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

RAILWAY INVESTIGATION REPORT
R06T0022

MAIN-TRACK DERAILMENT

CANADIAN PACIFIC RAILWAY
FREIGHT TRAIN 230-30
MILE 114.65, MACTIER SUBDIVISION
BUCKSKIN, ONTARIO
31 JANUARY 2006

Canada

Transportation Safety Board of Canada | Bureau de la sécurité 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 Investigation Report

Main-Track Derailment

Canadian Pacific Railway
Freight Train 230-30
Mile 114.65, MacTier Subdivision
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Report Number R06T0022

Synopsis

On 31 January 2006, at approximately 0750 eastern standard time, southward Canadian Pacific Railway freight train 230-30 derailed one car at Mile 114.65 of the MacTier Subdivision. The train continued at 45 mph to Mile 103.48 near Buckskin, Ontario, where it experienced an undesired emergency train brake application and 11 additional cars derailed. Approximately 400 feet of track, including the Buckskin Siding north turnout and signal structures, were destroyed and the preceding 11 miles of track was heavily damaged. There were no dangerous goods involved and no injuries.

Ce rapport est également disponible en français.

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1.0 *Factual Information*

1.1 *The Accident*

On 31 January 2006 at 0718 eastern standard time,[1] Canadian Pacific Railway (CPR) coil steel unit freight train 230-30 (the train) departed MacTier, Ontario, and proceeded southward destined for Hamilton, Ontario. The crew members, a locomotive engineer and a conductor, were qualified for their respective positions, familiar with the territory, and met fitness and rest standards. The train consisted of 3 locomotives and 33 cars, including 25 gondola cars loaded with steel coil. The train weighed 4124 tons and was 1934 feet long.

At 0804, while the train was travelling at 45 mph with the throttle in position 3, a train-initiated emergency brake application occurred at Mile 103.48. The lead locomotive came to rest at Mile 102.89, near Buckskin, Ontario (see Figure 1). The crew followed emergency procedures, inspected the train, and determined that 12 cars, the 19th to the 30th from the head end, had derailed.

Figure 1. Derailment location (Source: Railway Association of Canada, *Canadian Railway Atlas*)

At the time of the accident, the temperature was -2°C and the sky was overcast.

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

1.2 Site Examination

The 19th car from the head end, CP 346875, was the first derailed car. This car came to rest at Mile 103.6 in an upright position. Its No. 1 wheel set had dislodged from under the trailing truck and was on the right-of-way, west of the track near Mile 103.7. The L1 wheel from this wheel set had moved inboard off the axle wheel seat onto the axle body (see Photo 1). Score marks were observed on the wheel bore and axle body. The 20th to 30th cars came to rest in various positions along the right-of-way. The No. 1 wheel set from car CP 346875 was forwarded to the TSB Engineering Laboratory for examination.

Photo 1. No. 1 wheel set from car CP 346875 (Source: Canadian Pacific Railway)

In the immediate derailment area, approximately 400 feet of track, including the Buckskin Siding north turnout and signal structures, was destroyed and a signal building was damaged. At the north end of the derailment site, heavy gauge side damage to rails, anchors, tie plates, and crossties was observed. From this location, track damage consistent with wheel impacts extended northward on the main line for approximately 11 miles to a series of short trestle bridges that traverse the Moon River. The first marks observed were at Mile 114.65, on the base of the east (high) rail of a three-degree, right-hand curve (in the direction of travel). Within the 11 miles of damaged track, approximately 700 rail base breaks and 22 transverse rail fractures were observed. Eight miles of continuous welded rail (CWR) had to be replaced (see Figure 2).

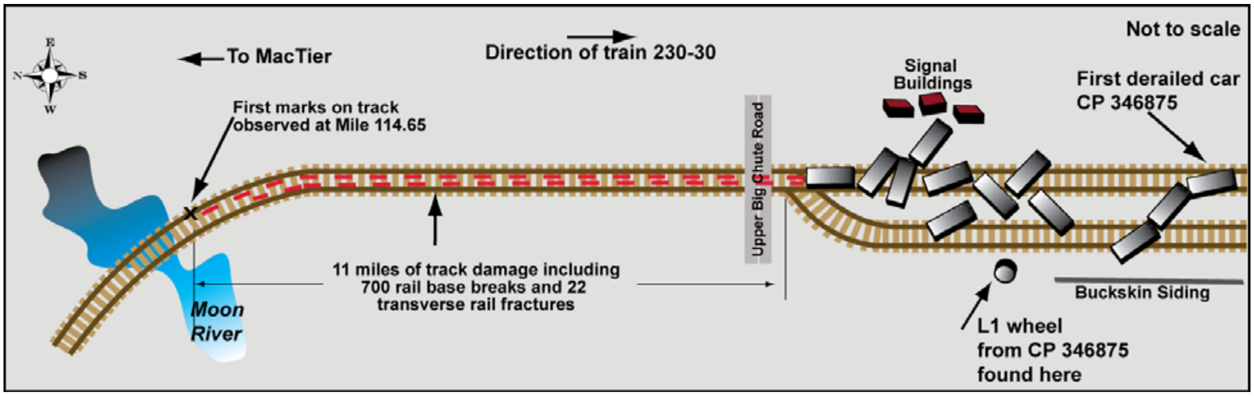

Figure 2. Derailment site

1.3 *Track Information*

The MacTier Subdivision consists of a single main track that extends northward from Osler, Ontario (Mile 0.0), to MacTier, Ontario (Mile 126.9). Train movements in the derailment area are governed by the Occupancy Control System as authorized by the *Canadian Rail Operating Rules* (CROR) and supervised by a rail traffic controller located in Montréal, Quebec. The track is Class 4 according to Transport Canada (TC)–approved *Railway Track Safety Rules* (TSR). The maximum speed permitted is 50 mph for expedited freight trains. Rail traffic consists of approximately 29 freight trains per day with an annual tonnage of about 30 million gross tons.

Throughout the derailment area, the track consisted of 115-pound CWR. The rail was laid on 14-inch tie plates, secured to hardwood ties with six spikes per tie. Every second tie was box-anchored. The ballast consisted of crushed rock and slag. The cribs were full and the shoulders extended from 12 inches to 24 inches beyond the end of the ties. Between Mile 114.7 and Mile 114.3, the track descends gradually then transitions to a 1.1 per cent ascending grade in the southward direction.

Throughout the derailment area, track inspections were performed regularly in accordance with the TSR. The most recent visual inspection was performed in the derailment area by a hi-rail vehicle on 30 January 2006. During this inspection, several missing bolts were replaced, but no other exceptions were noted. CPR’s track evaluation car performed a track geometry inspection on 31 October 2005 and no urgent defects were identified. The rails were ultrasonically tested by the rail flaw detector car on 16 January 2006 and no anomalies were observed.

1.4 *Freight Car CP 346875*

The first derailed car was coil steel gondola car CP 346875. It was built in September 1999 and had a gross rail load (GRL) capacity of 286 000 pounds. Cars that carry loads in this capacity range are referred to as being in heavy axle load (HAL) service. Since the average weight for an empty freight car is approximately 63 000 pounds, cars in HAL service can carry loads of up to 223 000 pounds (approximately 110 tons). In contrast, standard freight cars have a GRL capacity of 263 000 pounds and can carry loads of up to 200 000 pounds (approximately 100 tons). Car CP 346875 was in captive coil steel HAL unit train service between Sault Ste. Marie, Ontario, and Hamilton. Track through this area is generally considered to be steep gradient and high-curvature territory.

The No. 1 wheel set was placed under car CP 346875 during routine maintenance at Sault Ste. Marie on 04 October 2004. The installed wheel set was from a shipment of wheel sets from the Progress rail wheel shop in Winnipeg, Manitoba (PRWW). The wheel mount date indicates that the wheels were mounted on the axle by Canadian National's (CN) Transcona wheel shop in Winnipeg, in December 1998. The roller bearing locking plate stamp indicates that reconditioned roller bearings were applied to the wheel set by PRWW in September 2004. PRWW was formerly CPR's main wheel shop and is currently its main wheel set supplier. There are no industry records available to track the service life of this wheel set, or to identify the cars it has been under from the time of its assembly in 1998 until the derailment in 2006.

1.5 *Freight Car and Wayside Inspection*

Railway freight cars are visually inspected according to TC–approved *Railway Freight Car Inspection and Safety Rules.* In addition to this requirement, other visual pre-departure and en route train inspections are conducted as necessary. The required inspections were performed on the train on 30 January 2006 and no exceptions were noted for car CP 346875.

To supplement the visual inspections of freight cars, CPR has equipped its rail network with electronic wayside inspection systems (WISs) to assess the condition of rolling stock equipment while en route. WISs are spaced approximately 25 miles apart along main-line track and normally include a hot box detector, a hot wheel detector, and a dragging equipment detector. Wheel impact load detectors (WILDs) are also installed at strategic locations along the track to identify shelled, flat, or broken wheels that exceed impact thresholds. Unless the wheels are already derailed, these systems do not detect loose or out-of-gauge wheels.

Technology is available that can detect out-of-gauge wheel sets before they derail. Wheel profile detectors (WPDs), built into the track structure, use optical scanners to record wheel tread profiles and wheel back-to-back measurements as rolling stock passes over the detector. CN is the only railway in Canada to install WPDs, one at Arnold, British Columbia, and the other at Nattress, Manitoba. Due to a directional running agreement, the CN site at Arnold also scans wheels on CPR traffic destined for the Vancouver, British Columbia, area. With the exception of these two locations, freight cars operating on other railways or interchange service in Canada do not receive WPD inspections.

