Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT
R00V0060

MAIN-TRACK DERAILMENT

CANADIAN PACIFIC RAILWAY
TRAIN NO. 607-059
MILE 97.5, CASCADE SUBDIVISION
MAPLE RIDGE, BRITISH COLUMBIA
19 APRIL 2000

Canada

Railway Investigation Report

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Canadian Pacific Railway
Train No. 607-059
Mile 97.5, Cascade Subdivision
Maple Ridge, British Columbia
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Summary

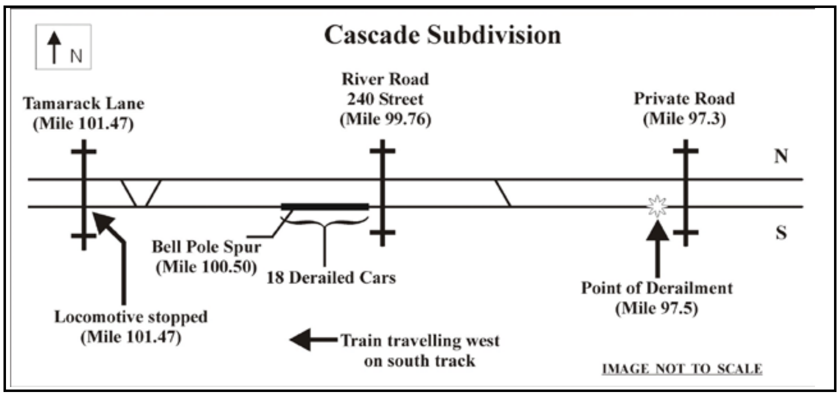
On 19 April 2000, at approximately 0328 Pacific daylight time, Canadian Pacific Railway westward freight train No. 607-059 derailed 18 loaded gondola cars at Maple Ridge, British Columbia, Mile 97.5 of the Cascade Subdivision. Approximately 1500 tons of prilled sulphur was spilt, most of which was recovered. There were no injuries.

Ce rapport est également disponible en français.

Other Factual Information

Westward Canadian Pacific Railway (CPR) unit sulphur train No. 607-059 (the train), en route from Hardisty, Alberta, to Port Moody, British Columbia, on the two-track portion of the CPR Cascade Subdivision, experienced a train-initiated emergency brake application[1] at 0328 Pacific daylight time (PDT).[2] The head end of the train came to a stop near Mile 100.5. After conducting the necessary emergency procedures, the train crew determined that 18 cars, the 28th car to the 45th car, had derailed near Mile 100.1. The cars were fouling both main tracks and an adjacent municipal road allowance. Most of the 18 cars sustained extensive damage and released their contents.

Figure 1 shows the track layout in the area.



The temperature was nine degrees Celsius. The skies were clear with good visibility, and the winds were light.

The train, powered by 2 locomotives, was hauling 101 loads of prilled[3] sulphur. It was 6063 feet in length and weighed 13 463 tons. A pull-by inspection had been performed by the inbound train crew at Boston Bar, British Columbia, Mile 0.0 of the Canadian National (CN) Yale Subdivision, and no irregularities were noted. The train had been scanned by hot box and dragging equipment detectors at seven locations on the Yale Subdivision between Mile 0.0 and Mile 85.0. No irregularities were noted at any of the detectors. The train had also passed a wheel

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1 Emergency brake applications can be categorized as either operator-initiated or train- initiated. In either case, a rapid reduction in brake pipe pressure triggers the emergency brake application.

2 All times are PDT (Coordinated Universal Time minus seven hours).

3 A congealed pellet of a manufactured substance.

impact load detector (WILD) at Mile 74.6 of the Yale Subdivision, where a wheel impact reading of 132 kips[4] was detected on the 28th car. The recorded speed of the train when it passed the detector was 29.2 mph.

The train had proceeded westward through the CN Yale Subdivision from Boston Bar to Matsqui Junction, British Columbia, Mile 87.9. It entered the CPR Mission Subdivision and traversed 1.4 miles, where it diverged to the CPR Cascade Subdivision through a connecting track. The train then continued westward on the Cascade Subdivision.

