Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT
R02C0054

MAIN-TRACK DERAILMENT

CANADIAN PACIFIC RAILWAY
TRAIN 771-23
MILE 36.6, RED DEER SUBDIVISION
CARSTAIRS, ALBERTA
23 JULY 2002

Canada

Railway Investigation Report

Main-Track Derailment

Canadian Pacific Railway
Train 771-23
Mile 36.6, Red Deer Subdivision
Carstairs, Alberta
23 July 2002

Report Number R02C0054

Summary

On 23 July 2002, at approximately 1722 mountain daylight time, Canadian Pacific Railway southward freight train number 771-23 derailed 15 loaded tank cars at Mile 36.6 of the Red Deer Subdivision, near the town of Carstairs, Alberta. Three of the tank cars leaked about 200 litres of ethylene glycol. Highway 2A and adjacent roads were closed for a one-half mile radius around the derailment site. There were no injuries.

Ce rapport est également disponible en français.

Other Factual Information

On 23 July 2002, at approximately 1505 mountain daylight time,[1] train 771-23 (the train) departed Red Deer, Alberta, destined for Calgary, Alberta. The train consisted of 2 locomotives and 82 loaded tank cars containing ethylene glycol. It weighed about 11 200 tons and was approximately 4300 feet long. The train crew consisted of a conductor and a locomotive engineer. They were qualified for their respective positions and met fitness and rest standards designed to ensure the safe operation of trains.

At 1722, as the train passed over Mile 36.6 on the Red Deer Subdivision, a train-initiated emergency brake application occurred. The track reportedly moved upward and then outward under the middle of the train and cars derailed. After conducting the necessary emergency procedures, the crew determined that 15 tank cars, the 50th car to the 64th car from the head end, had derailed.

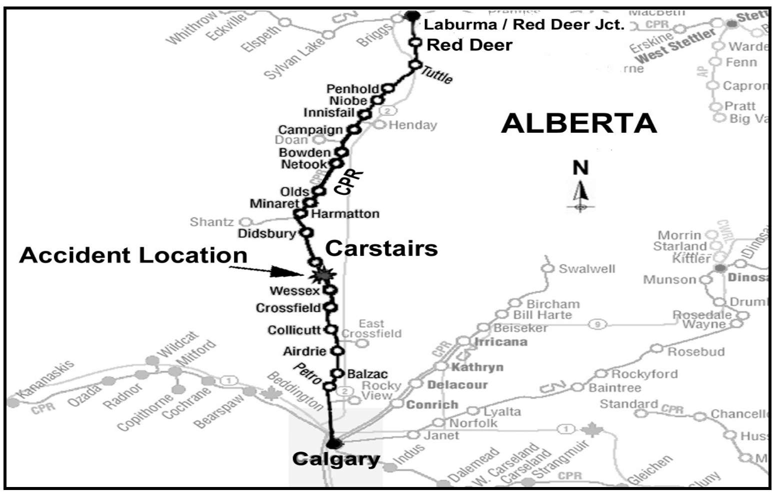

Figure 1. Accident location

The Carstairs Fire Department was notified of the derailment at approximately 1730 and arrived at the accident scene at about 1735. The Carstairs Fire Department restricted access to the site and evacuated an area within a one-half mile radius of the derailment, including a section of Highway 2A and a section of a road leading west from a public crossing at Mile 36.59. At about 1824, the Calgary Fire Department's hazardous materials personnel arrived and determined the tank car contents to be ethylene glycol. The site was then opened to emergency response crews. Tank cars EOGX4045, EOXG4170 and AOUX5109 were observed to be leaking product. The leaks were stopped by tightening flange bolts. About 200 litres of ethylene glycol was spilled. A berm was constructed at the northeast end of the site to prevent any escaped product from entering a nearby pond.

Approximately 440 feet of track and the public crossing were destroyed. Fourteen derailed tank cars were destroyed. There were no injuries.

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[1] All times are mountain daylight time (Coordinated Universal Time [UTC] minus six hours) unless otherwise stated.

The temperature at Olds, Alberta, the closest weather station to Carstairs, at the time of the derailment was 29°C. The winds were from the south at 11 km/h and the sky was clear.

The train's locomotives and leading 49 cars were taken to Canadian Pacific Railway's (CPR) Alyth Yard in Calgary for a full mechanical inspection. No defects were found. An examination of the 15 derailed tank cars did not find any pre-derailment defects.

