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

RAILWAY INVESTIGATION REPORT R14W0041

MAIN-TRACK TRAIN DERAILMENT

CANADIAN PACIFIC RAILWAY
FREIGHT TRAIN 490-15
MILE 43.10, MINNEDOSA SUBDIVISION
KEYES, MANITOBA
15 FEBRUARY 2014

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 R14W0041

Main-track train derailment
Canadian Pacific Railway
Freight train 490-15
Mile 43.10, Minnedosa Subdivision
Keyes, Manitoba
15 February 2014

Summary

On 15 February 2014 at 2211 Central Standard Time, Canadian Pacific Railway freight train 490-15 was proceeding eastward at 42 mph on the Minnedosa Subdivision when a train-initiated emergency brake application occurred and the train came to a stop. Subsequent inspection determined that 27 covered hopper cars loaded with potash and grain had derailed in the vicinity of the Keyes siding located at Mile 43.10 near Gladstone, Manitoba. About 1443 feet of main track and 292 feet of adjacent siding track were damaged. There were no dangerous goods involved and no injuries.

Le présent rapport est également disponible en français.

Factual information

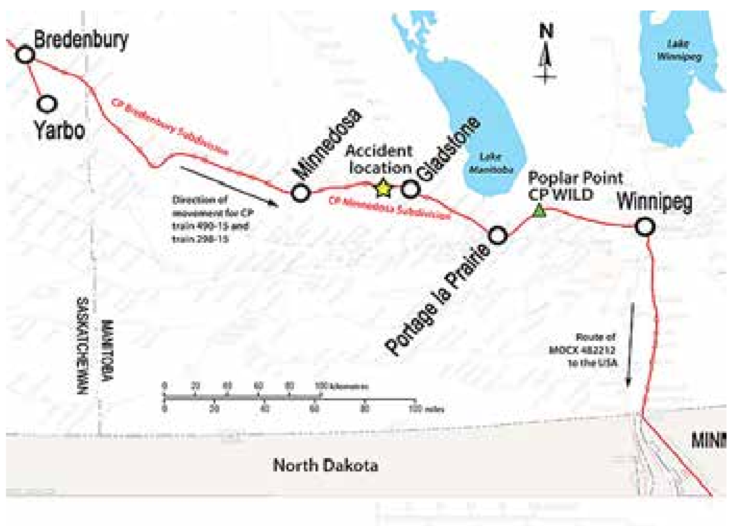
On 15 February 2014, Canadian Pacific Railway (CP) freight train 490-15 (train 490) originated at Bredenbury, Saskatchewan. The train consisted of 2 head-end locomotives, 50 loaded cars, and 22 empty cars. It was 4403 feet long and weighed 7363 tons. The train was operated by a locomotive engineer, a conductor who was training as a locomotive engineer, and a brake person. The train crew members met fitness and rest standards and were familiar with the territory.

Train 490 was assembled at Bredenbury, where it received a number 1A air brake test[1] and a roll-by inspection from the train crew prior to departing eastward, destined for St. Paul, Minnesota, United States. While en route, a roll-by inspection was conducted during a crew change at Minnedosa, Manitoba. Other visual inspections were performed by track maintenance employees and crew members from other trains met en route. No defects were noted during these inspections.

The accident

At about 2211,[2] train 490 was proceeding eastward at 42 mph on the Minnedosa Subdivision when the crew noted a rough section of track near Mile 43.0. Shortly thereafter, train 490 experienced an undesired emergency brake application (Figure 1).

Figure 1. Accident location (Source: Railway Association of Canada, Canadian Railway Atlas, with TSB annotations)



Subsequent inspection determined that 27 cars had derailed. The cars derailed were 22 cars loaded with grain, 2 empty covered hoppers, and 3 cars loaded with potash. There were no dangerous goods involved and no injuries.

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1 A number 1A air brake test is performed by the train crew when a train is made up at other than a safety inspection location. Air brakes are tested on all cars where the air brake system has been charged to within 15 psi of standard operating air pressure. A positive air brake reduction is applied to propagate a brake application. Brake application is then inspected on every car and brake release is also inspected on every car by means of a standing or pull-by inspection.

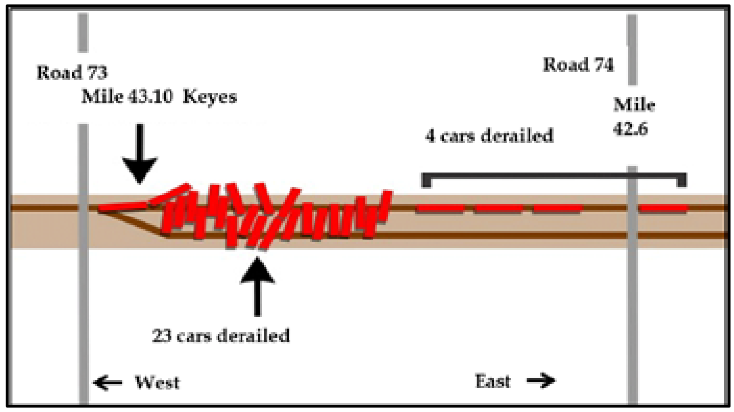
2 All times are Central Standard Time.

At the time of the accident, the sky was clear and the temperature was -21 °C.

Site examination

Site examination determined that 27 cars—the 16th to the 42nd cars inclusive from the head end of the train—had derailed. The derailed cars came to rest in various positions, blocking the main track and siding between Miles 42.6 and 43.10 (Figure 2).

