

Transportation Safety Board  
of Canada



Bureau de la sécurité des transports  
du Canada

**RAILWAY INVESTIGATION REPORT  
R11V0057**



**MAIN TRACK TRAIN DERAILMENT**

**CANADIAN PACIFIC RAILWAY  
UNIT COAL TRAIN 861-060  
MILE 30.0, CRANBROOK SUBDIVISION  
FERNIE, BRITISH COLUMBIA  
08 MARCH 2011**

**Canada**

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

## Railway Investigation Report

### Main Track Train Derailment

Canadian Pacific Railway

Unit Coal Train 861-060

Mile 30.0, Cranbrook Subdivision

Fernie, British Columbia

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### *Summary*

On 08 March 2011 at 0515 Pacific Standard Time, while proceeding westward, the crew on Canadian Pacific Railway unit coal train 861-060 reported the train going into emergency at Mile 30.0 of the Cranbrook Subdivision, near Fernie, British Columbia. Upon inspection, the crew determined that 27 loaded cars of coal had derailed. There were no injuries.

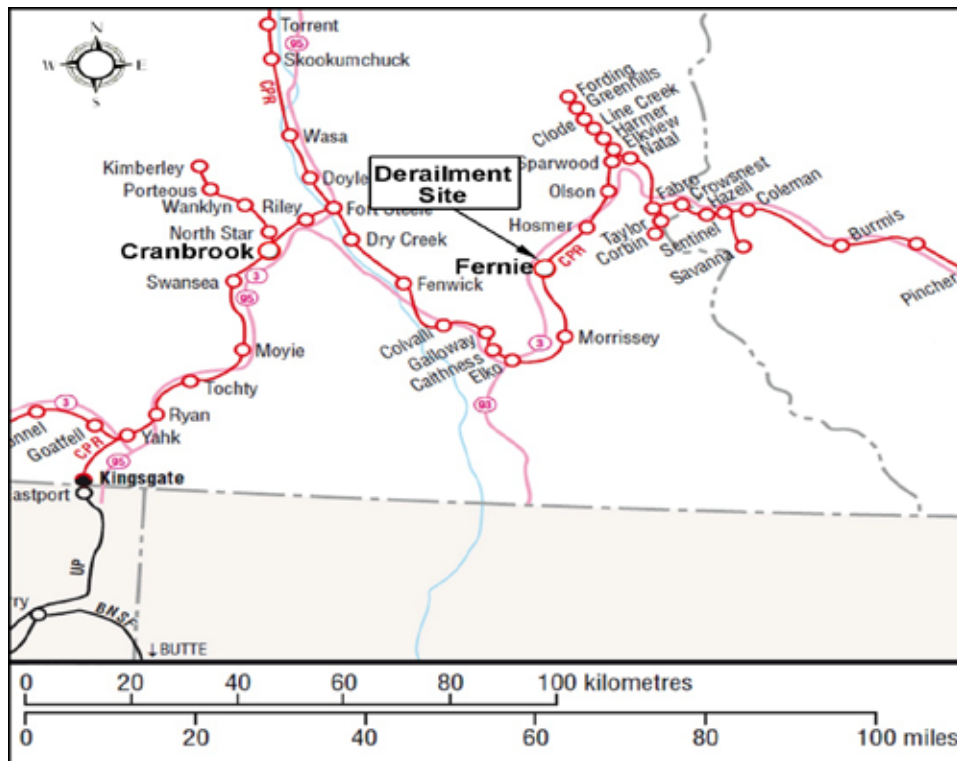
*Ce rapport est également disponible en français.*

## Other Factual Information

On 08 March 2011, Canadian Pacific Railway (CP) unit coal train 861-060 (the train), comprising 3 locomotives and 115 loaded coal cars, was operating westward in distributed power (DP) mode on the Cranbrook Subdivision. The train weighed 15,602 tons and measured 6513 feet in length. One locomotive was located on the head end of the train, 1 in the middle (70th position) and one at the tail end (118th position).

