Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT
R08E0150

MAIN-TRACK DERAILMENT

CANADIAN NATIONAL
FREIGHT TRAIN A41651-16
MILE 106.20, EDSON SUBDIVISION
PEERS, ALBERTA
18 DECEMBER 2008

Canada

Railway Investigation Report

Main-Track Derailment

Canadian National
Freight Train A41651-16
Mile 106.20, Edson Subdivision
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Report Number R08E0150

Summary

On 18 December 2008 at 0652 mountain standard time, Canadian National freight train A41651-16, proceeding eastward on the Edson Subdivision near Peers, Alberta, derailed 48 cars at Mile 106.20. There were no injuries and no dangerous goods involved.

Ce rapport est également disponible en français.

Other Factual Information

The Accident

On 18 December 2008 at 0550, [1] eastward Canadian National (CN) freight train A41651-16 (the train), consisting of 3 locomotives, 48 loads, and 99 empties, departed Edson, Alberta, on the Edson Subdivision, [2] destined for Edmonton, Alberta. The train weighed 9444 tons and was 8244 feet long. It was marshalled with 37 hopper cars loaded with limestone rock immediately behind the locomotives, followed by 6 centre beam bulkhead flat cars, 3 box cars and 1 centre beam bulkhead flat car all loaded with lumber, 12 empty covered hoppers, 1 loaded gondola car, 29 empty tank cars, and 58 empty grain hopper cars.

The train crew, a locomotive engineer and a conductor, took control of the train in Edson. They met fitness and rest standards and were familiar with the Edson Subdivision. Neither crew member noted any irregularities with the train when operating between Edson and the accident location. Both sides of their train were inspected by the crew of westbound train M359, which they met at Peers, Alberta. No exceptions were reported.

Locomotive event recorder (LER) information indicates that:

- Between 0633:55 and 0651:48, the train was travelling between 44 mph and 58 mph with the throttle in position 8, [3] the brakes released, and brake pipe pressure at 88 pounds per square inch (psi).

- The throttle was reduced to position 7 for 22 seconds between 0651:49 and 0652:11 as the train approached the zone speed change at Mile 107 at a speed of 59 mph.

- Shortly after passing Mile 107, there was a loud bang and a bump just before the locomotive entered the curve at Mile 106.3. Review of the video from a camera mounted on the front of the locomotive revealed that the train struck a deer at this location around this time.

- Between 0652:12 and 0652:14, the throttle was reduced to positions 6, 5, and then 3. At 0652:15, with the throttle in position 2 and the train travelling at 58 mph with the brakes released, a train-initiated emergency brake application [4] occurred.

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1 All times are mountain standard time (Coordinated Universal Time minus seven hours).

2 The Edson Subdivision is part of CN's core transcontinental route. It extends from Edmonton to Jasper, Alberta, Mile 235.7. It consists primarily of single main track.

3 Locomotive throttle positions range from 0, where the throttle is closed, to position 8, where the throttle is fully open.

4 A reduction in brake pipe pressure at a rate sufficient to cause control valves to move to the emergency position, applying the brakes on all the cars.

- The lead locomotive came to rest 77 seconds later (at 0653:32), just east of the crossing at Mile 105.24. It had traveled approximately 0.73 miles after the emergency brake application occurred.

