Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT
R04V0100

UNCONTROLLED MOVEMENT OF RAILWAY ROLLING STOCK

CANADIAN NATIONAL
TRAIN M-359-51-07
MILE 57.7, FRASER SUBDIVISION
BEND, BRITISH COLUMBIA
08 JULY 2004

Canada

Railway Investigation Report

Uncontrolled Movement of Railway Rolling Stock

Canadian National
Train M-359-51-07
Mile 57.7, Fraser Subdivision
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Report Number R04V0100

Summary

On 08 July 2004, at approximately 1430 Pacific daylight time, the train crew on westward Canadian National freight train M-359-51-07 initiated a service brake application in advance of a meet with eastward Canadian National freight train M-354-51-07 at a siding at Bend, British Columbia. When the service brake application failed to slow the train, the crew placed the train into emergency. The emergency brake application also failed to slow the train. The locomotive engineer contacted the crew from train 354 and informed them that train 359 was a runaway and requested train 354 to stop. Train 359 travelled approximately two miles in emergency before coming to rest approximately ¼ mile west of the siding west switch. There was no collision and there were no injuries.

Ce rapport est également disponible en français.

Other Factual Information

On 08 July 2004, at approximately 0810 Pacific daylight time,[1] Canadian National (CN) freight train M-359-51-07 (the train) departed Jasper, Alberta, destined for Prince George, British Columbia (see Figure 1). The train consisted of 2 locomotives, 18 loaded cars, and 18 empty cars. Sixteen of the loaded cars contained dangerous goods, six cars contained diesel fuel (UN 1202), six cars contained gasoline (UN 1203), and four cars contained methanol (UN 1230). The train was 2330 feet long and weighed approximately 3160 tons. The crew consisted of a locomotive engineer, a conductor, and a trainman. They met fitness and rest standards, were qualified for their respective positions, and were familiar with the subdivision.

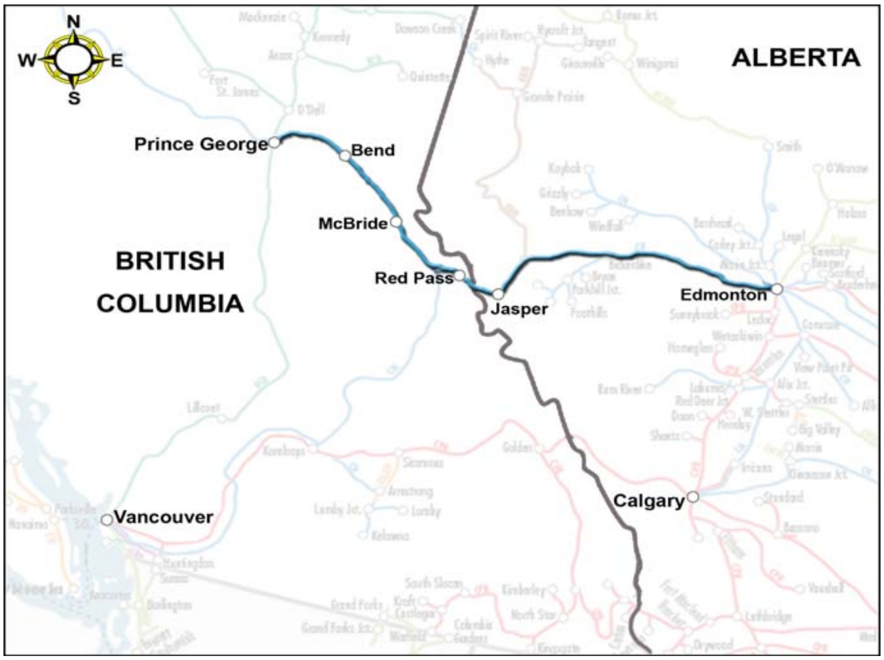

Figure 1. Location map of occurrence (Source: Railway Association of Canada, *Canadian Railway Atlas*)

En route, the crew was to lift[2] 46 cars at Red Pass, British Columbia, Mile 43.7 of the Albreda Subdivision, and change crews at McBride, British Columbia, Mile 0.0 of the Fraser Subdivision. In preparation for the stop at Red Pass, the locomotive engineer initiated a full service train brake application and observed no irregularities in the air brake system. The crew performed the switching operations to add a cut of 46 cars (6 loaded cars, including 1 car loaded with ties, and 40 empty cars) to the train. The tie car was to be set out at the Omaha Siding and therefore was placed immediately behind the locomotives. The Omaha Siding is situated two miles west of Red Pass. The train crew performed a No. 3 brake test and departed for the Omaha Siding. When the train was approaching the Omaha Siding, the locomotive engineer applied the train

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1 All times are Pacific daylight time (Coordinated Universal Time minus seven hours).

