RAILWAY INVESTIGATION REPORT
R00M0007

COLLISION AND DERAILMENT

VIA RAIL CANADA INC.
PASSENGER TRAIN NO. 14
MILE 65.1, NEWCASTLE SUBDIVISION
MIRAMICHI, NEW BRUNSWICK
30 JANUARY 2000

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

Railway Investigation Report

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Synopsis

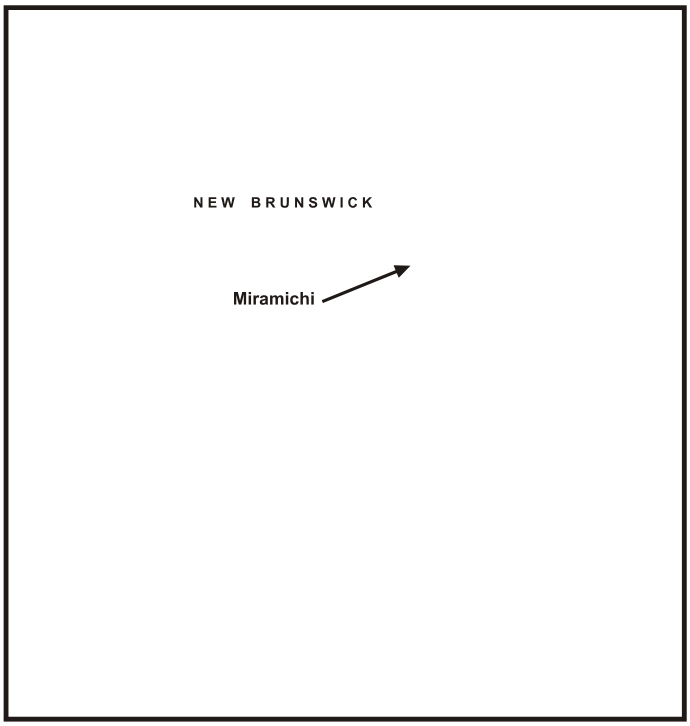
On 30 January 2000 at 1012 Atlantic standard time, VIA Rail Canada Inc. passenger train No. 14, proceeding eastward from Montréal, Quebec, to Halifax, Nova Scotia, at Mile 65.1 of the Newcastle Subdivision on the New Brunswick East Coast Railway, was diverted from the main track within the city of Miramichi, New Brunswick, by a crossover switch that was lined and locked in the reverse position. The train entered the adjacent yard track and, while proceeding at approximately 29 mph, collided with 11 stationary cars. Both locomotives and 7 of the 10 passenger cars derailed. There was no fire. A total of 127 people were on board. In total, 43 people were transported to a hospital in Miramichi. Six passengers, one on-train service crew member, and one emergency responder were admitted with serious injuries.

Ce rapport est également disponible en français.

1.0 Factual Information

1.1 The Accident

Eastward VIA Rail Canada Inc. (VIA) passenger train No. 14 (VIA 14) was carrying 113 passengers, 12 on-train service (OTS) employees, and 2 locomotive engineers. The train was travelling at about 70 mph as it approached the west cautionary limits[1] of the New Brunswick East Coast Railway (NBEC) Miramichi Yard at Mile 67.0 of the NBEC Newcastle Subdivision. One of the locomotive engineers initiated a radio broadcast message on channel 1, announcing the train's approach. The locomotive engineers received a radio message that all was clear in the yard from the NBEC 580 yard assignment crew, who were performing switching activities in the Miramichi Yard at the time (NBEC switch crew).

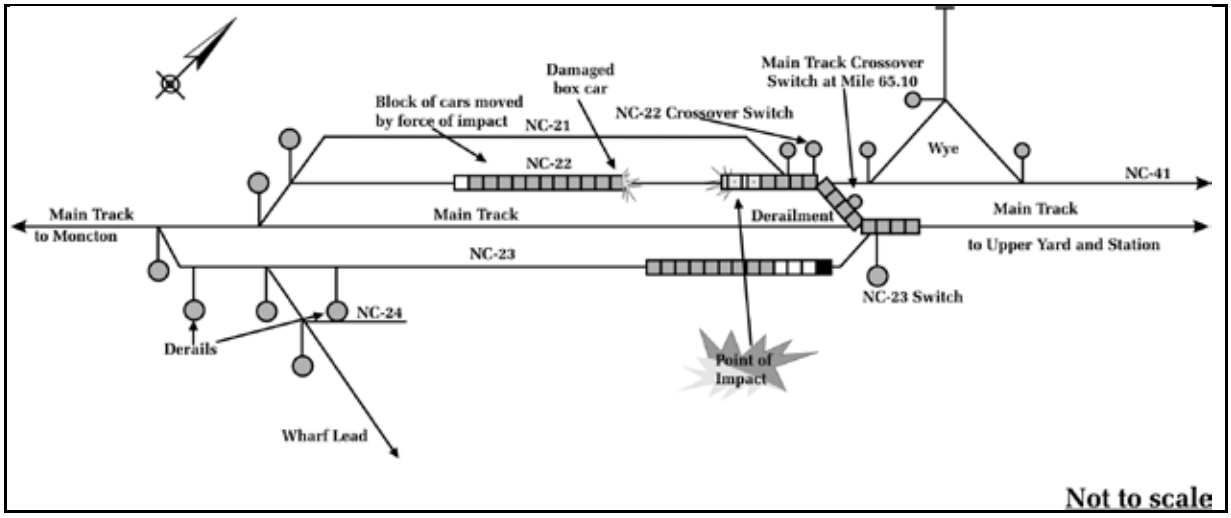


VIA 14 stopped for passengers with the lead locomotive positioned at the east end of the VIA station platform at Mile 66.18. Once boarding was completed at 1010[2], the train departed the VIA station. As the train passed the NBEC station, at Mile 65.75, the NBEC switch crew performed a pull-by inspection. The train was travelling at approximately 36 mph at that time. Once the pull-by inspection had been completed, the NBEC switch conductor communicated by radio that the inspection had been completed with no exceptions noted, and the crew of VIA 14 acknowledged the communication.

[1] All directional references as per time table.

[2] All times are Atlantic standard time (Coordinated Universal Time minus four hours) unless otherwise stated.

At 1012, the train accelerated and was proceeding at 41 mph, 1 mph higher than the maximum allowable zone speed, as it approached the switch for track NC-23 (a yard track south of the main track) at Mile 65.2 (see Figure 2). The locomotive engineer at the controls recalled that he saw that the main track crossover switch at Mile 65.1 was lined for the reverse position just after the lead locomotive passed the NC-23 switch. The NC-23 switch was 330 feet west of the main track crossover switch.



The locomotive engineer at the controls could not recall exactly what led him to believe that the main track crossover was lined in the reverse position—the switch target, the switch points, or both. The emergency brake was applied. Realizing that the train was going to be diverted into track NC-22 and collide with standing cars on that track, the crew members threw themselves to the floor and braced for impact.

Eleven freight cars were standing on track NC-22—10 loaded box cars of wood products, and 1 empty tank car—used to carry a non-regulated product. The cars were coupled together and hand brakes had been applied to the two most westerly cars. The car closest to the main track crossover switch, a box car loaded with fibreboard, was located about 595 feet from the switch. There was no rule, special instruction or bulletin to prevent employees from placing cars on the upper part of the track, close to the west switch.[3] Cars placed on the lower end of the

[3] In 1998, Bulletin 98101605 was issued by NBEC and stated that, "In order to allow the derail to function properly, always place car(s) as close as possible to it." The bulletin was a result of a runaway tank car that rolled out of track NC-23, narrowly averting a head-on collision with a westward VIA passenger train on the main track near the Miramichi River bridge.

grade (closer to the derail) would afford eastward approaching movements more stopping distance between the west switch and the standing cars.

The impact deformed the first loaded box car, forcing the load of fibreboard upward through the roof of the car and littering the roadbed with debris. VIA 14 then moved the cars 560 feet (see Photo 1). As well, the impact lifted the leading VIA locomotive up and off its front truck. The truck stopped and the forward momentum of the locomotive body drove the battery boxes and fuel tanks against the derailed truck, damaging the batteries and rupturing the fuel tanks (see Photo 2). The second locomotive, the baggage car, and six of the following passenger cars also derailed. Diesel fuel and battery acid were spilled. Two crossover switches and 450 feet of track were damaged.

1.2 Injuries

The entire train was evacuated. All passengers were examined by emergency medical service personnel and transferred to alternate transportation to their respective destinations. Forty-three people were transported to hospital. Six passengers, one OTS employee, and one emergency responder were admitted with serious injuries (see section 1.6). The remainder were treated for minor injuries and released. The two operating crew members were not injured.

1.3 Train Information

VIA 14 consisted of 2 locomotives and 10 passenger cars. The train was approximately 1070 feet long and weighed about 960 tons. It consisted of 1 baggage car, 2 coaches, 1 observation car, 4 sleeper cars, 1 dining car, and 1 lounge car.

The passenger cars were refurbished stainless steel equipment used in transcontinental service between Halifax, Nova Scotia, and Vancouver, British Columbia, and in the Gaspé peninsula, northern British Columbia and northern Quebec/Labrador.

1.4 Personnel Information

1.4.1 VIA Rail Canada Inc. (VIA) Crew

The operating crew members were qualified for their respective positions and met the requirements for rest and fitness for safe operation of trains. Both were experienced locomotive engineers.

1.4.2 New Brunswick East Coast Railway (NBEC) 580 Yard Assignment

The NBEC switch crew, who had been performing switching activities in the Miramichi Yard on the 580 yard assignment, comprised a conductor and a locomotive engineer. They were qualified for their respective positions and met minimum requirements for rest and fitness for the safe operation of trains.

In the three days before the derailment, the crew had worked three shifts totalling 32.5 hours. On the night before the accident, the crew had worked through the afternoon shift and gone off duty at midnight, approximately eight hours before their next shift. The locomotive engineer, who lived in Campbellton, New Brunswick, slept in a small rest area inside the NBEC station. The conductor lived in Miramichi, only minutes away from the yard, and slept at home. On the day of the accident, they had been on duty for slightly more than two hours.

1.4.3 NBEC 580 Yard Assignment Crew Training and Experience

The locomotive engineer was first employed by NBEC on 28 January 1998 as a conductor-in-training, after having worked for Canadian National Railways (CN) in track and infrastructure work for more than 20 years. He qualified as a conductor on 24 April 1998, as a locomotive engineer on 24 October 1998, and had worked as a full-time locomotive engineer as of June 1999. He had a valid medical card, and was qualified in the *Canadian Rail Operating Rules* (CROR).

The conductor was first employed by NBEC as a conductor-in-training on 02 November 1998. He qualified as a conductor on 06 February 1999 and had worked for NBEC in Miramichi for 15 months.

Both employees were trained by NBEC and by CANAC International Inc. (CANAC), a CN subsidiary company based in Montréal, Quebec. Course material used during training was similar to material used by CN and CANAC when training employees at CN and on other railways and met the standards of Transport Canada's (TC) *Railway Employee Qualification Standards Regulations*.

The employees had worked together at Miramichi for about one month before the accident. Operating employees working in the Miramichi Yard were supervised by officers who worked out of Campbellton. Support was occasionally provided by supervisors from other departments that worked out of Bathurst.

1.4.4 NBEC 580 Yard Assignment Work Plan

On the day of the accident, the NBEC switch crew started work at 0800, planned their initial duties and proceeded from the NBEC station. The crew had worked longer hours than normal during the previous few days because of recent snow falls in the area and the subsequent snow-removal and switch-cleaning duties.

The initial work plan the crew developed was to pick up a box car in the upper yard, reverse down to the lower yard, and then move forward through the NC-22 crossover to the main track. They first would switch a car out of track NC-23, then free-drop[4] the box car from the main track past the locomotives into track NC-23. Next, they would make a reverse movement back through the crossover and then move forward to turn the locomotive consist and the car in the wye track nearby.

The conductor directed movements by radio, as he was not always visible to the locomotive engineer. The four track switches involved in the movement plan were within 400 feet of each other; two of the switches were main track switches equipped with high-security locks.

The switching movements were performed as planned. It had been clearly understood that the locomotive engineer would reline the inside and main track crossover switches once the movement was clear of the main track. However, the conductor could not initially get the box car to roll freely due to snow conditions. The conductor then walked back to the east end of the car, saw the locomotive engineer getting ready to line the inside crossover switch to its normal position and radioed him to wait because he may need the locomotives to move the car. The locomotive engineer complied. The conductor reapplied the hand brake, released it and kicked the brake rigging. The car then started to roll into track NC-23.