The event recorder data revealed that the train-initiated emergency brake application occurred while the train was travelling at 31 mph with its air brakes released. It also revealed that, at approximately Mile 37.5, the dynamic brake (DB) was being applied at a DB factor of 4.4. The DB was increased to a factor of 7.4 at about Mile 37.0, and then reduced to a factor of 6.6 just before the derailment site.

Train movements on the Red Deer Subdivision are governed by Occupancy Control System rules authorized by the Canadian Rail Operating Rules and controlled by a rail traffic controller located in Calgary. The maximum authorized track speed for freight trains is 55 mph. On 22 July 2002, a temporary slow order restricted train speeds to 30 mph between Mile 36.0 and Mile 37.0 due to maintenance work undertaken to repair a track buckle.[2]

The Red Deer Subdivision is a single main track that extends from Mile 0.0, Calgary, to Mile 95.6, Red Deer. The track structure consisted of 115-pound RE continuous welded rail (CWR) manufactured by Algoma between 1981 and 1983. The CWR was installed on double-shouldered tie plates, and fastened to eight-foot No. 1 softwood ties with two spikes per plate.

In the vicinity of the derailment, the track was tangent and located within a sag vertical curve. When the train came to a rest, the track ahead was at an ascending 1.0 per cent grade, while the track behind was at a descending 1.1 per cent grade. The derailed cars were located at the bottom of the vertical curve. The track was built on an eight-foot fill consisting of local material. Subgrade soils were sampled and the analysis determined that the subgrade was stable. There was an average of 60 ties per 100 feet of track. Approximately 30 per cent of the ties were in poor condition, and could not withstand the full force applied by the rail anchors. The ballast was composed of crushed gravel fouled with sandy silt material. The ballast cribs were full, but in isolated areas, the shoulders had fallen away.

Most of the destroyed rail was recovered. An examination of the recovered rail determined that there were no defects that would have caused the derailment of the train. Wheel flange marks on the rail head had indicated that the point of derailment (POD) was at Mile 36.62, 203 feet north of the public crossing. Beginning 120 feet north of the POD, there was a 60-foot section of the west rail that was not anchored. Beginning 160 feet north of the POD, there was a 20-foot section of the east rail that was not anchored. The rest of the track within the derailment area was anchored, generally, every second tie. Many rail anchors were not tight against the ties. North of the POD, rail anchors on the west rail were up to two inches south of the tie, indicating rail creep in a southward direction. South of the POD, ties were skewed by up to four inches, indicating that the west rail had moved in a northward direction.

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[2] A track buckle is a lateral misalignment of track. Track buckles are usually caused by one or more of the following forces: high compressive rail forces, weakened track conditions, train vehicle forces and poor track geometry.

On 21 May 2002, two 10-foot plugs (bonded insulated joints) were installed to replace two bolted insulated joints. These plugs were welded into the CWR at Mile 36.64 with five thermite welds. The rail anchors were replaced on the 10-foot plug. The rail temperature was not recorded and the weather was recorded as cold, wet, and overcast. The maximum ambient temperature at Olds was 8°C. Of the five thermite welds, only one was identified on the rail web with a weld number and date (A24 05/21/02). The information on record regarding the welds was not complete, indicating only that three welds were made between Mile 36.0 and Mile 37.0.

On 22 July 2002, the day before the accident, at about 1730, a surfacing crew noticed a four-inch to six-inch track buckle to the west at Mile 36.63, extending for a distance of about 20 feet. The ballast shoulder on the west side of the track had fallen away. For approximately 100 feet, the ballast and track surface was low. The surfacing crew, under the direction of the relieving track maintenance foreman (RTMF), lifted and lined (surfaced) the track for a distance of 200 feet, raising the track a maximum of three inches. The ballast shoulders and cribs were restored. A 30 mph slow order was placed on the track between Mile 36.0 and Mile 37.0. When the surfacing was performed, the maximum daily ambient temperature at Olds was 25°C. The preferred rail laying temperature for CWR in the Red Deer Subdivision is 80°F (27°C). The temperature of the rail was not taken and the record of the rail laying temperature was not available. A Track Buckle Report was not completed. The rail was not destressed.

