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

RAILWAY OCCURRENCE REPORT

DERAILMENT

CANADIAN PACIFIC LIMITED
MILE 108.05, TABER SUBDIVISION
LETHBRIDGE, ALBERTA
17 OCTOBER 1994

REPORT NUMBER R94C0137

Canada

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Synopsis

Canadian Pacific Limited (CP) freight train No. CP 971-14, travelling westward on the Taber Subdivision, derailed six tank cars containing methanol at Mile 108.05 in Lethbridge, Alberta. Four of the derailed cars lost product and approximately 230,700 litres of methanol was released. A 20-square-block area of the city was evacuated and secured by police until the spilled and remaining methanol was removed from the site. There were no injuries as a result of the accident or the product spill.

The Board determined that the derailment was caused by a rail fracture which was initiated by the propagation of undetected fatigue cracks in rail that had worn beyond condemnable limits.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 The Accident

Westward Canadian Pacific Limited (CP) freight train No. CP 971-14, travelling at approximately 30 mph, experienced a train-initiated emergency brake application at approximately 0630[1] while negotiating a right-hand curve in the direction of movement, at Mile 108.05 of the Taber Subdivision in Lethbridge, Alberta.

After conducting the required emergency procedures, the crew determined that the 26th to the 31st cars had derailed. The 26th to the 30th cars were on their side south of the track and leaking product. The 31st car was upright.

The derailment site was quickly secured by first responders and entry to nearby business areas was prohibited. No one was injured.

1.2 Damage to Equipment

Five tank cars were extensively damaged.

1.3 Other Damage

Approximately 300 feet of track was destroyed.

1.4 Personnel Information

The train crew consisted of a conductor, a trainman and a locomotive engineer. They were qualified for their positions and met fitness and rest requirements established to ensure the safe operation of trains.

1.5 Train Information

The train was powered by 3 locomotives and was hauling 29 loads and 6 empties. It was approximately 2,267 feet long and weighed about 3,861 tons.

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

1.6 Particulars of the Track

The Taber Subdivision is a single main track in Alberta, extending from Medicine Hat to Lethbridge. The annual traffic over this portion of the subdivision is approximately 15 million gross tons with 8 to 10 trains per day. The maximum authorized speed for freight trains at Mile 108.05 is 35 mph.

The track structure in the derailment area consisted of partly worn 100-pound head-free jointed rail in 72-foot lengths. The rail was of differing manufacture, rolled between 1947 and 1964, and laid in 1983. The rail was fastened to softwood ties on single-shouldered plates and box-anchored every tie. The ballast was crushed gravel with full cribs and 18-inch shoulders. The drainage was good.

Mile 108.05 is located in a 3-degree 37-minute curve on a 0.44 per cent grade.

The track had been inspected by the roadmaster in a Hi-rail vehicle on 13 October 1994 and by the section foreman on 14 October 1994. No irregularities were noted in the area of the derailment.

An ultrasonic rail flaw detection vehicle tested the rail on 06 November 1993 and no defects were identified at Mile 108.05.

A CP track evaluation car tested the track for geometrical configuration and rail wear on 04 October 1994. No geometrical deficiencies were recorded in the derailment area. The laser rail wear measuring device, part of the track evaluation car, showed that the rail had 9/16 inch head wear, and there was no information on flange wear. When there is "no information," a horizontal line is shown on the laser rail plot and, on the wear graph, a trace of the last valid reading continues until a new valid reading, distinct from the peaks and valleys of the normal wear plots, is obtained. The laser rail wear measuring system was designed with only American Railway Engineering Association (AREA) rail profiles in mind and used the rail width at a point 5/8 inch below the top surface of the rail as a basis for the gauge-to-centre wear measure. In this case, it was found that the 5/8 inch point of measure did not appear on the profile of worn head-free rail. The processing logic did not allow the calculation of the gauge-to-centre wear when the 5/8 inch point of measure undershot the rail head. CP standards indicate that 100-pound rail is condemnable when the head wear is more than 3/8 inch with zero flange wear. When the flange wear reaches beyond 1/8 inch, the allowable head wear is 3/32 inch.

The results of the laser rail evaluation conducted on 04 October 1994 had not reached the local track maintenance personnel at the time of the accident.

1.7 Method of Train Control

Traffic on this subdivision is controlled by the Occupational Control System (OCS) authorized by the Canadian Rail Operating Rules (CROR) and is supervised by a rail traffic controller (RTC) located in Calgary, Alberta.

1.8 Weather

The temperature was two degrees Celsius, the skies were overcast, and visibility was unrestricted.