2 "Lifting" is the act of adding cars to a train.

brake to stop the train. No anomalies were reported. The tie car was set off and the locomotives re-coupled to the standing portion of the train. After performing a brake test to ensure brake pipe continuity, the train departed for McBride.

Basic Train Brake Test Requirements in Canada (more detail can be found in railway General Operating Instructions or Transport Canada–approved *Railway Freight and Passenger Train Brake Rules*)		
Name of Test	**When Required**	**Performed by**
No. 1	When a train is made up at a designated inspection location	Certified car inspectors
No. 1 A	When a train is made up at other than a safety inspection location	Train crews
No. 2	a) When cars that have not been previously tested at that location are added to a train[3] b) When the locomotive engineer is changed	Train crews
No. 3	a) When solid blocks of previously tested cars are added to a train b) When a locomotive is added to a train after the train has received a yard test c) When a locomotive consist is changed or altered	Train crews

Table 1. Overview of train brake test requirements

Approximately 2.3 miles into the journey, the locomotive engineer applied the train brake to control the train speed. He observed that the input and display unit (IDU)[4] did not display a corresponding reduction in the tail-end brake pipe pressure and attributed this to the fact that the brake system was not yet fully recharged.

In preparation for the stop at McBride, the locomotive engineer slowed the train with the dynamic brake and applied the train brake to bring it to a stop. However, the train stopped approximately six car lengths (300 feet) past the intended location.

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3 Except solid blocks of cars that have previously received a No. 1 brake test.

4 The IDU is the display module of the Train Information and Braking System (TIBS). It displays the brake pipe pressure at the rear of train. An emergency toggle switch positioned on the IDU enables the locomotive engineer to initiate an emergency brake application at the rear of the train through radio telemetry.

The relieving crew consisted of a locomotive engineer, a conductor, and a trainman. They met fitness and rest standards, were qualified for their respective positions, and were familiar with the subdivision. There was no information communicated during the transfer between crews to suggest that the train was not functioning properly.

The relieving crew boarded the train and the locomotive engineer released the train brake, noted an increase in the tail-end brake pipe pressure as displayed on the IDU, and departed McBride. At approximately Mile 6 of the Fraser Subdivision, the locomotive engineer applied the train brakes. The train brakes did not react as quickly as expected, so the dynamic brake was applied to control the train speed.

At approximately Mile 11 of the Fraser Subdivision, the conductor took control of the train. He had qualified as a conductor locomotive operator (CLO)[5] and had gained experience operating trains. The CLO used only the throttle to control the train's speed until he was preparing to slow the train in advance of the meet with train 354 at Bend.

At Bend, the train was required to clear the main track at the siding east switch. In preparation to take the siding, the CLO initiated a train brake application but then realized that the train brakes were not slowing the train. Both the conductor and the locomotive engineer then initiated emergency braking. The locomotive engineer used the conductor's emergency brake valve located on the left side of the cab, while the CLO placed the automatic brake valve handle in the emergency position. However, there was still no noticeable deceleration.

The locomotive engineer called the crew of opposing train 354 to inform them that their train was uncontrolled and determined that train 354 was approximately 12.5 miles away. The CLO applied the independent brake to slow the train. When the train had slowed enough, the trainman de-trained and began applying hand brakes on the cars starting from the head end. He observed that the angle cock on the head end of the first car behind the locomotive was nearly at right angles to the brake pipe or almost closed. The brake cylinder pistons on the cars were not extended as expected during a brake application, and there was no squeal from the brake shoes coming into contact with the wheel treads. The train came to rest approximately 20 cars (¼ mile) west of the siding west switch. It had travelled approximately 1 ¼ miles past the designated meeting point and beyond the limits of authority that had been issued by the rail traffic controller (RTC).

There was no attempt to place the train into emergency from the tail end using the toggle switch on the IDU.

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5 CLO – The CLO program was initiated by CN in 1995 as part of a negotiated agreement between CN and the Canadian Council of Railway Operating Unions (CCROU). The program was designed to address a specific need for relief while operating locomotives on extended runs. Conductors would be trained to provide brief, intermittent relief for the locomotive engineer.

CN officials conducted a post-incident inspection of the angle cock and determined that, although it was only partially open, it was otherwise fully functional. After restoring the angle cock to the fully open position, they performed a No. 1 brake test and determined that the brakes on all the cars were functioning as required.