1.6 *Derailments Involving Canadian National's Transcona Wheel Shop*

Six weeks before the Buckskin derailment, another CPR main-track train derailment was initiated by a loose wheel. On 16 December 2005, CPR freight train 230-15 derailed car CP 346898, a gondola car loaded with steel coils, at Mile 58.9 of the Hamilton Subdivision. CPR's investigation revealed that a loose 36-inch wheel, mounted by the CN Transcona wheel shop in January 2000, had moved inboard, resulting in the loss of wheel set gauge and causing the derailment. The wheel set from the CPR derailment on the Hamilton Subdivision was also forwarded to the TSB Engineering Laboratory for examination. In both of these accidents, the roller bearing locking plate stamp identified that reconditioned roller bearings were applied to the wheel set by PRWW in September 2004.

Since the Buckskin derailment, there have been two additional derailments caused by CN's Transcona wheel shop loose wheels.

From 2000 to date, CN has documented a total of 15 main-track derailments in Canada caused by loose wheels (see Figure 3). A detailed listing of these derailments is presented in Appendix A. In addition, it has documented at least two other loose wheel derailments that occurred outside Canada. CN has reported an additional 48 wheel sets with loose wheels detected by subsequent inspection (see Appendix B). In each of these cases, the wheels were mounted by the CN Transcona wheel shop between April 1998 and February 2001 and became loose.

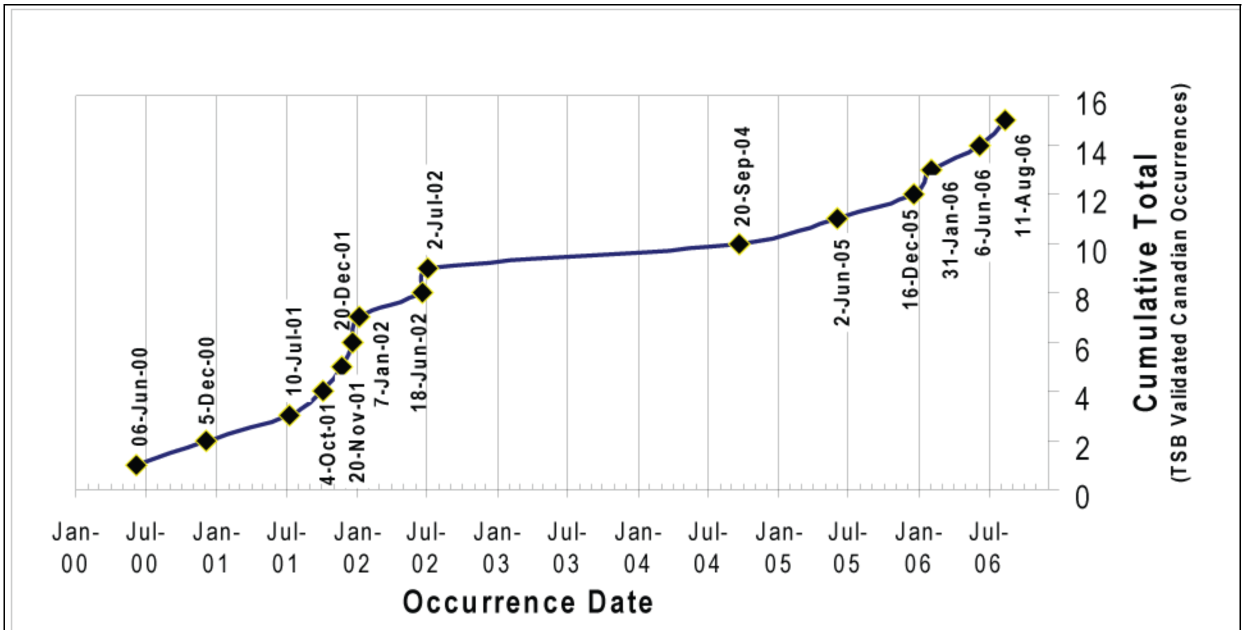

Figure 3. Cumulative main-track derailments in Canada involving loose 36-inch Canadian National Transcona wheel shop wheel sets, by date

1.7 *Association of American Railroads Wheel Shop Practice and Wheel Set Assembly*

Wheel sets are assembled in compliance with the Association of American Railroads (AAR) *Manual of Standards and Recommended Practices* (MSRP), Section G, Part II.[2] The manual sets out the minimum manufacturing standards for practices related to wheel set manufacturing and reconditioning.

Wheel sets are assemblies consisting of two wheels, which are bored and pressed onto an axle wheel seat, and two roller bearings pressed onto the axle journals. The wheel bores are centred then bored to a diameter sufficiently smaller than their matching axle wheel seat to ensure the proper interference fit. In the wheel boring process, one rough cut and one finishing cut are usually made to match each wheel bore to a specific axle wheel seat. After boring, the matched wheels and axle are aligned, the mounting surfaces are lubricated, and the wheels are pressed on (see Photo 2). The same practice is followed for all freight car wheel sets.

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2 Association of American Railroads, *Wheel and Axle Manual, Manual of Standards and Recommended Practices* (G-II Manual), 16th Edition, revised 01 May 1998.

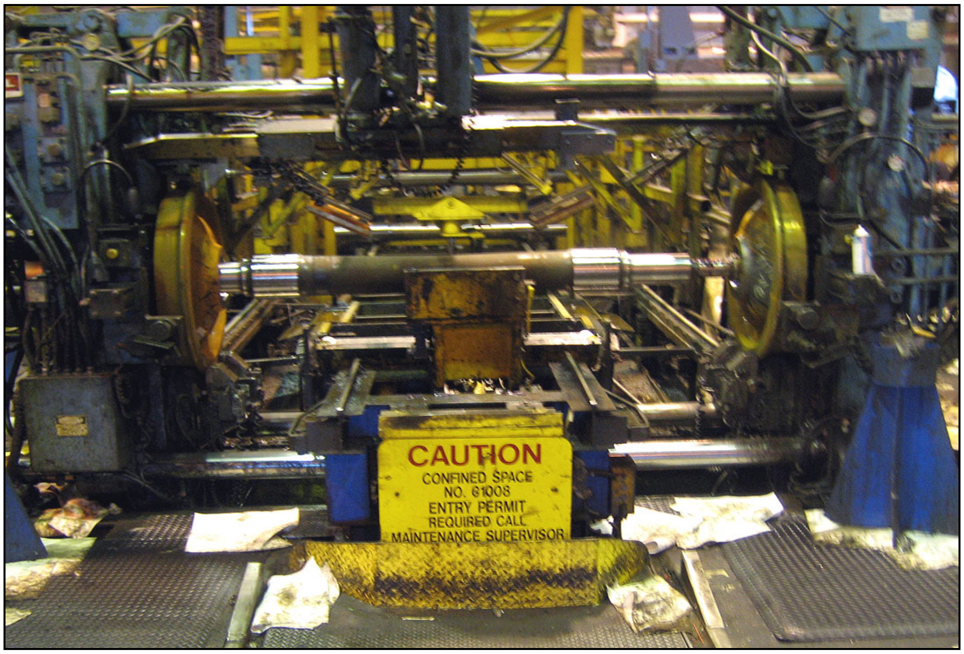

Photo 2. Wheel mount press

The CN Transcona wheel shop wheel shop is an AAR–approved facility. The AAR conducts audits to verify that shop processes meet its standards. Non-compliance can result in decertification or fines. Between April 1998 and February 2001, the AAR conducted four audits of the Transcona wheel shop. In each case, the Transcona wheel shop processes were in compliance with AAR standards.

In 1998, Section G, Part II, of the AAR MSRP required that, for 36-inch wheel set assemblies, which are used in both regular (263 000 GRL) and HAL (286 000 GRL) service:

- The bore finishing cut should be approximately 1/64 of an inch thick.[3]
- To ensure a proper interference fit between the wheel bore and axle wheel seat, a wheel mounting press-on tonnage of between 90 tons and 160 tons must be attained and recorded. The wheel mount tonnage records must be kept for five years.[4]

The standard did not set minimum requirements for surface finish, feed rate of the ram, or speed of cut.

In 2004, the G-II Manual was revised, but the requirements relating to wheel bore finish, wheel mount press-on tonnage, and record keeping remained unchanged. The current wheel boring, mounting and record keeping standards were developed at least 40 years ago, when most of the record keeping was done on paper and the majority of rail traffic was 50-ton and 70-ton freight cars, well below today's 110-ton (286 000-pound GRL) capacity HAL cars.

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3 Rule 1D5 of the G-II Manual, 1998, p. 5.

4 Figure 4.23 (p. 61) and Rule 1E1 (p. 5) of the G-II Manual, 1998.

1.8 *Wheel Set Recording Marks, Service Life, and Record Keeping*

When wheels are mounted, the wheel mount date and shop identifier are stamped on the outboard hub of one of the wheels. Then, roller bearings are pressed onto the axle journals and a locking plate is installed on the roller bearing end cap. Markings on the locking plate identify the date the bearing was manufactured or reconditioned and the shop that applied the roller bearings. For wheel sets that have wheels and bearings mounted at the same time in new or remount assemblies, the locking plate information closely matches the wheel press-on information. For wheel sets that have been reconditioned through a wheel shop and have had wheel treads re-profiled and/or roller bearings replaced, the locking plate information will not match the wheel mount information.

The AAR requires that wheel set manufacturing information (for example, wheel mounting tonnage, wheel, axle and roller bearing manufacturing dates, serial numbers, reconditioning information) be recorded and maintained for five years by the wheel shop that performed the work. The PRWW wheel shop applies a bar code to the axle body that links all wheel set information. CPR retrieves the information using a bar code scanner and downloads the AAR required information directly into car maintenance records. CN digitally records wheel manufacturing and press-on tonnage information at its wheel press, but manually enters the AAR required information into car maintenance records.

Wheel sets are periodically removed from freight cars for defects or maintenance under criteria set out in the *Field Manual of the AAR Interchange Rules*. Removed wheel sets are replaced with a new or reconditioned wheel set. Wheel sets may be reconditioned several times, placed in service under several different cars after initial assembly and remain in service for up to 20 years. Rule 41, Section F, of the manual outlines information that railways are required to record from both the removed and newly installed wheel set when wheel sets are changed out. This information is used primarily for AAR billing purposes. Rule 41 does not require wheel mount dates or wheel serial numbers to be recorded when wheel sets are installed under freight cars.

