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

RAILWAY INVESTIGATION REPORT
R05Q0010

MAIN-TRACK DERAILMENT

CANADIAN NATIONAL
TRAIN M-307-11-22
MILE 86.41, DRUMMONDVILLE SUBDIVISION
SAINT-CYRILLE, QUEBEC
23 FEBRUARY 2005

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

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Canadian National
Train M-307-11-22
Mile 86.41, Drummondville Subdivision
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Report Number R05Q0010

Summary

On 23 February 2005, at 2045 eastern standard time, Canadian National freight train M-307-11-22 was travelling westward towards Montréal, Quebec, when 29 cars derailed at Mile 86.41 of the Drummondville Subdivision near Saint-Cyrille, Quebec. About 600 feet of track was destroyed and about 4000 feet of track was damaged. Twenty-eight cars were destroyed and one car was slightly damaged. One tank car carrying propane (UN 1075) caught fire and exploded, damaging a mill adjacent to the railway right-of-way. Twenty people were evacuated as a safety precaution. There were no injuries.

Ce rapport est également disponible en français.

Other Factual Information

Train Operation Information

On 23 February 2005, Canadian National (CN) freight train M-307-11-22 (the train) from Dartmouth, Nova Scotia, departed the yard in Joffre, Quebec, for Toronto, Ontario. It was 5935 feet long, weighed 6898 tons and consisted of 2 locomotives, 44 loaded cars and 45 empty cars, including tank cars containing chlorine, propane and flammable liquids. The crew consisted of a locomotive engineer and a conductor. Both were familiar with the route characteristics, were qualified for their respective positions, and met fitness and rest standards.

The trip westward to Montréal, Quebec, was without incident until the train experienced an undesired emergency brake application at Mile 87.30 near Saint-Cyrille, Quebec (see Figure 1), as it was travelling at 48 mph. A deflagration occurred and a fireball erupted near the back of the train. The front of the train came to a stop about 2000 feet west of the 10e Rang crossing (Mile 87.38). After carrying out the emergency procedures, the crew followed the instructions provided by the rail traffic controller (RTC), uncoupled the locomotives and moved away from the accident site. Snow covered the ground, there was a light cloud cover and the temperature was -20.6°C.

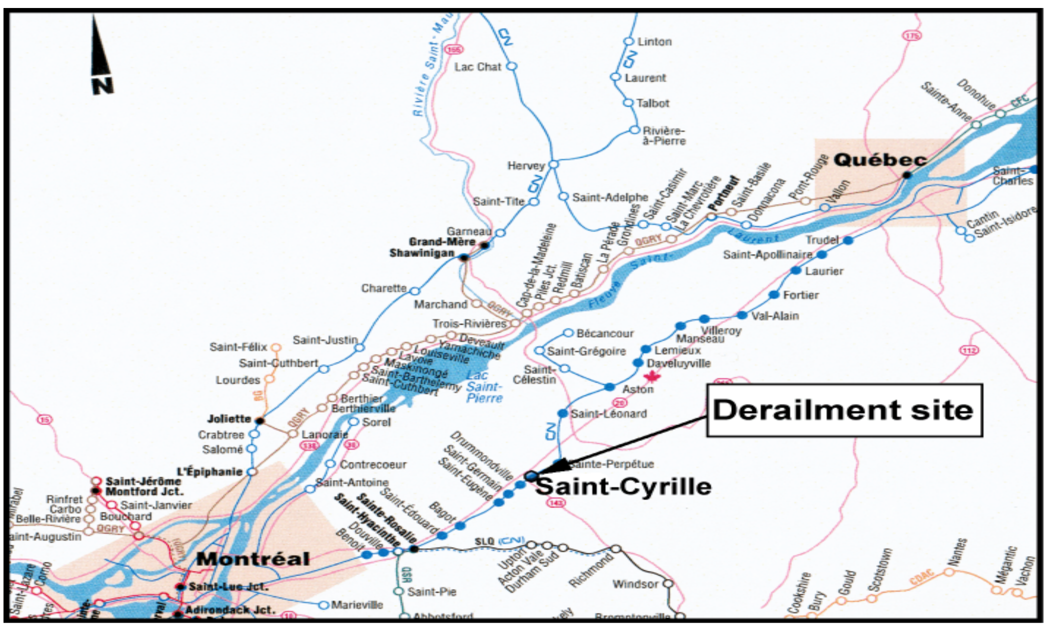

Figure 1. Map of the derailment area (Source: *Canadian Railway Atlas*, Railway Association of Canada)

