# RAILWAY OCCURRENCE REPORT
# R95T0259

INCIDENT

BETWEEN CANADIAN NATIONAL
AND VIA RAIL CANADA INC.
PASSENGER ROLLING STOCK DAMAGE
KINGSTON SUBDIVISION
15 AUGUST 1995

Transportation Safety Board
of Canada

Bureau de la scurit des transports
du Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

# Railway Occurrence Report

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# Between Canadian National and VIA Rail Canada Inc. Passenger Rolling Stock Damage Kingston Subdivision 15 August 1995

# Report Number R95T0259

## *Synopsis*

On 15 August 1995, 24 wheels on VIA Rail Canada Inc. LRC (Light, Rapid, Comfortable) train No. 65 were found with apparent impact damage while the train was undergoing a trip inspection at the Toronto Maintenance Centre. Repair records revealed that similar marks had been found on other LRC trains as far back as August 1994. As the railways attempted to determine the cause of the damage, LRC trains continued to be affected by an apparent track anomaly. A train was damaged in October 1995 and two others were marked in July 1996.

The Board determined that the damage to the wheels was most likely the result of impact with spalled rail bound manganese frogs (at the point where the wheel load transfers from the running surface of the point of frog to the wing) at various locations on the LRC corridors, and that track maintenance standards and practices and regulatory oversight did not recognize the spalled condition as a safety defect and had not taken LRC wheel size and speed into consideration.

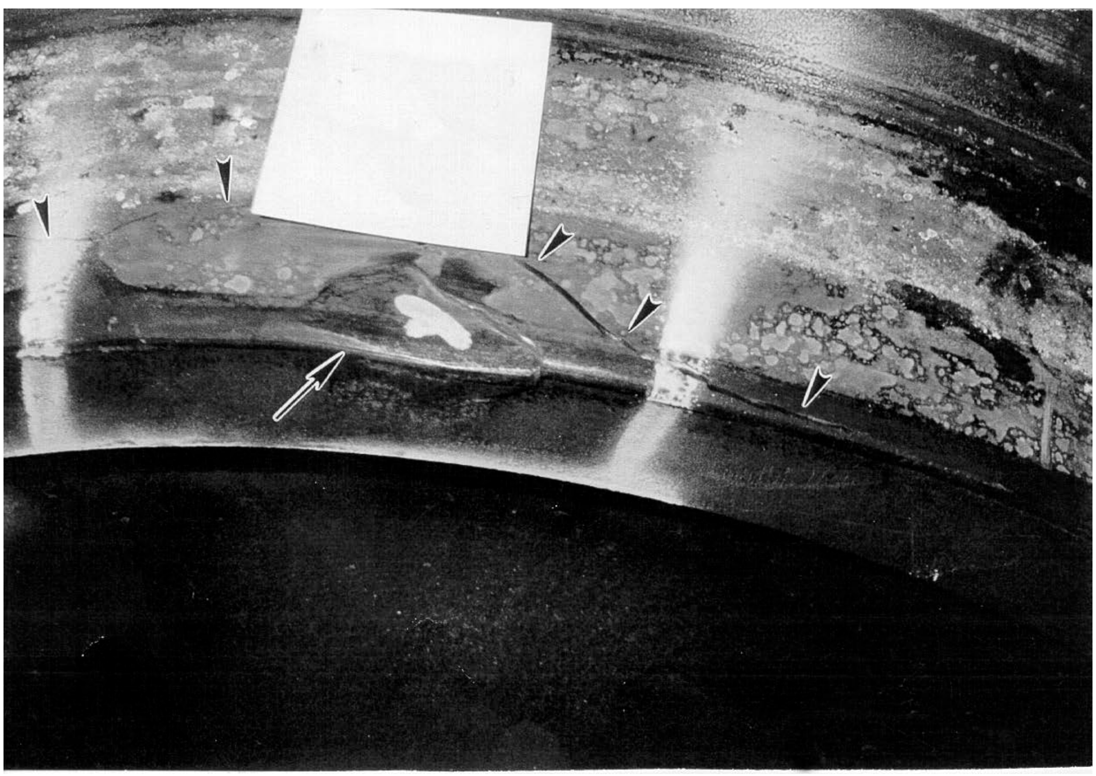
*Ce rapport est également disponible en français.*

