RAILWAY INVESTIGATION REPORT
R00T0067

MAIN TRACK TRAIN DERAILMENT

ONTARIO NORTHLAND RAILWAY
FREIGHT TRAIN NO. 402
MILE 63.4, TEMAGAMI SUBDIVISION
TEMAGAMI, ONTARIO
14 MARCH 2000

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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Ontario Northland Railway
Freight Train No. 402
Mile 63.4, Temagami Subdivision
Temagami, Ontario
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Report Number R00T0067

Summary

On 14 March 2000, Ontario Northland Railway southward freight train No. 402, travelling from Englehart, Ontario, to North Bay, Ontario, derailed 29 cars at Mile 63.4 of the Temagami Subdivision, near Temagami, Ontario. Twenty-five derailed tank cars contained sulphuric acid, three derailed boxcars contained lumber products, and one derailed boxcar was empty.

Approximately 386 000 litres of sulphuric acid was spilled. Approximately 242 000 litres of the product was absorbed by the surrounding ground and approximately 144 000 litres entered the Martin Creek waterway, 35 000 litres of which migrated to Hornet Lake. None of the spilled product was recovered in its natural state. There was minimal mortality to organisms and fish in Martin Creek and Hornet Lake. There were no injuries.

Ce rapport est également disponible en français.

Other Factual Information

The Accident

On 14 March 2000, at approximately 1340 eastern standard time (EST)[1], Ontario Northland Railway (ONR) southward freight train No. 402 departed Englehart, Ontario, destined for North Bay, Ontario. The train consisted of 2 locomotives, 38 tank cars loaded with sulphuric acid, 11 boxcars loaded with lumber products, 1 empty boxcar and 1 car loaded with steel ingots. The train was approximately 2 700 feet long and weighed 6 600 tons.

The operating crew consisted of a conductor and a locomotive engineer. They were familiar with the physical characteristics of the subdivision. The maximum permissible speed at this location is 45 mph for freight trains and 50 mph for passenger trains. ONR special instructions restrict trains handling loaded sulphuric acid cars to 40 mph.

Train No. 402 was made up by joining two separate trains; one that originated at Kidd Creek, Ontario, and another that originated at Noranda, Quebec. Pre-departure inspections and brake tests on the cars were conducted by mechanical personnel at Kidd Creek and at Noranda. Another brake test was conducted by the train crew when the two trains were combined at Englehart, Mile 138.5 of the Temagami Subdivision, with no exceptions noted.

A wayside hot bearing/wheel and dragging equipment detection system located at Mile 80.6 did not register any defects.

At approximately 1610, while the train was rounding a right-hand curve at Mile 63.4, a train-initiated emergency brake application occurred. The event recorder transcript indicated that the train speed was 39 mph at that time. Before the emergency brake application, the brakes were fully released and the throttle was in the No. 1 position.

After conducting the necessary emergency procedures, the crew determined that 29 cars had derailed, commencing with the 13th car behind the locomotives and extending to and including the 41st car.

Twenty-five tank cars of sulphuric acid were involved in the derailment. Twelve of those cars lost product in varying amounts. Four cars had their tank shells breached as a result of impact with wheels, bolsters and/or couplers from preceding derailed cars. Ten cars lost product as a result of damage to their top fittings; two of these cars were also punctured. Six of the ten cars sustained damage to their rupture disc assemblies. Five cars located at the south end of the derailment site rolled down an embankment at the time when their forward speed was near zero. Despite this rather gentle roll, the top fittings (mainly the rupture disc/safety vent assembly) on four of the five cars sheared off. Some cars sustained damage to air lines and/or the loading hole covers.

The loss of sulphuric acid was estimated to be 386 000 litres. It ranged from a minimal amount for one car to nearly total loss of product for others. About 242 000 litres of the spilled acid was absorbed into the ground at

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[1] All times are EST (Coordinated Universal Time (UTC) minus five hours) unless otherwise stated.

the north end of the derailment site. Most of the remaining 144 000 litres of acid flowed into Martin Creek which runs parallel to the rail track at the south end of the derailment site. An estimated 35 000 litres of sulphuric acid which spilled into the creek migrated to Hornet Lake.

Twenty-three of the derailed cars were extensively damaged. It was determined from the location of the wreckage that the 17th car (UTLX14536) from the locomotives likely derailed first and the rigid connection of the double-shelf couplers between the tank cars resulted in the derailment of four cars ahead, the 16th, 15th, 14th and 13th cars behind the locomotives. A post-derailment inspection of the running gear on the first derailed car did not indicate that there were any mechanical defects that likely contributed to the derailment. Approximately 1 100 feet of track was destroyed.

The single main track at Mile 63.4 is oriented in a north-south direction on a level grade and is located in a three-degree curve.

In the curve, the 115-pound jointed rail was installed new in 1978, manufactured by Algoma Steel. There were approximately 3 000 No. 1 grade mixed softwood and hardwood ties per mile. The tie plates were double-shouldered, with four spikes per tie plate. The rail was box-anchored every second tie. High spikes were observed in the curve. The rail surface was dry. A stationary rail lubricator at Mile 63.5 was out of order. ONR's Hi-rail lubricator truck had not operated over this territory for approximately three weeks.