[4] A switching procedure where a car positioned on a grade is allowed to move on its own, using the force of gravity to initiate movement, to roll into a designated track.

The conductor then radioed the locomotive engineer. The radio conversations were not recorded, and exactly what was said by the conductor was not clearly recalled by either employee, but the communication was to the effect that the conductor would not need the locomotive engineer to assist him in moving the box car into track NC-23 and for the locomotive engineer to continue. The locomotive engineer did so, assuming that the conductor would place the main track crossover switch into its normal position as he would walk by it on his way to the wye track.

While the conductor secured the box car in track NC-23 and lined the NC-23 switch for the main track, he saw the locomotive engineer placing the inside crossover switch at track NC-22 in its normal position and assumed that the locomotive engineer had previously restored the main track crossover switch at Mile 65.1. As the conductor and the locomotive engineer had agreed to meet at the east leg of the wye track, the conductor started to walk to that location. The locomotive engineer proceeded west, with the two locomotives and trailing car to that location as well. The conductor walked past the main track crossover switch, not noticing that it had been left lined and locked in the reverse position. He went to the east wye track switch on track NC-22, as the locomotives and car were operated onto the east leg of the wye track. The crew members then proceeded to complete the planned movement.

After completing other work, the crew heard the VIA 14 locomotive engineer on the radio announcing the entrance to Miramichi cautionary limits. At about 1000, the NBEC locomotive engineer radioed the passenger train to say that they were clear in the upper yard and VIA 14 acknowledged. This radio conversation was not recorded. The NBEC crew members conducted the pull-by inspection on the VIA train as it passed the NBEC station. After the inspection, they heard a collision and immediately proceeded to that location to help.

1.5 Passenger Safety

Crew and passenger injuries resulted largely from unrestrained carry-on baggage and heavy items, such as chairs and tables moving about in the cars, broken glass, or contact with other sharp objects. One OTS employee was seriously scalded by hot water from one of the buffet warming trays in the dining car.

Between July 1999 and April 2001, the TSB responded to four other VIA accidents (TSB occurrence Nos. R99T0298, R99S0100, R99H0009, and R01M0024). Over the course of these investigations, numerous passenger safety data were determined to be common to the occurrences. A separate examination encompassing all five accidents was undertaken to provide a better understanding of the passenger safety data, and to present a more complete picture of the issues identified as they relate to rail passenger safety.

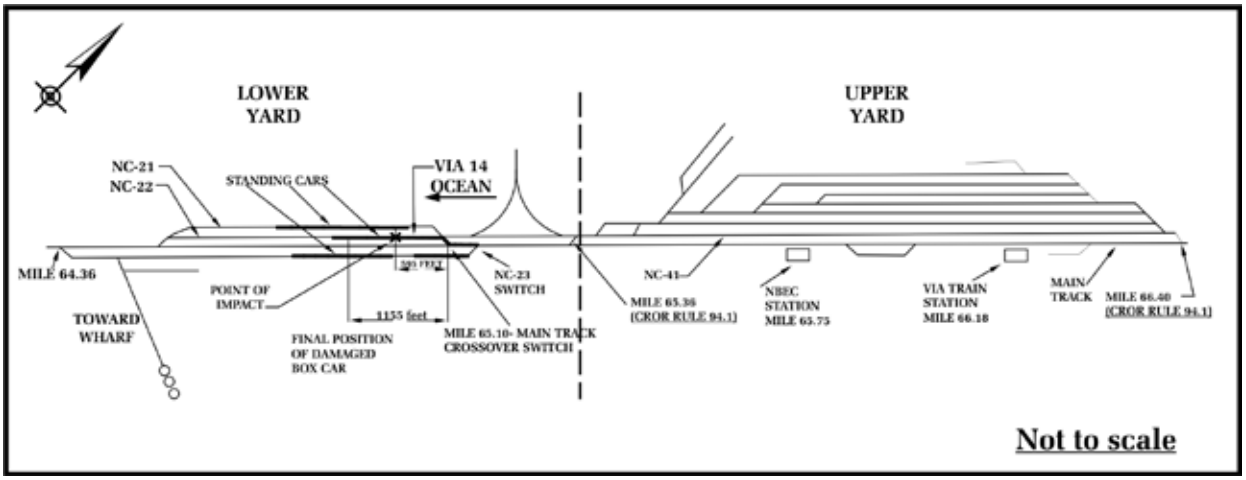
1.6 Emergency Response

The train crew immediately reported the accident to the rail traffic controller (RTC). Nearby residents, as well as some passengers in possession of cellular telephones, initiated a 911 emergency call, facilitating the timely notification of all emergency services. The emergency response was rapid and professional. The City of Miramichi was appropriately prepared and had the services necessary to respond effectively. Responding agencies included police, fire, ambulance, health services, NBEC, VIA, as well as TC and New Brunswick Transportation. More than 20 police and fire department vehicles were dispatched. Nine ambulances, 28 paramedics, 2 rescue sleds, 2 snowmobiles, and a helicopter were involved in the emergency response. Those passengers not requiring immediate medical attention were transported by buses to a local community hall. Passengers on board who had medical training, including one doctor, assisted in treating the injured. One emergency responder was injured while breaking a non-emergency exit window; he was struck in the throat by a shard of glass.

1.7 Occurrence Site Information

The Newcastle Subdivision is a single main track subdivision that was owned and operated by CN until 1998. The subdivision extends 173.2 miles from Catamount (Mile 0.0), the junction point with CN, to Campbellton (Mile 173.2), the junction point with the Matapedia and Gulf Railway.

1.7.1 Miramichi Yard



The yard tracks in Miramichi extended from Mile 66.4 to Mile 63.5. There were two separate yards, known as the upper and lower yards (see Figure 3). The two yards were joined together by the main track and by track NC-41 which, when it reached the main track crossover at Mile 65.1, was redesignated track NC-22 in the lower yard. The main track was tangent from Mile 66.4 to Mile 64.0. The track grade was minus 0.8 per cent descending for eastward trains.

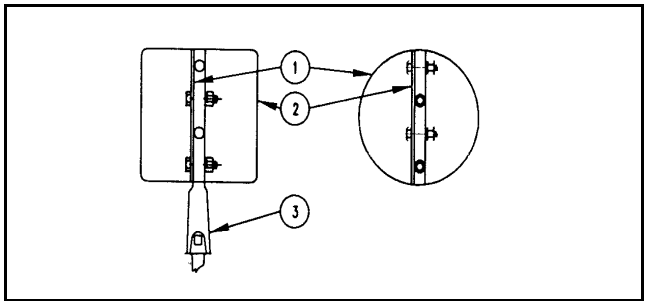
On the day of the accident, approximately three feet of snow had piled up between the main track and the adjacent yard tracks on both sides of the main track as a result of recent snow plowing.

1.7.2 Track Details

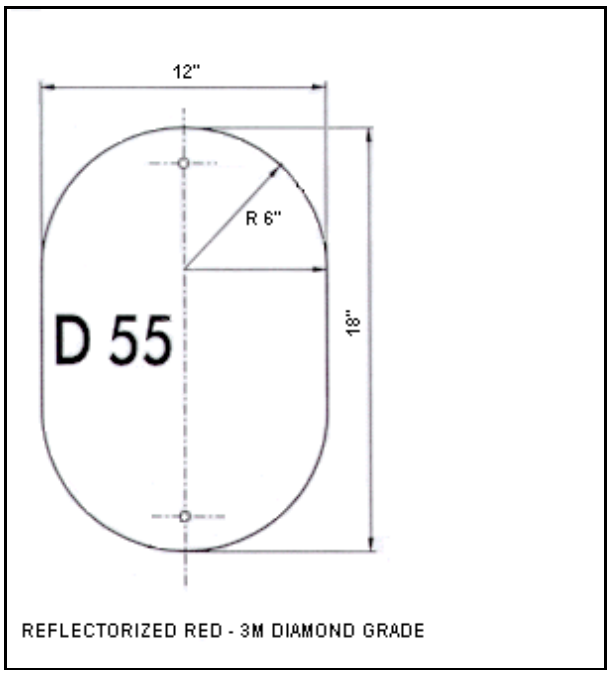
The main track was 100-pound jointed rail, laid on 11-inch double-shouldered tie plates, secured to eight-foot hardwood ties with four spikes per tie. The rail was anchored every third tie, with approximately 2960 ties per mile. The main track turnout was a No. 10 with a rated design speed of 15 mph. The ballast was crushed gravel or stone. Ties and rail in the main track were in good condition.

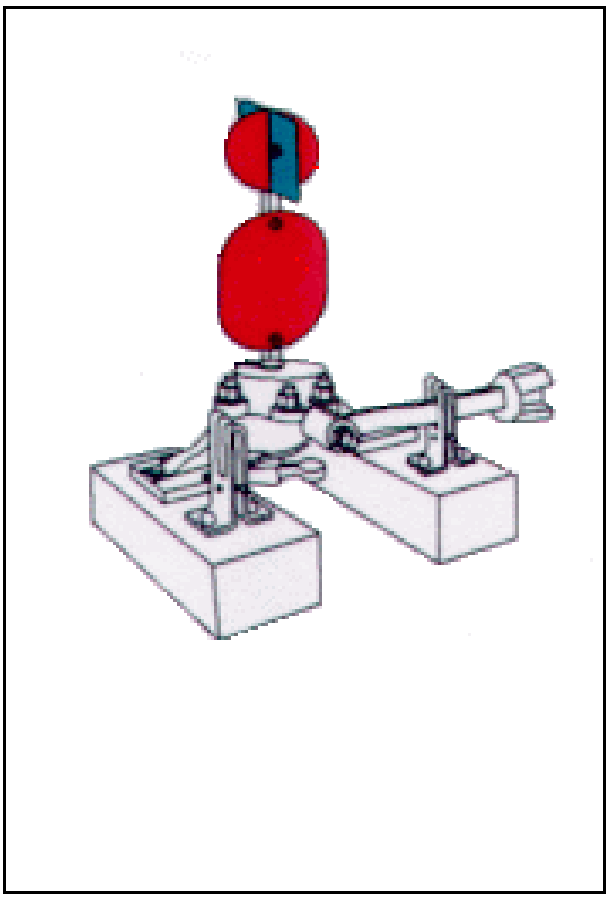
All switches at Miramichi, including main track switches, were hand operated.

1.7.3 Switch Stand and Specification



The switch stand for the main track crossover switch at Mile 65.1 was a 36-D low, rigid type that was patented in 1933 (see figures 4, 5, and 6). This type of lower profile switch stand is used in main track installations when it is necessary to place a switch stand between adjacent tracks where clearances are reduced. NBEC followed the CN Engineering (Maintenance-of-Way) *Manual of Standard Practice Circulars* (SPC) dated 1994, and CN *Standard Plans*, dated 1996, as its maintenance standards for track-related activities. According to that standard, a 36-D low, rigid switch stand must be equipped with a mast extension approximately 25 inches high to which a D 55 switch target, 12 inches wide and 18 inches high, is attached. In Occupancy Control System (OCS) main track territory, it must be topped with a tip assembly consisting of a tip mast, approximately eight inches high, to which a red reflectorized eight-inch disk and a green reflectorized eight-inch square are attached.

