# RAILWAY INVESTIGATION REPORT
R01T0006

## MAIN TRACK DERAILMENT

CANADIAN NATIONAL
TRAIN NO. M-310-31-15
MILE 143.00, KINGSTON SUBDIVISION
MALLORYTOWN, ONTARIO
16 JANUARY 2001

# Railway Investigation Report

# Main Track Derailment

Canadian National
Train No. M-310-31-15
Mile 143.00, Kingston Subdivision
Mallorytown, Ontario
16 January 2001

Report Number R01T0006


## *Summary*

On 16 January 2001, at approximately 0335 eastern standard time, Canadian National freight train M-310-31-15, proceeding eastward at about 45 mph, derailed 26 cars at Mile 143.0 of the Kingston Subdivision, near Mallorytown, Ontario. The derailed cars included two tank cars loaded with propane. There was no loss of product and no injuries. A public school was closed for the day as a precautionary measure.


*Ce rapport est également disponible en français.*

# *Other Factual Information*

On 16 January 2001, Canadian National (CN) freight train M-310-31-15 (the train) departed Toronto and proceeded eastward on the south main track of the Kingston Subdivision, destined for Montréal. As the train passed over a hot box detector (HBD) at Mile 151.1 an alarm signal was transmitted to the train. The locomotive engineer immediately began dynamic braking to reduce the speed of the train. In the event of an alarm, CN's General Operating Instructions (GOIs) require the locomotive engineer to stop the train immediately, and advise the rail traffic controller (RTC) of the location where the train was brought to a stop. While the train was decelerating, the locomotive engineer contacted the RTC and was advised that the HBD office in Edmonton, Alberta, had no record of the train passing over the HBD, and that the train was to proceed to Mile 138.2, Mallorytown, Ontario, for further inspection.

Several minutes later, the RTC requested the locomotive engineer to stop the train and inspect the 107th car from the head-end. Before the locomotive engineer could bring the train to a stop the train experienced a train-initiated emergency brake application. After conducting the necessary emergency procedures, the crew determined that 26 cars within a block of 36 cars, the 94th car to the 129th car, had derailed. Two derailed cars were loaded with propane (UN 1075). There was no release of product.

Twenty-one cars derailed and remained upright on the track roadbed. Three others, the 116th, 120th and 121st also derailed and came to rest at varying angles to the main track. The last two cars, the 117th car and the 118th car (both empty boxcars) were propelled off their trucks and came to rest 50 feet south of the track. The tail-end continued eastward 250 feet, the approximate length of the five displaced cars.

The crew consisted of a locomotive engineer and a conductor. They were both familiar with the subdivision, met fitness and rest standards, and were qualified for their respective positions.

The train was approximately 9450 feet long and weighed about 11 700 tons. It was powered by 2 locomotives and was hauling 76 loaded cars and 73 empty cars. The trailing locomotive did not have dynamic braking capability. The head-end portion of the train was comprised primarily of empty cars, while the tail-end portion was primarily loaded cars. There was a block of empty cars located between two loaded blocks. It is not uncommon to marshal trains with loaded cars on the tail-end.

The Kingston Subdivision consists of double main track, extending from Montréal to Toronto and is a main corridor for passenger and freight traffic, including dangerous goods. The permissible track speed is 100 miles per hour (mph) for passenger trains and 60 mph for freight trains. Train movements are controlled by Centralized Traffic Control (CTC), authorized by the Canadian Rail Operating Rules and supervised by an RTC located in Toronto, Ontario.

In the area of the derailment, the track consisted of standard 132RE and 136RE rail, hardwood ties and crushed rock ballast. The track was last inspected 15 January 2001 by a hi-rail vehicle and no defects were noted.

The track configuration in the vicinity of the derailment location was two "S" shaped horizontal curves within a sag vertical curve. When the train came to rest, the head-end was situated on an ascending 0.7 per cent grade while the tail-end was situated on a descending 0.7 per cent grade. The cars had derailed at the bottom of the vertical curve.

Inspection of the site revealed that the south rail had rolled over for approximately 2600 feet, but was not broken. Spikes had been either pulled out or sheared off. The first markings were noted on the ties at Mile 143.00, approximately six inches from the gauge side of the south rail. There were no marks on the ball of the rail. A telegraph pole cross arm had been broken off and was located on the ground near one of the box cars. Paint found on the cross arm appeared to match that of the box car. Recent damage was observed on the couplers and to the car body end frames on a large number of derailed cars. The centre sill of the 118th car had buckled.

