Transportation Safety Board
of Canada

Bureau de la sécurité des transports
du Canada

# RAILWAY OCCURRENCE REPORT

## CN NORTH AMERICA
## DERAILMENT
## TRAIN NO. 302-27
## MILE 56.7, RUEL SUBDIVISION
## NEAR WESTREE, ONTARIO
## 30 JANUARY 1994

## REPORT NUMBER R94T0029

Canada

# MANDATE OF THE TSB

The Canadian Transportation Accident Investigation and Safety Board Act provides the legal framework governing the TSB's activities. Basically, the TSB has a mandate to advance safety in the marine, pipeline, rail, and aviation modes of transportation by:

- conducting independent investigations and, if necessary, public inquiries into transportation occurrences in order to make findings as to their causes and contributing factors;
- reporting publicly on its investigations and public inquiries and on the related findings;
- identifying safety deficiencies as evidenced by transportation occurrences;
- making recommendations designed to eliminate or reduce any such safety deficiencies; and
- conducting special studies and special investigations on transportation safety matters.

It is not the function of the Board to assign fault or determine civil or criminal liability. However, the Board must not refrain from fully reporting on the causes and contributing factors merely because fault or liability might be inferred from the Board's findings.

## INDEPENDENCE

To enable the public to have confidence in the transportation accident investigation process, it is essential that the investigating agency be, and be seen to be, independent and free from any conflicts of interest when it investigates accidents, identifies safety deficiencies, and makes safety recommendations. Independence is a key feature of the TSB. The Board reports to Parliament through the President of the Queen's Privy Council for Canada and is separate from other government agencies and departments. Its independence enables it to be fully objective in arriving at its conclusions and recommendations.

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# Railway Occurrence Report

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# Derailment
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# Near Westree, Ontario
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## *Synopsis*

A CN North America (CN) eastward freight train derailed 23 freight cars, the 46th to the 68th behind the locomotives, as the train passed through a curve at Mile 56.7 of the Ruel Subdivision, 80 miles northwest of Sudbury, Ontario. Three tank cars containing dangerous goods released product. There were no injuries.

The Board determined that the derailment was a result of a rail head fracture initiated by a vertical split head defect.


Ce rapport est également disponible en français.

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# 1.0 Factual Information

## 1.1 The Accident

CN North America (CN) eastward freight train No. 302-27 departed Foleyet, Ontario, Mile 148.3 of the Ruel Subdivision at 2330 eastern standard time (EST), on 29 January 1994, destined for Montreal, Quebec.

At approximately 0505 EST, 30 January 1994, just after the train passed through a curve at Mile 56.7, it experienced a train-initiated emergency brake application.

After conducting the necessary emergency procedures, the crew members inspected the train and determined that the 46th to the 68th car had derailed. Product was leaking from three derailed tank cars. No one was injured.

## 1.2 Damage to Equipment

One rail car sustained minor damage, one sustained substantial damage, and 21 were destroyed.

## 1.3 Other Damage

Five hundred feet of main track was destroyed and 600 feet of track sustained substantial damage.

## 1.4 Personnel Information

The train crew included a conductor and a locomotive engineer. They were qualified for their respective positions and met fitness and rest standards established to ensure the safe operation of trains.

## 1.5 Train Information

The train, powered by two locomotives, was hauling 17 empties and 65 loads, including liquefied petroleum gas, anhydrous ammonia and vinyl acetate. The train was about 5,300 feet in length and weighed approximately 8,000 tons.

## 1.6 Particulars of the Track

The subdivision is single main track extending 296 miles from Capreol to Hornepayne, Ontario. At Mile 56.7, the authorized speed is 50 mph for freight trains. There was no slow order in effect in this area at the time of the derailment. Traffic over this location consists of an average of 17 trains per day.

The derailment occurred on tangent track, at the end of a one-degree right-hand curve in the direction of movement, on a 0.1 per cent ascending grade.

The south rail consisted of little worn 136-pound continuous welded rail (CWR), rolled in 1992 and laid in May 1993. The north rail, displaying a combined head and flange wear of 3/8 inch and well within standard, consisted of 132-pound CWR, rolled and laid in 1971. The rail was laid on concrete ties and fastened with Pandrol clips, all in good condition. Ballast was crushed slag with full cribs and 16-inch shoulders.

The track had been inspected on 28 January 1994 by an assistant track supervisor. No irregularities were observed.

An ultrasonic test vehicle had scanned the rail in the area of Mile 56.7 on 24 November 1993. No defects were noted. The subdivision had also been ultrasonically tested in February, March, May and August 1993.

## 1.7 Method of Train Control

Traffic in this area is controlled by the Centralized Traffic Control System (CTC), authorized by the Canadian Rail Operating Rules and supervised by a rail traffic controller (RTC) located in Toronto, Ontario.