The derailment area covered a distance of 5000 feet and was to the west of the Mitchell Road crossing (Mile 86.41). The first car that derailed, gondola car WC 65061, the fifth car in the train, remained coupled to the front of the train. The next 27 cars detached from the train and piled up to the south of the main track on the service track and Camirand mill land, between the switch (Mile 87.25) and the 10e Rang crossing. The last car that derailed remained upright on the railway right-of-way with the leading truck derailed.

Car WC 65061 was followed immediately by three other cars loaded with scrap metal and then by tank cars CGTX 64270 and GATX 9200 carrying propane and by tank car PROX 83006 carrying chlorine. Tank car CGTX 64270 caught fire and exploded, damaging the mill, which was empty at the time of the accident (see Photo 1). Cars GATX 9200 and PROX 83006 were heavily damaged and affected by the fire, but did not lose their content. The other cars carrying dangerous goods (hydrocarbons, UN 1863) were among the last to derail. They were damaged but were not affected by the fire and did not lose their content.

Photo 1. Damaged facade of the mill (photo taken two months after the accident)

At Mile 85.55, the impact marks were visible on the south rail head. Several feet westward, the south rail was broken, a piece of wheel from a car was found on the ground between the rails and three other pieces were found under the snow in the ditches. Impact marks and deep gouges were found in the asphalt on the subgrade of the Mitchell Road crossing, on the south side of the track. The marks extended all the way to the pile-up of cars.

Examination of the derailed cars showed that car WC 65061 had lost its rear truck. The truck was directly westward of the pile-up of derailed cars. The wheel plate of wheel L2[1] was fractured; part of the plate remained attached to the axle and the wheel rim broke into three main pieces of equal length and a small fragment (see Photo 2).

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1 Left wheel of the second axle from the end of the car that has the hand brake