A cluster of 14 adjacent track ties located approximately 12 feet north of the point of derailment was severely deteriorated[2]. Tie plate wear marks and elongated spike holes enabled an approximation of the pre-derailment track gauge. Static gauge, measured by reassembling these 14 ties, indicated that excessive gauge widening began at the rail joint on the east rail approximately 25 feet north of the point of derailment. The largest measurement was 57 7/8 inches, 1 3/8 inches wider than the standard gauge of 56 1/2 inches. Maximum allowable speed in accordance with Canadian National's (CN) Standard Practice Circular[3] (SPC) 3101 for a track gauge condition of 57 7/8 inches is 15 mph. The damaged condition of the 7 remaining ties between the point of derailment and the 14 recovered ties was such that the gauge could not be measured. However, the remaining fragments showed that they had been in an advanced state of deterioration. Gouge marks from a wheel tread were evident on the gauge side of the west rail coincident with the location where tie destruction began. There were heavy impact marks on the gauge side joint bar. One fractured joint bar was located on the west rail at the point of derailment. At a joint located approximately 21 feet north of the point of derailment on the east rail, one of the joint bars was fractured and the other was cracked.[4] All three joint bars were manufactured in 1956 (44 years before the derailment). It is not known when they were placed in service. There is no specified service life for joint bars.

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2 TSB Engineering Branch report LP 032/00 depicting cross-sections of 10 of these ties is available upon request from the Transportation Safety Board of Canada.

3 ONR had adopted CN's engineering standard practice circulars.

4 TSB Engineering Branch report LP 032/00 containing metallurgical analysis of the joint bars is available upon request from the Transportation Safety Board of Canada.

One gauge rod[5] was recovered from the derailment debris. Track maintenance staff indicated that two gauge rods were installed in May or June 1999 in the vicinity of the derailment because the track gauge was widening. There was no record of the location where these rods were installed. The investigation determined that gauge rods were frequently used on ONR main track to effect repairs. There are no published standards or guidelines respecting the use of gauge rods. However, general track maintenance principles dictate that gauge rods should not be used on main track except under emergency circumstances and then only for the shortest possible duration. Once a gauge rod is tensioned to correct gauge, the track structure relies on each individual rod (of which there were only two) to withstand the lateral forces imposed at the rail/wheel interface. Once the gauge rod(s) can no longer withstand the lateral forces, loss of gauge occurs.

Track Inspection and Maintenance

Training and Qualifications

Since the 1970s, ONR has been formally training track supervisors, extra gang foremen, track maintenance foremen, and track maintainers, originally through an in-house development program but more recently through railway training consultants. A qualified track maintainer must have completed on-the-job training and formal classroom training before completion of two years of service. To qualify as a relieving track maintenance foreman, the employee must have completed the track maintainers' course and be qualified in Canadian Rail Operating Rules (CROR). In order to qualify as a permanent foreman, the employee must have successfully completed formal foremen's training within one year. Foremen refresher courses are offered occasionally; for example, track maintenance foremen who received training before 1993 were given a refresher course in 1997. To qualify as a track supervisor, the employee must have completed the track foremen's course and have a minimum of five years' track experience. A large turnover of track supervisors in 1990 prompted an in-house training program for potential new track supervisors. In 1996, all incumbent track supervisors received a refresher supervisors' training course.

All employees who had completed track foremen's training were considered to be qualified track inspectors.

Personnel

The track maintenance workforce between North Bay and Temagami decreased from 33 in 1988 to 14 in 2000. That decrease was primarily due to the mechanization of track work. The number of experienced, qualified track supervisors and foremen also decreased considerably since 1996, and was related to a high number of retirements. The Temagami Subdivision was experiencing a particularly high level of turnover in part because of the difficulty in attracting employees to relocate to this isolated area on a permanent basis.

The assigned workforce between Mile 42 and Mile 76 (Temagami section) consisted of one track supervisor, one foreman, two track maintainers and one truck driver. Normally, the track supervisor performed the track inspections. In the absence of a track supervisor, the track inspections were performed by various track foremen or track maintainers. On this section of track, the assigned responsibility for track inspection changed 11 times

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[5] Gauge rods are used to temporarily assist in preventing the widening of track gauge and are installed between the rails at the base of each rail. Under normal conditions, it is expected that track ties and fasteners will maintain gauge without the assistance of gauge rods.

during the 15-month period from January 1999 to March 2000. The regularly assigned track supervisor was absent from this territory for approximately 50 per cent of the time during this period, having successfully bid to work on work gangs. During his absence, his track inspection duties were assigned to three relieving track supervisors (one of whom was not trained as a track supervisor). During the same 15-month period, the responsibility for track maintenance in this section of track also changed 11 times. The assigned foreman who was responsible for maintenance was present for approximately 1.5 months. Just under eight months were covered by trained foremen; the remaining time was covered by track maintainers who had not completed the track foremen's training course.