# 1.0 Factual Information

## 1.1 The Incident

### 1.1.1 Wheel Impact Marking

On 15 August 1995, VIA Rail Canada Inc. (VIA) train No. 65 made an uneventful trip from Montreal to Toronto. No operating exceptions were noted by the train crew during the trip, most of which was on the Canadian National (CN) Kingston Subdivision (approximately 320 miles) at speeds of up to 100 mph. After the passengers detrained at Union Station, the train was moved to the Toronto Maintenance Centre for a trip inspection. During the trip inspection, 24 wheels, on what had been the south side of the train during the trip, were observed to have impact damage. The impact marks were all roughly the same size and were located on the wheel tread near the face of the rim; the severity of the damage varied (see Figure 1).



On 17 August 1995, VIA initiated a walk-by inspection as LRC trains stopped at each station along the Kingston Subdivision. A VIA employee performed each inspection, which included an examination of both sides of the train, focussing on the exposed surfaces of the wheel tread, rim face, plate, and hub of all wheels. At the same time, enhanced CN track patrols were dispatched along the Kingston Subdivision to examine the track. No damaged wheels were discovered and no track problems were identified.

On 20 August 1995, an LRC train equipped with impact measuring devices was dispatched along the Kingston Subdivision in an attempt to identify locations of excessive wheel impact, while operating at the authorized timetable speed. No excessive wheel impact measurements were noted.

The following week, CN personnel, over a period of 48 hours, inspected the wheels of freight trains travelling along the Kingston Subdivision. No marked wheels were noted.

On 25 October 1995, TSB investigators and CN personnel observed a track frog with a spalled manganese wing at Mile 270.6 near Port Hope, Ontario. The spall, located at the weight transfer point of the frog, was about 1½ inches wide, 8 inches long and ¾ inch deep (see Figure 2).

Frog spalling is the result of rolling contact fatigue between the wheels and the frog. A horizontal crack develops below the surface of the wing. Continued service results in vertical fatigue cracks propagating from the ends of the horizontal crack, and eventual separation of a large piece of the manganese wing. The sharp-edged cavity created in the running surface imparts the most serious damage to the very next wheel to traverse it, and then the wheel damage subsides as the continuous traffic action pounds and blunts the edge of the cavity.

[1] A large casting used in track work to allow wheel flanges to cross over opposing rails in turnouts.

In response to the spalled manganese frog found at Mile 270.6, the TSB performed the following three simulations at that location to determine if a wheel tread would contact the base of the spall:

1. A VIA LRC wheel set was placed over the spalled area.
   Result: the edge of the wheel tread contacted the base of the spall.

2. The spall cavity was sprayed with paint just before a VIA LRC train passed over, at about 10 mph.
   Result: the wheel tread did not contact the base of the spall.

3. The spall cavity was sprayed with paint and a VIA LRC train passed over at the authorized timetable speed of 45 mph.
   Result: the wheel tread contacted the base of the spall, marking the wheel tread with paint.

On 14 November 1995, the TSB and CN conducted a Hi-rail examination of the Kingston Subdivision between Mile 38 and Mile 117 to examine frogs and switches. Spalling defects on rail bound manganese frogs—requiring immediate attention—were found at Mile 92.1, Mile 104.7, Mile 101.9, and Mile 113.3. At Mile 113.3, the spall defect had developed to the point of requiring an immediate speed reduction and frog replacement. This frog was sent to the TSB Engineering Branch for examination.