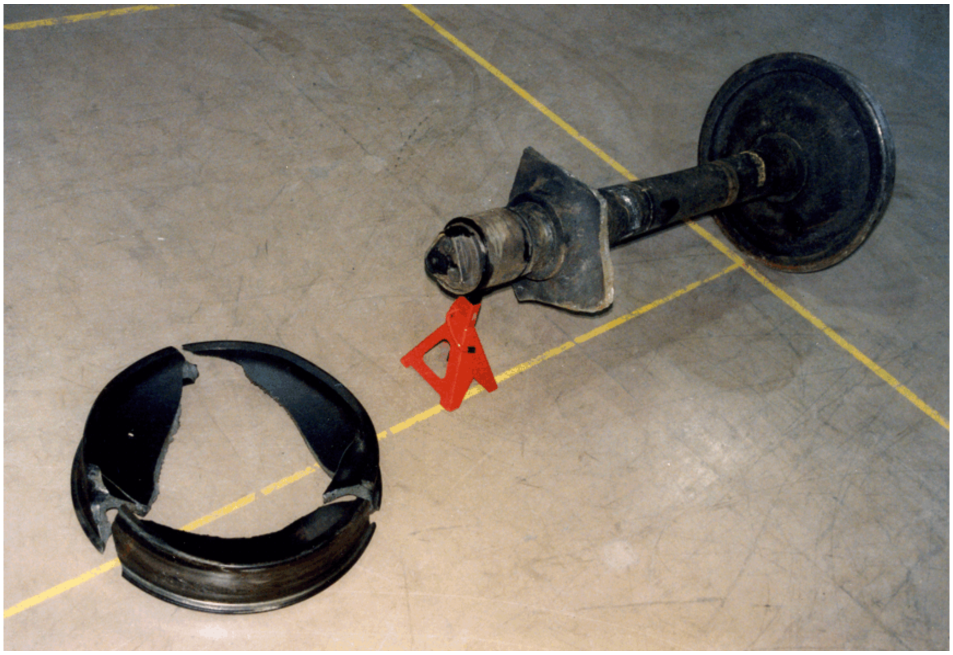

Photo 2. Axle LR2 and pieces of wheel L2

The Drummondville Subdivision consists of a single main track that extends from Saint-Romuald, Quebec, Mile 4.4, to Sainte-Rosalie, Quebec, Mile 125.1. It carries up to 10 VIA Rail Canada Inc. passenger trains and 18 freight trains per day. Train movements are governed by the Centralized Traffic Control System in accordance with the *Canadian Rail Operating Rules* (CROR) and supervised by an RTC located in Montréal.

In the derailment area, the track was a Class 5 track according to Transport Canada–approved *Railway Track Safety Rules* (TSR). The maximum authorized speed was 95 mph for passenger trains and 65 mph for freight trains.

Accident Site

The track is tangent between Mile 85.7 and Mile 86.2, and then curves (two degrees to the left) to Mile 86.6. It has an ascending grade varying from 0.0 to 0.2 per cent. The track was in good condition and consisted of 136-pound continuous welded rail on 14-inch double-shouldered tie plates laid on hardwood ties.

The last track inspection had been performed by the assistant track supervisor on a hi-rail vehicle the day before the derailment. No flaws had been noted in the immediate derailment area.

Emergency Response

The public security officials in the municipality of Notre-Dame-du-Bon-Conseil were notified immediately after the accident and carried out the emergency response plan. Because of the fire and dangerous goods in the other tank cars, the area within a one-kilometre radius of the accident site was sealed off and about 20 people were evacuated as a safety precaution. The contents of all the derailed tank cars were transferred to trucks and other tank cars. The access ban was lifted after the contents of the chlorine tank car were transferred.

History and Repairs to Car WC 65061

Car WC 65061 was equipped with eight two-inch-thick brake shoes with an average service life of 12 months under normal operating conditions. The car had undergone numerous repairs, especially to its brake system. All repairs had been entered in the SAP computer system. The history of all recent data (less than 24 months) can be viewed in all repair shops, but the system does not generate an automatic warning when recurring conditions arise. The following repairs were made to car WC 65061 since January 2004:

- Between January 2004 and January 2005, 12 brake shoes had been installed on the car. The car had undergone brake tests using the single car testing device, and the slack adjuster had been replaced.

- On 02 February 2005, four brake shoes, including two at location RL2, and brake beam support LR2 were identified as defective and were replaced at the Taschereau Yard in Montréal.

- On 13 February 2005, the car was part of train 306 when this train uncoupled in the Napadogan Subdivision. When the train was recoupled, the conductor noted that a wheel on the car was knocking on the rail and immediately contacted the RTC. The car was declared “bad order” and was left on a siding in Cantor, New Brunswick. The car’s status was entered in the computer system as “in bad order due to a wheel defect,” and an electronic notice was transmitted to the authorities concerned, including the equipment repair shop in Moncton, New Brunswick.

- On February 14, the car was inspected in Cantor by a team of carmen. Shelling was noted on wheel R4. Four brake shoes were installed, including two on axle LR2. The car was moved using a hand winch, but no major defects were identified. The car’s brake operating valves were isolated and the car was declared to be “in bad order” with defect code BF (isolated brake operating valves). The RTC was notified that the car could travel to Moncton without restrictions to be repaired.

- On February 15, the car was sent to Moncton on train 507 and placed on the repair track. The work order listed the BF defect code and the shelling on the running surface of wheel R4. Wheel R4 was again checked and found to be within the shelling limits prescribed by the Association of American Railroads (AAR). The car then underwent brake tests using the single car testing device on 16 February 2005 on the Moncton repair track. An air leak was observed, requiring the replacement of an angle cock and a brake hose.