Figure 2. Site diagram



About 1443 feet of main track and 292 feet of adjacent siding track were damaged. No marks were observed on the track infrastructure leading to the derailment area. No significant pre-existing mechanical equipment defects were identified during examination of the head-end of train 490 and the derailed equipment.

In the vicinity of Mile 43.10, a piece of broken rail (about 12 feet in length) was recovered from the north rail. The west end of the fractured rail was battered. The mating fracture surface of the broken rail was not recovered. The broken rail was forwarded to CP's Test Department for further examination.

Subdivision and track information

The Minnedosa Subdivision consists of single main track that extends west from Portage la Prairie, Manitoba (Mile 0.0) to Minnedosa (Mile 77.9). Train movements in the vicinity of the derailment are governed by the occupancy control system (OCS) as authorized by the *Canadian Rail Operating Rules* (CROR) and supervised by a rail traffic controller (RTC) located in Calgary, Alberta. OCS rules apply in non-signalled territory where an RTC supervises train movements on the territory through the use of clearances, track occupancy permits, general bulletin orders, and other instructions as may be required.

In the vicinity of the derailment, the track is rated as Class 3, according to Transport Canada–approved *Track Safety Rules*. The maximum speed permitted is 40 mph for freight trains. In 2009, rail traffic and tonnage over this portion of track consisted of 4 trains per day and 733 000 gross-ton miles per year. At the time of the accident, rail traffic consisted of 7 freight trains per day with an annual tonnage of about 1.1 million gross-ton miles.

Throughout the derailment area, the tangent track consisted of Algoma 115-pound continuous welded rail that was rolled in 1968 and installed in 1976. It was laid on 14-inch double-shouldered tie plates, secured with 6 spikes per tie to a mix of 8-foot-long hardwood ties (30%) and softwood ties (70%). Every second tie was box-anchored. The ballast consisted of crushed rock and slag. The cribs were full, and the shoulders extended from 12 to 24 inches beyond the end of the ties. The condition of the subgrade and drainage was fair.

Track inspections were performed regularly in accordance with the *Track Safety Rules*. The most recent track inspection had occurred on 14 February 2014, with no anomalies noted in the vicinity of the derailment. The most recent track geometry tests of the Minnedosa Subdivision were on 03 October 2013 on the main line and on 14 November 2013 within the Keyes siding. A rail flaw inspection test was performed on 24 January 2014. For each of these tests, no defects were noted in the area of the derailment. The track structure was in good condition.

Previous trains through the derailment area

In the 7 hours prior to the derailment, 2 other CP trains travelled through the derailment location.

CP train 298-15

On 15 February 2014, eastbound CP freight train 298-15 (train 298) departed Sutherland, Saskatchewan, destined for Clearing, Wisconsin, United States. Train 298 received an operating pre-departure inspection and a number 1A air brake test by the train crew. According to the CP train service schedule, train 298 was scheduled for a full mechanical inspection and a number 1 air brake test on arrival in Winnipeg, Manitoba. While en route, the train was subject to wayside inspections performed by track maintenance employees and crew members of trains met en route, with no defects noted.

After travelling eastward over the Sutherland, Wynard, and Bredenbury subdivisions, train 298 stopped at Minnedosa (Mile 77.9, Minnedosa Subdivision) and lifted additional cars, including covered hopper car MOCX 482212 (load of potash), which was added with the A-end leading. Train 298 departed Minnedosa at about 1500. At approximately 1600, after travelling 35 miles further east, train 298 traversed the area of the derailment without incident. The temperature was -16 °C. Train 298 continued to proceed in OCS territory on the Minnedosa Subdivision until Portage la Prairie, where it entered into signalled centralized traffic control (CTC) territory at Mile 56.3 on the Carberry Subdivision.

At 1712, train 298 traversed CP's wheel impact load detector (WILD) site at Poplar Point, Manitoba, located at Mile 39.0 of the Carberry Subdivision. Six of the 8 wheels on car MOCX 482212 recorded measured impacts exceeding 140 kips.[3] Train 298 was immediately stopped and the car was inspected by the train crew. All wheels on the car exhibited numerous large slid flats throughout the circumference of the wheel treads. Subsequently,

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

the brakes on car MOCX 482212 were cut out and the train proceeded to Winnipeg at 15 mph.[4] Upon arrival in Winnipeg, the car was shopped for repair.

No subsequent track inspection for broken rail had occurred over any portion of the route that train 298 had travelled prior to the wheel impacts recorded at Poplar Point, nor was one required by operating protocols.

CP train 119-12

On 15 February 2014, westbound CP freight train 119-12 (train 119) received a certified mechanical inspection and air brake test prior to departure from Winnipeg. At 1817, train 119 traversed the CP WILD site at Poplar Point. No significant wheel impacts were recorded and train 119 continued westward onto the Minnedosa Subdivision. At about 2100, after travelling an additional 48 miles, train 119 traversed the area of the derailment at Keyes without incident. A review of the video from the forward-facing camera did not identify any visible or audible rail break near the occurrence site.

Wheel impacts and broken rails

Rail steel is known to have reduced fracture toughness and ductility at low temperatures, particularly if a rail defect, which can act as a stress riser, is present. It is also generally recognized that wheels producing high-impact loads may cause damage to equipment (axles and journals) and track infrastructure. Canadian National Railway (CN) had previously analyzed wheel-impact and broken-wheel data from 1992 to 1995. The analysis established a causal link between high wheel impact loads and broken rails.

The TSB has investigated at least 5 occurrences caused by broken rails resulting from high wheel impacts (Appendix A).

