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

RAILWAY INVESTIGATION REPORT
R08W0058

MAIN-TRACK COLLISION AND DERAILMENT

CANADIAN PACIFIC RAILWAY
FREIGHT TRAINS 498, 497, AND 292
MILE 97.5, WEYBURN SUBDIVISION
CENTENNIAL STATION, NEAR RALPH, SASKATCHEWAN
07 APRIL 2008

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Railway Investigation Report

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Summary

At approximately 0807 central standard time on 07 April 2008, southbound Canadian Pacific Railway (CPR) freight train 498-07 struck the tail end of stationary CPR train 292-05 at Mile 97.5 of the Weyburn Subdivision at Centennial Station near Ralph, Saskatchewan. Seven cars on train 292-05 derailed and two cars on train 498-07 derailed. In addition, two cars on CPR freight train 497-04, which had stopped adjacent to train 292-05 in Centennial siding, derailed. A fire ensued involving two cars loaded with glycol, one dangerous goods car containing vinyl acetate, one residue liquefied petroleum gas tank car, and one empty bulkhead flat car. Local residents within a one-mile radius of the accident were evacuated. There were no injuries.

Ce rapport est également disponible en français.

Other Factual Information

On 07 April 2008 at 0245 central standard time [1], the crew on Canadian Pacific Railway (CPR) freight train 498-07 (train 498) were called to take train 498 south from Moose Jaw, Saskatchewan (SK) to North Portal, SK, via the Weyburn Subdivision (see Figure 1).

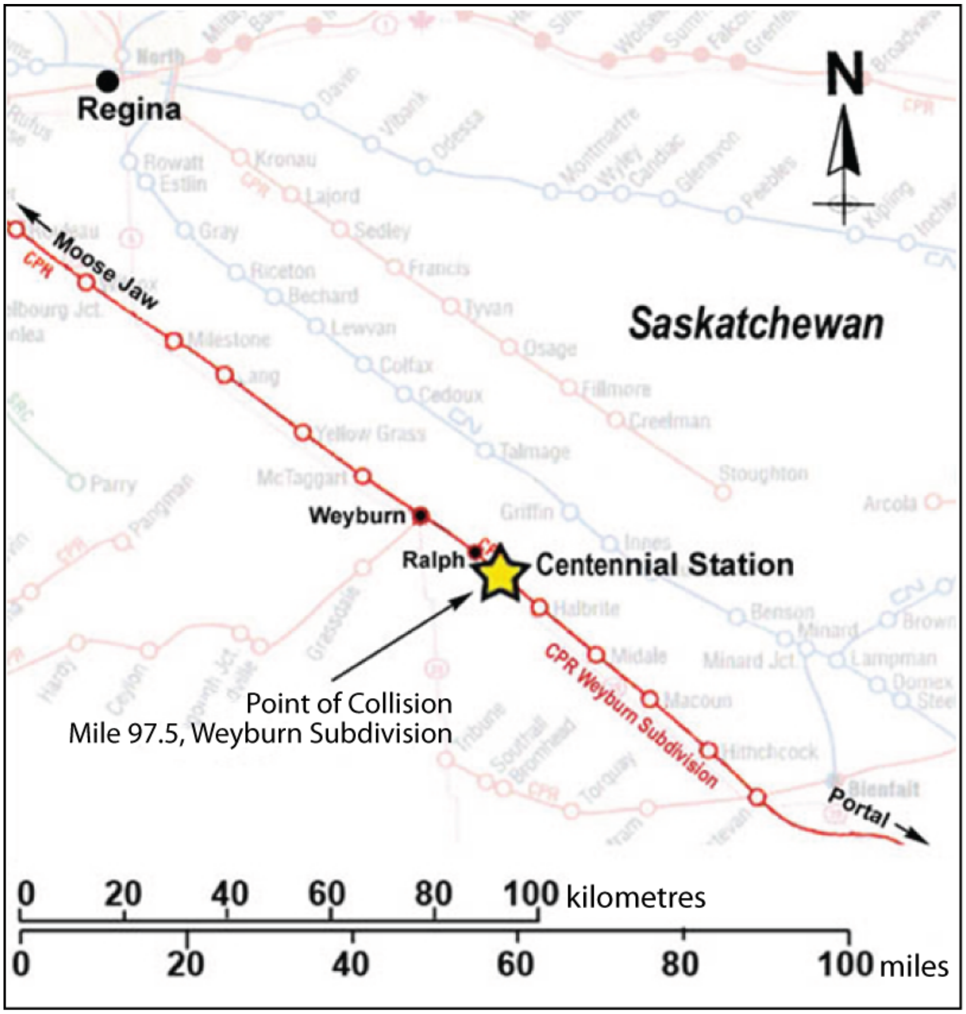

Figure 1. Map of the derailment location (Source: Railway Association of Canada)

Train 498 departed Moose Jaw at 0532. The crew was issued a series of clearance authorities that allowed the train to proceed between well-defined locations with a restriction to protect against train 292. Train 292 was also en route to North Portal via the Weyburn Subdivision roughly 45 minutes ahead of train 498. Prior to arriving at Centennial, train 498 was sufficiently behind train 292 that its journey was not affected by the instruction to protect.