- On February 17, the car was put on train 308 to be delivered to a client in Truro, Nova Scotia, to pick up a load of scrap metal.

- On February 21, the loaded car was placed on train 307 heading for Toronto. Certified car inspectors did a safety check in Moncton as required by the train's inspection schedule. No defects were noted.

- On February 23, at the Joffre Yard, the train underwent a brake pipe continuity test and a No. 2 brake test and the cars added to the train underwent a safety check. During the continuity test, the wear on the brake shoes of axle LR2 on car WC 65061 was noted. The brake operating valves were isolated and the air was purged from the brake system. The car's status was entered in the SAP computer system and appeared on the train consist with mechanical code BH, "in bad order due to defective brakes," with the comment "car can be moved safely." The car was authorized to continue its route without restrictions and was to go to its final destination in Contrecoeur, Quebec, to be unloaded and then sent to a repair track.

The *Railway Freight Car Inspection and Safety Rules* allow a car with a safety defect to be moved to another location for repair as long as the car is safe to move and the nature of the car's defects and the movement restrictions are communicated to the employees concerned.

Wayside Detector Readings

In addition to inspections by employees, the condition of rolling stock is also checked using a network of wayside inspection systems (WISs) and wheel impact load detectors (WILDs) placed along the tracks. WISs include dragging equipment detectors and hot box and hot wheel detectors. WILDs measure the impact load generated by each wheel of a car and identify wheels with flats, and wheels whose running surface exhibits shelling or spalling, is out-of-round or is affected by an excess of metal. WISs are positioned at intervals of 10 to 15 miles on main tracks, and WILDs are placed at strategic locations.

On its way from Halifax, the train passed several WISs, with the last one at Mile 82.1 of the Drummondville Subdivision, five miles east of the accident site. No defects were reported. The train did not pass over any WILDs because the only WILD installed between Montréal and Halifax is located near Bagot, Quebec, at Mile 117.2 of the Drummondville Subdivision, about 25 miles west of the accident site. However, a review of the historical data of the WILDs over which the car had passed during the year preceding the accident, in particular the last reading of the Bagot WILD (when the car was moved from Taschereau to Cantor on 12 February 2005), did not show any significant difference between the impact load of wheel L2 and the other wheels on the car. The last 10 impact load readings for wheel L2 on this car ranged between 26 kips[2] and 83 kips, which is below the 100-kip minimum threshold established by CN.

Engineering Laboratory Report

The wheel set on gondola car WC 65061, consisting of the broken wheel, the four fragments of the wheel rim that were recovered and the brake control valves, was sent to the TSB Engineering Laboratory for analysis (engineering reports LP 027/2005 and LP 043/2005).

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[2] 1 kip = 1000 pounds

The failed wheel was a 33-inch, Class U, curved-plate wheel (CM 33 model) designed for a 50-ton capacity. Wheels in this category are no longer manufactured and are gradually being replaced by Class C wheels with a 100-ton capacity. The wheel was manufactured in January 1987 at ABC Rail (formerly Abex Southern Corporation), in Calera, Alabama, United States (code SO). These wheels are cast and then control-cooled, and do not undergo any heat treatment.

The wheel was oval, and its running surface had a flat that was crushed by 0.38 inch over a length of 22 inches. This same area displayed plastic deformation (see Photo 3) that reached up to one inch in width (the width of the surface went from a nominal size of 5.72 inches to 6.75 inches).

Photo 3. Plastic deformation of the running surface on wheel L2

It also exhibited shelling in the deformed area, but the shelling did not exceed the AAR allowable limits. The opposite wheel on the axle also had a plastic deformation about 0.23 inch wide and 5.5 inches long. There were no signs of discolouration or burn on the running surface of the wheels (see Photo 3).

Because the wheel was broken into several pieces, it was not possible to take its out-of-round measurements. However, if the flattened surface of the wheel (0.38 inch) is plotted against the out-of-round values, the impact load caused by wheel L2 can be estimated by referring to a CN study conducted in 1994-1995. According to that study, which establishes a correlation between the WILD data and out-of-round measurements, the impact load generated by an out-of-round of 0.38 inch would be greater than 200 kips.

