# RAILWAY OCCURRENCE REPORT

## VIA RAIL INC.
## DERAILMENT
## VIA TRAIN NO. 37
## MILE 72.9, CN ALEXANDRIA SUBDIVISION
## OTTAWA, ONTARIO
## 31 JANUARY 1991

## REPORT NUMBER R91H0006

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



# Railway Occurrence Report

# VIA Rail Inc.
# Derailment
# VIA Train No. 37
# Mile 72.9, CN Alexandria Subdivision
# Ottawa, Ontario
# 31 January 1991

# Report Number R91H0006

## *Synopsis*

Travelling at a speed of 30 mph, VIA Rail Inc. (VIA) train No. 37, carrying 137 passengers, derailed at Mile 72.9 of the CN North America Alexandria Subdivision. There were no injuries as a result of this derailment; however, the locomotive, one coach, approximately 100 feet of track and one switch frog were damaged. All passengers were moved to the Ottawa Station in undamaged coaches without incident.

The Board determined that the derailment was caused by the failure of the axle at the L-2 location of club car No. 3474 when in-service stresses placed on the axle from shelled wheels exceeded the designed "endurance limit" of the axle.

Ce rapport est également disponible en français.

# *Table of Contents*

# 1.0 Factual Information

## 1.1 The Accident

VIA Rail Inc. train No. 37 (VIA 37) destined for Ottawa, Ontario, with 137 passengers, departed Montreal, Quebec, at 1750 eastern standard time (EST) on the CN North America (CN) Alexandria Subdivision. The required brake tests and mechanical inspection had been successfully completed before departure.

At Casselman, Ontario, Mile 47.5, VIA 37 was stopped for approximately five minutes while waiting for CN freight train No. 882 to clear the single main track. VIA 37 then continued and accelerated to 80 mph without incident.

At approximately Mile 53.0, VIA on-board service staff in Light, Rapid, Comfortable (LRC) club car No. 3474 noticed a warning light illuminated on the on-board hot box detector panel. The warning light indicated that there was an open probe condition at the L-2 location of the club car. Such a warning light is indicative of an open or shorted bearing temperature sensor. The conductor was notified, and the train was stopped for an inspection. The identified bearing and the remaining bearings on the same truck were checked and found to be running cool. A subsequent pull-by inspection, conducted before the trip was continued, failed to reveal any other mechanical defects. As a matter of additional precaution, one of the crew members
remained by the on-board hot box detector panel in the club car until he was required to prepare the train for arrival at the Ottawa Station.

VIA 37 slowed to 30 mph for Mile 72.5, as required by timetable, and successfully negotiated the switch at Mile 72.7. However, while proceeding through the frog at the subsequent switch at Mile 72.9, the trailing wheel set of the lead truck of club car No. 3474 derailed. No one on the train was aware that a derailment had occurred.

The train continued, maintaining a speed of 30 mph, until Mile 74.04 where the leading wheel set also derailed which, in turn, pulled the trailing truck of the locomotive off the tracks. This alerted the two locomotive engineers and the movement was brought to a stop at approximately Mile 74.15.

After alerting the rail traffic controller (RTC) of the situation and assessing the damage to the train, the crew moved the passengers to the three unaffected coaches and an assist movement was requested from CN. This special movement brought the passengers to the Ottawa Station without further incident.

## 1.2 Injuries

There were no injuries as a result of this derailment.

## 1.3 Damage to Equipment

The leading truck of club car No. 3474 was extensively damaged. The compartment inspection covers of the car were dented, and several holes were punched through

the underside sheeting. The No. 2 axle was broken in the area of the suspension bearing, and the wheel and bearing on the left side (L-2) were missing. The trailing wheel set of the trailing truck on locomotive No. 6423 required replacement.

## 1.4 Other Damage

The switch frog at the point of initial derailment was damaged and required replacement. Approximately 100 feet of track was damaged in the vicinity of the subsequent derailment at Mile 74.15.

## 1.5 Personnel Information

The operating crew consisted of two locomotive engineers positioned in the lead locomotive, and a conductor and an assistant conductor positioned in the coaches.

The operating crew members were qualified for their respective positions and met fitness and rest standards established to ensure the safe operation of trains.

## 1.6 Train Information

VIA 37 is a regularly scheduled passenger train operating from Montreal to Ottawa. On the day of the derailment, it consisted of one locomotive, VIA No. 6423, LRC club car No. 3474 and LRC coaches Nos. 3339, 3317 and 3343. There were 137 passengers on board the train.

## 1.7 Particulars of the Track

The Alexandria Subdivision is a single main track which handles both passenger and freight traffic.