The last track geometry car inspection was carried out on 21 November 2001, and no defects were identified. The last ultrasonic and induction inspection was conducted on 01 May 2002 and no internal defects were found. On 19 July 2002, the track maintenance foreman (TMF) visually inspected the track at Mile 36.6 and no anomalies were noted. On 23 July 2002, at about 0930, the track maintenance supervisor (TMS) visually inspected the track at Mile 36.6 and noted that the surface was good, the cribs were full, the line was straight and the ballast shoulders had been restored. No further action was recommended.

CPR's train records indicate that, between the time that the track was surfaced and the time that Mile 36.6 was inspected by the TMS, eight freight trains handling a total of 46 000 tons had passed by. After the inspection and until the time of the derailment, an additional two freight trains handling a total of 13 000 tons had passed over Mile 36.6. The train crews had not reported any unusual track conditions.

Both the RTMF's and the TMS's employment records indicate that they were qualified for their respective positions. However, neither had taken CPR's CWR course, although the TMS had viewed videos on CWR maintenance during safety meetings. The CWR course Trainee Manual covers the theory, restressing, inspection and maintenance of CWR. The manual explains in part that:

- When dealing with track buckles, after the proper corrective action has been taken, the cause of the buckle should be determined.

- If there are indications that rail stress is out of adjustment, restressing must be carried out as soon as practicable.

- Signs of improperly stressed rail include a buckle, anchors that are missing or away from or embedded in the tie, skewed ties, churned or displaced ballast section.

CPR's General Operating Instructions (GOI), Section 16 (issued 01 March 2002), Item 7.6 outlines procedures intended to reduce the longitudinal forces applied to the track structure. It states in part that:

> . . . the DB handle MUST NOT be placed in a position higher than No. 5. This instruction also applies approximately one half mile prior to the beginning of, or when the locomotive is moving over any track governed by temporary speed restriction.

Standard Practice Circular (SPC) 06, *Prevention of Track Buckling* (issued 01 April 2000), deals with track buckling and its prevention. It outlines the causes of track buckles, high risk situations and conditions, inspection warning signs, and preventative action. It explains that:

- Track buckles can be caused by several factors including high compressive rail forces, weakened track conditions, and train vehicle forces.

- High compressive rail forces can occur when the CWR temperature is greater than the temperature at which the rail was last laid or adjusted, and when a locomotive undertakes DB action, especially on a descending grade. Rail tightness is also affected by the number and effectiveness of rail anchors.

- Track resistance is lowered if ballast is missing from the ends of ties or has been disturbed by maintenance work. Track disturbed by surfacing can lose up to 80 per cent of its resistance to buckling.

- Equipment can create buckling by causing lateral wheel forces. Lateral forces can occur in tangent track from car movement caused by line or surface deviations or by truck hunting. A buckle usually begins as a small deviation or kink. Each passing locomotive or car can increase the problem until the track shifts sharply or buckles. Buckles can also be caused by slack action or heavy DB.

- Track buckles will tend to occur during periods when the air temperature is high.

- When track buckles do occur, they often appear close to grade crossings, at the bottom of a heavy grade, on recently disturbed track (through surfacing), or where previous track buckles have not been permanently repaired.

- Tracks with loose or not enough anchors, and tracks with defective ties show lower track resistance and must be carefully watched.

- Signs that the rail is experiencing a high degree of compressive stress and that a track buckle is possible include wavy rail, new alignment problems such as kinks in tangent track, rail running through the anchors, and rail requiring additional anchors or the resetting of existing anchors.

- All warning signs must be dealt with immediately. When a tight rail condition is located, take immediate steps to protect train traffic. This usually involves stopping traffic and/or placing a slow order until the problem is fixed. When a track buckle is located and cannot be repaired by lining and tamping the track or other actions, the rail must be cut. This is not a permanent solution. The causes of the buckle must be determined and permanent repairs made.

- The work should be scheduled during the cool of the day.

- In order to ensure that track stability is restored while surfacing and lining is being performed, the following speed restrictions must be applied:

  - 10 mph if all ties have been tamped and run-outs made. All cribs have been filled with ballast and all shoulders have been pulled up;

  - 25 mph if all ties are tamped and all cribs have been filled and shoulders have been pulled up;

  - authorized track speed if track is brought to full standard and plus 50 000 tons of traffic have passed over the repaired area.

