RAILWAY INVESTIGATION REPORT
R98T0292

YARD DERAILMENT

CANADIAN NATIONAL
TRAIN NO. M333-31-26
MILE 0.0, HALTON SUBDIVISION
MACMILLAN YARD
CONCORD, ONTARIO
26 NOVEMBER 1998

Transportation Safety Board of Canada

Bureau de la scurit des transports du Canada

Railway Investigation Report

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Synopsis

On 26 November 1998, at approximately 0645 eastern standard time, Canadian National train No. M333-31-26, departing MacMillan Yard in Concord, Ontario, derailed three loaded tank cars on the Green Route track. The derailed tank cars were loaded with anhydrous ammonia; the protective housing and valving on one of the cars were damaged, resulting in a minor leak. The yard was evacuated, and the public roadways in the area, including Highway 7, were closed for approximately five hours. There were no injuries.

The Board has identified a safety deficiency relating to the maintenance standards and practices in heavy tonnage “other than main tracks.” The safety recommendation issued by the Board to address the identified safety deficiency is presented in Section 4.

Ce rapport est également disponible en français.

1.0 Factual Information

1.1 The Accident

On 26 November 1998, at approximately 0645 eastern standard time (EST)[1], Canadian National (CN) train No. M333-31-26 (the train), departing MacMillan Yard, crossed over from track No. CNW004 onto the Green Route track (the crossover). A train-initiated emergency brake application occurred. Once the train came to a stop, the conductor detrained and observed that three tank cars had derailed: tank car PLMX 3447 had rolled down a 20-foot embankment to the west of the tracks, tank car UTLX 92367 was lying on its side, and tank car PLMX 4651 had remained upright. There were no injuries.

1.2 Damage

Approximately 100 feet of track was destroyed. All three tank cars sustained damage to their jackets, shells, stub sills, steps, and ladders. The protective housing on tank car PLMX 3447 plowed through the asphalt surface and was crushed under the weight of the car, resulting in a minor leak. CN emergency response personnel evacuated MacMillan Yard, and the local police closed public roadways in the surrounding area, including Highway 7, for about five hours. This action was conducted in a timely and professional manner.

1.3 Yard Movements

Movements leaving MacMillan Yard towards southern Ontario and Chicago proceed along the Halton outbound track. The minimum annual tonnage over this track is approximately 17 million gross tons (MGT).

Since the Green Route track which leads to the Halton outbound track is used to make up trains, the level of tonnage travelling over the Green Route track can be three to four times higher than that on the Halton outbound track. The maximum allowable train speed for yard operations in MacMillan Yard is 15 mph, which was increased from 10 mph in May 1998. The allowable speed on the Halton Subdivision between Mile 0.0 and Mile 0.7 is 30 mph; on the remainder of the subdivision, the allowable speed is between 40 mph and 55 mph.

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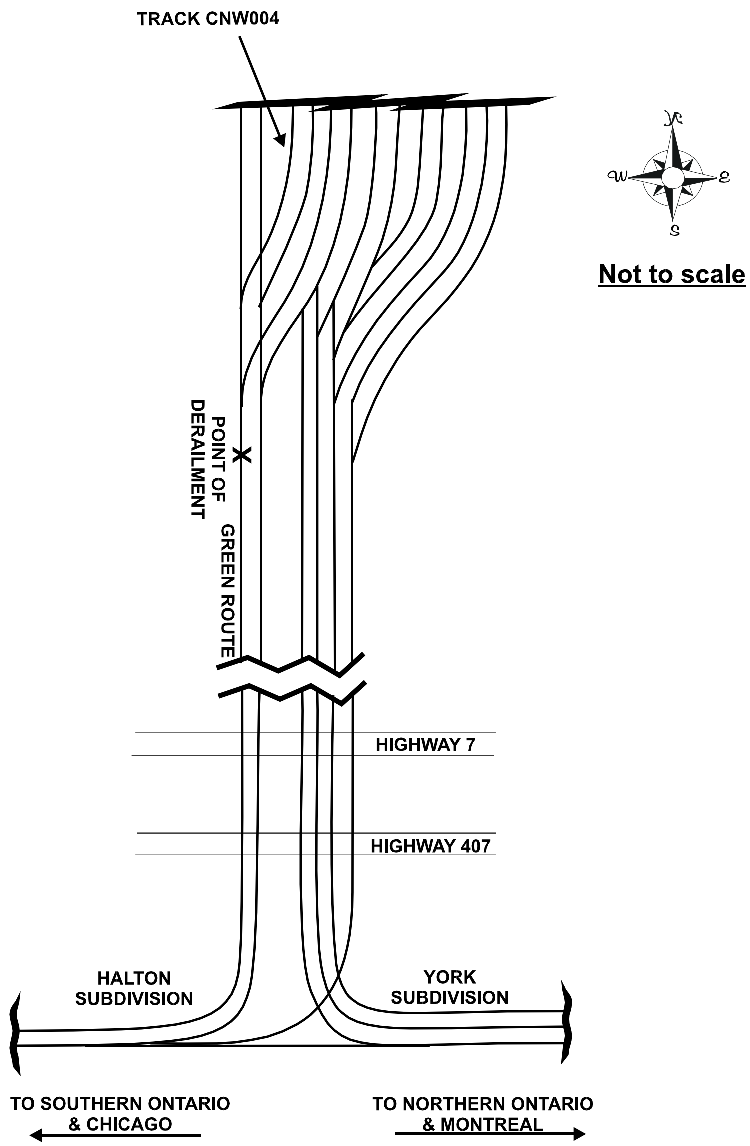
[1] All times are EST (Coordinated Universal Time (UTC) minus five hours) unless otherwise stated.



