Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT
R03Q0036

MAIN-TRACK DERAILMENT

CANADIAN NATIONAL
TRAIN Q-120-31-30
MILE 46.0, DRUMMONDVILLE SUBDIVISION
VILLEROY, QUEBEC
30 JULY 2003

Canada

Railway Investigation Report

Main-Track Derailment

Canadian National
Train Q-120-31-30
Mile 46.0, Drummondville Subdivision
Villeroy, Quebec
30 July 2003

Report Number R03Q0036

Summary

On 30 July 2003, at 1150 eastern daylight time, Canadian National freight train Q-120-31-30, while proceeding eastward, derailed 32 intermodal platforms at Mile 46.0 of the Drummondville Subdivision, near Villeroy, Quebec. Approximately 2200 feet of track was destroyed, and another 1900 feet was damaged by the derailment. Thirty-one platforms received minor damage, and one platform was destroyed. None of the cargo containers or trailers, several of which contained dangerous goods, were damaged in the derailment. No one was injured.

Ce rapport est également disponible en français.

Other Factual Information

Train Operating Information

On 30 July 2003, at about 0700 eastern daylight time,[1] Canadian National (CN) freight train No. Q-120-31-30 (the train) departed Montréal, Quebec, destined for Halifax, Nova Scotia. The train, an intermodal express freight train, was 9973 feet long and weighed 9310 tons. It consisted of 4 locomotives and 145 loaded intermodal platforms. There were two crew members, a locomotive engineer and a conductor. Both crew members were familiar with the route, qualified for their positions and met established fitness and rest standards.

The trip eastward from Montréal was without incident until the train experienced an undesired emergency brake application at Mile 46.0, near Villeroy, Quebec (see Figure 1), as it was travelling through a speed restriction zone. The crew carried out the emergency procedures and determined that 32 platforms had derailed.

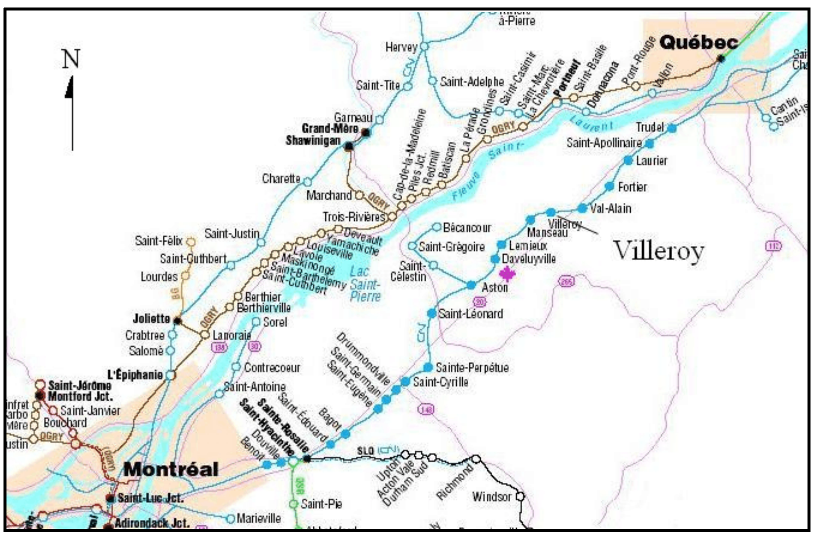

Figure 1. Location of the derailment (Source: Railway Association of Canada, *Canadian Railway Atlas*)

The first derailed platform was CN 677111 (D), the third platform of a Five-Pak intermodal car, and the 39th platform of the train. Its rear truck was derailed. The 40th to the 65th platforms remained on the track. The next derailed platform was DTTX 427493 (B), the third platform of a Tri-Pak, and the 66th platform. The following 30 platforms were derailed upright along the grade. The train had passed over six wayside inspection systems on the subdivision, and no equipment defects were noted. None of the derailed cars had a pre-existing equipment defect or condition that would have caused or contributed to the derailment.

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[1] All times are eastern daylight time (Coordinated Universal Time minus four hours).

