National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 21, 2002

In reply refer to: R-02-8 through -12

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The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

These recommendations address (1) the determination and designation of maximum authorized train speeds with sufficient safety margins to ensure that a train can be stopped by the air brake system alone, and (2) locomotive engineer support and training. The recommendations are derived from the Safety Board's investigation of the January 30, 2000, derailment of CSX Transportation (CSXT) coal train V986-26 near Bloomington, Maryland, and are consistent with the evidence we found and the analysis we performed. As a result of this investigation, the Safety Board has issued five safety recommendations, three of which are addressed specifically to CSXT, and two of which are addressed to all class I railroads, including CSXT. Information supporting the recommendations is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

About 7:00 a.m. on January 30, 2000, eastbound loaded CSXT coal train V986-26 lost effective braking while descending a section of track known as "17-mile grade" from Altamont to Bloomington, Maryland, and derailed 76 of its 80 "bathtub" high-side gondola cars when the train failed to negotiate curves at excessive speed. The derailed cars destroyed a nearby occupied residence, killing a 15-year-old boy and seriously injuring his mother. Three other occupants of the residence escaped with little or no injury. Track and equipment damages were estimated to be in excess of $3.2 million. There was no resulting fire or hazardous materials release.[1]

[1] For more information, see National Transportation Safety Board, *Derailment of CSX Transportation Coal Train V986-26 at Bloomington, Maryland, January 30, 2000*, Railroad Accident Report NTSB/RAR-02/02 (Washington, D.C.: NTSB, 2002).

The National Transportation Safety Board determined that the probable cause of the January 30, 2000, derailment of CSXT train V986-26 near Bloomington, Maryland, was the railroad's practice of including dynamic braking in determining maximum authorized speed without providing the engineer with real-time information on the status of the dynamic braking system.

To a large extent, train speeds and train handling are determined empirically within the limitations of the track structure and signal or train control systems. As with the maximum authorized speed through the accident area, most speed limits have not changed over a long period, particularly speed limits for common trains like coal trains, even though the weight of trains has steadily increased over time. CSXT has been able to maintain relatively high speeds despite increasing train weight because of the emphasis on and continued improvement of locomotive dynamic braking.

In this accident, dynamic braking on the two trailing locomotive units, while available, could not be activated because of the defective multiple-unit cable between the first and second locomotive units. Because he did not have the benefit of full dynamic braking, the engineer had to increase the air brake application beyond what normally would have been expected in order to control speed. By so doing, he unwittingly overheated the tread-brake system. Further, the maximum authorized speed for the accident grade had been established based on the assumed availability and use of dynamic braking. Judging from the CSXT's experience of successfully negotiating 17-mile grade at the maximum authorized speed, the combination of dynamic and air braking was, in fact, adequate to hold a train at or under the established maximum authorized speed as the train progressed down the grade. The Safety Board concluded that if all the available dynamic braking could have been activated on the accident train, the derailment probably would not have occurred.

Unfortunately, problems can occur when, as in this accident, the dynamic braking system functions only partially or suddenly and unexpectedly fails when the train is moving too fast to be stopped by the air brakes alone. Calculations and dynamometer testing confirmed that CSXT eastbound loaded coal trains on 17-mile grade could not be controlled or stopped at the maximum authorized speed without the use of significant dynamic braking. The Safety Board concluded that by using the effects of dynamic braking in its speed calculations, CSXT established a maximum authorized speed over and down 17-mile grade that was too high to ensure that heavily loaded trains could be stopped using air brakes alone.

The lead locomotive unit had no device for checking the real-time condition of the dynamic brakes on the trailing locomotive units (or the signal continuity through the multiple-unit cable), nor was such a device required at the time of the accident. Nor did the company have a requirement that the dynamic braking system be tested before or during use to determine how well it was functioning. After the accident, CSXT instituted a running dynamic brake test procedure for its Mountain Subdivision.

As a result of its investigation of the runaway and subsequent derailment of a Southern Pacific Transportation Company train in San Bernardino, California, in 1989, the Safety Board issued the following recommendation to the Federal Railroad Administration (FRA) regarding dynamic braking:

R-90-23
Study, in conjunction with Association of American Railroads, the feasibility of developing a positive method to indicate to the operating engineer in the cab of the controlling locomotive unit the condition of the dynamic brakes on all units in the train.

The Safety Board classified this recommendation "Closed—Unacceptable Action/Superseded" after its investigation of a runaway Union Pacific train at Kelso, California. After that accident, the Safety Board issued the following safety recommendation to the FRA:

R-98-6
Require railroads to ensure that all locomotives with dynamic braking be equipped with a device in the cab of the controlling locomotive unit to indicate to the operating engineer the real-time condition of the dynamic brakes on each trailing unit.

This recommendation was classified "Open—Acceptable Response" on January 11, 2000.

The FRA has included in the new power brake regulations (49 *Code of Federal Regulations* 232.109) the following dynamic braking requirements:

(a) A locomotive engineer shall be informed in writing of the operational status of the dynamic brakes on all locomotive units in the consist at the initial terminal or point of origin for a train and at other locations where a locomotive engineer first takes charge of a train.

(g) All locomotives equipped with dynamic brakes and ordered on or after August 1, 2002, or placed in service for the first time on or after April 1, 2004, shall be designed to:

(1) Test the electrical integrity of the dynamic brake at rest; and

(2) Display the available total train dynamic brake retarding force at various speed increments in the cab of the controlling (lead) locomotive.

(h) All rebuilt locomotives equipped with dynamic brakes and placed in service on or after April 1, 2004, shall be designed to:

(1) Test the electrical integrity of the dynamic brake at rest; and

(2) Display either the train deceleration rate or the available total train dynamic brake retarding force at various speed increments in the cab of the controlling (lead) locomotive.

While the new regulation does not require a dynamic braking display for each trailing locomotive unit, as recommended by the Safety Board, a total real-time dynamic braking effort display as described above may be as useful and acceptable. The Safety Board is also pleased to note that the accelerometer will be used in conjunction with the FRA regulation that will require a train descending a grade of 1 percent or greater to be immediately stopped if it exceeds the maximum authorized speed by more than 5 mph. Therefore, the Board has reclassified Safety Recommendation R-98-6 to the FRA "Closed—Acceptable Alternate Action."

At the time of the accident, the maximum authorized speed from Swanton (milepost [MP] 219.4) to Bloomington (MP 206.2) was 25 mph. CSXT lowered the maximum authorized speed to 20 mph after the accident in an attempt to create a safe speed. CSXT Rule 34-D requires that, on descending grades of 1 percent or more, a train must be stopped using an emergency brake application if the train's speed reaches 5 mph more than the maximum speed permitted for that train. Thus, even under the reduced postaccident maximum speed of 20 mph, the engineer could still attain 25 mph before attempting to stop the train.

According to commonly accepted air brake industry standards, a train with cars that have 36-inch diameter wheels, such as the accident train, should not exceed an average braking horsepower (bhp) of 30. The accident train had such a bhp, but only when it was traveling about 15 mph. At 20 mph, its bhp was 49.54; and at 30 mph, its bhp was 64.40. The large disparity in bhp between the recommended 30 and the actual number the accident train had at its maximum authorized speed translates into significant increases in the heat generated at the interface between the brake shoe and wheel tread. The increases in heat, in turn, degrade the brake shoes and cause heat fade and the loss of molecular adhesion, resulting in a catastrophic loss of retardation and braking power—a runaway train.

Actual brake shoe force measurements were taken for each brake application on identical coal cars on August 8, 2000. Using these shoe forces, the bhp calculations were then substantiated by dynamometer tests performed on August 22, 2000. These test results also indicated that the heat from the applied accident train brakes had reached the critical point about the time the train began to pass through Swanton Flats, MP 219.4, only about 3.6 miles into 17-mile grade. By that time, the temperature of the brake shoes/wheels exceeded the thermal limit of the brake shoes and resulted in a loss of braking power.

The dynamometer tests validated the theoretical calculations. The calculations and dynamometer tests showed that the maximum authorized speed of 25 mph was too high and that, in fact, any speed above 15 mph was too high to allow the train to be brought to a stop by the air brakes alone. The maximum authorized speed down 17-mile grade should probably have been no greater than 15 mph to ensure safe operation in the event of either partial or full dynamic brake failure or an unintended release of the air brake.

CSXT does actively update its train handling practices as train equipment improves. To a large extent, it does the updating by using computer simulators, such as a train dynamics analyzer. The analyzer is used to match methods of train handling with current and proposed maximum authorized speeds; however, no software is yet capable of replicating the loss of braking caused by heat fade. (Such software is under development.) Since a train dynamics analyzer cannot replicate heat fade, a simulator may indicate that a train can be stopped when, in reality, it may be unstoppable. Running an actual train on steep grades and applying the brakes until heat fade occurs is dangerous and expensive and is therefore not practical. The most available current methods of determining the maximum authorized speed are by calculation or by using dynamometers; however, most railroads use neither.