1 All times are central standard time (Coordinated Universal Time minus six hours).

At 0735, the rail traffic controller (RTC) issued a clearance authorizing train 498 to proceed from the south siding switch at Weyburn to the south siding switch at Centennial. This clearance included a restriction to protect against train 292 from the north siding switch at Centennial.

At approximately 0801, after passing Weyburn (Mile 85.1), the crew on train 498 contacted the RTC to request a clearance to proceed beyond Centennial. The RTC informed them that train 292 was stopped on the main track between the north and south switches at Centennial. Following this communication, the crew on train 498 became aware that they and train 292 would both meet northbound train 497 at Centennial. Train 292 had been stopped at Centennial for over 45 minutes.

At approximately 0802, the conductor of train 498 also gave a track release to the RTC that they were clear of Mile 89. Shortly thereafter, at approximately 0803, train 498 received an "all clear" broadcast from the hot box detector (HBD) at Mile 94.7 (An HBD broadcast overrides other radio communications). The conductor of train 498 then contacted train 292 to request arrangement to close-up [2]. The close-up was granted to train 498.

Just prior to reaching Centennial, the conductor's attention was focused on completing various secondary tasks, including listening for the HBD message, radio communications, and completion of paperwork.

At 0806, train 498, travelling at 36 miles per hour (mph), passed the north switch at Centennial. Shortly thereafter, the crew realized that they would collide with train 292 which was stopped ahead on the main track. The crew applied the emergency brakes. Approximately 20 seconds later, train 498's lead locomotive collided with the tail end of train 292. As a result of the impact, seven cars on the tail end of train 292 derailed and two cars on train 498 derailed. In addition, two cars on train 497, which was stationary in Centennial siding, derailed during the resulting side collision with derailed cars from train 292 (see Figure 2).

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2 A close-up provides a following train permission to pull up close to another train's tail end. The leading train must be stopped.

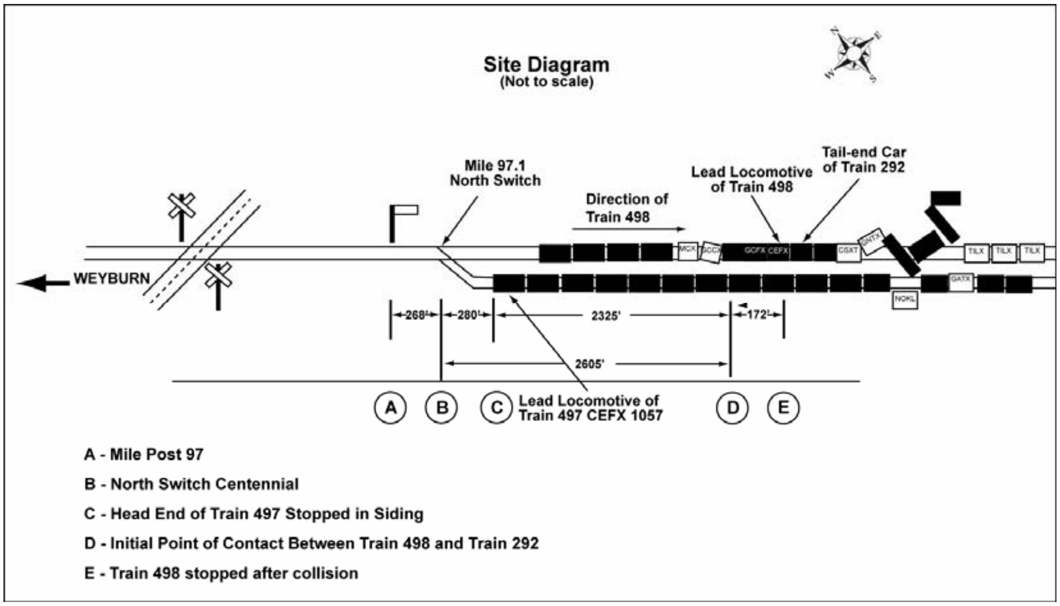


Figure 2. Derailment site diagram

Subsequent to the derailment, the locomotive engineer from train 498 initiated an emergency call. As a result of the damage to the cars, a fire erupted at the tail end of train 292 (see Photo 1). Five cars were involved in the fire: two loaded tank cars containing glycol (UN 3082), a tank car containing vinyl acetate (UN 1301), a residue liquefied petroleum gas (UN 1075) tank car, and one bulkhead flat car. The crews on train 498 and train 497 evacuated from the immediate derailment area. There were no injuries to any of the crew members.

Photo 1. Resulting fire after collision (Source: CPR)

At the time of the occurrence, the skies were clear, the wind was calm, and the temperature was 5ºC.

Local first responders from the town of Weyburn arrived on scene shortly after the fire occurred. The Weyburn Fire Department was also dispatched and arrived shortly thereafter. Local Royal Canadian Mounted Police (RCMP) arrived within a few minutes of the call from the railway. The RCMP helped with the evacuation of six homes situated within a one-mile radius of the accident site. The evacuated residents were allowed to return home the next day.