The rail in the vicinity of the derailment is 115-pound standard rail in 39-foot lengths on No. 2 hardwood ties, laid in 1966 on 12 inches of crushed rock ballast. There are 3,110 ties per mile. The tie plates are double-shouldered, with four six-inch spikes per tie. The rail anchors are the Fair type with six ties boxed per rail length. The joint bolts are in good condition with six bolts per rail joint.

Although the frog at the initial derailment point was partially worn and replaced after the accident, TSB investigators determined that both the frog and the associated switch did not contribute to the accident.

## 1.8 Method of Train Control

Train operations on the Alexandria Subdivision are controlled by the Rail Traffic Control Centre located in Montreal, utilizing a Centralized Traffic Control system, Canadian Rail Operating Rules and CN Special Instructions.

## 1.9 The Weather

The temperature was minus 13 degrees Celsius, the winds were westerly at 11 km/ h, with clear skies.

## 1.10 Recorded Information

The event recorder data confirmed a train speed of 30 mph at the point of initial derailment. All monitored train operating systems were functioning as intended.

## 1.11 Occurrence Site Information

The initial derailment occurred at the switch at Mile 72.9 on tangent track with no grade. This point on the CN Alexandria Subdivision is within the Ottawa city limits near Ridge Road.

## 1.12 On-board Hot Box Detector System

LRC cars are equipped with on-board hot box detector systems. The control panels fitted on the cars display either "normal" (green light), "warning" (yellow light) or "danger" (red light) conditions. "Warning" and "danger" indications include activated lights to identify the exact bearing triggering the other than "normal" indication. Open or shorted probe circuit indicators and actual bearing temperatures are also displayed.

Instructions outlining crew requirements when confronted with an other than "normal" indication are contained in the respective railway company timetables. CN requires the "open probe" condition to be followed up after the train has moved an additional distance (not to exceed 50 miles) at track speed, at which time the train must be stopped and the condition of the journal at the failed circuit determined. Further inspections must be conducted, at not greater than 50-mile distances, until the terminating station is reached.

## *1.13 Other Information*

A post-derailment inspection revealed that the disc brake actuator and brake calliper assembly at the L-2 location of club car No. 3474 were missing. As well, a portion of the brake calliper bridge had been lost with a recent fracture present in the cross-section of the bridge. The suspension link pin hole on the inboard side was elongated, and the link pin bushing was missing. The second suspension link pin bushing was present and not elongated. This would indicate that, at some time before failing completely, the suspension link pin had become partially dislodged.

A portion of the calliper bridge was found at Mile 37.3 which was 15.7 miles before the location where an "open probe" indication was displayed on the on-board hot box detector panel in the club car. A large portion of the calliper assembly with the actuating cylinder was found at Mile 46.3. The missing brake components which are inboard of the wheel and difficult to see were not noticed when the crew inspected their train at Mile 53.0 and examined the bearing on the L-2 wheel.

## *1.14 Tests and Research*

It was initially suspected that the brake calliper and actuator struck the axle, initiating the fracture. The failed axle assembly and fragments from the brake calliper and actuator assembly were forwarded to the TSB Engineering Laboratory for analysis (LP 25/ 91). The following conclusions were made:

1. The disintegration of the brake assembly and the axle failure were unrelated.

2. The axle failed by fatigue from two crack origins diametrically opposed.

3. The cracks initiated from sites provided by corrosion pits that formed because of moisture accumulation under the seal wear and backing rings.

4. Two fatigue cracks were also found at the same location on the end of the axle, opposite to the location of the failure.

5. Ultrasonic testing showed that a crack deeper than the depth of the groove machined into the axle in the area of the bearing backing ring shoulder is detectable.

6. The cause of the brake disintegration could not be established from the available evidence.

## *1.15 Subsequent Axle Failures*

On 17 February 1992, VIA train No. 34, proceeding at 78 mph, derailed at Mile 15.3 of the CN Alexandria Subdivision. The investigation revealed that the trailing axle on the trailing truck of coach No. 3339 had also broke at a bearing backing ring groove. Ultrasonic testing revealed a crack in a similar position at the opposite end of the failed axle. Significant corrosion was not present on the axle surface under the seal wear and backing rings. This axle had been ultrasonically tested on 12 June 1991. No cracks had been found in the axle at that time.

On 29 February 1992, VIA train No. 621, proceeding westward on the CN Saint-Hyacinthe Subdivision near Saint-Lambert at less that 15 mph, experienced a broken axle inboard of the brake rotor on coach No. 3319. This axle had only been in service since 19 December 1991.

On 16 March 1992, eastward VIA train No. 46, travelling at 89 mph, derailed at Mile 204.27 of the CN Kingston Subdivision. The subsequent inspection of the train disclosed that an axle on club car No. 3461 had also broke in the area of a bearing backing ring shoulder groove.