Track inspection subsequent to broken rail

In locations where train movements are governed by signalled CTC, protection from broken rails, such as those that occur due to high wheel impacts, is inherently built into the signal system. A broken rail within CTC will usually interrupt the track circuit, which causes signals governing movements to display their most restrictive indication, which is usually a red (stop) signal. If this occurs, a train must receive permission to pass a stop signal from an RTC as per CROR Rule 564.[5] Once this permission is received, the train can proceed through

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4 The recommended speed from the wheel impact load detector.

5 *Canadian Rail Operating Rules* (CROR) 564, Authority to Pass Stop Signal.

(a) A train or transfer must have authority to pass a block signal indicating Stop.

(b) The RTC may authorize the train or transfer to pass the signal but before doing so must:

i. ensure that there are no conflicting trains or transfers within, or authorized to enter, the controlled block affected (other than one authorized by Rule 567 or 577); and the block at restricted speed not exceeding 15 mph,[6] and the crew members must be on the lookout for broken rails. There is no such protection in OCS territory.

Presently, neither CN nor CP have company guidelines or instructions that require track in OCS territory to be inspected after the passage of a train with high wheel impacts known to exceed 140 kips. However, both railways may carry out special inspections following some high wheel impact events. Also, at CP, train crews are required to immediately report indications consistent with a broken rail to the RTC.

Car MOCX 482212 information

MOCX 482212 was a 100-ton, 60-foot-long, covered hopper car built in 1982. This car was equipped with 3 top-load loading compartments and a gravity unloading system. Original equipment for the car included 6 ½ X 12-inch trucks, 36-inch wheels, high friction composite brake shoes, ABDW service and emergency brake valves, foundation-type air brake piston, and an automatic slack adjuster. Between July 2013 and February 2014, CP replaced 6 brake shoes, an air hose support bracket and a coupler knuckle pin. On 12 January 2014, the No. 1 and No. 4 wheel sets were changed out by the Beltline Railway Company (BRC) in Chicago, Illinois, United States.

On 18 February 2014, CP determined that the SAB DRV-2 slack adjuster on MOCX 482212 was defective, and the car failed a single car air brake test. Subsequently, the slack adjuster and the service and emergency brake valves were changed out. The components were sent to Red River Air Brake Company in Winnipeg for reconditioning. All 4 of the car’s wheel sets were changed out and sent to CP’s Test Department for examination.

A slack adjuster is a component that automatically adjusts slack in freight car brake rigging to maintain correct air brake cylinder piston travel and ensure uniform braking.

Slack within the brake rigging increases with the wear of the brake shoes, wheel treads and brake rigging. The slack decreases when new brake shoes are applied, wheel sets are changed out, or brake rigging is repaired.

A slack adjuster takes up excess slack as it is created within the braking arrangement and lets out slack when required to maintain proper clearances for brake rigging and ensure effective transmission of braking power to the brake shoes.

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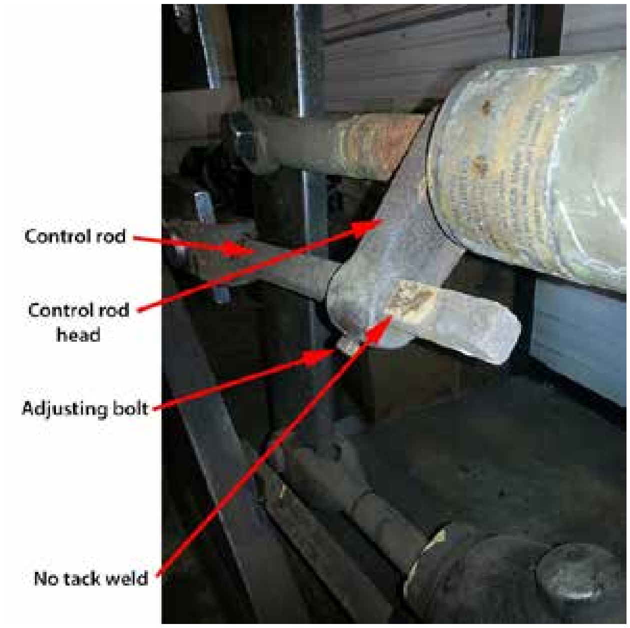
ii. provide protection against all opposing trains or transfers.

[6] RESTRICTED speed: A speed that will permit stopping within one-half the range of vision of equipment, also prepared to stop short of a switch not properly lined and in no case exceeding SLOW speed (15 mph).

At Red River Air Brake, the slack adjuster for car MOCX 482212 was tested on an SA-01 test rack (Photo 1). The slack adjuster passed the "take up" portion of the test, but failed the "let out" portion.

Photo 1. Slack adjuster on test rack



During teardown of the slack adjuster, it was determined that the cut-out cock, 4 reservoir gaskets and the branch tee gaskets were leaking due to normal wear. A slack adjuster failure can result in the brake rigging becoming too tight. Such a condition can lock the wheels in place, causing wheel tread slid flats and ultimately high wheel impacts on the rail.

It was also noted that the control rod on the slack adjuster was not tack welded to the control rod head as required, potentially allowing it to move from its initial setup position, which can affect its performance.

MOCX 482212 movement and wheel impact load detector history

Starting from October 2013, MOCX 482212 had been travelling a similar route on CP main track. It would depart Yarbo, Saskatchewan, loaded with potash destined for the Chicago area, where it was interchanged with other railways for various destinations in the area. It would then return westward over the same route, as an empty car. For example, on 02 February 2014, the car traversed the CP Poplar Point WILD site westward as an empty car en route to Yarbo. Then on 15 February 2014, while proceeding eastward as a loaded car, it was flagged for high impact wheels at the CP Poplar Point WILD site.