At about 0515, <sup>1</sup> while proceeding at 25 mph, the train experienced a train-initiated emergency brake application <sup>2</sup> at Mile 30.5, near Fernie, British Columbia (Figure 1). After inspection, the conductor determined that 27 cars had derailed, beginning with the 32nd car (CP 963806) and ending with the 58th car (LUSX 4797).

The train 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.



**Figure 1.** Derailment location

(Source: Railway Association of Canada, *Canadian Railway Atlas*)

<sup>1</sup> All times are Pacific Standard Time.

<sup>2</sup> Emergency brake applications can be of 2 types; train-initiated or operator-initiated. In either case, a rapid reduction in brake pipe pressure triggers the emergency brake application.

## *Subdivision and Track Information*

The Cranbrook Subdivision begins at Crowsnest (Mile 0.0) and proceeds westward, ending at Cranbrook (Mile 107.7). Movements are governed by the occupancy control system (OCS) as authorized by the *Canadian Rail Operating Rules* (CROR) and supervised by a rail traffic controller (RTC) located in Calgary, Alberta.

In 2010 <sup>3</sup>, there had been approximately 54 million gross tons (MGT) of rail traffic between Sparwood (Mile 17.7) and Fort Steele (Mile 95.6). Trains operating over this portion of the subdivision include about 1,900 loaded unit trains (coal, grain and potash), 1,900 empty unit trains and 1,200 manifest trains. <sup>4</sup> Some manifest and unit trains are interchanged with the Union Pacific Railroad at Kingsgate, British Columbia.

The track consisted of 136 pounds Nippon continuously welded rail (CWR) laid on 16-inch eccentric double shoulder tie plates and fastened to 9-foot hardwood ties with 5 spikes per tie plate. The track was box-anchored with Fair anchors every 2nd tie. The ballast was CP Grade 4.5 with full cribs and shoulders.

The derailment occurred in the body of the 5.5° right-hand curve near Mile 30.0. The track at this location is situated on a 1.2% downgrade to the curve where it changes to a 0.6% downgrade. The timetable speed is 40 mph from Mile 12.9 to Mile 29.7, and 30 mph from Mile 29.7 to Mile 37.7, making it Class 3 track according to the Transport Canada (TC)-approved railway *Track Safety Rules* (TSR). There were no temporary slow orders in effect in the vicinity of the derailment.

## *Site Examination*

A total of 27 cars derailed west of the point of derailment (POD) at approximately Mile 30.0. CP 963806 was the 32nd car in the train and the first of the derailed cars (Figure 2). At the time of the occurrence, the site was snow covered. Over the previous 4 weeks, this area had experienced a variety of weather conditions, including thawing conditions, rain, and heavy snowfalls followed by freezing temperatures.

At the POD, an examination of the high (south) rail revealed marks on the gauge side of the rail that were consistent with a rail roll-over, wheel-drop event. There were also accompanying impact marks on the adjacent rail anchors made by the derailed equipment.

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<sup>3</sup> The quoted train figures are counts for 2010, and correspond to about 14 trains per day or 5000 trains per year. These levels are somewhat low as economic recovery was taking hold through 2010. More typically, steady-state train counts in 2011 would be about 1,000 trains higher, or about 3 additional trains per day.

<sup>4</sup> Manifest trains are mixed merchandise trains which are comprised of different types of rolling stock loaded and/or empty.