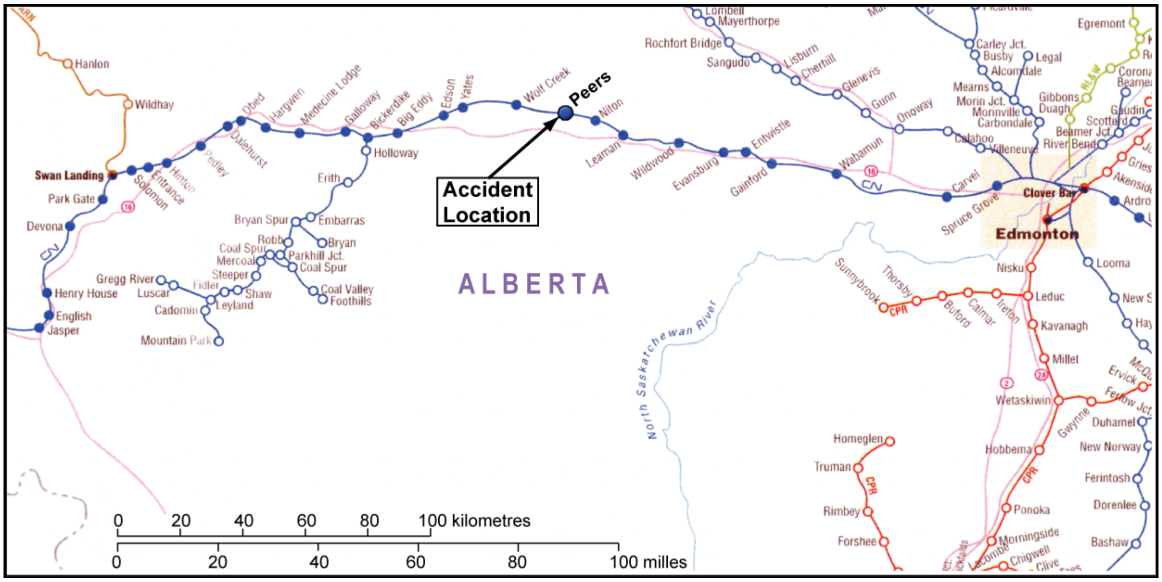

Figure 1. Accident location on the Edson Subdivision

After making the necessary emergency broadcast and notifying the rail traffic controller (RTC), the conductor initiated an inspection and discovered that 48 cars, the 22nd through 69th, had derailed (see Photo 1). The derailed cars included 16 loaded hopper cars, 7 loaded centre beam bulkhead flat cars, 3 loaded box cars, 12 empty covered hopper cars, a loaded gondola, and 9 empty tank cars. The first 6 derailed cars had left the track on the high side of the curve. The following 42 cars were derailed on both sides of the track. Approximately 1715 feet of main track was damaged.

Photo 1. View of derailment, looking east

Weather

At the time of the accident, the temperature was approximately -27°C and the wind was from the northwest at 6 km/h. Environment Canada records for Edson, approximately 20 miles west of the derailment location, indicate that temperatures had been cold since December 12 (six days earlier). The lowest temperature recorded during this period was -37.1°C on December 14. A slight warming occurred on December 16 and 17.

Track Information

Train movements on the Edson Subdivision are governed by the Centralized Traffic Control System (CTC), authorized by the *Canadian Rail Operating Rules* (CROR) and supervised by an RTC located in Edmonton. The maximum authorized speed through the accident location is 60 mph for all trains. The track is classified as Class 4 according to the *Railway Track Safety Rules* (TSR). The track throughout the occurrence area consisted of single main track constructed on a moderate fill section.

Leading to the accident location from Mile 108.4, the track is located on a descending grade that varies between 0.55 and 0.36 per cent. There is a 1°45′ right-hand curve (in the direction of travel) at Mile 107.7. The derailment occurred at Mile 106.2 in a 2°40′ left-hand curve (in the direction of travel) on a 0.36 per cent descending grade. Based on the 16 October 2008 TEST [5] report, the curve was 2292 feet long with average superelevation of 4.87 inches. According to CN's Engineering Track Standards (ETS), minimum superelevation for 60 mph on a 2°40′ curve is calculated as the balanced superelevation of 6.7 inches, less 2 inches. The maximum permissible superelevation is 5 inches. The TSR is less restrictive, allowing 3 inches of superelevation imbalance and a maximum of 6 inches of superelevation.

Rail in the curve was 136-pound Nippon Steel head-hardened continuous welded rail manufactured in 2002. The rail was installed on concrete ties with elastic fasteners on a full, clean rock ballast section. There were no signs of track damage leading up to the point of derailment (POD). The POD was located in a 400-foot-long section of wood ties that had been left over from track panel installation from a previous derailment in December 2001. The first rail break was observed about 80 feet from the west end of the concrete ties eastward on the wood tie section. The rail in this section was on 16-inch tie plates fastened to the ties with spikes and box anchored every tie.