1.9 *Canadian National–Led Research to Determine the Cause of Transcona Wheel Shop Loose Wheels*

In late 1997, the CN Transcona wheel shop had been experiencing a higher-than-normal frequency of wheel mount misfits in the assembly of 100-ton 36-inch wheel sets. In April 1998, the Transcona wheel shop implemented a modified wheel boring process using a different shaped finishing bit in an effort to resolve the misfit rate. While the modified boring process conformed to AAR standards, the new bit produced a cut with deeper, wider-spaced grooves and sharper peaks. The belief was that these peaks would plastically deform more easily and "lay down" during wheel mounting, thus reducing the misfit rate. Initial results were positive, but over time, the misfit rate increased. The modified wheel boring process was discontinued in February 2001.

According to the CN Transcona wheel shop production records, approximately 26 800 36-inch wheel sets were produced between April 1998 and December 1999, and another 17 000 were produced between January 2000 and February 2001, using the modified boring process.

In June 2000, CN observed several out-of-gauge wheels and at least one derailment in its coal fleet resulting from loose wheels (see Appendices A and B). All involved 100-ton 36-inch wheel sets assembled by the Transcona wheel shop. The loose wheel phenomenon was primarily observed in HAL service on territory where there were heavy grades and curvature with increased use of train air brakes. But over time, it has also been observed in regular 100-ton service.

By October 2001, the frequency of out-of-gauge wheel sets (8) and derailments (5) caused by loose Transcona wheel shop wheel sets had increased. CN initiated a number of studies with outside experts to determine why these wheel sets were experiencing an anomalously high number of in-service failures.[5, 6, 7] Initially, the problem was thought to be related to wheel manufacturing since most of the wheels involved were manufactured by Griffin Wheel. However, this was discounted by the studies. The studies were completed by February 2002 and linked the loose wheel events to the modified wheel boring process that the CN Transcona wheel shop had used between April 1998 and February 2001. The studies determined that:

- The deeper, wider-spaced grooves and sharper peaks produced by the modified Transcona wheel shop boring process reduced the contact area between the wheel bore and axle wheel seat by as much as 60 per cent, when compared to the earlier wheel boring process.

- The reduced contact area leads to higher stresses in the remaining areas of contact and causes fretting at the tips of the bore spirals.

- The fretting process occurs over time. It starts at the outboard and inboard interfaces between the wheel hub bore and the axle wheel seat and works inward toward the centre of the wheel hub bore.

- With normal freight car curving, lateral forces acting on the wheel flange cause the wheel to tip slightly, which forces the tips of the harder bore spirals into the softer axle wheel seat material (see Figure 4).

- The tipping forces initiate brinell indentations on the axle wheel seat and progressively loosen the interference fit.[8]

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5 Griffin Wheel, *Metallurgical Analysis of Loose Wheel Axles Returned from Canadian National Railway*, 19 November 2001.

6 T.F. Conry, Ph.D., *Report on the Out-of-Gauge Wheel Problem*, 20 January 2002.

7 J.D. Makinson, Ph.D, P.E. and H.C. Iwand, P.E., Rail Sciences Incorporated Presentation to CN on the "Results of CN Out-of-Gauge Wheel Investigation," 08 February 2002.

8 Section II, 9(e) of the Transport Canada–approved *Railway Freight Car Inspection and Safety Rules* prohibits a railway from placing or continuing a freight car in service with a wheel that shows evidence of being loose.

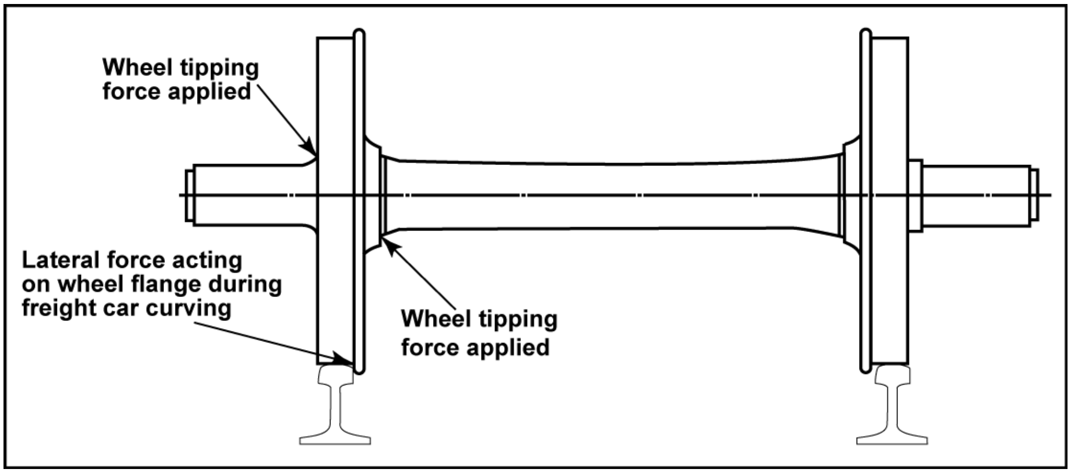

Figure 4. Forces acting on a wheel during curving

- The process continues to the point where only a small band of spirals near the centre of the wheel retained the interference fit. Under these conditions, these 36-inch wheels can rotate (screw) inboard, and occasionally outboard, off the axle wheel seat while in service, producing loose and out-of-gauge wheel conditions (see Photo 3).

Photo 3. Wheel movement on axle seat (2 ½ inches), typical of loose wheel-related occurrences

CN representatives indicated that the majority of loose wheel failures likely involved wheel sets with mounting tonnages at the low end of the 90-ton to 160-ton press-on standard. However, CN was only able to provide the recorded mounting tonnages for 14 wheel sets. Additional wheel mount tonnage data were unavailable because they had exceeded the AAR five-year minimum requirement for data retention. Of the 14 wheel sets that had recorded press-on tonnages, 10 of them (71 per cent) had press-on values of 110 tons or less.

1.10 *Industry Response to Transcona Wheel Shop Loose Wheel Issue*

TC was alerted to the Transcona wheel shop loose wheel issue by a CN presentation in November 2001. Similar presentations were made to several Class 1 railway companies, in Canada (Canadian Pacific Railway) and the United States (Burlington Northern Santa Fe, CSX Transportation, Florida East Coast Railway, Kansas City Southern, Norfolk Southern, and Union Pacific).

CN informed TC that it had been tracking loose wheels in its coal fleet and that the problem had been traced to a modified wheel boring process used between April 1998 and February 2001. CN indicated that it was working with the AAR to develop an advisory that would cover the subject wheel population. CN also noted that the current AAR wheel bore and assembly standards may need to be improved to eliminate this type of phenomenon in the future and later stated that current AAR standards may be marginal for modern HAL freight car duty. In 2002, TC monitored the CN wheel set gauging, car inspections, and wheel set exchanges related to this issue.

At CN's request, the AAR issued Circular C-9388 containing Early Warning (EW) 5183 to all member railroads on 30 November 2001. This notice targeted approximately 5000 foreign tank cars and called for the removal of any wheel set with CN Transcona wheel shop markings on the roller bearing locking plate dated June 1998, February 1999, March 1999, or September 1999. However, freight cars equipped with Transcona wheel shop wheel sets were still free to move in interchange service throughout Canada and the United States. Consequently, in early 2002, CN representatives again toured the major Class 1 railways in Canada and the United States to brief them on the loose wheel problem.

On 19 February 2002, at CN's request, the AAR issued Circular C-9428 containing Maintenance Advisory (MA) 74. MA 74 expanded the inspection criteria and the recall to include a total of 9381 foreign cars and called for the removal of all CN Transcona wheel shop wheel sets with roller bearing mounting dates between April 1998 and December 1999, when cars are found on the shop or repair track. As the cars were inspected by railway line point personnel, the AAR alert on the car was to be removed and the activity was to be reported to CN to maintain a centralized record. MA 74 did not include the CN car fleet or Transcona wheel shop wheel sets assembled between January 2000 and February 2001 and contained no requirement for wheel shop personnel to inspect wheel mount dates to identify Transcona wheel shop wheel sets assembled between April 1998 and February 2001. As of 09 November 2007, CN estimated that 10 000 to 12 000 Transcona wheel shop wheel sets remained in service.

1.11 Canadian National Internal Response to Transcona Wheel Shop Loose Wheel Issue

Internally, CN implemented additional procedures to protect against Transcona wheel shop loose wheel events in CN traffic:

- In October 2001, CN began manual back-to-back wheel measurements on its coal fleet using a hand-held laser measuring tool.
- In the fall of 2002, CN installed two WPDs, one at Arnold and the other at Nattress. As a result of the installation of the WPDs, manual checking of back-to-back measurements on wheel sets stopped.
- In March 2002, CN instructed all wheel shop personnel to inspect the wheel mount date stamped on the wheel hub on all incoming wheel sets. The personnel were instructed to de-mount the wheels from the axle of any Transcona wheel shop wheel sets identified with mount dates between April 1998 and February 2001 (that is, the full manufacturing window).
- CN performed a number of accelerated wheel inspections on its own fleet of coal gondola cars and on certain other similar fleets operating on CN lines (such as SULX, PWCX, BCNE, CNHX and CEFX). These inspections targeted the removal of Transcona wheel shop wheel sets assembled within the full manufacturing window.