Track Inspections

The track was inspected on 14 March 2000, the day of the derailment, at about 1000, by a track maintenance foreman travelling in a Hi-rail vehicle. No deficiencies were noted. The Temagami Subdivision main track is normally visually inspected three times per week, which exceeds the requirements of Transport Canada's (TC) *Track Safety Rules* (TSR). The TSR require that the track be inspected twice weekly with at least two calendar days between inspections.

The most recent track geometry test run before the occurrence was on 10 November 1999. The results indicated that there was a 3/4-inch wide gauge in the vicinity of the point of derailment at Mile 63.4. An earlier track geometry test run on 15 June 1999 showed a wide gauge of 11/16 inch. The gauge condition known to exist at the derailment location did not require the application of a temporary slow order, and the railway did not apply one. Test runs dated 12 May 1998 and 05 October 1998 did not detect any wide gauge beyond the set threshold of 1/2 inch.

Rail flaw detector equipment tested the rail on 23 November 1999 and noted no defects in the area of the derailment.

ONR had an annual tie inspection program that required visual inspection of ties. Pressure-treated ties may appear to be sound, but it is difficult to assess the condition of the tie beneath the surface.

Before the derailment, ONR had scheduled a gauge restraint measurement test for April 2000 to verify the integrity of its main track. The gauge restraint measurement system (GRMS) measures track strength by applying non-destructive vertical and lateral loads. GRMS's have been under development for a number of years and have proven to be an effective way to determine track strength and tie condition. The gauge restraint measurement test was conducted shortly after the derailment. ONR used the test results to identify critical weak sections of track and has since taken corrective action to replace defective ties where required. ONR also plans to use the results to assist in planning future tie programs. Currently, there are no set standards or criteria regarding the use and interpretation of the test results.

Certain conditions, such as the existence of small fatigue cracks in joint bars, cannot be detected through any of the current industry methods of inspection.

Track Tie Programs

In the early 1980s, ONR based its tie renewals on a five-year cycle. Tie programs between 1991 and 1993 were deferred or cancelled. In recent years, only priority areas throughout the system were addressed, thus deviating from the original cycles. In 1995, 16 600 ties were installed on the Temagami Subdivision between Mile 82 and Mile 138. In 1999, 19 000 No. 1 softwood and hardwood ties were scheduled to be replaced. Due to a supply shortage, only 8 000 new ties were installed. For the year 2000, the remaining 11 000 track ties left over from the 1999 program and some spot renewal were scheduled for installation between Mile 82 and Mile 138. In addition, 14 500 ties were scheduled for installation between North Bay, Mile 0.0, and Mile 82.

The track through the curve at Mile 63.4 was undercut in 1998. In the process of undercutting, fouled ballast is removed from underneath the track while the track is suspended and the fouled ballast is replaced with clean ballast. The track is then resurfaced and realigned. During this process, only the ties which dropped off under their own weight were replaced. No further assessment of the ties was performed.

Track Strength—Simulation Analysis

The TSB engaged the services of Rail Sciences Inc. (RSI) of Atlanta, Georgia, U.S., to determine the lateral forces that may have been imposed on the rails at the point of derailment. RSI performed a simulation analysis, using the Association of American Railroads (AAR) NUCARS simulation program. The simulation model was based on a loaded 44-foot tank car similar to the tank cars involved in the derailment. Actual track and equipment data were incorporated into the model to the extent possible. TSB investigators reviewed the methodology of the simulation, and although it was necessary for RSI to make a number of assumptions, the TSB considers the conclusions of the simulation valid.

Various combinations of mechanical and track conditions were simulated. Three cases were reported:

- a nominal case, with typical operating conditions,
- a probable case, with worn components, and
- a worst case, with negative conditions beyond the scope of possibility at this site.

RSI concluded from the simulation results that even the worst case[6] equipment conditions would not be causative for this derailment. Track of nominal strength would be able to resist the additional lateral loads caused by such equipment. The dynamic analysis concluded the following:

- NUCARS simulation results show a 10 000-pound lateral load on the high rail, assuming worst case mechanical conditions, and a 5 000-pound lateral load, assuming moderate mechanical conditions. While it was not possible to measure the actual strength of the track in the three-degree curve, RSI has measured load capacities on other track structures in nominal condition. Those measurements indicate that these forces are insufficient to widen the gauge on track in nominal condition.

- The derailment was caused by track structure too weak to resist nominally acceptable lateral wheel loads.

- A lack of lubrication in the vicinity of the derailment increased lateral forces on the rail.

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6 "Worst case scenario"—The bolster of the truck was stiffened and the side bearings were given high friction contact to produce a high turning moment. The wedge dampening forces were reduced to allow the truck to warp and the gauge corner of the high rail was given a low coefficient of friction, while the low rail was kept dry.

TSB Engineering

The TSB Engineering Branch analysed the joint bar fractures and made a qualitative assessment of the tie condition at the point of derailment.[7] The following conclusions were made:

- The fracture toughness of the subject joint bars was approximately one third that of a new comparison joint bar.
- The fractures and cracks observed in the subject joint bars initiated as a result of pre-existing fatigue cracking.
- Of the 10 ties sectioned for analysis, 2 showed sound material in the tie plate area, and the remainder were severely weakened due to splitting and dry rot.