1.9 Recorded Information

The event recorder data indicated that the train experienced a train-initiated emergency brake application at 0634:41 while it was travelling at a recorded speed of 29.6 mph. All other recorded train information systems were shown to be operating as intended.

1.10 Occurrence Site Information

The derailment site was located in a commercial area in the central part of the city. The right-of-way was bordered by a four-lane highway to the south (Highway No. 3) and a two-metre-high chain-link fence on the north. A shopping centre was located at the north right-of-way fence and commercial buildings, including an entertainment club, were situated south of the highway.

The single main track was paralleled to the north by a siding. The last derailed car, UTLX 41717, remained upright with the trailing truck on the track. The five completely derailed cars came to rest on their sides or inverted south of the track on the track subgrade and in the right-of-way ditch. Leaking product was mixed with water in the ditch.

The south rail immediately west of car UTLX 41717 had broken into smaller pieces leaving a 27-foot gap in the rail. The broken rail was part of a 36-foot length rolled in 1947, which had been welded onto another 36-foot section rolled in 1964. Approximately nine feet of the 1947 vintage section of rail remained fastened to the ties. The fractured end (west) displayed a well-developed and oxidized crack in the head/web area. The rail exhibited 1/2 inch head wear and 7/16 inch flange wear. The north rail was displaced but did not break.

There were no tie, rail, or roadbed markings before the broken rail. The derailed cars displayed no evidence of a pre-derailment equipment failure.

The first completely derailed car, PROX 40655, suffered a sheared vacuum relief valve and lost approximately 38,000 litres of product. The second car, ACFX 87276, received a small gash-like puncture in the head area and lost approximately 57,000 litres of product. The third car, ACFX 89851, was also punctured on the right side of the head and was leaking heavily on the underside of the tank. The fourth car, PROX 40737, was leaking from the vacuum relief valve in the dome area.

Broken pieces of the section of the missing south rail were found at the site. One piece, comprised of the base and web and measuring 24 inches in length, matched the westerly fracture at the intact south rail. The web displayed a well-oxidized crack.

The pieces of broken rail were forwarded to CP Rail Systems Test Department in Winnipeg, Manitoba, for examination.

1.11 Dangerous Goods

1.11.1 The Product

Methanol (methyl alcohol), Class 3.2, UN 1230, is a colourless flammable and poisonous liquid. The flash point is 11 degrees Celsius. It is a fire hazard and its vapours present the risk of explosion. The lower explosive limit of methanol is 6.0 per cent and the upper explosive limit is 36.5 per cent by volume. Vapours are heavier than air and will spread along ground and collect in low and confined areas such as sewers and basements. It is considered to be a human poison by ingestion and skin contact in that it affects the nervous system. Death can occur from ingestion of less than 30 millilitres (about one ounce).

1.11.2 Emergency Response

At approximately 0630, a truck driver travelling on Highway No. 3 witnessed the derailment and immediately telephoned for an emergency response. The police and fire department arrived within seven minutes. The fire department and police followed the City of Lethbridge Emergency Response Action Plan and evacuated a 20-block area and shut off the electric power and natural gas supply to the area.

A CP command post was set up on Highway No. 3, approximately 1,000 metres upwind from the derailment site. The site command post was set up at the derailment site approximately 100 metres from the nearest tank car. The site command post was controlled by the fire department and access to the area was restricted.

Representatives from the emergency response teams from the railway, the shipper, Alberta Environment and Transport Canada were on site assisting and overseeing the containment and reclamation of the methanol.

Two dikes were built in sequence to contain the flow of methanol into pools. The methanol was diluted with water and pumped into tanker trucks and disposed of at authorized waste areas. The derailed tank cars were emptied, then purged and removed. The contaminated soil was excavated and transported to a designated site. Approximately 56,000 litres of methanol was lost to the environment.

Fire-fighting units and emergency response vehicles gained access to the site via the highway to the south and through a private entrance gate on the north side of the track. The fire department supplied foam and water to the derailed equipment as required and maintained this capability until off-loading was completed.

1.11.3 Evacuation

The evacuation was ordered jointly by the police and fire department. The evacuated area contained commercial establishments only. Highway No. 3, running south of the derailment, was closed to traffic. The area was evacuated from approximately 0700, 17 October 1994, to 1200, 18 October 1994. The highway was re-opened on 19 October 1994 at approximately 0200.

