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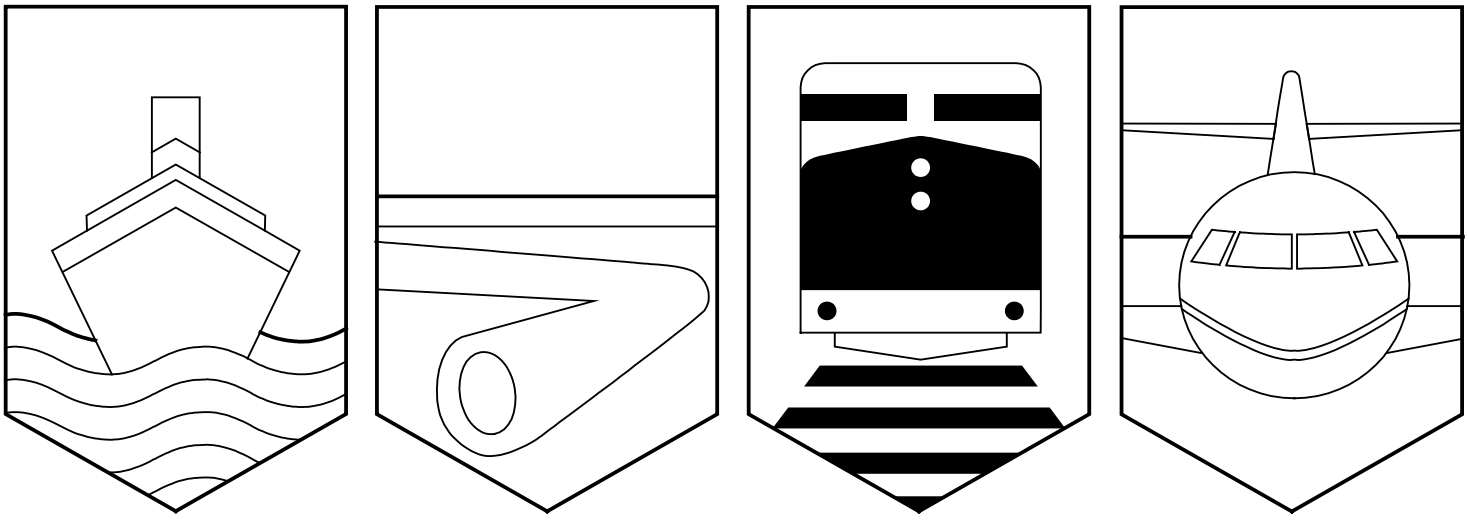

RAILWAY OCCURRENCE REPORT

COLLISION BETWEEN

CANADIAN PACIFIC LIMITED
TRAIN NO. 819-021 and TRAIN NO. 996-30
MILE 119.9, MOUNTAIN SUBDIVISION
GREELY, BRITISH COLUMBIA
01 OCTOBER 1995

REPORT NUMBER R95V0218

Canada

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Railway Occurrence Report

Collision Between

Canadian Pacific Limited
Train No. 819-021 and Train No. 996-30
Mile 119.9, Mountain Subdivision
Greely, British Columbia
01 October 1995

Report Number R95V0218

Synopsis

On 01 October 1995, at approximately 0640, Canadian Pacific Limited (CP) freight train No. 819-021 (train 819), proceeding west, collided head-on with CP train No. 996-30 (train 996), proceeding east, at Mile 119.9 of the Mountain Subdivision at Greely, British Columbia. The lead locomotives of both trains were extensively damaged. Crew members of both trains sustained minor injuries. There was no derailment.

The Board determined that the collision occurred when the crew of train 819 did not take appropriate action in response to the Clear to Stop Signal approaching Greely and the Stop Signal at Greely, and operated head-on into train 996. The crew had become impaired by fatigue due to excessive waking hours without a restorative rest period. Localized dense fog present at the time of the collision restricted the visibility of the signal at Greely.

Ce rapport est également disponible en français.

1.0 Factual Information

1.1 The Accident

1.1.1 Train 996

The crew of train 996, consisting of a locomotive engineer and a conductor, came on duty at 0510 at Revelstoke, British Columbia, Mile 125.7 of the Mountain Subdivision, to operate their train east to Field, British Columbia, Mile 0.0.

As the crew members departed Revelstoke at 0620 on the south main track, the rail traffic controller (RTC) informed them that they would be picking up a locomotive at the back track at Greely, Mile 119.9, approximately six miles east of Revelstoke.