Weather

At the time of the derailment, the weather was one degree Celsius with snow flurries.

Emergency Response

Immediately following the derailment, the train crew contacted the rail traffic control centre. The rail traffic control centre then initiated its procedures for the handling of emergencies concerning dangerous goods. By 1615, the appropriate personnel at ONR had been contacted, and the ONR emergency plan was initiated.

ONR immediately notified the first responders, provincial and federal government agencies, and the consignee of the dangerous goods shipment. Emergency Response Forms were in the possession of the conductor and were available to the first responders. The first priority for ONR, all through the post-accident activities, was to ensure safety and mitigate the effects of the

[7] TSB Engineering Branch report LP 032/00 is available upon request from the Transportation Safety Board of Canada.

sulphuric acid spill. Emergency response teams from Noranda Inc. and Falconbridge Inc., the shippers of the sulphuric acid, responded in accordance with established emergency response plans.

ONR established its command post at the Temagami town hall, approximately 15 km from the derailment site. At the derailment site, a security perimeter was established around the derailed equipment including the area that was contaminated by the spilled sulphuric acid. Entry to the site was controlled by security personnel at the highway entrance located approximately 6 km from the site. Access to the site was controlled by ONR officials.

Because of the site access constraints, containment of the spill began early on 15 March 2000. An extensive spill monitoring program was implemented at the site and at various locations downstream.

To assist in dealing with the spilled sulphuric acid, ONR procured the services of several outside companies, including consultants, coordinators and environmental clean-up and remediation specialists. In addition, consulting services were retained for all aspects of civil engineering, including track stability. The waterway adjacent to the railway track, approximately one mile downstream, was dammed and a syphoning system was installed to keep the sulphuric acid from entering Hornet Lake. Provincial authorities instructed local residents to refrain from using lake water or well water until the contamination was neutralized. ONR placed crushed limestone in areas where spilled product collected, to contain and neutralize the spilled product. The remaining product from the derailed cars was transferred to other rail cars during the following several days. The neutralization of the sulphuric acid which entered the waterways was completed by the end of July 2000. Limestone, soda ash and caustic soda were used to neutralize the sulphuric acid.

ONR had conducted regular emergency response training, participated in the region's emergency drills, and had initiated contact with various community emergency responders to discuss the transportation of dangerous goods.

Sulphuric Acid

Sulphuric acid is the fourth most commonly carried dangerous good in North America. Only petroleum gas, caustic soda and molten sulphur are transported in larger carload numbers.

Sulphuric acid is a colourless to amber-coloured viscous liquid usually shipped in a concentration of about 93 per cent to 98 per cent. The specific gravity of the acid is about 1.84 at 15 degrees Celsius, nearly twice that of water. The maximum permitted concentration of sulphuric acid as a mist is 1 mg/m^3 of air. Sulphuric acid is considered to pose a serious health hazard from any bodily contact with the liquid or by inhalation of mist. Upon contact, it is extremely irritating, corrosive, and toxic to tissue, resulting in rapid destruction of the tissue and causing severe burns. If much of the skin is in contact, it is accompanied by shock, collapse, and symptoms similar to those seen in severe burns.

Sulphuric acid is classified for transport as a “corrosive” and shipped under identification number UN 1830. Primary bulk distribution of sulphuric acid from the point of manufacture is by rail. When transported by rail, it is usually loaded in bulk into specification 111A100W2 tank cars.

Although some of the sulphuric acid had mixed with water, quantities of it flowed along the waterway and settled in deeper pockets of the lake. This settlement enabled environmental experts to continually monitor both its mass and strength, as well as limit the environmental impact.

Specification 111 Tank Cars

Specification 111 tank cars are intended for transportation of materials which are, under normal conditions, liquid. The vapour space of the car is at atmospheric or slightly elevated pressure only. Most of the specification 111 tank car fleet in North America is built for general service, meaning that the tank cars may be loaded with a wide variety of dangerous goods or non-dangerous goods. Data from 1999 indicated that approximately 189 000 specification 111 tank cars were in service in North America. Data from 1993 indicated that about 64 000 tank cars were in dangerous goods service. Based on data collected between 1965 and 1986, the AAR concluded that the failure of top fittings is the primary cause of accidental releases of dangerous goods.

In order to transport sulphuric acid, purpose-built tank cars are used because of the high density of the product. A typical tank car for sulphuric acid service is about 45 feet long, with an empty weight of about 27 tons. The volume of the tank is typically about 50 000 litres which translates into a fully loaded weight of about 130 tons. Specification 111 tank cars for transportation of sulphuric acid are not permitted to have bottom outlet valves unless they are being transported as a unit train which consists of cars of sulphuric acid only. Cars with bottom unloading valves are equipped with skid plates to prevent shearing off in case of an accident. Alternatively, bottom outlet valves may be recessed into the tank. However, on tank cars such as those involved in this derailment, top fittings have no protection against shearing off in a rollover.