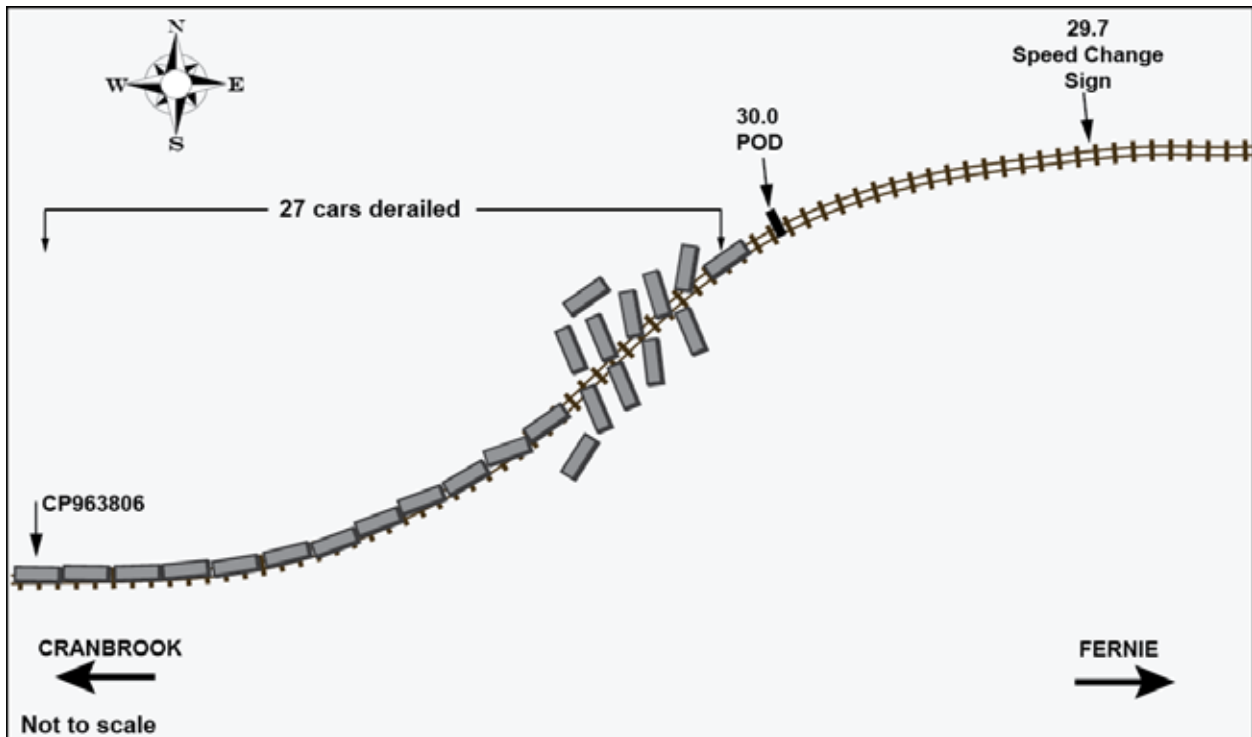


Figure 2. Derailment site diagram

## *Track Geometry Information*

Track geometry testing had been conducted on the Cranbrook Subdivision using the track evaluation car (TEC) <sup>5</sup> and the deployed gauge restraint measurement system (DGRMS) on 15 December 2010. Because snow conditions can affect the accuracy of the TEC optical measuring system, the DGRMS system is often used during winter months in conjunction with the TEC. TEC tests had been conducted on this subdivision on 16 September 2010 and 29 June 2010 as well.

The TEC defect report for the 15 December test showed “not valid” defects between Mile 29 and Mile 31. These “not valid” defects were probably caused by blowing snow that had affected the optical measuring system on the TEC. The DGRMS brush chart for the December 15 test showed extensive gauge widening of up to  $\frac{3}{4}$  inch in the derailment curve. At other locations in the vicinity of the derailment, wide gauge was greater than  $\frac{3}{4}$  inch. The peak wide gauge value was 1.28 inches (i.e., just over  $1\frac{1}{4}$  inches) which is less than the DGRMS urgent value of  $1\frac{5}{8}$  inches for all classes of track.

TEC defect thresholds relate to TSR prescribed limits, whereas the DGRMS standards relate to an extreme loading condition and are internal to CP. For the 15 December test, the track at the derailment site complied with all Transport Canada–approved track safety standards.

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<sup>5</sup> TEC car testing uses non-contact laser gauge systems to measure loaded and unloaded gauge.