1.4 Weather

The temperature at the time of the derailment was approximately minus 10 degrees Celsius. The skies were cloudy and the winds light.

1.5 Train Information

The train consisted of 4 locomotives, 81 loaded cars, 13 residue cars, and 35 empty cars. It was approximately 8 400 feet in length and weighed about 12 000 tons.

1.6 Personnel Information

The train crew included a locomotive engineer and a conductor, both located in the lead locomotive. They were qualified for their respective positions and met established fitness and rest standards.

1.7 Recorded Information

Event recorder data indicated that the train experienced a train-initiated emergency brake application while it was travelling at approximately 9 mph.

1.8 Particulars of the Tank Cars

The three derailed tank cars were laden with liquefied anhydrous ammonia, UN 1005, Class 2.4, a corrosive gas. Liquefied anhydrous ammonia emits vapours which are extremely irritating and corrosive. Contact with this liquefied gas may cause burns, severe injury, and/or frostbite.

The TSB Engineering Branch examined the three derailed tank cars (report LP 144/98). There was no damage to the valves of car PLMX 4651 or car UTLX 92367. The examination of car PLMX 3447 revealed the following:

- Valves within the nozzle and outlet arrangement had been subjected to impact. The side of the protective housing remained intact while its lid was bent and indented.

- There was no damage to the mechanism of the two eduction angle and vapour line valves or in their respective excess flow valve. No damage was observed on the pressure relief valve, the sampling line, or the thermometer well. All three were seated firmly onto the housing plate. There was no evidence to suggest that the two eduction angle valves, the vapour line valve, the pressure relief valve, the sampling line, or the thermometer well leaked subsequent to the impact.

- The gauging device graduated rod was found significantly bent as a result of the impact. This bend could have caused an improper seal and subsequent leakage.

- The clearance of the lid over the nozzle and outlet arrangement valve housing was approximately 2.54 cm. This allowed contact with both eduction valve stems, as well as the gauging device cover, and directly contributed to the damage to the gauging device.

1.9 Particulars of the Track

Through the derailment area, the track structure consisted of 115-pound rail, laid on double-shouldered tie plates on softwood ties and fastened with four spikes per tie. The ballast was crushed rock.

Ties were rail anchored every second tie over 200 feet on each side of the crossover. Ties were 15 per cent defective. Ballast was contaminated with dirt and mud, and a soft spot was noted.

Wheel flange marks were observed on the ties one foot south of the crossover. The rail had broken at four locations. The fractures were located on two adjacent rails, joined together with a four-bolt joint bar. One rail length was manufactured in 1960 and was re-laid in 1989, having

been moved from another location. The second one was manufactured and laid in 1995.
Six rail sections were sent to the TSB Engineering Branch for analysis. The analysis (report LP 143/98) concluded the following:

