Log R-674

SR

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: February 25, 1998

In reply to refer to: R-98-1 through -7

Honorable Jolene M. Molitoris
Administrator
Federal Railroad Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

On January 12, 1997, about 11:52 a.m. Pacific standard time, the Union Pacific Railroad (UP) unit freight train 6205 west derailed 68 cars on the UP Los Angeles Subdivision, milepost (MP) 238.7, near Kelso, California. The train consisted of 3 locomotive units and 75 loaded covered hopper cars. While descending Cima Hill, the engineer inadvertently activated the multiple-unit (MU) engine shutdown switch, which shut down all the locomotive unit diesel engines and eliminated the train's dynamic braking capability. The train rapidly accelerated beyond the 20-mph authorized speed limit despite the engineer's efforts to increase the train's air braking, which the engineer placed in emergency 1 minute and 2 seconds after dynamic braking loss. The train's consist weight was listed at an average of 13 tons per car less than the train actually weighed. The train eventually reached a speed of 72 mph and derailed 68 of its 75 cars while exiting a siding near Kelso, California.[1] No fatalities, injuries, fires, or hazardous materials releases resulted from the accident. The total damage cost was $4,376,400.

Placement of safety-critical controls was one of the major safety issues raised by this accident. Early in the National Transportation Safety Board investigation, it became apparent that the locomotive engineer had inadvertently activated the MU engine stop switch inside the lead locomotive unit. The red Stop button of the MU engine stop switch was found still depressed after the accident. Also, the suddenness with which the engine shutdown occurred indicated that the switch had been struck immediately before the accident. No other reason for the engine shutdown was discovered.

The activation of the MU engine stop switch precipitated the accident. The stop switch activation shut down the diesel engines, resulting in dynamic braking loss. The dynamic brake loss initiated the runaway. Because neither the engineer nor the conductor was aware of what had

[1]For additional information, read Railroad Accident Report — *Derailment of Union Pacific Railroad Freight Train 6205 West Near Kelso, California, January 12, 1997* (NTSB/RAR-98/01).

caused the locomotive units to shut down, they did not take action to reactivate the units or immediately place the train in emergency. By the time the crewmembers put the train in emergency, it was already in runaway status.

The placement of the MU engine stop switch on the lower left panel of the engineer's control console made it subject to inadvertent activation. Investigators' informal postaccident discussions with locomotive engineers revealed that such activations had been common on locomotives equipped with switches in the same location. Sometime after 1989, General Motors Electro-Motive Division (EMD), the builder of the SD60M locomotive, became aware that inadvertent activation of the MU engine stop switch was a problem. EMD attempted to work with the purchasers of the affected locomotives to correct the poor placement of the switch.

While EMD's attempts to address the problem evidenced some concern over the safety implications of the switch location, the UP management did not consider changing the location a priority modification. Instead, the UP categorized it as a "comfort or convenience" modification. Consequently, the UP did not expedite protection or relocation of the switches. Although EMD had communicated with the UP about this issue as early as January 1990, the UP had taken steps to modify the MU engine stop switches on only 8 of its 184 affected SD60M locomotives by 1996. None of the affected UP locomotives had had their switches relocated.

Correspondence between UP representatives and EMD revealed that some UP representatives and EMD understood that the location of the MU engine shutdown switch had safety implications because crewmembers could, by inadvertently activating the switch, simultaneously shut down all locomotive units. The correspondence indicated concern regarding this possibility. Safety-conscious railroad managers should have foreseen that an unintentional shutdown of all motive power on an operating train could jeopardize train control. This danger should have been particularly conspicuous with respect to trains that traveled on steep grades such as Cima Hill, where dynamic braking has become critical. The Safety Board concluded that the failure of UP management to recognize the MU engine shutdown switch location as a safety hazard and to expedite effective switch protection or relocation created the conditions that led to the accident.

The Kelso accident also raised the issues of train speed and braking safety margins. The rapidity with which the Kelso train engineer was overtaken by events underscores the need for railroads to maintain realistic operating safety margins in case an unexpected failure occurs. Safety margins that were adequate for rail operations 20 years ago are not necessarily adequate today. As time has passed, railroad equipment technology has progressed, and so have the size and weight of freight cars and the weight and speed of trains. These changes have altered the ways trains operate, particularly in steep-grade areas, and have eroded the efficacy of braking safety margins.

Engineers' determinations of safe maximum train speeds and train-handling methods are made based on the weight of the train (trailing tonnage). The train's tonnage dictates to the engineer the maximum speeds and the braking methods that may be used and indicates whether air brake retainer valves must be set. The accuracy of the engineer's determinations regarding these train-handling limits depends on the accuracy of the figures used to report the weight of each freight car.

