Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT R11T0034

DAMAGE TO ROLLING STOCK WITHOUT DERAILMENT OR COLLISION VIA RAIL INCORPORATED PASSENGER TRAIN 70 MILE 21.40, OAKVILLE SUBDIVISION OAKVILLE, ONTARIO 06 FEBRUARY 2011

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

Damage to Rolling Stock Without Derailment or Collision
VIA Rail Incorporated
Passenger Train 70
Mile 21.40, Oakville Subdivision
Oakville, Ontario
06 February 2011

Report Number R11T0034

Summary

On 06 February 2011 at approximately 0930, eastward VIA Rail Inc. (VIA) passenger train 70, with 1 locomotive, 7 coaches, 106 passengers and 5 crew, passed over a wayside hot box detector at Mile 33.00 on the Canadian National Oakville Subdivision with no alarms noted. The train continued for a scheduled stop in Oakville, Ontario (Mile 21.40). While stopped at the Oakville station, the stationmaster observed smoke originating from the R4 axle on the fourth coach (VIA 4009). Subsequent examination determined that the R4 axle journal roller bearing was severely overheated and had failed. The coach was set out before the train was allowed to proceed. Passengers were transferred to a GO Transit train and proceeded to destination.

Ce rapport est également disponible en français.

Other Factual Information

On 06 February 2011 at approximately 0740, [1] eastward VIA Rail Inc. (VIA) passenger train 70 (VIA 70) departed London, Ontario, destined for Toronto, Ontario. The train was comprised of 1 locomotive and 7 head end power (HEP) coaches with 106 passengers and 5 crew members on board. While VIA owns some track, the majority of VIA trains interchange with either Canadian National (CN) or Canadian Pacific Railway (CPR) and operate on CN or CPR track.

At about 0930, VIA 70 passed a Canadian National (CN) wayside hot box detector (HBD) at Mile 33.00 (Aldershot) of the CN Oakville Subdivision with no alarms noted (Figure 1). While the average HBD reading for all axle journal roller bearings (roller bearings) on VIA 70 was 1.7 mm to 1.8 mm, [2] coach VIA 4009 registered a reading of 3.4 mm in the R-4 postion, which was still below the established CN HBD alarm thresholds.

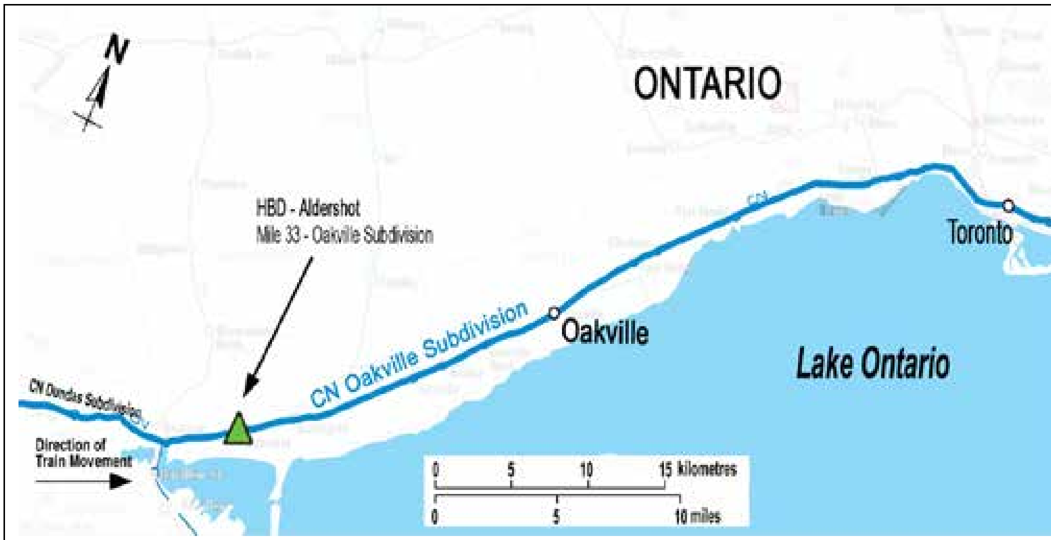

Figure 1. Occurrence location (Source: Railway Association of Canada, *Canadian Railway Atlas*)

The train continued for a scheduled stop in Oakville, Ontario (Mile 21.40). While stopped at the Oakville station, the stationmaster detected a burnt odour. On closer inspection, smoke was observed coming from the R-4 outboard roller bearing on coach VIA 4009, the 4th coach in the HEP consist. Subsequent examination determined that the roller bearing was severely overheated and had failed. The passengers were transferred to a GO Transit train for furtherance to destination. The coach was set out before the train was allowed to proceed. The wheelset was removed and sent for examination.

Subdivision and Track Information

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1 All times are Eastern Standard Time.

2 An HBD system consists of track occupancy circuits, infrared sensors, an axle counter, a unit which digitally records the heat profile and a chart recorder. The system detects and records infrared energy (heat) from each roller bearing. The heat signal from each roller bearing is stored digitally and plotted on a chart. When plotted, each roller bearing on the train is represented by a line on the paper that is proportional to the heat recorded. A millimeter (mm) of heat recorded on the chart is roughly equal to 12°Fahrenheit (F) above the ambient outdoor temperature.

The Oakville Subdivision is a multi-track main line that extends westward from Toronto Union Station (Mile 0.0) to Hamilton (Mile 39.3). Train operations are controlled by the Centralized Traffic Control system, authorized by the Canadian Rail Operating Rules (CROR), and are supervised by a rail traffic controller (RTC) located in Toronto. The authorized timetable speed is 95 mph for passenger trains and 60 mph for freight trains.

On the day of the occurrence, a Train General Bulletin Order (TGBO) was in effect, restricting the main track speed between Mile 36.4 and Mile 32.7 to 60 mph for passenger trains and 40 mph for freight trains. Rail traffic through Oakville consists of approximately 4 freight trains, 18 VIA passenger trains and 80 GO Transit commuter trains per day.

VIA Railway Equipment

VIA primarily operates 3 types of passenger rolling stock: Renaissance, Light Rapid Comfortable (LRC) and HEP coaches. The Renaissance coaches are about 15 years old, LRC coaches are approximately 30 years old and HEP coaches are about 60 years old. Most of the passenger rolling stock has been refurbished.

Wheelsets for Renaissance and HEP coaches are equipped with outboard roller bearings while LRC coach roller bearings are located inboard of each wheel. The Renaissance and LRC coaches are equipped with on-board roller bearing heat detection systems; the HEP coaches are not.

VIA has about 220 HEP coaches, which represents approximately 50% of its fleet. About 20% of the HEP coaches operate at speeds up to 95 mph and in the Quebec–Windsor corridor while the remaining HEP coaches operate on VIA’s transcontinental route. On average, HEP coaches travel about 138 000 miles per year. HEP coaches are equipped with 6 ½ inch X 12 inch outboard roller bearings and rely primarily on wayside HBDs for protection against enroute roller bearing failure. Unlike freight cars (Photo 1), roller bearings on the HEP cars are encased in a large journal box (Photo 2).