As already noted, the Safety Board has previously investigated runaway train accidents at San Bernardino and Kelso, California, involving the Southern Pacific and the Union Pacific railroads. There have been similar incidents on the BNSF Railway on Cajon Pass. All these accidents and incidents involved, as does the Bloomington accident, the dependence on and sudden loss of dynamic braking. The Safety Board is concerned that maximum authorized speeds enabling a train to stop by the air brake system alone are not, and have not been, audited or re-evaluated by the major carriers as frequently as necessary over time as trains have become heavier and braking systems have changed. Therefore, the Safety Board believes that the class I railroads should calculate steep-grade maximum authorized speeds to ensure that trains can be stopped by use of the air brake system alone and should establish procedures to periodically revise maximum authorized speeds as necessary.

While the Bloomington accident engineer's actions do not appear to have directly caused or contributed to the accident, some of his actions, or some of his failures to act, reflect upon the efficacy of his supervision, training, and support.

The engineer had more than 29 years of railroad experience at the time of the accident. He was well regarded by railroad management and coworkers as a "senior" engineer. He had been in engine service since 1976 and had made numerous runs along the Grafton to Cumberland route. He had come back to road service on January 9, 2000, a few weeks before the accident. He had just had his last rules class and test 3 days before the accident. He had completed 2 days of recertification[2] training (49 CFR Part 240) at the CSXT Training Center, Cumberland, Maryland, on May 4, 1999, which consisted of classroom presentations and tests. And yet, in this accident, the engineer's train handling was not optimal.

According to FRA inspectors, CSXT operating officers, and CSXT engineers with knowledge of and experience with 17-mile grade, it is possible to control a loaded coal train headed by three modern locomotive units with a 12-pound or less brake pipe reduction and light throttle or dynamic brake modulation. Earlier in the trip, the helper engineer had noted that the train engineer had used more air brake than was normal or routine. The accident engineer stated several times that he attributed his use of more air brake than usual to the wet snow and icy rail; however, his need to power against a 17-pound reduction with up to a 6th notch of throttle belies this contention.

The engineer said he was afraid that the train would stall at Swanton Flats if he did not power against the brakes. Thus, he should have realized that the brakes were effective and not affected at that time by snow or ice. An engineer who was fully situationally aware and who understood the grade and the newer locomotives would likely have been aware that something was wrong long before the point where the train could not be controlled with customary train handling.

CSXT rules state, "When necessary to apply power descending long heavy grades, trains must not be pulled[3] for a distance greater than 2 miles if the brake pipe reduction is 18 pounds

[2] Recertification is not the same as requalification.

[3] In order for the train to be pulled regardless of whether the train brakes are applied, the locomotives must be in the power mode.

[psi] or greater." According to the event recorder, the engineer had steadily increased the air brake application for more than 10 minutes, until he had a 17-pound reduction of the brake pipe[4] at MP 220.12 (Swanton) at a speed of 24 mph. He maintained the 17-pound reduction for the next 9 minutes at a speed of 24 mph. It is significant that he powered against this 17-pound reduction through Swanton for about 5 minutes and 2 miles, at one point reaching the 6th notch on the throttle. He further reduced the brake pipe to 18 pounds at MP 216.46 at a speed of 28 mph.

Thus the engineer had been operating at the limit or just short of the 18-pound limit, and the brakes had probably already reached the thermal point of no return at the speed the train was moving. He continued to make progressive 1-pound reductions for about the next 4 minutes as the speed of the train increased to 34 mph, when he finally placed the brakes in emergency. Had the engineer gone into emergency shortly after reaching the 18-pound reduction, as required by rule, he probably would not have been able to stop, since the train's brakes were probably already beyond the critical thermal limit.

The actions of the engineer, and the effects of those actions, point out a problem with the CSXT "18-pound" rule. As written, the rule is inadequate to ensure that an engineer does not, as the accident engineer did, power against his brakes at a speed that is likely to cause excessive heat generation and loss of control. All the calculations for bhp are based on the factor of speed or velocity—the greater the speed, the greater the bhp and heat energy generated by the friction brakes. The CSXT rule does not include a critical limit for speed. The Safety Board concluded that, because the CSXT rule regarding powering against the brakes does not address train speed, it is inadequate to ensure that an engineer does not exceed the bhp and heat energy limitations of the tread brake system and thereby create conditions that can lead to a runaway train.

The engineer said that he had transferred from a yard to a road assignment only a few weeks before the derailment. Consequently, the general road foreman told the engineer that he could have a pilot for two roundtrips. For the engineer's first trip on the assignment, a pilot was provided for the westbound leg, from Cumberland to Grafton (uphill, in the opposite direction of the accident train). Because the crew returned to Cumberland by taxi, the engineer did not make an eastbound trip (which would have taken him down 17-mile grade) with the pilot.

The engineer said that when he was called for his second trip, he asked that a pilot accompany him on the return to Cumberland. But, he said, a crew caller told him that the crew caller and the lead crew caller would decide whether the engineer needed a pilot and, if so, would provide one. No pilot was provided.