Track Inspection and Maintenance

The track through the derailment area was inspected prior to the derailment by hi-rail on 14, 16 and 17 December 2008, with no exceptions noted. On 27 November 2008, a transverse defect in 136-pound 1981 Algoma carbon rail was removed at Mile 106.1 from the high rail of the curve. On 22 January 2008, a defective field weld in 136-pound 1993 Nippon Steel was also removed near the POD. This plug was in tangent track in the north rail, just east of the POD. Both plugs were located on concrete ties. Although the plugs were part of the derailment track damage, they were intact following the derailment.

The Edson Subdivision rail was ultrasonically tested by Sperry on 09 December 2008, nine days before the derailment. A defective field weld was detected and changed out in the south rail at Mile 104.7. A review by Sperry of this test revealed normal and expected responses from known track features through the derailment area. An uninterrupted search for internal flaws was performed through the area of concern with no recorded responses due to defects.

Track geometry TEST data from the vicinity of the derailment that were recorded on 27 September 2008 and 16 October 2008 were reviewed. Urgent defects are defined as deviations exceeding TSR minimum safety requirements for track geometry. Near-urgent defects are defined as deviations approaching TSR minimum safety requirements for track geometry, and priority defects are defined as deviations exceeding CN allowable maintenance tolerances.

- No urgent defects were recorded in the curve on the 27 September 2008 geometry test. Twelve feet of near-urgent wide gauge recorded in the curve on the 16 October 2008 test was corrected on 25 October 2008.

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5 TEST refers to CN's track evaluation system that measures track geometry parameters with an instrumented rail car.

- The 27 September 2008 test recorded six feet of track with gauge wider than ¾ inch, which is the minimum criterion for a priority gauge defect on Class 4 track. A total of 964 feet of track had gauge wider than ½ inch within the 2284 feet of track tested through the curve.

- Examination of the brush chart (that is, graphical representation of the TEST car measurements) for the 27 September 2008 test indicates wide gauge, a superelevation "bump" of 0.41 inches over 17 feet at Mile 106.4, and cant [6] leading up to this point. On the 16 October 2008 test, superelevation through the curve averaged 4.87 inches. CN ETS require minimum superelevation of 4.7 inches on a 2°40′ curve for 60 mph freight speed. The minimum superelevation according to the TSR is 3.7 inches (less restrictive).

- The brush chart for the 16 October 2008 test indicated the same superelevation "bump" and cant. The test measured 216 feet of track gauge greater than ¾ inch wide (priority defect), and 943 feet of track gauge greater than ½ inch wide in the curve.

- Cant of approximately 2 degrees outward toward the vertical was recorded on both tests. Standard cant is 1 in 40 (1:40) or approximately 1.43 degrees. Two degrees of cant means that the rail may actually be tilting slightly outward toward the field side, slightly increasing the gauge.

Equipment Inspection

The derailed cars were inspected on site and no obvious defects were discovered. The non-derailed locomotives and cars were inspected and no impact marks were observed on any wheels. Mechanical maintenance and repair records from CN and Procor (the car owner) for the 21 leading cars indicate that routine maintenance and inspections were performed during the previous five years.

To supplement the visual inspection of freight cars, CN has equipped its network with electronic wayside inspection systems (WIS) to assess the condition of rolling stock while en route. These systems are spaced approximately 12 miles apart along the track and normally include a hot box detector that measures bearing temperature, a hot wheel detector that measures wheel temperature, and a dragging equipment detector. The results of WIS inspections are gathered at a centralized location and warnings are issued to train crews when a threshold limit is reached or exceeded. In this occurrence, train A41651-16 (the occurrence train) did not trigger any alarms at the WIS site located at Mile 116.3. In addition, no alarms were triggered by westbound train M359 (which met train A41651-16 at Peers) at the WIS site located at Mile 104.8.

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[6] Rails are not seated level in tie plates, but at a 1:40 cant that slopes inward toward the centre of the track. Rail cant promotes wheel set self-centering and steering.