Table 1 summarizes WILD impact data for wheels on MOCX 482212, starting from 28 September 2013 to the day of the occurrence.

Table 1. Wheel impact load detector history of car MOCX 482212

Date/ direction of travel	Location of WILD site	Train speed (mph)	Car status (load / empty)	Whe el pos.	Actual impact (kips)	Cal. impact at 50 mph (kips)	Wheel pos.	Actual impact (kips)	Cal. impact at 50 mph (kips)
2013-09-28 East	Red Wing, Minnesota, United States	44.73	Load	L1	61.32	64.34	R1	41.85	42.98
				L2	47.62	49.08	R2	45.51	46.62
				L3	52.08	54.39	R3	55.86	58.70
				L4	63.07	66.67	R4	64.34	67.78

Date/ direction of travel	Location of WILD site	Train speed (mph)	Car status (load / empty)	Wheel pos.	Actual impact (kips)	Cal. impact at 50 mph (kips)	Wheel pos.	Actual impact (kips)	Cal. impact at 50 mph (kips)
2013-10-15 West	Georgeville, Minnesota, United States	54.01	Empty	L1	29.70	29.70	R1	18.96	18.96
				L2	21.63	21.63	R2	13.12	13.12
				L3	21.27	21.27	R3	20.22	20.22
				L4	27.47	27.47	R4	26.87	26.87
2013-10-24 East	Poplar Point, Manitoba	28.5	Load	L1	51.64	72.90	R1	41.82	54.59
				L2	44.26	58.98	R2	40.63	49.03
				L3	62.57	95.57	R3	51.94	76.85
				L4	52.21	75.53	R4	46.36	63.88
2013-11-16 East	Red Wing, Minnesota	40.4	Load	L1	61.47	73.66	R1	41.23	46.21
				L2	48.31	55.44	R2	41.12	44.30
				L3	64.80	8.05	R3	55.24	65.34
				L4	49.86	57.41	R4	54.47	63.26
2013-11-28 West	Poplar Point, Manitoba	49.9	Empty	L1	40.67	44.07	R1	31.56	34.02
				L2	18.88	20.07	R2	15.25	16.02
				L3	26.84	28.75	R3	25.92	27.89
				L4	35.38	38.55	R4	36.75	40.02
2013-12-23 East	Poplar Point, Manitoba	41.7	Empty	L1	42.65	57.14	R1	30.63	40.15
				L2	20.82	26.23	R2	18.27	22.46
				L3	28.06	36.85	R3	18.93	23.96
				L4	34.46	46.08	R4	28.72	37.97
2014-01-07 West	Poplar Point, Manitoba	48.4	Load	L1	91.47	93.37	R1	64.92	65.94
				L2	63.73	64.71	R2	50.21	50.75
				L3	62.22	63.15	R3	55.27	55.97
				L4	88.56	90.36	R4	62.74	63.69
2014-01-09 West	Georgeville, Minnesota	55.67	Load	L1	92.62	92.62	R1	54.70	54.70
				L2	55.65	55.65	R2	44.93	44.93
				L3	57.47	57.47	R3	54.13	54.13
				L4	71.49	71.49	R4	69.52	69.52
2014-01-31 West	Red Wing, Minnesota	44.82	Empty	L1	13.48	13.93	R1	13.23	13.71
				L2	18.77	19.72	R2	15.18	15.79
				L3	33.36	35.73	R3	21.54	22.83
				L4	15.55	16.33	R4	18.31	19.21
2014-02-02 West	Poplar Point, Manitoba	39.35	Empty	L1	14.51	19.28	R1	14.24	17.99
				L2	31.02	46.68	R2	13.12	16.08
				L3	35.61	54.57	R3	34.24	52.17
				L4	17.51	23.98	R4	17.51	23.80

Date/ direction of travel	Location of WILD site	Train speed (mph)	Car status (load / empty)	Wheel pos.	Actual impact (kips)	Cal. impact at 50 mph (kips)	Wheel pos.	Actual impact (kips)	Cal. impact at 50 mph (kips)
2014-02-15 East	Poplar Point, Manitoba	34.59	Load	L1	167.76*	222.17*	R1	146.79*	193.91*
				L2	189.60*	255.04*	R2	166.89*	223.26*
				L3	79.76	97.91*	R3	111.00*	144.04*
				L4	153.81*	203.54*	R4	142.4*	187.01*

* Impact exceeds the condemning limit of 90 kips for measured wheel impacts set in Rule 41 of the 2014 Field Manual of the AAR Interchange Rules.

Wheel impact load detectors

The development and installation of WILD technology is an industry initiative that has enhanced rail safety by proactively identifying high impact wheels so that they can be removed before they cause damage to rolling stock or track infrastructure.

These wayside inspection systems (WIS) measure the impact load of a wheel on the rail, usually through a strain-based system or accelerometer-based system. The strain-based system quantifies the force applied to the rail through a mathematical relationship between the applied load and the deflection at the base of the rail. The strain gauges are physically mounted on the web of the rail, about halfway down from the top of the rail head. Strain in the rail is used as a direct measure of the load at the rail head. The unit of measure for wheel impacts is kip.

WILD systems are usually installed on tangent track with a track speed of 50 mph with the object being to record the measured impact at track speed. The measured wheel impact force is directly related to speed. When a wheel tread defect is present, the faster the train travels, the greater the measured wheel impact will be. Conversely, any reduction of train speed as it traverses a WILD site can reduce the measured wheel impacts.