Crew Information

The crews on train 498 and train 292 consisted of a locomotive engineer and a conductor. The crew on train 497 consisted of a locomotive engineer, a conductor, and a conductor trainee. All three crews were qualified for their respective positions, familiar with the territory, and met current fitness and rest standards.

The locomotive engineer on train 498 had 30 years of service and the conductor had 15 years of service. They had frequently worked together as a crew. Both crew members were called to work at approximately 0245 on the morning of 07 April 2008. They had to report to the Moose Jaw rail yard by 0345 to assume responsibility for train 498 departing at 0530 on the morning of 07 April 2008. A compilation of the amount of rest on the two nights preceding the occurrence indicated that both crew members had approximately 7.5 to 8.5 hours of rest on 05 April 2008, and 6.5 hours on 06 April 2008. These periods of rest were not all sleep.

Train Information

Train 498 consisted of two locomotives and 33 cars. It weighed approximately 4778 tonnes and was 2098 feet in length. The train had received a number one air brake test by a certified car inspector prior to departing Moose Jaw. Equipment maintenance records indicate that all cars had been maintained in a serviceable condition. The locomotives on train 498 were equipped with dynamic brakes. Post-accident testing of the dynamic brakes determined that they were fully functional.

Train 497 consisted of four locomotives and 100 cars. It weighed 7263 tonnes and was 6442 feet in length.

Train 292 consisted of two locomotives and 102 cars. It weighed 8947 tonnes and was 6507 feet in length. The last car on train 292 was equipped with a flashing marker. However, at the time of the occurrence, the flashing marker had been automatically turned off by a light-sensing photo cell to conserve energy during daylight hours.

Recorded Information

The download from train 498's locomotive event recorder (LER) provided the following information:

Time	Mileage	Speed	LER Event
0804:23	95.91	42 mph	Throttle reduced from 1 to 0
0804:52	96.25	42 mph	Dynamic brake applied at notch 1.8
0805:18	96.55	41 mph	Dynamic brake increased to notch 3.3
0806:04	97.07	38 mph	Dynamic brake fully applied
0806:15	97.17	36 mph	Lead locomotive passed the north siding switch Centennial
0806:33	97.36	34 mph	Emergency brakes applied
0806:51	97.50	22 mph	Train 498 collides with Train 292
0807:22	97.55	0 mph	Train 498 comes to a complete stop

Weyburn Subdivision

The Weyburn Subdivision is 158 miles long and extends from Pasqua, SK to North Portal, SK. Subdivision track speed ranges between 25 mph and 50 mph. In the vicinity of the Centennial siding, the speed for the main track is 50 mph. Train movements on this subdivision are governed by the Occupancy Control System (OCS) as authorized by the *Canadian Rail Operating Rules* (CROR) and supervised by an RTC located in Calgary, Alberta. To ensure safe, efficient train movement, the RTC issues operating instructions which include clearances, track occupancy permits (TOPs), and general bulletin orders (GBOs).

Traffic volumes on the Weyburn Subdivision range from 12 trains per day to 20 trains per day with an average of 18 trains per day. The Weyburn Subdivision is a secondary main line.

Track Information

The main track in the vicinity of the occurrence consisted of 115-pound Algoma continuously welded rail (CWR) manufactured in 1982. The ties were No. 1 softwood ties with standard double-shouldered tie plates. The rail was anchored with three spikes per tie. The ballast was crushed rock with 16-inch shoulders. Prior to the accident, no significant track exceptions had been noted in the vicinity of the accident. The track in the area of the derailment was maintained within the guidelines for Class 4 track.

The track in Centennial siding consisted of 115-pound CWR manufactured in 1974. The siding was approximately 8900 feet in length.

Applicable CROR Rules

When one train is following another train, applicable CROR rules for voice communications between crew members and with other train crews include:

A. CROR Rule 90 System Special Instruction regarding communication between crew members specifies (in part):

Voice communication – additional requirements

1. In addition to the requirements of Rule 90, voice communication must be made at the following times and places:
   a) Before departure from location where crew receives operating authority, stating:
      - Name of station from which the train is departing;
      - Location train is first restricted by limit of operating authority (item 3), item 4, 6, 7, or 8 of clearance.
   b) In OCS, unless otherwise specified by subdivision footnote, before passing station mile signs en route, stating:
      - Name of the station;
      - Location the train is first restricted by limit of operating authority (item 3), item 4, 6, 7, or 8 of clearance.

When all crew members are located in the operating cab of the lead locomotive:

- A crew member will make such announcement on the standby radio channel designated in the time table.

B. CROR Rule 142 regarding Understanding between Crew Members specifies (in part):

(a) Every conductor, locomotive engineer, pilot and snow plow foreman must read and have a proper understanding of GBO, clearances and DOB [daily operating bulletin] as soon as possible after they have been received. Each GBO, clearance and DOB must be made available to other crew members, as soon as practicable, ensuring that each crew member has read and understands them and, when required, the arrangements for protection between crews and between foremen and crews.

