Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

RAILWAY INVESTIGATION REPORT R16D0073

Misaligned switch and derailment

Canadian National Railway
Freight train M39421-11
Mile 93.22, Sherbrooke Subdivision
St. Lawrence & Atlantic Railroad
Acton Vale, Quebec
11 August 2016

Canada

Transportation Safety Board of Canada
Place du Centre
200 Promenade du Portage, 4th floor
Gatineau QC K1A 1K8
819-994-3741
1-800-387-3557
www.tsb.gc.ca
communications@bst-tsb.gc.ca

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Summary

On 11 August 2016 at approximately 2119 Eastern Daylight Time, Canadian National Railway Company freight train M39421-11 was travelling eastward on the Sherbrooke Subdivision of the St. Lawrence & Atlantic Railroad. At Acton Vale, Quebec, at Mile 93.22, the crew noticed that the switch was lined for the siding. The train's emergency brakes were applied, but the train was unable to stop before reaching the switch. It diverted into the siding and struck a derail, causing the derailment of the lead locomotive. The derail was destroyed and the track was slightly damaged. No one was injured.

Le présent rapport est également disponible en français.

Factual information

The accident

On 11 August 2016, Canadian National Railway Company (CN) freight train M39421-11 left Montréal, Quebec, and travelled eastward on CN tracks to Sainte-Rosalie, Quebec, where it entered the St. Lawrence & Atlantic Railroad (SLA) Sherbrooke Subdivision en route to Richmond, Quebec (Figure 1). The trip from Montréal was completed without incident. At 2119,[1] as the train was travelling at 23 mph and approaching the west turnout switch of the siding at Acton Vale, Quebec (turnout 272), the crew noticed that the switch was lined for the siding. The train's emergency brakes were applied 180 feet from turnout 272, but the train was unable to stop before the switch. The lead locomotive passed through turnout 272 at approximately 20 mph and entered the siding, where it struck a derail on the siding and derailed.

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

The train consisted of 3 locomotives, 62 loaded cars, and 17 empty cars. It weighed approximately 8200 tons and was 4700 feet long. The crew consisted of 1 locomotive engineer and 1 conductor, and they were accompanied by a trainee. The crew were familiar with the territory, met fitness and rest standards, and were fully qualified for their respective positions.

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1 All times are in Eastern Daylight Time (Coordinated Universal Time minus 4 hours).

After the train had stopped, the crew contacted the rail traffic controller to notify him that the train had diverted into the Acton Vale siding and that the lead locomotive had derailed. Inspection of the train found no other derailed cars. Three level crossings[2] in the town of Acton Vale were obstructed by the train for several hours.

The sky was clear, the temperature was 26 °C, and the sun had set at approximately 2000.

Site examination

The locomotive came to a stop on the siding track, about 330 feet east of the turnout 272 switch. The locomotive's leading truck had derailed to the south side of the track. A hinged derail locked in the derailing position was found beneath the locomotive. The derail was destroyed.

Figure 2. Red targets of switch 272 at Acton Vale

Turnout 272 led to the siding that runs alongside the main track. It had a hand-operated No. 12 switch designed for a maximum speed of 15 mph. The switch stand was positioned on the south side of the track. The switch was undamaged and lined for the siding (reverse position). It was fitted with a high-security lock, but the lock had not been put back through the locking eyelet. The lock was locked[3] and was hanging freely from a chain attached to the switch stand. The switch stand mast was fitted with a standard oblong red reflectorized target and a small red reflectorized target facing the track[4] (Figure 2). The surface of the targets was clean and in good condition. According to the video recording from the locomotive's forward-facing camera, the red targets were visible at a distance of approximately 1500 feet. Other light sources were present along the track.

To the west of turnout 272, the main track is tangent for approximately 2500 feet, running alongside a bicycle path and a walking path.

From the siding, the wye track and the Acton Vale quarry are accessible via turnout 273. Switch 273 was in the normal position and locked with a high-security lock.[5] A hinged derail was positioned on the track leading to the quarry (Figure 3).