The metallurgical analysis of the wheel plate samples showed the presence of microporosity caused by dissolved hydrogen bubbles that were trapped when the wheel was manufactured. The voids were spread across the entire surface of the wheel plate. The degree of porosity was relatively low and could not be detected by the conventional detection devices used in nondestructive tests. The degree of porosity would not have caused the wheel to be rejected because porosity is not standardized in the industry. Three fatigue cracks 10 to 15 mm long in the external part of the wheel plate spread from voids.

The material had a carbon content of 0.66 per cent and a Brinell hardness of 248. In comparison, Class C wheels have a hardness between 321 and 363; as a result, they are less malleable and stand up to wear better.

Car WC 65061 was equipped with an ABD type brake control valve. The service valve portion had been manufactured in 1968 and had been maintained and refurbished in 1997, and the emergency valve portion had been manufactured in 1969 and had never been serviced since that date.

The brake control valve sections were tested on an AAR–approved automatic brake test rack at a certified air brake shop. It was not possible to test the service valve portion because of air leakage in a part that was damaged in the derailment. However, the internal parts were deteriorated, but showed no defects and were in good operating condition.

The emergency valve portion functioned during the tests, but did not meet the required performance standards. It did not pass four test rack tests and was disassembled for analysis. The analysis revealed poor operation of the diaphragm and the high-pressure slide valve because of deterioration of the materials after 36 years of use.

The retaining valve passed the tests. However, air leaks were identified on the periphery of the contact surface of the two portions that form the part. The leaks were caused by metal corrosion and by the deterioration and contamination of the rubber diaphragm.

Analysis

Train operation conformed to company procedures and government safety standards. The track was in good condition and no defects had been reported in the last inspection. Since the wheel fragments found east of the pile-up of derailed cars matched wheel plate L2 of gondola car WC 65061, the analysis will focus primarily on the failure of that wheel, and the related inspection and maintenance practices for cars, and on WILDs.

A few feet before the location where the south rail failed, impact marks were visible on the rail head and fragments of wheel L2 were found a little more to the west. Therefore, the wheel failed at the location where these impact marks were observed, at approximately Mile 85.55. Since it was no longer being supported, the truck side frame on the south side slumped and hit the Mitchell Road crossing subgrade, causing wheel R2 to derail. The truck continued to drag until it reached the switch for the service track to the mill. At the switch, it turned south, causing the following cars to derail. Tank car CGTX 64270 was punctured, allowing propane to escape and catch fire, damaging the mill.

Class U wheels such as wheel L2 have a lesser capacity than Class C wheels, which are now replacing them. Because their steel did not undergo heat treatment, they are not as hard and deform easier. The out-of-roundness of the wheel and the plastic deformation of the running surface illustrate this aspect and show that wheel L2 had been subjected to excessive stresses caused by impact loads. These impact loads are amplified by the very deformation that they cause with every rotation of the wheel. The effect of the impact loads amplified by the wheel's plastic deformation, the low ambient temperature and the porosity observed in the wheel plate led to the initiation and propagation of the cracks that caused the failure of the wheel on car WC 65061.

Due to derailment damage, it was not possible to test the service brake valve. However, there was no evidence to suggest that it was not in good operating condition because there were no apparent defects.

Although the emergency valve portion functioned during the tests, it did not meet the applicable performance standards and it did not pass all the required tests on the test rack. In addition, its internal parts had deteriorated because it had not been serviced since 1969. Considering the state of deterioration of the internal parts, it is possible that the emergency valve portion functioned intermittently, which could explain why car WC 65061 passed the single car testing.