A wheel impact load detector system (WILD) consists of sensors that measure the impact of each passing wheel on the track. Out-of-round wheels, flat spots, and other imperfections can produce high-impact loading that can lead to broken wheels or rails. Information from WILD systems is gathered at a centralized location for coordinated monitoring, assessments, and immediate alerts to train crews, if necessary. When the WILD threshold limit (that is, 140 kips [7]) is reached or exceeded, action required can include an immediate train stop and set-out, or a speed restriction. Data from the WILD site at Mile 23.8 on the Edson Subdivision was reviewed for occurrence train A41651-16 and for westbound train M359. The wheel impact measurements recorded for these two trains did not exceed CN's threshold values.

Analysis of Broken Rails and Car Components

Following visual examination of the broken rails and car components at the accident site, five pieces of broken rail and portions of broken wheels were sent to the TSB Laboratory for further testing. Detailed examination results and conclusions are contained in reports LP 008/2009 – Examination of Rail Pieces and LP 022/2009 – Examination of Wheel Pieces. In summary:

- The rail fracture surfaces all had a coarse grainy appearance with chevron markings and tear ridges. There were no indications of fatigue, long-term rubbing, heavy corrosion, or pre-existing cracks. This appearance was consistent with fresh overstress fracture.

- The rail heads were in generally good condition and did not exhibit any shells, flaking, cracking, or other damage.

- Selected specimens of rail material met the requirements of CN Specification 12-16C, except for head hardness, which was slightly below the specified value. However, this minor variance was not considered significant for this occurrence.

- Examination of the wheel segments revealed that they were in good condition, and did not exhibit any cracks, shells, or flat spots. Minor heat checking was observed, but was consistent with normal service. There was no indication of excessive wear or pre-existing damage that would have led to the occurrence.

- The hardness and chemical composition of the wheel material were consistent with specifications. All the fracture surfaces had an appearance consistent with fresh overstress fracture. There were no indications of fatigue. The wheel fractures were likely the result of damage that occurred during the derailment.

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[7] 1 kip = 1000 pounds

Cold Weather Inspections and Operations

Sections 35 to 39 of CN's Engineering Track Standard 7.0 (Track Inspection Guidelines) contains inspection and speed restriction requirements for extreme cold weather operations.

Specific requirements include:

- Daily cold weather track inspections will be undertaken on rail with a history of defects when the temperature is less than -25°C and on all tracks when the temperature is less than -35°C.
- On track having rail with a history of frequent defects, [8] all freight trains shall be restricted to a speed of 35 mph or track speed, whichever is more restrictive.

Over the past five years, CN has continued to increase the number of rail flaw detector tests during cold weather months, reducing the number of main-track broken rail derailments.

Based on the number and type of defects recorded in the area of the derailment, CN does not consider the track susceptible to cold weather–related rail failure. Daily inspections were conducted on the two days prior to the derailment.

For trains containing mixed cargo, loads and empties, such as train A41651-16, CN guidelines restrict this type of train to 8000 feet in length when the temperature reaches -25°C, and to 7000 feet in length when the temperature reaches -30°C, due to the difficulty in maintaining adequate train brake air line pressure at cold temperatures.

Effect of Cold Temperature on Rail Steel

During cold temperature operations, the ability of the track and infrastructure to endure in-service forces, to withstand damage, and avoid breakage is reduced. Rail strength typically decreases in winter, primarily due to rail contraction, thereby increasing the internal tensile stresses that facilitate crack initiation, leading to the increased growth rate of transverse defects.

Rail strength is generally much higher than the in-service stress, and failures are rare—especially in new, clean, high-strength rail steels. However, as the rail strength declines due to cold temperature, the ability of the rail to withstand high transient loads, particularly higher-than-normal impact loads due to shelled wheels, is reduced.

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[8] "History of frequent defects" is a qualitative assessment to be made by the Track Supervisor based on number and type of defects in a given location.