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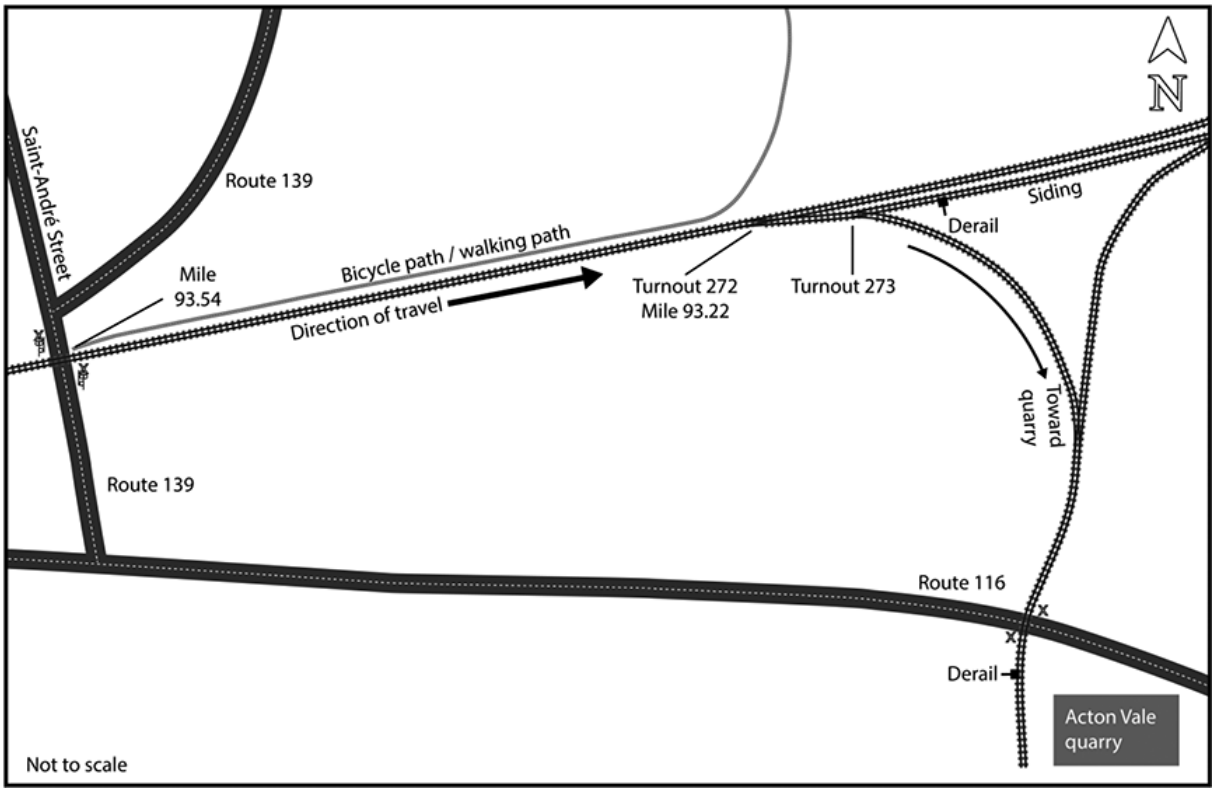
2 Level crossings on Saint-André, du Marché, and Dalpé streets.

3 The key of a high-security lock cannot be removed unless the lock is locked.

4 When a main-track switch is in the normal position, a small rectangular green target is visible, while in the reverse position, the red circular targets face approaching movements.

5 The use of high-security locks on non-main tracks is at the discretion of the railway company.

Figure 3. Diagram of tracks at Acton Vale



Subdivision information

The Sherbrooke Subdivision belongs to the SLA. It consists of a single main track that extends east to west from Island Pond, Vermont, at Mile 0.0, to Sainte-Rosalie, at Mile 110.3. Train movements are governed by the rules of the occupancy control system (OCS) authorized by the *Canadian Rail Operating Rules* (CROR) and supervised by a CN rail traffic controller stationed in Montréal.