Even after implementing additional procedures to protect against Transcona wheel shop loose wheel events, loose and out-of-gauge Transcona wheel shop wheel sets continued to be found on both CN and foreign cars. When loose wheels were found by a foreign car owner, CN and/or the car owner would conduct an accelerated inspection and removal program for the suspect Transcona wheel shop wheel sets. These inspections targeted Transcona wheel shop wheel sets assembled within the manufacturing window outlined in MA 74 (April 1998 to December 1999). However, when a foreign car owner reported a Transcona wheel shop loose wheel event outside the MA 74 manufacturing window, CN initiated accelerated wheel set removal programs targeting all Transcona wheel shop wheel sets assembled within the full manufacturing window (April 1998 to February 2001).

1.12 TSB Engineering Laboratory Report

Three loose CN Transcona wheel shop–mounted wheel sets were forwarded to the TSB Engineering Laboratory for failure analysis. These wheel sets included wheel sets from both CPR derailments (Buckskin and Hamilton) and a third loose wheel that was considered causal in a Quebec North Shore and Labrador (QNS&L) derailment that occurred on 11 August 2006. Three additional comparison wheel sets were selected from a population of Transcona wheel shop wheel sets removed from the CPR steel coil fleet during an accelerated inspection and removal program in the spring of 2006. The comparison wheel sets included:

- A wheel set mounted in February 1998, just before the full manufacturing window (April 1998 to February 2001).

- A wheel set mounted in April 1998, within the manufacturing window subject to MA 74 (April 1998 to December 1999).

- A wheel set mounted in October 2000, outside the manufacturing window subject to MA 74 (April 1998 to December 1999) but within the full manufacturing window (April 1998 to February 2001).

The following observations are drawn from TSB Engineering Laboratory report LP 026/2006:

- Before sectioning of the subject wheel sets, each of the wheel bore/axle wheel seat interfaces displayed various stages of deterioration in the intended interference fit between wheel and axle.

- All of the wheel bore/axle wheel seat assemblies examined displayed fretting and produced red oxide indicating that there was slight flexure, due to wheel tipping forces, occurring between the wheel bore and the axle wheel seat. The greater the flexure, the greater the amount of oxide generated (see Photo 4).

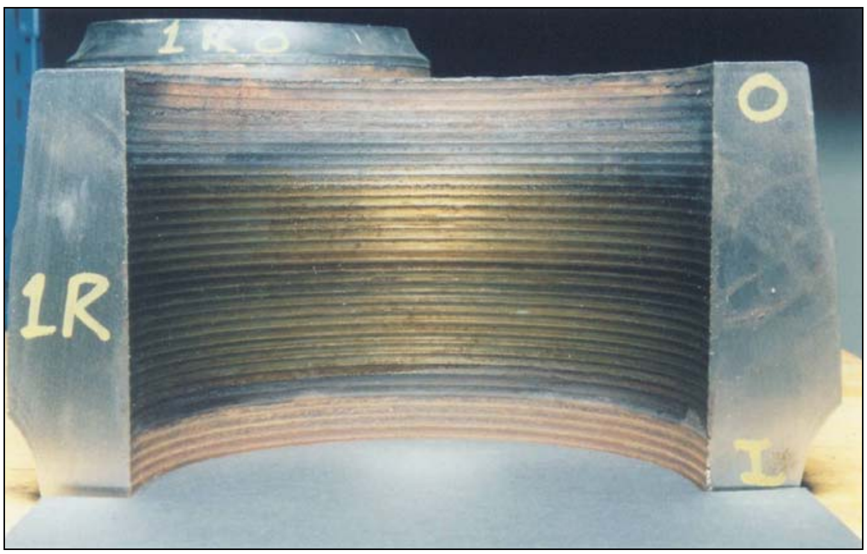

Photo 4. Typical cross-section of wheel bores examined

- All of the wheel seats, including those from the wheel set mounted outside the manufacturing window (February 1998), exhibited red oxide and surface brinelling[9] at the wheel seat extremities, which was consistent with flexure at the wheel bore/axle wheel seat interface (see Photo 5).

[9] Damage to a solid surface caused by one or more plastically formed indentations brought about by overload. (Source: American Society for Metals, *Metals Handbook*, Ninth Edition. Metals Park, Ohio 44073.

Photo 5. Typical axle wheel seat examined

- The observed axle wheel seat brinelling indicates a slight difference in material hardness between the wheel bore and axle wheel seat. The axle wheel seat brinelling was more severe on the three laterally displaced wheels. It appears that the brinelling of the axle wheel seats initiates movement at the wheel bore/axle wheel seat interface.

- Only the three wheels that experienced lateral displacement exhibited ratchet marks, galling or plastic deformation. The ratchet marks indicate minute rotational movements between wheel bore and axle wheel seat under load while the galling indicates larger rotational movement between bore and seat under load.

- The bore rate for the wheels examined varied between four and five turns per inch. Even on wheels bored at a feed rate of five turns per inch, movement between the wheel bore and axle wheel seat was occurring.

- With the exception of the QNS&L wheel, each of the other five wheel sets examined had reconditioned roller bearings applied by the PRWW wheel shop between March 2004 and January 2005.

The failure mechanism observed in the three laterally displaced wheels examined was consistent with the known failure mechanism associated with the Transcona wheel shop loose wheels.

1.13 *Canadian Pacific Railway Accelerated Wheel Removal Program on Coil Steel Cars*

Following CPR's first coil steel service CN Transcona wheel shop loose wheel derailment in December 2005, CPR contacted CN. CPR was aware of MA 74; however, the loose wheel involved was assembled in January 2000, just outside the population identified in MA 74. While these discussions were ongoing, the second CPR coil steel service loose wheel derailment occurred (Buckskin).

In response, CPR mechanical staff at Toronto Yard initiated an accelerated wheel inspection and removal program to inspect all 400 cars in this pool service. Although CPR was aware that the production window might extend from April 1998 to February 2001, its staff was instructed to inspect for Transcona wheel shop wheel sets with wheel mounting dates between January 1998 and December 2000.

CPR delegated the implementation of the marking and shipping requirements to line point personnel. There was little or no head office management supervision of handling practice and documentation. When a Transcona wheel shop wheel set was identified, it was removed from service, tagged for processing and then CPR was to notify the PRWW wheel shop of its shipment. CPR line points were supposed to identify the suspect Transcona wheel shop wheel sets that were within the MA 74 window of April 1998 to December 1999 in accordance with the procedures set forth in MA 74 that required that orange tape or paint was to be applied on the axle body. However, CPR instructions to its line points did not specify how to mark wheel sets removed according to its accelerated program criteria but not subject to MA 74. For the most part, these wheel sets, once removed and documented, were handled in a manner indistinguishable from other bad order wheels. At the request of the TSB, 28 wheel sets were marked with green paint on the wheel rims to assist in the selection of Transcona wheel shop wheel sets for laboratory analysis.

In total, CPR changed out 69 wheel sets in this service population. Of these 69 wheel sets, 57 were suspect Transcona wheel shop wheel sets and 12 were removed for other reasons. Of the 57 suspect Transcona wheel shop wheel sets removed:

- 6 wheel sets were from the MA 74 window of April 1998 to December 1999; and
- 51 wheel sets were from outside the MA 74 window but within the expanded CPR window of January 1998 to December 2000.

None of the 57 suspect Transcona wheel shop wheel sets were marked to indicate that they were suspect Transcona wheel shop wheel sets. The TSB selected and inspected 25 Transcona wheel shop wheel sets assembled within the full manufacturing window. Locking plate information indicated that 13 of them were reconditioned by various wheel shops since they were initially assembled. In addition, it was noted that:

- 28 of the 57 suspect Transcona wheel shop wheel sets (that is, only those marked with green paint) were identified by the PRWW wheel shop as being handled appropriately; and

- the remaining 29 wheel sets (approximately 50 per cent) were not properly identified and inadvertently sent to the PRWW wheel shop as regular bad order wheels.

The PRWW wheel shop identified the application of MA 74 as a handling line responsibility. Furthermore, MA 74 contained no AAR instructions to wheel shops to look for incoming suspect Transcona wheel shop wheel sets. Consequently, suspect Transcona wheel shop wheel sets that were not clearly identified as suspect wheels, or according to MA 74 guidelines, were treated like any other bad order wheel set. If they were within reconditioning limits, they were returned to service.

CPR was unable to provide confirmation of communications regarding the shipping of suspect Transcona wheel shop wheel sets or instructions to PRWW to inspect incoming wheel sets for the Transcona wheel shop wheel mount dates. CPR has been unable to locate these wheel sets, and indicates that they were likely processed as regular bad order wheels.

1.14 Transport Canada Regulatory Overview

When a defective component that may affect the safety of train operations is identified, railways, though not required, typically notify TC. Once notified, TC will review and monitor the railway's action plan. If the railway plan does not adequately address the safety issue, TC will take follow-up action and direct the railway to make improvements.

TC-approved *Railway Freight Car Inspection and Safety Rules*[10] establish safety thresholds for freight cars. Section II of the rules describes safety defects that, when present, prohibit a railway company from placing or continuing a freight car in service. These defects include a wheel that shows evidence of being loose (Section II, 9(e)). When a TC inspector identifies a safety defect outlined by these rules, the railway company is required to report the corrective action taken to the TC regional office within 14 days of the inspection. However, without a TC inspection, there is no requirement for a railway company to report such defects to TC. Furthermore, the rules do not require railways or manufacturing companies to retain wheel set manufacturing information.

In comparison, the *Canadian Aviation Regulations*, which set forth minimum standards for the maintenance of aeronautical components,[11] outline that the following component information must be retained:

- product identification (aircraft registration marking, nomenclature, type/model number, name of the manufacturer, part number, and serial number);
- a brief description of the work performed;
- reference to the standard used in the performance of work;

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10 *Railway Freight Car Inspection and Safety Rules*, 1994.

11 *Canadian Aviation Regulations*, Part V – Airworthiness, Standard 571 – Maintenance (April 1987).

- the date on which the maintenance is performed and the employee who performed it;
- reference to the *Canadian Aviation Regulations* as appropriate;
- description of any defects found before disassembly;
- a general description of any work still to be completed; and
- any details necessary to establish the technical history of a part that may have been in service in another aircraft before installation.