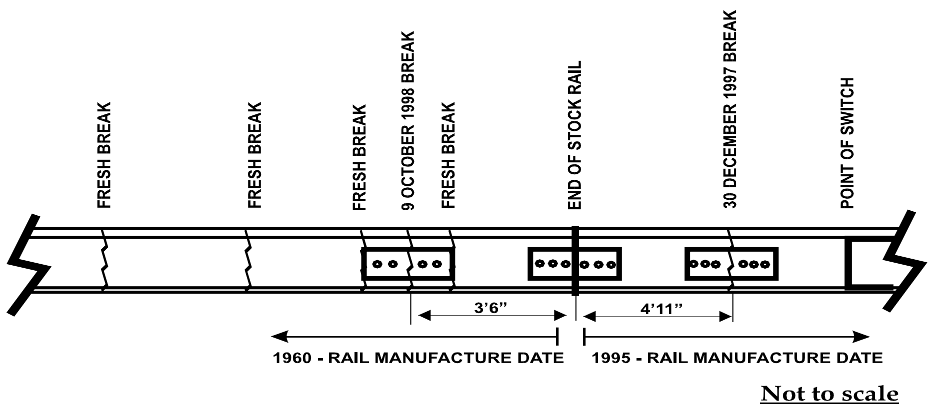
- The four recent rail fractures were mostly overstress in nature. A sub-surface fatigue crack extending across approximately five per cent of the cross-section was observed on the two fractures where details were still visible in the head area. The extent of the sub-surface fatigue cracking, while sufficient to lead directly to fracture, would serve to provide areas of stress concentration where fracture could initiate.

- Sub-surface fatigue cracks were associated with shelling damage. Sub-surface cracking of this type tends to progress internally in directions transverse and longitudinal to the rail axis, making it undetectable by external visual inspection.

- Shelling damage was due to excessive wear.

- The vertical rail wear was 9.5 mm and the combined vertical and gauge side lateral wear reached 14.5 mm.

- Wheel flanges were striking the tops of the joint bars.



Immediately south of the crossover switch point, the rail had a previous fracture that had been observed on 09 October 1998. The adjacent rail length also had been fractured on 30 December 1997.

Both previous fractures had been reported by passing train crews. In both cases, maintenance-of-way personnel were dispatched immediately and repaired the fractured rail with joint bars. The joint bar repairs and the existing rail joint bar were located within a span of eight feet five inches, segmenting the rail into two sections—3 feet 6 inches and 4 feet 11 inches.

1.10 Track Inspection Program

The rail was tested by a rail flaw detection car on 05 June 1998 and no defects were noted in the derailment area. A walking inspection of the crossover was performed by the assistant track supervisor on 09 November 1998, noting "replace rail south/west leg." Although no time frame was specified for the work, it was scheduled to be carried out sometime in December, after the next rail flaw detection car inspection. On 20 November 1998, the section crew removed the ballast from the cribs at the crossover switches in preparation for the winter.

CN's track inspection and maintenance programs are undertaken to identify areas that can jeopardize safe train operations and plan to take appropriate remedial action to address deficiencies. CN's Standard Practice

Circulars (SPCs) and Transport Canada's (TC) *Railway Track Safety Rules* (TSR) outline standards and procedures for inspecting and maintaining tracks.

Inspection and maintenance standards relating to track geometry (such as gauge, surface, and alignment) are essentially based on track speed. Tracks are divided into six classes depending on the allowable track speed. Class 1 corresponds to a track where the maximum allowable speed for freight trains is 10 mph, while Class 6 is the highest class with an allowable speed of up to

100 mph. The higher the class, the more stringent the allowable deviations from the standards become. Based on requirements relating to train operations, a distinction is made further between “main track” and “other than main track” (yards and industrial spurs).[2]

For Class 1, 2, and 3 “main tracks and sidings,” the following track inspection frequency is required:

- With Geometry Car Inspection:
  - Weekly, with at least three calendar days between inspections, or before use if the track is used less than once a week; or
  - Twice weekly, with at least two calendar days between inspections, if the track carries passenger trains or more than 3 MGT of traffic during the preceding calendar year.

- Without Geometry Car Inspection:
  - Twice weekly, with at least two calendar days between inspections, or before use if the track is used less than once a week; or
  - Thrice weekly, with at least one calendar day between inspections, if the track carries passenger trains or more than 3 MGT of traffic during the preceding calendar year.

For Class 4, 5, and 6 “main tracks and sidings,” the following track inspection frequency is required:

- With Geometry Car Inspection:
  - Twice weekly, with at least two calendar days between inspections.

- Without Geometry Car Inspection:
  - Thrice weekly, with at least one calendar day between inspections.

Geometry car inspections are performed at the following minimum frequency: on Class 4, 5, and 6 tracks and on Class 1, 2, and 3 tracks that carried more than 25 MGT of traffic during the preceding year, twice per year; otherwise once per year.