For class 3 track, the threshold for an urgent wide gauge defect <sup>6</sup> is 1¼ inches; for a near-urgent wide gauge defect <sup>7</sup> it is 1⅛ inches; and for a priority wide gauge defect <sup>8</sup> it is ¾ inch. No lateral loads other than that applied by the loaded boxcar in the TEC consist are applied to the track during testing for gauge with the TEC.

On coal routes, for class 2 as well as class 3, 4 and 5 track, the TEC will automatically flag wide gauge of ¾ inch as a priority defect.

The TEC defect report for the 16 September test (i.e., about 3 months earlier) showed no priority or urgent wide gauge defects in the derailment curve. However, the TEC brush chart showed non-actionable wide gauge of up to ¾ inch throughout the curve with 4 priority wide gauge defects and 1 priority spiral cross level defect in the body of the curve or in the exit spiral.

The TEC defect report for the 29 June test (i.e., approximately 6 months before the occurrence) showed 3 priority wide gauge defects, 1 priority spiral cross level defect and 5 priority GRMS measured defects (2 gauge widening and 3 projected loaded gauge). The TEC brush chart also showed wide gauge of up to ¾ inch in the curve, with some locations greater than ¾ inch. The maximum wide GRMS gauge measurement recorded in the curve during this test was 1.58 inches (i.e., just over 1½ inches).

The TEC system has a channel that is reported as cant from the Laserail <sup>9</sup> measurement system on the car. These measurements are considered variable until they have been validated in the field and are not currently used by CP as a safety indicator. Rail cant cannot be measured under snow conditions, as Laserail requires optical scanning of the full rail height.

At the time of the occurrence, approximately 40% of the traffic on the Cranbrook Subdivision was loaded coal trains (westward direction). Wide gauge, along with tie plate movement, spike lifting and rail cant is an indication that the ties and fastenings were being subjected to large lateral loads. <sup>10</sup> High spikes were reported in the curve, and approximately 21% of the ties at this location were considered defective.

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<sup>6</sup> All urgent defects are defined as minimum TSR safety standards and must be corrected as soon as possible. Speed restrictions must be immediately placed to protect train movements against urgent defects and remain in place until the condition is corrected.

<sup>7</sup> Defects that are within ⅛ inch of becoming urgent and must be inspected and corrected as soon as possible.

<sup>8</sup> Priority defects must be inspected and corrected as soon as practicable, and if necessary, protected by slow orders. Priority defects are defined as a CP maintenance standard, not a TSR standard.

<sup>9</sup> Laserail is the trade name of the optical sensing system used on the TEC.

<sup>10</sup> On 5 March 2005, a CP westbound coal train derailed in a 6° right-hand curve at Mile 32.1 Cranbrook Subdivision (R05V0046). The cause was determined to be broken screw fasteners on the high rail in the body of the curve. Moreover, only 4 screw fasteners had been installed for each tie plate during the previous rail relay project when 5 were required.

## *Track Maintenance Information*

The rail in the curve had been re-gauged in 2008. In the previous 2 years, high spike conditions in the curve had been reset by plugging and re-spiking. Curves showing gauge widening on the TEC brush charts were monitored, and if the gauge conditions deteriorated between the tests, a gauging program was planned for the curve. After the June 29 TEC test, the wide gauge was again repaired in the curve.

## *Gauge Restraint Measurement System*

The gauge restraint measurement system (GRMS) uses a hydraulically loaded split axle to laterally push outward on each rail to expose gauge restraint weaknesses. CP first employed GRMS to evaluate track strength in 1999. The original GRMS system consisted of a split axle using a running axle in a freight car truck.

In 2008, CP converted its testing system to a deployable GRMS (i.e., DGRMS). The new technology addressed certain deficiencies in the original system and provided a higher level of performance, lower maintenance and higher productivity. The DGRMS was designed as a 5th axle that is deployed from the frame of a rail-bound vehicle, as opposed to using one of the vehicle's running axles. The system is mounted under a loaded boxcar which is part of the TEC consist. DGRMS applies vertical and lateral loads to the rail and measures lateral rail deflection. The system has the ability to test rails which are covered in snow.