In all three cases, the equipment had remained upright and coupled together and the trains were brought to a controlled stop. No one was injured.

## *1.16 Subsequent Tests and Research*

### *1.16.1 Wheels*

The three additional axles which broke had been equipped with wheels which showed shells. Several shells exceeding one inch in diameter were present in all cases.

Tests were undertaken to measure the dynamic stress imposed on the axles by the wheels displaying shelling. Wheels with and without shells were mounted on VIA equipment and run on the CN Kingston Subdivision under controlled conditions. Shell size was limited to less that one inch in diameter. Stress on the two axles was electronically measured and recorded.

A review of the results disclosed that the axle equipped with the shelled wheels recorded dynamic stress peaks in the area of the bearing backing ring grooves and the inboard rotor seats near to the "endurance limit" of the axle (i.e., the stress limit beyond which the axle can fail). The axle equipped with the unflawed wheels recorded dynamic stresses at a significantly lower level and within the anticipated design limits.

### *1.16.2 Axle Material Analysis*

The metallurgical analysis of the additional broken axles conducted by the TSB Engineering Laboratory (LP 44/ 92) revealed that the steel conformed to the material specifications as outlined in the Association of American Railroads' Manual of Standards and Recommended Practices. The axles also met design specifications for size; however, the micro hardness examination of the bearing backing ring grooves failed to indicate the effects of "cold rolling" as indicated in the manufacturer's drawings.

The broken axle from the 29 February 1992 derailment had been placed into service on 10 December 1991, after having been re-sized from a larger axle to conform to the LRC design. The examination revealed that it had failed at the shoulder of the inboard disc brake rotor seat. A crack at this location had propagated in fatigue to approximately 10 per cent of the diameter. The remaining fracture surface displayed a brittle failure. Cracks were evident in the bearing backing ring grooves at both ends of the axle. A Charpy V-Notch (CVN) impact test revealed that the axle would have been less resistant to fracture at temperatures below zero degrees Celsius.

The last axle to break displayed a failure originating at corrosion pits similar to the axle from VIA 37.

### *1.16.3 Original Design Analysis*

A review of the manufacturer's original drawings and design calculations revealed that the groove machined into the axle for the bearing backing ring would be the area of highest stress concentration and the weakest part of the axle. The axle bearing backing ring groove also had to be properly

"cold rolled" to meet the designed "endurance limit" of the axle.

*1.16.4 Wheel Shells*

In 1990, VIA altered its condemning limit for wheel shell size from one inch to one and one-half inches in reaction to proposed limits to be stipulated in minimum safety standards for equipment in passenger service under development by Transport Canada. The maintenance condemning limit for wheel shells found on a freight car, as outlined in the Association of American Railroads' Field Manual, is one inch.

# 2.0 Analysis

## 2.1 Introduction

The axle break on VIA 37 was initially thought to be an isolated event. Laboratory analysis quickly uncovered corrosion pits in the bearing backing ring grooves and appropriate safety measures were adopted. The second and subsequent axle failures, however, proved the original hypothesis invalid, prompting further study. The analysis will discuss the events surrounding the accident on VIA 37 but focus on the events which followed.

## 2.2 Consideration of the Facts

### *2.2.1 The VIA 37 Axle Break*

Neither the method of train operation nor failure of the track led to this accident. The coincidental loss of brake components and resultant on-board hot box detector warning activation detected at Mile 53.0 were dealt with in a manner exceeding CN requirements. The failure of the crew to notice the missing brake parts is understandable, considering the nature of the indication (loss of probe function) and difficulty in visually inspecting under the train in the area where the brake assemblies are located.

### *2.2.2 Subsequent Axle Breaks*

The subsequent breaks involving an axle with little corrosion that had passed a recent ultrasonic examination, an axle that had been in service for only 14 months and an axle which broke at a different location pointed to other sources of failure. Metallurgical composition and design were not found to be deficient.

The axle field testing indicated that wheels in service with shells measuring less than one inch in diameter place stresses on axles that approached the design "endurance limit" of the axles. It is concluded therefore that wheels with shells measuring more than one inch would exceed the "endurance limit". The tests further demonstrated that both the bearing backing ring grooves and the inboard rotor seats are the major areas of stress concentration.

It is apparent that the wheels in service with shells in excess of one inch in diameter placed stresses on the axles which broke at points where these forces were concentrated. The axles had also been compromised by corrosion, improper cold rolling of the bearing backing ring grooves and, in one case, a metallurgical anomaly that resulted in the axle becoming brittle at low temperatures.

# 3.0 Conclusions

## 3.1 Findings

1. VIA 37 was brought to a controlled stop at Mile 74.57 when the trailing wheel set of the locomotive was pulled off the track by the derailed leading truck of club car No. 3474.