2.0 Analysis

2.1 Introduction

The train was operated and the track was maintained in compliance with railway and regulatory requirements. There were no operating or track conditions considered causal in this occurrence. The analysis will therefore focus on equipment components that played a role in this accident and in similar derailments. The adequacy of current industry standards for wheel set assembly, the ability of the industry to track wheel sets through their service life and the retention of manufacturing data will also be analyzed.

2.2 The Accident

The 19th car from the head end, CP 346875, was the first derailed car. It came to rest at Mile 103.60 in an upright position. The trailing 11 cars also derailed and came to rest in various positions along the right-of-way. The trailing No. 1 wheel set from car CP 346875 had dislodged from under the B-end truck and was located west of the main track about 500 feet north of the car. The L1 wheel from this wheel set had moved inboard off of the axle wheel seat onto the axle body. Score marks observed on the wheel bore and axle body indicate that the wheel had been unseated for some time.

Track damage consistent with single wheel set impacts extended northward from the derailment site for 11 miles. The damage terminated at the initial marks observed on the base of the east (high) rail of a three-degree, right-hand curve (in the direction of travel) on a short trestle bridge traversing the Moon River at Mile 114.65. The location of the derailed car and its No. 1 wheel set, the loose L1 wheel and the observed track damage revealed that car CP 346875 derailed at Mile 114.65 when the L1 wheel became loose while traversing a curve, migrated inboard and dropped in between the rails. Shortly after, the mate wheel also dropped into gauge. Subsequently, the derailed wheel set damaged track for 11 miles until it struck the north Buckskin Siding turnout, dislodged from under the car and caused the following 11 cars to derail.

2.3 Transcona Wheel Shop Loose Wheel Derailments

Since 2000, all 15 wheel sets involved in loose wheel derailments in Canada, and 48 loose or out–of-gauge wheel sets detected by inspection and removed before failure were bored and mounted at the Transcona wheel shop between April 1998 and February 2001. During this period, the CN Transcona wheel shop used a modified wheel boring process for assembling these 36-inch, 100-ton wheel sets. When compared to the earlier process, the modified process reduced the contact area between the wheel bore and axle wheel seat. The reduced contact area led to higher stresses in the remaining areas of contact that initiated fretting at the tips of the bore spirals and resulted in brinell indentations on the axle wheel seat progressively loosening the interference fit. These 36-inch wheels can rotate inboard, or outboard, off the axle wheel seat while in service, producing loose and out-of-gauge wheel conditions.

Initially, most of the loose wheel derailments occurred with wheel sets that had been in service between two and four years. However, there was a second cluster of four loose wheel failures, between September 2004 and August 2006, which suggests that Transcona wheel shop wheel sets assembled within the suspect manufacturing window of April 1998 to February 2001 had been removed from initial service and returned to service under a different car. This was further confirmed by the TSB inspection of 25 Transcona wheel shop wheel sets where 13 of them had been reconditioned by various wheel shops and placed under another car. Such was the case with the L1 wheel from car CP 346875 that caused the derailment. This wheel set was assembled by the Transcona wheel shop in December 1998 and reconditioned by PRWW in September 2004. In October 2004, CPR placed the reconditioned wheel set under the car, which was being used in HAL coil steel service. The loose wheel derailment occurred just over a year later when brinelling, fretting and movement at the wheel bore/axle seat interface progressively loosened the L1 wheel until a combination of lateral and rotational forces displaced the wheel inboard.

2.4 *Association of American Railroads Wheel Boring and Mounting Standards*

Approximately 43 800 wheel sets were produced by the CN Transcona wheel shop using the modified wheel boring process between April 1998 and February 2001 and each of these wheel sets has the potential to become loose while in service. Loose wheel events initially occurred in wheel sets that were predominantly used in HAL service and in territories where steep grades and high curvature was present, similar to the territory in which car CP 346875 was operating. However, such failures have also occurred in regular, less demanding 100-ton service. The failures prompted an industry recall and several accelerated wheel removal programs, yet derailments and loose wheel events continued to occur.

Each of the 43 800 wheel sets was produced by the Transcona wheel shop in accordance with the Section G, Part II, AAR MSRP (G-II Manual) industry standard in place at the time of assembly. In addition, four AAR audits of the Transcona wheel shop, which were conducted during the same period, confirmed that the wheel shop was in compliance with AAR standards. Therefore, the G-II Manual industry standard for wheel boring and mounting permitted the use of a modified wheel boring process that produced wheel sets with an increased risk of loose wheel failure.

For the wheel sets involved in loose wheel derailments or identified with loose or out-of-gauge wheels before failure, CN could only provide recorded mounting tonnages for 14 wheel sets. Most of the mounting tonnage data were unavailable because CN did not retain those data beyond the AAR five-year minimum requirement. However, CN indicated that the majority of the loose wheel failures involved wheel sets that had mounting tonnages at the low end of the 90-ton to 160-ton standard for 36-inch wheels. Of the 14 loose wheels with available press-on tonnage information, 11 (71 per cent) had press-on values of 110 tons or less. Even though the sample size was small, 36-inch wheel sets with mounting press-on tonnages below 110 tons appear to have an increased risk of becoming loose while in HAL (286 000-pound) service.

2.5 Industry Response and Recall Protocols for Transcona Wheel Shop Loose Wheels

When CN began to experience an elevated number of loose and out-of-gauge wheel events in 2000, its initial response was positive. CN implemented back-to-back wheel set inspections for cars in its rotary dump coal fleet, arranged for AAR audits of its wheel shop facility, and initiated research to identify the root cause for these loose wheel events.

By February 2002, CN had:

- determined the failure mechanism and root cause of the Transcona wheel shop loose wheel events;
- determined that all wheel sets manufactured by the Transcona wheel shop between April 1998 and February 2001 were produced using the modified boring process;
- determined that these wheel sets were more likely to fail when placed in HAL service in high-curvature territory with steeper grades where train braking was more severe; and
- compiled a list of cars in which the suspect wheel sets may have been installed.

Internally, in March 2002, CN directed its wheel shop personnel to inspect all incoming wheel sets for the Transcona wheel shop wheel mount dates, rather than roller bearing locking plate information, within the full manufacturing window of April 1998 to February 2001. It conducted targeted accelerated wheel set removal programs in its coal car fleet. In late 2002, in consultation with TC, CN installed WPDs at Arnold and Nattress.

Externally, CN informed TC of the Transcona wheel shop loose wheel issue before CN and the AAR issued Early Warning (EW) 5183 (30 November 2001). EW 5183 targeted 5000 foreign tank cars that had Transcona wheel shop wheel sets applied during 4 of 35 production months. On 19 February 2002, CN and the AAR issued MA 74 expanding the recall criteria to include a total of 9381 foreign cars and called for the removal of all Transcona wheel shop wheel sets with roller bearing mounting dates between April 1998 and December 1999, when cars were found on the shop or repair track. While issuing EW 5183 and MA 74 were positive steps in mitigating the risks associated with Transcona wheel shop loose wheels, the documents contained several gaps and undefended risks remained. Specifically:

- Both EW 5183 and MA 74 directed only railway line point inspection personnel (that is, not wheel shop employees) to inspect wheel bearing locking plates. As a result, any suspect Transcona wheel shop wheel set that had been removed from its original car and had wheel bearings changed out through regular wheel set reconditioning activities before MA 74 was issued would not be identifiable using MA 74 guidelines and would remain in service.

- MA 74 did not indicate to the industry that the Transcona wheel shop wheel sets assembled between January 2000 and February 2001 had the same potential for loose wheel failure. Therefore, 14 of 35 total production months, which accounted for approximately 17 000 potentially defective wheel sets, were not subject to the AAR early warning or maintenance advisory. Consequently, despite CN's accelerated removal of these wheel sets in its fleet, many of these wheel sets remained in service on other railways and, as illustrated in this occurrence, when removed, they were reconditioned and returned to service.

- There was no requirement for wheel shop personnel to inspect locking plate or wheel mount dates to identify Transcona wheel shop wheel sets assembled between April 1998 and February 2001. Consequently, suspect Transcona wheel shop wheel sets not identified in accordance with MA 74 guidelines or removed through regular car maintenance activity (roller bearing or tread defects) were processed by foreign wheel shops and returned to service.

By February 2002, CN understood the failure mechanism, scope, and magnitude of the Transcona wheel shop loose wheel issue. Internally, CN took a number of actions that mitigated the risk to its own fleet but did not inform the rest of the North American rail industry to take similar action. Had the industry applied the same approach as CN, car fleets could have been inspected for suspect Transcona wheel shop wheel sets and those missed through railway line point inspection would have had a second line of defence at a wheel shop, where wheel set migration through reconditioning could have been prevented. As of 09 November 2007, CN estimated that 10 000 to 12 000 suspect Transcona wheel shop wheel sets remained in service.

As demonstrated by this occurrence, the recall protocols of AAR EW 5183 and MA 74 were limited and incomplete. This enabled a Transcona wheel shop wheel set, with a known susceptibility to loose wheel failure, to be reconditioned through a foreign wheel shop and placed into HAL service under car CP 346875 in October 2004.

2.6 Tracking Wheel Set Components

The failed wheel set from car CP 346875 was assembled in December 1998. A review of the wheel mount and locking plate information from the wheel set indicates that it had been removed from the initial car it was placed under and reconditioned at least once before being placed in service under car CP 346875. There were three opportunities to remove the wheel set before failure. The wheel set could have been quarantined or scrapped when it was:

- removed from the initial car it was placed under, assuming that it was removed after the problem was identified in late 2001 and industry notifications were issued in early 2002;

- processed through the PRWW wheel shop in October 2004; or

- applied to car CP 346875.

The wheel set in this occurrence was one of eight Transcona wheel shop loose wheels that caused derailments in Canada after MA 74 was issued and Transcona wheel shop wheel sets were recalled. The inability of the industry to effectively locate and remove suspect wheel sets from service before failure increases the risk that loose wheel derailments will continue to occur.

