National Transportation Safety Board
Washington, DC 20594

Safety Recommendation

Date: December 19, 2002

In reply refer to: H-02-33

Ms. Annette M. Sandberg
Acting Administrator
Federal Motor Carrier Safety Administration
400 Seventh Street, S.W.
Washington, DC 20590

About 9:05 p.m. on December 21, 1999, a 1999 Setra 59-passenger motorcoach, operated by Sierra Trailways, Inc. (Sierra Trailways), was traveling eastbound on State Highway 50 along a 7-mile-long downgrade west of Canon City, Colorado, when it began to fishtail while negotiating a curve near milepost (MP) 272.3. At the time, the motorcoach was traveling 63 mph. The speed limit on the descent was 65 mph, with an advisory speed limit of 55 mph on the curves along this section of the roadway. The driver recovered the vehicle from the fishtail, and the motorcoach gained speed as it descended the mountain. Approximately 36 seconds later,[1] as the motorcoach was traveling about 70 mph, the driver lost control of the vehicle on a curve. The motorcoach drifted off the right side of the road, struck MP 273 and a delineator, returned to the road, rotated clockwise 180 degrees toward the centerline, and departed the north side of the roadway backward. The vehicle rolled at least 1.5 times down a 40-foot-deep embankment and came to rest on its roof. The driver and 2 passengers were killed; 33 passengers sustained serious injuries and 24 sustained minor injuries.[2]

The temperature at the time of the accident was in the low 20°s F with light snow. A Colorado Department of Transportation road crew had been salting and sanding the road throughout the day and reported in a postaccident interview that parts of the roadway were icy. Passengers also described patches of ice and snow on the roadway.

The National Transportation Safety Board determined that the probable cause of this accident was the motorcoach driver's inability to control his vehicle under the icy conditions of the roadway; the driver initiated the accident sequence by inappropriately deciding to use the retarder under icy conditions. Why the busdriver did not, or was unable to, slow the vehicle before the crash could not be determined.

[1] Time sequence derived from the Detroit Diesel Electronic Controls electronic control module (ECM) installed on the engine.
[2] For additional information, read National Transportation Safety Board, Highway Accident Brief, NTSB/HAB-02/19 (Washington, D.C.: NTSB, 2002).

A National Transportation Safety Board simulation of events before the accident, using witness reports, physical evidence, and data downloaded from the Detroit Diesel Electronic Controls IV[3] (DDEC IV) ECM[4] installed on the engine, indicated that the fishtail probably occurred around the curve at MP 272.3. Although the ECM data did not differentiate between application of the brakes and activation of the retarder,[5] investigators were able to determine that the retarder activated before the curve and remained active as the bus entered the curve.[6] The combination of the longitudinal friction for the retarder and the lateral friction required to steer through the curve at 63 mph exceeded the available friction, and the bus fishtail was initiated at the drive axles. The retarder, when applied, requires longitudinal friction at the drive axle wheels. The simulation indicated that if the same longitudinal deceleration that was obtained for the bus using the retarder had been distributed to all six wheels using the bus's antilock brake system (ABS), the bus would have negotiated the curve without losing control because the longitudinal force would have been lower at each wheel.

A retarder/steering-induced wheel slip at the drive axle would have triggered an ABS event,[7] resulting in the retarder being automatically deactivated and the transmission lockup clutch being disengaged, which would have allowed the motorcoach to roll forward with little resistance. A few seconds after the fishtail, the DDEC IV data indicated that the busdriver shifted the transmission into neutral, which took the reverse torque off the drive axle and prevented the retarder from reactivating.[8] Witnesses reported that the busdriver seemed to regain control of the motorcoach at that time.

Data from the DDEC IV indicated that the motorcoach continued to slowly gain speed as it descended the mountain and that the busdriver stepped on the brakes six times before the crash. Five brake applications were held for about 1 second[9] and did not result in a reduction in speed.[10] One brake application lasted about 3 seconds and resulted in a 1.5-mph decrease in speed.

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[3] Detroit Diesel's fourth generation control module.

[4] The DDEC IV ECM provides operational data for a vehicle and its engine that are used primarily for diagnostic purposes. Maintenance and fleet managers can draw on the data to review and assess driving performance and its impact on the wear of the vehicle and its engine. The recorded data include trip activity, speed versus rpm, engine load versus rpm, periodic maintenance, engine usage, and hard brake activity.