The back track at Greely is accessed from the north main track. In anticipation of train 996 picking up the locomotive, the RTC had lined the crossover switches at Greely for the train to cross over from the south main track to the north main track.

At the advance signal to the crossover track at Greely, Signal 1216S, train 996 received a Clear to Medium Signal indication, requiring that the train be brought to medium speed, 30 mph, before passing the next signal. Encountering localized dense fog and anticipating lifting the locomotive from the back track, the locomotive engineer reduced brake pipe pressure by 10 pounds per square inch (psi). Train speed was slowed below the 30 mph maximum speed allowed at the crossover to approximately 16 mph approaching Signal 1200S, at the crossover. Both crew members then overheard a radio broadcast that was not clearly identified by either of them but sounded like, "get off your train." They had previously overheard the crew of a westward train communicate the station name sign approaching Greely as required by rule and suspected that this radio broadcast was meant for them. The locomotive engineer of train 996 elected not to release the train brakes as he normally would have and continued slowing the train. When they were about 250 feet from Signal 1200S, they observed the headlight and ditch lights of a westward train emerging out of the fog, moving toward them on the south track. Both crew members recalled concluding that the opposing train would not be able to stop at the signal east of the crossover, Signal 1199S, and would strike them before they diverged. The conductor and the locomotive engineer then moved through the door behind the control stand onto the catwalk, from which they both jumped onto the ground. The locomotive engineer had moved the independent brake handle to full application as he departed. Both crew members immediately moved south to a position of safety. Train 996 had nearly stopped when it was struck by train 819, travelling at approximately 10 mph, at Mile 119.9. The collision damaged the lead locomotives of both trains. Impact occurred at approximately 0640.

1.1.2 Train 819

The train crew of train 819 consisted of a locomotive engineer and a conductor. They were to move their train westward on the Mountain Subdivision from Golden, British Columbia, Mile 35.0, to Revelstoke. They came on duty on 30 September 1995 at 2210 at Field, and were taxied to Golden, arriving at 2250. Train 819 was delayed at Golden for 4.5 hours due to track-related technical problems in the area of the MacDonald Tunnel. Train 819 departed Golden at 0320, 01 October 1995.

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

The locomotive engineer of train 819 recalled that before departing Golden he was feeling tired and agitated. He also recalled that he just wanted to get the trip over with and get home, and that he was beginning to be affected by fatigue.

After departing Golden, the locomotive engineer continued to be agitated, and he recalled that the handling characteristics of the train taxed his concentration. He felt he had been severely affected by the portion of the trip through the MacDonald Tunnel, which took about 45 minutes at approximately 12 mph in maximum throttle. He described the noise and vibration as extreme. Nearing the end of the tunnel, he recalled he experienced nausea, dizziness, and a feeling of what he described as "extreme fatigue." He was unable to focus his eyes. As they exited the tunnel, he advised the conductor that he did not think he could make it. Shortly after exiting the tunnel, he opened his window and let in some fresh air. He remembered that this revived him somewhat and since, by his calculation, Revelstoke was approximately one hour away, he decided to continue.

Approaching Greely on the south main track, train 819 received a Clear to Stop Signal indication at Signal 1183S. The conductor and locomotive engineer both remembered that they identified and called the signal to each other. The conductor recalled having announced the station mile sign for Greely, as well as their lead locomotive number and direction of travel over the standby radio channel in accordance with operating rule requirements.

Approximately one mile before the next signal, Signal 1199S, train 819 entered a dense localized fog bank. The locomotive engineer recalled that he became disoriented and confused when he was unable to see Signal 1199S. He indicated that, in clear visibility, this signal can be seen from a distance of approximately one mile. He was controlling his train speed with the use of a minimum reduction train brake application and locomotive dynamic brakes as the train descended the grade of approximately 1.4 per cent into Greely. At a speed of approximately 36 mph and a distance of approximately 2,700 feet from the Stop Signal at Signal 1199S, the locomotive engineer released the train brakes.