The CN Transcona wheel shop loose wheel failure mechanism was traced to a manufacturing anomaly that was neither detectable nor out of specification at the time of production. During the service life of these wheel sets, this anomaly can progress to the point where the wheel set fails in service with a potential for derailment. However, the progression to in-service wheel failure can take a number of years and, in that time, the wheel sets may be reconditioned several times and placed under several different cars after their initial assembly. Such wheel sets may remain in service for up to 20 years. Consequently, by the time a problem manifests itself, it may be impossible to know which cars contain the suspect wheel sets.

When wheel sets are first assembled or reconditioned, the wheel shops record all wheel, axle and roller bearing information, including wheel serial numbers and wheel mounting dates. PRWW is able to track this information using a bar code tag that it attaches to the axle body. CPR has bar code readers that extract this wheel set information for automatic entry into its Car Maintenance Information System for AAR billing purposes. All the wheel set information is available from the bar code but only information required by Rule 41, Section F of the *Field Manual of the AAR Interchange Rules* is recorded. CN also follows Rule 41 and manually records the same information. In each case, wheel mounting dates and serial numbers are not recorded when wheel sets are installed under freight cars, even though the information is readily available and easily obtained. Had either wheel serial numbers or mounting dates been recorded, an industry-wide search of car maintenance databases targeting that information may have been able to locate suspect Transcona wheel shop wheel sets regardless of which car they were under at the time of the recall.

In comparison, the aircraft industry in Canada does not have this problem when tracking safety-critical components. While TC–approved *Railway Freight Car Inspection and Safety Rules* contain no requirement for rolling stock data retention, the TC *Canadian Aviation Regulations* require that operators record "any details necessary to establish the technical history of a part that may have been in service in another aircraft prior to installation." Therefore, when a defective component, process or installer is identified in the aircraft industry, the problem can be tracked and the risks mitigated. In the railway industry, the absence of a system to record and track manufacturing data that uniquely identifies wheel set components throughout their service life increases the risk that components known to be susceptible to failure will not be readily identified and removed from service in a timely manner.

2.7 *Canadian Pacific Railway Overview in Accelerated Wheel Removal Program*

CN informed TC, the AAR and major Class 1 railways of the issue and identified the dates for the full production window of the suspect Transcona wheel shop wheel sets in late 2001. However, conflicting instructions were issued to the industry in EW 5183 and MA 74. Consequently, CPR was uncertain of the dates of the full Transcona wheel shop production window and its staff was instructed to inspect for Transcona wheel shop wheel sets with wheel mounting dates between January 1998 and December 2000 rather than the full Transcona wheel shop wheel set production window of April 1998 to February 2001. CPR line point personnel were supposed to mark the suspect Transcona wheel shop wheel sets in accordance with MA 74 or some other fashion. Initially, all 57 suspect Transcona wheel shop wheel sets removed during the accelerated removal program in spring 2006 were unmarked and placed with regular bad order wheel sets. While 28 of these 57 wheel sets, those that were later marked with green paint at the request of the TSB, were recovered by PRWW, the remaining 29 wheel sets were forwarded to the PRWW wheel shop along with regular bad order wheels. CPR has been unable to locate these 29 wheel sets. Furthermore, there was no AAR instruction to wheel shops to inspect for incoming suspect Transcona wheel shop wheel sets at that time. Therefore, it is likely that these suspect Transcona wheel shop wheel sets were treated as regular bad order wheel sets and returned to service if they were within reconditioning limits.

CPR was unable to produce any written instruction issued to staff regarding the marking of these wheel sets for shipping. While CPR had established guidelines for the wheel set inspection and removal process, there were no guidelines for marking and shipping the suspect CN Transcona wheel shop wheel sets. Consequently, local procedures were developed that resulted in an ad hoc response to the marking and shipping of the wheel sets. The absence of clear company guidelines for the marking and shipping of suspect Transcona wheel shop wheel sets removed during CPR's accelerated wheel removal program increases the risk that potentially defective wheel sets captured through the process will return to service and cause derailments.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. Car CP 346875 derailed at Mile 114.65 when the L1 wheel became loose while traversing a curve and migrated inboard, causing both wheels to drop between the rails. The derailed wheel set damaged track for 11 miles until it struck the north Buckskin Siding turnout, dislodged from under the car and caused the following 11 cars to derail.

2. While in service between October 2004 and the derailment date, undetectable brinelling, micro-movement and fretting at the wheel bore/axle seat interface progressively loosened the reconditioned L1 wheel until a combination of lateral and rotational forces displaced the wheel inboard.

3. The Association of American Railroads (AAR) *Manual of Standards and Recommended Practices*, Section G, Part II industry standard for wheel boring and mounting, in place at the time of the wheel set manufacture, permitted the use of a modified wheel boring process that produced wheel sets with an increased risk of loose wheel failure.

4. The recall protocols of AAR Early Warning 5183 and Maintenance Advisory 74 were incomplete, which enabled a Transcona wheel shop wheel set with a known susceptibility to loose wheel failure to be reconditioned through a foreign wheel shop and placed into heavy axle load service under car CP 346875 in October 2004.

3.2 Findings as to Risk

1. Thirty-six inch wheel sets with mounting press-on tonnages below 110 tons appear to have an increased risk of becoming loose while in heavy axle load (286 000-pound) service.

2. The absence of a system to record and track wheel set components throughout their service life means that loose wheels will not always be identified and removed from service in a timely manner, thereby increasing the risk that derailments will continue to occur.

3. The absence of clear company guidelines for the marking and shipping of suspect Transcona wheel shop wheel sets removed during Canadian Pacific Railway's accelerated wheel removal program increases the risk that potentially defective wheel sets captured through the process will return to service and cause derailments.

4.0 Safety Action

4.1 Action Taken

4.1.1 TSB Rail Safety Advisories

In July 2006, the TSB issued Rail Safety Advisories (RSAs) 03-06 and 04-06:

- RSA 03-06 identified that Maintenance Advisory (MA) 74 only refers to the Canadian National (CN) Transcona wheel shop wheel sets assembled between April 1998 and December 1999 and not the full manufacturing window (April 1998 to February 2001). In addition, MA 74 contained no requirement for industry personnel to inspect the wheel mount date to identify Transcona wheel shop wheel sets assembled between April 1998 and February 2001. The RSA identified that the railway industry had not been adequately advised to identify and remove suspect Transcona wheel shop wheel sets and suggested that Transport Canada (TC), in consultation with the industry, may wish to review the criteria for identifying Transcona wheel shop wheel sets and expedite their removal before in-service failure.

- RSA 04-06 identified that the Transcona wheel shop used a modified wheel boring process between April 1998 and February 2001. The modified process resulted in a 60 per cent reduction of contact area between the wheel bore and axle wheel seat. The reduced contact area led to higher contact stresses and caused fretting that progressively loosened the interference fit. Despite these problems, the modified process met existing Association of American Railroads (AAR) standards. With the risk that this method might be applied at other wheel shops and result in a similar loose wheel problem, the RSA suggested that TC, in consultation with the railway industry, might wish to review the wheel boring and mounting practices outlined in Section G, Part II of the AAR *Wheel and Axle Manual, Manual of Standards and Recommended Practices* (G-II Manual) and assess their adequacy with respect to the current freight car heavy tonnage operating environment.

Concurrent with the release of this report, an RSA was sent to the United States Federal Railroad Administration (FRA). This RSA summarized the safety issues related to the removal of suspect Transcona wheel shop wheel sets and the tracking of wheel set components.

4.1.2 Industry Response

On 31 July 2006, the AAR, in consultation with CN, issued Circular C-10343, which contained MA 74 Supplement 1 (MA 74-S1), and instructed railways to continue looking for cars with Transcona wheel shop wheel sets with locking plate mount dates between April 1998 and December 1999. The supplement also instructed wheel shops to inspect for Transcona wheel shop wheel mount dates (stamped on hub) through the entire manufacturing window of April 1998 to February 2001. Once a wheel shop found a suspect Transcona wheel shop wheel set, the wheels were to be demounted.

On 23 October 2006, the AAR issued Circular C-10377 implementing changes to AAR's G-II Manual Rule 1.3.5 to define minimum finish bore limits for wheels.

On 28 November 2006, the AAR, in consultation with CN, issued AAR Circular C-10415, which contained MA 74 Supplement 2 (MA 74-S2). It provided a new expiration date for the removal of the wheel sets, more detailed instructions for the disposition of the wheel sets and expanded the date range for the suspect wheel sets to include the full manufacturing window (April 1998 to February 2001) for Transcona wheel shop wheel sets with a susceptibility to come loose.

CN installed wheel profile detectors (WPDs) at Armstrong, British Columbia, and Nattress, Manitoba, in the fall of 2002 in response to the loose wheel issue. Since that time, CN determined that there was traffic dedicated to the northern route that would never receive a WPD inspection. To reduce the risk of a loose wheel derailment and provide similar protection to cars in captive northern service, CN installed a WPD at Stony Plain, Alberta, in February 2007. The WPD provides back-to-back wheel set gauging and automatically measures brake shoe wear on each car.

On 09 October 2007, the AAR, in consultation with CN, issued AAR Circular C-10598, which contained MA 74 Supplement 3 (MA 74-S3) to clarify inspection guidelines to follow when determining if a suspect Transcona wheel shop wheel set needs to be removed. The supplement provides instruction for track-side personnel to inspect for the wheel manufacturing date, wheel mount date and roller bearing locking plate dates. It also extends by one month the date range for the roller bearing locking plate information (April 1998 to March 2001) as well as the wheel mounting date (March 1998 to February 2001).