Unless the engineer is provided with the correct weight or appropriate maximum weight for the train on which to base his determinations, he may be placed in a potentially dangerous situation.

According to the UP, train 6205's cars were initially assigned by computer the default maximum car weight of 143 tons each, which was then mistakenly changed by a clerk to approximately 130 tons each. The engineer used the inaccurate weights in making his train-handling decisions. Postaccident car weights were found to be around 143 tons. The additional train weight of 975 tons was unknown to the engineer.

Regardless of whether the engineer knew the actual weight of the train, the maximum authorized train speed down Cima Hill for train 6205 west would have been 20 mph. But beyond the fixed limit of authorized speed, engineers control trains by making experience-based judgments as dictated by conditions. As such, the accident engineer would probably not have significantly altered his braking procedure down the grade had he known the actual train weight, beyond increasing dynamic and pneumatic braking as he felt necessary to control the train. The unknown additional weight, however, eroded any safety margin that had been built into the UP's speed requirements for bringing a train down Cima Hill. Further, the greater weight would have caused the train to speed down the grade faster than it would have at a lower weight and impelled it more quickly beyond the point of no return. Therefore, the Safety Board concluded that, although the unknown additional train weight of 975 tons was not causal to the accident, it contributed to the severity and magnitude of the derailment.

Of additional concern regarding train speed and braking margins, research has shown that train wheels and brake shoes cannot withstand infinite levels of friction-generated heat. Too much heat generated during braking causes brake shoes to wear and deteriorate rapidly, metal to flow on the wheel tread, and trains to lose their stopping ability. In the past, the use of air brake retainer valves (retainers) allowed engineers to control trains down long grades without exceeding the limits of the brake equipment. Then, air brake system air capacity was the limiting factor. Retainers help preserve compressed air capacity and the potential capability to brake a train. Retainers, however, still depend on the same tread-braked system that is subject to heat limitations. With or without retainers, excessive heat at the tread brake can cause the air braking system to become ineffective.

Evidence from the Kelso accident suggests that train weights and speed levels may have reached the physical limitations of the tread-braked freight car. The engineer was attempting to keep the train within the 20-mph speed limit established by the UP for a train of that weight at that location. Retainers had been set. The train's air brakes were functioning properly and the engineer used the brakes correctly. But even after he had placed the train's tread-braked cars in emergency at 30 mph, the engineer of the accident train could not stop it from running away. The air brakes alone were insufficient to keep the train from experiencing significant acceleration in these circumstances. Postaccident UP brake tests conducted on Cima Hill showed that the air brakes alone could stop a train similar to the accident train at speeds up to 25 mph but not much beyond that speed. The accident train accelerated to 25 mph within 30 seconds of MU stop switch activation.

The accident train, therefore, while it was performing as required by the UP, could not be sufficiently slowed with air brakes alone on the Cima Hill downgrade to ensure safe operation much beyond the maximum authorized speed. The data indicate that the air brakes could not function successfully in this situation because frictional tread-brake heat generation had reached performance-damaging levels. The Safety Board concluded that, due to increases in train weights and speeds, frictional tread-brake heat generation has become a limiting factor for safe train operation, particularly in steep-grade territories.

The Kelso accident also illustrated that dynamic braking use has affected safe train speeds and braking margins. While the UP in theory considers dynamic braking a nonessential mechanism, it has in practice relied on the safeguard that, as long as the dynamic braking system works, total dependence on the air brakes (with their heat-fade weaknesses) can be avoided. As the Kelso accident demonstrated, once dynamic braking is lost, a train operating on a steep downgrade can become uncontrollable within seconds, even though the air brake system is fully functional. The Safety Board therefore concluded that the UP's operational reliance on dynamic braking for controlling heavy and fast-moving trains on steep grades, without acknowledging and protecting dynamic braking as a safety-critical system, is imprudent. The fact that the accident occurred because dynamic braking was lost indicates that some railroads may have allowed their margins of safety to erode by maintaining train-handling practices rendered obsolete by the heavier weights and faster speeds of today's trains.

Operational speeds and train-stopping capability have traditionally been associated with the amount of air pressure that has been reduced from the brake pipe (the level of air braking required). The UP required that a train be stopped after an 18-psi brake pipe pressure reduction failed to control train speed. Other railroads had similar requirements. The Safety Board does not consider that such brake pipe reduction requirements provide timely operational guidance or a sufficient safety margin to traincrews. By the time a dangerous situation is recognized, it may already be too late for crewmembers to take effective corrective action. In the Kelso accident, although he was attempting to abide by the UP's maximum train speed requirement for the area, by the time the engineer realized that a problem existed and initiated a 12- to 17-psi reduction, the train still became a runaway within 62 seconds. The Safety Board therefore concluded that the UP has authorized maximum train speeds that provide insufficient safety margins in the event of dynamic braking failure.