## 1.8 Weather

The skies were clear, visibility was unrestricted, and the temperature was minus 45 degrees Celsius.

## 1.9 Recorded Information

The event recorder data indicated that the train experienced a train-initiated emergency brake application while it was travelling at a recorded speed of 46 mph with the brakes released and the throttle in the No. 8 position. Other recorded train operating systems were shown to be operating as intended.

## 1.10 Occurrence Site Information

The derailment site was at the end of a bog in an isolated area. The nearest inhabitants were located in the village of Westree, Ontario, seven miles to the northwest.

At approximately Mile 57.6, the point where track destruction commenced, the north rail extended approximately 148 inches further eastward than the south rail. There were no markings on the roadbed, ties or rails leading up to Mile 57.6.

The first derailed car, the 46th behind the locomotives, a loaded bulkhead flatcar, came to rest on its side in the south right-of-way ditch, 1,200 feet eastward from Mile 56.7. The 47th to 67th cars inclusive came to rest in a tangled heap measuring approximately 500 feet in length just beyond the point where track destruction began. The 68th car, the last car to derail, came to a stop with the leading truck resting on the roadbed and the trailing truck remaining on the undamaged track.

Pieces of broken rail from the north and south rails were found approximately 10 feet eastward from the end of the south rail under the last derailed car. A visual inspection of the pieces of south rail revealed that the rail head had broken off on the gauge side.

An inspection of the derailed cars revealed that the drawbar on the leading end of the derailed 47th car was broken off at the key area within the carrier housing. The break location displayed a rust area, indicating an approximate 40 per cent pre-existing fracture. The front portion of the missing drawbar was not located.

The rail pieces were forwarded to the TSB Engineering Laboratory for examination.

## 1.11 Dangerous Goods

### 1.11.1 The Products

#### 1.11.1.1 Vinyl Acetate

Approximately 79,000 kilograms of vinyl acetate was spilled. Vinyl acetate is a colourless liquid that polymerizes to a solid on exposure to light. It has a lower explosive limit of 2.6 per cent, an upper explosive limit of 13.4 per cent, and an "open cup" flash point of minus 1.1 degrees Celsius. The permissible exposure limit is 10 parts per million (ppm) and short-term exposure limits are set at 20 ppm. It is moderately toxic by ingestion or inhalation and is a skin and eye irritant. It is a highly dangerous fire hazard when exposed to heat, flame or oxidizers. It can react with air or water to form peroxides which catalyze an exothermic polymerization, a reaction that has caused several large industrial explosions.

Both loaded tank cars which released vinyl acetate were 111A-specification tank cars.

*1.11.1.2 Methanol*

Methanol is a clear liquid with an alcohol odour. The burning point is 65.6 degrees Celsius, the lower explosive limit is 5.5 per cent and the upper explosive limit is 36.5 per cent. Although it is classified as a "flammable liquid", it is also considered to be a human poison by ingestion and skin contact. It is mildly toxic by inhalation. The toxic effect is exerted upon the nervous system, particularly the optic nerves. Death from ingestion of less than 30 millilitres (about one ounce) has been reported.

The loaded tank car leaking methanol was a 111A-specification tank car.

*1.11.1.3 Propane*

Propane is a colourless liquefied gas in tank cars and has a lower explosive limit of 2.4 per cent, an upper explosive limit of 9.5 per cent, and an "open cup" flash point of minus 105 degrees Celsius. The permissible exposure limit is 1,000 ppm. It is a highly dangerous fire hazard when exposed to heat or flame and can react vigorously or explosively with oxidizers. Propane affects the central nervous system at high concentrations and is an asphyxiant.

The loaded tank car of propane involved in the derailment was a 112-J specification tank car. The tank car was heavily damaged but experienced no loss of product.

*1.11.2 The Spill and Emergency Response*

As the conductor walked towards the derailed cars, he could smell product and was able to determine from the train consist that cars containing dangerous goods were derailed. As a consequence, he did not venture near the spill area. He returned to the lead locomotive and alerted the RTC to the released product. The crew then uncoupled the locomotives from the train and moved well eastward, away from the derailment area.

CN personnel trained in the assessment of dangerous goods handling arrived at the scene at approximately 1530 EST and determined that one tank car of vinyl acetate had been punctured and released the entire car load of product. Another tank car of vinyl acetate sustained impact damage and a minor leakage was evident at the dome area. A tank car containing methanol sustained damage to the bottom unloading valves, resulting in substantial leakage. A tank car of liquefied propane gas sustained substantial damage to the jacket and carriage but the tank was not punctured nor did product leak.

Most of the spilled vinyl acetate flowed into the adjacent bog area. However, the derailment action had created a depression in the south ditch estimated to be 10 feet across and four feet deep. That ditch subsequently filled with a mixture of vinyl acetate and methanol.