Photo 1. Freight car arrangement

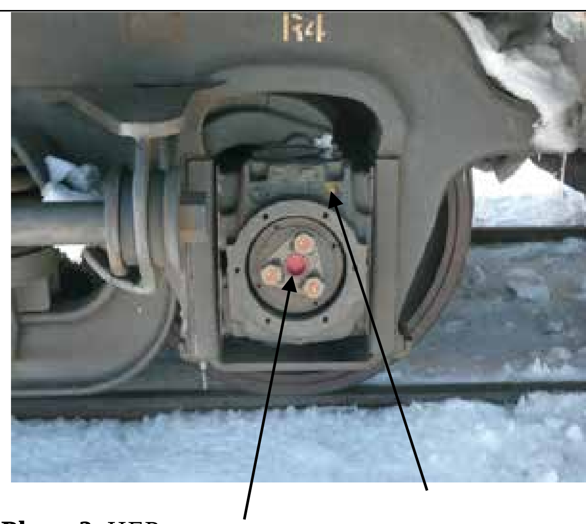

Photo 2. HEP arrangement
Note: plastic cap and stench bomb

HEP journal boxes are equipped with a heat-activated stench bomb that emits a slight odor and dye to aid with detection of overheated roller bearings during routine inspections. In addition, the truck side has long pedestal legs secured by a 4-inch wide pedestal tie strap at the bottom.

Wheelset and Roller Bearing Assemblies

Wheelset assemblies consist of 2 wheels, which are bored and pressed onto an axle wheel seat, and 2 roller bearing assemblies pressed onto the axle journals. Once the wheels are mounted, the wheel mount date and shop identifier are stamped on the outboard hub of 1 of the wheels, then roller bearing assemblies are mounted on the axle journals. During wheelset assembly, new roller bearings are only matched with new roller bearings. When reconditioned roller bearings are used, these are matched with reconditioned roller bearings made by the same company. Reconditioned roller bearings account for the majority of roller bearings in service today.

A roller bearing assembly (Figure 2) consists of an outer cup which houses 2 tapered roller cone assemblies separated by a spacer. Each cone assembly consists of a raceway, rollers and a cage. Inboard and outboard seals, seal wear rings, a backing ring and an end cap complete the roller bearing assembly. The cup, rollers and cones are case hardened with precision finishes to ensure closely matched mating surfaces. The cage is essentially a spacer that retains the rollers in place within the cone assembly. Cages are generally punched (cold formed) from a sheet of low carbon malleable steel. The entire assembly is pressed on an axle journal, seated against the axle journal fillet radius and is retained by an end cap secured to the end of the axle with 3 cap screws fixed in place by a locking plate.

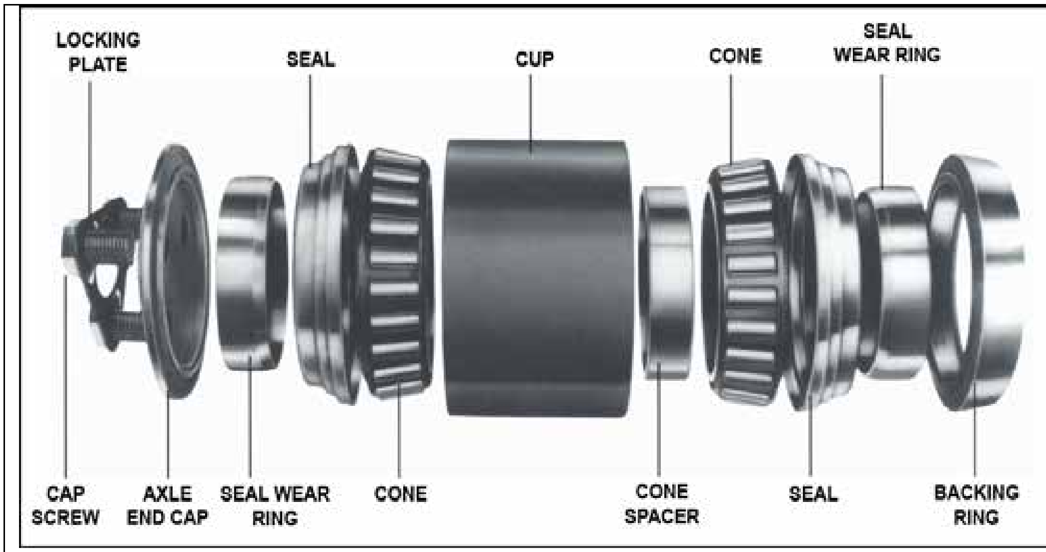

Figure 2. Roller bearing components (Source: Timken AP Bearing Parts)

VIA Wheelset Information

VIA wheelsets are assembled in compliance with the Association of American Railroads (AAR) Manual of Standards and Recommended Practices (MSRP), Section G, Part II. The manual sets forth the minimum manufacturing standards for wheelset manufacturing and reconditioning. All VIA coach wheels and roller bearings are mounted by Progress Rail Services in Montreal, Quebec.

VIA's roller bearing supplier is Timken. Timken's subsidiary, Rail Bearing Services (RBS), [3] reconditions all VIA coach roller bearings. Roller bearings are assembled in compliance with the AAR MSRP, Section H-II, Roller Bearing Manual which sets forth the minimum standards for roller bearing manufacturing and reconditioning. Roller bearing reconditioning comprises the disassembly, cleaning, inspection, repair (if necessary) and reassembly of the roller bearing.

VIA roller bearings remain in a captive pool and are equipped with a custom end cap that has a 1 ½ inch diameter hole in the center. While in service, for bearings on the right (R) side of the car, the center hole is plugged with a plastic cap (Photo 2) and fitted with a rubber seal around the hole on the interior of the end cap to prevent the ingress of contaminants. For bearings on the left (L) side of the car, an anti-lock brake device, which also provides protection from contaminants, is attached to the end cap. The VIA end caps were designed this way so that once the wheelset is removed from the car, it can be centered on a lathe and the wheel treads can be machined to remove surface defects without removing the roller bearings.

Regulatory Requirements for Passenger Cars

Railway passenger cars are visually inspected according to Transport Canada (TC) approved *Railway Passenger Car Inspection & Safety Rules* (November 8, 2001 TC O-0-26). The rules require safety inspections to be performed on passenger cars where trains are made up, lay-over or after they are added to trains or interchanged. The visual inspections include checking for overheated wheels and roller bearings. The rules also require that an overheated roller bearing detector and alarm system, or other appropriate method of heat detection, be provided for each roller bearing that is mounted inboard of a wheel. There is no such instruction for roller bearings mounted outboard of a wheel as it was assumed that they were protected by HBDs.

AAR Restrictions for Freight Car Truck Designs

In the past, the AAR has encountered freight car truck designs that shield roller bearings from HBDs. To mitigate the risk of derailment due to roller bearing burn-offs, the AAR required freight car owners to identify such designs on the equipment record (UMLER) to alert interchanging railways that a freight car with the problematic design was being handed off. Effective January 2007, Rule 90 Section B-5 (n) was added to the interchange rules indicating that all freight cars with truck side frame designs that shield roller bearings from HBDs, unless equipped with other AAR approved means of detection (such as on-board detectors) were prohibited from interchange between railways.