(b) Crew members within physical hearing range are required to remind one another of the restrictions contained in GBO, clearances and DOB in sufficient time to ensure compliance.

C. CROR Rule 303.1 specifies (in part):

(e) When the preceding train has stopped, arrangements may be made with the following train to "close-up". These arrangements must be made in writing between the crews of both trains. When the preceding train resumes movement, the following train will be governed by paragraph (c).

Paragraph (c) specifies:

Except as provided in paragraph (e), a train so restricted must not leave the location named nor leave any identifiable location until the preceding train has reported that it has left an identifiable location ahead. This report must be recorded in writing by a crew member of the following train. Such information may be received from the RTC. Note: Identifiable locations as listed in Rule 49 (b) must be used.

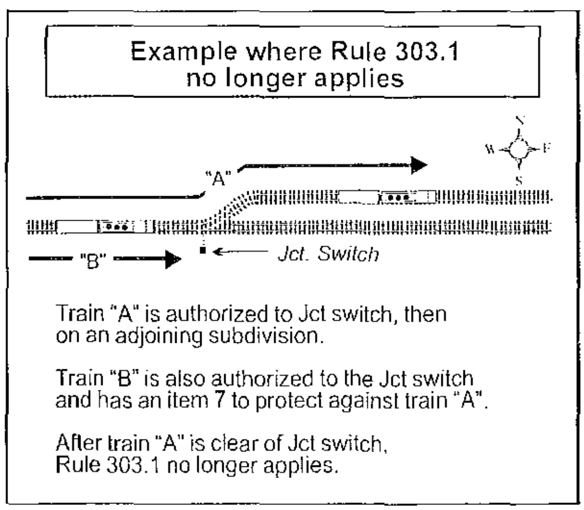
D. CPR — System Special Instruction pertaining to Rule 303.1:

In OCS outside ABS [Automatic Block Signal System]. Rule 303.1 applies and Rule 303 (b) does not apply.

In the application of this rule, station names (ex: Borden, Can tic, etc.) must not be used without a specific identifiable location.

Examples: "Borden" cannot be used.

"Station Name Sign Borden", "East siding switch Borden", etc. must be used instead. The following diagram illustrates the application of the note in Rule 303.1.



E. CROR Rule 49 (b) specifies (in part):

The limits of a TOP must be defined as between two identifiable locations, such as:

(i) whole miles;

(ii) specific siding switches;

(iii) other main track switches specifying location or stating mileage;

(iv) specified signals identified by number;

(v) specific yard limit signs or cautionary limits signs, specifying location or stating mileage; or

(vi) station names.

Crew Application of OCS Rules

The crews involved in this occurrence were familiar with the CROR Rules related to OCS movements. They understood that to receive permission to close-up, the train giving the authority would be stopped on the track ahead of them. They were aware that "close-up" permission arranged between train crews must be in writing.

During the investigation, it was determined that the "recording in writing" portions of CROR Rule 303.1 (e) and CPR System Special Instruction (SSI) were not consistently applied by the crews of trains 498 and 292.

Positive Train Control

Positive Train Control (PTC) is a system for electronically monitoring and controlling train movements to provide increased safety. It was developed with the purpose of reducing train collisions, overspeed derailments, overlaps of authority, and other human factors-related accidents.

Essentially, the train reports its position to the control centre via a wireless data link. The control centre's safety interlocking logic uses data from all trains to issue limits of movement authority and speed limits to each train, being careful to keep safe separation between trains.

The train's onboard computer monitors the data against actual train location and speed to determine potential and actual unsafe conditions. If the train is approaching the end of its limits or it is nearing its speed limit, the onboard computer warns the engineer, who is expected to take appropriate action. Should this not occur, the onboard computer can automatically initiate a safety brake application to bring the train to a stop. Similarly, if the train exceeds its allowable speed limit, the brakes can be applied to stop the train. The onboard computer also monitors various locomotive systems such as power and brakes, and automatically sends diagnostic and alarm data to the control centre when appropriate.

There are currently 11 different PTC projects in development or in the early stages of implementation on nine different passenger and freight railroads in the United States (U.S.). Four North American Class 1 railways have implemented or are currently testing this technology on a limited basis on specific subdivisions. The U.S. Congress has legislated that all Class 1 freight rail and passenger operations implement PTC by 31 December 2015 on main tracks used by passenger services [3], as well as on tracks where freight trains carry dangerous goods.

TSB Examination of Field of View from Locomotive Cab

The day following the collision, investigators from the TSB aboard a CPR rail locomotive, and starting from approximately Mile 95, approached Centennial at a speed below 20 mph. This was performed at approximately 0800, at a similar time to the collision with comparable weather and lighting conditions.