The Transport Canada-approved *Railway Freight Car Inspection and Safety Rules* do not have provisions for condemning in-service wheels due to high wheel impact loads. There are currently no regulatory requirements or thresholds governing WILD use in either Canada or the United States. However, in its response to TSB Rail Safety Advisory (RSA) 11/11 entitled "Broken Wheels with Previous AAR [Association of American Railroads] condemnable WILD Readings," Transport Canada (TC) indicated that it would be creating a joint TC/industry forum to undertake a comprehensive review of WIS and WILD criteria. From this review, TC may create guidelines, standards or rules governing the use of WIS, including WILD. To date, there have been no tangible developments.

Field Manual of the AAR Interchange Rules – Rule 41

Rule 41 of the 2014 Field Manual of the AAR Interchange Rules states in part:

> RULE 41 - STEEL WHEEL DEFECTS – OWNER'S RESPONSIBILITY
>
> 1. Condemnable at Any Time
>
> 1.A.r. Wheel Out-of-Round or 90,000 Pounds (90 kips) or Greater Impact.
>
> (1) Detected by a wheel impact load detector reading 90,000 pounds (90 kips) or greater for a single wheel. The detector used must meet the calibration and validation requirements of Appendix F. The detector must reliably measure peak impacts and must provide a printable record of such measurements. Device calibration records must be maintained. Wheels with condemnable slid flat spot(s) are handling line responsibility and must not be billed otherwise.
>
> 2. Condemnable When Car Is on Shop or Repair Track for Any Reason
>
> 2.A.f. Detected by a Wheel Impact Load Detector reading from 80 kips to less than 90 kips for a single wheel. The detector used must have been calibrated per Appendix F. The detector must reliably measure peak impact and must provide a printable record of such measurements. Device calibration records must be maintained. Wheels with condemnable slid flat spots are handling line responsibility and must not be billed otherwise. This will be considered an Opportunistic Repair for the repairing party.
>
> HANDLING LINE RESPONSIBILITY – CONDEMNABLE AT ANY TIME
>
> 1. Slid Flat:
>
> (a) 2 inches or over in length.
>
> (b) 2 or more adjoining spots each 1 ½ inch or over in length.

Transport Canada-approved Railway Freight Car Inspection and Safety Rules

The Transport Canada-approved *Railway Freight Car Inspection and Safety Rules* set forth criteria for determining slid flat wheel defects. Part II – Safety Defects, Section 9.1 states in part:

> A railway company shall not place or continue a car in service if:
>
> d. a wheel has a slid flat spot that is more than 2 ½ inches (63.50 mm) in length or two adjoining flat spots each of which is more than 2 inches (50.80 mm).

The *Railway Freight Car Inspection and Safety Rules* do not have WILD condemning criteria for wheels.

Canadian Pacific Railway wheel impact load detector sites and thresholds

CP currently has 21 WILD sites throughout its system in Canada and the United States. However, at the time of the derailment, CP had no WILD site between Edmonton, Alberta, and Poplar Point, Manitoba, a distance of approximately 700 miles.[7]

CP's WILD thresholds have evolved over time, and evaluate the measured impact and the calculated impact for a given wheel. The measured impact is the actual wheel impact force recorded. The measured impact value is then subjected to a speed-corrected algorithm to produce the calculated impact. The algorithm is a proactive measure that takes an actual impact level at a slower speed and estimates it using linear progression to an impact at 50 mph. This speed-corrected algorithm allows CP to evaluate wheel impacts to a normalized speed of 50 mph. However, the algorithm is sensitive to wheel defect type, low speed conversion, and assumed linearity. Each railway uses a different algorithm, which can be adjusted at any time, to arrive at the calculated value and has different condemning criteria for calculated impacts. There is no regulatory or industry standard for calculated values. As such, the management of wheel removals by the railway industry using the calculated impact can be somewhat discretionary.

In Northern Ontario, CP requires a car to be bad-ordered[8] immediately when the measured wheel impact is ≥ 130 kips or the calculated wheel impact[9] is ≥ 150 kips. For the remainder of the CP system, the WILD guideline requires a car be bad-ordered immediately for measured wheel impact of ≥ 140 kips or calculated wheel impact of ≥ 170 kips. When a car on a train is bad-ordered, the train speed is reduced and the car is set off at the next designated WILD set-off location.

For measured impacts of ≥ 100 kips, CP requires the car to be bad-ordered when empty. As such, loaded cars are allowed to proceed to destination with no restrictions, but the car must undergo repairs once it is unloaded.

For calculated impacts between 90 kips and 110 kips, CP has a number of opportunistic threshold limits (OP1 – OP4). In these cases, CP flags the car in its Car Information Management (CIM) System, but does not bad-order the car. Freight car WILD records are also entered into the AAR Integrated Railway Remote Information Service (InteRRIS) system, which is used by railways throughout North America. Cars with WILD readings above the AAR condemning limits are flagged with an alert in the system. When cars are interchanged between railways, the receiving railway can identify cars with AAR

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7 In November 2014, Canadian Pacific Railway installed a wheel impact load detector at Mile 52.35 on the Wilkie Subdivision, approximately 320 miles east of Edmonton, Alberta.

8 Flagged for repair in an electronic system.

9 All thresholds based on calculated impact values also imply that the measured impact values are at least greater than or equal to 90 kips as per Association of American Railroads Interchange Rule 41 A.1.r.

condemnable WILD impacts for subsequent follow-up and action. This allows a car to proceed to destination without restrictions and be repaired when operationally convenient. However, if it is not operationally convenient, the car can return to service without removal of the subject wheel set.