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[3] As of 01 October 2011, the services formerly provided by Rail Bearing Services Inc. became a part of The Timken Corporation.

Visual and Wayside Roller Bearing Inspection

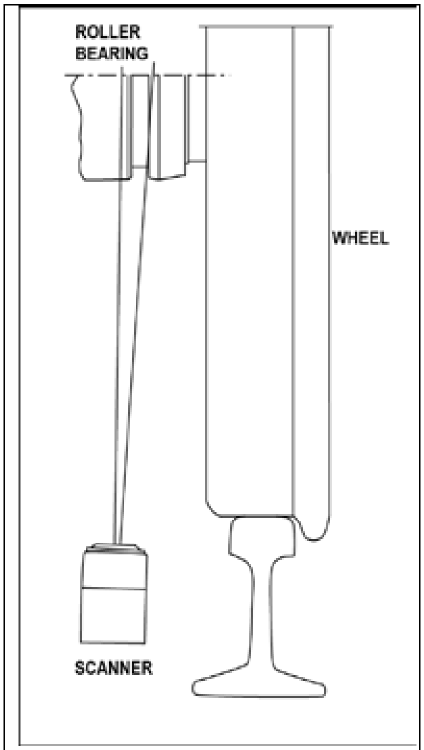

Figure 4. HBD scanner pattern

VIA Inspectors are trained to look for roller bearing stench bomb activation and other signs of roller bearing distress. If a suspect bearing is discovered, the wheelset is removed from the car and the bearing is subjected to a more detailed visual inspection. A visual pre-departure inspection was conducted for VIA 70 with no exceptions noted.

In addition, whenever a wheelset is removed from a VIA car for wheel tread defects, the roller bearings are rotated and a cursory inspection is performed before the wheelset can be turned and returned to service.

To supplement visual inspections, railways have equipped the rail network with electronic wayside inspection systems (WISs) to assess rolling stock condition while en route. WISs are typically spaced 15 to 30 miles apart along main-line track. Each WIS normally includes an HBD, and some also incorporate hot wheel and / or dragging equipment detectors. An HBD scans each roller bearing for heat as the train passes over an infrared sensor (Figure 4). HBD scanners are typically set to record heat on the cup exterior in the area of the inboard cone raceway and backing ring of freight car roller bearings. There are no regulatory requirements for HBDs. Each railway establishes and maintains its own system and alarm thresholds for overheated roller bearings.

CN Hotbox Detector System

While travelling on CN lines, the roller bearings on VIA trains are monitored by CN’s HBD system. On mainline corridors, CN HBDs are spaced about 15 miles apart and are interconnected to a network. Roller bearing temperature data can be accessed through a centralized control centre that is staffed 24 hours a day by RTCs and RTC Mechanical Technicians (RTCMechs).

When roller bearing temperature readings produce a “Hot” bearing alarm, a field talker is activated to notify the train crew. In these situations, the RTCs and RTCMechs receive pop-up alarms on their computers. The RTC confirms the receipt of the alarm with the train crew and the train is brought to a controlled stop for inspection. The crew reports back to the RTC with the inspection results and the RTC then communicates the results to the RTCMech. The RTCMech records the inspection results and updates the car history.

“Hot” alarms over 2 consecutive HBDs will result in the automatic setout of the suspect wheelset, regardless of the crew inspection results. CN has established the following “Hot”alarm thresholds for roller bearings:

- Hot Box Alarm = 15 mm or 174°F.
- Hot Differential end to end = 8 mm or 104°F.

In addition to monitoring HBD field alarms, the system conducts real time trending of HBD data which allows RTCMechs to monitor roller bearings that are heating up. Based on trending data, CN has established the following "Warm" alarm thresholds for roller bearings:

- Warm Box = 12 mm or 135°F.
- Warm Differential end to end = 6 mm or 78°F.

When a "Warm" bearing alarm is produced, the RTCMech is required to monitor the roller bearing temperature over subsequent HBDs. The RTCMech may check HBD charts and / or car history for previous elevated roller bearing temperatures. The RTCMech may also stop the train and instruct the crew to inspect the suspected warm bearing. When a "Warm" bearing alarm occurs at the last detector before a terminal, the RTCMech may arrange to have the car inspected upon arrival.

CN has also developed a number of low level alerts which are below the "Hot" and "Warm" HBD alarm thresholds. The low level alerts are not automatically displayed and do not necessarily require any action from the RTCMech, but they do provide an additional level of defence against overheated roller bearings. The low level alerts are not indicative of a finite heat value, but are based on different methods of comparing recorded roller bearing information.

These methods are

- comparing higher than average roller bearing heat with the average of other roller bearings on the same side of the train; and
- comparing higher than average roller bearing heat with the average of other roller bearings on the same side of the car or locomotive.

Low level alerts can be used

- to check previous readings for roller bearings producing "Hot" or "Warm"alarms; and
- for trending purposes. For example, cars with a history of elevated (low level) roller bearing temperatures are identified for maintenance-level wheel change to remove suspect bearings during scheduled inspections.

The CN HBD system records low level alerts and displays them as yellow bars on a tape. All tapes are generated electronically and can be viewed again to check on the past history of the car.

Roller Bearing Reconditioning Standards

Roller bearings are designed to last the life of the wheelset without additional lubrication or maintenance. Roller bearing reconditioning standards are based on freight car practice which requires the removal and inspection of roller bearings whenever a wheelset is removed and sent to a wheel shop for reconditioning. During re-conditioning, freight car wheelsets can be re-profiled any number of times (with roller bearings removed) provided the wheelset meets re-conditioning criteria and there is adequate tread thickness for re-profiling. On average, freight car wheelset service life is estimated at approximately 220 000 miles. [4] [5] However, AAR rules do not require the removal of roller bearings for any age or mileage criteria.

Whenever roller bearings are removed, they must be inspected and reconditioned in accordance with the AAR MSRP H-II . The AAR MSRP H-II standards are considered as a minimum standard. However, a number of coal-hauling utilities and at least one high mileage intermodal carrier have established additional reconditioning specifications that does not permit any spalling or defects in raceway components. [6]

For reconditioning purposes, once removed from a wheelset, each roller bearing assembly component is cleaned and inspected by an approved roller bearing shop for damage. Rule 1.15 defines terminology for various surface anomalies or defects and provides descriptions of limits for roller bearing damage. Any parts that exhibit surface anomalies, which exceed the inspection criteria and cannot be satisfactorily repaired, must be rejected. The AAR MSRP H-II applies primarily to freight car roller bearings. However, unless otherwise specified by the railway, the same standard applies to passenger roller bearings of the same Class. [7]

Rule 1.15.5 describes limits for fatigue cracks, fatigue spalling or flaking. This rule states (in part) that:

- Minute cracks in load-carrying surfaces that are a first indication of metal failure should be ground out to preclude spalling. Fatigue spalling or flaking originates as minute fatigue cracks, and eventually pieces of metal drop out. This occurs in the roller path of inner (cones) and outer (cups) rings and in the roller surface. The following are prohibited from entering service:
    1. Rollers with spalls or cracks.
    2. All unrepaired spalls on the inner and outer ring raceway.
    3. Repaired spalls greater than 3/8 inch on any side by 1/8 inch deep.
    4. More than two repaired spalls in a 2-inch circumferential section of the raceway.
    5. A bridge or separation less than 3/16 inch long between any two repaired spalls.
    6. Total number of repaired spalls exceeding six in any raceway.