SPC 23, *Surfacing and Lining* (issued 01 April 2000), states, in part:

> If possible, do not surface when the rail temperature is more than 10 degrees F above the laying or adjusting temperature.

SPC 28, *Track Maintenance of CWR* (issued 01 April 2000), deals with the maintenance of track with CWR including defect repairs. Section 9.0, "Repair of Buckled Track," states in part that, when repairing buckled track:

> a. Provide immediate track protection.
>
> b. Make temporary repairs by placing the track in the best possible alignment where it will not move. . . .
>
> c. For permanent repairs that require cutting, . . . ensure that all the required anchors are applied and properly adjusted. . . .
>
> d. Prepare a Track Buckle Report and submit it to the Local Engineering Manager.

SPC 32, *Track Inspection* (issued 01 April 2000), deals with track inspection including frequency, methods used, corrective action to be taken, and reporting procedures. Section 6.0, "Buckled Track," states in part:

- When inspecting track, pay particular attention to signs of rail moving through anchors and signs of track moving with the traffic current.

- Whenever possible, track inspection should be conducted during the heat of the day.

- Additional attention should also be given to track recently disturbed by spot surfacing and lining.

Analysis

The mechanical condition of the train was not considered a causal factor to the accident. Examination of the rail did not reveal any defects that would have led to the derailment. The train derailed while the locomotive was applying its DB over a section of track on which the lateral stability had been reduced by recent surfacing work. Therefore, the analysis will focus on the formation of the compressive stress within the rail, the repair of the track buckle, the stability of the track structure, the maintenance and inspection practices of the track in CWR territory, and the operation of the train.

On 22 July 2002, the rail had experienced a sudden release of compressive stress in the form of a track buckle. Lifting and lining the track to repair the buckle had the effect of reintroducing the compressive stress into the rail. In addition, as the air temperature on the day of the derailment increased beyond the temperatures experienced on the previous day, the rail temperature rose further above its stress-free, or neutral, temperature. Consequently, thermal expansion of the rail increased the compressive stress. As well, the braking action of the train, as it approached and passed over the derailment area, pushed the rail forward and further increased the compressive stress within the rail.

The track bed was in a weakened state. The rail anchors were either loose or missing, and were not sufficient to prevent rail creep. The ballast was fouled with sandy silt material, the shoulders had fallen away and the ties were skewed. Surfacing the track disturbed the ballast and reduced its lateral strength. Consequently, as the train passed over the weakened section of track, further increasing the compressive stress, it is likely that the lateral wheel forces from the car movements caused small deviations, or kinks, to occur in the rail. With each passing car, the deviations increased until the track shifted sharply and buckled, causing the train to derail.

The inspection of the track by the TMS was carried out during the morning on the day of the derailment, and not during the heat of the day when rail temperatures are high, as recommended in SPC 32, *Track Inspections*. Even so, the indications that the rail was in a high degree of compressive stress (loose or missing anchors, skewed ties, the formation of a track buckle), and that the track structure was in a weakened state (including recently disturbed ballast) were apparent. Had the inspection been carried out during the heat of the day, the signs that the rail was under considerable compressive stress might have been even more apparent. Inspecting the track in the morning before thermal expansion of the rail had occurred contributed to the TMS not being aware of the magnitude of the compressive stress within the rail.

The inspection of the track on the morning of the derailment did not identify the indications that the track was susceptible to buckling. The fact that the buckle had occurred when the ambient temperature was only 25°C was an indication of the magnitude of the compressive stress within the rail. In addition, surfacing undertaken to repair the track buckle lined the track but did not reduce the compressive stress within the rail. No effort was made to determine the cause of the compressive stress or to effect permanent repairs. SPC 06, *Prevention of Track Buckling*, is silent on the actions required to permanently repair rail under high compressive stress. Also, SPC 28, *Track Maintenance of CWR*, is silent on the conditions that necessitate cutting or destressing the rail when repairing track buckles. However, CPR's CWR course mentions that, if there are indications that rail stress is out of adjustment, restressing must be carried out as soon as practicable, and states that a track buckle is a sign of an improperly stressed rail. Neither the RTMF nor the TMS had attended this course. The CWR course has not been presented on a consistent basis to maintenance-of-way (MOW) personnel. Training of the MOW personnel should enable them to recognize the signs of track buckle development, and to be able to determine the actions required to repair and prevent their occurrence.