### *1.1.2 Interim TSB Recommendations*

On 05 December 1995, the Board issued the following interim recommendations. To reduce the risk of a derailment due to a wheel failure, the Board recommended that:

> The Department of Transport require that all spalled manganese wing rails that could damage LRC wheel treads be located, and repaired or removed;
>
> (R95-03, issued December 1995)
>
> The Department of Transport evaluate the effect of speed on the impact forces on manganese wing rails during weight transfer of LRC wheels, and impose speed restrictions if required;
>
> (R95-04, issued December 1995)
>
> The Department of Transport confirm the adequacy of the inspection and maintenance standards and practices for manganese wing rails used by CN North America on track used by LRC trains; and
>
> (R95-05, issued December 1995)

> The Department of Transport determine whether conventional passenger car or freight wheels are being damaged by spalled manganese wing rails in operations outside the LRC corridor.
> (R95-06, issued December 1995)

Transport Canada's (TC) response to Board recommendations R95-03, R95-05 and R95-06 was viewed as satisfactory. TC inspectors examined all frogs on the Montreal–Toronto corridor and were satisfied that there was no threat to safe railway operations. TC also reviewed CN's inspection and maintenance standards and practices concerning manganese wings and believes safety requirements are being met. TC explored the issue of similar damage being experienced outside the LRC corridor and found no evidence that wheel damage was occurring elsewhere.

On 08 December 1995, in response to TSB Recommendation R95-04, CN placed a temporary slow order on VIA LRC trains. CN rescinded the slow order on 14 December 1995 after consultation with Dr. D.H. Stone, an expert on wheel failure phenomena with the Association of American Railroads. Dr. Stone concluded that, unless the wheels have been grossly overheated and then chilled, the tread surface is in a state of residual compression. Cracks that might form as a result of cold working at a notch are not dangerous to wheel performance as they would not run into the wheel radially, but would run parallel to the wheel surface and eventually chip out.

### *1.1.3 Conflicting Laboratory Reports*

#### *1.1.3.1 CANAC Railroad Technologies*

CANAC Railroad Technologies (CANAC) was retained by CN to evaluate the damaged wheels. CANAC produced a report in March 1996, which concluded:

1. While sharp edges on lubricator plungers and RBM (rail bound manganese) frogs in laboratory tests both dented VIA LRC Class B wheels, it is felt that the circumstantial evidence more strongly points to the plungers as the probable cause of the observed damage. The plungers are considerably harder than the frogs.

2. It is felt that the removal of the lubricator plungers by CN from the VIA routes (fait accompli) has provided a passive solution to the wheel denting problem, but time with no damage will have to provide the final proof.

### 1.1.3.2 TSB Engineering Branch

The TSB Engineering Branch examined three damaged VIA LRC wheels and the spalled frog. The results are recorded in report LP 174/95, dated 16 June 1996, and are summarized as follows:

Damaged LRC Wheels

1. Marks consistent with high-pressure impact were observed on the lip of the wheels at the outboard edge of the tread.

2. The impact marks and metallurgical findings observed on the wheels were consistent with damage resulting from the interaction with frogs in poor condition.

3. The subjective nature of the inspection criteria listed in Standard Practice Circular (SPC) 3500 and the CN Manganese Trackwork Welding Training Guide may be a factor that influenced the poor maintenance observed on the subject frog. Quantitative criteria would reduce the subjective nature of the inspection.

4. A load analysis showed that wheel speed is the most significant factor influencing the severity of impact when wheels traverse cavities in damaged and spalled out frogs.

The Frog

1. The frog was damaged as a result of spalling (rolling contact fatigue).

2. The spalling had reached an extent such that large sections of the running surface were missing.

3. Spalling likely started as cracking in the heat-affected zone of the repair weld.

Load Analysis of Damaged Railway Wheel

1. The damage is considered to be caused by the wheel striking the far edge of the cavity and pressing downwards as the wheel climbs up out of the cavity.

2. Both smaller wheel diameter and higher train speed contribute to higher impact forces on the wheel as it passes over a cavity. This leads to greater damage to passenger car wheels, which have a smaller diameter and which travel more quickly. Of these two effects, train speed is considered

[2] This report is available upon request from the Transportation Safety Board of Canada.

to be most significant. The damage threshold speed was not determined, but is considered to lie above the normal speed range of freight trains, and within the speed range of passenger trains.

