highway Field Report--"1981 GMC Astro Jackknife and Loss of Control, near Decatur, Texas," August 13, 1985 (NTSB-FTW-85-H-TR38), and Highway Field Report--"1981 Freightliner Jackknife and Overturn, near Mineral Wells, Texas," April 3, 1986 (NTSB-FTW-86-H-TR09).

H-89-43

Urge your members to install the advisory placards provided by the engine retarder manufacturers that warn against using the retarder on slippery/wet surfaces when the vehicle is empty or lightly loaded or that warn against using the engine retarder to shift gears in these conditions. (Closed--Acceptable Action)

--to the manufacturers of engine retarders:

H-89-44

Revise existing owner's manuals and placards to warn against the use of the engine retarder on slippery/wet surfaces when the vehicle is empty or lightly loaded, and call special attention to this warning in the owner's manuals for drivers operating a single-driver axle tractor. (Closed-- Acceptable Action)

--to the Federal Highway Administration:

H-89-45

Include in the commercial driver's license testing procedures questions regarding the proper operation of engine retarder systems. (Closed--Reconsidered)