CN established a command post six miles east of the derailment location. A perimeter barrier was established 500 feet east and west of the derailment site and respirators were used by all personnel that were required to work within these boundaries.

The vinyl acetate from the leaking tank car, the remaining product in the derailed tank car of methanol, and the contents of the derailed tank car of propane were pumped into other rail tank cars. Transshipping was completed on 03 February 1994.

No attempt was made to recover the spilled products. Both the vinyl acetate and methanol would quickly degrade and not pose an environmental risk.

Provincial environment officials continued to monitor the site and reported that, by the summer of 1994, no visible signs of product remained. Monitoring of test holes drilled in the vicinity have disclosed that the water table is not contaminated.

## *1.12 Tests and Research*

Pieces of both the north rail and south rail examined by the TSB Engineering Laboratory (Report LP 17/94) determined that the north rail fractures were overstress in nature and originated at impact marks on the rail base. The south rail contained a vertical split head (VSH) defect. The VSH was suspected to have started in the centre of the affected section of the south rail. It likely spread in both directions, although this could not be confirmed since only the rail pieces displaying the westward end of the VSH were recovered. The eastward end and much of the centre were not found. The fracture geometry suggested that, as the VSH progressed and the rail head broke off, the centre of the affected section fragmented. The gap in the rail grew in both directions as successive sections of rail head broke off. The origin of the defect was not found in the recovered pieces.

An inclusion count was conducted on a section of rail head from the south rail to compare the steel cleanliness with the present standard. The results showed that the inclusion count by area was over three times the present allowable limit (effective 01 July 1993). At the time of manufacture (1992), the steel met CN specifications.

## *1.13 Other Information*

### *1.13.1 Series 111A Tank Cars*

The three rail cars that released product were classified as CTC-111A tank cars. This type of tank car, referred to as DOT-111A in the United States and CTC-111A in Canada, is used to transport flammable liquids, acids and other corrosives. These tank cars are non-pressure, and can be insulated or non-insulated. They do not normally have head shields and are pressure-tested at relatively low pressures (60 pounds per square inch (psi) to 100 psi), depending on the type. They can be constructed of carbon steel, aluminum alloy, or alloy steel (stainless). They all are equipped with double-shelf couplers. These cars are not considered to provide the same degree of derailment protection against loss of product as the classification 112 and 114 cars, designed to carry flammable gases.

The United States National Transportation Safety Board Safety Study (NTSB/SS-91/01) into the Transport of Hazardous Materials by Rail questions the safety of classification 111A tank cars. Forty-five selected accidents and incidents occurring over a one-year period beginning in March 1988, and several previous major accident reports and other safety studies were reviewed. The report determined that this classification of tank car has a high incidence of tank integrity failure when involved in accidents and that certain hazardous materials are transported in these tank cars even though better protected cars (less liable to release the transported product when involved in accidents) are available.

### *1.13.2 Crew Observations*

The crew members indicated that nothing unusual was felt or experienced as the lead locomotive passed over the derailment area. They also stated that the CTC signal located approximately three miles west of the derailment site displayed a clear signal indication as the train approached this location and moved into the block.

### 1.13.3 *Vertical Split Head Rail Defects*

A VSH rail defect is a progressive longitudinal fracture in the head of the rail, where separation along a seam spreads vertically through the head at or near the middle of the head. The VSH grows rapidly once a seam has opened up. This rail defect presents a hazard to train movements because it is usually not visible on the surface until it has grown to a length of several feet. Since the VSH extends longitudinally, a considerable portion of track is normally adversely affected once growth commences.

A catastrophic VSH break will destroy the gauge integrity sufficiently, in many cases, to allow a wheel to drop inside the rail.

### 1.13.4 *Ultrasonic Testing*

Pandrol Jackson Technologies Inc. provide ultrasonic testing service to CN. The test system attempts to locate rail defects according to a pre-set test criteria. The test technique relies on the ability of ultrasonic waves to propagate through the rail and identify discontinuities such as voids or cracks.

The CN defect detection specification requires that the ultrasonic testing equipment identify 95 per cent of VSH defects six inches or longer in length.

# 2.0 Analysis

## 2.1 Introduction

The operation of the train conformed to company instructions and government safety standards. The train separation and derailment was sudden and without warning. The analysis will focus on areas, not related to the operation of the train, that were considered to determine the cause.

## 2.2 Consideration of the Facts

### 2.2.1 Equipment

Before the point where track destruction began, there were no marks on the track or roadbed to indicate that a wheel climb had occurred or that equipment failure such as a broken wheel or axle had initiated the derailment.

A broken drawbar such as found on the leading end of the second car to derail would cause immediate train separation and not affect the preceding car. The drawbar would fall to the roadbed, marking the ties, rail and roadbed before jamming under a car and initiating the derailment and track destruction. Since the preceding car also derailed and no marking of the ties, rail and roadbed was evident, the broken drawbar was thought to have broken during the derailment and not considered to be a cause or contributing factor.