The typical arrangement of the upper part of a sulphuric acid tank car includes a fill hole which is usually about eight inches in diameter, a discharge outlet which is about two inches in diameter, an air connection and valve which is usually one inch in diameter and contains a rupture disc assembly. The rupture disc covers the opening in the safety vent. The safety vent is a device designed to relieve excess pressure from the inside of the tank but does not close after it is ruptured. Although many general service specification 111 tank cars have safety valves that close after excessive pressure is released, tank cars in sulphuric acid service have rupture discs instead. The use of rupture discs is preferable to safety valves where the assembly is exposed to corrosive products such as acid. A typical arrangement of the appurtenances on the top of a sulphuric acid tank car is depicted in Figure 3. It should be noted that there was no top fitting protection on any of the tank cars involved. Figure 4 shows the tank with top fittings sheared off. Tank cars leased by Noranda Inc. are equipped with hydro-damps to reduce the risk of rupture disc failure by reducing the sloshing of the liquid acid.


UTLX

Any tank car used for the transportation of dangerous goods by rail in Canada must comply with the Canadian General Standards Board (CGSB) standards. Amongst these standards is a requirement that certain cars be equipped with protective housings.[8] TC does not consider these requirements to be applicable to specification 111A tank cars used to transport sulphuric acid, including the cars involved in this derailment, because these cars do not typically have valves or fittings. In any event, these protective housing requirements are aimed at preventing vandalism of the cars equipped with valves or fittings to permit the loading and unloading of the contents and not at providing rollover protection.

The thickness of the protective housing for top fittings on specification 111 tank cars is prescribed to be a minimum of 1/8 inch. All pressurized cars built to specifications 105 or 112 require a minimum wall thickness of 3/4 inch and a minimum top thickness of 1/4 inch for protective housing.

TSB data indicate that over 60 per cent of all types of post-accident product releases from specification 111 tank cars were from damaged top fittings. The following investigations identified the need for additional rollover protection to mitigate the risks of future dangerous goods spills:

- TSB report R92D0111—Sixteen cars derailed at Mile 30.4 of the Kingston Subdivision in Les Cèdres, Quebec. Five of the cars contained liquefied petroleum gas. One of the cars sustained impact forces which damaged a vapour valve and caused a loss of product. TC advised the Board that it was addressing the issue of valve protection through direct input to the AAR Tank Car Committee. The Board report noted that:

  > Transport Canada is pursuing the issue of the protection of tank car valves through direct input with the Association of American Railroads Tank Car Committee and has initiated research into reducing the negative consequences of dangerous goods releases. It is also promoting advances in containment integrity, including improvements in tank car designs.

  In 1994, TC referred to the above-noted report advising the Board that:

  > . . . the Department has initiated work directed to reducing the negative consequences of dangerous goods accidents. Our efforts are, therefore, focussed primarily on preventing releases such as better tank car designs and not, as your report states, on reducing the negative consequences of dangerous goods releases.

- TSB report R94C0137—Six specification 111 tank cars containing methanol derailed at Mile 108.05 of the Taber Subdivision in the city of Lethbridge, Alberta. Four of the cars lost approximately 230 700 litres of product and caused the evacuation of a 20-square-block area of the city. There were no injuries.
  The Board was concerned that carriage of certain dangerous goods in minimum standard specification 111 tank cars might be putting persons and the immediate environment at risk in the event of an accident. The Board believed that these risks could be mitigated by reducing the

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8 CAN/CGSB-43.147-97 entitled "Construction and Maintenance of Tank Car Tanks and Selection and Use of Tank Car Tanks, Portable Tanks and Rail Cars for the Transportation of Dangerous Goods by Rail" was made mandatory in 1998.

probability of product release through design improvements to protect the cars, especially the top fittings, and/or by limiting the type of products that can be carried. As a result, the Board made recommendation R96-13:

> 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.

In February 1997, TC advised that it was prohibiting the movement, in specification 111 tank cars, of chemicals that satisfy the condition of packing Group I of Class 6 (poisonous substances) of the *Transportation of Dangerous Goods Regulations*. TC also advised that it was examining, on an ongoing basis, thousands of other dangerous goods that are transported to categorize them with respect to adverse characteristics and to update the list of products prohibited from being transported in specification 111 tank cars. Shipment of sulphuric acid was not restricted.

- TSB report R95D0016—Twenty-eight specification 111 tank cars loaded with sulphuric acid derailed at Mile 82.2 of the La Tuque Subdivision near Gouin, Quebec. Approximately 230 000 litres of sulphuric acid was released causing environmental damage, and all but one car released the product as a result of damaged top fittings.

Environmental Issues

ONR operates through Crown land called the Temagami Comprehensive Planning Area. The Ontario government established four land-use zones in this area: protected areas, special management areas, integrated management areas, and developed areas. In addition, the area contains seven provincial parks. The derailment occurred in the Jumping Caribou Lake Integrated Management Zone.