The Drummondville Subdivision consists of a single main track that extends from Saint-Romuald, Quebec, Mile 4.4, to Sainte-Rosalie, Quebec, Mile 125.1. It carries up to 10 VIA Rail Canada Inc. passenger trains and 18 freight trains per day. Train movements are governed by the Centralized Traffic Control System in accordance with the *Canadian Rail Operating Rules* (CROR) and are supervised by a rail traffic controller (RTC) located in Montréal. In the area of the derailment, the track was classified as Class 5 track according to Transport Canada's *Railway Track Safety Rules* (TSR). The maximum authorized time table zone speed for passenger trains was 95 mph and 65 mph for freight trains. A speed restriction of 60 mph was in effect between Mile 46.0 and Mile 46.07.

The train was in possession of an operating authority granted by a train general bulletin order (GBO) issued under CROR Rule 83.2. The GBO contained speed restrictions related to track condition, including the one in effect between Mile 46.0 and Mile 46.07. Shortly before the accident, at 1133, the RTC issued by radio a supplementary GBO to the train, containing a speed restriction of 25 mph for all trains between Mile 46.0 and Mile 46.07, due to track maintenance work.

Recorded Information

As the train approached the speed restriction zone, its speed was gradually reduced, using the locomotive dynamic brake (DB). At Mile 46.07, the initial point of restriction, the locomotives were in IDLE and the speed was reduced to 31 mph. As the train travelled through the restriction zone, its speed was further reduced to 25 mph at Mile 45.5, and to 24 mph at Mile 45.3. The locomotive was then operated at a speed of between 24 mph and 25 mph, with the throttle gradually increasing from IDLE to notch 5 and up to notch 8. From Mile 44.76 to Mile 44.65, the train speed dropped from 24 mph to 17 mph, and the throttle reduced quickly from notch 8 to IDLE. At Mile 44.64, the train brake pipe pressure dropped from 84 pounds per square inch (psi) to 78 psi and then to 0 psi. The locomotives came to a stop at Mile 44.55.

Site Information

The track was tangent from Mile 52.2 to Mile 41. It had a predominantly ascending grade varying from 0.0 to 0.4 per cent, in the direction of train movement, from Mile 52 to Mile 42.3, except for a short sag, approximately 0.8 miles long, between the main-track siding switches at Villeroy. The track structure consisted of 136-pound continuous welded rail laid on 14-inch double-shouldered tie plates, secured with six spikes per tie, and anchored every third tie. There were approximately 3120 ties per mile. The ties were properly anchored.

The derailment zone extended from a point located 56 feet east of the 16th Line Road public crossing (Mile 46.07) for a distance of 4073 feet. Between the 16th Line Road crossing and the Highway 20 overpass at Mile 44, there were several farm crossings, three of which were in the derailment zone. Two of the farm crossings were not in use. The 16th Line Road crossing was in poor condition, with visible deterioration of the crossing planks and degradation and collapse of the asphalted road surface immediately adjacent to the rails, due to the pumping of the track. The railway had planned to renew the crossing in August 2003.

Throughout the entire derailment zone, including the crossings, the ballast was contaminated, water saturated, and the track was pumping (see Figure 2). The surrounding land area was essentially flat farmland, some in pasturage and some with crops, with drainage ditches intersecting with the railway and road ditches. There were three culverts and one bridge between Mile 44 and the 16th Line Road crossing. The culverts were not obstructed. The ditches on both sides of the track were approximately six feet below the base of the rail and contained water.

Figure 2. Contaminated ballast and pumping ties

The track underneath the last 30 derailed platforms was completely destroyed. In the zone of destruction, the majority of the ties were in poor condition, showing signs of water saturation and rot through half of their thickness. Two farm crossings were destroyed and the third was seriously damaged. The crossing planks were in fair condition on the surface, but were saturated with water at their base. Each of the three farm crossings had at least 19 consecutive underlying ties that were deteriorated and water saturated.

The track had buckled outwards to the south side. The buckle, starting approximately 30 feet east of the public crossing, reached a maximum of eight inches at a distance of 56 feet from the crossing (see Figure 3), where fresh wheel flange marks were noted on the gauge side of the south rail. Wheel flange marks were noted through the entire derailment zone, ending underneath the first derailed car.