Rail traffic in the sector consists of 1 CN freight train per day, 6 days a week, and 1 SLA switching train twice a week. It is extremely rare for these 2 trains to meet because their schedules do not overlap. The maximum authorized speed is 25 mph.

Particulars of the track

The main track consisted of 100-pound bolted rails manufactured by Dominion in 1948 and laid on 11-inch double-shouldered tie plates, fastened to each tie by 2 spikes. Every second tie was box-anchored, and the ballast consisted of crushed rock, 0.5 inches to 2 inches in diameter.

The siding consisted of 85-pound rails, manufactured in 1907. Each rail was laid directly on the ties and held in place by 2 or 3 spikes; there were no rail anchors.

Inspections had been conducted in accordance with the provisions of the *Rules Respecting Track Safety*. The most recent visual inspection of the track had been carried out on 09 August 2016 and had revealed no defects.

Equipment inspection

The train was marshalled at CN's Taschereau Yard in Montréal. Before departing, it underwent a mechanical inspection and a brake test. While en route, the train passed several wayside inspection systems.[6] None of these inspections detected any anomalies.

Track work

On the morning of the accident, maintenance work had begun on the main track using 2 machines[7] operated by a private contractor. The work was carried out under the supervision of SLA personnel, who were the sole persons authorized to operate switches and derails.

Work began to the west of turnout 272. The warning devices of the 3 level crossings located in central Acton Vale (Saint-André, du Marché, and Dalpé streets) had been disabled during the work to prevent unnecessary disruptions to road traffic. At approximately 1200, one of the machines broke. Because the machines work in tandem, both machines were moved to the Acton Vale quarry so that the broken machine could be repaired. The route leading to the quarry required the switches at turnouts 272 and 273 to be handled and the derail located at the entrance to the quarry to be placed in the non-derailing position.

Handling of switches 272 and 273

An SLA track foreman (the foreman) saw to the handling of the switches and the derail. The foreman had more than 40 years' experience and was familiar with the territory. He met fitness and rest standards and was qualified for the position.

The foreman arrived by pickup truck, which he parked beside the track, between turnouts 272 and 273. The foreman took the following steps to allow the machines to pass:

- The foreman unlocked the lock of switch 272 (main track), removed it from the locking eyelet, and left it hanging freely on the end of its chain.
- He walked to switch 273, unlocked it, and placed it in the reverse position.
- He returned to switch 272.
- After remembering that he could leave switch 272 in the reverse position without triggering the warning devices of the 3 level crossings, since they had been disabled beforehand, he placed switch 272 in the reverse position.
- He returned to wait for the machines to pass at switch 273.

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6 Wayside inspection systems include hot-box and dragging-equipment detectors, and some also have wheel impact load detectors.

7 A ballast regulator and a tamper.

- After the 2 machines had passed, the foreman restored switch 273 to the normal position and locked it.
- He returned to his truck and informed one of the machine operators that switch 272 had been restored to the normal position and locked.
- He recorded the information that switch 272 was in the normal position and locked.
- The foreman left by truck to remove the derail at the entry to the quarry.

Rule 104 of the Canadian Rail Operating Rules

The handling of switches on SLA territory is subject to Rule 104 of the CROR, which states the following:

> […]
>
> (h) Unless otherwise specified by special instructions, the normal position for a main track switch is for the main track route. Except as provided in paragraph (i), main-track switches must be left lined and locked in normal position.
>
> […]
>
> (o) Unless otherwise specified by special instructions, non-main track switches, when equipped with a lock, must be lined in normal position and locked after having been used.
>
> […]
>
> (q) The employee handling a main track hand operated switch in non-signalled territory must, from the location of the switch, communicate with another employee to confirm the position in which the switch has been left, lined and locked. The employee receiving this report must repeat it back to the employee who handled the switch. Communication may be achieved by personal contact, radio or telephone. […]

On the day of the accident, the train crew had not received any instructions informing them that the west turnout of the Acton Vale siding was in the reverse position.