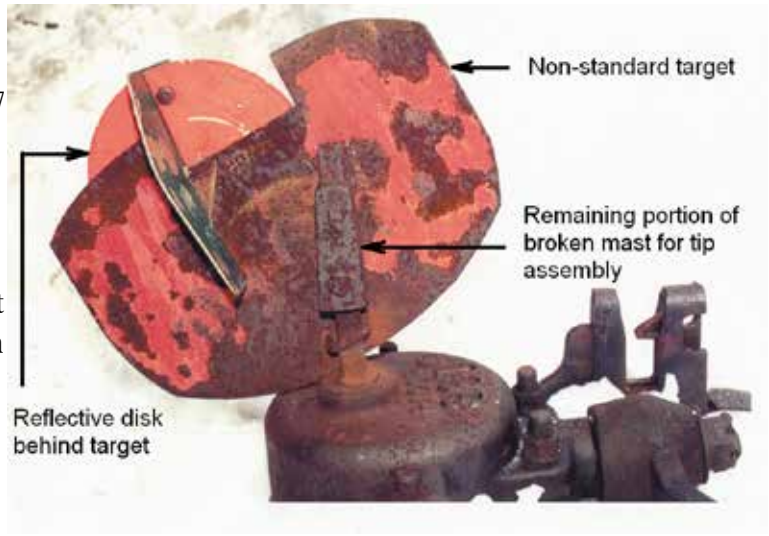




1.7.4 Mast Extension, Tip Assembly and Target Condition

Photo 3 shows the condition of the target and tip assembly for the main track crossover switch at Mile 65.1 as found immediately after the accident. Examination of the mast extension, tip assembly, and target revealed the following:

Mast Extension



The mast extension was 12 inches in length, not 25 inches as stipulated in the SPC. It was fractured in two pieces, one 7 inches long, the other 5 inches long. Construction was of forged steel with a cross-section measuring about ¾ inch square and about eight inches long with an integral one-inch-square socket and set screw. It conformed to a CN specification for a part to be used in a target tip assembly for forged switch masts, and was not designed for use with a large switch target. It was not painted black to SPC specifications, and was completely rusted, including the fracture surfaces. It was equipped with four bolt holes to permit the fastening of the tip targets directly to it by nuts and bolts.

Tip Assembly

The tip assembly was equipped with reflectorized material showing red on an eight-inch disk and green on an eight-inch square. Each piece was secured to the top of the mast extension by one bolt each, rather than by the standard CN specification of two each.

The red and green tip assembly attached to the larger broken piece of the mast extension was rotated 180 degrees and jammed down onto the red target, partially obscuring the red reflective surface of the upper tip assembly in the direction of travel of the approaching VIA train.

Target

A red-painted sheet steel switch target, 10 inches high by 15 inches wide, was below the tip. It was of a slightly irregular shape and was loosely attached to the ⅞-inch-square vertical shaft (spindle) by a U-bolt. The set screw in the smaller broken mast fragment was used to hold the larger red target down on the spindle. Witness marks from rotational movement of the target against the tip mast were evident on the face of the painted red surface of the target.

1.7.5 TSB Engineering Laboratory Examination

The mast, target and tip assembly were forwarded to the TSB Engineering Laboratory for further examination and analysis (report LP 017/00). Examination led to the following observations and conclusions:

- Large Red Target: This target was badly rusted to the point where only 20 per cent of the red paint remained on its rear face and about 25 per cent on its front face. This target also displayed numerous small, circular impact marks consistent with bullet impacts.

- Red and Green Tip Assembly: The top of this target was originally about 16 inches above the level of the adjacent track rail crown. After the fracture and temporary replacement, the top of the target was lowered another 3.5 inches over the circular red target.

- There were 13 small, circular-type spall impact marks on the rear face of the green plate, consistent with bullet impact marks. The front face of the target had also been hit once about one inch from the top by what appeared to be a large-calibre bullet which penetrated and tore out the plate to the edge. On penetrating, the bullet nicked the thread of the bolt beyond its penetration hole.

- It was concluded that the switch target and tip assembly provided were:

  a) in a deteriorated and rusty condition for some time;

  b) lower in height than desirable for optimum visibility in winter with banked snow alongside the tracks;

  c) broken off by a rifle shot, fracturing the support shaft, and temporarily repaired, thereby lowering the top targets 3.5 inches and partially obscuring the normal visibility of the circular, red target.

1.7.6 Main Track and Yard Inspections at Miramichi

Main track and yard inspections were performed in compliance with requirements. No defects related to switch target and/or mast condition at the main track crossover switch were noted in either the NBEC subdivision main track inspection records or the NBEC yard inspection records. There were also no records of these switch target conditions having been reported by track inspectors or employees of NBEC or VIA operating crews.

1.7.7 CN Police Records and Vandalism

CN police indicated that, in 1996, there was a reported incident of vandalism through the use of firearms in the Miramichi Yard area. No specific tracks or switch targets were identified in the report.

1.7.8 Regulatory Overview—Track

NBEC is a provincially regulated railway. The New Brunswick Department of Transportation is responsible for safety overview of NBEC operations. The province has an agreement whereby TC does the safety overview, applying *Railway Safety Act* (RSA) standards and practices. TC inspectors perform twice-yearly safety audits of NBEC. It was determined that TC inspectors passed through the Miramichi Yard area at least once during safety inspections. Although the last main track inspection included most of the Newcastle Subdivision, it did not include the tracks around Miramichi Yard. TC track safety inspection records for the last five years contain no reference to switch target or mast defects at the main track crossover switch at Mile 65.1.

1.8 Communications

The NBEC *General Operating Instructions* contained provisions for the use of radios, including requirements for repeating and confirming the understanding of any radio messages received. There were no specific instructions governing the use of radios to confirm the position of main track switches between crew members when main track switches were used by crews.

1.9 Weather

The weather at Miramichi at the time of the accident was clear, sunny and cold. The temperature was -11° C, winds were light, and visibility was 15 miles.

1.10 Recorded Information

1.10.1 VIA 14 Recorded Information

VIA 14 departed the Miramichi VIA station at a recorded time of 1010:22. It was moving at 41 mph at 1012:18. One second later, the locomotive engineer sounded a blast on the horn. Based on recorded distances, it can be calculated that, at that time, the locomotive would have been in the vicinity of a main track switch for track NC-23, approximately 850 feet from the point of impact, and 255 feet before the main track crossover switch.

At 1012:23, at a point about 13 feet before the main track crossover switch, the emergency brake was applied. Brake pipe pressure dropped to 0 pound per square inch (psi) at 1012:25. Between 1012:25 and 1012:34, the train decelerated from 41 mph to 29 mph, the speed at impact. The locomotive came to rest at 1012:39, five seconds later. The train travelled 608 feet from the time the emergency brake was applied to the point of impact.

1.10.2 NBEC 580 Yard Assignment Recorded Information

Locomotive event recorder data from one of the two locomotives used by the 580 yard assignment showed that the locomotive made 40 movements (22 in forward, 18 in reverse) between 0800 and 1012. Total distances covered and stops and starts were consistent with the movements to perform the planned work described by the operating crew. Movements between 0853 and 0857 were consistent with the crew's description of forward and reverse movements, including an entry at 0857:17 showing that the locomotive stopped, and then continued its forward movement before reversing direction to turn in the wye. Distances covered from start to finish were consistent with the distances covered to perform the work plan.

1.11 Method of Train Control

Train movements on the NBEC Newcastle Subdivision are controlled by the OCS authorized by the CROR, and are under the supervision of an NBEC RTC located in Campbellton. Between Mile 60.5 and Mile 68.1, the maximum authorized speed was 40 mph for both passenger and freight trains.

1.12 Operating Requirements Related to Cautionary Limits

1.12.1 NBEC Time Table and CROR Rule 94.1

The NBEC time table designated Mile 61.0 to Mile 67.0 of the Newcastle Subdivision as being cautionary limits.

Operating areas designated as cautionary limits typically involve heightened levels of overall railway activity. These can include, but are not limited to, such things as increased amounts of switching, multiple movements working at similar times, increased numbers of yard tracks or industrial sidings, and locations where track maintenance forces are concentrated.

Section 1.1 of the NBEC time table, Special Applications, stated:

> **Miramichi - Rule 94.1** is applicable at switches of track NC-41 at Mile 65.36 and Mile 66.4
>
> **Miramichi - Rule 104 (b)** - Switches of track NC-41 located at Mile 65.36 and Mile 66.4 may be left lined and locked in reversed position.

CROR Rule 94 reads as follows:

94. CAUTIONARY LIMITS

(a) A train, engine or track unit is authorized to use the main track within cautionary limits.

(b) Trains and engines must operate at caution speed within cautionary limits.

CROR Rule 94.1 reads as follows:

94.1 ADDITIONAL RESTRICTION IN CAUTIONARY LIMITS

On a subdivision specified in the time table, in the application of caution speed as required by Rule 94, a train or engine must also be prepared to stop short of a switch not properly lined.

Caution speed is defined as "A speed that will permit stopping within one-half the range of vision of equipment or a track unit."

While proceeding through the cautionary limits, the operating crew watched for the correct positioning of the two referenced main track switches and observed that they were lined in the normal position.

1.12.2 Previous CROR Provisions

Before 1994, the CROR defined caution speed and dealt with cautionary limits in the following manner:

CAUTION SPEED

A speed that will permit stopping within one-half the range of vision of equipment or a track unit and in no case exceeding SLOW SPEED. (emphasis added)

SLOW SPEED

A speed not exceeding fifteen miles per hour.

1.12.3 Rationale for Removing Slow Speed Requirement

After rules are approved by the Minister of Transport, the railway is bound by the requirements of those rules. Railways may enhance the requirements of a particular rule, but may not apply a rule in a way that reduces the safety requirements of the rule without TC's approval as required by the RSA. TC monitors the railways to ensure compliance.

In 1993, the Railway Association of Canada (RAC) requested TC's approval for changes to the CROR,

including the removal of the maximum speed cap of 15 mph within cautionary limits. It was considered redundant when applying the primary requirement that trains must be prepared to stop within one-half the range of vision. There was a concern that operating employees would primarily focus on the speed requirement of 15 mph, rather than the need to stop within one-half the range of vision.

The RAC stated that the definition change would remove an operating restriction, thereby improving service efficiency without adversely affecting safety, and TC concurred. This change and others were approved by the Minister of Transport in February 1994.

1.12.4 Transport Canada's Interpretation of CROR Rule 94.1

Section 21 of the RSA contains a requirement for uniformity of rules applicable to railways in that ". . . the Minister shall, to the extent that it is, in the opinion of the Minister, reasonable and practicable to do so, ensure that those rules are uniform with rules dealing with a like matter and applying to other railway companies." With respect to the question ". . . must a train or engine proceeding at caution speed be prepared to stop short of all main track switches not properly lined within the mileages of the cautionary limits identified in the time table?" TC has indicated that

> . . . the Rule itself provides the railways with the flexibility to meet their respective operating requirements. The Rule is broad enough that whether the time table instruction specifies a particular switch, several switches, or, specifies all switches within cautionary limits, the operation would be permissible. It is therefore dependent on what the railway has identified in their time table as to which case applies.

1.12.5 Application of CROR Rule 94.1 by CN and CP Rail

CN applies CROR Rule 94.1, Additional Restriction in Cautionary Limits, in a manner that requires that trains be prepared to stop short only of those main track switches specifically designated by the time table subdivision footnotes or by general operating bulletin.

Canadian Pacific Railway (CP Rail) clarifies its interpretation of CROR Rule 94.1 (ex., St. Lawrence and Hudson Railway [SL&H] East-West Corridor Time Table No. 2, page 170) in the following manner:

> This is to advise crews that they may encounter main track hand-operated switches (emphasis added) lined and locked in the reverse position, and must operate at a speed that will permit stopping short of a switch not properly lined.

NBEC interpreted CROR Rule 94.1 in the same manner as CN. VIA crews operating on NBEC were taught the CN interpretation of CROR Rule 94.1. TC was aware that, although VIA, CN, and NBEC applied CROR Rule 94.1 similarly, the rule was applied differently by CP Rail.

1.12.6 Historical Evolution of Operations at Miramichi

For decades, the Newcastle Subdivision was operated by CN under the Uniform Code of Operating Rules (UCOR) using the time table–train orders method of operation. There was a superiority of trains. In the Miramichi area, an Automatic Block Signal System (ABS) gave added protection by informing approaching train crews of the presence of other trains or open main track switches. Most trains were required to proceed at restricted speed (maximum 15 mph) within yard limits on the main track unless the main track was known to be clear.

Over time, the operating environment and traffic levels changed. CN abandoned time table–train orders on the Newcastle Subdivision, and changed over to the Manual Block Signal System of the UCOR. Reference to train superiority disappeared, and time table authority no longer governed the movements of trains and engines. ABS signals were removed from service, but the yard limits restriction of UCOR Rules 93 and 93A still applied; that is, stopping within one-half the range of vision.

With the change from the UCOR to the CROR in 1990, yard limits were removed from the operating time table, requiring all main track movements to have operating authority. In addition, the introduction of cabooseless train operations required that crews be able to leave the main track switches of sidings lined and locked in the reverse position. Rule provisions governing hand-operated switches reflected these changes in operating practice. At Miramichi, the time table designated upper yard track NC-41 as a siding. The rules required all other main track switches, including crossover switches, to be lined and locked for the main track. Subsequent changes to the time table introduced cautionary limits to the area, eliminating the requirement for main track movements to have operating authority. With the introduction of cautionary limits, trains using the main track were required to move at caution speed, which before 1994 was defined to include the requirement not to exceed 15 mph.