On 07 January 2014, MOCX 482212 traversed the CP WILD detector at Poplar Point under load where an actual impact of 91.47 kips was recorded for the L1 wheel and 88.56 kips was recorded for the L4 wheel. On 09 January 2014, MOCX 482212 traversed the CP WILD detector in Georgeville under load where an actual impact of 92.62 kips was recorded for the L1 wheel. The car was flagged in CP's CIM system for an opportunistic repair. The WILD records were entered and flagged with alerts in the AAR InteRRIS system. Subsequently, the wheel sets were changed out by the BRC on 12 January 2014 and the car was returned to service.

Examination of the broken rail and MOCX 482212 wheels

On 26 March 2014, at the CP Test Department in Winnipeg, CP and the TSB conducted a joint examination of the broken rail from the occurrence site and the 4 wheel sets removed from car MOCX 482212.

Broken rail

The west end of the rail displayed a fracture surface with characteristics typical of brittle failure. The fracture surface exhibited heavy batter, which is consistent with a rail that had broken, but remained in place for some time and was damaged by multiple wheel impacts (Photo 2).

Examination of the bottom of the rail base identified tie locations (Photo 3). It appeared that a single crosstie narrowly supported the broken rail before the derailment. There was no evidence of any deleterious material, metallurgical or manufacturing defects in the rail.

Photo 2. Fracture surface with rail end batter showing tie position

Photo 3. Base of rail

Wheel examination

All wheels displayed numerous non-condemnable intermittent shells, spalls and minor tread build-up. The wheel treads displayed numerous slid flats ranging from 1 inch to 3.5 inches in length throughout the tread circumference (Photo 4).

Visual examination of the wheel treads revealed the following:

- The L1 wheel tread had one 2.25-inch-long condemnable slid flat. The mate R1 wheel had 5 condemnable slid flats ranging from 2.0 inches to 2.25 inches in length;
- The L2 wheel tread had 2 adjoining condemnable slid flats (2.5 and 3.5 inches long) that combined to form a 6-inch-long flat spot on the tread surface (Photo 5). The mate R2 wheel tread had one 2-inch-long and one 3.5-inch-long condemnable slid flats;
- The L3 and R3 wheel treads displayed a number of slid flats ranging from 1.25 inches to 1.75 inches in length throughout the tread circumference. None of these slid flats were condemnable; and
- The L4 wheel tread had one 2.75-inch-long condemnable slid flat. The mate R4 wheel tread had two 2.75-inch-long condemnable slid flats.

Photo 4. MOCX 482212 wheel sets

Photo 5. L2 wheel tread

Analysis

Train 490 was handled in accordance with company and regulatory requirements. There were no pre-existing track conditions in the vicinity of the derailment and no equipment conditions on train 490 that were considered causal or contributory. The analysis will focus on previous trains through the area, the condition of car MOCX 482212, requirements for track inspection following the removal of wheels for high WILD impacts and the criteria for slid flat wheel conditions.

The accident

On 15 February 2014, at 2211, Canadian Pacific Railway (CP) freight train 490-15 (train 490) was proceeding eastward at 42 mph when it experienced a train-initiated emergency brake application and the derailment occurred at Mile 43.10 of the Minnedosa Subdivision.

There were no marks observed on the track infrastructure leading into the derailment area. Inspection of the head-end of train 490 and the derailed equipment did not reveal any mechanical equipment defects that could be considered as causal. A piece of broken rail was identified and recovered from the north rail in the vicinity of Mile 43.10. The west end of the broken north rail was battered, which is consistent with the broken rail having been exposed to eastbound wheels. This suggests that a sudden rail failure had occurred on the north rail and the track came apart under train 490. With no identifiable equipment issues on train 490, previous trains through the area were identified and wheel impact load detector (WILD) data reviewed.

On the day of the occurrence, at approximately 1600, CP freight train 298-15 (train 298) had travelled eastward through the area of the derailment without incident. Shortly thereafter, at 1712, train 298 traversed the CP WILD site at Poplar Point, Manitoba (Mile 39.0 of the Carberry Subdivision), where 6 of the 8 wheels on car MOCX 482212 recorded measured impacts exceeding CP WILD guideline removal requirements of 140 kips. All wheels on this car had numerous large slid flats throughout the wheel tread circumference.

About 4 hours after the defective wheels were identified on car MOCX 482212, westbound CP freight train 119-12 (train 119) traversed the area of the derailment without incident.

In this occurrence, the rail had failed catastrophically in brittle mode, which is consistent with a single event such as a high impact load. There were no mechanical defects identified on train 490 and no significant wheel impacts recorded from train 119. However, 6 wheel impacts from freight car MOCX 482212 on train 298 had been recorded that exceeded CP WILD removal criteria. One of these high wheel impacts likely caused the broken rail. The rail break occurred on the edge of a tie, which left the broken rail partially supported and difficult to visually detect, facilitating the passage of westbound train 119. However, train 490, the second eastbound train through the area, derailed when it encountered the broken north rail that had likely failed under the passage of train 298, approximately 6 hours earlier.

Rail failure and wheel impact load detector impacts

Rail steel is known to have reduced fracture toughness and ductility at low temperatures. It is also recognized by the industry that wheels producing high impact loads may cause damage to equipment (axles and journals) and track infrastructure. Previous industry studies and TSB investigations have established a causal link between high wheel impact loads and broken rails.