MacMillan Yard is considered as a Class 2 “other than main track.” For yard tracks, CN’s SPC 3100 (“Track Inspection”) and TC’s TSR require that a routine inspection, by track motor car or Hi-rail, be performed

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[2] The Canadian Rail Operating Rules (CROR) define “main track” as “a track extending through yards and between stations, upon which trains or engines are authorized and governed by one or more methods of control.” A yard is “a system of tracks, other than main tracks, provided for the making up of trains, storing of cars and for other purposes, over which movements may be made, subject to prescribed signals, rules and special instructions.”

"monthly with at least 20 calendar days interval between inspections, or before use if the track is used less than once a month." In addition, CN requires that a walking inspection, by the track supervisor, assistant track supervisor, or qualified replacement, be performed at least once a year.

On main tracks, routine inspections are complemented by regular mechanized inspections, including the use of a geometry and rail wear measurement car (TEST car) and a rail flaw detection car. The frequency of these inspections depends on several factors: location, speed, tonnage, track condition, and maintenance history. For yard tracks, no mechanized inspection is required; however, CN operates the rail flaw detection car twice per year over heavy tonnage tracks in MacMillan Yard.

For standards relating to track strength and construction (e.g. size and condition of the rail, type and number of ties per mile, ballast characteristics), in addition to the speed, the annual tonnage is also taken into consideration. For main tracks, CN uses the Speed Tonnage Rating[3] (STR). For instance, SPC 3200 ("Use and Handling of Rail") prescribes the use of rail depending on the STR of the track and the rail wear limits for different rail sizes. For 115-pound rail, SPC 3200–Appendix A indicates that the vertical rail wear limit is 8 mm, while the sum of vertical and gauge side lateral wear limit is 13 mm. When rail wear exceeds these limits, the rail must be removed from the main track. There is no indication of the course of action in the case of yard tracks.

SPC 3200–Appendix B lists the rail type and category to be used for different portions of track according to the STR.

The minimum distance between joint bars is not specified in CN's SPCs. However, the minimum required length for closure rail[4] is indicated in SPC 3200 and SPC 3204 ("Laying Rail"). Both require that closure rails not be shorter than 3.66 m (12 feet). Short-jointed rail lengths are not recommended because the spacing between the joint bars can coincide with the truck spacing and amplify the dynamic impact, track infrastructure forces, and equipment.

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3 A coefficient that combines the annual tonnage (MGT) and the class (track speed).

4 Closure rails are short rails used to repair rail fractures. The rail is cut on each side of the break, removed, then replaced by a rail section to close the gap.

The Green Route's STR is calculated to be at least 19 (based on a track speed of 15 mph and an annual tonnage of 17 MGT) but could be as high as 59 (based on a track speed of 15 mph and an annual tonnage of 51 MGT). The STR for the Halton Subdivision main track is 28 (based on a track speed of 50 mph and an annual tonnage of 17 MGT). The first portion of the subdivision is 23 (based on a track speed of 30 mph and an annual tonnage of 17 MGT).

1.11 Regulatory Overview

TC's Railway Safety Directorate has a track monitoring program in place which is aimed at providing an overview of the railways' state of compliance with TC's TSR. TC has regional rail safety offices located in Moncton, Montréal, Toronto, Winnipeg, Calgary, and Vancouver. It is not feasible for an infrastructure inspector to cover all trackage in a given region every year because of the size of some regions. A method based on random sampling is used to select the territory to be covered. Sample sizes are based on each region's extent of trackage, risk assessment, and historical data on the subdivisions. Sample distribution is biased towards track groups presenting higher risks (high-speed and high-tonnage main tracks). The program does not specifically include yard tracks although yard inspections may be triggered by accidents, incidents, or high rates of defects found in previous inspections.

Before the derailment, TC track inspectors last monitored MacMillan Yard between 18 February 1997 and 20 February 1997; no defects were noted at that time.

2.0 Analysis

2.1 Introduction

The method of train operation played no role in this occurrence. The analysis will focus on the condition of the rail involved in the derailment and related inspection and maintenance practices.

2.2 Track Condition

Wheel flange marks on the top of the ties and the joint bar, and rail breaks at either end of the joint bar were consistent with a wheel of tank car PLMX 4651 climbing the rail and derailing. The next two tank cars then derailed, leading to a train-initiated emergency brake application.

