Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT
R00W0246

MAIN-TRACK DERAILMENT

CANADIAN PACIFIC RAILWAY
TRAIN NO. 340-901
MILE 5.8, CARBERRY SUBDIVISION
NEAR WINNIPEG, MANITOBA
30 NOVEMBER 2000

Canada

Railway Investigation Report

Main-Track Derailment

Canadian Pacific Railway
Train 340-901
Mile 5.8, Carberry Subdivision
Near Winnipeg, Manitoba
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Summary

At approximately 0040 central daylight time on 30 November 2000, eastward Canadian Pacific Railway train 340-901, travelling at approximately 36 mph on the south main track of the Carberry Subdivision near Winnipeg, Manitoba, derailed 18 hopper cars of wheat at Mile 5.8. The derailed cars sustained extensive damage, spilled much of their content and blocked the north and south main tracks and the adjacent main track of the Canadian National Oak Point Subdivision.

Ce rapport est également disponible en français.

Other Factual Information

Canadian Pacific Railway (CPR) train 340-901 (the train) departed Brandon, Manitoba, Mile 133.1, destined for Winnipeg, Manitoba, Mile 0.0. It was approximately 7400 feet long and weighed about 15 200 tons. It was powered by 2 locomotives and comprised 117 loaded hopper cars and 3 empty hopper cars. The locomotive event recorder data showed that the train experienced an uncommanded emergency brake application while the locomotive engineer was maintaining speed at about 36 mph with about half throttle applied (position No. 3) and the air brakes released. The train had just gone through a hot box and dragging equipment detector at Mile 18.1 with no exceptions noted.

Train movements on the Carberry Subdivision are controlled by the Centralized Traffic Control System authorized by the Canadian Rail Operating Rules and supervised by a rail traffic controller (RTC) located in Calgary, Alberta. From Mile 53.7 to Mile 1.5, the subdivision is double main track. At Mile 5.9, the CPR Glenboro Subdivision connects with the Carberry Subdivision from the south. The Canadian National (CN) Oak Point Subdivision crosses the Carberry Subdivision at Mile 5.8 and runs adjacent to, and south of, the CPR right-of-way to Winnipeg. The maximum authorized speed is 60 mph between Mile 50.7 and Mile 5.8 and 40 mph from Mile 5.8 to Mile 3.6.

Immediately upon sensing the emergency brake application, the crew members initiated an emergency radio broadcast on the train radio standby channel to alert other CPR trains of their emergency situation. They then contacted the RTC, who protected both the north and south main tracks. Consistent with a protocol between CPR and CN dealing with emergency situations on adjacent tracks, the CPR Chief RTC immediately alerted his CN counterpart in Edmonton, Alberta, who protected the affected CN track.

Markings on the north rail were observed at Mile 11.7 and were followed by a furrow of heavy tie gouging and ballast marking on the north gauge side of the track. These markings led to heavy damage to the frog at the Glenboro switch at Mile 5.9 and subsequent track destruction.

Many of the derailed cars (69th to 86th inclusive) tipped and spilled their contents along both the north and south main tracks and the CN main track. The CPR south and north main tracks from Mile 5.9 to Mile 5.6 were either severely damaged or destroyed. The CN crossover at Mile 5.8 was severely damaged.

The first derailed car, CPWX 604225, with the "A" end leading, remained coupled to the head end of the train, with the leading truck still on the rails, and came to a stop in the vicinity of Mile 4.6. The trailing truck was completely derailed to the south and had a broken wheel at the L-3 location. The wheel had broken into several pieces. A large piece remaining on the axle was lodged in the truck frame. A section of rim was located on the roadbed east of Mile 11.2; the other pieces were not recovered.

The broken wheel was a 36-inch, Class C, two-wear curved plate wheel (CJ-36) with an original 2⅛-inch (54 mm) rim thickness (1/8 inch or 3.2 mm in excess of the Association of American Railroads [AAR] requirement) designed for use on 100-ton freight cars. It was manufactured in February 1976 by Griffin Wheel of Saint-Hyacinthe, Quebec, and at manufacture, had been ultrasonically tested and determined to be fit for service. The wheel set had been mounted on the axle in April 1976 and had reconditioned roller bearings applied in 1991. The wheel set had also been reprofiled at one point in its service life, although no record of this procedure could be located.