After the 1994 rule change, the caution speed definition in the CROR allowed trains and engines to operate at any speed up to the authorized maximum speed for the zone, provided that they were capable of stopping within one-half the range of vision of equipment or a track unit. If the main track was seen to be clear and conditions of visibility were good, crews routinely operated at speeds up to the zone maximums. Within cautionary limits at Miramichi, the time table zone speed for that portion of the Newcastle Subdivision was 40 mph for all trains.

The provisions of CROR Rule 94.1, requiring that trains be prepared to stop short of switches lined and locked in the reverse position, were not invoked until CN established cautionary limits. CN relinquished ownership of the Newcastle Subdivision to NBEC in 1998. NBEC continued to use the CROR OCS rules as a basis for train operation. NBEC has continued the use of CROR Rule 94.1 to designate specific switches within cautionary limits from operational start up. No other switches within cautionary limits were considered to require Rule 94.1 protection.

1.13 Operating Requirements Related to Main Track Hand-Operated Switches

1.13.1 Main Track Hand-Operated Switches in OCS Territory

Safe operation of trains in non-signalled OCS territory is dependent on strict observance of the rules by all employees who handle main track switches. The RTC has no information about the position of hand-operated switches, and no indicators are installed, other than the switch targets and tips, to communicate the position of main track switches to the crew of an oncoming train.

Year	Passenger Trains in OCS outside ABS	Passenger Trains in Yard Limits or Cautionary Limits	Freight Trains in OCS outside ABS	Freight Trains in Yard Limits or Cautionary Limits	Total non-signalled areas
1993	1	0	2	0	3
1994	0	0	11	0	11
1995	1	0	4	0	5
1996	1	0	3	0	4
1997	0	0	10	0	10
1998	0	0	5	0	5
1999	1	0	3	0	4
2000	4	1	9	0	14
2001	3	0	3	0	6

Table 1. Reported occurrences of trains encountering reversed main track hand-operated switches in non-signalled areas

TSB data from 1993 to 2001 regarding reported occurrences of trains unexpectedly encountering reversed main track hand-operated switches in non-signalled areas are shown in Table 1. The data are highly variable, ranging from a low of 3 occurrences in 1993 to a high of 14 in 2000. The annual average is about 7 occurrences.

1.13.2 Main Track Hand-Operated Switches within Cautionary Limits

The RTC has little control over main track traffic within cautionary limits. Present Traffic Control System (TCS) computer dispatching systems do not allow main track switches to be directly protected. Protection can be afforded, but only through a process that requires the RTC to apply protection indirectly (ex., by not authorizing entry into the adjacent track blocks at both ends of a cautionary limit zone, and then issuing the proper *General Bulletin Order* (GBO) protection for the main track switches within cautionary limits). There are no physical means by which the RTC can protect against the condition.

1.13.3 Main Track Hand-Operated Switches and Switch Locks

Main track hand-operated switches in Miramichi were equipped with high-security locks as required by TC. Any switch operator who unlocks such a lock must re-lock it to recover his/her switch key. Train and engine crews were routinely required to operate several main track switches in proximity to one another equipped with high-security locks, sometimes at the same time. Train crews would therefore have to lock main track switches in the reverse position to maintain possession of their switch keys for other locations; this was what the NBEC 580 yard assignment required at Miramichi Yard.

1.13.4 CROR Rule 104—Main Track Hand-Operated Switches

The requirements for switch targets and the handling of main track switches and crossovers were contained in CROR Rule 104, which reads in part as follows:

> 104. HAND OPERATED SWITCHES
>
> (a) Except as provided in paragraph (b), main track switches must be lined and locked for the main track when not in use. A main track hand operated switch must display a reflectorized target, or light and target, to indicate the following:
>
> [. . .]
>
> (b) When directed by GBO, clearance or special instructions, and protection has been provided against all affected trains or engines, a main track switch may be left lined and locked in the reversed position. When not so directed, it must not be left in the reversed position unless in charge of a switchtender or a crew member who must be in position to restore the switch to its normal position before it is fouled by a train or engine approaching on the main track.
>
> [. . .]
>
> (d) Except as provided by paragraph (b), the conductor and locomotive engineer must, when practicable, ensure that switches manually operated by their crew members are left in the normal position. Other employees are not relieved of responsibility in properly handling switches.
>
> [. . .]
>
> (n) When a crossover is to be used, the switch in the track on which the train or engine is standing must be reversed first. Both switches must be reversed before a crossover movement is commenced and the movement must be completed before either switch is restored to normal position.

Railway rules required that non-designated main track switches be left lined in the normal position. Train crews were expected to proceed, relying on other employees to comply with this rule.

1.13.5 Railway Track Safety Rules and Standard Practice Circulars (SPC)

The *Railway Track Safety Rules*, Part II, Subpart D, Section XII, Switches, stated:

[. . .]

(g) Each switch position indicator must be clearly visible at all times.

The SPC being used on the NBEC (dated 1994) contained the standard applied by NBEC at Miramichi. SPC 3506, *Switch Stands, Switch Lamps, and Targets* described the standards applicable to main track switches, which stated, in part:

10 a) Switch stands on main tracks must be equipped with a red non-reflectorized target.

[. . .]

d) Targets must indicate the colour aspects shown by the lenses as prescribed in Clause 11.

11 a) All switch stands (except (a) when there is no scheduled night operations, (b) main track switches in single track ABS territory and (c) in artificially lighted yards with No. 22 stands) must be equipped with switch lamps, oil or electric, or switch lamps with reflectorized lenses as directed by the Track and Roadway Engineer. Switch lamps with reflectorized lenses may be replaced by double blade reflectorized targets in areas where there is vandalism.

b) Switch lamps on main track switches shall have two green lenses and two red lenses installed so that when the switch is in its normal position and set for the straight track or lead, the green lenses will show to approaching trains on the normal operated route. When the normal operated route follows a diverging track, it is defined in the working timetable, special instructions, or bulletins.

12 a) Switch stands, lamps, targets, masts, connecting rods and all other component parts must be kept in good operating condition and must have defective parts repaired or replaced immediately.

b) Reflectorized lenses and reflectorized targets must be kept clean and must be replaced when the reflective material begins to show signs of deterioration.

Main track switches on the Newcastle Subdivision were equipped with painted targets and reflectorized tip assemblies in accordance with the 1994 SPC.

1.14 Switch Target Recognition

1.14.1 Miramichi Main Track Switch Target Simulation

The VIA locomotive engineer at the controls saw the target as being reversed and red just after the first locomotive passed by the NC-23 switch. The switch was 330 feet from the main track crossover switch at Mile 65.1.

Simulations to test the visibility of the non-standard main track crossover switch targets were performed at the accident site on 02 February 2000 (see Photo 4).

The tests were conducted at the same time of day. Cars were placed on the adjacent track to recreate lighting conditions at the time of the accident. For safety reasons, the tests were conducted at slow speed.

The colour and geometry of the non-standard target could first be seen from approximately 300 feet. At about 500 feet, the target was seen as black in colour and of no discernable geometry.

The colour and geometry of a standard switch arrangement in good condition could be seen from slightly less than 900 feet in the conditions that existed at the site.

1.14.2 CANAC Study for CN on Switch Target Recognition

In 1999, CN commissioned a CANAC study on switch target recognition. Tests were conducted using standard-size switch targets of different configurations, including the No. 10 red-painted 12-inch by 18-inch target, fully covered with varying types of reflectorized materials. The CANAC study did not include tip assemblies. This study showed that, in various light conditions with unobstructed visibility in daytime, a 12-inch by 18-inch painted switch target could be detected by colour at distances ranging from 2282 feet to 3229 feet. In similar daytime conditions, a reflectorized 12-inch by 18-inch target with a reflectance rating of 215 candles could be detected by colour at distances ranging from 1765 feet to 3897 feet.

Nighttime testing showed that a standard No. 10 red-painted 12-inch by 18-inch target could be detected by colour at a distance of 1039 feet. A target of the same type with the entire surface area fully reflectorized could be detected by colour at a distance in excess of two miles.

As a result of these tests, CN changed its engineering standards for switch targets to require fully reflectorized switch targets for hand-operated switches, and subsequently installed fully reflectorized switch targets on all main track hand-operated switches.

1.14.3 Main Track Switch Target Visibility Test (Walkley Yard)

Subsequent to this occurrence, TSB personnel conducted tests at the Walkley Yard in Ottawa to determine visibility distances for the main track crossover switch target and for other target configurations. Six qualified locomotive engineers and one qualified conductor made numerous independent observations of normal or reversed targets from the cab of a stationary locomotive located on tangent track between 500 feet and 3500 feet from the target. After observing a target for four seconds, each locomotive engineer or conductor made one of three possible responses: “normal”, “reverse” (at the level of certainty needed to initiate emergency braking), or “wait” (indicating that, on the job, the observer would have waited until the locomotive was closer to the target to be certain of the switch alignment). Targets were equally likely to be normal or reversed. The tested targets were:

1	the occurrence target on its broken mast
2	a painted target with painted tip assembly on a low mast
3	a painted target with reflectorized tip assembly on a low mast
4, 5	two reflectorized targets (two brands of reflectorized material) with reflectorized tip assembly on a low mast
6, 7	two reflectorized targets (two brands of reflectorized material) with reflectorized tip assembly on a high mast

Although differing conditions between Walkley Yard and Miramichi prevented direct determination of the expected sight distance for the occurrence target, reliable conclusions could be made regarding the occurrence target sight distance relative to sight distance for targets in good condition (see Figure 7).

It can be seen that, while reversed targets in good condition are detected without error at a distance of 2000 feet with tip reflectorization, and at 1750 feet with no tip reflectorization, the occurrence target (No. 1) is not detected error-free even at 500 feet. Even in the undemanding conditions of the Walkley Yard simulation, the occurrence target could only indicate switch position at less than half the distance of targets in good condition.[5]

[5] See Appendix A for a full description of the Walkley Yard target visibility test.

1.14.4 Operator Perception-Response Times to Emergency Warnings

While a simple trigger response to an emergency warning may require less than two seconds to initiate, any requirement for situational evaluation will lengthen perception-response time to four to six seconds on average. A high-speed rail simulation[6] has shown an average perception-response time of 8.6 seconds to initiate braking for an unexpected block signal. Although participants were trained and tested MIT students, they were not experienced locomotive engineers.

Commercial aviation research[7] has shown that commercial pilot response times for simulated traffic alert and collision avoidance system[8] warnings average 5.4 seconds, and 60 per cent of responses fall between four and six seconds. As the authors of that study advised, the U.S. Federal Aviation Administration incorporated a human performance standard of four to six seconds perception-response time into its final rule[9] regarding ground proximity warning systems.

A perception-response time of four to six seconds would not be abnormal in the situation encountered by the locomotive engineer in this occurrence, given the need to evaluate a complex situation and decide between the alternatives of full service braking or emergency braking, and the extremely low probability of encountering an unexpectedly reversed main track switch.

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6 S. Askey and T. Sheridan, Safety of High Speed Ground Transportation Systems - Human Factors Phase II: Design and Evaluation of Decision Aids for Control of High-Speed Trains: Experiments and Model, Final Report DOT-FRA-ORD-96/09, 1996.

7 DOT/FAA, Investigation of Controlled Flight Into Terrain, Final Reports DOT-TSC-FA6D1-96-01 and DOT-TSC-FA6D1-96-03, 1996.

8 Traffic alert and collision avoidance system is a cockpit system that provides pilots with aural and visual warnings of impending midair collisions, and states the most appropriate flight manoeuvre to avert collision.

9 FAA/DOT, "Final Rule: Terrain Awareness Warning Systems", 2001, *http://www.faa.gov/avr/arm/6866.doc*

1.15 Passenger Train Braking Capability

1.15.1 Definition of Stopping Distance

The U.S. Federal Railroad Administration (FRA) defines stopping distance in the *Code of Federal Regulations* as follows:

> 236.741 Distance, stopping.
>
> The maximum distance on any portion of any railroad which any train operating on such portion of railroad at its maximum authorized speed, will travel during a full service application of the brakes, between the point where such application is initiated and the point where the train comes to a stop. (emphasis added)

There is no direct definition of stopping distance as such in Canadian regulations. However, it is assumed that, in the Canadian context, the FRA definition is valid. TC E-07-08, *Signal and Traffic Control Systems Standards, Railway Signaling Design Principles*, Section 3.7, reads as follows:

> 3.7 Each signal shall be located with respect to the next signal or signals in advance which govern train movements in the same direction so that a restrictive aspect can be complied with by means of a brake application, other than an emergency application, initiated at such signal. (emphasis added)

1.15.2 VIA 14 Stopping Distance

Data from the VIA locomotive event recorders involved in the Miramichi accident were examined to establish approximate stopping distances for the train for both full service and emergency braking stop situations (see Appendix B). Based on the extracted information, it was determined that, with a four-second reaction time, the VIA train would have required approximately 1170 feet to stop in emergency, and approximately 1320 feet to stop with a full service brake application, from a speed of 41 mph.