The DGRMS system has 2 test modes: normal and winter. The normal mode is considered full operation in which all instruments, including non-contact laser gauge systems, are used to measure loaded and unloaded gauge. Winter mode is used when weather and/or snow conditions prevent proper visual inspections and the use of optical sensors. During winter mode, safety inspections are performed using the contact gauge measurement capability of the split axle. Precise gauge information is obtained directly by measuring the distance from one GRMS wheel to the other. The split axle monitors gauge conditions by applying 6350 kg of lateral load and 9000 kg of vertical load which results in an L/V ratio of 0.7.

## *CP Track Maintenance Standards*

*CP Track Standards* SPC 16 1.1 e(i) and (ii) state that

eccentric tie plates must be installed on curves 3° or greater where the curve elevation is ½ inch or more; or on curves or portions of curves where experience has shown that one or both rails cant outward enough to require frequent re-gauging and re-adzing.

SPC 16 1.1 f(i) and (ii) state that

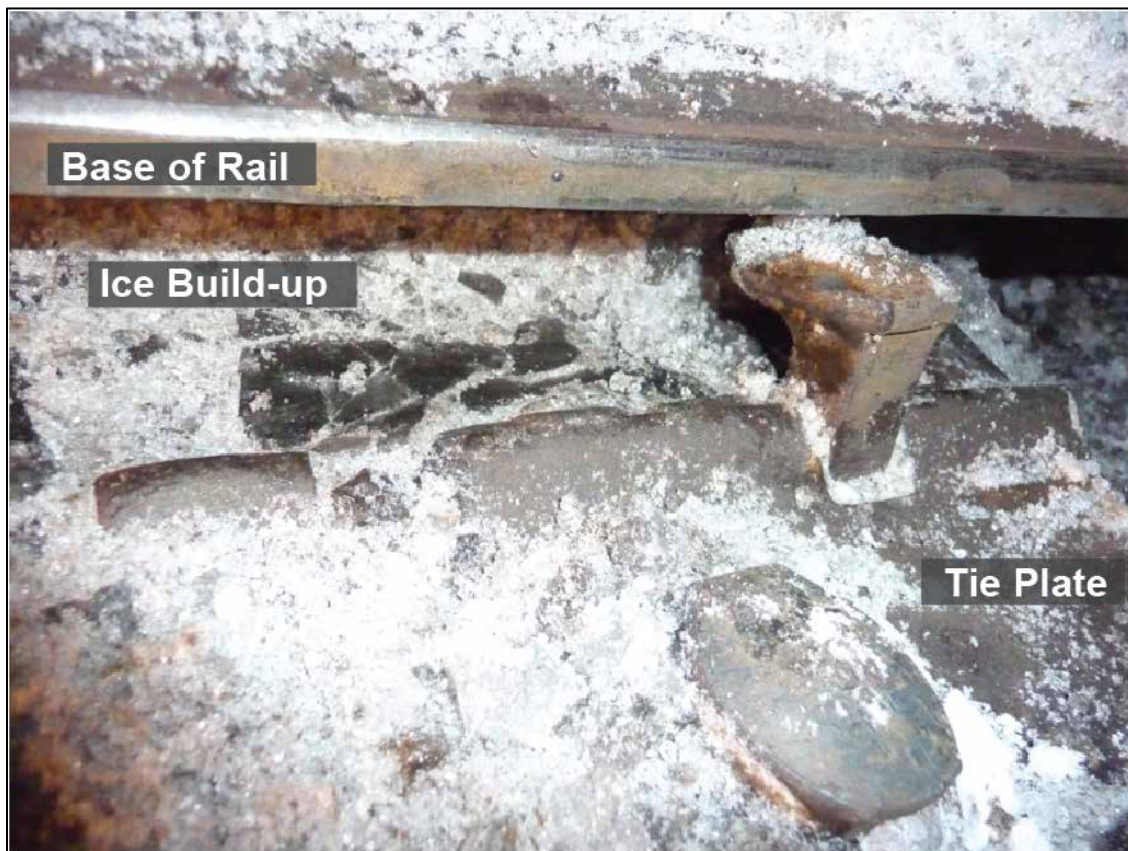
rolled tie plates complete with elastic fasteners and screw spikes in 136 lb territory must be installed on curves ≥ 8° or on curves where broken spikes are evident. Elastic fasteners and rolled plates are more resistant than conventional spiked track to wide gauge, spike lifting and breaking, tie degradation and excessive rail cant caused by lateral curving forces.