The impact of intermittent functioning of the emergency valve portion during release of the service brakes could not be determined. However, since January 2004, 20 brake shoes had been installed on car WC 65061, 8 of which (including 4 on axle LR2) were in the three weeks immediately preceding the accident. This number is abnormally high and is symptomatic of poor functioning of the brake system or of wheels that are out-of-round, because the average service life of brake shoes is 12 months in normal operating conditions. All the repairs to the brake shoes and brake rigging on car WC 65061 had been entered in the SAP computer system. However, because the system did not have an automatic warning mechanism, the abnormally high number of brake shoes installed on the car during the 13 months preceding the accident was not noticed. The absence of an automatic notification system linked to the SAP computer system did not make it possible to alert the repair teams and to isolate car WC 65061 in order to take the required corrective action.

Four brake shoes, including two at location LR2, and brake beam support LR2 were replaced on the car at the Taschereau Yard on 02 February 2005. The car then travelled to Bagot without a noticeable difference in the WILD readings between wheel L2 and the other wheels. Consequently, there is reason to believe that the deformation of wheel L2 had not reached a noticeable stage when it passed Bagot and that it worsened on the section between Bagot and Cantor. Since the car was not loaded, the deterioration in the wheel's initial deformation is not likely to have been caused by excessive stresses between Bagot and Cantor. However, intermittent rubbing of the brake shoes due to poor functioning of the brake system could have led to the deterioration because the brake shoes installed a few days earlier at Taschereau were once again replaced at Cantor.

The investigation was not able to establish a link between the premature wear of the brake shoes and the deformation of wheel L2 because the running surface of the wheel did not exhibit any heat or discolouration, or any changes to the internal structure of the metal. Nevertheless, the premature wear of the shoes could not have occurred without excessive rubbing between the shoes and the wheels. The lack of rubbing marks, especially if the rubbing was intermittent, could be explained by the weather conditions (swirling snow) and low ambient temperature that would have kept the metal at a low temperature.

During the decoupling of train 306 at Cantor, the conductor notified the RTC that a wheel on car WC 65061 was knocking on the rail, without specifying its exact position. The defect was thus initially identified by the noise that the moving wheel generated. The car was then inspected twice and repaired by certified car inspectors at Cantor, and then on the repair track at Moncton. However, since the exact position of the defective wheel was not known, the two inspections focused on the brake system and the shelling on wheel R4, which seems to have been confused with the defect reported to the RTC. As a result, the reported defect was not corrected.

During the continuity test at the Joffre Yard, the condition of the brake shoes on car WC 65061 was observed, but because not all of the car's components were inspected, the condition of the running surface of wheel L2 was not noted. When the brake operating valves were isolated, the condition of the car was considered safe and the car was authorized to continue its trip to its final destination to be unloaded there and repaired as authorized by the *Railway Freight Car Inspection and Safety Rules*.

Although the inspections and repairs to car WC 65061 were done by certified car inspectors with extensive experience, they did not detect the deformation on the running surface of wheel L2. All the inspections, except for the one done by the conductor at Cantor, were done when the car was stationary. It is therefore likely that the defect on the wheel was not very pronounced and could be detected only by the noise it generated when the wheel was in motion.

Trains coming from eastern Canada can travel long distances before the wheel impact loads are measured by a WILD system. For example, trains from Halifax cover a distance of more than 700 miles before passing the first WILD at Bagot. In these conditions, the risk of not detecting out-of-round wheels, shelling and other wheel defects that have not become very pronounced or that are difficult to detect in the safety inspection, rises to the point that high impact loads can occur that may have a detrimental effect on the track or equipment. Given the severity of the plastic deformation of wheel L2 and the impact it must have generated, the presence of a WILD on the car's route between Truro and Québec would probably have made it possible to detect the wheel's condition and avert the accident.

Findings as to Causes and Contributing Factors

1. The train derailed after wheel L2 on car WC 65061 failed.

2. The effect of the impact loads, which were amplified by the plastic deformation of the wheel, low ambient temperature and porosity observed in the wheel plate, led to the appearance and propagation of cracks that caused the wheel to fail.

3. Wheel L2 was of Class U and therefore had a lesser capacity than the Class C wheels because its steel was softer and more susceptible to deformation, hence the severity of the plastic deformation observed on the wheel.