On 15 February 2014, car MOCX 482212 on train 298 recorded the following wheel impacts at the Poplar Point WILD site:

Table 2. Wheel impacts recorded by car MOCX 482212 on train 298 at the Poplar Point WILD site on 15 February 2014

Date / direction of travel	Location of WILD site	Train speed (mph)	Car status (load/ empty)	Wheel pos.	Actual impact (kips)	Cal. impact at 50 mph (kips)	Wheel pos.	Actual impact (kips)	Cal. impact at 50 mph (kips)
2014-02-15 East	Poplar Point, Manitoba	34.59	Load	L1	167.76*	222.17*	R1	146.79*	193.91*
				L2	189.60*	255.04*	R2	166.89*	223.26*
				L3	79.76	97.91*	R3	111.00*	144.04*
				L4	153.81*	203.54*	R4	142.4*	187.01*

* Impact exceeds the condemning limit of 90 kips for measured wheel impacts set in Rule 41 of the 2014 Field Manual of the AAR Interchange Rules.

Seven of the 8 wheels on MOCX 482212 exceeded the Association of American Railroads (AAR) Rule 41 condemning limit of 90 kips for measured wheel impacts. Six of the 8 wheels exceeded the CP WILD bad-order immediately guideline limit of 140 kips for measured wheel impacts.

Examination of the wheel sets from MOCX 482212 determined that all wheel treads had numerous slid flats ranging from 1 inch to 3.5 inches in length that extended circumferentially throughout the treads. The most significant wheel condition was the L2 wheel tread, which had 2 adjoining condemnable slid flats (2.5 inches and 3.5 inches long) that combined to form a 6-inch-long flat spot on the tread surface. This tread defect corresponded to the car's highest measured wheel impact of 189.60 kips at a speed of 34.59 mph. This equates to a calculated WILD impact of 255.04 kips at 50 mph. The rail failed catastrophically in brittle mode likely as a result of a high wheel impact imparted on the rail by a condemnable 6-inch-long slid flat wheel tread on the L2 wheel of car MOCX 482212 on train 298.

Brake system defects on MOCX 482212

On 02 February 2014, car MOCX 482212 travelled westward over the CP Poplar Point WILD site as an empty car while en route to Yarbo, Saskatchewan. No significant WILD impacts were noted. On 15 February 2014, after the car was loaded in Yarbo, it proceeded eastward as a loaded car when it was flagged for high impact wheels at the CP Poplar Point WILD site.

The presence of the slid flats on all 4 wheel sets suggests that there were brake problems that caused the brakes on the car to intermittently apply and not fully release. Following the occurrence, it was determined that the slack adjuster on car MOCX 482212 was defective, and the car failed a single car air brake test, which indicated that the brake valves were also defective. Subsequently, the slack adjuster as well as the service and emergency brake valves were changed out and sent for reconditioning.

When tested on a test rack, the slack adjuster passed the “take up” portion of the test, which indicates that the slack adjuster could take up slack in the brake rigging in order for the brakes to properly apply. However, the slack adjuster failed the “let out” portion of the test. A number of gaskets on the slack adjuster were leaking due to normal wear.

The combination of brake valve failure and slack adjuster failure had likely resulted in the brake rigging becoming too tight. Such a condition can lock the wheels in place causing wheel tread slid flats. The slid flats on all wheels of car MOCX 482212 likely resulted from a combination of defective brake valves and a slack adjuster that failed en route.

Protection against broken rails in occupancy control system territory

The magnitude of the wheel impacts recorded on car MOCX 482212 combined with the cold ambient temperatures were conditions that are known to increase the potential for broken rails.

Train 298 travelled through the derailment area and broke the north rail at Mile 43.10 approximately 6 hours before the derailment of train 490. About 5 hours before the derailment, the CP WILD site at Poplar Point identified high wheel impacts for all 4 wheel sets of car MOCX 482212 on train 298. CP has layers of protection built into its operational procedures, including the requirement for train crews to immediately report indications consistent with a broken rail to the rail traffic controller (RTC). In this occurrence, there was no track inspection performed on the route that train 298 had followed through occupancy control system (OCS) territory. The next westbound train (train 119) travelled through the area of the derailment at track speed without incident about 1 hour before the derailment occurred. There were no visible indications of broken rail prior to the occurrence. The broken rail, which had likely occurred during the passage of train 298, remained undetected in service for about 5 hours after the defective wheels were identified on car MOCX 482212.

In locations where train movements are governed by signalled centralized traffic control (CTC), protection against broken rails is built into the signal system. A broken rail in CTC territory will usually interrupt the track circuit, which causes the signals that govern the movements to display the most restrictive indication, which is usually a red (stop) signal. If this occurs, a train must receive permission to pass a stop signal from an RTC and then proceed through the block at restricted speed (15 mph) while watching for broken rails.

There is no such protection in OCS territory. While Canadian National Railway (CN) and CP may carry out special inspections following some high wheel impact events, neither company has explicit guidelines or instructions for track in OCS territory to be inspected after the passage of a train with known high impact wheels. If there are no explicit protocols in place to inspect the track in OCS territory after the passage of a train with known high impact wheels, broken rails caused by high wheel impacts from a previous train may remain undetected, increasing the risk of derailment for subsequent trains.

Slid flat wheel defects

The R3 wheel on car MOCX 482212 had a measured wheel impact of 111.00 kips and a calculated wheel impact of 144.04 kips at a train speed of 34.59 mph. While these wheel impact values exceeded the AAR Rule 41 condemning limit of 90 kips, they did not exceed the CP WILD removal criteria which require the car to be bad-ordered immediately for measured wheel impacts ≥ 140 kips or calculated wheel impacts ≥ 170 kips. There are no condemning criteria for WILD impacts in the Transport Canada-approved *Railway Freight Car Inspection and Safety Rules*. At CP, wheel sets that exceeded the AAR condemning limit, but did not exceed the CP WILD removal criteria, would typically be flagged for removal when the car was empty, allowing the wheel set to remain in service until the car was off-loaded.