The conductor was aware that the locomotive engineer had operated the automatic brake valve, but recalled thinking that he had increased the train brake application. The locomotive engineer reported that he was looking out the side window of the locomotive attempting to determine his location. The conductor reminded the locomotive engineer that they should expect to encounter a Stop Signal indication at the next signal. The locomotive engineer indicated that he did not regain awareness of his exact location until his train passed the stationary locomotive in the back track at Greely, recognizing where he was relative to train 996. The locomotive engineer placed the train brakes in emergency and made a radio broadcast telling the crew of train 996 to get off their train. Approximately 900 feet before impact and immediately before detraining, the headlight of train 996 became visible to the crew of train 819. The crew members detrained on the south side of the locomotive while the train was moving at an estimated speed of 25 mph; both sustained minor injuries. After the collision, the crew members of both trains located each other and ascertained that there were no life-threatening injuries. An emergency radio broadcast was then made to the RTC from one of the stationary locomotives. The RTC was advised of the collision and asked to arrange for an ambulance and to have company officers respond.

1.2 Injuries

All four crew members received minor injuries when they jumped from their trains.

1.3 Personnel Information

The crews of both trains were qualified for their positions and in compliance with regulatory requirements respecting mandatory time off duty and maximum hours of service.

1.4 Train Information

Train 996, handling 22 loaded cars and 75 empty cars, was powered by four locomotives. The train weighed approximately 5,535 tons and was about 6,200 feet in length.

Train 819 was handling 112 loaded cars of coal. It was powered by four locomotives, two on the head end and two robot-controlled locomotives located in the middle of the train. The train weighed approximately 15,700 tons and was about 7,100 feet in length.

1.5 Recorded Information

1.5.1 Train 996

At a recorded time of 0637:55.8, train 996 was travelling at a speed of 29.3 mph with the throttle in the No. 4 position and the brakes released. At a recorded time of 0638:42.5, brake pipe pressure was reduced to 73 psi from 83 psi. At a recorded time of 0639:39, the throttle was increased to position No. 6 and the speed had dropped to 20.9 mph. At a recorded time of 0639:59, the throttle was moved to "0" and the recorded speed had dropped to 13.8 mph. At this time, brake cylinder pressure began to rise, indicating another brake application. Brake cylinder pressure then rose continually as speed dropped. At a recorded time of 0640:24, forward motion had ceased.

1.5.2 Train 819

Between a recorded time of 0632:40 and 0632:50 and at a recorded speed of 38.9 mph, brake pipe pressure was reduced from 87 psi to 80 psi, indicating a minimum reduction application of the train brakes. The dynamic brake was in the No. 8 position during this period. At a recorded time of 0639:05, brake pipe pressure increased from 80 psi to 87 psi indicating the train brake was released. The dynamic brake remained in the No. 8 position. At a recorded time of 0639:31 and at a recorded speed of 34.7 mph, brake pipe pressure dropped to 3 psi and a digital channel designated "A" appears in the data indicating that an operator-initiated emergency brake application occurred. Train 819 continued, and at a recorded time of 0640:17, deceleration from a speed of 10.4 mph to a speed of 6.3 mph in one second was shown. Forward motion was shown as stopped at a recorded time of 0640:21. Locomotive event recorder data from the extended log indicate that between Golden and Greely, train 819 was operated in excess of the maximum permitted speed at numerous locations and by up to 8.4 mph. The following table shows the speed variation and maximum permitted speed between Golden and the point of collision:

RECORDED			CP T
DISTANCE FROM FIELD, B.C.		SPEED VARIATION (MPH)	MAXIMUM PERMITTED SPEED (MPH)
36.959	to 45.822	26.2 — 49.4	50
45.822	to 51.8	49.4 — 56.8	50
51.8	to 52.4	45.2 — 50.5	45

52.4	to	53.0	41.0	—	44.2	40	52.4	to	53.0
53.0	to	53.5	35.7	—	42.1	35	53.0	to	53.5
53.5	to	54.0	28.4	—	34.7	30	53.5	to	54.0
54.0	to	54.2	27.3	—	28.4	25	54.0	to	54.2
54.2	to	55.61	27.3	—	34.7	35	54.2	to	65.9
55.649	to	59.091	35.7	—	41.0	35			
59.2	to	60.779	30.5	—	34.7	35			
60.923	to	65.9	35.7	—	37.8	35			
65.9	to	68.049	30.5	—	36.8	30	65.9	to	68.3
68.125	to	89.9	7.4	—	29.5	30	68.3	to	89.9
							MacDonald Track		
89.9	to	99.6	23.1	—	28.4	20	89.9	to	99.6
99.6	to	100.899	23.1	—	25.2	25	99.6	to	102.5
100.934	to	102.5	26.3	—	30.5	25			
102.5	to	104.994	21.0	—	27.3	20			102.5
105.001	to	106.285	22.1	—	34.7	35			105.0
106.324	to	119.532	37.7	—	39.9	35			
119.532	to	119.9	34.7	—	0.0	35			