1. At Mile 95 (approximately 2.5 miles from the point of impact), train 498's crew could have noticed train 497's dimmed headlight. However, it would have been difficult for the crew to clearly distinguish between train 497 in Centennial siding and train 292 on the main track. Only after moving closer to Centennial did it become easier to distinguish the two trains.
2. The more difficult task for train 498's crew was not so much to distinguish the two trains, but to identify which train was moving. When approaching from the north, given that the track is tangent in the vicinity of Centennial siding, train 498's crew would have seen the tail end of train 292 and the front end of train 497 but no other portions of these trains.
3. In this occurrence, the locomotive engineer's seat was situated approximately 4 feet from the front window of the locomotive cab. The locomotive engineer was using a sun visor on his left side. This visor had been placed in this position earlier in the morning when the sun was just above the horizon and in the locomotive engineer's field of view (FOV). However, at the time of the occurrence, the sun was approximately 20 degrees above the horizon and was at the 11 o'clock position in his FOV. The position of the sun did not directly affect the forward field of view from the locomotive cab.

Visual Cues to Confirm Mental Models

Mental models are partial representations of complex situations. Mental models are created to achieve specific goals, hence the filtering of inputs and the use of what is perceived to be the most critical information [4].

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[3] U.S. Public Law 110-432, the *Federal Rail Safety Improvements Act*, enacted in October, 2008.

[4] International Journal of Human-Computer Studies, pages 60, 117-128 (2004), *When mental models go wrong, Co-occurrences in dynamic, critical systems*. D. Besnard & D. Greathead, CS-TR 791, Department of Computing Science, University of Newcastle upon Tyne, 2003

For dynamic tasks (for example, driving a vehicle or operating a train), the operator’s mental models are created from experience, expectations, anticipation, visual cues, and audio cues. Once an operator creates a mental model, the operator will tend to look for reinforcements to support the mental model and will tend to reject any contradictory evidence. This type of mental processing is referred to as confirmation bias or hypothesis lock [5].

Induced Motion Phenomena

Induced motion is the false perception that stationary objects move when in the presence of other objects that really move. The induced motion phenomena can occur when there is relative motion between objects from the perspective of the viewer.

Induced motion can also be explained by the motion aftereffect (MAE) phenomenon [6]. MAE occurs when a viewer stares at a moving object for several seconds. Then, for a short time afterwards, if the viewer looks at a stationary object, it will appear to be moving, but in the opposite direction.

Relative Positions of the Trains

Figure 3 displays the relative positions of the three trains at various times within a four-minute period just prior to the collision.

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5 R.G. Green et al., *Human Factors for Pilots* (Aldershot, 1991), pages 61 and 62

6 G. Mather, F. Verstraten and S. Antis (1998), The Motion Aftereffect: A Modern Perspective. Cambridge, Mass: MIT Press, pages 4-6

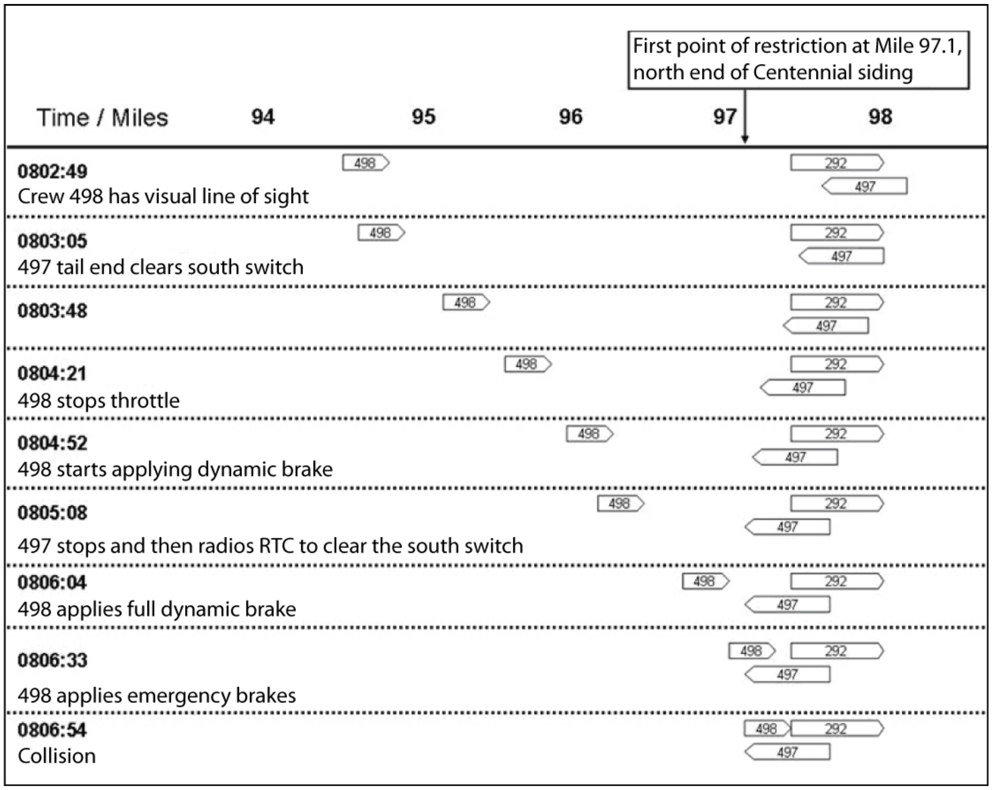

Figure 3. Relative positions of the trains

During the investigation, it was determined that:

