RAILWAY INVESTIGATION REPORT
R99M0046

DERAILMENT

CANADIAN NATIONAL
TRAIN NO. Q106-21-08
MILE 9.7, BEDFORD SUBDIVISION
BEDFORD, NOVA SCOTIA
09 OCTOBER 1999

Railway Investigation Report

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Mile 9.7, Bedford Subdivision
Bedford, Nova Scotia
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Summary

At 0403 Atlantic daylight time on 09 October 1999, eastward Canadian National freight train No. Q106-21-08, proceeding towards Halifax, Nova Scotia, through Bedford, Nova Scotia, at about 30 mph on the north main track of the Bedford Subdivision, derailed the leading truck of the second locomotive and the first eight cars at about Mile 9.7. There were no injuries and no dangerous goods were involved.

Other Factual Information

Canadian National (CN) train No. Q106-21-08 comprised 3 locomotives, 64 loads and 3 empties and was 4 580 feet long and weighed about 4 470 tons. The crew consisted of a locomotive engineer and a conductor.

Movements over this section of the subdivision were governed by the Occupancy Control System and Automatic Block Signal System (ABS). The ABS signals, which will indicate a break in the track circuit, govern eastward movements on the south main track between Mile 15.6 and Mile 0.50 and westward movements on the north main track from Halifax to Mile 15.4, and therefore did not provide protection.

The temperature was six degrees Celsius under scattered clouds with good visibility. A slight reflection from the headlight on one of the rails was seen just before the crew experienced a loud noise under the locomotive and felt it drop slightly.

Event recorder data revealed that the train approached the derailment area at about 0401:00 Atlantic daylight time (ADT)[1] at a speed of 48 mph. At 0401:10, a service brake application was initiated reducing train speed to 30 mph by 0402:45. At 0402:52, the train experienced a train-initiated emergency brake application while travelling at 30 mph with the automatic brake released and the throttle in idle.

The lead locomotive, the trailing truck of the second locomotive and the third locomotive remained on the track. The leading truck of the second locomotive was completely derailed. The derailed cars were either upright or on their sides over a distance of approximately 200 m (655 feet). Corn from two damaged hopper cars was spread over the derailment site. There was no indication of any pre-existing rolling stock malfunctions or defects. The rails were fractured in several places and bent under and about the derailed cars. Over 800 feet of track was damaged.

The authorized maximum speed changes at the location where the accident occurred. East of the site (Mile 1.4 to Mile 9.7), the maximum authorized speed is 30 mph for freight trains and 45 mph for passenger trains. West of the site (Mile 9.7 to Mile 26.7), the maximum authorized speed is 40 mph for freight trains and 55 mph for passenger trains.

In the derailment area, the subdivision was double main track. Both tracks were composed of 100-pound continuous welded rail secured by double-shouldered tie plates and box-anchored every second tie. At Mile 9.7, there was a 4.5-degree curve with a descending grade of about 0.1 per cent towards Halifax. The ties, fastenings and ballast were in good condition.

The rail on the north track, manufactured in July 1980, had been relaid in 1998 after having been previously used on the CN Kingston Subdivision in Ontario. Wear on the rail was 6 mm (1/4 inch) vertical and 3 mm (1/8 inch) lateral for the gauge side with no wear on the field side. This wear is within the allowable limits of 10 mm (3/8 inch) for vertical wear and 14 mm (9/16 inch) for combined vertical and lateral wear of 100-pound rail as specified in CN's Engineering Maintenance-of-Way Manual of Standard Practice Circular (SPC) 3200.

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[1] All times are ADT (Coordinated Universal Time (UTC) minus three hours) unless otherwise stated.

Eight pieces of broken rail were observed. One piece of fractured rail originating from the high side of the curve had severe battering about the head at the west-facing fracture surface and two small areas of fracture surface “smearing.” Gauge-side rail head shelly damage and some oxidation (rust) were also present. At the fracture surface, the base was not marked by rail anchors or a tie plate, indicating that the fracture area had rested between ties. This piece of rail was sent to the TSB Engineering Branch for examination.

The seven other pieces of broken rail had fracture surfaces with neither significant head battering nor fracture surface smearing. These pieces of rail were therefore considered to have fractures consistent with the forces, impacts and dislocations from the derailing equipment.

The TSB Engineering Branch (report No. LP 126/99) concluded that:

1. The top surface of the rail, on the gauge side, exhibited obvious shelling damage.

2. The rail section had been significantly battered and smeared, obscuring most of the fracture details on the gauge side of the head and in the web area.

3. Two areas of the rail fracture revealed features which could be identified as overstress in nature. These were on the field side of the head and the base of the rail. The mode of failure on the gauge side of the head and the web could not be identified due to damage. Two longitudinal progressive fatigue cracks initiated from the web transverse fracture.

4. The presence of two progressive fatigue cracks in the web, their shape and orientation suggest that the crack had first initiated near the rail top surface and progressed to the mid-web area. This crack most probably lay dormant until a subsequent overstress crack, from the bottom of the rail, led to complete rupture. The initial crack in the head may have been the result of shelling damage and therefore would have been sub-surface and not visible externally. However, shelling damage is detectable on the surface of the rail and is a well-known precursor for the initiation of sub-surface cracks.

5. The rail microstructure and hardness were consistent with typical rail material. There were no material deficiencies noted which could have contributed to the failure.

The TSB Engineering Branch also noted that the two web fatigue cracks had occurred recently, but were more than a few days old at the time of the accident.

CN’s SPC 3202 defines “shelly rail” as:

> A progressive horizontal separation which may crack out at any level on the gauge side, generally at the upper gauge corner. It extends longitudinally not as a true horizontal or vertical crack, but at an angle related to the amount of rail wear.

SPC 3202 describes the appearance of shelly rail as: “dark spots irregularly spaced on the gauge side of the running surface . . . longitudinal separations at one or more levels in the upper gauge corner, with discoloration from bleeding . . . it occurs most frequently on curves.” SPC 3202 does not designate shelly rail as a defect requiring a remedial action.

Contact stresses from the passage of trains lead to the development of shelly damage. Such damage is common in curves on high traffic subdivisions and does not normally elicit concern on the part of maintenance-of-way personnel. Shelly damage is known to develop in transverse components that lead to rail fracture in some instances.

The *Railway Track Safety Rules* approved by the Minister of Transport on 27 March 1992 do not specifically refer to shelly rails in the list of defects for defective rails.

The *Railway Track Safety Rules* require that Class 3 track, such as the track on the Bedford Subdivision, be ultrasonically inspected once per year and, if the track is inspected at least annually by a track geometry car, inspected visually twice per week.

The track was inspected visually twice per week and by a track geometry car four times per year.

The last visual track inspection of the north track in the Bedford area was conducted by a track inspector in a Hi-rail vehicle on 08 October 1999. No reportable defects were noted at Mile 9.7.
The last track geometry car inspection was carried out on 12 July 1999, and several wide gauge defects were found in the area. These problems were repaired on 12 July and 13 July 1999. Surface roughness, cross-level and alignment were found to be within prescribed limits. The frequency of these inspections met or exceeded the requirements of the *Railway Track Safety Rules*.

The last ultrasonic test was conducted on 23 June 1999 and no defects in the area were noted. CN schedules ultrasonic testing based on considerations such as the amount of traffic, the weight and wear of the rail, curvature and grade, and general track condition. The Bedford Subdivision was scheduled for ultrasonic testing four times per year and had been tested on 06 January 1999 and 24 March 1999 with the next test planned for 14 December 1999. This type of testing does not identify small sub-surface cracks emanating from the shelly damage.

The TSB database shows that there has not been a derailment associated with rail or track defects on the Bedford Subdivision in the last decade.

Analysis

There is no information to indicate that train handling, rolling stock integrity, rail metallurgy, or track geometry contributed to this accident. The slight overspeed (up to 8 mph) that occurred westward from the derailment area had no bearing on events.

The rusted and battered piece of the recovered north rail is indicative of a rail failure that derailed the train.

The reflection from the rail and the TSB Engineering Branch examination revealing that the examined piece of rail displayed fracture surfaces “more than a few days old” indicate that:

- the lead locomotive struck a partially fractured rail in a manner that led to rail shatter and displacement, or

- the lead locomotive hit an area of rail missing a section of the head causing further damage and rail displacement.

While the mode of failure could not be precisely identified, the TSB Engineering Branch suggested that the origin of the initial fracture and the initiation of the downward progression was in the area of microcracks emanating from shelly damage on the rail head. Cracks progressing downward from shelly damage are not visually detectable and the weekly track inspection regimen cannot identify this developing hazard.

The initial track fracture progressed from being an undetectable size at the time of the last rail flaw detection test on 23 June 1999 to complete failure on or before 09 October 1999, 67 days before the next scheduled ultrasonic testing. CN relies on this testing to identify and remove fractures before they develop to a size that compromises safe train operation. While the defect occurred between scheduled ultrasonic inspections, the absence of track-related accidents on this subdivision over the last 10 years indicates that track inspection and maintenance standards are generally effective.

The shelly damage existed for an unspecified period of time but did not cause concern on the part of the track inspection personnel although such damage is known to result in sub-surface microcracks and rapid crack growth leading to partial or complete rail failure. The *Railway Track Safety Rules* do not require any remedial action for “shelly rail” although they do make reference to fractures which may arise from shelly defects. CN’s SPC 3202 makes reference to “shelly rail.” However, SPC 3207 does not specifically designate shelly rail as a defect requiring a remedial action in its Defect Identification and Remedial Actions table.

Findings as to Causes and Contributing Factors

1. A damaged rail derailed the second locomotive, leading to track destruction and the derailment of the first eight cars.

2. The rail was damaged but not completely severed before the arrival of the train.

3. The rail fractured as a result of the downward progression of microcracks emanating from shelly damage.

Findings as to Risk

1. Visual track inspection cannot identify developing fractures from shelly damage.

Other Findings

1. The overall track maintenance and inspection programs were effective, although the frequent ultrasonic testing did not pick up this defect.

2. The investigation provides one indication that shelly damage can result in sub-surface microcracks and rapid crack growth leading to partial or complete rail failure. Neither the *Railway Track Safety Rules* nor CN's Standard Practice Circulars fully address this issue.

Safety Action Taken

The recommended remedial action for shelly damage is rail grinding. Grinding effectively removes surface and gauge corner irregularities by re-profiling the rail head. An active rail grinding program has now been initiated on the Bedford Subdivision, and identified sections of rail will be ground twice per year.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 25 July 2001.