Spalls on the cup and cone raceways are permitted to be repaired using approved methods provided that the repaired spalls measure less than ⅜inch on any side by ⅛inch deep. Repaired spalls (old or new) must be marked with a suitable scribing tool in a location near the spall, but not on the raceway, by the approved shop performing the repair. For the cone, the repairs must be marked on the large diameter end face.

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[4] AAR Transportation Technology Centre Inc.,Technology Digest TD-04-020, *Weibull Analysis of Coal Car Wheel Life*, November 2004.

[5] AAR Transportation Technology Centre Inc.,Technology Digest TD-11-042, *Wheel Life Comparison 3-Piece Trucks Versus M-976 Trucks*, October 2011.

[6] Brenco Technical Forum 94-1, *Spalling: Its Effect on Bearing Performance*, Brenco Incorporated 1994.

[7] Bearing sizes are defined by classes. For example, for roller bearings mounted extrernal to the wheel, Class D represents a 5 ½ inch X 10 inch bearing, Class E represents a 6 inch X 11 inch bearing and Class F represents a 6 ½ inch X 12 inch bearing.

Roller Bearing L10 Fatigue and Service Life

Roller bearing components can be used in perpetuity provided they meet reconditioning criteria. In practice, roller bearings and their components have a finite life which is defined by fatigue. L10 fatigue life [8] is defined as a calculated life (hours, miles, etc.) when a group of identical new roller bearings operating under controlled laboratory conditions will first show evidence of fatigue spalling. During testing, the development of a spall that measures about 0.01 square inch on a cup raceway, cone raceway or roller is defined as a laboratory failure. For a given population of identical bearings, 90% will meet or exceed the predicted life and 10% will fail before reaching that value (hence L10).

There is a difference between the small fatigue spall that defines roller bearing Ll0 life in laboratory testing and the spalling that determines the end of roller bearing life in railway service. For this reason, the AAR reconditioning standards permit the repair of spalls on raceways within certain limits. However, a small fatigue spall that requires repair during reconditioning is still an indicator that the bearing is beginning to fail in fatigue. In addition, a repaired spall on a raceway increases the contact stress in the vicinity of the repair and also introduces a stress riser at the edge of the repair. When the roller is directly over a repaired spall, there is less raceway surface supporting the load.

It is recognized in the industry that repaired spalls have a negative effect on bearing life when compared to raceways with no repaired spalls. For example, a raceway with one ⅜ inch repaired spall has a calculated life of only 36.5% that of a new or undamaged raceway. [9] While the calculated life would be greater for repaired spalls of a smaller dimension, given the variability of the repairs, there is no defined L10 predictive life for reconditioned roller bearings. In the field, other factors are known to negatively affect service life as roller bearing failure itself is not limited to fatigue spalling. AAR overheated roller bearing data for 2008–2010 (Table 1) identified that the following defects account for over 90% of confirmed overheated roller bearing failures:

% of Confirmed Roller Bearing Failures	Cause
31.9	Fatigue Spalling
25.8	Water Etching
14.6	Mechanical Damage
10.9	Loose Bearing
4.6	Adapter Defect
3.7	Wheel Defect

Table 1. Causes of confirmed roller bearing overheats

VIA Roller Bearing Reconditioning Standards

[8] Brenco Technical Forum 90-1, *Bearing Life*, Brenco Incorporated 1990.

[9] TSB Investigation Report R11T0016.

VIA roller bearing reconditioning standards require that roller bearings be reconditioned in accordance with the standards set forth in the AAR MSRP H-II . In addition, VIA has the following instructions for roller bearing cup and cone assembly reconditioning for each type of passenger coach.

Renaissance Coaches:

Cup

1. Counterbore dimension maximum of 8.2530 inch.
2. Cup outside diameter minimum of 9.0500 inch.
3. Apply plastic plug K145179 to outer diameter holes.
4. Mark load zone with paint crayon.
5. Do not apply VIA decals.

Cone Assembly - Bore size must be OEM (5.1168 inch to 5.1178 inch). Remanufactured or chrome plated cones can be used. Only product from VIA Renaissance bearings may be used.

HEP Coaches:

Cup - VIA Rail Specifications decal to be applied. Only product from transit or passenger bearings may be used.

Cone Assembly - Remanufactured or chrome plated cones can be used. Only product from transit or passenger bearings may be used.

LRC Coaches:

Cup

1. No heat discoloration / smearing / peeling / brinelling / indentations / heavy water etching on the raceways.
2. No decals to be applied to the outer diameter.

   Note: Reground or chrome plated cups are NOT to be used. Only acceptable cups identified as VIA material are to be used.

Cone Assembly

1. Bore size must be OEM (5.6870 inch to 5.6880 inch).
2. No heat discoloration / smearing / peeling / brinelling / indentations / heavy water etching on rollers or inner raceway.

   Note: Remanufactured or chrome plated cones can be used. Only product from VIA LRC bearings may be used.

Examination of the Failed R4 Roller Bearing

The only visible marking on the failed (R4) roller bearing was on the outboard cone, indicating that it had been manufactured in 1979. During the teardown examination, the following observations were made for the R4 roller bearing:

- The plastic end cap plug was missing and the exposed threads were rusted.

- The major R4 roller bearing components were severely heat discolored, smeared and plastically deformed.
- The inboard cage was skewed and, along with the rollers, remained fused to the cup while the cone was fused to the axle journal. Some spalling was observed on the cone raceway.
- The outboard rollers, cage and both seals were destroyed. Some spalling was observed on the cup path and cone raceway.

Due to the severity of the damage, it was not possible to precisely determine the cause of the R4 bearing failure. However, the observed damage suggests that spalling resulted in cage failure and bearing seizure causing the overheat.

For the mate (L4) roller bearing, the major components (i.e., cup, inboard cone assembly and outboard cone assembly) had been manufactured in 1981, 1976 and 1972, respectively. This roller bearing had been reconditioned a number of times.

Other Recent VIA Roller Bearing Failures on HEP Coaches

Since this occurrence, there have been 4 other roller bearing failures involving VIA HEP coaches:

VIA 4000 - 12 February 2011

At about 1720, eastward VIA passenger train 60 (VIA 60), equipped with HEP coaches, passed a wayside HBD at Mile 4.80 on the CN Montreal Subdivision, with no alarms noted. The train continued on to destination at Montreal Central Station (Mile 0.0). After the passengers disembarked, the train proceeded to the VIA Montreal Maintenance Centre for servicing and inspection. During regular “C” trip inspection, the R4 roller bearing on VIA 4000, which was the second car on VIA 60, was observed to be severely overheated. The wheelset was removed and sent for examination (TSB Occurrence No. R11D0026).