The track showed signs of severe pumping from the public crossing to the rear of the last derailed car at Mile 46. The ballast was completely saturated with fines and mud. Where the ties had shifted, the voids at the end of the old ties were filled with water and mud.

Figure 3. Track buckle looking east

Within the derailment zone, new ties had been laid out for replacement from the road crossing eastward for a distance of approximately 600 feet on the north side of the track. Prior to the arrival of the train, 25 of the ties had been changed, covering a distance from the road crossing of approximately 240 feet. Eleven of the ties were west of the last derailed car, and the remainder underneath the derailed cars in the initial zone of track destruction. Within this working zone, all the rail anchors had been removed. None of the newly placed ties were spiked, including a cluster of four consecutive ties. Both ballast shoulders had been disturbed where the old ties had been removed and the new ties installed. Some old ties were hanging or were barely seated on the disturbed ballast as the newly installed ties were ¾ inch to 1 ½ inches higher than the old ties left in track.

Weather

At the time of the derailment, the weather was clear, light cloud cover, with a temperature of 20.6°C. During the three months preceding the derailment, precipitation in the area had been above average, totalling 274.7 mm.

Railway Inspections

CN Standard Practice Circular (SPC) 3100, revised January 2003, governs the track inspection frequency. The Assistant Track Supervisor (ATS) last inspected the track by hi-rail on 27 July 2003, three days prior to the accident; no irregularities were reported. The latest track geometry inspection was performed by a TEST car on 21 June 2003. Urgent cross-level defects were identified and a slow order protection was placed; the maximum allowable speed was reduced to 60 mph. There were no rail defects noted within the zone during the most recent rail flaw detection. The condition of the 16th Line Road crossing and the adjacent area of pumping, poor tie condition, and the severity of the ballast contamination had been identified by the railway, and the repair work planned for the area.

At the time of the derailment, renewal work was in progress on the zone adjacent to the crossing. Two section work teams, including two foremen, were assigned the job of performing the renewal work in this zone. The local foreman of the work team from the zone was responsible for the combined work team. The assistant track supervisor responsible for this territory was performing a track inspection elsewhere on the subdivision and was not present to oversee the assigned work. However, he instructed the foreman in charge of the work to place a speed restriction in the working zone, but did not specify the required speed.

The TSR require that the ballast restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by railway rolling stock and thermal stresses by the rails, and provide adequate drainage for the track. According to SPC 3100, track pumping and ballast contamination must be identified and noted during track inspection.

Both the TSR and SPC 3300 require, for tangent track located in Class 5 tracks, a minimum of 12 sound ties in any 39-foot length of track. In addition, SPC 3300 requires that there be not more than four or more consecutive defective ties.

Regulatory Audits

On 30 July 2003, Transport Canada safety officers were carrying out a safety audit of the Drummondville Subdivision. The inspection was interrupted at Mile 53 because of the accident. The safety officers reported ballast contamination and track pumping at several locations. The class of track was downgraded from 5 to 3 by the railway at four locations between Mile 114 and Mile 63.5.

Track Structure

The track sits in a crushed rock ballast layer, on top of a gravel sub-ballast layer over the subgrade. The crushed rock ballast layer is an important element in the structure. It ensures proper drainage and provides lateral and longitudinal rigidity of the track structure. Much of the subgrade on the Drummondville Subdivision was built from local fill materials. The soils of the south shore lowlands of the St. Lawrence River Valley are largely silt and clay-based. These soils absorb and retain significant moisture from normal runoff and natural drainage, and are known to contribute to accelerated ballast contamination due to normal movement of the track structure under traffic.

Ballast friction generated by passing trains will cause the ballast material to abrade over time, creating a fine powder that will fill the interstices between the ballast, reducing friction and resistance to movement, and impeding proper drainage. Normal flexing of the track under vertical load will cause the finer particles in the sub-ballast layer and roadbed to migrate into the ballast layer over time, progressively contaminating the ballast layer and reducing its effectiveness. In the presence of water, the contaminated ballast turns into a liquefied mud layer.

Track Maintenance Requirements and Training

When wooden track ties are changed, the ballast shoulders and cribs are loosened, and the rail anchors and track spikes are removed. Once all the new ties are installed, spiked and anchored, ballasting, track alignment, surfacing, and shoulder compaction are performed to ensure the proper level of stability.