Post-derailment track inspection determined that the train's point of derailment (POD) was at Mile 97.5. One wheel set then travelled derailed from the POD to Mile 100.1, where a track switch was contacted, precipitating the main derailment. Approximately 500 feet of the north and south main tracks were destroyed.

Prilled sulphur from the derailed rail cars spilled onto the municipal road allowance, impeding traffic for approximately 18 hours. CPR and local police were on hand to direct motor vehicle traffic. CPR personnel removed the spilled sulphur, and normal traffic flow was restored by 2320 the same day. Exposure to ignition sources was controlled, reducing the risk posed by the spilled sulphur.

The crew, consisting of a locomotive engineer and a conductor, came on duty at 2230, 18 April 2000 at North Bend, British Columbia, Mile 0.0 of the Cascade Subdivision. The crew members were to operate their train westward from Boston Bar, Mile 0.0 of the CN Yale Subdivision, to Coquitlam Yard, in Port Coquitlam, British Columbia, Mile 111.9 of the CPR Cascade Subdivision. They were qualified for their respective positions and met established rest and fitness standards.

CPR and CN have a joint running agreement in parts of British Columbia. Under the terms of this agreement, both railways operate trains westward on CN track and trains eastward on CPR track. Specifically, westward trains are operated from Basque, Mile 57.2 of the CN Ashcroft Subdivision, to Matsqui Junction, Mile 87.9 of the CN Yale Subdivision, and eastward trains are operated from Mission Junction, Mile 87.9 of the CPR Cascade Subdivision, to Nepa, Mile 54.8 of the CPR Thompson Subdivision.

The method of train control on the CN Ashcroft and Yale subdivisions is Centralized Traffic Control System (CTC) authorized by the *Canadian Rail Operating Rules* (CROR) and supervised by a rail traffic controller (RTC) located in Edmonton, Alberta. The method of train control on the CPR Cascade and Thompson subdivisions is CTC, authorized by the CROR and supervised by an RTC located in Calgary, Alberta. The method of train control on the portion of the CPR Mission Subdivision that connects the CPR Cascade Subdivision to the CN Yale Subdivision (between Mission Junction and Matsqui Junction) is also CTC, supervised by an RTC located in Calgary.

The maximum permissible timetable speed at the occurrence site for freight trains was 50 mph. Locomotive event recorder data indicated that the train-initiated emergency brake application occurred while the train speed was approximately 30 mph.

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[4] A kip is a load of 1000 pounds' dead weight.

The last certified car inspection for the train was performed on 10 April 2000 in Coquitlam. No exceptions were noted. The train received subsequent pull-by inspections by train crew members at all crew-change locations with no exceptions noted.

Post-derailment track inspection on the CN Yale Subdivision and CPR Mission and Cascade subdivisions revealed marks on the head of the rail commencing at about Mile 35 of the Yale Subdivision, continuing westward to the POD. A broken rail was discovered at Mile 86.4 of the Yale Subdivision.

CN's WILD measurements are transmitted to the rail traffic control centre in Edmonton where the data are reviewed by qualified personnel. Wheel impacts that exceed pre-determined limits are noted as exceptions. Railway procedures require that the RTC be advised of exceptions so that suspect cars can be set off. When the train passed over the detector at Mile 74.6 of the CN Yale Subdivision, no readings that warranted the setting-out of any cars were reported for the train. However, the 132-kip reading that was later determined to be from the 28th car in the train, SULX 2068, did prompt follow-up action.

The WILD exception report has established parameters with identified action steps to be taken. CN's criteria, for example, are that, with a threshold of 140 kips or greater, the action to be taken is as follows:

- When the rail car is inbound, meaning approaching a terminal, it is to be set off at the inbound terminal for mechanical staff to inspect. No notification is given to the RTC in this circumstance.

- When the rail car is outbound, meaning that the rail car has just left a terminal, it is to be set off at the first siding designated by the RTC. It is the RTC's responsibility to alert the crew to stop the train.

When an impact between 125 kips and 139 kips is registered, a message is sent to the car repair facility assigned for that particular train and an inspection is scheduled for the car when it passes through the designated terminal. RTCs are not normally made aware of single impacts in the range of 125 kips to 139 kips.