### 2.2.2 Vertical Split Head Defect

The train entered the block on a clear signal indication, signifying that the rail was not broken at that time or, if broken, had not separated. No rail defects were observed or felt as the locomotive consist passed the derailment point.

Laboratory tests revealed that the broken north rail, although older and worn, was fractured as a result of impact forces on the rail base. The broken south rail, however, contained a well-developed VSH defect. In all probability, the rail head broke at the rail defect under the train, allowing the wheels of the 46th car to drop to the rail bed, breaking the south rail completely and in the process striking and breaking the north rail, ultimately destroying the track and derailing the following 22 cars.

### 2.2.3 Rail Inspection and Ultrasonic Testing

The last ultrasonic test at the location, conducted approximately two months before the derailment, gave no indication of the existence of a rail defect at Mile 56.7. It is possible that the VSH defect was non-existent or at the stage where the seam was just forming.

The well-developed nature of the VSH, however, suggests that the defect existed at the time of the last visual inspection of the track two days before the derailment. Such inspections, carried out on Hi-rail vehicles, have limited potential for detection of this type of defect.

### 2.2.4 111A Tank Cars

The susceptibility of 111A tank cars to release product at derailment and impact is well documented. The transport of a variety of the most hazardous products in such cars continues.

*2.2.5 Dangerous Goods Containment*

The dangers associated with the dangerous goods release were quickly realized by the train crew members. They immediately notified the RTC and avoided exposure. The railway's emergency procedures were carried out in a timely and effective manner considering the remoteness of the location and the severe weather conditions.

The spilled product has broken down, as expected, and has proven not to be an environmental hazard.

# 3.0 Conclusions

## 3.1 Findings

1. Train operation conformed to company instructions and government safety standards.

2. The derailment occurred as a result of a rail head fracture under the train caused by a vertical split head (VSH) defect on the south rail.

3. The ultrasonic rail testing equipment did not detect the presence of a VSH defect at the derailment location during testing two months before the derailment.

4. The development and growth of a VSH defect are unpredictable and the likelihood of the defect being present at the fracture location at the time of testing cannot be evaluated.

5. The broken drawbar on the leading end of the second car to derail was a result of the severe increase in draft forces created by the successive derailment of following cars.

6. Environmental damage proved to be minimal and the spilled product has degraded and dissipated as expected.

7. Emergency response procedures were carried out in a timely and effective manner.

## 3.2 Cause

The derailment was a result of a rail head fracture initiated by a vertical split head defect.

# 4.0 *Safety Action*

## 4.1 *Action Taken*

### 4.1.1 *Rail Testing*

As a result of previous occurrences involving defective rails, the Board made four recommendations to the Department of Transport for improving rail testing in the following areas:

a) a reassessment of the adequacy of Canadian railway requirements for main track rail testing, taking into account the age of the rail and the nature of the traffic;
(R92-23, issued January 1993)

b) research to improve the effectiveness of current rail testing methods;
(R92-24, issued January 1993)

c) improvement for identifying rail defects on curved track and identifying vertical split head defects; and
(R93-01, issued April 1993)

d) a reassessment of the adequacy of the training and suitability of the working conditions for the operators of rail testing vehicles.
(R93-02, issued April 1993)

In response to these recommendations, Transport Canada indicated that initiatives taken by the railways have improved the reliability of detection of sizeable vertical split head defects in track. More frequent ultrasonic testing and improved operator qualifications have been established so the test indications can be better interpreted. In addition, the industry has increased awareness of rail defect types and has improved its ability to visually detect them. Also, the industry has developed systems that provide local supervisors continuous evaluation of rail wear for immediate action or timely replacement.

### 4.1.2 *Research and Development of Rail Inspection Technology*

A joint project to test and develop rail inspection technology is being conducted by the Transportation Development Centre, involving CN, Canadian Pacific Limited, Tektrand International Inc., Canac International Inc., and Transport Canada.

### 4.1.3 *Quality Control Initiatives*

CN and Sydney Steel have jointly retained the services of a quality consultant to review all CN and Sydney Steel processes involved in delivering quality rail. CN inspectors will continuously monitor 1995 rail production at the Sydney Steel plant before shipment to CN's Transcona rail welding facility in Winnipeg, Manitoba.

### 4.1.4 *Restrictions on the Use of 111A Tank Cars*

Amendment Schedule No. 21 to the Transportation of Dangerous Goods Regulations makes mandatory the use of revised tank car standard CAN/CGSB 43.147-94. This standard restricts the use of 111A tank cars, and removes over 80 dangerous goods previously authorized for transportation in Class 111 cars.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, John W. Stants, and members Zita Brunet and Hugh MacNeil, authorized the release of this report on 19 May 1995.*

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