## *Accumulation of Ice at the Base of the Rail*

During site examination, ice was present on the high rail tie plates in the vicinity of the POD (Photo 1), including in the rail seat area. A combination of weather conditions and track conditions, including inadequate drainage, is normally required for this condition to develop.

Weather records from Environment Canada for Cranbrook indicate that between 11 February and 20 February the temperature was above 0° during the day and below freezing at night. There was also precipitation in the form of rain of approximately 23 millimetres between 11 February and 14 February, followed by snow accumulation of about 58 centimetres between 15 February and 17 February. After 17 February and for the rest of the month, the temperature was below freezing and was as low as -32°C.

During temperature variations involving freeze/thaw cycles, rain, snow and snow showers, along with melt water can produce ice build-up at the base of the rail. In these situations, the ice build-up can result in the canting of the rail. Rail cant can be difficult to notice during a visual inspection and even more so when the ground is covered in snow.



**Photo 1.** Ice build-up on tie plate



## *Recorded Information*

The locomotive event recorder (LER) download of the head-end unit (CP 9716) was reviewed. The following was determined:

- Between Mile 12.9 and 29.7, the train was operated using a combination of a minimum reduction train brake applications and dynamic braking (DB).<sup>11</sup>
- DB applications of up to DB 7.2 (maximum DB is 8) were used to keep the train speed at or near the 40 mph maximum.
- Just before the change of timetable speed to 30 mph at Mile 29.7, the train was operating at 37.5 mph with the train brakes released and the DB shut off.
- At Mile 29.02, the locomotive engineer made a minimum reduction train brake application and moments later reapplied the DB.
- At Mile 29.7, the train speed was 32.1 mph and the DB position was 5.4.
- While travelling down the 1.2% grade before entering the curve near Mile 30.1, a 10 psi brake pipe reduction was applied and the DB was slowly decreased.
- At Mile 30.52, while travelling at 25.1 mph, a train-initiated emergency application occurred.

## *Train Dynamics Analysis*

An analysis of the operation of the occurrence train as it approached the POD was conducted to understand the dynamic forces at work and the role they played in the derailment. The following was determined:

- No train handling exceptions were noted in the LER records before the derailment and emergency brake application.
- A combination of DB and air brakes was used to control the speed of the train on the descending grades prior to derailing.
- The simulated in-train forces and transformed truck side lateral/vertical forces (L/V) were at low levels during the period of time leading up to the derailment. The overall maximum draft force was approximately 62 kips and the maximum buff force was 47 kips.
- The derailment and emergency brake application probably occurred between 0511:38 and 0511:39 when the train brake was released and the DB was reduced.

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<sup>11</sup> The dynamic brake system uses the locomotive traction motors to provide resistance against the rotation of the locomotive axles. Energy is produced in the form of electricity and is dissipated as heat through resistors (i.e., the dynamic brake grids). Dynamic brake can be used alone or in conjunction with the train air brake system.