Weather

At the time of the occurrence, the temperature was 13°C. The skies were overcast and it was raining.

Train Inspection

The train had received a No. 1 brake test[6] at Walker Yard in Edmonton before departing. No defects were reported. At Jasper, a No. 2 brake test and a pull-by inspection were performed and no anomalies were reported. There was no information transferred between the inbound and outbound crews to suggest that the train was not functioning as intended. In addition, all cars added to the train at Red Pass had received a No. 1 brake test before being added to the train.

Locomotive Event Recorder

Recorded information indicated the following:

- A train brake application of 15 pounds per square inch (psi) was made to stop the train at the Omaha Siding.

- A 14 psi train brake application was made during the journey from the Omaha Siding to McBride.

- A full service train brake application (25 psi) was made, while the train was travelling at 11 mph, to stop the train at McBride.

- An 11 psi train brake application was made while the train was travelling from McBride to Bend.

- The train was travelling at 34 mph when it passed over the siding east switch at Bend.

- The train travelled approximately two miles after an operator-initiated emergency brake application was made from the lead locomotive at a speed of 38 mph, as the train approached the siding east switch at Bend.

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6 A No. 1 brake test requires a thorough safety inspection of all cars including the observation of the application and release of the brakes. This test must be performed by certified car inspectors.

- Up to 80 psi of locomotive independent brake cylinder pressure was used to slow and stop the train at Bend.

While the locomotive event recorder met existing regulatory requirements, it did not record end-of-train data or dynamic brake level. This information is provided by some locomotive event recorder systems.

Events at the Omaha Siding

At the Omaha Siding, the train was stopped on the main track with the tie car beside the location where it was to be set off. The trainman detrained and uncoupled the cars behind the tie car after he had been notified that the brakes were applied. While the locomotives and the tie car were pulling away, the trainman partially opened the angle cock on the standing portion of the train to vent the air from the brake pipe. As the air was venting, he removed the derail on the adjacent track to facilitate the set-off.

When the tie car was secured, the trainman returned to the standing portion of the train and re-coupled the locomotives. Once the locomotives were re-coupled, he attached the hoses and opened the angle cock on the locomotive. He did not reopen the angle cock on the standing portion of the train nor did he note anything unusual as he opened the angle cock on the locomotives, filling only the two air hoses between the trailing locomotive and the first car.

While the locomotives were being re-coupled and the brake pipe pressure was being restored, the locomotive engineer exited the locomotive cab and re-entered it after re-coupling was complete. Since he was outside the cab while the brake pipe pressure was being restored, he could not observe the air flow meter[7] readings or take note of the time required to restore the brake system. While outside, he did not observe the sound associated with demand on the locomotive air compressor that normally occurs when main reservoir pressure drops below 130 psi (for example, when train brakes are released and recharging is taking place). After re-entering the cab, the locomotive engineer released the train brake, observed that the tail-end brake pipe pressure was being restored and departed the Omaha Siding with the brake system within acceptable limits but not yet fully charged, at 71 psi on the tail end.

Use of the Angle Cock when Setting off Cars

The angle cock (see Figure 2) is a valve located along the brake pipe at both ends of a car or locomotive. In the fully open position, the handle is in line with the brake pipe, and in the fully closed position, the handle is at right angles to the brake pipe. It can be opened or closed by the train crew to vent or preserve the air pressure in the brake pipe when cars or locomotives are uncoupled. Although not an approved practice, some railway personnel have been known to partially open an angle cock, on the standing portion of a train, to facilitate slow venting of the brake pipe. Trains proceeding in service with a partially open angle cock may have a reduced ability to apply the train brakes, or may not be able to apply the train brakes at all.

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7 The air flow meter is located in the locomotive and is designed to provide an accurate indication of the air flow rate from the locomotive to the rest of the train.

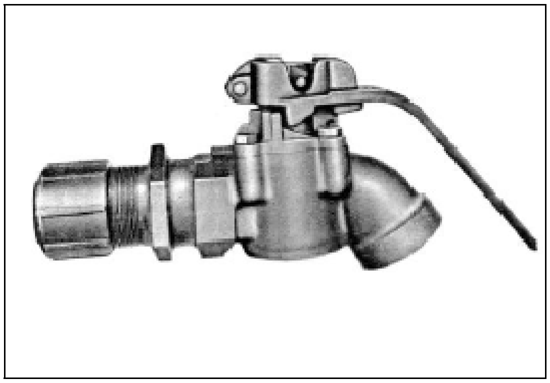

Figure 2. Angle cock

CN's General Operating Instructions (GOIs), dated 01 June 2003, require that, when setting off cars, the angle cock on the equipment be left fully open and the train brakes be applied in either full service or emergency. Other railways require their employees to leave unattended cars in emergency.