4. The conductor of train 306 reported the condition of wheel L2 to the rail traffic controller (RTC) but the safety action undertaken did not succeed in correcting the defect.

5. Although the inspections and repairs to car WC 65061 were done by certified car inspectors with extensive experience, they did not make it possible to detect the deformation on the running surface of wheel L2.

6. Contrary to the inspection done by the conductor at Cantor, the other inspections were done by certified car inspectors when the car was stationary. It is therefore likely that the defect on the wheel was not very pronounced and could be detected only by the noise it generated when it was in motion.

Findings as to Risk

1. Without a wheel impact load detector (WILD) between Halifax and Québec, trains coming from eastern Canada can travel long distances before the wheel impact loads are measured; the risk of not detecting wheel defects that are difficult to detect in the safety inspection is therefore higher.

2. The absence of an automatic notification system linked to the SAP computer system does not make it possible to alert repair teams and to isolate a car that has recurring defects.

Other Findings

1. Despite the deteriorated condition of the internal parts, car WC 65061 passed the single car test, probably because the emergency valve portion functioned intermittently.

2. The absence of rubbing marks on the running surface of wheel L2 could be explained by the intermittent functioning of the brake system and by the weather conditions.

Safety Action Taken

On 25 February 2005, Canadian National (CN) issued a policy, effective immediately, requiring that cars with defects affecting safety devices, brakes, couplings, bodies and trucks (code AA to code VZ) be inspected to ensure that they can be safely moved to a location where carmen are stationed. The cars will then have to be repaired before being authorized to continue their route. In addition, only restricted personnel is authorized to enter the mechanical code indicating that a car can be safely moved to its final destination for repair.

According to the pamphlet titled *Freight Car Inspection – Key Points*, July 2005 revision, CN's policy is to ensure that the braking system on all cars of a train is in good operating condition at the originating station.

Rolling stock employees were given refresher courses on inspecting cars and on brake tests using the single car testing device.

CN issued instructions to perform pull-by inspections inbound and outbound at designated safety inspection locations and other strategic locations.

CN launched a project to introduce an automatic notification system to identify cars with recurring defects and to alert repair shops in order to isolate the defective cars and take the necessary corrective action. The first phase of the project focuses on the defects related to the braking system on cars.

Rule 41 (Section A-2k) of the Association of American Railroads (AAR) *Field Manual of the AAR Interchange Rules* was modified in 2006. Wheels with impact loads of 80 kips to 90 kips will be treated as if they were defective when cars are sent to repair tracks. In addition, the Equipment Health Management System approved by the rail industry is of the opinion that there is reason to intervene when wheels have an impact load exceeding 65 kips (Rule 14, Section E-15).

CN implemented an extensive program to reduce the number of SO wheels in its system.

Safety Concern

Trains travelling in eastern Canada can travel long distances before the wheel impact loads are measured by a wheel impact load detector (WILD). For example, trains from Halifax cover a distance of more than 700 miles before passing the first WILD at Bagot. Given that the impact generated by the wheel on car WC 65061 on an earlier trip was already 83 kips and that its flattening as measured after the accident should have generated an impact of at least 200 kips, there is reason to believe that the presence of a WILD on the car's route between Truro and Québec would have made it possible to detect the wheel's condition and probably avert the accident.

In the absence of a WILD, inspections by certified car inspectors become a primary safety tool in identifying defective cars. However, even when these inspections are conducted by experienced certified inspectors, they have their limitations, as demonstrated by this accident. Consequently, the risk of not detecting out-of-round wheels, shelling and other wheel defects that have not become very pronounced or that are difficult to detect in the safety inspection, rises to the point that high impact loads can occur that may have a detrimental effect on the track or equipment.

The Board recognizes that incorporating pull-by inspections and implementing new AAR Rule 41 are measures that are likely to reduce the risk of accidents caused by wheels with high impact loads. However, the Board is concerned that these measures may still not be sufficient in certain areas of the territory because of the absence of a supplementary inspection system such as the WILD system.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 08 August 2006.