Locomotive lighting equipment

The lead locomotive was equipped with a working lighting system consisting of 2 headlights and 2 ditch lights. Both sets of lights are angled vertically to strike the rails 800 feet ahead of the locomotive. Horizontally, the headlights are aligned with the centreline of the track, whereas the ditch lights are angled so as to cross the centreline at 400 feet.

Protection against switches in the reverse position

In accordance with standard railway operating practices in Canada, main-track switch targets are considered a visual reference that, in addition to indicating the switch's position, assist the train crew in pinpointing the exact location of a switch.

Unless the crew members have been formally notified that they may encounter a specific switch lined and locked in the reverse position, they are not required to adjust their train speed in order to stop short of switches that may be reversed.

There are technologies that can inform train crews of, or prevent trains from crossing, a switch left in the reverse position. A number of signalling and train control systems can provide another line of defence in addition to the CROR and individual railway company instructions.

Systems such as positive train control (PTC) or centralized traffic control (CTC) are designed to control track networks. Generally, these are reserved for passenger-train territories or for high–traffic density tracks. Other systems are more limited and therefore more suitable for secondary tracks or areas of low traffic density, such as the Sherbrooke Subdivision. Essentially, they allow switches and switch-position detectors to be controlled remotely.

Remote-controlled switches

Remote-controlled switches use a duotone multi-frequency communication system. With a radiotelephone keypad, a digital recording can confirm turnout locations and switch positions This system can be used to remotely control power-operated switches and reverse the switch position if necessary.

Switch-position detector

A duotone multi-frequency communication system can confirm turnout locations and the position of switches. This detector is used to determine the position of switches and can issue the information on demand through a talker message over the radio system (Figure 4).

Figure 4. Switch-position detector

Braking distance

For road vehicle drivers or locomotive engineers, reaction time consists of detecting, identifying, deciding on, and initiating an action. Studies of road vehicle drivers provide insights on their performance when visual stimuli require a reaction, such as for braking. For road vehicle sight and stopping distance calculations with respect to road signs and public level crossings, a minimum reaction time of 2.5 seconds is recommended.[8] The complexity of a situation and

[8] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, 2001, p. 110-111, available at

unexpected stimuli are known to cause significantly longer reaction times.[9]

Based on a reaction time of 5 seconds and the data from the locomotive's event recorder, the braking distance required to stop the train involved in the accident, starting from the detection of the switch target, was 700 feet.

Previous TSB investigations on switches left in the reverse position

R12Q0030 (Hegadorn) – On 09 August 2012, VIA Rail Canada Inc. passenger train P600-21-09 was proceeding southward at 24 mph on the CN Lac St-Jean Subdivision when it unexpectedly diverted into the siding at Hegadorn, Quebec, Mile 78.11. The north switch of the siding had been left in the reverse position by track maintenance employees. There was no derailment. A total of 59 passengers were on board, in addition to the train crew. No one was injured.

R00T0179 (Rockwood) – On 09 July 2000, VIA Rail Canada Inc. passenger train 683, travelling westward at 39 mph on the Goderich-Exeter Railway Guelph Subdivision, unintentionally diverted into the siding at Mile 41.37 in Rockwood, Ontario. The east switch of the siding had been left in the reverse position by employees carrying out work in the area. Upon entering the siding, the train collided with track machines. The collision resulted in the derailment of the locomotive and the following 2 coaches; however, all train equipment remained upright. Twelve passengers and 2 employees sustained minor injuries.

R99H0007 (Thamesville) – On 23 April 1999, VIA Rail Canada Inc. train 74, travelling eastward on the north main track of the CN Chatham Subdivision, at Thamesville, Ontario, encountered a reversed switch, crossed over to the south main track and derailed at Mile 46.7. The derailed train collided with stationary rail cars on an adjacent yard track. The 2 members of the train crew who were in the locomotive cab were fatally injured. Four people were admitted to hospital with serious injuries. Seventy-seven of the 186 passengers and crew on board were treated in hospital. Numerous others received first aid on site.