In 1976, Griffin Wheel manufactured cast wheels with a bottom fill pressure-pour technique using nine risers. The pressure-pour technique allows for a smooth, even flow of liquid steel into the mould, reducing surface imperfections and re-oxidation that can generate oxide inclusions. The resultant thermal centre (last area to cool) would have been between 1½ inches and 1¾ inches (40 mm and 45 mm) below the tread surface. Micro-shrinkage porosities develop at the thermal centres as the volume of the last liquid to solidify is greater than the volume of the resultant solid metal. In 1976, Griffin Wheel based its ultrasonic testing for CJ-36 two-wear wheels and CK-36 (36-inch) multi-wear wheels on a calibration that provided a full screen height response signal amplitude based on a 1/8-inch (3.2 mm) flat bottom hole, two inches below the rim surface, with the rejection criterion set at a signal response amplitude of half the screen height. The rejection level for 36-inch, one-wear wheels was set at a half screen height response based on a 1/8-inch bottom hole at 1½ inches from the rim surface.

The wheel set and a recovered piece of rim were taken to the CPR/University of Manitoba Engineering Laboratories in Winnipeg and examined in the presence of a TSB engineer. The subsequent TSB Engineering Laboratory report (LP 130/00) concluded that:

- The wheel failed from fatigue cracking that initiated at a micro-shrinkage porosity introduced during manufacture.

- Based on information that the wheel, when new, had a rim thickness of 54 mm (2⅛ inches), the micro-shrinkage was originally located 41 mm (1⅝ inches) below the tread surface, but at the time of failure, wear had reduced this to 13 mm (½ inch). At the time of failure, the rim thickness was 25 mm (1 inch).

- The micro-shrinkage porosity interacted with surface stresses to form cracks. The subsurface cracks would not be visible externally.

- No thermal cracks or shelling damage were observed on either wheel.

- Wheel hardness and chemical composition were within specifications.

The report also indicates that, if the porosity is in the rim and subsurface stresses reach the porosity, it acts as a stress riser, initiating cracking. The cracks develop and propagate parallel to the rim surface.

The examination also determined that the area of micro-shrinkage porosity consisted of several voids measuring up to 4.49 mm (0.148 inch) in length. Griffin Wheel advises that micro-porosities of this size resting 1⅝ inches (41 mm) below the rim surface would not have been reason for rejection in 1976.

AAR requirements state that a wheel is condemnable at any time for “thin rim, 7/8 inch (22.2 mm) or less for 28, 36 and 38-inch wheels.” In 1976, AAR standards required that wheel rims be ultrasonically tested at manufacture and that the testing procedure scan for metallurgical defects calibrated from a reflection standard based on the acoustical image from a 1/8-inch flat bottom hole located a minimum of 1¼ inches (32 mm) from the rim surface, with the rejection level set at the full screen height. Rim thickness varies with the design but generally one-wear wheels have a new tread thickness of 1½ inches (38 mm), two-wear wheels, 2 inches (50 mm), and multi-wear wheels, 2½ inches (64 mm). In 1999, the AAR bottom hole reflection standard was revised, changing the rejection standard from a full screen height signal to a half screen height signal from a 1/8-inch flat bottom hole at 1¼ inches from the rim surface.

Transport Canada's (TC) *Railway Freight Car Inspection and Safety Rules* state the following: "A railway company may not place or continue a car in service if : . . . (h) the thickness of a wheel rim is 11/16 inches (17.4 mm) or less."[1] In addition to the AAR and TC requirements, CPR has developed *Freight Car Inspection Policies* ". . . designed to protect against train accidents or personal injury caused by defective equipment while at the same time causing minimal interference with train operations." With respect to wheel condition, pre-departure visual inspections, conducted by qualified employees, are in part carried out to uncover broken or cracked wheels. Between 21 and 29 November 2000, CPWX 604225 had received several such inspections and no wheel anomalies had been noted.