- It was not possible to definitively identify the first car to derail or the exact point of the emergency brake application due to the lack of synchronization, sampling time difference and communication delay between the LER records of the locomotives.
- The first cars to derail were located at the “node point”<sup>12</sup> of the distributed power train, somewhere between the 43rd and 47th cars.
- After the train-initiated emergency took place, the independent brake of the lead locomotive was not bailed off. This action was not consistent with normal operating practices; however, it did not contribute to the derailment.
- The slack/impact among the cars around the “node point”, though not very high, might have caused the wheel to drop off the rail due to the track structure having been weakened.
- The combination of upward deflection of the rail due to heavy vertical loads and the longitudinal creeping of the rail caused by the cumulative braking forces of heavy trains on the descending grade contributed to the ice and snow build-up between the rail base and the tie plates, weakening the track structure.

## *Equipment Information*

A review of the inspection and repair records for the locomotives and rail cars was conducted. The locomotives were working as intended with no exceptions. The rail cars had received a certified car inspection (CCI) on 06 March 2011 in Golden, British Columbia. No defects were noted during this inspection.

The following TSB Laboratory report was completed:

- LP038/2011 - Rail Dynamics Analysis

This report is available upon request from the Transportation Safety Board of Canada.

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<sup>12</sup> The node point is the point at which the in-train forces change from Buff to Draft.

## *Analysis*

The investigation determined that the mechanical condition of the train did not play a role in this accident. The analysis will focus on track geometry, train dynamics and weather.

## *The Accident*

Canadian Pacific unit coal train 861-060 was travelling westward near Mile 30.5 of the Cranbrook Subdivision when it experienced a train-initiated emergency brake application and derailed 27 loaded cars of coal. The derailment occurred when the high rail rolled over, allowing the wheel of a car to drop inside the south/high rail on a 5.5° curve due to excessive wide gauge. When the first car derailed and decelerated rapidly, the cars in front of them (west) were pulled off the track in a stringline fashion. The cars behind (east) ran in and piled up on the derailed cars ahead.

Wide gauge of up to ¾ inch had existed throughout the curve for at least 3 TEC tests conducted over a 6-month period before the derailment. However, no priority or urgent wide gauge defects had been present at this location. As such, no track maintenance with respect to re-gauging was required. For the speed of operations in effect at the time of the derailment, the track at the derailment site complied with all Transport Canada-approved track safety standards.

## *Wide Gauge and Rail Cant*

Wide gauge is detected, measured and monitored through both visual inspection and automated inspection using the track evaluation car (TEC) and the gauge restraint measurement system (GRMS). In this occurrence, extensive gauge widening of up to ¾ inch had existed throughout the curve. The wide gauge was repaired in the curve after the 29 June TEC test, but it was clear from the 15 December DGRMS test that non-actionable, dynamic wide gauge persisted in the curve.

Loss of cant contributes to gauge widening. In this occurrence, the initial gauge widening condition was exacerbated by gradual outward canting of the high rail over time with the passage of many trains. Canting of the high rail occurred when ice built up between the base of the rail and the tie plates to the point of wheel drop-in. This ice accumulation had been facilitated by the pumping action of trains which drew snow or melt water to the base of the rail. With significant temperature variations over the previous 4 weeks, there had been a number of freeze-thaw cycles at the derailment location.

Re-gauging is not normally performed unless there are actionable wide gauge defects (gauge greater than 1¼ inch). While this may be appropriate in warmer and dryer climates, it may not be in wetter, colder environments in areas that are subject to freeze/thaw cycles and frequent heavy unit train traffic. Non-actionable wide gauge defects can worsen in winter months due to ice build up between the base of rail and tie plate resulting in excessive cant that can remain

undetected before the next automated inspection interval, increasing the risk of rail roll-over and wide-gauge derailments.