1. When the crew of train 498 had a visual line of sight of Centennial siding, train 497 was moving northward (towards train 498) in the siding alongside train 292 which was stopped on the main track.
2. Approaching Centennial siding from the north, the crew of train 498 could see the tail end of train 292 and the front end of train 497, but no other portions of these trains. Only after they moved further along the track would the crew have seen other landmarks such as Mile Post 96 and the north end of Centennial siding.
3. When train 497 came to a full stop, the front end of train 497 was approximately 2500 feet past the tail end of train 292.
4. Prior to the accident, the relative positions of train 498 and train 497 in relation to train 292 were not changing at the same rate. Train 498 was moving southward at approximately 40 mph while train 497 was moving northward at approximately 16 mph.
5. When train 498 was approximately one mile from the tail end of train 292, train 497 radioed the RTC to indicate that they had cleared the south switch at Centennial siding.
6. The locomotive engineer on train 498 thought that train 292 was moving and that it would soon clear the south switch in spite of 498's restriction at the north switch Centennial and the arrangements made to close-up.

Other Related Occurrences

TSB records indicate that, since 1998, there have been 14 main track tail-end train collisions on federally-regulated rail lines in Canada. Of these 14 occurrences, 9 occurred in Centralized Traffic Control (CTC) territory and the remainder in OCS territory.

Two of these occurrences involved a train crew's lack of situational awareness due to incorrect assumptions. These two occurrences are briefly summarized as follows:

- On 01 March 1998, Canadian National (CN) freight train A-447-51-01 collided with the tail end of stationary CN train C-771-51-28 at Mile 165.4 of the Edson Subdivision near Obed, Alberta. Train 771 had stopped on the main-line to check for a sticking brake. The crew of train 447 made the assumption that train 771 was at least 1.5 miles ahead based on their interpretation of an automated voice transmission provided by a wayside inspection system. Contributing to this accident was poor visual conspicuity of the tail end of train 771 (TSB report R98C0022).
- On 22 July 2004, CPR freight train 387-150 travelling westward struck the tail-end of CPR freight train 101-19 at Mile 97.0 of the Maple Creek Subdivision near Kincorth, SK. Just prior to the accident, the crew on train 387 observed a stationary eastbound train in the vicinity of the east end of the siding. However, the crew of train 387 did not know that train 101 was stopped on the main track with its tail-end on the curve. Instead, the crew incorrectly assumed that train 101 was completely in the siding. Once the crew of train 357 realized that train 101 was on the main track, it was too late to stop their train.

Analysis

In this occurrence, neither track infrastructure nor equipment irregularities were found to be contributory to this accident. There were no indications that fatigue contributed to this occurrence. The analysis will focus on the actions and communications of the train crews leading up to the collision. In addition, the analysis will focus on the applicable CROR rules, hot box detector (HBD) messages, Positive Train Control (PTC), and situational awareness.

The Accident

At 0735, the rail traffic controller (RTC) issued a clearance authorizing train 498 to proceed from the south siding switch at Weyburn to the south siding switch at Centennial. This clearance included a restriction to protect against train 292 from the north siding switch at Centennial. Approaching Centennial, the locomotive engineer on train 498 thought that train 292 was moving, as had been the case for most of train 498's journey. Based on his mental model, however, the locomotive engineer was planning to take the train to the south end of the siding before stopping. The full length of the siding was approximately 8900 feet. However, with train 292 occupying most of the siding length, approximately 2500 feet of track was available within the siding.

Roughly six minutes before the collision the crew of train 498 learned that trains 292 and 497 were at the Centennial siding. The crews arranged for a close-up so 498 could proceed beyond the north switch, however, the locomotive engineer still expected that train 292 would be on the move. The relative motion of the stationary train 292, the slowly moving train 497 and their own approaching train 498 may have reinforced the engineer's mental model. The conductor of train 498 was busy, but aware that braking had been initiated, and assumed that the locomotive engineer was preparing to close-up. By the time the crew of train 498 realized that train 292 was stationary, there was insufficient time to stop the train despite placing the train into emergency. Therefore, the main track collision occurred when train 498 failed to stop short of train 292 during the close-up, causing the ensuing derailment, collision, and fire involving train 497.

On the morning of the occurrence, train 292 had been well ahead of train 498 until it was required to stop at Centennial. The crew of train 498 was neither aware of the length of time that train 292 had been stopped, nor aware when train 497 pulled up the siding. The lack of clear communication between crew members allowed the locomotive engineer on train 498 to operate under the assumption that train 292 was departing Centennial as train 498 approached the north switch.

For tasks such as close-ups, the conductor normally monitors the locomotive engineer's handling of the train. In this occurrence, the conductor's attention was focused on completing various operational tasks such as the completion of paperwork for a track release for Mile 89 (this writing down was not required by the rules), radio communications with train 292 for close-up, and listening for the report from the HBD. As train 498 approached the north switch of Centennial, the conductor's attention was not focused on the primary task of overseeing the engineer's handling of the train. In addition, because the locomotive engineer had over 25 years of experience and they had worked together before, the conductor trusted the locomotive engineer and likely assumed that everything was under control for the close-up. The conductor, focused on other operational tasks just prior to reaching Centennial and confident in the locomotive engineer's judgement, did not oversee the execution of the close-up.