[5] When active, a vehicle retarder provides a supplemental means of slowing a vehicle, thereby reducing brake wear. A retarder brakes only the drive axle and is activated when a driver releases the throttle. The transmission retarder on the accident motorcoach functioned by creating resistance to slow the transmission output shaft, which is connected to the main drive shaft that ultimately turns the wheels.

[6] Investigators primarily used the DDEC IV "hard brake" report to reconstruct the preaccident and accident events. A "hard brake" report includes data from the previous 1 minute prior to the braking event and 15 seconds after its occurrence. The "hard brake" data relate to vehicle speed at the drive axle, engine rpm, percent throttle, percent engine load, brake use, and clutch use. Brake application is not necessary to trigger a "hard brake" report if the drive axle wheels decelerate at a rate of 7 mph per second or more.

[7] An ABS event occurs when wheel slip is detected by the ABS. Such an event can occur when a driver is braking with the service brakes (brake pedal) on a slippery surface, when retarder/steering-induced wheel slip is detected, or when a vehicle is sliding and wheel slip is detected by the ABS.

[8] The Allison operator's manual states, "If you let the vehicle coast in N (Neutral), there is no engine braking and you could lose control." Had the driver instead placed the retarder lever in the "off" position, the reverse torque would have been taken off the drive axle and the driver would have been able to downshift and use engine resistance to help slow the motorcoach.

[9] According to Detroit Diesel engineers, a single application, representing 1 second on the DDEC "hard brake" report, can be from 1/40 second to 1 39/40 seconds long. The DDEC records brake applications that result in a minimum of 3.5 pounds per square inch of pressure or more.

[10] During four of the five brake applications, the speed of the bus increased 0.5 to 1.0 mph.

As the motorcoach approached MP 273, the busdriver made a throttle application of 2,200 rpm for about 6 seconds on a left-hand curve. About the same time, the bus yawed to the right, departed the roadway shoulder, and went onto the dirt. Physical evidence indicated that the bus struck MP 273 and a delineator before the busdriver was able to steer the motorcoach back onto the pavement. The simulation suggested that the busdriver's steering input was such that it probably angled the bus toward the north embankment on the opposite side of the roadway. The busdriver subsequently steered to the right, initiating a 180-degree-clockwise rotation of the motocoach, and the vehicle traveled backward down the opposite lane. Evidence indicated that the motorcoach's left-rear bumper struck another delineator on the left side of the road, and the bus proceeded backward down the north embankment, rolling at least 1.5 times on its side before coming to rest on its roof.

The accident motorcoach was not the vehicle usually assigned to the busdriver. In October 1998, the driver began operating a 56-seat 1999 Setra and logged about 62,600 miles on that vehicle. Both the 1999 Setra motorcoach and the accident vehicle were equipped with an integral hydraulic retarder mounted at the rear of the transmission. The busdriver received little training on the use of the transmission retarder from either Setra or Sierra Trailways.[11]

Prior to driving the 56-seat 1999 Setra, the busdriver operated a 1998 Prevost model H3-45 for about a year. This Prevost motorcoach was equipped with an engine retarder, which is generally less powerful than a transmission retarder.[12] Before operating the 1998 Prevost motorcoach, the busdriver drove other Prevost models that were also equipped with engine retarders.

According to the president of Sierra Trailways, the busdriver had made about 50 trips to Colorado ski resorts, including 7 to Crested Butte. However, he believed that the accident trip was the first time that the busdriver had operated a transmission retarder-equipped motorcoach into the mountains during winter.[13] Therefore, the busdriver had driven an engine retarder-equipped motorcoach on virtually all his trips to the Colorado mountains. Because of his extensive experience with engine retarders and lack of training and experience with transmission retarders, he may not have been fully aware of the differences between the two types of retarders, which may have influenced his selection of a retarder setting and ultimately led to the fishtail.