Representatives of the Ministry of Natural Resources (MNR) of Ontario were present at the derailment site, acting as a resource for ONR and its environmental consultants for immediate tactical and strategic information to be used in the containment phase, such as water flows and tributaries, and impact of the spill on users of the lake and species in the lake. The MNR also monitors all short- and long-term activities in occurrences like this for compliance with its legislation and policy. No exceptions were noted.

The MNR, the federal Department of Fisheries and Oceans and ONR are working on a post-impact assessment and remediation plan.

The Ontario Ministry of the Environment, through its Operations Division, is responsible for administering the ministry's approvals and licensing programs as well as for an investigative and enforcement program to ensure compliance with environmental laws. The Investigations and Enforcement Branch is responsible for all aspects of environmental enforcement within the ministry. The ministry's primary role in the event of a spill is to ensure that whoever is responsible for the spill contains it and cleans up the site in accordance with ministry guidelines.

Representatives of the Ministry of the Environment were present at the occurrence site, monitoring containment and clean-up activities, assessing the adverse effects of the spill, and discussing any concerns with ONR and its environmental consultants. The Ministry of the Environment will continue to monitor the site clean-up. No exceptions were noted.

Environment Canada emergency officers were present during the initial stages of the emergency response to the derailment. Their role was to monitor and provide advice on environmental issues, particularly as they related to fish habitat protection and pollution prevention under the *Fisheries Act*.

Approximately one month after the derailment, an estimated 230 000 m^3 of water at the bottom of Hornet Lake had a pH[9] of 2.5. The acid-neutralizing treatment called for pumping the water from the bottom of the lake, adding a slurry of lime (calcium hydroxide) and discharging the treated water back down to the bottom of the lake. The treatment produces calcium sulphate (gypsum), a naturally occurring mineral that is present throughout southern Ontario. An estimated 40 days of 24-hour-a-day treatment was required to fully neutralize the water. Water downstream was not affected by the spill.

A preliminary survey of aquatic biota[10] was taken between 04 April and 07 April 2000 to document the immediate and short-term effects of the sulphuric acid discharge. The results indicated partial mortality of benthos[11] and fish in the immediate vicinity of the derailment site (Martin Creek), a similar but smaller effect at Hornet Lake, and no evidence of biological impact downstream of Hornet Lake.

Overall assessment by environmental officials was that the containment of the dangerous good and the control of the clean-up of the derailment site were accomplished in a satisfactory manner, considering the magnitude of the spill, the chemical involved, and the location of the derailment. The method of water treatment selected by ONR is considered by Energy, Mines, and Resources Canada to be the best available technology. The MNR and the Ministry of the Environment have reviewed the program.

Ontario Northland Transportation Commission

ONR is operated by the Ontario Northland Transportation Commission (ONTC). The ONTC is a Schedule II agency of the Province of Ontario, which is a development agency that promotes sustainable economic growth

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9 pH is a measure of acidity/alkalinity with a scale ranging from 0 to 14, with 7 representing neutrality, numbers less than 7 representing increasing acidity and those greater than 7, increasing alkalinity.

10 The flora and fauna of a region.

11 Organisms that live on or in the bottom of a body of water.

in Northern Ontario. The ONTC develops and operates transportation and communication links across the area, and delivers services, including those mandated by the province. Headquartered in North Bay, the ONTC has approximately 1 060 full-time staff.

ONR provides freight transportation on a 700-mile railway system in north-eastern Ontario and north-western Quebec. ONR also operates passenger trains between Toronto and Moosonee, Ontario. The rail shops in North Bay perform a variety of contract work for external customers, including rolling stock rebuilds, repairs and overhauls.

ONR is governed by the *Ontario Northland Transportation Commission Act*, R.S.O. (1990), Chapter 0.32. The ONTC reports to the Ministry of Northern Development and Mines of Ontario. The *Ontario Northland Transportation Commission Act* provides wide-ranging powers to the ONTC over all aspects of ONR operation.

The ONTC is required, under the *Ontario Northland Transportation Commission Act*, to submit an annual report to the Lieutenant Governor in Council and to present the report before the Ontario legislative assembly. The report includes the report of the Provincial Auditor, the operations of the ONTC for the fiscal year, and any information deemed to be of public interest by the ONTC or as required by the Lieutenant Governor in Council.

The *Ontario Northland Transportation Commission Act* does not prescribe specific safety regulations. The premise by ONR management is that the safety of operations should be either as prescribed by federal regulations, or else at a higher level. As such, the following safety criteria were adopted by ONR:

- Track Standards and Specifications: ONR uses CN's Manual of Standard Practice Circulars and Recommended Practices, and TC's TSR as a basis for its track maintenance procedures.

- General Operating Instructions: The General Operating Instructions used by ONR are comparable to those used by CN and Canadian Pacific Railway (CPR), the two major railways in Canada. ONR has adopted and operates in accordance with the CROR and abides by the regulations governing the transportation of dangerous goods which is regulated by TC.

- Equipment and Mechanical: ONR complies with TC's *Railway Freight Car Minimum Inspection and Safety Standards* and is certified by the AAR to perform maintenance and repair work for railway companies in Canada and the United States.