In May 2001, CN SPC 3300 required that, if trains pass through a working zone while tie renewal is in progress, not more than three consecutive ties be left unspiked on tangent track and train speed not exceed 20 mph. It also required that a temporary slow order of 30 mph be imposed on a working zone until at least 100 000 tons of traffic have passed through the zone once the work has been completed.

In the revisions of January 2003, SPC 3300 was amended, requiring that a 10 mph restriction be applied to track being worked under traffic. It also required a temporary slow order of 25 mph to be imposed on a working zone for at least one train if shoulder ballast stabilisation and compaction is done during surfacing work, or else that the slow order be maintained until at least 50 000 tons of traffic have passed through the zone once the work has been completed.

Dissemination of Safety-Critical Information

The changes in the SPCs were communicated to all affected employees via e-mail, and employees were required to update their printed copies of the SPCs. A training session on the revisions was given in April 2003 to all track supervisors and their assistants in the area prior to the beginning of the summer maintenance season, and copies of the revised SPCs were distributed. CN also trained many of the section foremen who performed track work. The ATS responsible for the territory where the accident occurred had not yet attended a training session due to scheduling availability. The local foreman in charge of the combined work team had received the SPC training, but his colleague from the adjacent area had not.

Analysis

The train derailed as a result of a track buckle while travelling over track on which maintenance work was being performed. Since none of the derailed cars had a pre-existing equipment defect, equipment condition did not cause or contribute to this accident. The analysis will focus on the weakening of the track structure caused by the work in progress, train operation, the protection of track work, communications and training for track work.

Integrity of the Track Structure

The bearing capacity of the track was reduced, leading to track pumping and a rapid deterioration of the track geometry. The lateral strength of the track, which is normally provided through lateral friction on the base of the tie and lateral pressure on the ballast shoulders at the end of the tie, was also diminished, due to the presence of the contaminated ballast that turned into mud and by the loosening of the shoulder ballast necessary for tie replacement. However, it is inconclusive as to whether the additional loss in lateral resistance due to contamination was a prerequisite factor to the derailment. In addition, the new ties were not spiked prior to the arrival of the train, leaving the rails partly unrestrained laterally. As the old ties left in track were shallower than the new installed ties, they were lifted away from the underlying ballast, further compromising the lateral strength of the worked segment of track.

As the lateral resistance of the track had been reduced, the forces exerted on the track structure by the moving train could not be contained, allowing the track to shift out of alignment and buckle. The initial track buckle caused a wheel climb and derailment of the trailing truck of the 39th car. The track buckle increased under the passing train until the 66th platform derailed, followed by the cars behind it.

Train Operation

As the train approached the working zone, it was slowed down using a combination of throttle modulation and locomotive dynamic brake. The dynamic brake was re-applied in order to comply with the speed restriction. With the locomotives having been in IDLE up to this point for almost 30 seconds, the train slack would have started to stretch naturally due to normal grade resistance. The use of dynamic brake occurred just as the first car to derail entered the working zone, causing a slight run-in of train slack. Even though the train entered the working zone 6 mph above the maximum authorized speed limit, only modest in-train forces were generated; however, the lateral components of these forces at the speed at which the train was travelling were sufficient to initiate the track buckle.

The progressively increased drag of the train as the cars derailed and were dragged along the grade was compensated for by increasing throttle, until it was evident that the train was not responding as expected, and the throttle was reduced to IDLE just as a train-initiated emergency brake application caused by the derailment occurred. The use of heavy tractive effort when it was evident that the train was not responding properly increased the severity of the derailment.

Protection of Track Work

It is recognized that track panel resistance to lateral dynamic loads is weakened when track work is being performed. Any work that destabilizes the ballast layer and shoulders must be given due consideration, and safe movement of trains ensured by complying with the safe procedures and practices contained in the SPCs.