To leave cars with a full service brake application, the conductor closes both angle cocks after the locomotive engineer has indicated that the brakes are fully applied. The locomotives are uncoupled and moved a safe distance from the cars causing the air hoses to become separated. The conductor carefully opens the angle cock on the standing portion of the train so that the air vents slowly and does not place the train into emergency. Once the conductor has heard the air flow reach its maximum, he fully opens the angle cock. It is necessary to do so to prevent the unintentional release of the train brakes and the uncontrolled movement of the rolling stock.

To leave cars standing with an emergency application of the train brakes after the cars have been brought to a stop using a service brake application, the locomotive engineer places the train brakes into emergency. The conductor closes the angle cock on the locomotive and the locomotive engineer recovers and releases the brakes on the locomotive. The locomotive is moved a safe distance away from the standing cars. Alternatively, the angle cock is closed on the locomotive after a service brake application has been made and the cars are then separated. The separation of the locomotive from the cars parts the air hoses and causes air to vent rapidly from the standing portion of the train, putting it into emergency. The angle cock handle on the standing portion of the train remains open.

Setting off cars by applying a service brake application is operationally expedient because it depletes the air from the auxiliary reservoir only, requiring less time to recharge the brake system than after an emergency brake application. However, conductors may forget to restore the angle cock to the fully open position, or may intentionally leave the angle cock closed while setting off cars (bottling the air). Railways generally prohibit this practice as it can lead to runaway rolling stock and CN specifically forbids this practice.

Currently, the TSB is investigating one such occurrence (R05H0011) where the air was bottled on a standing cut of cars and an unintentional brake release occurred, resulting in the standing cut of cars colliding with the head end and puncturing a dangerous goods tank car.

When locomotives are connected to the standing portion of a train after the air hoses have been coupled, the angle cock on the locomotive is opened slowly to re-establish the supply of air. There is noticeable audible and sensory feedback as a high volume of air rushes through the valve. It takes a number of careful movements of the angle cock handle to fully open the valve and facilitate air flow. However, if the angle cock on the standing portion of the train is closed, such as after the set-off at the Omaha Siding, there is very little air flow and, consequently, the auditory and sensory feedback will be noticeably different.

Wabtec's Air Brake System Testing

TSB investigators visited Wabtec's 250-car air brake test rack in Wilmerding, Pennsylvania. A series of tests were conducted to examine the response of the air brake systems on a 100-car train to an application and release cycle with the angle cock on the leading car in a position that severely restricted the flow of air. The test results showed that it was possible to adjust the angle cock handle to achieve a rate of air flow such that the brakes could be released but not applied. This occurred with the handle at 79 degrees. Although the entire range of travel of the angle cock was 90 degrees, the valve was fully closed at 80 degrees.

This position, 79 degrees, proved to be a critical point in the travel of the angle cock handle. By slightly opening it or slightly closing it, from this position, the functionality of the air brakes on the test rack was significantly affected. Moving the angle cock more towards the closed position completely restricted air flow through the angle cock, preventing restoration of the tail-end brake pipe pressure in release and application of the train brakes in the application zone. Moving the angle cock more towards the open position allowed the restoration of brake pipe pressure in release and application of the train brakes in the application zone.

The Wabtec tests also revealed that, when the train brakes were released with the angle cock severely restricting the air flow in the brake pipe, brake pipe pressure at the rear of the train increased by approximately 10 psi within the first 6 minutes and increased another 5.5 psi over the next 53 minutes. The initial rapid increase was a result of the utilization of the emergency reservoir pressure in each car as enabled by the quick release feature of modern air brake control valves. The more gradual increase was caused by the air flow from the head end through the restricted brake pipe. It was noted that the reduced recharging rate may be insufficient to allow for a successful follow-up brake application subsequent to the release of the train brakes.

Additional tests demonstrated that a 100-car train, with minimal leakage in the brake system, will recharge in 5 to 8 ½ minutes after a minimum brake pipe pressure reduction of 6 to 8 psi and in 10 to 14 minutes after a full service brake pipe pressure reduction of 25 psi.

Brake Test Requirements when Setting off Cars

CN's GOIs address the brake test requirements when setting out cars. Section 7.15, dated 2002, states in part that, when locomotives are re-coupled to a train and no cars have been added "it is only necessary to re-couple the brake pipe and establish continuity." The GOIs define "continuity" as the "capability of transmitting a signal between the controlling locomotive and the rear car of the train, through the brake pipe." Consequently, locomotive engineers release the brake and look for an increase of at least 1 psi on the IDU to confirm continuity.