The recorded data from the HBD indicated that there was a hot journal reading on axle number 429, the 107th car behind the locomotive. The car body and running gear were examined after the derailment and no pre-derailment defects were noted. The other derailed cars were also examined and no exceptions were observed.

The locomotive event recorder (LER) data indicated an emergency brake application occurring at 0335 at a recorded speed of 45 mph with the train brakes released and the throttle in the No. 8 position. Immediately after the emergency brake application, the LER recorded both the bailing-off of the independent brake and an acceleration surge. The LER system had no functioning end-of-train (EOT) channel to record the time the brake signal reached the tail-end.

The TSB Engineering Laboratory conducted a train dynamics simulation using the Automatic Dynamics Analysis of Mechanical Systems software, to study the effect of the train consist and the track profile on in-train buff forces. The simulation (summarized in Engineering Report LP22/2001) revealed the following:

- The emergency brake application initiation point was within the front quarter of the train, most likely on the fortieth car.

- The estimated maximum buff force was 1.0 to 1.3 million pounds and was located at the 121st car[1]. The simulation revealed this was where the maximum buff force occurred due to the 28 loaded cars behind running into it.

- Because of the marshalling of the train, the buff forces generated during the emergency brake application were increased.

- The grades and the curves of the track weakened the resistance of the train to compression buckling due to the buff forces.

US Federal Railroad Administration (FRA) studies[2] have been conducted to evaluate the operation of freight train air brakes. These studies have shown that during emergency brake

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1 The Association of American Railroads freight car design requirements are to sustain a compressive columnar load of at least 1 million pounds. *AAR Manual of Standards and Recommended Practices*, Section C, Part II, Vol. I - Specifications for Design, Fabrication, and Construction of Freight Cars, M-1001.

2 DOT/FRA/ORD-84-16 - *Freight Train Brake System Safety Study* - November 1984;
R-185-Track Train Dynamics Report - *TTD Guidelines for Optimum Train Handling, Train Makeup, and Track Considerations* - November 1979.

applications, run-in on an empties-ahead/loads-behind configured train can generate significantly higher buff force impacts as compared to trains with a uniform weight distribution.

CN uses a computerized system for train service design. This system is designed to recognize marshalling conflicts which are in violation of CN GOIs requirements. Within CN's GOIs regarding marshalling, there are no constraints on tonnage distribution within the train. CN's train design planning systems do not take weight distribution within the train into consideration when the train service plan is produced. Other Canadian railway companies require that freight trains be made up, to the maximum extent practicable and subject to destination blocking, with the loads marshalled closest to the locomotives to reduce the probability of undesirable track/train dynamics occurrences.

The TSB has recently conducted investigations into three occurrences (R01M0061, R00Q0023 and R02W0060) in which the issue of high in-train buff force levels on long trains, made up in empties-ahead/loads-behind or loads/empties/loads configurations, was examined.

## *Analysis*

The manner of operation of the train was in accordance with company and regulatory requirements. The track was in good condition. An inspection of the rolling stock revealed no pre-derailment defects. The type of damage to the derailed cars (ends, couplers and a centre sill), the expulsion of the boxcar bodies from the train, the compressed state of the cars remaining on the track, the rolled-over but not broken rail, and the lack of wheel climb marks, are indicative of a wheel lift derailment involving high in-train buff forces. Similar circumstances were observed in three recent TSB investigations. The analysis will focus on the initiation point of the emergency brake application, the generation of in-train buff forces, and train make-up practices.

The derailment occurred after the train experienced a train-initiated emergency brake application. The likeliest origin of the brake application was within the front quarter of the train, but it was not possible to determine the initiating car. An EOT brake channel would have helped narrow down the source of the unintentional emergency brake application during the investigation. However, CN's LERs are not equipped with a functioning EOT channel. The absence of an EOT channel increases the likelihood that cars whose brake systems initiate an unintentional emergency brake application will not be identified during an investigation and will remain in service.