2. The leading truck of club car No. 3474 derailed as a result of axle failure at the L-2 location.

3. The axle broke in the area of a groove machined in the axle for the bearing backing ring because in-service stresses placed on the groove exceeded the "endurance limit" of the axle design.

4. The axle was subjected to unusually high operating stresses due to wheel tread shells.

5. The disc brake actuator and brake calliper assembly on the left side (L-2) of club car No. 3474 were missing.

6. The missing brake components and the failure of the axle are unrelated.

## 3.2 Cause

The derailment was caused by the failure of the axle at the L-2 location of club car No. 3474 when in-service stresses placed on the axle from shelled wheels exceeded the designed "endurance limit" of the axle.

# 4.0 Safety Action

## 4.1 Action Taken

### 4.1.1 Corrosion Pitting of Axles

As a result of preliminary information, the TSB forwarded a Safety Advisory to Transport Canada in April 1991, advising that axle failures may be related to corrosion pitting and that early signs of failure might be detected through ultrasound testing. Subsequent ultrasound testing by VIA found six axles to have an anomaly. The corresponding LRC coaches were removed from service.

As a further preventive measure, VIA began using another lubricant that contained a corrosion inhibitor on the roller bearings of LRC axles.

### 4.1.2 Interim Recommendations

Further investigation of the axle failures revealed that other factors in addition to corrosion had caused the failures. Therefore, in March 1992, the Board recommended that:

> The Department of Transport ensure that all axles on VIA LRC equipment that have not been ultrasonically tested within the past month be removed from service for testing as soon as practicable.
>
> (R92-01, issued March 1992)

> The Department of Transport require that the axles of all VIA LRC equipment be ultrasonically tested at intervals not to exceed the average monthly mileage of the LRC fleet to ensure the continuing integrity of the axles.
>
> (R92-02, issued March 1992)

> The Department of Transport inform any other operators of equipment employing axles of the design used on LRC equipment of the potential for rapidly propagating fatigue cracks.
>
> (R92-03, issued March 1992)

> The Department of Transport require a program of dynamic testing on LRC axles to assess in-service stresses under actual operation conditions.
>
> (R92-04, issued March 1992)

> The Department of Transport, in cooperation with VIA, evaluate the adequacy of the current LRC axle design, manufacture, and maintenance, and if necessary, develop a plan for the replacement of all current LRC axles.
>
> (R92-05, issued March 1992)

VIA immediately took action in line with recommendations R92-01 to R92-04. Following the failure of another axle on 16 March 1992, VIA removed all LRC coaches and club cars from service. VIA subsequently acquired and installed new axles for its LRC fleet and, after research

and tests revealed the design of the replacement axle was acceptable, VIA resumed LRC service in April 1992.

### 4.1.3 In-Service Stress Tests

A TSB Safety Advisory was forwarded in May 1992 alerting Transport Canada to the results of axle in-service stress tests performed by VIA. These tests revealed that wheels with large diameter tread shells were subjecting the axles to high stress loads. The advisory proposed that the one-inch diameter shell condemning limit for wheels on passenger cars be maintained pending finalization of the standard. VIA continues to use the

one-inch standard.

*4.1.4 Wheel Tread Shells*

A survey of VIA equipment revealed that shelled wheels were widespread. Forty-three per cent of the wheels surveyed had shells larger than the one-inch condemning limit; seven per cent had eccentric rolling surfaces (radially out-of-round) and eleven per cent of wheel sets had wheels of varying circumferences. VIA concluded that the principal cause of the wheel defects was the improper operation of anti-slide wheel protection devices. Also, there was a belief among employees that shells "work themselves out" when, in fact, wheels with shells aggravated the eccentricity of wheels.

VIA introduced revised inspection procedures and increased audits to ensure that wheels were properly inspected. In addition, a comprehensive review of the anti-slide wheel protection system was conducted, resulting in a reduction in the frequency of tread defects.

*4.1.5 Axle Upgrading*

Transport Canada has indicated that VIA has taken several measures to upgrade LRC axles. The VIA action includes:

a) all axles originally in service were tested and only the axles meeting specifications for materials and manufacturing were retained;

b) a revised wheel tread standard is now under study to determine a possible standard of 3/ 4 of an inch for wheel shells;

c) axle stress relief grooves are now protected by rust preventative compounds;

d) American Association of Railroads and Canadian Standards Association quality assurance programs have been implemented for the manufacturing and maintenance of axles and wheel sets; and

e) a new axle has been designed with revised impact resistance, surface finish and hub seat design requirements. It has been successfully tested to speeds of 125 mph, using wheels with and without defects.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, John W. Stants, and members Gerald E. Bennett, Zita Brunet, the Hon. Wilfred R. DuPont and Hugh MacNeil, authorized the release of this report on 05 January 1995.*