According to the UP rules in effect for the accident train, 20 mph was the maximum safe speed for a train descending from Cima to Kelso with retainers set. After the accident, the UP issued orders that required trains on which retainers had been set to keep speeds at 15 mph or lower. The UP also required its crews operating in specified steep-grade locations, including the descent from Cima to Kelso, to stop trains immediately if speeds rose 5 mph above the authorized speed. While the exact speed at which the engineer might have effectively braked train 6205, given all the variables in this instance, has not been determined by investigators, the Safety Board concluded that some speed-based safeguard might have enabled the engineer to exercise greater control over the Kelso accident train.

The Safety Board considers that the UP's decision to implement the "plus 5 mph and stop" rule specified above is a step in the right direction. Nevertheless, the Safety Board considers that this narrowly defined order may not be sufficient to address the broad range of safety margin issues raised by this accident.

The Kelso accident also highlighted how important dynamic braking has become to railroad safety. The railroad industry maintains that dynamic braking is a noncritical feature. Railroads have claimed that dynamic brakes are not required for safety or train control and that the main purposes of dynamic brake use are fuel economy and maintenance reduction. Because regulations require that trains be safely handled with the air brake system alone, railroads do not acknowledge that dynamic brakes have become an important safety and train-handling feature. Actual railroad rules and train-handling routines, however, indicate that, in practice, dynamic brakes have become essential to train handling. During the Kelso accident, the train accelerated beyond the stopping speed of the train very rapidly (within 30 seconds) after dynamic brake loss. Therefore, the Safety Board concluded that railroads are operating trains in situations in which loss of dynamic braking will result in loss of train control.

The Safety Board has a history of recommendations regarding dynamic brakes. As a result of the investigation of an accident that took place at San Bernardino, California, in May 1989,[2] the Safety Board recommended that the FRA:

> Revise regulations to require that if a locomotive unit is equipped with dynamic brakes, the dynamic brakes function. (R-90-024)

On November 30, 1990, the FRA responded that it was reviewing the issue of regulations pertaining to dynamic brakes on locomotives and specified a range of responses available to the agency. The FRA, however, chose not to make a "definitive response" to the recommendation. On February 21, 1991, the Safety Board responded that the recommendation would remain classified "Open—Await Response" because of the FRA's lack of commitment to a specific action. Since then, the FRA has taken two actions in response to Safety Recommendation R-90-024, both of which were unsuccessful. First, the FRA issued a proposed rulemaking under the amendment of the Power Brake Law. The rulemaking was ultimately withdrawn. The FRA then placed the recommended action with its Railroad Safety Advisory Committee (RSAC) for handling. The RSAC was also unable to develop a satisfactory solution to the problem of providing for functioning dynamic brakes.

Separating high-priority components of needed rulemaking from the routine process and proposing them independently has been a successful strategy in the past, most recently with respect to the two-way end-of-train device recommendations resulting from the 1996 Cajon, California, derailment.[3] Because no progress on Safety Recommendation R-90-024 has been achieved in approximately 7 years, the Safety Board classifies Safety Recommendation R-90-024

---

[2]Railroad Accident Report — *Derailment of Southern Pacific Transportation Company Freight Train on May 12, 1989, and Subsequent Rupture of Calnev Pipeline on May 25, 1989, at San Bernardino, California* (NTSB/RAR-90/02).

[3]Railroad Accident Report — *Derailment of Freight Train H-BALTI-31 Atchison, Topeka, and Santa Fe Railway Company near Cajon Junction, California, February 1, 1996* (NTSB/RAR-96/05).

"Closed—Unacceptable Action/Superseded." The Safety Board concluded that the FRA should separate the dynamic brake requirements from the Power Brake Law rulemaking and immediately conclude rulemaking to require that railroads verify that the dynamic braking systems on all locomotives equipped with dynamic brakes are functioning properly before trains are dispatched.

In addition, as a result of the San Bernardino accident, the Safety Board made a recommendation to the FRA to:

> Study in conjunction with the 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. (R-90-023)

The FRA also considered this issue part of the proposed revisions of the Power Brake Law, which, as noted above, have not been successfully advanced. Consequently, the Safety Board classified Safety Recommendation R-90-023 "Open—Unacceptable Action."