Additionally, according to the engineer and to CSXT records, no supervisor had ridden with the engineer while he operated a train down 17-mile grade to monitor his performance or to provide specific train handling instruction and guidance, even though this area was a critical train handling portion of the railroad. And while the engineer had made one trip down the grade as an observer and had operated a train on eight trips down 17-mile grade in the weeks preceding the accident (most of them with loaded coal trains), neither he nor his supervisors could know for

[4] The brake pipe pressure is 90 psi minus the total reduction. In this case a 17-pound reduction will result in a brake pipe pressure of 73 psi.

certain whether his train handling technique was appropriate or whether it offered some safety margin in case of an unforeseen event.

After the engineer placed the train brakes in emergency with the automatic brake handle, he did not confirm that the emergency application had propagated to the end of the train until a minute and a half later when he saw the head-end display showing 0 psi pressure for the train's end-of-train device (EOT). Had he activated the EOT emergency brake application switch immediately after initiating the emergency application, he would have ensured that the emergency application had reached the end of the train.

Immediately throwing the EOT switch not only propagates the brake application more rapidly because the release of air pressure comes from both ends of the train rather than just the head end, but it also ensures full propagation even if a kink or other obstruction is blocking the trainline. Thus, the prudent action would have been to immediately flip the EOT emergency brake switch. The needless time taken to confirm that the emergency propagation was complete could, under some circumstances, have been critical. In this case, because the engineer had already exceeded the thermal limit of the brakes by the time that he placed the brakes in emergency, his failure to immediately initiate an EOT emergency application became moot.

The engineer said he had been trained to use the two-way EOT emergency switch only if the EOT was not showing 0 psi after an emergency brake application. Since using the switch causes no damage to any equipment on the train while offering the advantages of a quicker and more thorough response, the Safety Board fails to see the benefit in restricting its use to what is, in effect, a backup system. CSXT agrees and has an automatic two-way emergency EOT switch on all new locomotives. In addition, CSXT offers instruction in the use of the switch in its engineer classes and, in its operating rules, requires immediate use of the switch in an emergency.

During the runaway, the train crew was unable to contact the dispatcher but was able to contact the railroad operator at West Keyser, Virginia, as the train passed Bond at MP 212.6. The engineer attributed his inability to contact the dispatcher to the fact that the radio on the ex-Conrail lead locomotive was different from the radios found on the CSXT locomotives that he more commonly operated. Postaccident testing of the engineer's radio and subsequent investigation revealed that the radio worked as designed.

U.S. railroads use five basic styles of locomotive radios, each of which is compatible with the others, regardless of railroad. Except for superficial details such as dials, touch pads, and channel display, all railroad radios are similar; that is, they use the same frequencies or channels. Timetable instructions list the particular channels for emergency use and/or for calls to the dispatcher. Had the engineer properly set the channel for the dispatcher and then pushed the correct keypad number—either "9" for emergency or "5" for the dispatcher—he would have reached the dispatcher.

The Safety Board concluded that CSXT failed to train and oversee the engineer sufficiently and effectively as evidenced by (1) management's failure to provide the engineer with a pilot when requested, (2) management's failure to fully evaluate the engineer over the critical portion of the railroad where the accident took place, (3) the engineer's failure to use the

EOT emergency brake switch, (4) the engineer's imprudent use of power during brake application, and (5) the engineer's reported inability to use the radio to contact the dispatcher.

The National Transportation Safety Board therefore makes the following safety recommendations to CSX Transportation, Inc.:

> Systematically ensure that engineers are provided with pilots as appropriate and that locomotive engineers are fully evaluated over the whole of their territories, particularly in critical areas of train handling such as steep grades. (R-02-8)
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> Revise your locomotive engineer training and requalification programs as necessary to ensure that they address (1) the emergency use of the two-way end-of-train emergency switch, (2) the proper use of power during a brake application to prevent heat fade and loss of braking, and (3) the use of all styles of locomotive radios, especially their use during emergency situations to call the dispatcher. (R-02-9)
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> Modify CSX Transportation Rule 3.3.7, *Speed Control on Descending Grade*, Paragraph C, "Use of Power on Heavy Descending Grades," to impose a speed limit in addition to the maximum distance and brake pipe reduction currently imposed to prevent excessive heat generation, heat fade, and loss of braking ability. (R-0-10)
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> Calculate and document steep-grade maximum authorized speeds to ensure that trains can be stopped by use of the air brake system alone. (R-02-11)
>
> Establish procedures to revise steep-grade maximum authorized speeds as necessary. (R-02-12)

Safety Recommendations R-02-11 and -12 were also issued to all class I railroads. In your response to this letter, please refer to Safety Recommendations R-02-8 through -12. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Marion C. Blakey
Chairman