No. 2 Brake Test Requirement at a Crew Change Location

At the time of the occurrence, the GOIs dated 01 June 2002 and a revision dated 01 March 2003 were in effect. The Freight Air Brake Chart and associated notes in Section 7 instruct locomotive engineers on how and when to conduct air brake tests. They state in part that a No. 2 brake test is required when the locomotive engineer has been changed. To perform a No. 2 brake test at crew change locations (where the consist of the train is not altered), the inbound locomotive engineer would first ensure that the air brake system qualifies[8] before stopping the train with a service brake application that would reduce the brake pipe pressure by 6 to 8 psi on the tail end as displayed on the IDU. The revision to CN's GOIs changed the requirement to make a full service (25 psi) brake application and replaced it with the requirement to make at least a minimum (6 to 8 psi) reduction on the rear car of the train.

The outbound locomotive engineer would release the brake and observe a 6 psi increase in tail-end brake pipe pressure before departing. This rise in brake pipe pressure is interpreted to indicate that the brakes at the rear of the train have released. Before the 2003 revision, locomotive engineers looked for as little as a 1 psi increase in the tail-end brake pipe pressure to confirm release of the brakes before departing.

CN's *Locomotive Engineer Operating Manual* (CN Form 8960) states that the air flow meter is useful for detecting obstructions in the brake pipe such as a partially closed angle cock; however, it is not normally used to determine when the volume of air flow is too low. For example, crews generally use the air flow meter to determine when the flow of air is at or below the calibration line (60 cubic feet per minute) when conducting brake tests. There is no information in the brake test requirements to direct railway employees that the air flow meter can be useful in detecting restricted flow.

CN teaches its locomotive engineers to observe their air brake gauges, including the IDU and flow meter, and be wary for any irregularities during automatic brake applications and releases, including during brake tests.

Rail Safety Advisory Letter

The TSB issued Rail Safety Advisory (RSA) 617-06/04 to Transport Canada on 29 November 2004, indicating that the change in the No. 2 brake test procedures from requiring a 25 psi brake pipe pressure reduction to a 6 to 8 psi reduction may have played a role in the restricted air flow in the brake pipe going unnoticed. The RSA states the following:

> Given that a head-on collision was a potential outcome of this occurrence, Transport Canada may wish to establish the extent to which local changes to brake test procedures contributed to the completion of No. 2 brake tests, when air flow is restricted by a closed or partially closed angle cock.

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8 To qualify, the locomotive engineer must ensure that the system is charged to within 15 psi of the standard pressure for that train as measured at the rear of train and the air flow from the locomotives is at or below 60 cubic feet per minute.

Transport Canada responded to the RSA, stating that, because the change in brake test procedures are applicable only when the No. 2 brake test is performed as required at crew change locations and not when cars are added to a train, it believes that the current air brake testing regime is sufficient to detect an angle cock that is sufficiently closed to prevent the application of the brakes. Transport Canada's response also stated that the brake test procedure requiring a change in pressure, visible on the tail-end device, of between 6 to 8 psi is adequate to establish continuity. CN, who also responded to the RSA, indicated that it believes that a 25 psi brake pipe reduction is not necessary to establish a positive application to ensure an operational brake pipe.

Current U.S. Federal Railroad Administration (FRA) Requirements for No. 2 Brake Tests

Under current U.S. Federal Railroad Administration (FRA) requirements, when conducting a No. 2 brake test, the locomotive engineer has to initiate a 20 psi application of the train brake and, when using a Train Information and Braking System (TIBS), the locomotive engineer has to observe at least a 5 psi brake pipe pressure reduction and increase at the end of the train to confirm brake application and release.

Train Information and Braking System (TIBS)

The train was equipped with a TIBS, which consisted of three separate components: a communications logic unit (CLU) located in the short hood of the locomotive, a sense and braking unit (SBU) mounted on the trailing coupler of the last car, and an input and display unit (IDU) located in the locomotive cab. A toggle switch was located on the IDU in the locomotive cab for the locomotive engineer to actuate end-of-train emergency braking (see Photo 1). Section 7.3 (b) of CN's GOIs requires the operator to actuate the end-of-train emergency braking whenever an emergency application of the brakes is initiated.

Photo 1. Typical Association of American Railroads locomotive control stand

To place the train into emergency, the locomotive engineer normally uses the automatic brake valve. The brake valve and the TIBS switch are not co-located and consequently two actions are required to activate emergency braking simultaneously from both the head end and the tail end. However, a system is available that automatically initiates synchronous braking from both the locomotive and the tail end during emergency and service brake applications. Some railways in the United States have already equipped their trains with such systems.[9] As of 01 November 2001, the Association of American Railroads (AAR) requires that all new locomotives be equipped with automated end-of-train devices[10] to comply with FRA Regulation 49 CFR 232.405, *Design and Performance Standards for Two-Way End-of-Train Devices*.[11] The FRA

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9 National Transportation Safety Board, Railway Accident Report RAR-02-02, *Derailment of CSX Transportation Coal Train V986-26 at Bloomington, Maryland, January 30, 2000.*

10 Association of American Railroads (2001), *Revision of AAR Standards S-5701, End-of-Train Telemetry Devices, Circular Letter (c- 9359)*, Washington, D.C.

11 Federal Railroad Administration, Department of Transportation (2001), *Design and Performance Standards for Two-Way End-of-Train Devices*, Title 49, Transportation, Volume 4, Chapter II, Part 232, Brake Safety Standards for Freight and Other Non-Passenger Trains, Subpart E, End-of-Train Devices (Washington: U.S. Government Printing Offices, October 2001), pp. 448-449.

regulation requires all locomotives ordered on or after 01 August 2001, or first placed into service on or after 01 August 2003, to be designed to automatically initiate a simultaneous emergency brake application at the head end and tail end of the train whenever the locomotive engineer places the train air brakes in emergency.

A previous TSB investigation (R01M0061) analysed an occurrence where the train brakes were not put into emergency from the rear of the train when required. The report lists safety actions taken to reduce the likelihood of operators failing to activate the end-of-train emergency braking. Among the action listed, CN had initiated a program to equip its operating fleet of approximately 1600 road locomotives with an end-of-train system that automatically initiates synchronous braking from both the locomotive and the tail end during emergency and service brake applications.

In addition, Transport Canada revised the *Railway Locomotive Inspection and Safety Rules* in September 2002. Section 10.2 now requires new locomotives to meet AAR standards for the automated and simultaneous activation of two-way end-of-train devices during an operator-initiated emergency brake application.

As of April 2006, CN had converted 250 Canadian assigned locomotives with new IDUs and 198 end-of-train units to its new design for use in its Canadian operations. At the time of the occurrence, the lead locomotive of train 359 had not been modified to automatically activate the end-of-train braking.

Analysis

All cars on train 359 had undergone the required brake tests by certified car inspectors to ensure their mechanical integrity. All crew members involved in the operation of the train met fitness and rest standards and were qualified for their respective positions.

The train brakes were successfully used on a number of occasions between Jasper and the Omaha Siding where the tie car was set out, a distance of approximately 44 miles. However, when setting out the tie car at the Omaha Siding, the lead angle cock on the portion of the train left standing on the main track was placed in a partially open position rather than the fully open position, contrary to safe railway operating practices. Upon re-coupling, the angle cock was never restored to the fully open position before departing. Consequently, the train brakes did not apply when the crew attempted to slow the train in preparation for a meet with the opposing train at Bend.

This analysis will attempt to explain why the decision was made to deviate from a long-standing principle of safe train operations in the temporary securement of trains, in favour of a process that has been known to lead to the uncontrolled movement of rolling stock. In addition, the analysis will consider the circumstances under which the severely restricted brake pipe remained undetected between Red Pass and McBride, the requirements of the No. 2 brake test at McBride where there was a change of locomotive engineers, and the events between McBride and Bend. Also, the end-of-train emergency brake feature of the TIBS and the absence of a requirement to record essential end-of-train brake pipe pressure in current safety specifications will be discussed.

Tie Car Set-Off

When setting off the tie car, the trainman decided not to fully open the angle cock when he separated the head end from the standing portion of the train. His plan was to restore the angle cock to the fully open position after the brake pipe was completely vented. He likely decided to make this adaptation to the railway's standard operating procedure to save time. Individuals often make such adaptations when they believe there is little risk of their behaviour leading to negative consequences. He was remaining in close proximity to the stationary train and would be able to respond in the event of an unintentional release of the brakes. What was omitted from his risk assessment was the possibility of forgetting to restore the angle cock to the fully open position before departing. The consequence of operating a train with a severely restricted brake pipe was not likely considered. While adaptations to standard operating procedures normally take place through seemingly rational thought processes, they can lead to unforeseen results.

Other railway companies have guarded against the risk of runaways by requiring that a standing portion of a train always be left in emergency. CN, however, permits its employees to use either a full service or an emergency brake application.

When brake pipe pressure is restored to a short length of brake pipe (that is, the two air hoses between the locomotive and the first car), rather than along the entire length of the train, there is a significant difference in the volume of air travelling through an angle cock. This difference generates feedback to an individual opening an angle cock in such circumstances. The feedback is in the form of sound as well as sensory input that can be felt by the hand as the angle cock handle need only be moved into the "open" zone a very short time to fill a small volume. It remains unexplained as to why this feedback went unnoticed.

Angle Cock Position

Tests at the Wabtec facility demonstrated that the angle cock handle can be placed in a very narrow range of positions where the air flow through the angle cock is restricted to such an extent that the train brakes cannot be applied, but the tail-end brake pipe pressure can be gradually restored and the train brakes released.

When the train was departing the Omaha Siding, the locomotive engineer observed an increase in brake pipe pressure at the end of the train while completing the requirements of the continuity test; however, the crew was unable to apply the brakes later on. For example, at McBride, where the inbound crew overshot the intended stopping location, it is likely that the brakes could not be applied from the head end. A combination of dynamic and independent brake was used to eventually stop the train. While these events were cues to the inoperability of the train's braking system, they did not prompt either the inbound or outbound crews to suspect a problem.

At Bend, the train brakes were inoperable from the head end. Therefore, it is likely that the angle cock on the first car behind the locomotive had been placed within the narrow range of positions identified at the Wabtec facility during the set-off at the Omaha Siding. The continuity test was not effective in identifying the severely restricted brake pipe. Consequently, the train departed the Omaha Siding with continuity re-established and the train brakes inoperable. However, it should be noted that a variance of less than one degree from this position would have resulted in the train either not being able to establish continuity (more closed) or enabling limited functionality of the brakes (more open). Tail-end brake pipe pressure was not recorded; therefore, an accurate picture of brake pipe pressure increases and decreases throughout the train could not be determined.

Locomotive Engineer's Use of Gauges

During the No. 2 brake test at the crew change location at McBride, the outbound locomotive engineer did not observe a restoration in tail-end brake pipe pressure of 6 psi on the IDU as required by CN's GOIs. Moreover, there were several other occasions after the set-off at the Omaha Siding where critical information went unobserved. For example, there were two braking events where the air flow meter would have displayed an abnormally low air flow reading while the air brake system was restoring the brake pipe air pressure.

While it is common for locomotive engineers to use a combination of sensory feedback to monitor the train without referring to information displayed on the IDU and the air flow meter, the crews involved did not suspect anything untoward with the effectiveness of the train brake system. Crews have historically viewed the air flow meter as a device that indicates when demand for air is excessive; that is, during charging of a train's brake system or during cold weather operation. They have not normally viewed it as a device that can aid in the detection of a restricted brake pipe; that is, when demand for air is insufficient.

Changes to the No. 2 Brake Test at Crew Change Locations

Over the course of time, technological advancements have changed the way in which railways operate, including the manner in which brake tests are conducted. Historically, the No. 2 brake test at crew change locations was performed by the outbound locomotive engineer and the inbound conductor. This ensured a certain continuity of observation by requiring the outbound locomotive engineer, who would be relying on the brakes over the next subdivision, to perform both the application and the release portion of the test.

Under the requirements of the No. 2 brake test from CN's 2002 GOIs, the inbound locomotive engineer would have applied the train brake with a full service (25 psi) brake application; the outbound locomotive engineer would release the brake and depart once the brake pipe pressure at the rear of the train began to restore. Tests on the Wabtec test rack for a 100-car train with minimal brake pipe leakage revealed that it would take 10 to 14 minutes to fully charge the brake pipe upon the release.

Under the current test regime, the outbound locomotive engineer need only release the brake and note a 6 psi increase in the brake pipe pressure at the rear car of the train. The Wabtec tests revealed that it would take between 5 and 8 ½ minutes to completely recharge a 6 to 8 psi application, a potential savings of 5 to 7 minutes on a crew change. Although it is recognized that the requirement to observe a 6 psi increase on the IDU before departing makes the release portion of the brake test more restrictive, the change from a 25 psi reduction to a 6 psi reduction makes the application less restrictive. Changes in the brake test methodology have resulted in train crews performing fewer tasks and not interacting with each other to complete the No. 2 brake test. There is an overall reduction in opportunity for the observation of anomalies during the test and a possible reduction in the perceived importance of the test by train crews;

for example, the requisite 6 psi increase in tail-end brake pipe pressure was not observed at McBride. Consequently, these changes have increased the likelihood that an unsafe condition, such as the severely restricted brake pipe on train 359, would remain undetected.