Transition Ties Between Wood Tie and Concrete Tie Sections

Due to the difference in track modulus (that is, track stiffness) for wood tie and concrete tie sections, CN's Standard Practice Circular (SPC) 3303 had required the installation of a set of hardwood transition ties where concrete ties adjoin wood ties. The transition zone normally consisted of four 9-foot ties, four 10-foot ties, and four 11-foot ties, spaced approximately 20 inches apart with the longest ties installed next to the concrete ties. CN's experience showed that the transition ties were of limited benefit as track is tamped only under the rail no matter how long a tie is. Accordingly, SPC 3303, along with other SPCs, were replaced with CN's ETS, which do not require the installation of transition ties. In this occurrence, no transition ties were installed between the wood and concrete tie sections of track.

Analysis

The distribution of the derailed cars indicates that a sudden catastrophic failure, either of the track structure or of an equipment component, likely occurred. However, no single element points directly to the cause of this derailment. The analysis will evaluate a number of factors that may have contributed to this accident, including rail integrity, track structure, geometry, equipment condition, and weather conditions.

The Accident

There were no marks on the track structure leading up to the POD. The derailed train received a visual inspection by the crew of train M359 shortly before it derailed. No exceptions of the train or track were noted. The wheels on the 21 leading cars and locomotives that did not derail were examined and no anomalies were observed. Maintenance records for the first few derailed cars revealed that normal maintenance and inspections were performed on these cars prior to the derailment.

Some of the broken rail and wheel pieces were examined. No anomalies, such as pre-existing conditions that may have led to failure, were noted. Track and equipment inspections, and train operations were conducted in accordance with CN standards.

Prior to the train-initiated emergency brake application, the train was travelling at between 59 and 58 mph, with the brakes released on a downgrade from Mile 108.4. The train-initiated emergency brake application occurred only three seconds after the throttle was reduced from position 7 to position 2 with the train travelling at 58 mph and the brakes released. Because there was no change in grade that would have caused the locomotives to decelerate rapidly, the train would not likely have experienced a slack run-in, and there was no indication that such an event took place. No train-handling exceptions were noted and track/train dynamics were not considered to be a factor in this derailment.

A summary of the events leading to the accident (see Table 1) was developed based on the recorded information [9] from the locomotive camera and the LER.

Table 1. Times, events and locations

LER Time	Event	Field Mileage
0651:12	Head end passes Mile Point (MP) 107	106.97
0651:37	Head end strikes deer	106.57
	Head end enters curve	106.48
	Location of Car 22 at time of derailment	**106.17**
0652:03	Head end passes location of rail plug on high rail	106.15
0652:09	Head end passes location of rail plug on north rail	106.05
	Head end exits curve	106.04
0652:11	Head end passes MP 106	106.00
0652:15	Train-initiated emergency brake application occurs	105.95
0653:32	Head end comes to a stop	105.22

The locomotive was at Mile 105.95 when the train-initiated emergency brake application occurred. This places car 22 (that is, the first derailed car) approximately 1142 feet back in the curve at Mile 106.17, just west of the high rail plug. Assuming that the derailment sequence started just prior to the emergency brake application, the POD likely occurred at approximately Mile 106.20, in the wood tie section of track.

The rapid throttle reduction from position 7 to position 2 in three seconds, only one second before the emergency brake application, was made to control train speed on the downgrade, not in response to striking the deer or a perceived rail break. The bang was likely the locomotive striking the deer shortly before the derailment and not a rail breaking under the locomotive. At this point, the locomotive was out of the curve because, travelling at 58 mph, it would take approximately 13 seconds for the locomotive consist and the 21 cars that did not derail to continue eastward past the point where the first cars started to derail to the high side of the curve.

9 LER and camera times and mileages were synchronized. Because LER and camera mileages do not correspond to exact field locations, a conversion factor was required. According to the LER, the locomotive travelled another 77 seconds after the emergency brake application before stopping 100 feet east of a crossing at LER mileage 104.62. Given that the actual mileage location of the crossing was 105.24, the locomotive actually stopped at Mile 105.22. The difference of 0.60 miles was used to convert LER mileages to approximate field mileages.