1.16 Previous TSB Investigations Involving Caution Speed

The TSB has conducted several investigations into accidents involving the topic of caution speed. For example, as a result of an accident in Saskatchewan (TSB Report R96W0171), the Board stated that:

> [. . .] removing the previous 15 mph maximum speed limit within cautionary limits improved operating efficiency, but [the Board] is concerned that current operating speeds within cautionary limits have significantly reduced the margin of safety.

Subsequent to an accident in Quebec (TSB Report R98M0020), the Board concluded that, in the event of unexpected runaways on the main track, operation at caution speed may have contributed to the degree of damage and hazard to passengers, crew, and the environment. The Board expressed a safety concern that

> [. . .] the reduced requirements of caution speed, as defined in the CROR, may not be providing rail movements, particularly passenger trains, with an adequate safety defence against the increased risks that can exist within cautionary limits.

2.0 Analysis

2.1 Introduction

The accident is attributable to a main track crossover switch having been inadvertently left lined and locked in the reverse position. The non-standard condition of the switch target was the last means available for the train crew to detect the unsafe switch position. Although the event recorder data show a slight 1 mph overspeed (41 mph versus 40 mph), they also show operator reactions attempting to control train speed. The minor overspeed is not considered causal to this occurrence.

The analysis will discuss safety-related activities pertaining to switch target condition and recognition, train speed in cautionary limits, the *Canadian Rail Operating Rules* (CROR), operating practices, crew communications, and supervision of operations / track maintenance.

2.2 Switch Target Condition and Recognition

After the crew members of VIA Rail Inc. (VIA) passenger train No. 14 (VIA 14) confirmed the alignment of the designated switch at Mile 65.36, they were no longer specifically looking for a misaligned switch. However, if the event recorder data, showing that emergency braking was applied about 13 feet before the main track crossover switch, are considered in conjunction with the reaction time of four to six seconds needed to react to an unexpected stimulus,[10] it can be calculated that the locomotive engineer at the controls became aware of the unsafe condition between 253 feet and 374 feet from the switch. A simulation has shown the switch target to be first discernible from 300 feet. It is apparent, therefore, that the locomotive engineer at the controls was watchful and alert to the condition of the track and detected the unsafe condition at about the same time that such an observation was possible.

As the simulation also demonstrated, a standard painted switch target and tip assembly in good condition could be identified from about 900 feet. Considering the estimated required stopping distance of 1170 feet for VIA 14 (including a four-second reaction time) and the position of the standing equipment (about 595 feet east of the main track crossover switch), it can be calculated in these circumstances that an operating crew vigilant to track conditions could have stopped its train up to 325 feet before the standing cars. Therefore, it can be concluded that, although the locomotive engineer at the controls was vigilant to train operation, the poor condition of the switch target and tip assembly prevented the misaligned switch from being detected from a distance sufficient to avert the collision.

[10] Information on operator perception-response times to emergency warnings is contained in section 1.14.4.

2.3 Train Speed in Cautionary Limits

As outlined in section 1.12.1, cautionary limits typically encompass areas of railway operations that include multiple tracks and resultant switches, and a high amount of employee activity. The probability of encountering a non-designated main track switch in the "reverse" position is therefore increased in such areas.

Train operation is usually at a speed that allows train crews to comply with routine stopping requirements using a service brake application rather than the much stronger emergency brake application. This concept is incorporated in the *Railway Signalling Design Principles*, and is also seen in the U.S. Federal Railroad Administration (FRA) definition of "stopping distance." Stops using a service brake application are particularly important for passenger trains, as passengers may be moving about the cars, or in the process of consuming or being served hot beverages and are, therefore, vulnerable to injury at such times. As outlined in Appendix B, VIA 14, viewed as a typical VIA train, was calculated to require in excess of 1200 feet to stop using a full service brake application with the locomotive brake applied from a speed of 40 mph.

Studies respecting the distances that switch targets in the reverse position can be discerned (the CANAC International Inc. [CANAC] study outlined in section 1.14.2 and the Walkley Yard study outlined in section 1.14.3 and in Appendix A) and the simulation at Miramichi (section 1.14.1) provide insight into the safety margin afforded to train crews and passengers while travelling at authorized speeds.

Considering the typical VIA stopping distance previously mentioned, it can be concluded from the CANAC study that both painted and reflectorized switch targets on high masts provide an adequate advance notice of switch orientation (that is, more than 1750 feet in daylight conditions). Similarly, the Walkley Yard study shows that, in daylight conditions, a painted switch target and tip assembly in good condition on a short mast (a short mast is a common installation in a yard environment as proximate tracks trigger railway operation clearance considerations) is discernable error free from 1750 feet. However, the CANAC study also showed that the widely, but not exclusively, used reflectorized switch target had lower values in daylight conditions than a comparable size painted target (1765 feet versus 2282 feet, see section 1.14.2), and that, in night-time conditions, a painted switch target on a high mast is discernable from a maximum distance of 1039 feet, or about 250 feet short of the needed distance for the referenced speed and manner of braking.

The Miramichi Yard simulation demonstrated that a painted switch target in good condition on a short mast was only discernable from a distance of 900 feet. The decrease of approximately 850 feet of recognition distance compared to the Walkley Yard study is most likely attributable to the ambient conditions at the occurrence site (that is, target in shadow, and piles of snow

around the switch). The switch target recognition distance, determined from a simulation conducted in the actual working environment under winter conditions, is considered representative of expected target recognition distances in the operating environment.

The current requirement to proceed at caution speed does not prevent a train from being operated at maximum authorized zone speed, with the result that the combined reaction and stopping distances may exceed the distance at which switch alignment can be reliably determined by visual means. There are no other defences. Determination of a safe speed within cautionary limits requires consideration of:

- the service brake stopping distance of a typical VIA train;
- the outlined vagaries in switch target identification;
- the low safety margin seen in some instances; and
- other factors, such as reduced visibility due to time of day, adverse weather, or obscured sightlines.

In addition to the risks of unexpectedly encountering a reversed main track switch, the presence of other hazards within cautionary limits (as identified in section 1.12.1) must also be considered. Current requirements for caution speed are limited to "a speed that will permit stopping within one-half the range of vision of equipment or a track unit." The definition is silent with regard to any other hazard. Operating at maximum allowable zone speed within cautionary limits, where various hazards can be encountered, can pose a risk to safe train operations as it reduces the opportunity to protect against hazards other than equipment or a track unit, such as a non-designated main track switch left in a wrong position.

2.4 Interpretation of CROR Rule 94.1

The flexible interpretation of CROR Rule 94.1 allowed New Brunswick East Coast Railway (NBEC) to have it apply only to specific switches within cautionary limits, unlike the practice of Canadian Pacific Railways (CP Rail), for example. Because the operating rules do not allow main track switches to be left in a reversed position without authority, this created an expectation on the part of the NBEC crew that all main track switches (other than Rule 104 (b) or Rule 94.1 switches specifically identified in the time table) would be left lined and locked for the main track when not in use. This crew expectation also existed with VIA and Canadian National Railways (CN) employees. Operating in such a manner did not allow for human error and increased the possibility of crew members proceeding at a speed at which they cannot stop short of any misaligned main track switch within cautionary limits.

Under the more restrictive interpretation of CROR Rule 94.1, as applied by CP Rail train crews, the crew on VIA 14 would have been required to operate at a speed that permitted stopping short of the main track crossover switch in the prevailing conditions, and with train operation at

that speed, the collision would have been averted. The less restrictive interpretation of CROR Rule 94.1—that the rule only applies to designated switches—reduces the error tolerance of the system, thereby increasing the risk posed to rail operations by misaligned switches.

2.5 Uniformity of Rules

Railways routinely operate trains on other company's tracks for many reasons (e.g. running rights, detours as a result of derailments, and planned track work). For example, east of Montréal alone, VIA regularly operates over six railways (CN, NBEC, Matapedia and Gulf Railway, Baie des Chaleurs Railway, Gaspé Railway Corporation, Cape Breton and Central Nova Scotia Railway). These railways are all subject to the CROR.

Any time a train temporarily operates over another railway line, the host railway provides one of its own operating employees (called a 'pilot') to accompany and guide the operating crew.

Any ongoing planned operations over other railway lines normally require operating crews and their supervisors to be trained in the host railway operating circumstances and special instructions. VIA, for example, operates predominately over CN lines. They also operate over CP Rail, short lines and their own infrastructure. VIA crews are trained for operation over these various territories and are in possession of individual railway timetables, CROR manuals, General Operating Instructions, Daily Operating Bulletins, General Bulletin Orders (GBO), notices, circulars and any other relative documents, where required. However, as outlined in section 2.4, the way in which each railway is permitted to apply the rules may not coincide with rule interpretations which are taught to the crews by each employer. The number of railways over which VIA operates increases the risk of inconsistencies in operating practices of employees of different railways. In this occurrence, there was no such conflict, as both VIA and NBEC employees applied CROR Rule 94.1 similarly. The fact that some operating employees were unaware that CP Rail applies CROR Rule 94.1 differently suggest that there may be other locations, and perhaps even other railways, where misunderstandings can occur concerning specific application of some operating rules.

Without a uniform interpretation of operating rules industry-wide, or training that stresses the differences in rule interpretations, train crews may encounter various company-specific interpretations for similarly worded operating rules for which they have not been taught, thereby increasing the risk of an accident.

2.6 Evolution of Operations in the Miramichi Yard Area

The manner of operation on the main track in yard areas has been transformed with changes in operating rules and practices. Under the *Uniform Code of Operating Rules* (UCOR), yard engines operated at restricted speed unless the main track was known to be clear. The presence of signals did not relieve crews from this requirement.

In consideration of

- changes in the CROR governing the use of the main track in yard limits,
- adoption of cautionary limits and abandonment of the use of yard limits, and
- rule changes to the definition of caution speed and the introduction of reduced speed in yards,

the requirements limiting maximum zone speed, other than the requirement to stop within one-half the range of vision of equipment or a track unit, were dropped. This has led to the operation of trains at relatively high speeds on main tracks within cautionary limits. While the current definition of caution speed allows greater operating flexibility, the higher speeds may increase both crash probability, by lengthening stopping distances, and crash severity.

These successive changes to the rules and operating practices have affected operating safety. At Miramichi, the first change was the removal of the Automatic Block Signal System (ABS) signals. This removed the physical defence that signal systems provide with regard to main track switches. At first, the restricted speed requirement of the UCOR remained in place, limiting the probability of an accident and the potential consequences of this change. Subsequent rule changes led to removal of any restricted speed or slow speed cap on the main track in the yard area. The only defences remaining were the provisions of the CROR for the use of main track hand-operated switches. Mishandling of main track switches in these conditions may lead to a train being diverted from the main track in the event of a misaligned switch.

Safety is dependent upon absolute observance of operating rule requirements by railway employees handling main track switches and the probability of an approaching train crew spotting a switch target in time to stop. The possibility that a switch may be inadvertently left reversed or vandalized is not protected against. No other defence barrier exists to mitigate against the potential consequences of such an eventuality, as these defence barriers have been removed from the rules.

2.7 Crew Communications and Handling of Main Track Switches

There was a requirement not to restore either crossover switch until the movement was completed. However, the locomotive engineer had stopped his movement upon being distracted by the conductor, who had encountered a problem in getting the box car to roll free in the snow. The conductor was under the impression that the switches would be relined and properly locked by the locomotive engineer, and he turned his attention to his other tasks. The manner of handling main track switches, as changed from the work plan, was not confirmed by either crew member once the distraction occurred and their work plan was interrupted. Neither employee felt the need to communicate his understanding of changed conditions to the other crew member, based on his individual perspective of what was seen and heard. The basic requirement for conductors and

locomotive engineers is to confirm main track switch position (CROR Rules 104 (a), (d), and (n)) when practicable. There was no additional requirement to ensure that each crew member understood what the position of the main track switch was and confirm actual switch position. Because their operating practices did not employ consistent confirmation of switch position between crew members, a misunderstanding occurred and a main track switch in the path of the approaching VIA train was left lined and locked in the wrong position.