### *1.1.4 Additional Impact Damage*

On 11 July 1996, trains in both Toronto and Montreal were observed with impact marking identical to past damage. In response to this discovery, the TSB and CN conducted an extensive three-day examination, by Hi-rail, of frogs and switches between Mile 38.9 and Mile 319.7 of the Kingston Subdivision, beginning on 15 July 1996. Ten frogs were observed in service that were deemed by railway supervisors to be either "condemnable," "to be replaced," "due to be changed out," "scheduled to come out," or "scheduled for replacement." In addition, at Mile 256.1, four frogs with spalling were observed in the process of being replaced by maintenance-of-way employees, independent of the examination. Spalling, ranging from about ¾ inch deep and to approximately 24 inches long, with sharp, jagged edges, was observed at locations where weld repairs existed. Corrosion was noted over the surface of the spalls at most locations. Spalled wings were found on both the south track and north track.

CN, with the TSB, then checked frog conditions along the Oakville, Dundas, Strathroy, and Chatham subdivisions upon which VIA passenger trains operate. Damaged manganese wings were found. The damage consisted of chipping and spalling defects similar to those found on the Kingston Subdivision. The authorized timetable speed is 80 mph along these subdivisions. Frogs were also examined on the Saint-Hyacinthe and Drummondville subdivisions and were all noted to be in good condition.

## 1.2 Damage to Wheels on VIA LRC Trains

A summary of like occurrences, as supplied by VIA:

| Date | Train No. | Damage | Repair | Maintenance Centre |
|---|---|---|---|---|
| 12 August 1994 | VIA 52 | 16 coach wheels<br>4 locomotive wheels | 16 coach wheel sets replaced<br>4 locomotive wheels reprofiled | Montreal |
| 12 August 1994 | VIA 40 | 12 coach wheels<br>4 locomotive wheels | 12 coach wheel sets replaced<br>4 locomotive wheels reprofiled | Montreal |
| 01 March 1995 | VIA 66 | 12 coach wheels<br>4 locomotive wheels | 4 coach wheel sets replaced<br>8 coach wheels reprofiled<br>4 locomotive wheels reprofiled | Montreal |
| 31 March 1995 | VIA 36 | 12 coach wheels | 12 coach wheels reprofiled | Montreal |
| 15 August 1995 | VIA 65 | 24 coach wheels | 22 coach wheels reprofiled<br>2 coach wheels replaced | Toronto |
| 17 October 1995 | VIA 66 | 12 coach wheels | 12 coach wheels reprofiled | Montreal |
| 11 July 1996 | VIA 65 | 12 coach wheels | 12 coach wheels reprofiled | Toronto |
| 11 July 1996 | VIA 52 | 12 coach wheels | 12 coach wheels reprofiled | Montreal |

## 1.3 Particulars of the Track

The Kingston Subdivision is a double main track that extends from Dorval, Mile 10.3, to Toronto, Mile 333.8. The track contains many crossovers between the south track and the north track that permit trains to move from one track to the other in either direction. The authorized maximum timetable speed is 100 mph for passenger trains, 60 mph for freight trains and 65 mph for express freight trains. Approximately 20 passenger trains and about 28 freight trains pass over the Kingston Subdivision daily.

The track structure consists of a mix of 132-pound and 136-pound continuous welded rail with a mix of No. 12 and No. 20 turnouts. The track is in good general condition.

## 1.4 Track Maintenance

### 1.4.1 Transport Canada's Track Inspection Program

Since the passage of the *Railway Safety Act* in 1989, TC has held railways responsible for a safe railway system. TC's strategic objective is to perform track monitoring activities that will focus on safety systems and patterns of compliance, to determine systemic safety problems. The function of regional officers is not to inspect, but to carry out a monitoring or audit function. TC's program is based on random sample techniques and, when a systemic problem is identified in a section of track inspected, the rail safety infrastructure inspector will carry out extra track inspections outside the random sections of track to see if the same condition prevails elsewhere, hence to provide a sense of the overall state of compliance with TC's Track Safety Rules. Rail safety inspectors are also instructed that, when they deem it necessary to carry out follow-up inspections, they are to go beyond the defects identified in the samples, or those reported to the railways, and address systemic deficiencies. While TC headquarters provides guidance on how and what to monitor, individual track monitoring programs are developed by regions to suit local conditions. Selecting the type of inspection to be undertaken (whether cursory or detailed), and follow-up of compliance, is done by the region. Cursory inspections involve travelling over a subdivision (or portion thereof) assessing general conditions of the track, reviewing log books, geometry car reports and rail defect reports, and inspecting randomly picked components in depth. A detailed inspection involves the examination of every turnout and railway crossing on the main track.