Statistics on switches left in the reverse position

The TSB's database contains 45 occurrences (including this occurrence) between 01 September 2007 and 31 August 2016 in which a train crew arrived at a switch left in the reverse position, in territory subject to OCS rules, without receiving advance notice. These occurrences represent 0.4% of railway occurrences reported to the TSB during this period. From 2007 to 2011, there were 29 occurrences of this type; from 2012 to 2016, there were 16.

Passenger trains were involved in 15% (7) of the 45 occurrences. In 3 of these 7, the trains were unable to stop before reaching the switch in the reverse position.

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http://nacto.org/docs/usdg/geometric_design_highways_and_streets_aashto.pdf (last accessed 26 May 2017).

[9] Ibid., pp. 50–52.

Freight trains were involved in 85% (38) of the 45 occurrences. In 16 of these 38, the trains were unable to stop before reaching the switch in the reverse position.

In this occurrence, and on one other occasion, the train derailed after diverting onto a non-main track and striking a derail.

Analysis

There were no equipment or track defects present that were considered contributing factors in this occurrence. This analysis will focus on human factors, procedures for the handling of main-track switches, defence mechanisms against switches left in the reverse position, and other technologies.

The accident

On the day of the accident, a foreman of the St. Lawrence & Atlantic Railroad (SLA) was to handle switches 272 and 273 and the derail of the track leading to the quarry in order to allow 2 maintenance machines to reach the quarry. Because the foreman mistakenly thought that switch 272 could trigger the level crossing protection system, he wanted to minimize the time that the switch would remain in the reverse position so as to reduce the inconvenience to motorists. The foreman therefore adopted a non-routine sequence of tasks.

After the machines had passed, the foreman restored the turnout 273 switch to the normal position and locked it, but did not do so for switch 272. The foreman was preoccupied with the next task, which was to place the derail of the track leading to the quarry in the non-derailing position in order to allow the machines to continue on their way to the quarry. After restoring switch 273 to the normal position and locking it, the foreman believed that the switch of the main track (272) had also been restored to the normal position and locked. Accordingly, he transmitted and wrote down this erroneous information before leaving the site, inadvertently leaving switch 272 in the reverse position.

As the train approached switch 272, the emergency brakes were not applied until approximately 200 feet from the switch. This distance was insufficient to stop the train before the misaligned switch and, consequently, the train diverted into the siding, where it struck a derail and derailed.

Switch target

The reflective surface of the target was clean and in good condition. According to the video recording from the locomotive's forward-facing camera, the target was visible from the last level crossing, at a distance of approximately 1500 feet. Given the presence of several light sources and the fact that it was dark, the red reflection of the target did not stand out from its surroundings and was not easily perceptible.

The emergency brakes were not applied until approximately 200 feet from the switch, which indicates that the attention of the train crew was not focused far ahead of the train. Based on an estimated reaction time of 5 to 6 seconds for a complex, unexpected situation, it can be deduced that the crew members were not able to perceive the switch in the reverse position until the train was approximately 400 feet away. This distance corresponds to the best-lit zone in front of the locomotive, where the locomotive's ditch lights cross the centreline of the track. The train crew was not looking far enough ahead of the train to perceive the target of switch 272 in time.

In spite of its weaknesses as a visual alert system, the switch target can nevertheless be considered an additional line of defence. However, its effectiveness is limited: the visual stimulus is static, so the target may not consistently attract the attention of train crews. In addition, in some situations, sightlines may be restricted by track configuration, weather conditions, or vegetation.

Since traffic density on the subdivision is low and it is extremely rare for the Canadian National Railway Company (CN) train and the SLA switching train to meet, the switches at Acton Vale are almost never used. The members of the train crew had received no instructions indicating that switch 272 was in the reverse position, so they did not expect it to be in that position and did not focus their attention on the target from a distance. If train crews receive no instructions indicating that a switch has been left in the reverse position, a train travelling at the authorized speed may not be able to stop before reaching a switch left in the reverse position, increasing the risk of derailment.