For car MOCX 482212, both the L3 and R3 wheel treads displayed a number of slid flats ranging from 1.25 inches to 1.75 inches in length throughout their circumference. Although CP took the precautionary measure to remove the wheel set from service, the wheels were not condemnable under the TC-approved *Railway Freight Car Inspection and Safety Rules* and were not condemnable under the AAR Rule 41 limits for slid flat defects. This wheel set could have remained in service, albeit in a degraded condition. If wheel condemning criteria do not consider wheels with multiple slid flats extending throughout their circumference, these potentially degraded wheels can remain in service, increasing the risk of damaging the rolling stock and/or track infrastructure due to high wheel impacts.

Findings

Findings as to causes and contributing factors

1. Canadian Pacific Railway (CP) freight train 490-15, which was the second eastbound train through the area, derailed when it encountered the broken north rail that had likely failed under the passage of CP freight train 298-15, approximately 6 hours earlier.

2. The rail failed catastrophically in brittle mode likely as a result of a high wheel impact imparted on the rail by a condemnable 6-inch-long slid flat wheel tread on the L2 wheel of car MOCX 482212 on CP freight train 298-15.

3. The slid flats on all wheels of car MOCX 482212 likely resulted from a combination of defective brake valves and a slack adjuster that failed en route.

4. The broken rail, which had likely occurred during the passage of CP freight train 298-15, remained undetected in service for about 5 hours after the defective wheels were identified on car MOCX 482212.

Findings as to risk

1. If there are no explicit protocols in place to inspect the track in occupancy control system territory after the passage of a train with known high impact wheels, broken rails caused by high wheel impacts from a previous train may remain undetected, increasing the risk of derailment for subsequent trains.

2. If wheel condemning criteria do not consider wheels with multiple slid flats extending throughout their circumference, these potentially degraded wheels can remain in service, increasing the risk of damaging the rolling stock and/or track infrastructure due to high wheel impacts.

This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 10 June 2015. It was officially released on 14 August 2015.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

Appendices

Appendix A – Previous wheel impact/broken rail derailments

R99H0010 – On 30 December 1999, Canadian National Railway (CN) freight train U-783-21-30 was travelling westward on the north track of the Saint-Hyacinthe Subdivision. At Mile 50.84, near Mont-Saint-Hilaire, Quebec, the train derailed and cars fouled the adjacent south main track. At about the same time, CN freight train M-306-31-30 was travelling eastward on the south track and collided with the cars of train U-783-21-30 that had just derailed. Two crew members on train M-306-31-30 were fatally injured in the accident.

The report identified that the combination of low ambient temperatures and wheel impact loads that were below CN company wheel impact load detector (WILD) threshold limits was sufficient to initiate rail failure at an existing pre-crack.

R01H0005 – On 12 March 2001, at approximately 0230 Eastern Standard Time, Canadian Pacific Railway (CP) train 301-043, proceeding westward at about 40 mph, derailed 14 cars at Mile 85.0 of the Ottawa Valley Railway North Bay Subdivision, near Bonfield, Ontario. A broken rail had caused the derailment. The rail failure resulted from stresses generated by the impact loading from wheel R1 of car CPWX 601303, combined with tensile thermal stresses due to the low ambient temperature.

R02E0114 – At 0055 Mountain Standard Time on 04 December 2002, eastward CP freight train 614–046 derailed 42 loaded non-pressure tank cars of molten sulphur at Mile 11.8 of the Taber Subdivision, near Bullshead, Alberta. Ten tank cars were breached and released product which caught fire. About 20 people were evacuated from the area nearby. There were no injuries.

The derailment was likely caused by a sudden break on the north rail under the train. The operation of a loaded potash car with flat wheels on the previous train to operate over the point of derailment likely generated sufficient wheel impact to have caused a broken rail. The cold ambient temperature made the rail less ductile and prone to failure.

R03T0030 – On 23 January 2003, while travelling at 34 mph, CP freight train 213–22 derailed 29 cars at Mile 78.2 of the White River Subdivision. The temperature at the time was -20° C. The investigation determined that impacts from a broken wheel had broken the south rail and caused the derailment. Two days earlier, the same wheel had recorded an impact of 99 kips while travelling at a speed of 30 mph. This impact force was above the Association of American Railroads' (AAR) Rule 41 condemning limit of 90 kips, but below CP's WILD removal thresholds. Consequently, no maintenance action was initiated for the wheel set after the impact measurement.

R03T0064 – On 02 February 2003, while travelling at 37.5 mph, CP freight train 938–12 was inspected at a WILD site near Raith, Ontario, about 59 miles (95 km) west of Thunder Bay, Ontario. Although there were no wheel impacts greater than 140 kips, 4 of the recorded impacts were between 90 kips and 116 kips, which correlated to calculated impacts between 109 kips and 144 kips. No maintenance action was taken or required.

On 13 February 2003, CP freight train 938–12 was proceeding southward at 42.5 mph when it derailed 21 cars at Mile 39.5 of the Parry Sound Subdivision near Nobel, Ontario. The investigation determined that wheel impacts that were greater than the AAR Rule 41 condemning limit of 90 kips, but below CP's threshold of 140 kips, likely initiated a brittle fracture from the root of a pre-crack through the base of the rail, facilitating the final catastrophic rail failure.