## *Use of Elastic Fasteners and Rolled Tie Plates*

CP Track Standards state that “rolled tie plates complete with elastic fasteners<sup>13</sup> and screw spikes in 136-pound rail territory must be installed on curves  $\geq 8^\circ$  or on curves where broken spikes are evident.” Elastic fasteners and rolled plates are much more resistant than conventional spiked track is to wide gauge, spike lifting and breaking, tie degradation and excessive rail cant caused by lateral curving forces. With a curvature of  $5.5^\circ$ , the derailment curve did not qualify for rolled plates and elastic fasteners. This curve had a history of spike lift and re-gauging that indicated the existing spike fastening system did not provide adequate restraint for lateral curving forces. Although the curve geometry was closely monitored, spike lift during freeze/thaw cycles allowed water migration and ice build-up between the rail base and tie plate. Elastic fasteners would have increased resistance against rail roll (cant) by fixing the rail firmly in the tie plates. Current track standards for upgrading rail fastening systems (e.g., rolled tie plates, elastic fasteners and screw spikes) in higher-degree curves only may not adequately address the potential for rail roll-over and wide gauge derailments in lower-degree curves which have spike fastenings and where heavily loaded unit trains operate.

## *Train Dynamics Analysis*

The train dynamics analysis determined that the first car to derail was probably between the 43rd and 47th cars. It was also determined that the speed change at Mile 29.7 resulted in buff forces of up to 40 kips at the head end of the train. These forces on their own are not considered to be high. However, the cumulative effect of the in-train forces generated by heavy westbound unit trains slowing down from 40 mph to 30 mph at Mile 29.7 contributed to the progressive canting of the rail at this location.

After the train-initiated emergency brake application, the independent brake cylinder pressure was not bailed off in keeping with current railway operating practices. Although there were no adverse consequences, bailing off independent brake cylinder pressure subsequent to an emergency brake application is a standard procedure intended to minimize the build-up of in-train forces and the associated risks.

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<sup>13</sup> Elastic fasteners return to their original position or shape after the application of a load.

## *Findings as to Causes and Contributing Factors*

1. The derailment occurred when the wheel of a car dropped inside the south/high rail on a 5.5° curve due to rail roll-over that resulted in excessive wide gauge.
2. The initial wide gauge condition was in compliance with Track Safety Rules standards, but was exacerbated by gradual outward canting of the high rail when ice built up between the base of the rail and the tie plates.
3. Ice accumulation between the base of the rail and the tie plates was facilitated by the spike fastening system and freeze-thaw cycles over the previous 4 weeks which drew snow or melt water to the base of the rail through the pumping action of passing trains.
4. The cumulative effect of the in-train forces generated by heavy westbound unit trains slowing down from 40 mph to 30 mph at Mile 29.7 contributed to the progressive canting of the rail at this location.

## *Findings as to Risk*

1. Non-actionable wide gauge defects can worsen in winter months due to ice build-up between the base of rail and tie plate resulting in excessive cant that can remain undetected before the next automated inspection interval, increasing the risk of rail roll-over and wide gauge derailments.
2. Current track standards for upgrading rail fastening systems (e.g., rolled tie plates, elastic fasteners and screw spikes) in higher-degree curves only may not adequately address the potential for rail roll-over and wide gauge derailments in lower-degree curves which have spike fastenings and where heavily loaded unit trains operate.

## *Other Findings*

1. Although there were no adverse consequences from not bailing off the independent brake cylinder pressure subsequent to the emergency brake application, this is a standard procedure intended to minimize the build-up of in-train forces during an emergency stop.

## *Safety Action Taken*

Following this occurrence, CP Rail implemented the following safety action:

- In September 2011, rolled tie plates were installed in the derailment curve, in conjunction with the installation of new rail.

- The 30 mph speed sign was moved from its original location at Mile 29.7 to a location further east of the derailment curve. With this change, westbound trains will complete their braking before reaching this curve, resulting in reduced lateral loading in the curve.

Transport Canada has made the following change:

- The Rules Respecting Track Safety, which will come into force on 25 May 2012, establish a minimum frequency requirement for the electronic geometry inspection of all tracks, except yard tracks and inactive tracks. With respect to class 3 track carrying more than 35 million gross tons, the railway will be required to conduct testing with a heavy geometry inspection vehicle at least twice annually.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 18 April 2012. It was officially released on 09 May 2012.*

*Visit the Transportation Safety Board's Web site ([www.tsb.gc.ca](http://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.*