The AAR, through its Transportation Technology Center, Inc. (TTCI), is actively pursuing the use of radio frequency identification (RFID) tags to track railroad components. Testing of RFID tags was conducted in March 2007 at TTCI's Pueblo, Colorado, United States, test facility. RFID tags were applied on bolsters and side frames, axles, couplers, and wheels. Testing showed that RFID tags could be applied and read on railroad freight car components. Details of the testing are contained in AAR's TTCI Technology Digest TD-07-030, which was issued in October 2007. The use of RFID tags has now been passed onto the respective AAR technical committees for furtherance.

4.2 Action Required

4.2.1 Removal of Suspect Transcona Wheel Shop Wheel Sets

In 2000, loose wheels began to occur on CN's coal rail car fleet. By fall 2001, CN had traced the problem to a modified wheel boring process that had been used in the assembly of 36-inch wheel sets at its Transcona wheel shop between April 1998 and February 2001. The modified boring process resulted in wheel sets with reduced contact area between the wheel bore and axle wheel seat. Under normal service conditions, the reduced contact area led to higher stresses in the remaining areas of contact that initiated fretting at the tips of the bore spirals when the car was negotiating a curve. This resulted in brinell indentations occurring on the axle wheel seat that progressively loosened the interference fit. All of the wheel sets that were produced using the modified wheel boring process (approximately 43 800) have a high susceptibility to loosen, particularly in heavy-curvature territory.

Since loose wheels were first detected, CN and the AAR initiated an industry recall that included issuing AAR Early Warning letter (EW) 5183 and AAR Maintenance Advisory (MA) 74. However, due to shortfalls in the recall process, the risk has not yet been completely mitigated. Consequently, at least 25 per cent (10 000 to 12 000) of these wheel sets remain in service six years after the initial recall and loose wheel derailments continue to occur.

To date, at least 15 derailments in Canada have been attributed to suspect Transcona wheel shop loose wheels, 12 of which occurred after the recall process had been initiated. Since most of these two-wear wheel sets have an extended service life and the mode of failure takes time to develop, the risk of failure for these remaining wheel sets continues to increase the longer they remain in service.

Therefore, the Board recommends that:

> The Department of Transport ensure that all 36-inch Canadian National Transcona wheel shop wheel sets assembled between April 1998 and February 2001 be removed from cars operating in Canada.

R08-01

4.2.2 Tracking Wheel Set Components

There were gaps in the initial industry recalls of EW 5183 and MA 74 that did not include approximately 17 000 suspect Transcona wheel shop wheel sets assembled between January 2000 and February 2001. Aside from CN, the industry as a whole did not target the full population of suspect wheel sets for removal until July 2006. As a result, many wheel sets were permitted to remain in service or, as in this occurrence, removed from the original car, reconditioned and placed under a second car.

This was not the first time that a wheel population with a known manufacturing defect had caused multiple derailments and been subjected to an industry recall. In 2004, a Southern wheel failure on a Canadian Pacific Railway train resulted in two fatalities in Whitby, Ontario (TSB investigation report R04T0008). The AAR had previously issued recalls of wheels that contained known manufacturing defects produced by Southern Wheel, by Mafersa, and by Edgewater. In each of these cases, industry was aware of these wheels' susceptibility to failure, and had initiated recalls, but had been unable to track, locate, and remove all of them before failure.

When wheel sets are installed under freight cars, wheel set information such as month and year of manufacture, manufacturer code, heat treatment class, wheel flange and tread thickness is recorded. However, there is no requirement to record wheel mount date and wheel serial numbers even though the information is readily available. The absence of wheel serial numbers and mounting dates presented fundamental difficulties during the Transcona wheel shop wheel set recall process. Had this information been available, it would have provided an alternate method for locating the defective wheel sets. An industry-wide search of databases would have located the suspect Transcona wheel shop wheel sets, regardless of which car they were under at the time of the recall. In addition, databases could have been flagged to produce a warning before the installation of suspect Transcona wheel shop wheel sets.

The testing of RFID tags to track rail car components is a positive step towards solving the tracking problem. However, when compared to the aviation industry, the rail industry falls short in its ability to locate and remove defective components. Specifically, the *Canadian Aviation Regulations* require that, whenever components are installed into an airframe, the components and the procedures used for their installation are uniquely identified and permanently recorded. In this manner, components can be easily located if a problem develops at a later date with either the component or the installation procedure. With the transition to a more global supply network for the North American rail industry, the need for a system that has the ability to effectively and quickly locate potentially defective wheel set components in freight cars is essential.

Because the industry has no effective way to track wheel sets once they are removed from their original car, wheel sets with potentially defective components cannot be easily located and removed from service before failure. The inability to quickly locate defective wheel set components increases the risk of a failure, which can lead to a derailment.

Therefore, the Board recommends that:

> The Department of Transport ensure that railways adopt procedures and technologies to track all wheel sets.

R08-02

4.3 Safety Concern

4.3.1 Wheel Manufacturing Defects

The AAR *Manual of Standards and Recommended Practices* has a five-year minimum requirement for the retention of safety-critical wheel component data. This standard was established at a time when data archiving was predominantly paper-based and freight cars often received a five-year general shop inspection that frequently included wheel set renewal. However, the five-year general inspection has been discontinued. Consequently, wheel sets in today's operating environment are more likely to remain in service for periods well in excess of five years. With the move to digital technology, the ability to archive and retrieve large amounts of information has become easier and less expensive. Much of today's manufacturing information can be recorded and stored automatically at the time of assembly or installation.

This occurrence and the Whitby occurrence (TSB investigation report R04T0008) identified that wheel manufacturing defects can take many years to progress to the point of failure. The wheel set involved in this occurrence was assembled in December 1998 and failed approximately seven years later. However, the mounting tonnage for this wheel set was unavailable because CN did not retain it beyond the AAR five-year minimum requirement. Since such defects may take longer than five years to develop, the Board is concerned that current AAR standards for the retention of wheel mounting tonnage data are no longer sufficient to ensure that data are available when latent manufacturing defects surface.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 10 January 2008.

*Visit the Transportation Safety Board's Web site (**www.tsb.gc.ca**) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.*

Appendix A – Canadian National Transcona Wheel Shop Loose Wheel Derailments in Canada (2000-2006)

Rev. 23/01/2007

Seq. No.	TSB Occurrence No.	Car Initial	Car No.	Car Type	Date Found	Where Found	How Found	Train	Date Installed	Location	Out-of-Gauge Press Tons	Mate Press Tons	Out-of-Gauge Wheel Cast Date	Bearing Lock Tab Date	Press-on Date
1	**not reported**	CNA	192027	286K alum. gondola	**06-Jun-00**	Foothills Sub.	Derail. 1	C 79151-03	25-Jan-00	R4	100	108	Feb-99	Transcona 02/99	22-Feb-99
2	**BCR**	SULX	1266	263K steel gondola	**05-Dec-00**	Anderson Lake, B.C.	Derail. 17	BCR	20-Jan-99	R1				Transcona 11/98	Nov-98
3	**R01E0053**	CNA	192208	286K alum. gondola	**10-Jul-01**	Foothills Sub.	Derail. 1	C 78352-09	30-Jun-98	R4	120	127	May-98	Transcona 06/98	22-Jun-98
4	**R01V0169**	CNA	192213	286K alum. gondola	**04-Oct-01**	Clearwater Sub.	Derail. 1	C 78351-03	22-Feb-99	L1	100	100	Feb-99	Transcona 02/99	05-Feb-99
5	**R01V0208**	EOGX	4060	263K tank	**20-Nov-01**	CPR Montréal Sub.	Derail. 1	CP 771-19	19-Feb-99	R4	102	104	Dec-98	Transcona 02/99	05-Feb-99
6	**R01E0111**	PWCX	121927	263K 35-foot covered hopper	**20-Dec-01**	Edson Sub.	Derail. 1	U 72451-19	16-Feb-99	L1	148	146	Dec-98	Transcona 02/99	04-Feb-99
7	**R02W0002**	CNHX	197864	286K steel gondola	**07-Jan-02**	Cromer Sub.	Derail. 10	C 76841-07	20-Jan-99	R4	101	113	Jan-99	Transcona 12/98	15-Jan-99
8	**R02V0083**	CNA	412828	286K box	**Jun-02**	Mile 125.5, Ashcroft Sub.	Derail. 9	M30151-17							
9	**BCR**	SULX	2287	263K steel gondola	**Jul-02**	BCR – Lillooet	Derail. 1	BCR	01-Aug-00	R1			May-00	Transcona 05/00	May-00
10	**R04E0109**	PWCX	121978	Covered hopper	**20-Sep-04**	Mile 86, Edson Sub.	Derail. 25	U72451-20	02-Jul-98	L1			May-98	Transcona 06/98	Jun-98
11	**R05V0089**	EOGX	4078	263K tank	**02-Jun-05**	Mile 103, Ashcroft Sub.	Derail. 1	CP H66351-01	19-Feb-01	L1				Transcona 01/01	
12	**R05T0312**	CP	346898	286K gondola	**16-Dec-05**	CPR Hamilton Sub.	Derail. 1	CFCP	n/a – CPR	L1			Jan-00	PRWW 09/04	Jan-00
13	**R06T0022**	CP	346875	286K gondola	**31-Jan-06**	CPR MacTier Sub.	Derail. 14	CFCP	n/a – CPR	L4			Dec-98	PRWW XX/04	Dec-98
14	**R06E0042**	CN	196702	286K steel gondola	**02-Jun-06**	Chetwynd	Derail. 22	C75351-02	29-Oct-99	L/ R3					Oct-99
15	**R06Q0089**	IOCC	2943	286K hopper	**11-Aug-06**	Mile 41.5, Wacouna Sub.	Derail. 1	PL-603	05-Aug-03	R2			May-98	n/a	May-98

Appendix B – Canadian National Transcona Wheel Shop Out-of-Gauge/Loose Wheel Findings (2000-2006)