Roller bearing teardown inspection revealed:

- The plastic end cap plug was missing and the exposed threads were rusted.
- The outboard components were heat discolored. The outboard cup path was heavily spalled while the cone assembly was heavily smeared and plastically deformed with a number of rollers either missing or melted. The corresponding cage had a number of broken ribs.

The R4 bearing failure likely initiated with spalling on the outboard cup path, which led to cage failure and bearing seizure causing the overheat.

VIA 8340 - 29 April 2011

During a visual inspection of coaches at the Mimico Maintenance Centre in Toronto, a suspect roller bearing (R1) was discovered on coach VIA 8340. The wheelset was removed and sent for examination (TSB Occurrence No. R11T0133).

Roller bearing teardown inspection revealed:

- The plastic end cap plug was missing and the exposed threads were rusted.
- The outboard cup path and rollers were stained and indented. The outboard cup path exhibited a 2 inch wide concentrated region of heavy spalling which extended across the entire path.

The R1 roller bearing failure was caused by spalling on the outboard cup path.

VIA 8714 - 29 April 2011

VIA train crew on passenger train 2 (VIA 2) received an abnormally high HBD reading from the R3 roller bearing on coach VIA 8714. The crew used an infrared gun to check the temperature of the roller bearing and confirmed it to be 220 degrees. The train proceeded at 15 mph and set the car off at the next available location. The wheelset was removed and sent for examination (TSB Occurrence No. R11W0141).

Roller bearing teardown inspection revealed:

- The plastic end cap plug was missing and the exposed threads were rusted.
- The cup exterior displayed circumferential smearing indicating that it had been rotating in the journal box.
- The outboard components were heat discolored.Water etching was observed on the outboard cup path. The outboard cup path, cone raceway and rollers were heavily worn and exhibited spalling while the corresponding cage was worn past condemning limits.

The R3 bearing failure was likely initiated by lubrication breakdown which led to heavy wear and spalling of the outboard cup path, cone raceway and rollers. This resulted in bearing seizure and rotation in the journal box which caused the overheat.

VIA 4112 R2 - 30 April 2011

VIA passenger train 95 (VIA 95) was proceeding westward on the CN Grimsby subdivision when the crew received an alarm from the HBD located at mile 28.60. Upon inspection, the crew discovered a seized wheel on coach VIA 4112 as a result of an overheated R2 roller bearing. The wheelset was removed and sent for examination (TSB Occurrence No. R11T0095).

Roller bearing teardown inspection revealed:

- The plastic end cap plug was missing and the exposed threads were rusted.
- The cup exterior displayed circumferential smearing indicating that it had been rotating in the journal box.
- The outboard components were stained and indented.

- The inboard cup path and cone assembly were heat discoloured and smeared. The inboard cup path was heavily spalled while spalling to a lesser extent was observed on the corresponding cone raceway and rollers. The inboard cage was distorted and had 2 broken ribs.

The R2 bearing failure was initated by spalling of the inboard components which generated the failure of the corresponding cage. This resulted in bearing seizure and rotation in the journal box which caused the overheat.

Information recorded from the 5 teardown examinations performed on the VIA roller bearings (including the occurrence roller bearing) is summarized in the Table 1.

VIA Car No.	Fail Pos.	Method Detected	Cup Mfg Date	Cup Times Rework	Cup Last Rework	IB Cone Mfg Date	IB Cone Times Rework	IB Cone Last Rework	OB Cone Mfg Date	OB Cone Times Rework	OB Cone Last Rework
4009	R4	Visual	N/A	N/A	N/A	N/A	N/A	N/A	Apr-79	N/A	N/A
4000	R4	Visual	ZI-67	N/A	N/A	D-68	N/A	N/A	Dec-71	N/A	N/A
8340	R1	Noisy during hand turn	Feb-90	3	Jul-09	Nov-95	None	None	Nov-72	None	None
8714	R3	HBD	May-86	3	Aug-05	Sep-74	2	Jul-96	May-71	1	Aug-91
4112	R2	HBD	Jun-74	3	Apr-08	Feb-88	None	None	Jul-87	None	None
All roller bearings inspected were Class F, 6 ½ inch X 12 inch tapered roller bearing assemblies, manufactured by Timken and reconditioned by Timken subsidiary Rail Bearing Services.											
Yellow highlight denotes failed component manufacturing date.											

VIA Overheated Roller Bearing Data

Appendix A presents a summary of VIA overheated roller bearing data from November 2008-May 2011.

The following observations were made:

- There was 1 confirmed Renaissance coach outboard roller bearing failure as detected by the on-board roller bearing monitoring sytem.
- There were 3 confirmed LRC coach inboard roller bearing failures as detected by on-board roller bearing monitoring sytems.
- There were 10 confirmed HEP coach outboard roller bearing failures.
- Of the 10 HEP roller bearing failures, 5 were detected by wayside HBDs and 5 of them were detected by other means, usually visual inspection.
- Of the 10 HEP roller bearing failures, 7 occurred in a 1-year period between June 2010 and April 2011.
- There were no VIA burnt off axle journals recorded.

Passenger Car and Freight Car HBD Alarms

For comparison, HBD records were reviewed for VIA 70 (the occurrence train), VIA 60 (12 February 2011) and a typical freight train (Appendix B).

It was determined that:

- The average HBD reading for all roller bearings on the freight train was 4.5 to 4.6 mm.
- The average HBD reading for all roller bearings on both VIA trains which were equipped with HEP coaches was 1.7 mm to 1.8 mm.
- The R-4 position of VIA 4009 on Train 70 (occurrence bearing) recorded a reading of 3.4 mm and the R-4 position of VIA 4000 on Train 60 recorded a reading of 4.0 mm.

There have been other occurences where a roller bearing has failed when the recorded reading was below CN's HBD Warm alarm level, but was over 2 times hotter than the average roller bearing temperature for the train. For example, on 26 January 2011, a CPR freight train travelling southward on the CPR MacTier Subdivision derailed 21 cars near Buckskin, Ontario (TSB Occurrence No. R11T0016). The cause of the derailment was determined to be a burnt off axle journal that resulted from an undetected L4 roller bearing failure. Before the derailment, while travelling on CN track, the roller bearing that eventually failed had recorded temperatures below CN's HBD Warm alarm levels, yet were over 2 times hotter than the average roller bearing temperature for the train involved.

The following TSB Engineering Laboratory reports were completed:

- LP031/2011 – Bearing Examination – VIA Passenger Train 70, Car VIA 4009
- LP117/2011 – Bearing Examination – VIA Passenger Train 60, Car VIA 4000
- LP118/2011 – Bearing Examination – VIA Passenger Train 2, Car VIA 8714
- LP119/2011 – Bearing Examination – VIA Passenger Train 95, Car VIA 4112
- LP120/2011 – Bearing Examination – Car VIA 8340

These reports are available upon request from the Transportation Safety Board of Canada.