1.11.4 Series 111A Tank Cars

The four tank cars that leaked product were constructed to CTC and DOT-111A specifications. These types of tank cars are general-purpose tank cars used to transport flammable liquids, acids and other corrosives. They are not designed to carry product under pressure and can be insulated or non-insulated. Protuberances are located on both the top and bottom of the tanks and are vulnerable to damage as a result of a derailment. The 111A classification tank cars do not normally have head shields and are pressure-tested at 60 to 100 pounds per square inch (psi). They are all equipped with double-shelf couplers.

Tank cars constructed to the minimum prescribed DOT/CTC-111A specifications are not considered to provide the same degree of protection against loss of product as tank cars constructed to the DOT/CTC-105, 112 and 114 specifications. Cars constructed to these latter three specifications transport flammable, poisonous and corrosive gases, or highly poisonous liquids, and are equipped with head shields, thermal protection and protected valving in the dome area.

The United States National Transportation Safety Board *Safety Study into the Transport of Hazardous Materials by Rail* (NTSB/SS-91/01) questions the safety of 111A specification tank cars. The report determined that this series of tank cars has a high incidence of tank integrity failure when involved in accidents and that certain hazardous materials are transported in these tank cars even though better protected cars are available.

1.12 Tests and Research

The laboratory examination of the rail pieces revealed the presence of fatigue cracks along the web under the rail head. The cracks varied from 1/8 inch to full penetration of the web. The crack surfaces were oxidized. Numerous ratchet marks, indicative of multiple fracture initiation, were observed along examined fracture sources of the web. The remaining fracture surfaces exhibited features typical of catastrophic failure. No manufacturing flaws were found.

1.13 The Regulatory Initiative

Transport Canada has recognized the need to further restrict the transportation of the most dangerous/toxic chemicals to stronger built cars and has taken regulatory steps to address this concern. A revised tank car standard (CAN/CGSB-43.147-94) which further restricts the use of Class 111A tank cars has been implemented. The new standard prohibits the carriage of a further 80 commodities in these tank cars.

The U.S. Department of Transport, effective 01 January 1986, restricted certain commodities (based on their volatility and inhalation toxicity) from being carried in Class 111A tank cars in the U.S.

Acetic anhydride, Class 8, UN 1715, which is still permitted to be moved by 111A tank cars, was one of several products released in the derailments in St. Lazare, Manitoba, on 09 July 1991, and Oakville, Manitoba, on 18 December 1992, in which the local population endured a lengthy evacuation due in part to the perceived concerns about the inhalation toxicity of this commodity.

2.0 Analysis

2.1 Introduction

The operation of the train conformed to company instructions and government safety standards. No evidence was uncovered to indicate that equipment failure caused the accident. Therefore, the derailment is attributable to a rail break at Mile 108.05 as the rear portion of the train negotiated that point. The analysis will focus on the rail fracture and the release of the regulated product.

2.2 Consideration of the Facts

2.2.1 Rail Fracture

Head and web separation such as found in this instance represents a type of fatigue failure caused by torsion applied to the rail head. It is often found in curves. Although insufficient superelevation or improper rail cant can produce the eccentric loading that produces the torsional forces, it is felt that this piece of rail was beyond CP condemning limits and had simply remained in service too long.

The oxidization found at the web/rail head separation indicates that cracking had existed for some time before the break. This type of defect is, however, difficult to see and would not be detectable during the routine Hi-rail inspections. The last ultrasonic test had been carried out 11 months before and the defect may not have existed at that time.

Almost two weeks before the occurrence, the laser rail wear measuring equipment identified the head wear of the subject rail as being 9/16 inch, which is 3/16 inch beyond the condemning limit. The measured head wear in the field was, however, 1/2 inch. Similarly, the flange wear measurement shown by laser measurement was 1/16 inch, whereas the field measurement was 7/16 inch. It was not apparently well understood that the flat graphic depiction of rail wear in fact indicated "no information" and that the laser rail wear measuring system could not measure the gauge of worn head-free rail.

2.2.2 Dangerous Goods Response

The dangers associated with the dangerous good release were quickly realized by first responders and the steps taken to minimize the risk to the public and the environment were timely and effective.

The off-loading and site clean-up were professionally executed.

Although 56,000 litres of methanol was lost, it was diluted with water and would have quickly degraded. Environmental damage was minimal and not long lasting.

2.3 111A Tank Cars

The susceptibility of 111A tank cars to release product upon derailment and impact is well documented.

However, the transport of a variety of very hazardous products in such cars continues.