2.8 Supervision

2.8.1 Operations

The NBEC crew members had limited operating experience and worked in an area where there was little direct supervision. The NBEC crew members were likely unaware of the increased risk of human error they introduced into their work procedures by seemingly simple adaptations[11] of established work procedures (ex., the subject crew not employing consistent radio confirmation of switch position when controlling movements by radio and the crew not completely clearing the crossover before restoring one of the switches to normal as required by CROR Rule 104 (n)). Without frequent and direct railway supervision to educate and correct employee behaviour, the relatively inexperienced operating employees developed non-standard work practices related to radio communications and handling of main track switches, thereby increasing the likelihood of error.

2.8.2 Engineering

The use of standard practice circulars (SPC) dated 1994, when more current SPC had been issued by CN in 1998, indicates that NBEC was not current on practices being adopted by CN. (As an independent railway company, there was no requirement to do so.) CN had changed its engineering standards to require fully reflectorized switch targets for hand-operated switches, and subsequently installed fully reflectorized switch targets on all main track hand-operated switches. NBEC was still using some painted switch targets with reflective materials applied only to their tip assemblies. Railway use of the newer SPC standard would have prompted a review of the reflectivity of NBEC main track switch targets, and provided management with an opportunity to identify and correct the defective conditions noted.

[11] Adaptation is defined by the TSB as a planning failure where a deliberate decision to act against a rule or plan has been made.

Miramichi Yard was regularly inspected; however, none of the inspection reports took exception to the poor condition of the switch target, tip assembly, and mast for the main track crossover switch at Mile 65.1. Although the actual date that the target and switch mast were damaged could not be determined, the broken metal parts, bullet holes, and rust on the broken metal parts indicate that the switch had been in this condition for an extended period of time. Lack of detection of these conditions on inspection records suggests that, for the period since NBEC commenced operations, either these conditions were considered acceptable, or their inspections were not focused on identifying such defects. TC safety audits, performed semi-annually since the NBEC start up, also did not mention a defect at the main track crossover switch at Mile 65.1 related to damage to the target and mast. Railway track inspection and maintenance activities and the non-systematic manner in which regulatory safety audits were performed allowed the long-standing, less-than-adequate condition to remain undocumented and unaddressed.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. Because operating practices did not employ consistent confirmation of switch position between crew members, a misunderstanding occurred and a main track switch in the path of an approaching VIA Rail Canada Inc. train was left lined and locked in the wrong position.

2. The locomotive engineer at the controls was vigilant to train operation, but the poor condition of the switch target, tip assembly, and mast prevented the misaligned main track crossover switch from being detected from a distance sufficient to avert the collision.

3. Without frequent and direct railway supervision to educate and correct employee behaviour, the relatively inexperienced operating employees developed alternate work practices related to proper radio communications and the handling of main track switches.

3.2 Findings as to Risk

1. Operating at maximum allowable zone speed within cautionary limits, where various hazards can be encountered, can pose a risk to safe train operations as it reduces the opportunity to protect against hazards other than equipment or a track unit, such as a non-designated main track switch left in a wrong position.

2. The interpretation that *Canadian Rail Operating Rules* Rule 94.1 only applies to designated switches reduces the error tolerance of the system, thereby increasing the risk posed to rail operations by misaligned switches.

3. Without a uniform interpretation of operating rules industry-wide, or training that stresses the differences in rule interpretations, train crews operating on another railway may not apply a rule as intended, thereby increasing the risk of an accident.

4. While the current definition of caution speed allows greater operating flexibility, the higher speeds may increase both crash probability, by lengthening stopping distances, and crash severity.

5. Railway track inspection and maintenance activities, and the non-systematic manner in which regulatory safety audits were performed, allowed the long-standing, poor condition of the switch target and mast to remain undocumented and unaddressed.

3.3 Other Findings

1. The progressive elimination of safety defences, such as removing the advance warning provided by the Automatic Block Signal System, and elimination of maximum speed caps previously contained in the rules (restricted speed and slow speed), did not maintain or enhance the previous level of safety for train or engine operations in yard areas.

4.0 Safety Action

4.1 Action Taken

Soon after the accident, New Brunswick East Coast Railway (NBEC) and parent company Quebec Railway Corporation (QRC) took a number of active steps to enhance the safety of its operations. Meetings were first conducted with employees and supervisors. The meetings were later expanded to include representatives from Canadian National (CN), VIA Rail Canada Inc. (VIA), Transport Canada (TC) and the New Brunswick Department of Transportation. As a result of these discussions and its internal examinations, a multi-faceted safety action plan was identified. Furthermore, NBEC has submitted to the province its new safety management system which encompasses a systematic approach to safety management, including clear guidelines on the role and responsibilities of management and employees, establishment of performance safety objectives, and involvement of employees in risk management.

4.1.1 Inspection and Maintenance of Switch Targets

NBEC surveyed all main track switch targets and implemented a plan to repair and/or replace any that were in less-than-standard condition. All main track switches are now equipped with a regular-type switch stand mast with an elevated large target meeting the new CN specifications (diamond-grade material). Highly reflective material was added to all main track switch targets to increase their visibility, particularly in nighttime conditions. Improvements were also made to inspection procedures to ensure monthly focus on switch components on turnout inspection forms through the introduction of a switch inspection job aid (that is, switch stand mast, target, and tip assembly) to be used in addition to the standard turnout inspection forms.

The railway has committed to maintaining its infrastructure to the most recent CN standards, by adopting the most recent CN Standard Practice Circulars and Standard Plans, and intends to revise and apply any change or new standard as and when CN makes any change to in order to be able to apply the most up-to-date track maintenance standards.

4.1.2 Risk Management Initiative

The QRC has committed to continue/accelerate a risk management initiative that it had undertaken before this accident. The QRC conducted a review of all its operations to identify those locations where the risk of accidents was higher. It has identified five switching yards that pose elevated levels of risk because of the presence of work trains and mainline trains. (The five places identified were Campbellton, Bathurst, and Miramichi on the NBEC; and Rivière-du-Loup and Mont-Joli on the *Matapedia and Gulf Railway*.) To help reduce risk in these areas, the QRC has developed a policy of "segregation of activities"—to decrease the interfaces between yard switching operations and trains that circulate on the main track in these areas, particularly passenger trains. Consideration was given to dedicated track for passenger operations (where

possible), and modification of yard layout (eliminate/modify/relocate) turnouts. The review considered the length of cautionary limits, train speeds, switch stands, targets and tip assemblies, and derails.

As a result of this review, the cautionary limit zones in Miramichi, Bathurst, Campbellton, and Rivière-du-Loup were shortened. The maximum allowed speed within cautionary limits in those yards with main track switches was reduced to 20 mph. Use of the main track for switching at Miramichi has been reduced by moving the switching of the cars to Campbellton and Moncton where they are performed on yard tracks.

The NBEC operating time table and General Operating Instructions have been revised in depth. The revisions include the following:

- CROR Rule 40.2, a rule that required certain main track switches within cautionary limits to be lined and locked in the reverse position to protect track workers, is no longer applicable on all NBEC subdivisions. Workers are now protected through other measures.

- CROR Rule 94.1 and CROR Rule 104 (b) are no longer applicable to the main track switch within cautionary limits located at Mile 65.36. (This reduces the number of main track switches that employees are permitted to leave in a reverse position.) A similar change was made for cautionary limits in Bathurst.

- Daily operating bulletins for train operations have been implemented.

In addition, a level crossing being used by a local snowmobile club was closed at Mile 64.05 of the Newcastle Subdivision in the lower yard at Miramichi.

4.1.3 Operating Practices Related to VIA Passenger Trains

A joint working group was created involving the QRC, NBEC, VIA and labour. Inspections were undertaken on 17 February and 19 February 2000. The purpose of the inspections was to perform a complete review of interaction between passenger and freight operations. The working group focussed on operations within cautionary limits and main track switches (handling procedures and condition).

Management employees from VIA participated in Hi-rail inspections between Rivière-du-Loup and Halifax to personally assess the condition of all main track switch targets on the territory over which VIA 14 operates. As a result, VIA and the NBEC committed to conduct a review of operating conditions at regular intervals. These reviews have identified 12 unused main track switches. These switches have now been spiked for the main track, and are in the progress of being physically removed.

4.1.4 Operating Practices Related to Main Track Switches

On 24 July 2000, NBEC issued two operating bulletins pertaining to additional special instructions for communication procedures under CROR Rule 104 and Rule 123. One bulletin detailed further requirements for all track, transportation and VIA employees when handling main track switches, including increased communication between crews each time main track switches are handled. The other dealt with proper repeat of Occupancy Control System (OCS) clearances among crew members when using a radio or a cellular telephone for the issuance and cancellation of authorities. A copy of the complete wording of the NBEC bulletins is contained in Appendix D.

NBEC supervisors conducted a safety blitz with all its operating employees. During this safety blitz, the following points related to the handling of main track switches were emphasized:

- Permission to open a main track switch outside cautionary limits must always be obtained either verbally from the RTC or must be included on their OCS clearance (except when switching from the main track and the switch being used is not left unattended).

  Once permission has been granted, the RTC must place in the computer-assisted dispatching system a Warning Alarm Message. Such a message must remain in place until the train crew confirms that the main track switch has been returned to a normal position and locked.

- Two or more trains required to protect against another train or work train or foreman does not relieve the crew from complying with Rule 104.

- Employees must report the switch lined and locked in its normal position from the switch location.

- Employees must understand the differences between written permission under Rule 104 (b) on their OCS clearance versus verbal permission under Rule 104.

- The need for proper communication between crew members and compliance with communication procedures (that is, proper repeat of OCS clearances among crew members), as well as ensuring that, before leaving a location where a main track switch has been handled, employees confirm with each other that the switch has been lined and locked in its normal position.

On 14 November 2000, the Minister of Transport issued an Emergency Directive regarding the use of main track switches in non-signalled territory to VIA, CN, Canadian Pacific Railway (CP Rail) and RailAmerica Inc. pursuant to Section 33 of the *Railway Safety Act* (RSA).[12] As a result of the TC Emergency Directive, effective 01 December 2001, the Railway Association of Canada (RAC) (an association of 56 freight, passenger, commuter, and tourist railways that operate throughout Canada) issued the following change to CROR Rule 104:

> 104. HAND OPERATED SWITCHES
>
> (a) Unless otherwise specified by special instructions, the normal position for a main track switch is for main track movement. Except as provided in paragraph (b), main track switches must be lined and locked in normal position. A main track hand operated switch must display a reflectorized target, or light and target, to indicate the following:
>
> (Switch Target Diagrams)
>
> EXCEPTION: A light or reflectorized target need not be maintained on a main track switch in CTC and single track ABS or on a subdivision specified in special instructions.
>
> (b) A main track switch may be left in the reverse position when;
>
> 1) directed by GBO, clearance or special instructions, and protection has been provided against all affected trains or engines,
>
> 2) attended by an employee, who must be in position to restore the switch to normal before it is occupied by an approaching train or engine on the main track,
>
> 3) occupied by equipment,
>
> 4) required in the application of Rule 40.2,
>
> 5) in OCS or cautionary limits;
> i) equipment is left on the main track,
> ii) the equipment is left as close as practical to the switch, and
> iii) movement over the same switch is required when returning to such equipment,

[12] Paraphrased in Appendix C are some of the more salient measures ordered by the Directive.

6) in CTC, equipment is left within the same controlled block. When this cannot be done, RTC permission must be obtained.

Note: Except when switching, main track switches when left in the reverse position, must be left locked.

(c) Unless otherwise specified in special instructions, switches other than main track switches, when equipped with a lock, must be lined in normal position and locked after having been used. When equipped with a target, light or reflector it will indicate the following:

(Switch Target Diagrams)

(d) The employee handling a main track hand operated switch in non-signalled territory must, from the location of the switch, communicate with another rules qualified 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.

NOTE: This rule also applies where ABS signals do not govern movement in both directions.

(o) When a switch point lock is provided, it must be locked when the switch is left in normal position. Employees must familiarize themselves with the location of switch point locks.