Analysis

The train was operated and the track was maintained in compliance with railway and regulatory requirements. There were no operating or track conditions observed that were considered causal. The analysis will focus on VIA roller bearing failures, the ability of wayside HBD systems to detect overheated VIA passenger coach roller bearings and the reconditioning standards for VIA passenger roller bearings.

The Incident

Just before arriving at the Oakville station on 06 February 2011, VIA 70 passed over a CN HBD located at Mile 33.00 on the Oakville Subdivision, with no HBD alarms noted. Upon arrival for the scheduled stop in Oakville (Mile 21.40), the VIA stationmaster observed smoke originating from the R4 roller bearing on VIA HEP passenger coach 4009. The incident occurred when the VIA HEP coach roller bearing overheated and failed, yet was not detected by a CN HBD located less than 12 miles in advance of the station.

Hotbox Detection Systems

HBD records reviewed for VIA 70, VIA 60 and a typical freight train revealed a significant disparity between the freight and passenger train HBD readings. The average HBD reading for all roller bearings on the freight train was 4.5 to 4.6 mm while the average HBD reading for all roller bearings on both VIA trains, which were equipped with HEP coaches, was 1.7 to 1.8 mm.

The R-4 position of VIA 4009 (Train 70) recorded a reading of 3.4 mm and the R-4 position of VIA 4000 (Train 60) recorded a reading of 4.0 mm just prior to stopping. While the readings were below established CN HBD warm alarm thresholds, they were at least twice as high as the average reading for the passenger trains. The HEP coach roller bearings were likely heating up and beginning to fail without triggering an HBD alarm.

Due to the HEP coach truck arrangement in which the roller bearing is enclosed in an axle journal box and pedestal tie straps partially cover the bottom of the journal box, the HBD scanning pattern was obstructed. This obstruction resulted in unusually low and inaccurate roller bearing HBD temperature readings for the VIA HEP cars.

Unlike VIA’s Renaissance and LRC coaches, VIA HEP coaches are not equipped with automated onboard roller bearing monitoring systems that can alert operating crews to a developing roller bearing failure. Therefore, while in-service, approximately 50% of VIA’s passenger fleet remains vulnerable to inadequately monitored and potentially undetected roller bearing failure. This is of particular concern in the high speed Quebec–Windsor Corridor with areas of extended double main track and locations where train traffic can reach up to 100 trains per day. Under these circumstances, the absence of a system that consistently and accurately monitors VIA HEP coach roller bearings presents a risk overheated roller bearings will remain in service with a potential for catastrophic failure and commensurate risk to the travelling public.

Review of HBD data for both freight and passenger equipment determined that roller bearings have failed in situations where the recorded HBD temperature was below the CN Warm alarm threshold yet the temperature of the roller bearing was over 2 times higher than the average roller bearing temperature on the train. In each case, roller bearing teardown examinations confirmed the roller bearing failure and overheat. An HBD recorded roller bearing temperature that is 2 times higher than the train average roller bearing temperature may indicate a pending roller bearing failure.

Roller Bearing Failure and Reconditioning

Roller bearing cups, rollers and cones are case hardened while cone assembly cages are generally cold formed from low carbon malleable steel. Once any of the case hardened components begin to spall, small pieces of very hard steel begin to circulate with the grease as the roller bearing rotates. The softer cage material is worn away as it comes into contact with the hardened steel pieces. Eventually, the cage fails, the rollers are no longer held in place, the roller bearing geometry is compromised and the roller bearing ultimately fails. With regards to the R4 roller bearing on VIA 4009, due to the severity of the damage, the precise cause of the overheating could not be determined. However, the presence of spalling on the VIA 4009 R4 outboard cup path and both cone raceways in conjunction with the observed cage failures suggests that spalling resulted in cage failure and bearing seizure causing the overheat.

Since November 2008, over 70% (10 of 14) of the confirmed VIA overheated roller bearings occurred on HEP coaches. Of the 10 HEP roller bearing failures, 5 were detected by wayside HBDs and 5 of them were detected by other means, usually visual inspection. The HEP roller bearing failures appear to be increasing in frequency as 5 of them have occurred since February 2011. In each of the 5 cases, the failed components were over 20 years old with 1 as high as 44 years old. Many of the components had been reconditioned multiple times. Although there are exceptions, considering the age of the HEP fleet and that the VIA roller bearing fleet is captive, this potentially equates to a range of 2.84 to 5.95 million miles of roller bearing service life.

While the AAR does not require roller bearings to be removed for any age or mileage criteria, roller bearing components do have a finite life which is defined by the development of fatigue spalling. It is recognized that spalling can be initiated by a number of factors, but it is also an indicator that a roller bearing component has reached its fatigue limit. In the 5 roller bearing failures examined, spalling was observed in each case on either the cup paths and / or cone assemblies and was likely causal or contributory to each of the failures. Considering the age and potential service life of the VIA HEP roller bearings and that spalling was present in each of the 5 roller bearing failures, some of the fleet’s other roller bearing components may be nearing the end of their fatigue life and at risk of failure.

VIA roller bearing reconditioning standards require that roller bearings be reconditioned in accordance with the standards set forth in the AAR MSRP H-II manual, which is considered as a minimum standard. In addition, VIA has a separate roller bearing reconditioning standard for each type of passenger coach in their fleet. However, none of the VIA standards place any restrictions on the use of cup or cone raceways with repaired spalls. In contrast, some other railways have additional premium reconditioning specifications that do not permit any spalling or defects in raceway components.

AAR MSRP roller bearing reconditioning standards are based on freight car practice which requires the removal and inspection of roller bearings whenever a wheelset is removed and sent to a wheel shop for reconditioning. Based on the average freight car wheelset life cycle, this means that roller bearings would usually be removed and inspected during reconditioning about every 220 000 miles.

In comparison, when VIA wheelsets are removed for wheel tread defects and enough material remains on the wheel tread, VIA re-profiles the wheels with the roller bearings still mounted on the axle and the re-profiled wheelset is placed back under another VIA car. Of the 5 roller bearing failures examined, only 3 had legible reconditioning dates. One of the 3 roller bearings was last reconditioned over 5 years ago. With estimated VIA HEP coach mileage of 138 000 miles per year, the failed bearing could have potentially travelled 690 000 miles without having had a teardown inspection. This interval is approximately 3 times longer than the typical interval for reconditioning a freight car wheelset. The load on HEP bearings is however lower than that on freight car bearings.

Significantly longer intervals between roller bearing reconditioning may require more stringent reconditioning standards. VIA roller bearings can experience extended service life between teardown inspections, yet VIA standards permit the use of reconditioned roller bearing components that have repaired raceway spalls which are more likely to experience a reduced service life. Under these conditions, the absence of a more stringent company reconditioning standard related to the use of repaired spalls increases the risk of failure within VIA's aging captive roller bearing fleet.

Each of the VIA HEP roller bearing failures occurred on the R side. In each case, the plastic plug for the end cap hole was missing and the exposed threads were rusted, indicating that the plug had been missing for some time. Although the end cap plug hole is also protected by an inner rubber seal, the absence of a plastic end cap plug may permit contaminants to enter the bearing which could accelerate roller bearing failure.