Rule 104 of the Canadian Rail Operating Rules

As this occurrence shows, qualified employees may sometimes inadvertently leave a switch in the reverse position. Rule 104 of the *Canadian Rail Operating Rules* (CROR) is the primary line of defence against leaving a hand-operated switch on main tracks in occupancy control system (OCS) territory in the reverse position. Rule 104 stipulates that, after handling a switch, the employee must, from the location of the switch, communicate with another employee to confirm the position in which the switch has been left and locked. In this instance, although he had not handled switch 272, the foreman reported to one of the machine operators that the switch was in the normal position and locked.

When the foreman left the site, he believed he had restored switch 272 to the normal position and locked it. The foreman recorded this information on the appropriate form after reporting it. He then went to remove the derail on the track leading to the quarry where the machines were to be parked. Inadvertent mistakes[10] can happen when employees are not paying close attention to a routine task.[11]

To be effective, an administrative rule requires the full attention of employees who are performing operations. In this case, the foreman was probably preoccupied by the next task, which was to remove the derail from the track leading to the quarry. The safety afforded by Rule 104 of the CROR depends on employees' absolute compliance with operating rules. If administrative defences such as Rule 104 of the CROR are not followed, additional defences become necessary to prevent increased risks.

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10 An inadvertent mistake is an unintentional action caused by inattention.

11 J. Reason, *Human Error* (Cambridge University Press, 1990), pp. 55–56.

Defences against switches left in the reverse position

In this occurrence, the defences in place did not adequately serve their purpose. This is also true of other accidents that the TSB has investigated, which demonstrates that current lines of defence are insufficient to reduce the risks of collision and derailment when switches are misaligned.

Although statistics show that the frequency of accidents involving a misaligned switch is relatively low and falling, the fact remains that the potential consequences can be serious, particularly for passenger trains or trains transporting dangerous goods. If other physical defences that can alert train crews to misaligned switches are not put in place, the risks of collision and derailment will remain higher than they need to be.

Although railway companies have various additional safety measures in place to help prevent accidents caused by misaligned switches, such as switch targets and Rule 104 of the CROR, none of these measures can protect trains in all situations. These safety measures do not provide constant protection against train accidents. Other safety measures that are relatively simple but proven to be reliable are available on the market and can indicate switch alignment to train crews. Some of these systems, such as switch-position detectors, offer an effective method of protection for movements approaching main-track hand-operated switches in OCS territory. If a control system such as OCS is unable to detect a switch left in the reverse position, the rail traffic controller cannot guarantee the movement's safety, which increases the risk of an accident.

Findings

Findings as to causes and contributing factors

1. Switch 272 was inadvertently left in the reverse position after the foreman handled it and left the site.

2. The emergency brakes were not applied at a distance sufficient to allow the train to stop before the misaligned switch and, consequently, the train diverted into the siding, where it struck a derail and derailed.

3. The train crew was not looking far enough ahead of the train to perceive the target of switch 272 in time.

Findings as to risk

1. If train crews receive no instructions indicating that a switch has been left in the reverse position, a train travelling at the authorized speed may not be able to stop before reaching a switch left in the reverse position, which increases the risk of derailment.

2. If administrative defences such as Rule 104 of the *Canadian Rail Operating Rules* are not followed, additional defences become necessary to prevent increased risks.

3. If other physical defences that can alert train crews to misaligned switches are not put in place, the risks of collision and derailment will remain higher than they need to be.

4. If a control system such as the occupancy control system is unable to detect a switch left in the reverse position, the rail traffic controller cannot guarantee the movement's safety, which increases the risk of an accident.

Safety action

Safety action taken

St. Lawrence & Atlantic Railroad

With all of its engineering employees, the company reviewed bulletin GWCI-01-E on the *Canadian Rail Operating Rules* (CROR) and the special instructions that apply when a main-track switch is handled. In addition, all engineering employees received refresher training and were re-qualified on the CROR.

This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 30 May 2017. It was officially released on 08 June 2017.

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