(q) Unless or until the switch is seen to be in normal position, trains and engines approaching a main track hand operated switch in a facing point direction in OCS territory, unless otherwise governed by signal indication, must not exceed the following speeds from one-quarter of a mile of the switch;

PASSENGER 50 MPH
FREIGHT 45 MPH
FREIGHT handling Special Dangerous Commodities 40 MPH

4.1.5 Training and Qualification Procedures

NBEC reviewed its training and qualification procedures to ensure that all personnel were qualified and adequately trained. Comparisons were made with the training of NBEC personnel to external standards (e.g. CANAC). Operating employees who were previously trained in the operating rules by NBEC were provided with additional rules training by CANAC personnel.

4.1.6 Supervision

The QRC made a number of organizational changes. It removed individual service departments from NBEC and created an eastern service division that reports directly to personnel in Montréal. This change is intended to enable a greater focus on operating issues specific to the nature of each railway within the corporation and increase the efficiency/safety of their overall operations.

To add more depth to the management team, several key operating positions were filled with experienced railway individuals (all with more than 25 years of railway service). A new supervisory position was created and staffed in Campbellton on the NBEC, whose primary duties are to oversee the safety of all QRC operations. This position provides supervisory and training support for supervisors already in place on each railway. Safety performance is now tracked by using NBEC monthly statistics, compared to QRC and other similar size railways, and are reviewed regularly with the Health and Safety Committee. Monthly conference calls, with mandatory participation by senior railway management personnel, focus on topics of safety and emphasize continued supervisory involvement in risk-reduction activities.

An overall operational safety audit was conducted in March 2000. The audit included the following activities:

- observing employee compliance with applicable rules and procedures;
- identifying possible shortfalls in procedures;
- communicating expectations; and
- ensuring continued and consistent focus on safe working practices

The results of the safety audit were used to develop detailed safe work practice descriptions which are used by supervisors as an observation and application tool to be used on the job. The objectives are set and the results are monitored and discussed during the above mentioned monthly conference calls.

Arrangements were also made for an audit by RAC personnel regarding transportation of dangerous goods on the NBEC. The audit was conducted on 22 March and 23 March 2000.

The QRC has implemented a personal protective equipment policy and a job briefing policy on all its railways. Job aids, including a job briefing aide-memoire, were developed to ensure consistency of briefing procedures.

NBEC has embarked on a safety partner program, consisting of experienced employees with sound operating practices accompanying their peers in an observation/coaching role.

4.1.7 Passenger Safety

On 01 February 2000, TC issued a direction to VIA under subsection 145(2) of the *Canada Labour Code*, Part II, Occupational Safety and Health (see Appendix E). The direction pertained to the potential danger that hot water in the steam table of some VIA dining cars posed to employees at work. The applicable dining cars operated between Montréal and Halifax. VIA was required to take immediate steps to protect employees from the source of that danger. In response to this direction, VIA removed steam tables from all its dining cars that were so equipped.

Subsequent to examination of four other VIA accidents, on 20 July 2001, the TSB issued Rail Safety Advisory 05/01 to TC entitled "Observations of Railway Passenger Safety in Canada." This advisory, after describing how TC and VIA had improved passenger safety over the past 11 years by addressing previous Board recommendations, provided a brief investigative summary of the five accidents. Safety deficiencies identified as a result of these five investigations were then discussed in relation to previously issued Board recommendations addressing similar issues. The safety issues fell into four general categories: passenger preparedness, occupant protection, evacuation, and emergency response and rescue. The rail safety advisory concluded that many relatively minor issues relating to passenger safety remain unaddressed, which on their own do not pose a significant risk, but when taken in combination, indicate a possible systemic risk situation. It stated that:

> Transport Canada and industry may wish to examine these issues and in view of the potential combined risk, evaluate the adequacy of their existing regulatory and safety management approaches in these areas.

On 10 September 2001, TC responded advising that its staff had met with representatives of VIA on 13 August 2001 and was following up with VIA for confirmation of action taken, underway or proposed. In addition, TC provided the RAC with a copy of the rail safety advisory in order that its other passenger-carrying members could be apprised of these issues.

4.1.8 New Technologies for Indicating Position of Main Track Hand-Operated Switches on Non-Signalled Rail Lines

The Transportation Development Centre, on behalf of TC Rail Safety, retained the Transportation Group at the University of New Brunswick to conduct a study to identify the existence and availability of technologies capable of indicating the position of hand-operated switches on non-signalled rail lines. The study was designed to conduct a technical and scientific review of technologies using surveys directed to universities, research and/or development centres and suppliers/manufacturers of signalling equipment. The surveys were directed to institutions and firms in Canada, the United States, Europe and Australia. In addition, visits and interviews were held with representatives of TC, the RAC, CN, CP Rail, the Brotherhood of Locomotive Engineers and selected companies and institutions.

Using available data, which were limited in some cases, an initial cost-benefit analysis was undertaken to assess the savings from reduction in property damage, personal injuries and fatalities on main lines if a system were installed to provide advance warning to train crews on the position of hand-operated switches on non-signalled rail lines. Passenger travel time and cargo savings were also used in the analysis. An estimate of future accidents related to the improper positioning of hand-operated switches was made. An expanded analysis would require a more detailed historic accident database.

Ten technologies that appeared to have potential for application to the study objective were identified. Of these, five were considered to have the highest probability of successful application. The technologies identified ranged from a prototype under testing by CN to individual components that could be assembled to construct a system.

Discussions with experts and railway operators indicate that they believe that sufficient technological means exist to develop suitable products and/or implement existing technologies. The most important issues are that the selected system should provide a high level of reliability at the lowest cost, combined with ease of installation and operation, minimal maintenance requirements, and extended durability.

None of the technologies could be justified financially from a safety perspective only. However, the study noted that they should be economically viable if certain travel time savings were included[13].

[13] A note on the back of the front cover page states "the report reflects the views of its authors and not necessarily those of the Transportation Development Centre". Members of its steering committee expressed concern over the methodology used to obtain the cost-benefits.

4.1.9 Regulatory Harmonization of Operating Rules

TC has contacted the Railway Association of Canada, suggesting that the question of the various applications of CROR Rules 94.1 and 104(b) amongst membership railways be examined with a view to harmonize the railways' written instructions. TC is collaborating with all provinces on the *Federal-Provincial Regulatory Regimes Harmonization Project*. The purpose of the Harmonization Project is to ascertain, contrast and compare the federal and provincial rail safety regulatory regimes and to identify gaps and opportunities for greater regulatory harmonization between the various jurisdictions.

Also, officials from the NB Department of Transportation are following-up with both NBEC and TC regarding the issues of improved supervision and inspection practices.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 22 April 2003.

Visit the Transportation Safety Board of Canada web site - www.tsb.gc.ca - for information about the TSB and its products and services. There you will also find links to other safety organizations and related sites.

Appendix A - Target Detection Methodology

TSB personnel conducted tests at the Walkley Yard in Ottawa to determine visibility distances for the main track crossover switch target and for other target configurations. Six qualified locomotive engineers and one qualified conductor viewed normal or reversed targets from the cab of a stationary locomotive located between 500 feet and 3500 feet from the target. Targets from the following set were individually presented with 50 per cent likelihood of reversed alignment:

1	the occurrence target on its broken mast
2	a painted target with painted tip on a low mast
3	a painted target with reflectorized tip on a low mast
4, 5	two reflectorized targets (two brands of reflectorized material) with reflectorized tip on a low mast
6, 7	two reflectorized targets (two brands of reflectorized material) with reflectorized tip on a high mast

Within a single trial simulating an approach to a switch target, an observer viewed a target for a maximum of four seconds and recorded one of three responses on an individual response sheet—"normal", "reverse" (at the level of certainty needed to initiate emergency braking), or "wait" (indicating that, on the job, the observer would have waited until the locomotive was closer to the target to be certain of the switch alignment). Within a block of trials, all targets were presented in each orientation several times in random order, with the exception that reflectorized targets (targets 4 to 7) were not presented nearer than 2000 feet, as reversed reflectorized targets were always identified at that distance. The locomotive was moved to a different location for each block of trials. Table 2 shows the number of target presentations of each target.

		Distance to Target							
		500 feet	1000 feet	1500 feet	1750 feet	2000 feet	2500 feet	3000 feet	3500 feet
Target	1	8	8	28	8	28	8	10	4
	2	8	8	18	6	38	8	10	4
	3	8	8	22	8	26	8	10	4
	4	0	0	0	0	6	8	10	4
	5	0	0	0	0	6	8	10	4
	6	0	0	0	0	6	8	10	4
	7	0	0	0	0	6	8	10	4

Table 2. Total number of reversed target presentations

Visibility distances at the occurrence site are not directly comparable to visibility distances determined at the Walkley Yard test site (that is, the visibility distance to the occurrence target at Walkley Yard does not indicate the expected visibility distance to the occurrence target at the occurrence site) because conditions at the Walkley Yard test site differed from conditions at Miramichi in several important respects. First, at Walkley Yard, the target was directly illuminated by the sun, while at the occurrence site, the target was shaded by box cars on the adjacent track. Second, at Walkley Yard, the target background was dry light grey or brown ballast rather than snow, reducing contrast between the target and the background and perhaps making the colour easier to identify. Third, at Walkley Yard, the locomotive engineers were stationary, had no other tasks at the same time, and knew the target location exactly, unlike the cognitive workload within the actual operating environment and

occurrence circumstances. Finally, probability of a reversed target at Walkley Yard was 50 per cent, while under actual operating conditions, a locomotive engineer may work for years without encountering an unexpectedly reversed switch. Each of these situations will reliably cause considerable overestimation of switch target sight distance. Accordingly, target sight distances are likely to be much greater at Walkley Yard than at the occurrence site. However, these reasons equally affect the visibility of the occurrence target and targets in good condition. Therefore, the ratio of sight distances for the occurrence target relative to good condition targets is likely similar in both settings.

Results

For each distance and target type, "normal" and "wait" responses made to reversed target presentations were added together ("wait" responses were classified as detection failures because they would not lead to initiation of emergency braking) and divided by the total number of reversed target presentations to calculate the probability of detection failure for reversed targets. Table 3 shows the number of total detection failures for those target presentations, and Table 4 shows the proportion of detection failures.

		Distance to Target							
		500 feet	1000 feet	1500 feet	1750 feet	2000 feet	2500 feet	3000 feet	3500 feet
Target	1	1	1	21	8	22	8	8	4
	2	0	0	0	0	3	3	4	2
	3	0	0	0	0	0	2	3	2
	4					0	1	1	3
	5					0	7	6	3
	6					0	6	5	4
	7					0	7	9	4

Table 3. Reversed target detection failures

		Distance to Target							
		500 feet	1000 feet	1500 feet	1750 feet	2000 feet	2500 feet	3000 feet	3500 feet
Target	1	0.125	0.125	0.75	1	0.786	1	0.8	1
	2	0	0	0	0	0.079	0.375	0.4	0.5
	3	0	0	0	0	0	0.25	0.3	0.5
	4					0	0.125	0.1	0.75
	5					0	0.875	0.6	0.75
	6					0	0.75	0.5	1
	7					0	0.875	0.9	1

Table 4. Reversed target detection failure probability

While reversed targets in good condition are detected without error at a distance of 2000 feet with tip reflectorization and at 1750 feet with no tip reflectorization, the occurrence target is not detected error-free even at 500 feet. Even in the conditions of the Walkley Yard simulation, the occurrence target only begins to indicate switch position at about half the distance of targets in good condition.