1.6Motive Power Handling Characteristics - Train 819

The two lead locomotives were 3,000 horsepower (HP) General Motors (GM) SD40-2 locomotives. The two robot locomotives, located midway through the train, consisted of one GM 3,000 HP SD40-2 locomotive and one General Electric (GE) 4,400 HP, AC traction motor, high-adhesion locomotive. CP had recently purchased this series of GE locomotives, and it was being integrated into unit coal train operation in this territory. Before purchasing these GE locomotives, CP usually powered its unit coal trains on this territory with three GM SD40-2 3,000 HP locomotives at the front of the train and two remotely controlled GM SD40-2 3,000 HP locomotives in the middle of the train. The remotely controlled locomotives are controlled from the lead locomotive by the locomotive engineer via "Locotrol" equipment.

The locomotive engineer of train 819 recalled that the handling characteristics of his train were different from what he was used to. He suspected that the train was handling differently because of the configuration of the locomotive consist. He stated that, if he had been well rested, he probably would have looked upon the operation of this train as a learning experience and a challenge; in his tired state, however, he found it made him angry and agitated, and made his job more difficult. He recognized that the railway had recently purchased the GE locomotives and was varying their location in trains to find the best possible configuration. This was the first time he had operated a unit coal train with this configuration of locomotive consist.

1.7Immediate Work History - Crew of Train 819

The locomotive engineer of train 819 made his first trip after two weeks of annual vacation on 25 September, commencing at 2000, from Revelstoke to Field; he was off duty by approximately 0200, 26 September. He booked rest at Field until 0800 and requested a one-hour call. He was ordered at 0845 to come on duty at 0945; he operated a train back to Revelstoke and was at home by 1600. He went to bed early that evening and arose early the following morning, 27 September. On 27 September, he was

ordered for a Turnaround Combination Service (TCS) trip from Revelstoke to Field and back, on duty at 2200. Because he had not had much sleep before the call and because a TCS call meant that most likely he would be on duty for longer than usual, he did not accept the call until he was advised that the conductor was also a qualified locomotive engineer. He was deadheaded to Field by taxi, arriving at 0050, 28 September, and immediately went on duty for the return trip to Revelstoke. He departed Field at approximately 0200 and arrived in Revelstoke at approximately 0815 for a total on-duty time of 10 hours and 15 minutes. The conductor, also a qualified locomotive engineer, had

[2] Crews called in TCS are not permitted to request relief after 7 hours on duty to take effect after 10 hours on duty; they are required to be available for 12 hours. A TCS trip includes manning a train in one direction and dead heading in the other direction. Working and dead heading can be at either end of the tour of duty.

operated the locomotive between Golden and Ross Peak, a distance of 55 miles, while the locomotive engineer attempted to rest. Upon arrival, the locomotive engineer booked rest until 1400, 29 September.

Over the two weeks of his vacation, the locomotive engineer had established a regular pattern of night-time sleep. His second and third trips after vacation were night-time trips. He remembered that he had difficulty with the transition from sleeping at night to working at night.

On 30 September, the locomotive engineer of train 819 awoke at about 0500 and reported for duty at 0700 for train 772. He was on duty until 1447. He went to the bunkhouse, worked out in the gymnasium, and ate. At about 1800, he went to bed to get some sleep before returning to duty. He reports that he fell asleep, but was awakened by noises outside his room between 1900 and 1930. The maximum amount of sleep he obtained was, therefore, approximately one hour. When he reported for duty at 2210, he had been off duty for approximately 7.5 hours.

He recalled that, when he was ordered, he was aware that he had not had sufficient sleep. However, based on his estimate that it should not take more than about six hours to complete the trip, he thought he could handle it.

On 28 September, the conductor was ordered in Revelstoke for train 996 at 0515. He had been off duty for 20 hours and 41 minutes since his previous trip. He booked off duty in Field at 1316, booked rest until 1700, and was ordered at 1850 for train 401. He had been off duty for 5 hours and 34 minutes at Field. He booked off in Revelstoke at 0018 on 29 September, then was ordered in Revelstoke for train 772 at 0700 on 30 September. He had been off duty for 30 hours and 42 minutes. He booked off duty in Field at 1433, then was ordered at 2210 for train 819. He did not obtain any sleep during his off-duty time from 1440 until 2210.

The conductor of train 819 was qualified for his position and had experience on the Mountain Subdivision.