- Assessment Protocol: ONR reviews the Canadian Rail Carrier Assessment Protocol every two years and supplies copies to its sulphuric acid shippers. ONR also meets with its shippers on a regular basis to review the assessment protocol. ONR's last use of the Canadian Rail Carrier Assessment Protocol before the occurrence was in June 1999. The Canadian Chemical Producers' Association (CCPA) represents 75 chemical manufacturing industries with over 200 plants in British Columbia, Alberta, Ontario and Quebec, which collectively produce more than 90 per cent of all chemicals in Canada. The CCPA is also the driving force behind the Responsible Care initiative, a global effort aimed at addressing public concerns about the manufacture, distribution, use and disposal of chemicals. The Canadian Rail Carrier Assessment Protocol is a cooperative effort by the CCPA and the Railway Association of Canada to assist shippers and carriers to evaluate and improve the safety of shipping chemicals by rail. The Canadian Rail Carrier Assessment Protocol is divided into nine sections: general information; administration/management; safety, health and environmental protection; compliance with policy in census metropolitan areas; rail operations; incident and accident reporting; mechanical and engineering; quality; financial and security.

Analysis

A wide gauge condition identified by railway track inspection programs was allowed to remain with temporary repairs for about 10 months. Temporary measures implemented to hold the track gauge from spreading (installation of the gauge rods) masked the gauge condition and the continuing deterioration of the track structure. Significant amounts of sulphuric acid were released from cars of a type which the TSB had previously identified as inadequate for the safe transportation of dangerous goods such as sulphuric acid. The analysis will focus on track condition, inspection and maintenance practices, specification 111 tank cars as a means of shipping sulphuric acid, and organizational and management factors.

Track

Gauge Widening

Gauge widening was identified as a problem in this area, as witnessed by the installation of the gauge rods in the summer of 1999. The use of gauge rods was intended as a temporary measure, as it was expected that a scheduled gauging crew would correct the problem at that location later that summer. However, no such work was performed, and in the absence of a formal plan, no other remedial measures, such as slow orders, additional inspections or spot tie change-outs, were taken.

Shortly after the gauge rods were installed, a track geometry car tested this area. When the results were analysed, no excessive wide gauge was recorded. This created a false impression that the track gauge condition was adequate. However, as the ties continued to deteriorate over the following nine months, the load on the gauge rods increased, and the overall strength of the track diminished. This condition was not recognized. Eventually, the imposed lateral loads on the gauge rods exceeded their strength capabilities and the track gauge could not be maintained.

The general acceptance by the railway that track maintenance personnel will understand the limitations inherent in the use of gauge rods in the absence of formal standard practices for their use indicates the need for a review of this issue.

Tie Inspection Program

The visual inspection of ties does not provide an accurate assessment of tie strength or internal condition. An undetected overall weakening of the track structure may occur if a number of consecutive weak ties develop. Deteriorated ties in the general area of the derailment may have resulted in excessive flexure of the joint bars, accelerating their failure.

Follow-up Inspections

Follow-up inspections of the track did not identify the significantly deteriorated tie conditions, a potential fracture in the field side joint bar on the east rail, and the excessive movement of the tie plates.

Track Strength

Recent advances in technology, such as GRMS testing equipment, have made the measurement of overall track strength possible. Future use of track strength testing would provide an additional opportunity for the identification of track defects and the mitigation of related risks.

A track of nominal strength should be able to resist an average lateral load of 16 000 pounds. The simulation conducted by RSI using, to the extent possible, actual track and equipment data, shows that the worst case mechanical condition of rolling stock would generate an estimated lateral force of 10 000 pounds, and in a moderate mechanical condition, a lateral force of 5 000 pounds. Both scenarios suggest that the lateral forces applied would be well below normal operating design loads. Therefore, it can be concluded that, in order for the dynamic lateral loading to have caused the gauge widening, the track strength would have had to have been below a nominal level.

A recent undercutting program was performed in this area (in 1998), which included the replacement of some of the ties which fell off when the rails were raised. The spring and fall geometry car test results showed that the track gauge was within acceptable limits; however, the track gauge was actually being maintained by the gauge rods and early repairs to this weakened area were not made.

Railway Emergency Plan

Spill containment was begun as soon as practicable, in light of site access constraints. ONR's emergency plan was effectively implemented, and ONR's actions indicated that it placed a priority on the safety of people and limiting damage to the environment.

Specification 111 Tank Cars

The derailment again raised the issue of protection afforded to the top fittings on sulphuric acid cars as well as all specification 111 tank cars. In this occurrence, the failure of the top fittings accounted for about 80 per cent of the spilt sulphuric acid. The acid which leaked into the creek and eventually reached and contaminated Hornet Lake came from the cars which had top fitting damage only. The top fitting failure led to the contamination of the watercourse and lake. Improved protection would have reduced the probability of product loss and its impact on the environment. In the past, the failures of unprotected protrusions on specification 111 tank cars have led to accidental losses of sulphuric acid as well as other dangerous goods.

At the time of this occurrence, there were no requirements that specification 111 tank cars carrying sulphuric acid be equipped with top fitting protection to minimize the risk of product loss during rollover.