In this occurrence, the existing track condition was identified as being beneath SPC requirements, and a local speed restriction was imposed to ensure operating safety until remedial work was completed. In the course of performing the work, track integrity was temporarily reduced to an unsafe level for trains operating at relatively modest speeds. This transient weak track condition in the working zone was insufficiently protected when a 25 mph slow order was put in place despite the SPC requirement of a 10 mph temporary slow order while the work was in progress. Furthermore, a cluster of four consecutive ties was left unspiked despite the SPC requirement for a maximum of three consecutive ties.

The observed variance between company procedures (SPCs) and actual field practices with respect to the required protection of work zones and the number of ties that can be left unspiked suggests that the local employees' knowledge of the SPCs was inadequate. It also indicates that the training provided on SPC revisions did not meet its aim of disseminating safety-critical information to every employee responsible for track work, as it did not reach the ATS and a track foreman involved in the tie renewal.

Proper understanding and application of the maintenance standards is an essential element in railway safety. Therefore, it is necessary to ensure that all track maintenance employees affected by changes to work procedures are aware of these changes, and confirm that they are in possession of the knowledge necessary to ensure safe operation.

Ballast Contamination

Transport Canada's safety audits and inspections revealed that the railway had taken no safety action for identified track defects related to a ballast contamination condition generalized over the entire subdivision on one of the most heavily travelled subdivisions in eastern Canada. Even though it is inconclusive if ballast deterioration was prerequisite to this occurrence, track with contaminated ballast may deteriorate very rapidly below the levels required for safe high speed operation if exposed to prolonged wet weather conditions, increasing the risk to the public.

Farm Crossing Condition

Damage to the farm crossings in the derailment zone revealed conditions of ties and ballast under the crossings that were beneath the minimum safety standards stated in the TSR and SPCs. However, these underlying conditions were not recorded as they were not readily visible during routine track inspection by hi-rail. The presence of unsafe track condition at crossings will remain undetected unless additional inspections, such as walking inspections, specific inspections when crossing timbers are removed or TEST car inspection during periods when the ballast is saturated, are conducted.

Findings as to Causes and Contributing Factors

1. The train derailed as a result of a track buckle while travelling over track on which maintenance work was being performed.

2. As the train entered the working zone above the authorized speed limit, and with applied dynamic braking, the in-train forces generated were sufficient to initiate the track buckle as the lateral resistance of the track had been reduced by the track work.

3. The weak track condition in the working zone was insufficiently protected when the 25 mph slow order was put in place although the Standard Practice Circular (SPC) required a 10 mph temporary slow order while the work was in progress.

Findings as to Risk

1. Track with contaminated ballast may deteriorate very rapidly below the levels required for safe high speed operation if exposed to prolonged wet weather conditions, increasing the risk to the public.

Other Findings

1. The ballast was severely contaminated and transformed into a wet slurry that would not provide any friction resistance to lateral forces, thus, decreasing the lateral resistance; however, it is inconclusive as to whether the additional loss in lateral resistance due to contamination was a prerequisite factor to the derailment.

2. The use of heavy tractive effort when it was evident that the train was not responding properly increased the severity of the derailment.

3. The observed variance between company procedures and field practices suggests that the local employees' knowledge of the SPCs was inadequate.

4. The training provided did not meet its aim of disseminating safety-critical information, such as changes to SPCs, to every employee responsible for track work.

Safety Action Taken

As the ballast contamination condition had been identified by Canadian National (CN) track inspectors during previous routine track inspections and no protective action was taken, Transport Canada (TC) forwarded a Notice to CN on 31 July 2003, requiring the railway to address this deficiency.

On 14 August 2003, CN informed TC that the slow order would be maintained until the rehabilitation of the contaminated ballast on 08 September 2003. A follow-up audit was carried out by TC on 18 August 2003 from Mile 46.0 to Mile 74.5 and from Mile 100.5 to Mile 101.4. On 19 August 2003, TC issued a Notice and Order to CN imposing a speed reduction at 22 additional locations due to ballast contamination.

On 10 August 2004, TC and CN conducted a joint inspection on the Drummondville Subdivision. Further to this inspection, CN voluntarily reduced train speed at multiple locations on the Drummondville Subdivision.

CN is reviewing its testing procedure for safety-critical engineering courses such as those related to the Standard Practice Circulars to ensure that the evaluation process and pass/fail criteria properly reflect the necessary level of skill and knowledge.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 21 February 2005.