Negotiated provisions between the railway and the operating unions permit crews to request relief after 7 hours on duty, to take effect after 10 hours on duty. This provision would have permitted the crew of train 819 to request relief at approximately 0500 to take effect at 0800. The conductor of train 819 recalled that he had advised the proper authority that his crew would require relief as per this provision prior to departing Golden.

1.8Fatigue

1.8.1General

Fatigue is often used as a catch-all term for a variety of different experiences, such as physical discomfort from overworking a group of muscles, difficulty concentrating, difficulty appreciating potentially important signals, and problems staying awake.

1.8.2Alertness

Alertness is the optimal activated state of the brain. When people are alert, they are aware of what is happening around them and are able to think and take action. Without alertness, there can be no attentiveness, and without attentiveness, no performance. Selection, training, and motivation are ineffective moderators of performance if the human brain is not alert. Alertness is a dynamic state and may vary from second to second.

1.8.3The Effect of Fatigue on Performance

Researchers at the Defence and Civil Institute of Environmental Medicine ran a series of sleep deprivation experiments during which subjects were required to participate in a command post exercise for 54 hours, without sleeping. The subjects were trained in the tasks, and baseline performance measures were made. Regular standardized performance tests were conducted throughout the experiment. It was found that performance on cognitive, or mental problem solving, vigilance, and communication tasks showed a 30 per cent decrement after 18 hours of wakefulness. After 48 hours, a 60 per cent decrement was seen. Performance degradation, or impairment, is progressive, becoming worse as time awake increases.

Fatigue can lead to slowed reactions to normal or even emergency stimuli. It takes longer to perceive things, longer to interpret or understand them, and longer to react to them once they are identified. This means that a fatigued crew may be slow to respond to a potential collision, warning, or alarm.

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[3] M. Rosekind et al., *Crew Factors in Flight Operations X: Alertness Management in Flight Operations*, NASA Technical Memorandum DOT/FAA/RD-93/18, NASA Ames Research Center, 1994.

[4] Rosekind et al.

[5] R.G. Angus et al., "Sustained-operations Studies: From the Field to the Laboratory," *Why We Nap: Evolution, Chronobiology, and Functions of Polyphasic and Ultrashort Sleep*, ed. C. Stampi (Boston: 1992), 217-241.

Fatigue affects the ability to judge distance, speed, and time. Poor judgement, a symptom of fatigue, may be a result of impaired mental functioning or a lack of motivation. Motivation is a factor when a person is so fatigued that he/she is unable to devote the energy required to carefully assess all the relevant factors in making a decision.

When fatigue builds and pressure to sleep increases, people tend to want to get the job finished as soon as possible. The brain is also not working at peak efficiency. Either because of the motivation to finish the job at hand, or because they do not recognize an increasing level of risk, fatigued crews will often take shortcuts that they would not consider when they are alert. People are poor judges of their own alertness or fatigue levels. Caffeine, physical activity, or interesting conversation can mask the symptoms of sleep debt and fatigue. "Individuals (especially sleepy individuals) do not reliably estimate their alertness and performance."

1.8.4Microsleeps

The most extreme symptom of fatigue is uncontrollable sleep. An uncontrollable sleep period can be a microsleep, a nap, or a long sleep episode. A microsleep is a very short period of sleep lasting from a fraction of a second to two or three seconds. Although the existence of microsleeps can be confirmed by electroencephalography (EEG) recordings, people are not generally aware of them, which makes the phenomenon particularly dangerous. Microsleeps have been shown in tests to correlate with periods of low performance and they occur most frequently during conditions of fatigue. While asleep, a person is "perceptually isolated," and does not know what is going on around him or her.

1.8.5Sleep Debt

Individual sleep needs are unique, but over 90 per cent of the population needs between 7.5 and 8.5 hours of sleep per 24-hour day to maintain alertness. When we do not get enough sleep, a sleep debt develops. The degree of performance impairment increases as sleep debt increases. The seriousness of even a small sleep debt can be significant. During the week following the change from standard time to daylight saving time, for example, there is typically an 11 per cent increase in the number of traffic accidents. By contrast, the week following the change from daylight saving time to standard time typically shows a decline in the number of accidents.

Sleep debt is cumulative. Getting an hour less than one's sleep requirement one night results in a one-hour sleep debt. Repeating this for five nights in a row generates about the same symptoms and performance impairment as losing five hours of sleep in one night.