2.4 Dangerous Goods with Poison Inhalation Hazards

In this derailment, there was a large release of a flammable and poisonous product in an urban area, close to commercial establishments. That product was one of a number of toxic and volatile compounds that are still permitted to be carried by Class 111A tank cars. The decision to evacuate was taken primarily to control the accident scene from sources of ignition. In other recent cases, evacuations were carried out because of concerns either with the dangerous characteristics of the liquid, or to allay fears that persons may have had with fuming clouds or unusual odours. While evacuations solely to appease public concern may be unnecessary, it is also true that other decisions to evacuate have been taken based on inhalation hazards (such as acetic anhydride).

3.0 Conclusions

3.1 Findings

1. The train operation conformed to company instructions and government safety standards.

2. The rail contained old and undetected fatigue cracks along the fillet under the rail head which propagated as a result of forces incurred from the passage of the train. The crack propagation resulted in a head and web separation and ultimate fracture of the rail. The fracture of the rail resulted in the train derailment.

3. The section of rail which broke was worn beyond condemning limits, as determined by the CP track evaluation car two weeks before the derailment, but local track maintenance personnel had not yet been advised.

4. The laser rail wear measuring system did not provide a measure of rail wear for worn head-free rail.

5. Emergency response procedures were carried out in a timely and effective manner minimizing both the risk to the public and the environment.

6. Class 111A tank cars are more susceptible to release product upon derailment and impact than pressure tank cars, and yet there are a number of toxic and volatile liquids that are still permitted to be carried in minimum standard Class 111A tank cars.

3.2 Cause

The derailment was caused by a rail fracture which was initiated by the propagation of undetected fatigue cracks in rail that had worn beyond condemnable limits.

4.0 *Safety Action*

4.1 *Action Taken*

4.1.1 *Research and Development of Rail Inspection Technology*

A joint project to test and develop new rail inspection technology is being conducted by the Transportation Development Centre, involving Canadian National, Canadian Pacific Limited, Tektrand International Inc., Canac International Inc., and Transport Canada (TC). The project will focus on the following issues: the adequacy of testing equipment and technology; methods of data collection and the analytical processes; and alternate technologies for improved rail testing. Furthermore, the industry is presently examining ways to improve present technology in ultrasonic testing in which defects are displayed to provide an improved user-friendly system that could reduce the potential for operator errors.

4.1.2 *Restrictions on Use of 111A Tank Cars - Transport Canada*

Amendment Schedule No. 21 to the Transportation of Dangerous Goods Regulations makes mandatory the use of tank car standard CAN/CGSB-43.147-94. This standard restricts the use of 111A tank cars, and removes over 80 dangerous goods previously authorized for transportation in Class 111A cars.

4.1.3 *International Symposium on Tank Car Safety*

As a result of discussions between TC and the Federal Railroad Administration (FRA), a symposium titled "Ensuring Tank Car Safety" was held in February 1996 in Houston, Texas, to examine, in part, the recent incidences of product releases from the top fittings of Class 111A tank cars. This TC/FRA-sponsored initiative included the participation of the Railway Association of Canada, the Association of American Railroads, the Railway Progress Institute, Canadian and American railway companies, as well as other interested persons. The results of that symposium have not been published yet.

4.1.4 *Improvements to Processing Logic*

At the time of this accident, a problem existed with the laser rail wear measuring device where "last valid readings" continued to be displayed in areas where "no valid readings" were being obtained. Such invalid data could have been misinterpreted for actual wear measurements. The processing logic for computing and showing gauge-to-centre wear on head-free rail has since been changed so that that problem no longer occurs.

4.1.5 Improvements in Exception Report Timing

CP roadmasters now receive rail exception reports within 10 days of a test run compared to four weeks, which was the practice at the time of the occurrence.

4.2 Action Required

4.2.1 Class 111A Tank Cars: Susceptibility to Damage and Loss of Product

Class 111A tank cars are utility non-pressure cars used to carry a variety of liquid products, many of which are hazardous. They account for over half of all tank cars in service in North America. The majority of the more than 64,000 non-pressure tank cars carrying hazardous liquids in North America are Class 111A cars.

Both the damage sustained by the Class 111A tank cars involved in this occurrence and the risks posed by the subsequent product release are typical of that which have been identified in previous TSB investigations into accidents involving such cars. In this occurrence, due to the flammable nature of methanol, an evacuation was ordered. In two other occurrences, evacuations were necessary due to the release of acetic anhydride from Class 111A tank cars, at both St. Lazare, Manitoba, on 09 July 1991 (TSB report R91W0189) and at Oakville, Manitoba, on 18 December 1992 (TSB report R92W0300).