CPR's criteria for the threshold of 140 kips or greater is to reduce the train speed to 30 mph to the next terminal where there is mechanical staff on duty to inspect the car. On readings under 140 kips, the train continues with no restrictions.

Subsequent to the train returning to CPR's track, CN's RTC contacted CPR's RTC and advised of an abnormal reading on the WILD at Mile 74.6 of the CN Yale Subdivision. CPR's RTC contacted the train crew members at about Mile 92 of the CPR Cascade Subdivision, advised them of the WILD reading and instructed them to reduce their speed to a maximum 30 mph for the remainder of the trip.

An examination of the first car to derail, the 28th car from the head end, SULX 2068, revealed that the R-3 wheel, the leading wheel on the trailing truck, had shattered into three pieces. One piece consisted of one-half of the wheel, and the other half was broken into two pieces. Two of the broken pieces were located under this car and the other quarter piece was located beside the right-of-way at Mile 97.51. The broken wheel was a 36-inch, curved-plate, cast steel, Class C wheel manufactured by Griffin of Winnipeg, Manitoba, in September 1991. It is designed for service with light braking conditions and high wheel loads. The design is a "two-wear"[5]

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[5] A two-wear wheel is manufactured with a 1 1/2-inch rim thickness that allows for possible reprofiling

wheel used on 100-ton capacity cars. The use of this type of wheel is widespread in the North American car fleet. This type of wheel is generally regarded within the industry as being reliable.

The wheel was sent to the TSB Engineering Laboratory for analysis (TSB Engineering Laboratory report No. LP 038/00) and the following conclusions were made:

- The wheel failed when a large portion of the tread separated due to sub-surface cracking.
- The sub-surface cracking initiated in areas of shelling[6] damage along the tread surface.
- Shelling indicated that cracks were running radially from the surface into the rim.
- Cracks developed from the tread surface as a result of the high surface hardness that promoted crack initiation and growth. The hard surface layer was the result of cold work.[7] A thin and hard layer of untempered martensite[8] was present on top of the cold-worked surface layer, and would have increased the likelihood of crack initiation.
- The initial high hardness of Class C wheels makes them more susceptible to shelling leading to sub-surface cracking.
- The size limit of shells currently allowed by the Association of American Railroads (AAR) may not be a good indicator of the large sub-surface cracks that can develop from shells.
- Hardness values over the remainder of the wheel rim and plate were within maximum allowable limits.
- The rim thickness at 27 mm was above the condemnable service limit of 22 mm. At failure, the tread thickness was half of its original thickness of 54 mm.
- No manufacturing material deficiencies that contributed to the failure were observed.
- The wheel conformed to AAR metallurgical composition requirements.

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before reaching the absolute minimum of 1 inch allowed by the AAR for re-application.

6 Metallurgical failure of the surface (and just under the surface) of a wheel tread.

7 Permanent deformation caused by application of an external force to a metal below its recrystallization temperature.

8 The very hard structure in certain irons and steels that is usually formed by quenching (rapid cooling) from an elevated temperature.

The laboratory analysis revealed that the wheel fracture originated from a service-related defect—shelling—on the outboard half of the tread surface. The failure was progressive and resulted in complete separation of the unsupported rim. Before the wheel failure, overheating resulted in the formation of a circumferential band of heat checks that precipitated the development of shells on the outboard half of the tread surface.

The *2000 Field Manual of the AAR Interchange Rules* states the following with respect to shelled tread:

> When the shell or spall is 3/4 inch in diameter or larger and the shells or spalls are more or less continuous around the periphery of the wheel or whenever any shell or spall is 1 inch or more in diameter, the wheel must be removed from service. "Islands" of original tread surface metal contained in the shell or spall will not be considered as part of the area of the shell or spall.

Car SULX 2068, an open top gondola car, was built in June 1985. No maintenance records on the R-3 wheel were available from either CPR or the car owner, Sultran Ltd. However, each time a train receives a certified car inspection (CCI) by qualified car inspectors, the wheels of each car are to be visually inspected for anomalies. The CCI is to be done each time the train is to depart a designated location for that type of train. The designated inspection location for this train was Coquitlam. The CCI records for this car do not indicate any anomalies with the wheel that failed.