After the accident, the motorcoach's seven-position retarder lever was found in the second highest retarder position. Safety Board investigators found that the retarder lever could be moved easily from setting to setting. Since the lever may have been dislodged during the accident sequence, the true position of the retarder lever could not be determined reliably from the physical evidence. DDEC IV data and the Safety Board's accident simulation indicated that the retarder was on a high setting[14] at the time of the fishtail. Both the Setra operator's manual and Allison Transmissions (Allison) operator's manual that accompanied the bus warned that the retarder should be turned off when driving the motorcoach on a slippery surface. The Allison

[11] A videotape that accompanied each Setra bus introduced drivers to the retarder control lever. The tape did not describe the retarder functional characteristics or include information on retarder use under various road conditions. Sierra Trailways used this videotape to acquaint drivers with the new Setra buses.

[12] Richard Radlinski, instructor. "Braking Performance of Heavy Commercial Vehicles," Society of Automotive Engineering Seminar, September 10 and 11, 2001, Troy, Michigan.

[13] The Sierra Trailways president stated that he believed that the busdriver had driven to the Colorado mountains during the summer of 1999 in a Setra motorcoach equipped with a transmission retarder.

[14] The transmission retarder lever had six power levels and an "off" position. The lever was probably set on one of the three higher power levels.

manual states, "Using the retarder on wet or slippery roads can be like jamming on the brakes – your vehicle may slide out of control. To help avoid injury or property damage, turn the retarder enable to OFF when driving on wet or slippery roads." The retarder setting selected by the busdriver suggests that he may not have read, or chose to ignore, the warnings in the manuals.

After the retarder/steering-induced fishtail and braking event, the driver apparently shifted the transmission into neutral because he realized that an active retarder might initiate another fishtail. His action suggests that he was not immediately aware of how to turn off the retarder and may have reverted to the technique used by standard transmission drivers to disable the retarder. Using the retarder lever to turn off the retarder, instead of placing the transmission in neutral, would have allowed the driver to downshift and use engine resistance and conventional braking to slow the motorcoach. The Safety Board therefore concludes that the busdriver was not fully aware of how to properly use the transmission retarder.

The Safety Board has investigated a number of truck accidents that have involved the use of retarders during slippery road conditions. The most notable of these occurred in 1985 in Decatur, Texas, when a two-axle truck tractor, pulling two empty 27-foot van trailers, lost control on a slippery 3-percent downgrade and departed the roadway.[15] Investigators determined that the loss of control was initiated by the tractor's engine retarder, which was set at its maximum level. The Safety Board issued recommendations to the National Highway Traffic Safety Administration (NHTSA), the International Brotherhood of Teamsters (IBT), the American Trucking Associations, Inc. (ATA), and engine retarder manufacturers.[16] In response to these recommendations, NHTSA distributed copies of the booklet *A Professional Truck Driver's Guide on the Use of Retarders* to motor carriers and other interested parties; the engine retarder manufacturers revised their manuals to include specific instructions on the use of their retarders on slick surfaces and installed new instructional dashboard placards on all new vehicles; the IBT addressed retarder use in its commercial driver's license training for members and by urging its members to comply with advisory placards provided by the engine manufacturers; and the ATA informed its members of the retarder issues from the Decatur accident in its *Transport Topics* and *Trucking Safely* magazines. The Safety Board has not issued similar recommendations on retarder safety to motorcoach-related industries and associations. The circumstances of the Canon City accident suggest that motorcoach drivers may also benefit from further instruction on the different types of retarders and on their proper use during slippery road conditions.

The National Transportation Safety Board recommends that the Federal Motor Carrier Safety Administration:

> Develop, in cooperation with the United Motorcoach Association and the American Bus Association, a booklet that educates motorcoach drivers on the different types of retarders and on their use during low-friction-coefficient road conditions. Then, distribute this information to motorcoach carriers and other interested parties. (H-02-33)

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[15] NTSB-FTW-85-H-TR38.

[16] Safety Recommendations H-89-38 and -40 through -44. Safety Recommendation H-89-38 has been classified "Closed – Acceptable Alternate Action." The other recommendations have been classified "Closed – Acceptable Action."

The Safety Board also issued safety recommendations to the United Motorcoach Association, the American Bus Association, the Institute of Electrical and Electronics Engineers, and the Society of Automotive Engineers. In your response to the recommendation in this letter, please refer to Safety Recommendation H-02-33. If you need additional information, you may call (202) 314-6177.

Acting Chairman **CARMODY**, and Members **HAMMERSCHMIDT**, **GOGLIA**, and **BLACK** concurred in this recommendation.

Original Signed

By: Carol J. Carmody
Acting Chairman