The broken rail had experienced a sub-surface fatigue crack. No rail defects had been noted when the rail flaw detection car passed over the rail approximately six months before the derailment. It is not known whether the sub-surface fatigue crack existed at the time of that test.

2.3 Track Inspection and Maintenance

The railway's track inspection and maintenance program segregates "main track" and "other than main track." The existing division between the two categories evolved from train operation requirements. Factors such as tonnage and speed were not taken into consideration even though they are the main factors affecting the rate of track infrastructure deterioration. The fact that heavy tonnage tracks deteriorate faster and require more frequent inspections and remedial action is well recognized within the industry. For instance, both TC's TSR and CN's SPCs require additional inspections for tracks carrying heavier tonnage. Railway construction and maintenance standards are more stringent and require higher STRs.

Although yard tracks are often located near populated areas where the potential consequences of an accident might be greater, most of them carry very light traffic at a relatively low speed. Yard tracks are also located in an environment where external influences are better controlled by factors such as fencing, an extensive drainage system and the constant presence of railway personnel. Currently, all yard tracks are in the same category without any distinction between a storage track or a track that is used once a month and a major lead track. Therefore, the current classification might be acceptable in most cases. However, shortcomings in track inspection and maintenance practices become evident when heavy tonnage yard tracks, such as inbound or outbound tracks, are considered.

Yard tracks are also inspected less frequently relative to sections of track with similar speed. While a portion of track classified as a "main track" and having an allowable speed of 15 mph and a tonnage over 3 MGT would be inspected two to three times per week, the Green Route and Halton outbound tracks, both of which have a tonnage 15 times higher, are inspected only once per month. Although this complies with the inspection program at MacMillan Yard, it does not provide an adequate safety barrier. With monthly intervals between inspections, the current program affects the railway's ability to detect any unsafe condition in a timely fashion and take remedial action. For instance, the 1997 and 1998 rail breaks were not identified by track inspection and maintenance personnel; both were reported by train crews.

A walking inspection of the track performed 17 days before the derailment identified that the rail should be replaced. Due to the lack of clear maintenance criteria for "other than main tracks," the priority of the corrective action was not assessed adequately and no action was taken immediately. Had this section of track been classified as a main track or given a special status different from that of other lightly used yard tracks, the worn section of rail would have been removed immediately as required by SPC 3200 since the rail wear exceeded CN's allowable limits. Furthermore, the fact that the rail breaks occurred in the same area within a year is an indication of a rail that has reached its fatigue life, and thus should have warranted its removal from the track.

While the Green Route track has a higher STR than the Halton Subdivision main track, it did not receive the same attention as the main track portion since it is a yard track. In 1997 and 1998, rail breaks were repaired using joint bars. Although CN prohibits closure rails shorter than 3.66 m (12 feet), joint bars were installed within that distance. Since it is a yard track, the risk was perceived as being low; thus, compliance with SPC 3200 and SPC 3204 was not deemed necessary.

Without a more coherent safety program, track inspection and maintenance practices discrepancies (concerning different sections of track) will remain. Crucial track components such as heavy tonnage yard tracks will be under-inspected and thus present a significant safety risk.

2.4 Tank Car Protective Housing

The top of car PLMX 3447 was subjected to high impact loads when the protective housing plowed through the hard asphalt surface. The protective side did not sustain damage; however, the lid bent under impact and contacted the valves, devices, and lines located in the nozzle and outlet arrangement housing, causing the leak. A sturdier lid would probably not have deformed as much nor would it have contacted the eduction valve stems or the gauging device rod cover.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. The train derailed as a result of two rail breaks caused by surface and sub-surface cracking.

2. Rail wear exceeded Canadian National's (CN) allowable limits.

3. The existing division between "main track" and "other than main track" evolved from train operation requirements. Factors such as tonnage and speed were not taken into consideration even though they are the main factors affecting the rate of track infrastructure deterioration.

4. Both Transport Canada's *Railway Track Safety Rules* and CN's Standard Practice Circulars (SPCs) require additional inspections for tracks carrying heavier tonnage. However, this requirement applies only to main tracks.

5. For the track inspection program, all yard tracks are in the same category without any distinction between a rarely used track and a major lead track.

6. Due to the lack of clear maintenance criteria for "other than main tracks," the priority of the corrective action was not assessed adequately and no action was taken immediately.

7. Had this section of track been classified as a main track or given a special status different from that of other lightly used yard track, the worn section of rail would have been removed immediately as required by SPC 3200.