Organizational and Management Factors

The rapid turnover of personnel had an impact on the exchange of information regarding the status of the known wide gauge problem and any required corrective action. This may have reduced the perceived urgency and severity of the deteriorating track condition, and allowed the developing deficiencies to be left unattended. Communications and record keeping would have had to be exceptional during such frequent turnovers in order to keep the status clear.

For a significant percentage of the 15-month period before the occurrence, the Temagami section of track was inspected and maintained by personnel who had not been provided with the appropriate training for their positions. Through the remaining portion of the time when qualified personnel inspected the track and recognized the defects, they initiated a temporary repair at the accident site.

The rapid turnover of personnel increased the risk that continuity in monitoring the track condition would be lost. The use of less than fully trained supervisors and track inspectors increased the risk that deteriorating track conditions would not be noticed.

ONR has a defined policy on safety, as indicated by the criteria adopted in its procedures and standards. However, there was no independent review or audit process designed to identify existing or potential safety deficiencies. Improvements in ONR's quality assurance practices for track inspection and maintenance would likely improve the effectiveness of these programs and may prevent a recurrence of this type of accident.

Findings

Findings as to Causes and Contributing Factors

1. The deteriorated track ties, combined with the cracked and broken joint bars, resulted in a weakened track structure which could no longer support the applied stresses of rail traffic.
2. The use of a temporary measure (gauge rods) for an extended period of time masked deteriorating track conditions.

3. The rapid turnover of track maintenance personnel resulted in a loss of continuity in monitoring of track conditions, and the use of less than fully trained supervisors and track inspectors created a situation where deteriorating track conditions would not be noticed.

4. ONR's quality assurance practices for track inspection and maintenance did not lead to the necessary corrective measures to ensure that the previously identified weakened track at the derailment location was repaired.

5. The failure of the top fitting on specification 111 tank cars caused sulphuric acid to leak, resulting in environmental impact.

Findings as to Risk

1. Postponement of needed maintenance (tie installation and gauge correction), without the implementation of a temporary slow order to reduce the lateral forces applied to the track in the derailment area, increased the risk of derailment.

2. The industry-wide practice of visually inspecting ties cannot adequately assess individual tie strength.

3. The inability of the current industry methods of inspection to detect small fatigue cracks in joint bars increases the vulnerability of the track structure at joint locations.

4. In the absence of formal track standards for the use of gauge rods, track maintenance personnel are expected to limit the use of these devices based upon their knowledge and understanding of generally accepted track maintenance principles.

5. The absence of a standard requiring that specification 111 tank cars used in the transportation of sulphuric acid be equipped with top fitting protection designed to minimize loss of product during rollover presents a continuing risk to the public and the environment.

Other Findings

1. ONR's emergency plan was implemented in an effective and timely manner and minimized the effect of the spill on the environment.

Safety Action Taken

Following this occurrence, ONR has put forth the following initiatives to monitor and maintain the track structure:

- A gauge restraint measurement test was conducted shortly after the derailment. The gauge restraint measurement system (GRMS) measures track strength by applying non-destructive vertical and lateral loads. ONR used the test results to identify critical weak sections of track and has since taken corrective action to replace defective ties where required. A gauge restraint measurement test is scheduled for the fall of 2001 and ONR intends to perform such tests annually. Corrective actions to replace or repair defective track structure will be completed wherever weak conditions are found.

- Currently, ONR is completing training for track maintainers and track maintenance foremen. Track supervisor training will be provided to all existing supervisors and other personnel who may be required to work as relieving track supervisors. By December 2001, a formal procedure for certification of track supervisors and inspectors will be developed and implemented.

- The use of gauge rods is being reviewed and may result in the development of a standard.

- ONR has implemented two track inspection units which measure and detect wide gauge. These inspection units are being utilized on a regular schedule throughout the ONR rail system. A track geometry test car will continue to be used twice annually.

- In 2000, ONR installed 50 000 track ties which were concentrated on curves between North Bay and Temagami. The 2001 tie program consists of installing 100 000 track ties on the ONR rail system.

- The transient nature of the track maintenance workforce will be discussed with the unions in upcoming negotiations.

- A consultant engaged by ONR to review rail infrastructure and maintenance standards and practices reported that the overall condition of track, bridges and facilities compares favourably with any viable rail operation in North America, including that of Class 1 carriers.

An AAR Tank Car Committee Task Force (including a TC representative) was formed and it was agreed and subsequently adopted by the AAR that the specifications for fittings for acid cars be revised. The specifications will be applicable to all sulphuric acid cars, new and existing, and will provide requirements to be met to achieve an adequate level of top fitting protection. For example, safety vents and threaded assemblies that have proven to be vulnerable during the Temagami derailment will be prohibited. An implementation period of 10 years is proposed with the requirement that 50 per cent of existing cars be completed within five years. In addition, TC initiated a program to identify the most vulnerable cars in Canadian service and expedite modification to the new top fitting protection level.

Noranda Inc. has participated directly in the above task force and will comply fully with any new requirements recommended by the committee.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 19 July 2001.