The Wabtec tests revealed that a train with a severely restricted brake pipe, and consequently a low rate of air flow, can register a 6 psi increase on the IDU and meet the requirements of the No. 2 brake test at crew change locations. This is partially due to the use of emergency reservoir air for recharging by modern air brake control valves during activation of quick release. This demonstrates that train 359 could have met the requirements of the modified No. 2 brake test even with a severely restricted brake pipe.

Emergency Braking Procedures

When the conductor and the locomotive engineer realized that the train was not responding to the service brake applications, they both attempted to place the train brakes into emergency from the locomotives. However, when the train did not begin to slow down, neither crew member attempted to initiate an emergency brake application from the rear of the train by actuating the TIBS toggle switch. Had the toggle switch been actuated, it is likely that the train brakes would have been placed into emergency from the tail end and the train would have stopped before the meet location.

However, as the two controls are not co-located, they require two actions to actuate emergency braking from the head end and the tail end. During emergency brake activation, the person operating the train must quickly respond and perform a sequence of actions under pressure. To ensure that all motor components of the emergency procedure are reliably triggered, the response sequence must be overlearned;[12] that is, it becomes, through repetitive practice, an automatic process, thereby requiring less attention and making emergency responses more resistant to stress and interference by other tasks. If the emergency braking procedure is not overlearned, it is not as likely to be performed correctly in an emergency, leading to less-than-adequate emergency braking.

Comprehensive instruction on emergency braking is covered in a locomotive engineer's initial training; however, even that training does not recognize that an infrequently used skill must be overlearned to help ensure its effectiveness. While there is ongoing training provided to locomotive engineers where procedural requirements for effective emergency braking are covered, the training does not focus on the need to overlearn this critical but rarely applied behaviour to ensure success.

Although CN has fitted 250 locomotives with an end-of-train braking system that synchronizes the application of the train brakes from the head end and from the tail end, the majority of CN's locomotives still require the manual application of the end-of-train brakes (situation as of 20 April 2006). CN estimates that 500 road locomotives will be so equipped by the end of 2006.

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12 J.E. Driskell, R.P. Willis, and C. Copper (1992), "Effect of overlearning on retention," *Journal of Applied Psychology*, *77*(5), pp. 615-622.

Until all locomotives are fitted with a synchronous end-of-train braking system, or emergency procedures become overlearned, the risk remains that locomotive engineers will not initiate end-of-train braking when required.

Locomotive Event Recorder

The locomotive event recorder recorded the brake pipe pressure at the locomotives, but it did not record the brake pipe pressure at the rear of the train. A record of such critical information as end-of-train brake pipe pressure would have enabled a more complete understanding of the events surrounding this occurrence.

Findings as to Causes and Contributing Factors

1. When setting out the tie car at the Omaha Siding, the lead angle cock on the portion of the train standing on the main track was placed in a partially open position and never restored to the required fully open position upon re-coupling.

2. The partially open angle cock prevented the application of the train brakes when the crew attempted to slow the train in preparation for a meet with an opposing train at Bend.

3. Neither the performance of the continuity test nor the modified No. 2 brake tests were effective in helping the crews identify the severely restricted brake pipe and the resultant inoperable train brakes.

4. The crews did not refer to information displayed on the input and display unit (IDU) and the air flow meter, and therefore did not suspect anything untoward with the effectiveness of the train brake system.

5. Changes to the No. 2 brake test at crew change locations reduced the opportunity for the observation of restricted brake pipe air flow on train 359 that led to its uncontrolled movement.

6. Testing showed that train 359, even with a severely restricted brake pipe, could have met the requirements of an increase of 6 to 8 pounds per square inch (psi) in brake pipe pressure at the rear of the train due to the use of emergency reservoir air for release and recharging, once the signal to release had been successfully communicated.

Finding as to Risk

1. Until all locomotives are fitted with a synchronous end-of-train braking system, or the requirement to simultaneously activate the tail-end emergency brake feature is overlearned to the extent that it becomes normal behaviour, the risk remains that end-of-train braking will not consistently be initiated when required.

Other Finding

1. A record of such critical information as end-of-train brake pipe pressure would have enabled a more complete understanding of the events surrounding this occurrence.

Safety Action Taken

In 2004-2005, Canadian National modified all dynamic brake–equipped locomotives to retain the ability to employ dynamic brake subsequent to emergency brake applications.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 23 June 2006.

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