When the track was surfaced, the rail temperature was not taken. Also, the record of the rail laying or adjusted temperature was not available. Consequently, the surfacing crew and the RTMF could not determine whether the track buckle repair work was being undertaken within 10°F of the rail laying or adjusting temperature. This information is necessary when surfacing is planned to avoid disturbing the ballast when the rail temperature is too high or too low. Proper maintenance and record-keeping practices regarding rail temperatures would have assisted the surfacing crew and the RTMF in assessing the potential safety implications of surfacing the track.

The use of DB in excess of a factor of 5 within one-half mile of a slow order is not recommended as the operation imposes additional compressive stress on the rail. Reducing the amount of DB used while controlling the speed of the train within the slow order limits reduces the forces on a weakened section of track. The use of DB in excess of the amount recommended in Section 16 of the GOI imposed additional longitudinal forces on the rail, consequently increasing the compressive stress.

Findings as to Causes and Contributing Factors

1. As the train passed over the weakened section of track, increasing the compressive stress within the rail, it is likely that the lateral wheel forces from the car movements caused small deviations, or kinks, to occur in the rail. With each passing car, the deviations increased until the track shifted sharply and buckled, causing the train to derail.

2. Lifting and lining the track reintroduced compressive stress into the rail and disturbed the ballast, reducing the track's lateral strength.

3. Although there were indications that the rail was experiencing a high degree of compressive stress and that the track structure was in a weakened state, remedial action, such as cutting or restressing the rail, was not considered.

4. Inspecting the track in the morning, before thermal expansion occurred, contributed to the TMS not being fully aware of the magnitude of compressive stress within the rail.

5. The use of DB in excess of the amount recommended in Section 16 of the GOI imposed additional longitudinal forces on the rail, consequently increasing the compressive stress.

Other Findings

1. Training of the MOW personnel should enable them to recognize the signs of track buckle development, and to be able to determine the actions required to repair and prevent their occurrence.

2. Proper maintenance and record-keeping practices regarding rail temperatures would have assisted the surfacing crew and the RTMF in assessing the potential safety implications of surfacing the track.

3. SPC 06, *Prevention of Track Buckling*, is silent on the actions required to permanently repair rail under high compressive stress. Also, SPC 28, *Track Maintenance of CWR*, is silent on the conditions that necessitate cutting or de-stressing the rail when repairing track buckles.

Safety Action Taken

CPR has committed to rewrite SPC 06, *Prevention of Track Buckling*, which will include information related to the permanent repair of rails under compressive stress.

CPR has also committed to rewrite SPC No. 28, *Track Maintenance of CWR*, which will contain information on the cutting and destressing of rails when repairing track buckles. In addition to rewriting the two SPCs, CPR will provide appropriate training to staff, including the recognition of signs of track buckle development and the importance of proper track maintenance and record-keeping practices. CPR hopes to have this completed before the summer of 2003.

Canadian National (CN) has revised SPC 3205 (CWR) and training is presently underway.

In addition, CPR issued the following operating bulletin across the CPR system (Canada and the U.S.) on 01 August 2002 to instruct against the use of DB in excess of the amount recommended in Section 16 of the GOI:

> **Subject:** **Dynamic Brake Restriction when approaching Temporary Slow Orders**
>
> Background - Recent analysis of event recorder downloads have indicated that locomotive engineers are frequently in violation of dynamic brake restrictions when operating on yard tracks or when approaching or moving over track governed by temporary speed restriction. For your easy reference, the “note” to GOI Section 16, item 7.6 is provided below.
>
> 7.6 NOTE: When operating on any yard track, if the DB factor of the lead locomotive consist is 14 or greater, then the DB handle MUST NOT be placed in a position higher than No. 5. This instruction also applies approximately one half mile prior to the beginning of, or when the locomotive is moving over any track governed by temporary speed restriction.

> Compliance with this instruction is particularly important given CPR's recent change to allowable dynamic brake from DB factor 18 (180,000 lbs.) to DB factor 20 (200,000 lbs.). The intent of this instruction is to reduce the longitudinal forces which occur on the track structure immediately ahead of a locomotive consist which is in dynamic brake. These longitudinal forces can contribute to track buckling on yard tracks and track governed by temporary speed restrictions. Please make a habit of complying with this instruction.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 02 June 2003.

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