### *1.4.2 Frog Maintenance Requirements*

CN's SPC 3500 outlines that frogs:

> (a) [Be] In good operating condition . . . .
>
> (c) [and that] Point and adjacent running surface not [be] excessively worn. 10 mm maximum (3/8 inch).

The Track Safety Rules are used by TC to prescribe minimum safety requirements for railway track. The Rules do not identify any minimum safety requirements for the tread portion of a frog casting that is spalled; instead, they deal specifically with conditions of wear and the condition of the point.

CN states that, although SPC 3500 indirectly addresses the question of spalling, it is intended to prevent frogs from being in service when the vertical wear is so great as to permit wheel flanges to run on the bottoms of the frog flangeways.

### *1.4.3 Welding Guidelines*

Spall damage to frogs is repaired by weld-filling the spall and grinding the weld smooth. The repair is not as resilient as the original material. Wheel impact can cause the repair to chip out.

# 2.0 Analysis

## 2.1 Introduction

Although it was triggered specifically by the 15 August incident, this investigation was quickly expanded to cover a series of similar incidents of LRC wheel damage over a two-year period between August 1994 and July 1996. The length of the investigation is a reflection of the difficulty experienced by all involved in trying to find a definitive explanation. Although many hypotheses were explored, most were found to be highly improbable. The two hypotheses that were most supported as the proximate cause of the wheel damage are: defective RBM frogs (favoured by the TSB) and defective rail lubricator plungers (favoured by CN's technical advisor, CANAC). The analysis addresses both hypotheses and explains why the TSB considers the damaged frogs to be the much more likely explanation. More importantly, the investigative report outlines the safety risk presented by defective frogs and describes the action taken by TC and CN to reduce that risk.

## 2.2 The Wheel Damage

### 2.2.1 General

While it is accurate to state that the compressive residual stresses manufactured into VIA wheels increase the likelihood that cracks in the wheel tread initiating at impact points would safely travel parallel to the rim surface, the potential for catastrophic wheel failure existed. The VIA derailment of 22 April 1995 near Blue River, British Columbia (TSB report R95V0089), is attributable to wheel failure from internal overstress cracking. The investigation revealed that the wheels may not have been properly heat-treated at manufacture. It is apparent, therefore, that this safeguard cannot be relied upon to prevent wheel failure. It is also believed that, considering the size of some observed frog defects and the speed of VIA trains, there was a potential for derailment as a result of catastrophic wheel failure or rail failure from broken wheel impact forces.

### 2.2.2 Consideration of the Frogs

In June 1996, the TSB Engineering Branch report concluded that spalled frogs had caused the wheel damage.

[3] The 1996 report was amended in July 1998 to clarify some of the analysis.

While this conclusion was disputed by CN and CANAC, the Board is of the opinion that it is the conclusion most consistent with the physical evidence. It bases this opinion on a number of factors, including: the examination of the damaged frog; the examination of the damage to the wheels; the field examinations of numerous spalled frogs in service along the Kingston Subdivision, and the above-cited factors that repudiate the lubricator plunger hypothesis.

After impact damage to VIA wheels on the Kingston Subdivision, the frog at Mile 113.3 was removed and examined in the laboratory. It had been damaged by spalling or rolling contact fatigue. High-pressure impact marks were noted, at the outboard edge of the tread, on the lips of three VIA wheels examined at the laboratory. This was consistent with damage resulting from their interaction with frogs in poor condition. A load analysis indicated that wheel speed is the most significant factor influencing the severity of impact when wheels traverse cavities in damaged and spalled out frogs.

As a result of the investigative process, defective frogs were either removed from service or repaired, and this is believed to explain the wheel damage-free operation between October 1995 and July 1996, when service-related frog defects were again detected.