Griffin Wheel advises that, since 1976, it has continuously improved both the manufacturing and inspection processes. In the mid-1990s,the pour technique was changed from 9 risers to 13 risers, resulting in smaller and deeper thermal centres (2 inches to 2½ inches [50 mm to 63 mm] from the rim surface as compared to 1½ inches to 1¾ inches [38 mm to 45 mm]). Computer-assisted ultrasonic test equipment better penetrates the steel and provides radial and axial scans and data storage. Griffin Wheel has also reduced its criterion to the equivalent of a quarter screen signal height from a 1/8-inch flat bottom hole at 1¼ inches from the rim surface. To Griffin Wheel's knowledge, it has not had a shattered rim wheel failure since the implementation of the improved pouring and inspection processes.

Analysis

No train handling, rail or equipment anomalies were evident before the derailment and the markings on the roadbed at Mile 11.7 point to an equipment failure at that point. The analysis will discuss the broken wheel on the first derailed car and issues related to the manufacture, maintenance and inspection of these components.

Markings on the track infrastructure, damage to the L-3 wheel, and the final positioning of CPWX 604225 are consistent with the wheel having broken and derailed at Mile 11.7. The derailed wheel then travelled for nearly six miles on the ties and ballast before striking switch components from the intersecting track at Mile 5.9, causing track destruction and the derailment of the following 17 cars.

The wheel met metallurgical design specifications and was not worn to condemning limits. It broke apart as a consequence of fatigue cracking running parallel to the rim surface and emanating from a micro-shrinkage porosity introduced at the time of casting. The cracks and the micro-porosity were below the rim surface, and as is typical for this type of defect, displayed no surface manifestations. A visual operating inspection regime cannot detect this type of subsurface defect and prevent such wheels from continuing in service.

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[1] Transport Canada, *Railway Freight Car Inspection and Safety Rules*, Part II, "Freight Car Components," Section 9.1, paragraph (h).

Factors other than depth and size (i.e. shape and orientation) come into play when surface forces interact with micro-porosities to form cracks. It is noteworthy that this porosity was not cause for rejection by Griffin Wheel standards that were considerably more stringent than the AAR standards in effect until 1999. Furthermore, the improved and still current AAR standard (1999) only now meets the Griffin Wheel standard of 1976, which in this instance, did not prevent this potentially unsafe wheel from entering service. Therefore, wheels tested to these standards at manufacture (past and future) may contain micro-porosities that could compromise safety after many years of safe service.

Wheel wear and maintenance over a period of 24 years resulted in the micro-porosity coming close enough to the surface to interact with surface stresses to form the subsurface fatigue cracking that ultimately compromised wheel integrity. As the porosity was within 13 mm of the rim surface at wheel failure, it is possible that this is the approximate depth that a micro-porosity of this size is adversely affected by surface stresses and becomes a safety risk. In this instance, it is noted that Griffin Wheel calculates that the thermal centre for its 36-inch wheels is from 1½ inches to 1¾ inches (38 mm to 44 mm) from the rim surface. The micro-porosity was located 1⅝ inches (41 mm) from the rim surface, the wear limit is 15/16 inches (33 mm) from the original rim surface and the wheel failed when the rim had worn 1⅛ inches (29 mm) from the original rim surface. It would seem, therefore, that unless more stringent rejection criteria are employed, wear limits should take into consideration the potential for micro-porosities created by the processes of wheel manufacture and that such limits could reasonably be made to extend beyond the area of potential micro-porosity by more than 13 mm.

Findings as to Causes and Contributing Factors

1. A wheel on the 69th car broke in an area of subsurface fatigue cracking, emanating from an area of porosity introduced at manufacture, and derailed. The wheel eventually caused severe track damage and the derailment of the following 17 cars when it struck switch components at Mile 5.9.

Findings as to Risk

1. A visual operating inspection regime cannot detect this type of subsurface defect and prevent such wheels from continuing in service.

2. Wheels ultrasonically tested to AAR standards at manufacture (past and present) may contain micro-porosities that could compromise safety after many years of safe service.

Safety Action Taken

The AAR *Manual of Standards and Recommended Practices*, Section G11 (Wheel and Axle Manual), was revised 01 January 2003 and now includes the requirement that all second-hand or turned wheels be ultrasonically tested before being placed back into service.

The AAR is also working on a revised steel cleanliness specification and a revised specification that will set limits for residual tramp elements within new wheel blanks. No date has yet been set for these specification changes.

The above changes are expected to improve overall wheel quality and address the risks identified in this report.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 17 December 2002.

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