Unit trains of sulphur originate with empty sulphur cars at Coquitlam, and travel to the sulphur loading facilities in Alberta. Once trains are loaded with product, they return to Port Moody for unloading. During each cycle of movement, safety and maintenance inspections are performed only at Coquitlam. Visual inspections of this type cannot lead to the identification of sub-surface cracking on wheel treads. Other inspection methods, such as non-destructive ultrasonic testing, are needed to identify sub-surface cracking. These methods are currently not used during CCIs or otherwise on freight car wheel sets after they enter service.

Analysis

No information suggests that train handling, track, or roadbed defects contributed to the derailment. The WILD system functioned as intended.

Marks on the rail beginning approximately 40 miles in advance of the WILD at Mile 74.6 of the CN Yale Subdivision indicated that the R-3 wheel on car SULX 2068 was in the early stages of failure. Further, the 132-kip reading for this wheel set suggested a potential problem. While a reading of 132 kips did not meet either railways' threshold for immediate action, it was considered higher-than-normal impact and it presented an opportunity for pre-emptive intervention that was used. The action by CN's RTC (communication to CPR's RTC concerning the reading) led to the decision to reduce the train's maximum speed, thereby reducing the severity of the derailment.

Wheel impact detection is a positive railway safety initiative and the actions taken in this occurrence indicate prudent use of this information. However, as with any new technology, it may take some time to optimize the application of the data in train operations. Specifically, the railways may want to look at developing standard criteria so that car impact data will most effectively serve as a prevention tool.

Laboratory analysis indicated that the sub-surface cracking initiated in areas of shelling damage in the wheel tread surface. Such damage to the tread surface provided points of crack initiation and increased the wheel's susceptibility to failure. The high hardness of the tread surface designed into this type of wheel was increased by additional hardening that resulted from normal service use. The presence of a thin layer of untempered martensite on top of the cold-worked surface was indicative of overheating and cooling. Both of these factors combined with the presence of shelling to promote sub-surface crack initiation and growth.

The detection of sub-surface cracks that can be suspected when shelling is present relies on non-destructive inspection, typically using ultrasonic methods. This damage would not have been evident during standard visual car inspections. Current industry wheel inspection practices do not include the use of ultrasonic methods on a regular basis. The implementation of non-destructive ultrasonic testing, particularly on wheels identified with shelling, would promote the identification of sub-surface cracking and the removal of wheels from service before failure. In the absence of improved testing methods, the current AAR condemning limits for wheel shells may be inadequate to address the risks posed by sub-surface cracks initiated by shelling.

Findings as to Causes and Contributing Factors

1. The rim on the R-3 wheel of car SULX 2068 fractured due to sub-surface cracking that originated in areas of shelling on the wheel tread surface. This resulted in the derailment of the 28th car and ultimately the derailment of the following 17 cars.

2. Current industry wheel inspection practices were inadequate to identify the presence of the sub-surface cracking that precipitated the wheel failure.

Findings as to Risk

1. In the absence of improved testing methods, the current AAR condemning limits for wheel shells may be inadequate to address the risks posed by sub-surface cracks initiated by shelling.

Other Findings

1. Communication between CN and CPR regarding higher-than-normal wheel impact readings on the train led to a reduction of train speed, thereby limiting the severity of the derailment.

2. The potential for adverse consequences posed by the spilled sulphur was minimized by the absence of sources of ignition due to the control of vehicular traffic and an efficient clean-up operation.

Safety Action Taken

Section GII (Wheel and Axle Manual) of the AAR *Manual of Standards and Recommended Practices* is currently under revision. This revision is expected to become effective on 01 January 2003 and will include the requirement that all second-hand or turned wheels be ultrasonically tested before being placed back into service.

On 01 July 2002, the AAR approved a change to Rule 41 r. of the *Interchange Rules* that will allow wheels to be changed out when they generate impact loads of 90 kips or greater, or when they allow an out-of-round "run-out" greater than 0.070 inch.

Last year, CPR adopted changes to its WILD policy. In addition to monitoring actual wheel impact values, the WILD detection software now includes algorithms that recalculate wheel impact values to a standard speed of 50 mph. This policy also identifies specific set-off and repair actions to be taken and speed restrictions to be imposed.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 20 August 2002.