With respect to a possible broken wheel leading to the derailment, wheel marks would have been left on the track leading up to the POD, but none were found. In addition, a broken wheel is not likely to result in a sudden derailment and pile-up of cars, as was the case in this occurrence. Based on the evidence, it is concluded that the high rail likely broke under the 21st car or one near it. Because both rail plugs were observed to be intact following the derailment, it is likely that neither rail plug was causal or contributed to the derailment.

Effect of Cold Temperature Conditions on Rail

The derailment occurred in very cold weather when rail breaks are more common. Signal systems help to reduce derailments due to rail breaks, but when rails break under trains, there is no warning. Newer rail steels have become cleaner, harder, more wear-resistant, and stronger. However, cold temperatures still reduce fracture toughness and the ability of the rail to withstand high transient loads, particularly impact loads, thereby increasing the risk of rail break and derailment. The cold weather conditions at the time of the derailment reduced the ability of the rail to withstand in-service forces.

Track Geometry Conditions in the Vicinity of the Derailment

Gauge widening was recorded through much of the curve on both geometry tests conducted prior to the derailment. The near-urgent gauge defects were corrected in the curve; however the priority gauge condition grew between the two tests. Wood tie track normally exhibits more gauge widening than concrete tie track over time because spiked rails provide less resistance to lateral loads in curves than elastic fasteners on concrete ties. In addition, loss of cant, which contributes to gauge widening, was recorded. This condition was most apparent in the eastern third of the curve, likely on the wood tie section. For wood ties, gauge widening and loss of cant is mainly due to plate cutting. For concrete tie track, these conditions are mainly due to rail seat abrasion and/or worn insulators.

Both gauge widening and loss of cant are the normal reaction to high-speed, heavy wheel loading on a properly elevated curve. The wood tie section was an area less resistant to lateral curve forces than concrete tie track and, if conditions were allowed to deteriorate, more susceptible to rail rollover. The gauge widening, loss of cant, and the superelevation “bump” conditions in the vicinity of the derailment met the requirements for the TSR. These track geometry conditions were not considered causal to this accident.

Use of Transition Ties between Wood Tie and Concrete Tie Sections

The first rail breaks were observed to be approximately 1000 feet east of the west end of the curve on the wood tie section at approximately Mile 106.20. The wood tie section in the curve had been left in the track following the installation of a derailment panel in 2001. As in this case, jointed panel rails are normally re-laid soon after a derailment, but the wood ties are usually left in the track. No transition ties were installed between the wood and concrete tie sections. Although CN’s SPC 3303 required the installation of transition ties in the past, experience had shown that they were of limited benefit with respect to track geometry because track is tamped only under the rail no matter how long a tie is. SPC 3303 was replaced by the ETS and transition ties between concrete and wood tie sections are no longer required. The short wood tie section within the concrete ties in the curve and the absence of transition ties were not considered causal to the derailment.

The following TSB Engineering Laboratory reports were completed:

LP 008/2009 – Examination of Rail Pieces
LP 022/2009 – Examination of Wheel Pieces

These reports are available from the Transportation Safety Board of Canada upon request.

Findings as to Causes and Contributing Factors

1. A sudden catastrophic failure in the track structure occurred, leading to the derailment.

2. As the train was travelling through the curve, the high rail likely broke under the 21st car or one of the adjacent cars.

3. The cold temperature at the time of the derailment had reduced the fracture toughness of the rail and the rail's ability to withstand in-service forces, including high transient impact loads.

Other Findings

1. The gauge widening, loss of cant, and the superelevation "bump" conditions in the vicinity of the derailment met the requirements for the *Railway Track Safety Rule*s. These track geometry conditions were not considered causal to this accident.

2. The short wood tie section within the concrete ties in the curve and the absence of transition ties were not considered causal to the derailment.

Safety Action Taken

Transport Canada is conducting research into the effects of winter on railway operations.

Canadian National (CN) is continuing to place emphasis on rail flaw detector testing during cold weather months. This testing will include a significant increase in the number of rail flaw detector tests over its main line track. Where history and rail defect data indicate a higher risk of cold weather problems, increased track inspections and speed restrictions will be implemented.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 24 March 2010.

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