8. Although CN prohibits the use of closure rails shorter than 3.66 m (12 feet), joint bars were installed within that distance. Since the installation was on a yard track, the risk was perceived as being low; thus, compliance with SPC 3200 and SPC 3204 was not deemed necessary.

9. Without a more comprehensive safety program, track inspection and maintenance practices discrepancies (concerning different sections of track) will remain. Crucial track components such as the heavy tonnage yard tracks will be under-inspected, thus leaving unsafe conditions undetected.

3.2 *Other Findings*

1. The lid of the protective housing bent under impact and contacted the valves, devices, and lines located in the nozzle and outlet arrangement housing, causing the product leak.

2. Emergency response procedures were executed in a timely and professional manner and reduced the risk to employees and local residents.

3. With respect to frequency, track inspections were performed in accordance with existing rules and practices.

4.0 Safety Action

4.1 Action Taken

Transport Canada (TC), the Federal Railroad Administration and the Association of American Railroads are in the process of reviewing the design and retrofit requirements applicable to railway car top fitting protection. TC is presently reviewing past accident data on similar occurrences to determine the sturdiness of protective housing covers and the clearance between these covers and the service equipment underneath. Lessons learned from this accident and other accidents will contribute in determining the optimum requirements. The 13 February 2001 derailment in Red Deer, Alberta (TSB occurrence No. R01E0009—investigation ongoing), raises similar issues relating to design requirements applicable to top fitting protection. The cover, housing and service equipment from tank cars involved in the Red Deer accident were sent to the TSB Engineering Branch for analysis and comparison with tank car PLMX 3447.

TC and Canadian National (CN) had several meetings concerning the application of rules governing the inspection of "other than main tracks and sidings." Both organizations agreed that trackage in yards may have different usage and that the current rules concerning inspection frequency requirements need to be amended to better reflect this situation. On 12 May 2000, TC granted to CN, on one-year basis, an exemption to the *Railway Track Safety Rules* (TSR) to permit CN to evaluate a new inspection regime in MacMillan Yard based on track usage. A three-year extension to this exemption is anticipated. The new regime categorizes individual tracks into high, medium and low usage. The inspection frequencies are proportional to the frequency of use. The inspections of entrance and exit tracks at MacMillan Yard were increased to bi-weekly; this includes the Halton inbound and outbound tracks. If substantive changes to current track inspection requirements are warranted as a result of this trial, a rule change will be proposed through the normal consultation process with other federally regulated railways.

The Board recognizes that the initiatives taken by TC and CN are a positive step to correct discrepancies in inspection frequencies between different trackage located in same yards and will ensure that heavy tonnage tracks are inspected more frequently.

4.2 Action Required

It is well recognized within the industry that heavy tonnage tracks deteriorate faster and require more frequent inspections and maintenance than lower tonnage tracks. TC and CN have adopted changes that relate the inspection frequency to levels of traffic; however, no action was taken respecting discrepancies in track maintenance. The segregation between "main tracks" and "other than main tracks" carrying similar traffic was not addressed. That division evolved solely from train operation requirements and does not reflect the actual levels of risk as primary factors affecting the rate of track infrastructure deterioration, such as tonnage and speed. Both TC's TSR and CN's Standard Practice Circulars (SPCs) outline standards and procedures for maintenance; however, they apply only to "main tracks." In most yards, tracks carry very light traffic at low speeds; therefore, the risks are relatively low and the absence of clear maintenance criteria is less detrimental to safety. However, shortcomings in track maintenance practices become evident when heavy tonnage yard tracks, such as inbound or outbound tracks, are considered. The existing discrepancies between "main tracks" and "other than main tracks" jeopardize safety as they do not permit railway personnel to assess with consistency and accuracy the track condition and determine the appropriate safety action. Therefore, the Board recommends that:

> The Department of Transport and the Railway Association of Canada ensure that maintenance standards and practices address the level of risks in heavy tonnage "other than main tracks."
>
> R01-04

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 08 May 2001.

Appendix A - Glossary

cm	centimetre
CN	Canadian National
CROR	Canadian Rail Operating Rules
EST	eastern standard time
m	metre
MGT	million gross ton
mm	millimetre
mph	mile per hour
SPC	Standard Practice Circular
STR	Speed Tonnage Rating
TC	Transport Canada
TSB	Transportation Safety Board of Canada
TSR	*Railway Track Safety Rules*
UTC	Coordinated Universal Time
‘	feet
“	inches