Despite these recommendations, reliable information on the status of a train's dynamic braking is still not available to the engineer. The engineer of the Kelso accident train had reason to question whether the dynamic braking system was operative on his train. Although he apparently did not consider this issue, a bad order tag indicating malfunctioning dynamic brakes had been left on one of the train's locomotives. This bad order tag could have caused the engineer to doubt the reliability of the train's dynamic braking system. He had performed a running dynamic brake test from MP 309.3 to MP 292, and the brakes had responded as expected, although the engineer still could not know whether they functioned as designed. Cima is located approximately 37 miles past this checkpoint, at MP 254.6. The engineer made no further dynamic braking tests before reaching Cima and so had no verified information on whether or how the dynamic brakes were functioning as the train neared this significant downgrade.

Although the engineer assumed (in accordance with UP policy) that the brakes were operational, he had no means of checking whether they were, aside from conducting additional tests. No equipment in the lead locomotive provided information on the train's dynamic braking status. The Safety Board therefore concluded that the engineer in the Kelso accident had no practical means of knowing if or how many of his locomotive units were properly working in dynamic braking immediately before the accident or when used.

In recent years, the railroad industry has developed an effective and reliable device to display the real-time dynamic braking performance of trailing locomotive units. Such a display would permit an engineer to modify his train-handling strategy based on the information it provided, before being surprised by the failure of a dynamic braking system that he had depended upon using. The Safety Board concluded that installing a device in the cab of each controlling locomotive to indicate the real-time condition of the dynamic brakes on each locomotive unit in the consist would give valuable information to the engineer on train dynamic braking capability at any given moment. Therefore, since no progress has been made by the FRA on Safety Recommendation R-90-023, which addresses developing a positive method to indicate to the engineer the condition of the locomotives' dynamic brakes, the Safety Board classifies R-90-023 "Closed—Unacceptable Action/Superseded."

Finally, during the Kelso accident investigation, the Safety Board learned that UP personnel had not been formally trained on the appropriate way to set or use air brake pressure-retaining valves. Neither the conductor nor the engineer on the Kelso accident train had had any formal training on when or how to set the retainers, even though the practice was required by the UP and important to braking safety in steep areas. Both crewmembers said they had gained all the knowledge they had about retainers through on-the-job training and experience.

In this instance, the conductor precharged the brake cylinders by setting most of the retainers while the train brakes were still applied. Investigators were unable to determine with certainty whether this action had any effect upon the unfolding of events in the Kelso accident. Such a precharge may or may not be significant, depending on conditions and future braking actions, since any additional braking will be added to that pressure already in the precharged cylinders.

The crucial point is that neither the conductor nor the engineer had a well-defined plan about when the retainers should be set or how they should be charged. Neither had a true appreciation of the significance of uncharged or precharged brake cylinders. Further, neither understood the proper use of retainers in controlling train speed through cycle braking. Because the engineer did not release the air brakes on the accident train's descent down Cima Hill, the retainers could not function as designed and were rendered effectively useless.

It seems self-evident that any procedure that is important enough to be required by a railroad should be well understood by railroad personnel and included in the railroad's formal training program. The Safety Board concluded that the significance of retainer-setting procedures, proper retainer use, and the various choices involved should be understood by train crewmembers and included in railroad training programs.

Based on the foregoing information, the National Transportation Safety Board issues the following recommendations to the Federal Railroad Administration:

> Alert locomotive manufacturers and railroad operators about the dangers posed by improperly located safety-significant controls and switches in locomotives. (R-98-1)
>
> Require railroads to ensure that the actual loaded weights of cars in a train are provided to the traincrew or, if the loaded weights are unknown, to implement a method to ensure that the maximum loaded weight is assigned. (R-98-2)
>
> Require railroads to review steep-grade train-handling practices and, if necessary, make changes that will preserve a margin of stopping ability should a dynamic braking system fail. (R-98-3)

Carry out research, investigation, and analysis to determine maximum authorized train speeds for safe operation of trains of all weights, using speed-based margins of safety that can be easily measured by traincrews. (R-98-4)

Separate the dynamic brake requirements from the Power Brake Law rulemaking and immediately conclude rulemaking to require that railroads verify that the dynamic braking systems on all locomotives equipped with dynamic brakes are functioning properly before trains are dispatched. (R-98-5)

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. (R-98-6)

Require railroads to implement formal training on correct retainer setting and using procedures for traincrew members who may set or use air brake retainer valves. (R-98-7)

Also, the Safety Board issued Safety Recommendations R-98-8 and -9 to the Association of American Railroads, and R-98-10 through -16 to the Union Pacific Railroad.

Please refer to Safety Recommendations R-98-1 through -7 in your reply. If you need additional information, you may call (202) 314-6438.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman