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

# RAILWAY INVESTIGATION REPORT
# R04S0001

## MAIN-TRACK DERAILMENT

GODERICH-EXETER RAILWAY
VIA RAIL CANADA INC. TRAIN NO. 86
MILE 77.05, GUELPH SUBDIVISION
NEW HAMBURG, ONTARIO
08 JANUARY 2004

Canada

# Railway Investigation Report

# Main-Track Derailment

# Goderich-Exeter Railway
# VIA Rail Canada Inc. Train No. 86
# Mile 77.05, Guelph Subdivision
# New Hamburg, Ontario
# 08 January 2004

# Report Number R04S0001

## *Summary*

On 08 January 2004 at approximately 0635 eastern standard time, VIA Rail Canada Inc. passenger train No. 86 travelling eastward on the Guelph Subdivision derailed three cars at Mile 77.05, near New Hamburg, Ontario. The locomotive fuel tank was punctured, resulting in the loss of approximately 100 litres of diesel fuel. Approximately 1150 feet of track was damaged. One passenger was slightly injured.

*Ce rapport est également disponible en français.*

# Other Factual Information

On 08 January 2004 at 0614 eastern standard time,[1] VIA Rail Canada Inc. (VIA) passenger train No. 86 left Stratford, Ontario,[2] proceeding eastward on the Guelph Subdivision, destined for Toronto. At approximately 0626, while travelling at 60 mph, the train crew felt a slight bump followed by a surge in the train. The locomotive engineer made a full service train brake application and the train was brought to a controlled stop in approximately 1150 feet. The crew followed emergency procedures to ensure the safety of the train and passengers.

Inspection of the train revealed that all three cars behind the locomotive had derailed. Approximately 600 feet of track was destroyed, and 550 feet of track was damaged. One passenger was slightly injured. Another VIA train from Kitchener, approximately 15 miles away, was dispatched to the accident site. The passengers were transferred to this train to continue their trip to Toronto.

## Weather

At the time of the occurrence, the temperature was -14°C, with good visibility and west-southwest winds gusting up to 50 km/h.

## Particulars of the Train and Crew

The train was comprised of one locomotive and three passenger cars. The train weighed 238 tons and was 292 feet long. It was carrying 30 passengers, 2 locomotive engineers and 3 on-board service personnel. All crew members were qualified for their respective positions. Both locomotive engineers met regulatory fitness and rest standards.

## Particulars of the Track

The Guelph Subdivision is owned by Canadian National (CN). In November 1998, the Goderich-Exeter Railway (GEXR), a subsidiary of RailAmerica, Inc., entered into a lease agreement with CN to operate over this subdivision. Under the terms of the agreement, GEXR is responsible for regulatory compliance with track infrastructure requirements, including responsibility for regular track maintenance. The Guelph Subdivision is designated as Class 4 track,[3] with maximum allowable operating speeds of 70 mph for passenger trains and 55 mph for freight trains.

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

[2] All locations are in the province of Ontario.

[3] Transport Canada, *Railway Track Safety Rules*, Part II, A. Classes of Track: Operating Speed Limits.

The Guelph Subdivision extends in an east-west orientation from Mile 30.0 (the junction with the Halton Subdivision) to Mile 119.9 at London. At the time of the occurrence, temporary slow orders (TSOs) were in effect at all locations where jointed rail was used. These TSOs (Mile 51.0 to Mile 58.8, Mile 64.0 to Mile 78.0, and Mile 91.0 to Mile 116.0) restricted passenger train speed to 60 mph and freight train speed to 40 mph. These TSOs have been in effect since 1996.

In the vicinity of the derailment, the track is tangent and consisted of 100-pound open hearth jointed rail that had been manufactured in 1928 by the Dominion Iron and Steel Company, which no longer exists. The 39-foot rail lengths were joined by 24-inch joint bars and secured with 4 bolts per joint. The rail was laid on double-shouldered tie plates and fastened to eight-foot hardwood ties with four standard track spikes. The rail was cross lock anchored with 16 ties in each 39-foot section. The ballast, which consisted of crushed stone, provided good drainage. The track structure has been replaced in kind using rail manufactured by more modern methods.

Train movements on the Guelph Subdivision are governed by the Occupancy Control System (OCS) as authorized by the *Canadian Rail Operating Rules*, and are supervised by a rail traffic controller located in North Bay. There are no signals in OCS territory. Consequently, when OCS is the only form of train control, the area is known as dark territory. The volume of rail traffic in dark territory is normally less than the volume in areas equipped with signals.

## *Train and Track Damage*

An examination of the locomotive revealed that the running gear had sustained minor damage. In addition, the locomotive fuel tank had been punctured by a piece of broken rail, resulting in a small, one-half inch puncture in the bottom of the tank. The hole was directly above the north rail. Approximately 100 litres of diesel fuel leaked from the puncture. Prompt action from emergency responders minimized environmental damage from this leak. TSB records indicate that, since 1990, there have been 300 occurrences in which a locomotive fuel tank has been punctured or has leaked. At least 20 of these occurrences resulted in a fire. Twenty-seven of these 300 occurrences involved passenger train locomotives.

All three passenger coaches had minor damage to their running gear; however, the passenger compartments of the coaches sustained no obvious damage.

During site examination, damaged and broken rail was observed extending westward from the derailed cars for approximately 1150 feet. The point of derailment was identified at a broken north rail at Mile 77.05. Visual examination of the rail fracture surfaces identified a wholly enclosed internal transverse defect. This transverse defect extended through approximately 25 per cent of the rail head cross-section. A second smaller transverse defect was observed at the opposite end of the same broken rail. There was no oxidation or significant smearing observed on any of the fracture surfaces. The head wear on the rail was within the allowable wear limits established by RailAmerica, Inc. Several broken rail pieces found in the vicinity of the point of derailment were sent to the TSB Engineering Laboratory for analysis.

## *Engineering Laboratory Report*

According to markings stamped on the rail when it was manufactured, the rail was manufactured in 1928 using the open hearth method.

Three cross-sectional rail fracture surfaces were analyzed. Each facture surface contained round to slightly oval-shaped transverse defects, located approximately 17 mm below the rail head running surface. Chevron patterns on the fracture surfaces indicated that the rail break likely originated in the vicinity of the transverse defect.

Metallographic examination of a rail sample taken near the fracture origin revealed that there were a number of small (approximately 25 microns to 55 microns) elongated manganese sulphide inclusions. No subsurface cracking was observed. Inclusions of this size may not be detectable by ultrasonic testing, unless the inclusions are present in large quantities. In addition, the rail sample exhibited a large, coarse grain size, designated ASTM 3 (American Society for Testing and Materials level 3). Large grain size, which is known to facilitate crack propagation, is typically found in rail of this vintage, that is, rail that was manufactured prior to 1960. A more refined microstructure (fine grain size) is found in rail that has been manufactured using modern processes.

## *Track Inspection and Rail Testing*

For Class 4 track, Section 10 of the *Railway Track Safety Rules* (TSR) requires that, at a minimum, track must be inspected for defects twice a week by the track maintenance supervisor or other qualified personnel. In addition, in accordance with Section 13.1 of the TSR, a track inspector or track supervisor must inspect track at such a frequency and by using such a method so as to ensure that a line of track is safe for a train to operate at the authorized speed. These track inspections are performed using a hi-rail vehicle. The track had been inspected on 07 January 2004, the day before the derailment. Because of cold weather, two additional inspections had been performed during the week before the derailment. During these inspections, no anomalies were noted in the area of the derailment.

The TSR require that Class 4 track be tested by a track geometry car[4] twice a year. GEXR has been performing a minimum of three track geometry tests each year on the Guelph Subdivision. A track geometry test had been conducted on 31 October 2003. No track geometry deficiencies in the derailment area were found during this test.

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[4] A track geometry car electronically locates and identifies irregularities in track geometry such as cross-level, gauge, surface, and line. It provides a real time report of overall track conditions relative to standards for the class of track.

The TSR require that Class 4 track be tested for internal rail defects at least once a year. Rail defect testing on the Guelph Subdivision is normally conducted twice a year. A rail flaw detection car[5] tested the rail on 05 October 2003, and no rail defects were identified in the vicinity of the derailment. However, 27 rail defects were identified in the area between Mile 65.15 and Mile 77.47. These defects included: 17 bolt hole cracks, 2 head-web separations, 6 vertical split heads, and 2 bolt hole breaks.

In the month following the occurrence, additional rail flaw testing was conducted from Mile 50.80 to Mile 78.30. During these tests, 72 rail defects were noted, of which 63 were bolt hole defects. These defects were found in rail that had been manufactured in 1949. However, no defects were found in any open hearth rail.

### *Ultrasonic Rail Testing Technology*

Ultrasonic testing is the most common method of testing rail for internal defects. On this type of rail testing equipment, transducers, installed at different angles, emit ultrasonic waves into the rail to identify defects of different orientation and size. The returning sound waves are recorded by the test equipment and analyzed for variations from the emitted waves. If an impurity or defect of detectable size is present, the returning signal will be seen as a spike. Over time, technological advances in rail testing equipment have resulted in a more accurate process, faster information processing, and enhanced visual presentation of test results. However, rail testing technology still has limitations. According to the Recommended Minimum Performance Guideline for Rail Testing prepared by the American Railway Engineering and Maintenance of Way Association, depending on the size of the defect, transverse defects are only detectable between 65 per cent and 99 per cent of the time.

### *Open Hearth Rail*

The broken rail from the derailment site had been manufactured using the open hearth process. Rail manufactured prior to the late 1930s using this process have a known propensity for entrapping inclusions. The open hearth process has since been replaced by more modern methods of refining steel that provide better inclusion control.

RailAmerica, Inc. has a policy that open hearth rail must not be installed on the Guelph Subdivision. New rail purchases specify that "All 100-lb RA rail must be control cooled." In addition, maintenance foremen have been instructed to inspect all rail before installation to ensure that it has been control-cooled, bloom-cooled, or vacuum-cooled. There is no regulatory or company requirement to remove open hearth rail that is already installed on the Guelph Subdivision if it meets TSR requirements and the rail wear limits established by RailAmerica, Inc.

## *Analysis*

As there were no equipment or operational deficiencies contributing to the occurrence, the analysis will focus on crack propagation in vintage rail, on the use of vintage rail in main track, and on rail defect testing.

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[5] A rail flaw detection car uses induction or ultrasonic technology to detect internal rail defects that normally cannot be visually detected during routine track inspections.

## *The Accident*

Train No. 86 was proceeding on the Guelph Subdivision, at a speed of 60 mph, when it derailed over a broken rail. The lack of smearing and oxidation on the rail fracture surface were indicative that the rail broke under this train, rather than under a previous train. The rail separation likely occurred between the first and second trucks of the locomotive. This conclusion is supported by the fuel tank puncture between the trucks above the north rail, which was likely caused by a piece of broken rail.

The rail fracture initiated from a transverse defect in the head of the north rail. The defect likely originated from manganese sulphide inclusions, which were present in the rail at the time of manufacture. These inclusions eventually facilitated the initiation and propagation of transverse defects in the rail head. Since ultrasonic rail testing and hi-rail track inspections did not detect these defects in the rail, it is likely that the inclusions were not large enough to be detected during the last ultrasonic test.

## *Crack Propagation in Vintage Rail*

Impurity inclusions in rail steel are known nucleation points for crack initiation. The ease of crack nucleation at inclusion interfaces is a function of the aspect ratio of the inclusion, and a function of the bonding between the inclusion and the matrix. In general, pancake-shaped elongated inclusions have a greater aspect ratio, and this structure provides ready sites for cracks to form. In this occurrence, the open hearth rail contained elongated manganese sulphide inclusions, indicating that the transverse defect likely originated from the inclusions.

The more refined microstructure (fine grain size) that is found in rail manufactured by modern processes is more desirable than the coarse grain microstructure typically found in vintage rail manufactured prior to 1960. A finer grain size increases the yield and fracture strength of rail steel while simultaneously lowering the ductile-to-brittle transition temperature. In rail with fine grain size, a growing microcrack would encounter increased resistance that would possibly stop additional growth. In this occurrence, the large grain size (ASTM 3) is typical of vintage rail. The large grain size normally found in vintage rail combined with the presence of inclusions may lead to an accelerated rate of crack propagation, increasing the risk of rail failure.

## *Use of Vintage Rail in Main Track*

Most track inspections are conducted from a hi-rail vehicle. These inspections are the initial layer of defence in identifying track abnormalities and determining the urgency for corrective maintenance. However, this type of inspection is limited to detecting track problems that are easily seen, felt, or heard while operating the hi-rail vehicle. In this occurrence, the broken rail was caused by an internal defect that was not detectable by a visual hi-rail inspection.

As a second layer of defence, railways conduct ultrasonic rail testing to identify internal rail defects. Although there have been a number of recent technological advances in ultrasonic testing, reviewing and analyzing the recorded test graph is still subject to operator interpretation. In addition, current rail testing equipment can only detect transverse defects between 65 per cent to 99 per cent of the time, depending on the size of the defect. Because the science of ultrasonic testing is still evolving, it is not an infallible system for identifying internal rail defects. Given the limitations of current rail testing equipment and the increased potential for rail failure in vintage rail, using this type of rail in main-line service increases the risk to passengers, the public, and the environment.

### Open Hearth Rail

The open hearth process for manufacturing rail has been replaced by more modern methods of refining steel that provide better inclusion control. Open hearth rail has a known propensity to form transverse defects because of impurity inclusions entrapped in the steel. Typically, a crack originates from an inclusion and then spreads transversely across the rail head. Once developed, transverse defects will progress in fatigue under repetitive wheel loads until the rail fails, or the defect is detected. Most railways have a policy that open hearth rail should not be installed on main-line subdivisions. RailAmerica, Inc. specifies that open hearth rail is not to be installed on the Guelph Subdivision. However, if previously installed open hearth rail meets the TSR requirements and the head wear limits established by RailAmerica, Inc., there are no company or regulatory requirements to remove it from service.

## Findings as to Causes and Contributing Factors

1. The north rail broke under the lead locomotive, causing the three trailing passenger coaches to derail.

2. The rail fracture initiated from a transverse defect in the head of the north rail. The defect originated from manganese sulphide inclusions that were present in the rail at time of manufacture.

3. Ultrasonic rail testing and hi-rail inspections did not detect the internal defects in the rail. It is likely that the inclusions were not large enough to be detected during the last ultrasonic test.

## Findings as to Risk

1. Large grain size and the presence of inclusions in vintage rail may lead to an accelerated rate of crack propagation, increasing the risk of rail failure.

2. Given the limitations of current rail testing equipment and the increased potential for rail failure in vintage rail, using this type of rail in main-line service increases the risk to passengers, the public, and the environment.

## Safety Action Taken

On 01 March 2004, the TSB issued Rail Safety Advisory (RSA) 617-02/04 directed to the regulator and the industry. The advisory raised a concern over the use of vintage open hearth rail on main track where passenger trains operate and dangerous goods are carried.
The RSA suggested that the regulator survey Canadian railways regarding the use of open hearth rail on main lines. Further, the RSA queried GEXR on its replacement plans for open hearth rail. Subsequent to this advisory, the following safety actions were implemented:

- On 26 May 2004, GEXR scheduled an additional ultrasonic rail test on the Guelph Subdivision.

- GEXR conducted a visual inspection of all locations on the Guelph Subdivision that had jointed rail. During this inspection, all of these identified locations were documented.

- GEXR instructed its track maintenance supervisors to check and record the rail stamping on all rail being installed to ensure that no open hearth rail is included.

- In early May 2004, a Transport Canada (TC) Surface Regional Infrastructure Officer inspected a portion of the Chatham Subdivision in the vicinity of Chatham. This section of track carries high-speed passenger trains and is the only area on this subdivision where open hearth rail could have been present. During this inspection, no open hearth rail was identified.

- On 24 August 2004, GEXR advised TC that it had removed all open hearth rail from the jointed rail portion of the Guelph Subdivision.

- TC will continue to monitor the situation on high-speed main lines and will survey other Canadian railways to determine whether open hearth rail is still installed on main-line subdivisions. For this purpose, TC requested information from all relevant railways on whether open hearth rail is still installed on their main-line tracks, and what their policy is regarding open hearth rail.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 01 December 2004.*

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