The locomotive engineer of train 498 was about two miles from Centennial when he was initially able to distinguish between the tail end of train 292 and the front of train 497. At that moment, only train 497 was moving (at a slow speed towards train 498), but it was difficult to identify which train was moving.

After detecting some motion and operating with the mental model that train 292 ought to be departing, the locomotive engineer may have thought that train 292 was moving away from him, rather than train 497 moving towards him. If there was induced motion, it was likely because of the relative motion between train 497 and train 292. Train 498 was moving towards the two trains, but at a far greater speed than train 497. From the locomotive engineer's perspective, the front end of train 497 was becoming slightly larger at a faster rate than the tail end of train 292 was moving away from him. Having two trains in front of the locomotive engineer, with one train moving towards him and one train stationary, may have created a visual misperception as to which train was moving.

Although the sun was not directly in the locomotive engineer's FOV, it might have indirectly affected his visual acuity in trying to determine the precise location of the tail end of train 292. Before 0803, while the front end of train 497 was pulling towards the tail end of train 292, reduced visual acuity because of shadows was not an issue. As train 497 moved on the siding and pulled away from the tail end of train 292, at some point it is possible that it became more difficult to clearly distinguish the tail end of train 292 because of the shadows. In this occurrence, a reduced visual acuity would have occurred after the induced motion misperception.

Procedure for Executing a Close-Up

Speed restrictions govern virtually all aspects of railway operations. For example, when trains operate within "cautionary limits" or under "reduced speed", there is a requirement to stop within half the range of vision of equipment.

However, under Rule 303.1 (e) related to executing a "close-up", there is no requirement for the stopped train to provide a train location report or requirement for any speed restriction for the following train. Therefore, a following train can be travelling at any speed, up to the maximum subdivision speed, while performing the "close-up". The lack of specific operating procedures for executing a close-up, including communication protocols and speed restrictions, increases the risk of tail-end collisions.

Tail-End Conspicuity

When the tail end of a train is more visible, it will be seen sooner by a following train, thus providing more time to react if necessary. Visual attention is normally drawn to items that are large, bright, colourful, changing, or blinking.

In this occurrence, the tail end of train 292 was equipped with a flashing marker and a 3-inch by 5-inch standard reflectorized marker. However, during daylight hours, the flashing marker will normally be turned off by its automatic light-sensing photo cell. With only the reflectorized marker available during daylight hours, the dark appearance of the tail end of train 292 negatively affects its conspicuity. Since situational awareness often relies predominantly on visual cues, a more conspicuously-marked tail end for train 292 might have allowed the crew on train 498 to determine the location of train 292 earlier. Without additional visual stimulus to mark the tail end of a stopped train, the existing reflective marker may be insufficient to attract the attention of a following train, thus increasing the risk of tail-end collisions.

Communications between Crew Members

One of the key defences against unsafe acts or operating errors is the ongoing communication between crew members. CROR Rule 90 and Rule 142 (b) highlight part of the required communication protocol between crew members when operating a train. This routine ensures that rules, authorities, and restrictions are fully understood and complied with. In addition, this communication ensures that all crew members have the same understanding of each other's required action. Without consistent adherence to the execution of these routine requirements, defence barriers can be minimized.

In this occurrence, just prior to reaching the north switch at Centennial, the conductor's attention was focused on completing various operational tasks, such as: completing paperwork for track clearances for Mile 89, radio communications with train 292 for close-up, and listening for the report from the HBD. In doing these tasks, this conductor did not monitor the actions of the locomotive engineer by communicating with him to confirm the engineer's understanding of the close-up. This led to a reduced level of situational awareness for the crew. When crew members do not adequately communicate and confirm understanding (for example, during close-ups), there is an increased risk that miscommunications and perception errors will go undetected, potentially leading to train collisions.

Inconsistent Recording of Protect Against and Close-Up Authorities

Another key defence against operating errors is the reliance on all crew members clearly understanding their required tasks. CROR 303.1 (c), 303.1 (e), and CPR SSIs state that train crews must have a thorough understanding of each other's movements before taking action. The arrangements made between train crews must be in writing. Recording instructions in writing provides a record as to what was arranged and helps to clarify in one's mind how the task is to be carried out. It also provides an opportunity to ask questions and communicate if something is not clearly understood between crew members and with other train crews.

In this occurrence, the "recording in writing" portion of these rules was not consistently applied by the crew members on train 498 and train 292. Without consistently recording in writing all arrangements made between trains by both train crews, there is an increased risk of operating errors.

Communication Interruptions during HBD Broadcast

When approaching a siding for a train meet, there is an increase in the cognitive workload required to safely complete the train operation. Having minimal external distractions for the train crew is preferable at these locations.