Seq. No.	Car Initial	Car No.	Car Type	Date Found	Where Found	How Found	Train	Date Installed	Location	Out-of-Gauge Wheel Serial	Out-of-Gauge Press Tons	Mate Serial	Mate Press Tons	Out-of-Gauge Wheel Cast Date	Bearing Lock Tab Date	Press-on Date
1	CNA	192134	286K alum. gond.	**02-Jun-00**	Kamloops	CCI	C 78851-07	02-Jul-98	L1	93889	110	92753	117	May-98	Transc. 06/98	19-Jun-98
2	CN	196358	286K steel gond.	**12-Jul-00**	Kamloops	CCI	C 77651-10	02-Jul-98	R1	93793	95	92878	129	May-98	Transc. 06/98	19-Jun-98
3	CN	197154	286K steel gond.	**07-Mar-01**	Kamloops	CCI		20-Apr-99	R1	73243	98	73529	113	Mar-99	Transc. 03/99	12-Mar-99
4	CN	197154	286K steel gond.	**07-Mar-01**	Kamloops	CCI		20-Apr-99	L1	73529	113	73243	98	Mar-99	Transc. 03/99	12-Mar-99
5	CN	197209	286K steel gond.	**05-Oct-01**	Holloway	Inspection		31-Oct-99	R3	46078	123	45712	120	Jun-99	Transc. 09/99	03-Sep-99
6	CNA	192121	286K alum. gond.	**06-Oct-01**	Kamloops	Inspection	C 78351-04	14-Mar-99	R1	55264	92	54606	146	Feb-99	Transc. 02/99	22-Feb-99
7	CN	196845	286K steel gond.	**14-Oct-01**	Kamloops	Inspection		21-Mar-99	R2	58234	108	63845	132	Feb-99	Transc. 03/99	01-Mar-99
8	CN	196615	286K steel gond.	**29-Oct-01**	CPR – Golden	Inspection	CPR	31-Mar-00	L4	76148	119	76136	120	Mar-99	Transc. 03/99	22-Mar-99
9	CNHX	197695	286K steel gond.	**11-Dec-01**	Winnipeg	Inspection	U 76941-10	22-Jul-98	R3	11889	103	63909	98	Jun-98	n/a	26-Jun-98
10	PROX	41682	263K tank	**14-Jan-02**	Prince George	Inspection		10-Dec-99	L1	8744		8794		Oct-99	Transc. 11/99	Nov-99
11	SULX	2317	263K steel gond.	**26-Jan-02**	Kamloops	Inspection	S 70651-24	04-Feb-99	??4	25410				Dec-98	Transc. 01/99	Jan-99
12	BCNE	900431	286K steel gond.	**26-Jan-02**	Prince George	Inspection	M 35951-24	01-May-99	??2						Transc. 03/99	Mar-99
13	SULX	2321	263K steel gond.	**20-Aug-02**	CPR – Golden	Inspection	CPR	31-Jan-01	L1						Transc. 01/01	Jan-01
14	CNA	192185	286K steel gond.	**20-Oct-02**	Kamloops	Wheelspec		07-Mar-99	R/L3						Transc. 01/99	Dec-98
15	SULX	2134	263K steel gond.	**21-Oct-02**	Kamloops	Wheelspec		27-Aug-98	R/L2						Transc. 08/98	Aug-98
16	ICG	766035	263K cov. hopper	**01-Jan-03**	ARN – Grande Prairie	Inspection	ARN	09-Feb-01	L4	65380		70267		Feb-99	Transc. 03/99	Mar-99
17	BCNE	900431	286K steel gond.	**26-Jan-03**	Prince George	Inspection		01-May-99	L/R1					Mar-99	Transc. 03/99	Mar-99
18	BCNE	900445	286K steel gond.	**03-Feb-03**	Prince George	CCI		21-Apr-99	L1					Feb-99	Transc. 02/99	Feb-99
19	CN	196402	286K steel gond.	**07-Feb-03**	Arnold	Wheelspec		17-May-99	L/R4	55268					Transc. 02/99	Feb-99
20	CN	196808	286K steel gond.	**17-Feb-03**	Kamloops	Inspection		29-Mar-99	L/R2	58873				Feb-99	Transc. 02/99	Feb-99
21	BCOL	730921	263K centrebeam	**01-May-03**	William Lake, B.C.	Wheelspec	BCR	n/a – not CN	L/R3	n/a				May-99	Transc. 04/00	01-May-99
22	CN	196675	286K steel gond.	**21-May-03**	Roberts Bank	Wheelspec		24-Apr-99	R2						Transc. 02/99	
23	CN	558499	286K box	**12-Jul-03**	Thornton	Wheelspec		13-Mar-99	L/R2	n/a				Feb-99		
24	BCOL	873232	263K centrebeam	**20-Oct-03**	Arnold	Wheelspec		16-Jan-99	L/R4	28079				Dec-98		

Seq. No.	Car Initial	Car No.	Car Type	Date Found	Where Found	How Found	Train	Date Installed	Location	Out-of-Gauge Wheel Serial	Out-of-Gauge Press Tons	Mate Serial	Mate Press Tons	Out-of-Gauge Wheel Cast Date	Bearing Lock Tab Date	Press-on Date
25	CPWX	606037	263K cov. hopper	**20-Oct-03**	Arnold	Wheelspec	CPR	31-Mar-99	L/R1							
26	UNPX	102813	268K steel gond.	**17-Nov-03**	Cranbrook	Wheelspec	CPR	08-Mar-99	L/R4							
27	CN	197655	286K steel gond.	**23-Nov-03**	Symington	Inspection and Wheelspec	U76251-19	28-Jan-99	L/R1						Transc. 12/98	
28	CN	197628	286K steel gond.	**19-Dec-03**	Symington	Inspection and Wheelspec	U76251-16	22-Apr-99	L/R2						Transc. 02/99	
29	BCNE	900596	286K steel gond.	**20-Feb-04**	Symington	Wheelspec		20-Jan-99	L/R1	n/a						Dec-98
30	CNA	623082	centrebeam	**11-Mar-04**	Symington	Wheelspec	36692	15-Jun-00	L/R3	n/a				Apr-00		
31	CNA	192200	286K alum. gond.	**24-Mar-04**	Kamloops	Wheelspec		24-Jan-01	L/R2	59410				Dec-00		
32	CN	197646	286K steel gond.	**05-Sep-04**	BCR North Vancouver	Inspection		02-Nov-98	R1	n/a						
33	CNA	194153	286K alum. gond.	**07-Sep-04**	Arnold/ Golden	Wheelspec		20-Feb-03	L/R1	45415						
34	CNA	194090	286K alum. gond.	**07-Sep-04**	Kamloops	Wheelspec		23-Feb-01	L/R3	82667				Dec-00	Transc. 01/01	
35	CN	197587	286K steel gond.	**26-Sep-04**	Walker Yard	Inspection		02-Mar-99	L/R4	n/a					Transc. 02/99	
36	CNA	194102	286K alum. gond.	**10-Nov-04**	Kamloops	Inspection and Wheelspec		13-Feb-01	L/R1	55432				Jan-01		
37	SULX	1137	263K steel gond.	**28-Dec-04**	Thornton	Wheelspec		n/a – not CN	L/R1	n/a				Jun-98		
38	CN	197569	286K steel gond.	**05-Jan-05**	Kamloops	Inspection		02-Dec-99	R1	41149		41189		Jun-99	Transc. 08/99	Aug-99
39	BCNE	900343	286K steel gond.	**16-May-05**	Thornton	Wheelspec		05-Jul-00	L/R1	n/a				Feb-99		
40	EOGX	4162	263K tank	**15-Jun-05**	CPR Shuswap	Wheelspec		n/a – CPR	L3	47938		47340			PRWW 04/04	Jan-00
41	RTLX	2348	263K tank	**26-Jun-05**	CPR Shuswap	Wheelspec			L/R4							
42	SCMX	4248	263K tank	**22-Sep-05**	Symington	Wheelspec		n/a	L/R1	n/a				Oct-00		
43	CN	414827	263K box	**06-Mar-06**	Nattress	Wheelspec		31-Oct-99	L/R4	56907		56401		Sep-99		
44	CN	196834	286K steel gond.	**18-Mar-06**	Prince George	Inspection	C 76651-17	21-Jan-01	L1	60023		55557		Dec-00	Transcona	Dec-00
45	BCNE	901073	286K steel gond.	**29-Mar-06**	Prince George	Inspection	C 76651-28	31-Mar-00	L1	75477				Mar-99	Transc. 03/99	Mar-99
46	CN	196147	286K steel gond.	**15-Apr-06**	Arnold	Wheelspec		09-Jan-01	R4	40274				Jun-00		
47	CNHX	197918	286K steel gond.	**05-May-06**	Nattress	Wheelspec	C 78141-03	06-Apr-03	R4	n/a				Dec-99		
48	CNA	412811	263K box	**16-May-06**	Nattress	Wheelspec		19-May-99	L/R4	n/a				Feb-99		

Appendix C – Glossary

AAR	Association of American Railroads
CCI	certified car inspection
CN	Canadian National
CPR	Canadian Pacific Railway
CROR	*Canadian Rail Operating Rules*
CWR	continuous welded rail
EW	Early Warning
FRA	Federal Railroad Administration
G-II Manual	*Wheel and Axle Manual*, *Manual of Standards and Recommended Practices*
GRL	gross rail load
HAL	heavy axle load
MA	Maintenance Advisory
mph	miles per hour
MSRP	*Manual of Standards and Recommended Practices*
PRWW	Progress rail wheel shop in Winnipeg
QNS&L	Quebec North Shore and Labrador
RFID	radio frequency identification
RSA	Rail Safety Advisory
TC	Transport Canada
TSB	Transportation Safety Board of Canada
TSR	*Railway Track Safety Rules*
TTCI	Transportation Technology Center, Inc.
WILD	wheel impact load detector
WIS	wayside inspection system
WPD	wheel profile detector
°C	degrees Celsius