The susceptibility of minimum standard Class 111A cars to damage has been known throughout the North American railway industry, including railway safety regulators, for a considerable time. According to the U.S. Transportation Research Board Special Report 243 (1994), *Ensuring Railroad Tank Car Safety*[2], non-pressure tank cars (of which Class 111A tank cars form a large part) result in more than 80 per cent of the releases of products due to accident damage, and only account for approximately 60 per cent of tank car mileage. Conversely, pressure tank cars result in less than 20 per cent of accident-related releases and account for approximately 40 per cent of tank car mileage. The report attributed, in part, the better performance of pressure cars to thicker tank walls and better protected fittings. (Although the report references data before 1986, the Board is not aware of any trends that would significantly alter these ratios.)

An examination of recent TSB data on railway tank car occurrences in Canada indicates that approximately seven per cent of the Class 111A tank cars involved in derailments/collisions resulted in the release of a product, compared to about one per cent for pressure tank cars (Classes 105, 112 and 114)[3]. Over 60 per cent of product releases from Class 111A cars were from damaged top fittings, over 25 per cent were due to structural failure of the tank, mainly from punctures in the head or shells, and about 10 per cent were from bottom fittings. Unlike pressure tank cars, there is no mandatory

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2 The report used North American data; mileage data were between 1978 to 1986 and release data were between 1965 to 1986.

3 These percentages were based on TSB accident data for the three years before the early part of 1995, and included a sample base of over 400 cars each of Class 111A and Classes 105, 112 and 114.

requirement for the location and protection of top fittings with "skid" or "rollover" devices on Class 111A tank cars.

The Board is aware that consideration has been given to develop an enhanced general-purpose hybrid tank car with minimum acceptable standards somewhere between the current 111A and 105A classifications. Furthermore, the Board notes that some Class 111A cars exceed some of the prescribed minimum safety standards, thereby making them more suitable for specific uses and less prone to product releases as a result of derailments or collisions.

In view of the vulnerability of minimum standard Class 111A tank cars to product releases in accidents, the Board is concerned that the carriage of certain dangerous goods in such cars may be putting persons and the immediate accident environment at risk. The dangerous goods that exhibit high inhalation toxicity (a characteristic dependent on liquid toxicity and volatility) are of particular concern.

To mitigate the risks associated with transporting such goods, steps were taken in the United States in 1986 to preclude certain hazardous materials with high inhalation toxicity and/or high volatility from being carried in Class 111A tank cars. In Canada, the new standard (CAN/CGSB-43.147-94) is a similar positive step towards reducing these risks. However, many toxic and volatile liquids are still permitted to be carried in Class 111A tank cars in Canada and from the United States to Canadian destinations. Some of the commodities that exhibit inhalation toxicity characteristics are moved in significant quantities[4]. Some commodities are only moved in bulk from time to time, but also exhibit high inhalation toxicity[5]. Some other transported commodities exhibit potential explosive characteristics when mixed with air and are also toxic[6].

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4 For example, ethylene dichloride (UN 1184), ethylenediamine (UN 1604), acrylonitrile (UN 1093), acetic anhydride (UN 1715), and formaldehyde solutions (UN 1198, UN 2209).

5 For example, chloroform (UN 1888), acetyl bromide (UN 1716), acetyl chloride (UN 1717), methyl vinyl ketone (UN 1251) and acetonitrile (UN 1648).

6 For example, carbon disulphide (UN 1131), ethyl mercaptan (UN 2363), diethylamine (UN 1154), propylene oxide (UN 1280) and acetaldehyde (UN 1089).

Considering the vulnerability of minimum standard Class 111A tank cars to product releases in accidents, especially because of damage to the top fittings on the cars, and the large number of Class 111A cars continuing in service in which toxic and volatile liquids could be carried, the Board believes that further action is required. These risks could be mitigated by reducing the probability of product release through design improvements for protecting the cars, especially the top fittings, and/or by reducing the consequences of accidents by further limiting the types of products that can be carried in minimum standard Class 111A tank cars. The Board recognizes that this will require a collaborative effort involving such agencies as the Canadian General Standards Board, the U.S. Federal Railroad Administration and the Association of American Railroads Tank Car Committee. Nevertheless, the Board recommends that:

> The Department of Transport take immediate action to further reduce the potential for the accidental release of the most toxic and volatile dangerous goods transported in Class 111A tank cars -- for example, require design changes to improve tank car integrity in crashes or further restrict the products that can be carried in them.

R96-13

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, Benoît Bouchard, and members Maurice Harquail and W.A. Tadros, authorized the release of this report on 09 October 1996.