In this occurrence, southbound train 498 encountered a HBD at Mile 94.7, which was approximately 2.4 miles in advance of the north switch at Centennial siding. Shortly after train 498 completely passed this location, an HBD broadcast indicating "all clear" was received over the radio. Although it was not a factor in this accident, there was the potential for distraction through a communication interruption. Receiving an HBD broadcast at this location can lead to distractions and delays when communicating with other train crews. Therefore, preplanning and anticipation is required by crews on southbound trains in the vicinity of Centennial siding, given that the broadcast from the HBD at Mile 94.7 overrides other radio communication.

Train Monitoring Systems to Minimize Collision Risks

PTC is a system for electronically monitoring and controlling train movements to provide increased safety. It was developed with the purpose of reducing train collisions, overspeed derailments, overlaps of authority, and other human factors-related accidents.

In a functioning PTC system, a train's onboard computer monitors actual train location and speed to determine potential and actual unsafe conditions. If the train is approaching the end of its limits or nearing its speed limit, the onboard computer warns the engineer, who is expected to take appropriate action. Should this not occur, the onboard computer can automatically signal for a safety brake application to bring the train to a stop.

Findings as to Causes and Contributing Factors

1. The main track collision occurred when train 498 failed to stop short of train 292 during the close-up.
2. The lack of clear communication between crew members allowed the locomotive engineer on train 498 to operate under the assumption that train 292 was departing Centennial as train 498 approached the north switch.
3. The conductor was focused on secondary operational tasks and did not oversee the execution of the close-up.
4. Having two trains in front of the locomotive engineer, with one train moving towards him and one train stationary, may have created a visual misperception as to which train was moving.

Findings as to Risk

1. The lack of specific operating procedures for executing a close-up, including communication protocols and speed restrictions, increases the risk of tail-end collisions.
2. Without additional visual stimulus to mark the tail end of a stopped train, the existing standard reflective marker may be insufficient to attract the attention of a following train, thus increasing the risk of tail-end collisions.
3. When crew members do not adequately communicate and confirm understanding (for example, during close-ups), there is an increased risk that miscommunication and perception errors will go undetected, potentially leading to train collisions.
4. Without consistently recording in writing all arrangements made between trains by both train crews, there is an increased risk for operating errors to occur.

Other Findings

1. Positive Train Control (PTC) has the potential to significantly reduce collisions between trains.
2. Preplanning and anticipation is required by crews on southbound trains in the vicinity of Centennial siding given that the broadcast from the hot box detector (HBD) at Mile 94.7 overrides other radio communications.

Safety Action Taken

As a result of this accident, Canadian Pacific Railway (CPR) undertook various local initiatives such as safety blitzes, communication audits, and a review of the incident by the local health and safety committee. CPR amended the wording of its *Canadian Rail Operating Rules* (CROR) Rule 303.1 (c) and (e) to enhance the applicable protocols related to communications and recording in writing. Speed restrictions were introduced so the closing-up train must not enter the limits of the other train at more than 15 miles per hour and be prepared to stop short of the preceding train or transfer.

Transport Canada notes that in the new CROR version implemented on 26 May 2008, General Rule K was added. It states that when the term "in writing" is used in rules, special instructions, and general operating instructions, and the instructions are not received personally, then they must be copied by the receiving employee and repeated back to ensure the written permission, authority, or instruction was correctly received.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 14 January 2009.

Appendix A – Revised Canadian Pacific Railway (CPR) Canadian Rail Operating Rule (CROR) 303.1

303.1 RADIO PROTECTION AGAINST FOLLOWING TRAINS AND TRANSFERS

(Not applicable to trains or transfers in possession of a work clearance)

(a) Where specified in special instructions, protection against following trains and transfers will be provided as follows:

Rule 303.1 applies within OCS [Occupancy Control System] outside ABS [Automatic Block Signal System].

(b) The RTC [rail traffic controller] must not authorize a train or transfer to follow a preceding train or transfer until the crew of the following train or transfer has been restricted by its clearance as follows;

"To (following train or transfer) protect against (preceding train or transfer) from (location)".

(c) Except as provided in paragraph (e), a train or transfer so restricted must not leave the location named nor leave any identifiable location until the preceding train or transfer has reported that it has left an identifiable location ahead. This report must be recorded in writing by a crew member of the preceding and following train or transfer. Such information may be received from the RTC.

Note: Identifiable locations as listed in Rule 82 must be used.

(d) A train or transfer so restricted must not pass the preceding train or transfer.

(e) When the preceding train or transfer has stopped between two identifiable locations, arrangements may be made with the following train or transfer to "close-up" between these two locations. These arrangements must be made in writing between the crews of both trains or transfers.

Between these two identifiable locations, the following train or transfer must not exceed 15 mph and must be prepared to stop short of the preceding train or transfer.

When the preceding train or transfer resumes moving, the following train or transfer will be governed by paragraph (c).

Note: When the preceding train or transfer has left the location to which the following train or transfer is authorized, Rule 303.1 no longer applies.

Prior to transmitting a report to a following train or transfer, the conductor must confirm accuracy with other crew members. The person responsible for controlling the locomotive must confirm correctness to the following train or transfer.