### *2.2.3 Consideration of the Lubricator Plungers*

In its March 1996 report to CN, CANAC identified the lubricator plungers as the probable cause of the wheel damage. The TSB Engineering Branch did not concur as seven of the eight incidents of wheel damage had occurred on trains that had travelled between Montreal and Toronto on the Kingston Subdivision and there were no lubricators located on this corridor. It was also noted that, although the other train with damage had travelled on the CN Alexandria Subdivision (Ottawa to Montreal), and this subdivision had two lubricators located at Mile 30.1, this equipment had travelled from Toronto to Brockville, Ontario, on the Kingston Subdivision before diverging for Ottawa. The TSB Engineering Branch also noted that the mass and geometry of functioning plungers render them incapable of creating the damage observed. If a lubricator was jammed or seized solid with the plunger above the rail head (a necessary condition for the plungers to dent the wheels), one would have expected the lubricators on the Alexandria Subdivision to have been in such a condition, but they were not.

It would seem that the lack of recurrent impact damage soon after the removal of the lubricators lent credibility to their (CANAC) hypothesis. The TSB notes that its Engineering Branch report of June 1996 identified the problem, but that this report was disputed by TC and CN at the time. Since the attention to frogs in the Montreal–Toronto corridor (prompted by the TSB investigation) temporarily mitigated the safety risk, this response did not affect passenger safety.

### *2.2.4 The Maintenance and Repair of Frogs on the Main Track*

Although the observed condition of the track met the maintenance requirements of the CN SPC and the CN Manganese Trackwork Welding Training Guide, the issue of a spall defect on the wing of a frog is not properly addressed. Requirements for the maintenance and repair of frogs focus on situations where the frog is worn, and the spalling per se is not recognized as a safety defect. It is apparent that spalling can pose a safety hazard.

# 3.0 Conclusions

## 3.1 Findings

1. The most likely source of the wheel damage was the passage of LRC equipment, at speed, over spalled wings of rail bound manganese frogs.

2. Damage to the LRC wheel treads could lead to a wheel failure and derailment or to subsequent track failure and derailment from the associated heavy impact forces.

3. Though many spalls appear not to cause wheel damage, their presence on track used in passenger service is a safety risk.

4. CN track maintenance standards and practices, and regulatory safety inspections, did not include wing spalls as a safety defect.

## 3.2 Cause

The damage to the wheels was most likely the result of impact with spalled rail bound manganese frogs (at the point where the wheel load transfers from the running surface of the point of frog to the wing) at various locations on the LRC corridors, and track maintenance standards and practices and regulatory oversight did not recognize the spalled condition as a safety defect and had not taken LRC wheel size and speed into consideration.

# *4.0 Safety Action*

## *4.1 Action Taken*

CN promptly commenced inspections of track structures on the LRC corridor to identify the frogs suspected of causing wheel damage, and repaired or replaced all frogs having spalled manganese wings. VIA inspected all LRC equipment, and renewed or repaired all wheels that were identified as damaged.

VIA and the Board carried out laboratory evaluations of the damage to the wheels in an effort to identify and eliminate the cause.

## *4.2 Safety Concern*

There has been no recurrence of this type of LRC wheel impact damage since 11 July 1996. Transport Canada advises that the issue continues to be given special attention and that, although its railway safety inspectors have identified defective manganese frogs in service, damage characteristic of the condition that dented LRC wheels has not been observed.

The Board notes that the badly spalled condition, as observed in this investigation, is still not considered to be safety sensitive and cause for repair or replacement per railway standards or regulatory requirements. Although the Board recognizes that the probability of LRC wheel failure from impact with spalled manganese frogs is low, such an eventuality cannot be discounted.

The Board agrees that the heightened awareness of this matter from the various occurrences and this investigation will help mitigate the risk in the short term. However, the Board remains concerned that Transport Canada does not recognize spalled manganese frogs as a safety-sensitive defect for high-speed passenger corridors and that the Track Safety Rules do not identify spall limits and outline repair or replacement requirements.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 08 January 1999.*

# *Appendix A - Glossary*

| | |
|---|---|
| CANAC | CANAC Railroad Technologies |
| CN | Canadian National |
| LRC | Light, Rapid, Comfortable |
| mph | mile(s) per hour |
| RBM | rail bound manganese |
| SPC | Standard Practice Circular |
| TC | Transport Canada |
| TSB | Transportation Safety Board of Canada |
| VIA | VIA Rail Canada Inc. |