When the emergency brake application occurred, the brake pipe air pressure at the point of initiation dropped, causing the air pressure along the brake pipe to decrease. With conventional train brake operation, the time required for the brake pipe air pressure to decrease along the length of the brake pipe, and the time required for the brake cylinder air pressure to increase, delays brake activation between cars. Consequently, the cars closest to the point of initiation will experience effective braking first. Therefore, when the initiation point is within the head-end of the train, the delay in effective braking will result in the cars at the tail-end receiving effective braking action last. In longer trains, the tail-end may not receive any effective braking action at all. With any braking, when the train is stretched, a run-in of train slack will occur and in-train buff forces will be generated.

The magnitude of the in-train buff force is related to the marshalling practices. When a train is marshalled with loaded cars at the tail-end, the tail-end momentum increases, and the buff force caused by the run-in increases. When high buff forces are applied to a block of empty cars the risk of derailment increases. The risk of derailment is further increased on curved track as the lateral component of the force increases, causing the cars to be pushed out of the train.

Train 310-31-15 was a long train, marshalled with a heavily loaded tail-end, and a block of empty cars located between two loaded blocks. The TSB Engineering Laboratory analysis determined the emergency brake application point was within the front quarter of the train, most likely on the fortieth car, an empty car in a block of other empties ahead of the heavier and loaded part of the train. When the emergency brake application was initiated, the light head-end began to decelerate sooner and faster than the heavier tail-end, causing a run-in to occur.

The tail-end run-in impacted on the block of empty cars, compressing them against the loaded cars ahead. The buff force generated was great enough to cause the buckling of the centre sill of the 118th car, indicating that the force exceeded its design specifications. Given the characteristics of the track, with the presence of vertical and horizontal curves, the buff forces generated during the emergency brake application caused the train to derail.

CN's marshalling GOIs and train design planning systems have no constraints on tonnage distribution and train length. Other Class 1 railway companies require that freight trains be made up, to the maximum extent practicable and subject to destination blocking, with the loads closest to the locomotives. A train service plan which does not consider the effect of tonnage distribution and train length on the generation of buff forces, increases the risk of derailment during an emergency brake application. As a derailment generally obstructs both tracks, the risks are further increased on double main track subdivisions, such as the Kingston Subdivision, which carries high speed passenger trains and dangerous goods freight cars.

## *Findings as to Causes and Contributing Factors*

1. A combination of the geometric alignment of the track, the marshalling of the train and the buff forces generated during the emergency brake application contributed to compression buckling of the train and its subsequent wheel lift derailment.

## *Findings Related to Risk*

1. The magnitude of in-train buff forces generated during emergency brake applications is related to marshalling practices, and can exceed the design specifications for railway cars.

2. Marshalling GOIs and train planning systems that have no constraints on tonnage distribution and train length do not allow effective control of buff forces during an emergency brake application.

3. As a derailment generally obstructs both tracks, the risks are increased on double main track subdivisions, such as the Kingston Subdivision, which carries high speed passenger trains and dangerous goods freight cars.

## *Other Findings*

1. The absence of an EOT channel increases the likelihood that cars whose brake systems initiate an unintentional emergency brake application will not be identified during an investigation and will remain in service.

## *Safety Action*

Transport Canada (TC) has written the Railway Association of Canada (RAC) to discuss the development and implementation of a train design system that takes tonnage and train length into consideration.

Canadian National (CN) has 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 applications. As of May 2003, CN had equipped 98 locomotives and acquired 437 end-of-train devices for use in their Canadian operations. CN is using risk assessment strategies to determine which trains are to be equipped with this enhanced end-of-train braking system. An added benefit of this system upgrade is that as part of the process, locomotives are being wired to record the EOT pressure.

CN has also changed General Operating Instruction (GOI) 5.3 that directs how a train must respond to a wayside inspection alarm. Previously, the instruction allowed for the train stop to be made based on analysis from the RTC Centre. The railway's GOI now requires that a train stop immediately, in keeping with good train handling practices, on receiving a wayside inspection alarm.

CN has implemented advanced warning alarms (AWA) on the RTC display. These alarms provide an added measure of safety in the event that the train does not receive an alarm as a result of a talker system failure. In such circumstances, the RTC must immediately communicate this information to the train to ensure a stop is made.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 16 July 2003.*

*Visit the Transportation Safety Board of Canada web site, www.tsb.gc.ca for information about the TSB and its products and services. There you will also find links to other safety organizations and related sites.*