Regulatory Overview

Unless equipped with another approved means of detection (such as on-board detectors), freight truck designs that shield roller bearings from HBDs are prohibited by the AAR from interchange between railways. In contrast, there is no such Canadian regulatory restriction for passenger coaches with similar truck designs.

In addition, while the TC approved *Railway Passenger Car Inspection & Safety Rules* require an overheated roller bearing detector and alarm system for each roller bearing mounted inboard of a wheel, there is no such instruction for roller bearings mounted outboard of a wheel as it has always been assumed that these roller bearings are protected by HBDs. However, as demonstrated by this occurrence, not all roller bearings mounted outboard of a wheel can be effectively monitored by current wayside HBD systems. Therefore, as written, the rules do not ensure that all passenger cars are effectively protected against overheated roller bearings, increasing the risk of roller bearing failures and derailments.

Findings as to Causes and Contributing Factors

1. An overheated roller bearing on a VIA HEP coach was not detected by a CN HBD and then failed within the next 12 miles.

2. The VIA HEP coach axle journal boxes, which enclose the roller bearings, and the pedestal tie straps that partially cover the bottom of the journal boxes interfered with the HBD

scanning which resulted in unusually low and inaccurate roller bearing HBD temperature readings.

3. The roller bearing likely failed when spalling resulted in cage failure and bearing seizure causing the overheat.

Findings as to Risk

1. The absence of a system which consistently and accurately monitors VIA HEP coach roller bearings presents a risk that overheated roller bearings will remain in service with a potential for catastrophic failure and commensurate risk to the travelling public.

2. Considering the age and potential service life of the VIA HEP roller bearings and that spalling was present in each of the 5 roller bearing failures, some of the fleet's other roller bearing components may be nearing the end of their fatigue life and at risk of failure.
3. The absence of a more stringent company reconditioning standard related to the use of repaired spalls increases the risk of failure within VIA's aging captive roller bearing fleet.

4. The Transport Canada approved *Railway Passenger Car Inspection & Safety Rules* do not ensure that all passenger cars are effectively protected against overheated roller bearings, increasing the risk of roller bearing failures and derailments.

Other Findings

1. An HBD recorded roller bearing temperature that is two times higher than the train average roller bearing temperature may indicate a pending roller bearing failure.

Safety Action Taken

TSB Rail Safety Advisory

On 17 March 2011, the TSB issued Rail Safety Advisory Letter (RSA) 03/11 to Transport Canada (TC), VIA and CN. The RSA indicated that VIA HEP coaches and some locomotive truck arrangements interfere with the scanning pattern of HBDs which can result in unusually low and inaccurate roller bearing temperature readings. It appears that there is no on-board detection system or wayside HBD system to reliably protect HEP passenger equipment and certain freight locomotives against roller bearing overheating. The RSA suggested that Transport Canada may wish to ensure that all rolling stock is adequately protected against roller bearing overheating and catastrophic failure.

On 28 March 2011, CN responded that it had met with VIA to review the issue and were advised that VIA intends to install onboard detection equipment on its fleet. CN also reviewed its records regarding journal failures on locomotives. Based on this review, there has not been a burnt off journal on its locomotive fleet in over 10 years. The review also determined that although locomotive bearings tend to run at lower temperatures due to their larger size, overheating can and has been successfully detected by CN's wayside HBD system and trending process using its standard "alarm" thresholds.

On 27 May 2011, Transport Canada responded indicating that VIA intends to install on-board detection equipment on its fleet. In the interim, one car set of tie-bars were modified with a cut-out. The intent was to monitor this car in service to assess if the wayside HBD scanners can operate properly with the modified tie-bars. If the test is clearly positive, VIA would prepare a cost estimate to modify all tie-bars on the HEP I and HEP II fleets, with corridor HEP I and HEP II coaches being the priority.

On 14 October 2011, TC provided an update. The update stated that, while initially VIA had committed to equip all corridor HEP baggage cars and all HEP II cars with on-board bearing detection systems by the end of 2011, VIA has subsequently changed its plan due to funding and production constraints.

VIA Rail Inc.

On 30 November 2011, VIA provided an update on a number of activities related to failures of HEP roller bearings:

- On board roller bearing monitoring is being installed on all corridor (higher speed) HEP baggage cars. To date, there are 4 of 8 cars equipped and the remaining cars will be completed by the end of 2011. Installation of bearing monitoring on the 33 corridor HEP II cars is delayed until the second quarter of 2012, once new funding is confirmed by the Government.
- To help mitigate the risk on the HEP II cars in the short term, VIA is modifying the pedestal tie bars. VIA has designed a cut out on the tie bar to allow the scanner to see the journal box that houses the roller bearing. Consultation with railway truck experts identified that the tie bars should not be removed. Testing on a prototype showed that the scanner reading was slightly higher on the modified car.
- VIA has equipped 5 HEP cars with the modified tie bars and will have 5 more completed by the end of 2011. VIA will monitor the modified cars to confirm that there is an improvement in wayside scanner readings. The intent is to have the HEP II fleet modified by early February 2012.
- VIA is reviewing its bearing requalification specification and is considering some form of age limit for requalified components. The intent is to issue a revised specification by the end of the first quarter of 2012.
- VIA issued Equipment Maintenance Service Bulletin T041, *Axle (wheelset) Bearing Failures: Replace Suspect Wheelsets for Bearing Inspection*, in June 2011 to emphasize the need to be more vigilant of unusual bearing noise and visual indications of bearing distress. This has resulted in increased VIA wheelset removal for noisy or stiff bearings, some in which defects were subsequently confirmed.

Safety Action Required

Safety Concern

In the United States, unless equipped with another approved means of detection (such as on-board detectors), freight truck designs that shield roller bearings from HBDs are prohibited from interchange between railways. In Canada, with no similar restriction for passenger coaches, VIA trains equipped with truck arrangements that shield roller bearings from HBDs are regularly operated on CN and CP track.

VIA's Renaissance and LRC passenger coaches are equipped with automated onboard roller bearing monitoring systems while HEP coaches are not. Since November 2008, over 70% (10 of 14) of the confirmed VIA overheated roller bearings occurred on HEP coaches. Not only do the HEP coach roller bearings have a higher frequency of failure, they are currently the least likely to be detected by a monitoring system.

Due to the HEP coach truck arrangement, in which the roller bearing is enclosed in an axle journal box and pedestal tie straps partially cover the bottom of the journal box, the HBD scan of the roller bearing is obstructed. The obstruction results in unusually low and inaccurate roller bearing HBD temperature readings for HEP cars. To address this problem, VIA had originally indicated that it would install on-board detection equipment on all of its 220 HEP coaches. However, due to funding and production constraints, the plan was subsequently modified to include only 33 corridor HEP II cars.

The TC approved *Railway Passenger Car Inspection & Safety Rules* require an overheated roller bearing detector and alarm system for each roller bearing mounted inboard of a wheel. For roller bearings mounted outboard of a wheel, there is no such requirement as it was assumed that outboard roller bearings are monitored by HBDs. However, this investigation has demonstated that not all roller bearings mounted outboard of a wheel can be consistently and accurately monitored. Therefore, the Board is concerned that in the absence of comprehensive industry action or TC rules or guidelines to ensure all passenger cars are protected against overheated roller bearings, there is an increased risk of roller bearing failure and commensurate potential for passenger train derailment.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on18 April 2012. It was officially released on 22 May 2012.