Appendix B - Passenger Train Braking Distances

COMPARISON OF METHODOLOGIES
EMERGENCY STOP DISTANCES—FOUR-SECOND REACTION TIME

SPEED	EXTRAPOLATED DISTANCE *Locomotive Brake Applied	AVERAGED DISTANCE *Locomotive Brake Applied	THEORETICAL DISTANCE *Locomotive Brake Applied
45	1357	1366	1389
41	1170	1178	1204
40	1126	1133	1159
35	914	920	949
30	723	728	758
25	552	556	587
20	401	404	434
15	271	273	299

FULL SERVICE STOP DISTANCES—FOUR-SECOND REACTION TIME

SPEED	AVERAGED DISTANCE *Locomotive Brake Applied	THEORETICAL DISTANCE *Locomotive Brake Applied	DISTANCE *Locomotive Brake Released
45	1540	1564	1967
41	1323	1350	1682
40	1271	1298	1614
35	1027	1057	1297
0	807	839	1014
25	612	644	765
20	441	472	549
15	294	322	365

VIA 14 STOPPING DISTANCE
VIA LOCOMOTIVE 6450—DISTANCE EXTRAPOLATION FROM DOWNLOAD
CALCULATED AT ONE-SECOND INTERVALS USING OBSERVED
MAXIMUM DECELERATION RATES FROM DOWNLOAD DATABASE AVERAGES

TIME	DATE	THR POS	SPEED (mph)	ACCL (mph/s)	DISTANCE (feet)	BP (psi)	BC (psi)
1010:22	1/30/00	4	1.00	0	0	99	0
1010:27	1/30/00	4	3.00	1.1	11	99	0
1010:29	1/30/00	4	5.00	1.1	21	99	0
1010:32	1/30/00	7	5.00	0.3	42	99	0
1010:33	1/30/00	7	7.00	1.1	53	99	0

VIA 14 STOPPING DISTANCE

VIA LOCOMOTIVE 6450—DISTANCE EXTRAPOLATION FROM DOWNLOAD

CALCULATED AT ONE-SECOND INTERVALS USING OBSERVED MAXIMUM DECELERATION RATES FROM DOWNLOAD DATABASE AVERAGES

TIME	DATE	THR POS	SPEED (mph)	ACCL (mph/s)	DISTANCE (feet)	BP (psi)	BC (psi)	
1010:36	1/30/00	7	9.00	1.1	84	99	0	
1010:38	1/30/00	8	9.00	0.45	111	99	0	
1010:39	1/30/00	8	11.00	1.1	121	99	0	
1010:42	1/30/00	8	13.00	1.1	174	99	0	
1010:45	1/30/00	8	15.00	1.1	232	99	0	
1010:48	1/30/00	8	17.00	1.1	301	99	0	
1010:50	1/30/00	8	19.00	1.1	348	99	0	
1010:52	1/30/00	8	21.00	1.1	407	99	0	
1010:54	1/30/00	8	21.00	0.45	470	99	0	
1010:55	1/30/00	8	23.00	1.1	502	99	0	
1010:58	1/30/00	4	25.00	1.1	607	99	0	
1011:03	1/30/00	4	27.00	1.1	787	99	0	
1011:10	1/30/00	4	29.00	1.1	865	99	0	
1011:17	1/30/00	4	31.00	1.1	1368	99	0	
1011:25	1/30/00	4	33.00	1.1	1732	99	0	
1011:27	1/30/00	2	33.00	0.13	1827	99	0	
1011:29	1/30/00	2	33.00	0.13	1927	99	0	
1011:33	1/30/00	2	35.00	1.1	2117	99	0	
1011:48	1/30/00	2	37.00	1.1	2888	99	0	
1012:01	1/30/00	2	39.00	1.1	3596	99	0	
1012:14	1/30/00	2	41.00	1.1	4340	99	0	MAXIMUM SPEED
1012:19	1/30/00	2	41.00	-0.07	4641	99	0	HORN BLOWN
1012:20	1/30/00	2	41.00	-0.07	4704	99	0	
1012:23	1/30/00	0	41.00	-0.07	4884	64	0	EMERGENCY
1012:24	1/30/00	0	41.00	-0.07	4942	2	6	
1012:25	1/30/00	0	41.00	-0.07	5005	2	19	
1012:26	1/30/00	0	41.00	-0.07	5064	2	33	
1012:27	1/30/00	0	41.00	-0.07	5127	2	56	
1012:28	1/30/00	0	39.00	-1.1	5185	2	70	
1012:29	1/30/00	0	39.00	-0.9	5243	2	78	
1012:30	1/30/00	0	36.00	-2.1	5296	2	78	
1012:32	1/30/00	0	33.00	-2.1	5401	2	78	
1012:33	1/30/00	0	31.00	-2	5444	2	78	
1012:34	1/30/00	0	29.00	-2	5491	2	83	IMPACT
1012:35			27.00	-1.8	5531			
1012:36			25.20	-1.8	5568			

VIA 14 STOPPING DISTANCE

VIA LOCOMOTIVE 6450—DISTANCE EXTRAPOLATION FROM DOWNLOAD

CALCULATED AT ONE-SECOND INTERVALS USING OBSERVED
MAXIMUM DECELERATION RATES FROM DOWNLOAD DATABASE AVERAGES

TIME	DATE	THR POS	SPEED (mph)	ACCL (mph/s)	DISTANCE (feet)	BP (psi)	BC (psi)
1012:38			21.60	-1.8	5634		
1012:39			19.80	-1.8	5663		
1012:40			18.00	-1.8	5689		
1012:41			16.20	-1.8	5713		
1012:42			14.40	-1.8	5734		
1012:43			12.60	-1.8	5753		
1012:44			10.80	-1.8	5768		
1012:45			9.00	-1.8	5782		
1012:46			7.20	-1.8	5792		
1012:47			5.40	-1.8	5800		
1012:48			3.60	-1.8	5805		
1012:49			0	-1.8	5811		
0		Time					

DISTANCE TRAVELLED IN EMERGENCY TO IMPACT	607
EXTRAPOLATED DISTANCE FROM EMERGENCY	921
WITH REACTION TIME ADDED	1170

Rolling stock observed performance characteristics used for braking beyond point of impact.
Train went distance of 607 feet from emergency to impact.
Train would require distance of 921 feet to stop from emergency initiation.
Based on train crew's recollection of events, reaction time to stimulus is four seconds.
Train was 850 feet from impact point at that time.
With reaction time added, extrapolated stop distance is 1170 feet.

Appendix C - Transport Canada Emergency Directive

On 14 November 2000, the Minister of Transport issued an emergency directive regarding the use of main track switches in non-signalled territory to VIA, CN, CP Rail and RailAmerica Inc. pursuant to section 33 of the *Railway Safety Act*. Paraphrased below are some of the more salient measures ordered by the directive.

1. Passenger trains shall not exceed 50 mph when encountering a facing point switch in non-signalled territory until the operating crew members can confirm that the switch is properly lined for their intended movement.

2. All other track movements, except for those trains handling special dangerous goods, shall not exceed 45 mph when encountering a facing point switch in non-signalled territory until the operating crew members can confirm that the switch is properly lined for their intended movement. Trains handling special dangerous goods are restricted to 40 mph instead of 45 mph.

3. All employees using main track switches in non-signalled or Automatic Block Signal System territory must immediately confirm to another employee by personal contact, radio, or other communication, that they have fulfilled the requirements of CROR Rule 104 by announcing that the "switch at *insert location and name* has been restored for the main track (or other route authorized by Rule 104(b))." Employees must not leave switches unattended until they have been restored to the main track (or other authorized route), and the above noted confirmation procedure is repeated.

4. In addition to the above-noted items, the referenced railways are required to submit detailed plans of additional measures to be implemented with regard to further mitigation of the risks associated with the use of main track switches in non-signalled territory.

   With respect to items 3 and 4, the referenced railways must report monthly with respect to the progress of implementation of mitigation measures, covering, but not limited to, such items as

   - training and examinations given to employees with respect to the use of switches;
   - proficiency testing conducted with respect to the use of switches, including results; and
   - progress with the development and installation of new technologies, procedures and/or methods.

This directive was to remain in effect for a period of six months unless the Minister of Transport was satisfied that the risk associated with the use of main track switches had been adequately mitigated.[14]

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[14] Effective 01 December 2001, the RAC issued a rule change to CROR Rule 104 incorporating additional safety elements of the TC directive into the new rule (see section 4.1.4).

Appendix D - NBEC Operating Bulletins

Operating Bulletin CROR. Rule 83(a) No 2000/07/18/01
TO ALL TRACK, TRANSPORTATION EMPLOYEES AND VIA RAIL CREWS

Rule 104 (b) is revised to include the following special instruction:

Special Instruction (5)

Effective Saturday July 22nd, unless permission is provided to leave a main track switch in reverse position as per Rule 104 (b) on the OCS clearance, a member of a train or engine crew required to handle a main track switch outside cautionary limits must receive verbal permission from the RTC. The RTC must be advised immediately from the switch location when a switch is lined and locked in normal position. This verbal permission does not relieve the train or engine crew from compliance with Rule 104.

When two or more trains are required to protect against each other, or a train is required to protect against a work train, or a train is required to protect against a foreman and permission to handle a switch is not included on the OCS clearance as per Rule 104 (b), permission to use a main track switch must be obtained from the train, engine or foreman granting permission to enter the limits and must be included in the instructions made between crew members or between crew members and foreman. The train or foreman granting permission to use the switch in reverse position must be advised from the switch location when the switch is returned to normal position and locked. This permission does not relieve the train or engine crew from compliance with Rule 104.

Exception: When switching is to be performed from the main track and part of the train remains on the main track during switching move, verbal permission to operate the switch is not required.

An employee qualified in the Rules for the Protection of Track Units and Track Work must:

(i) before leaving a location where a main track switch has been handled, confirm with another qualified employee (unless no other employee is immediately available) that the switch has been lined and locked in normal position. If no other employee is immediately available the employee must initiate a radio broadcast on the designated end to end standby channel that the switch has been lined and locked in normal position.

(ii) when authorizing a train or engine to enter WORK LIMITS, have confirmed with another qualified employee (unless no other employee is immediately available) the position of main track switches handled, such information must be included in the permission granted.

Example: "CFMG 6109 East, okay to proceed through my limits with no restrictions. I am in the clear at Charlie and siding east switch at Charlie that I have handled is lined and locked in normal position. Call when you clear my limits."

(iii) When cancelling an OCS clearance, the employee must verbally advise the RTC of all main track switches used within the limits of the clearance and that they have been left lined and locked in normal position.

Example: "RTC, Okay to cancel the work clearance for foreman White between Able and Charlie. We handled both siding switches at Baker, and they have been left lined and locked for normal position."

Operating Bulletin CROR. Rule 83(a) No 2000/07/18/02
TO ALL TRACK, TRANSPORTATION EMPLOYEES AND VIA RAIL CREWS

Rule 123 is revised to include the following instruction.

Special Instruction (1)
Effective immediately Radio communication must be used for the issuance and cancellation of authorities. Cellular phone may be used when radio signal is too weak
or a communication tower is out of service. When cellular phone is used as a method of
radio communication, all radio Rules must be complied with.

Should a cellular phone be required to copy or cancel an authority, a repeat must be
Obtained from both the conductor and locomotive engineer.

Appendix E - TC Direction to VIA Concerning Steam Tables in Dining Cars

IN THE MATTER OF THE *CANADA LABOUR CODE*
PART II—OCCUPATIONAL SAFETY AND HEALTH

DIRECTION TO THE EMPLOYER UNDER SUBSECTION 145(2)

On February 01, 2000, the undersigned safety officer conducted an inspection in the work place of on board train crews (dinning car VIA 8417) operated by VIA Rail Canada, being an employer subject to the *Canada Labour Code*, Part II, at 2 Place Ville Marie, Montreal, Quebec, H3B 2C9.

The said safety officer is of the opinion that a condition exists that constitutes a danger to employees at work:

The hot water contained in the steam table of VIA dining car #8417 has the potential to be splashed on employees in the event of a derailment, emergency stops or other sudden movements.

Therefore, you are HEREBY DIRECTED, pursuant to subsection 145(2)(a) of the *Canada Labour Code*, Part II to take measures immediately for guarding the source of the danger.

Issued at Moncton, NB, this 4th day of February, 2000

Appendix F - List of Supporting Reports

The following TSB Engineering Laboratory report was completed:

LP 17/00—Rail Switch Target Examination

This report is available upon request from the Transportation Safety Board of Canada.

Appendix G - Glossary

ABS	Automatic Block Signal System
CANAC	CANAC International Inc.
CN	Canadian National Railway
CP Rail	Canadian Pacific Railway
CROR	Canadian Rail Operating Rules
CTC	Centralized Traffic Control System
FRA	Federal Railroad Administration
GBO	General Bulletin Order
mph	mile per hour
NBEC	New Brunswick East Coast Railway
OCS	Occupancy Control System
OTS	on-train service
psi	pound per square inch
QRC	Quebec Railway Corporation
RAC	Railway Association of Canada
RSA	*Railway Safety Act*
RTC	rail traffic controller
SPC	Standard Practice Circular
TC	Transport Canada
TCS	Traffic Control System
TDC	Transportation Development Centre
TSB	Transportation Safety Board of Canada
UCOR	Uniform Code of Operating Rules
U.S.	United States
VIA	VIA Rail Canada Inc.