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

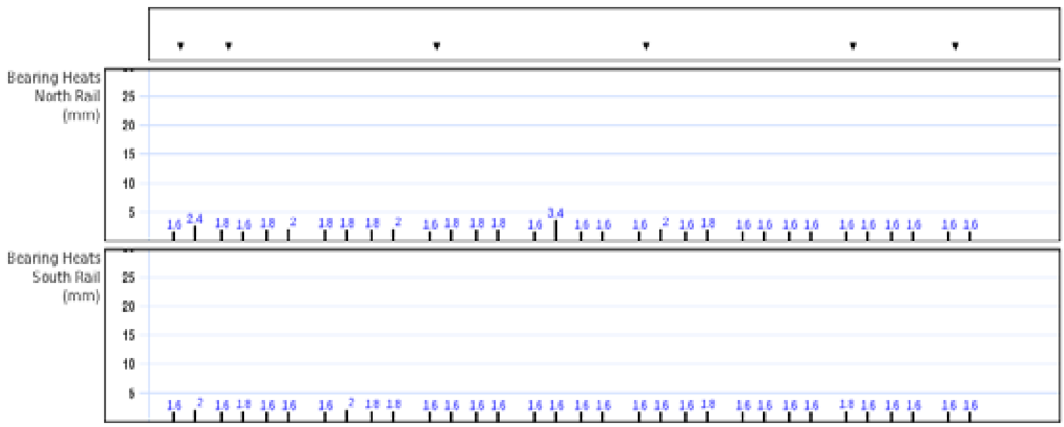
Appendix A – VIA Overheated Roller Bearings November 2008-2011

				On board system		Wayside	Other	Conf.
Fail Date	**Car Type**	**Car #**	**Pos**	**Installed**	**Alerted**	**Detected**	**Detection**	**Hot**
1-Nov-08	HEP	8404	L1	No	N / A	Yes	No	Yes
10-Mar-09	LRC	3308	L2	Yes	Yes	N / A	N / A	Yes
8-Apr-09	REN	7401	L1	Yes	Yes	N / A	N / A	Yes
17-Jun-09	LRC	3342	R2	Yes	Yes	N / A	N / A	Yes
23-Jun-09	LRC	3312	R2	Yes	Yes	N / A	N / A	Yes
12-Oct-09	HEP	8405	R2	No	N / A	No	Yes	Yes
30-Nov-09	HEP2	4122	R3	No	N / A	Yes	No	Yes
16-Jun-10	HEP	8305	R4	No	N / A	No	Yes	Yes
12-Sep-10	HEP2	4008	R2	No	N / A	Yes	No	Yes
6-Feb-11	HEP2	4009	R4	No	N / A	No	Yes	Yes
13-Feb-11	HEP2	4000	R4	No	N / A	No	Yes	Yes
29-Apr-11	HEP	8714	R3	No	N / A	Yes	No	Yes
29-Apr-11	HEP	8340	R1	No	N / A	No	Yes	Yes
30-Apr-11	HEP2	4112	R2	No	N / A	Yes	No	Yes
					4	5	5	14

Appendix B – Comparision of HBD Readings

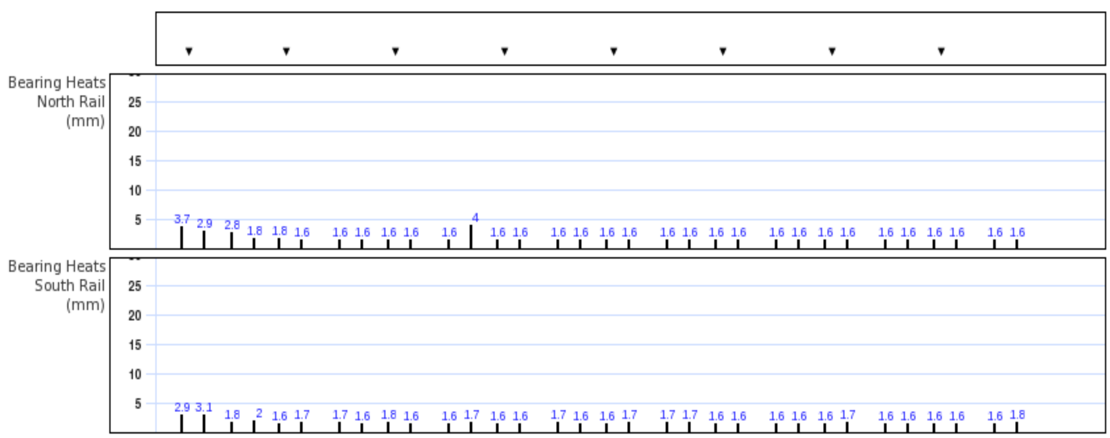
VIA Train 70 HBD Readings – Mile 33 Oakville Subdivision. – 06 February 2011

Site:	ASH2
Fullname:	Aldershot Track 2
Subdivision:	Oakville
Mile:	33
Territory:	3AC
WIS type:	DHP2000
Circuit Number:	LLL_325
Branch or Main:	main
Backup Power:	
Date:	2011-02-06
Arrival Time:	09:30:18
Speed In:	62 mph
Direction:	E
Number of Cars:	6
Number of Axles:	32
North Rail Bearing Avg	1.8 mm
South Rail Bearing Avg	1.7 mm
North Rail Wheel Avg	20°F
South Rail Wheel Avg	24°F
Integrity Alarms	
No integrity alarms present	



VIA Train 60 HBD Readings – Mile 4.8 Montreal Subdivision. – 12 February 2011

Site:	HENS
Fullname:	St. Henri South
Subdivision:	Montreal
Mile:	4.8
Territory:	2AE
WIS type:	STC_Sentry
Circuit Number:	CSHBD0103
Branch or Main:	main
Backup Power:	Yes
Date:	2011-02-12
Arrival Time:	17:20:58
Speed In:	66 mph
Direction:	E
Number of Cars:	8
Number of Axles:	32
North Rail Bearing Avg	1.8 mm
South Rail Bearing Avg	1.7 mm
North Rail Wheel Avg	Unavailable
South Rail Wheel Avg	Unavailable
Integrity Alarms	
No integrity alarms present	



First 2 Locomotives & 6 Cars of Typical Freight Train HBD Readings

Site:	ASH1
Fullname:	Aldershot Track 1
Subdivision:	Oakville
Mile:	33
Territory:	3AC
WIS type:	DHP2000
Circuit Number:	LLL_325
Branch or Main:	main
Backup Power:	

Date:	2011-02-28
Arrival Time:	07:53:48
Speed In:	41 mph
Direction:	W
Number of Cars:	78
Number of Axles:	316
North Rail Bearing Avg	4.5 mm
South Rail Bearing Avg	4.6 mm
North Rail Wheel Avg	18°F
South Rail Wheel Avg	27°F

Integrity Alarms

No integrity alarms present