1.8.6Restorative Rest

The only restorative rest is sleep. People who do not get enough sleep, or whose sleep is of poor quality, become fatigued and their performance suffers. Diet, exercise, rest without sleeping, and varying workload are not effective countermeasures to fatigue in the long term. Interrupted or poor quality sleep will not restore alertness either. The only way to restore performance is to sleep. In cases of severe sleep

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deprivation or accumulated sleep debt, two nights of normal sleep will usually be sufficient to restore normal alertness levels. “Sleepiness is such a powerful biological signal, that in an uncontrolled, spontaneous way, no matter how motivated, well trained, or professional, your brain can shut you down regardless of your situation. Even in a potentially lethal situation, your brain can shut you down to get the sleep that it needs."

1.8.7Biological Clock

Over time, the daily cycle of light and dark has become hardwired into our brains in the form of a biological clock. This biological clock controls various chemical and neurological systems. The overall result is that we have a daily cycle which can be measured in several ways. The most important effect is that people are programmed to be awake during the day and asleep at night. We do adjust to new schedules, but slowly.

Humans have two periods of maximal sleepiness in each 24-hour period. Although there are individual variations, the primary sleepiness period generally occurs between 0300 and 0500. A secondary sleepiness period occurs between 1500 and 1700. Each of these is preceded by a period of maximal wakefulness. Regardless of the motivation and situation, people can have difficulty remaining awake during maximum sleepiness periods. Conversely, obtaining sleep during the periods of maximum wakefulness is difficult, and often the sleep obtained is not restorative.

1.9The Current Regulatory Approach to Fatigue

Railways under federal jurisdiction in Canada operate within regulatory requirements specifying both maximum hours of service and mandatory time off duty for train crews. Both of these requirements came about through the actions of the regulator in response to safety concerns. Mandatory time off duty requirements were imposed upon the railways subsequent to the Hinton train disaster in 1986. The regulator imposed maximum hours of service requirements upon the railways after it became known that operating employees were remaining on duty for excessive amounts of time.

Mandatory time off duty requirements apply only to employees who are called from an employee pool and do not otherwise have a regularly scheduled assignment or to employees who are called into pool service from other classes of train service. Employees covered by these requirements who have been on duty in excess of 10 hours will not be required to go on duty in pool service for at least 8 hours.

Maximum hours of service requirements are applicable to railway operating employees in any class of train service. These requirements specify that no employee shall be on duty in excess of 18 hours in a 24-hour period; the maximum time on duty in a single tour of duty is 12 hours, and 16 hours in case of work train service or in case of emergency.

1.10Part II of the Canada Labour Code

Railways under federal jurisdiction are subject to Part II of the *Canada Labour Code* (CLC). Part II of the

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[8] Rosekind, M. R. (1995). Physiological considerations of fatigue. In *Fatigue Symposium Proceedings*, Tyson Corners, VA.

CLC, section 128.(1), states:

Subject to this section, where an employee while at work has reasonable cause to believe that

(a) the use or operation of a machine or thing constitutes a danger to the employee or to another employee, or

(b) a condition exists in any place that constitutes a danger to the employee, the employee may refuse to use or operate the machine or thing or to work in that place.

There have been several cases where employees of federally regulated concerns have exercised their right to refuse work based on the perception that their own condition represented a danger. However, the Canada Labour Relations Board (CLRB) has ruled consistently that, in order for a safety officer to find danger in a refusal mediation, the danger must be a tangible thing that the safety officer can physically see or detect at the time of his investigation. Therefore, an employee's condition does not constitute a danger as defined by Part II of the CLC.

1.11Method of Train Control

The method of train control on the Mountain Subdivision is Centralized Traffic Control System (CTC) authorized by the Canadian Rail Operating Rules (CROR) and supervised by the RTC located in Revelstoke. Train movements are governed and authorized by signal indications. There is currently no form of automatic intervention associated with the CTC that is capable of stopping a train or enforcing speed requirements. There is no form of passive warning system

associated with the CTC to indicate a train's proximity to areas of restriction or other rolling stock. There is no system backup to the signal indications provided by the CTC in response to the presence of rolling stock or track conditions. The Mountain Subdivision was upgraded to CTC in 1970.

1.12The Weather

At the time of the collision, the sky was dark and partly cloudy, the winds were calm, and there was localized dense fog. The temperature was three degrees Celsius.

2.0Analysis

2.1Introduction

The physical evidence and recorded data support the sequence of events as outlined by the respective crew members and described in Section 1. Train 996 was operated in compliance with company procedures and government safety standards. Westward train 819, however, was operated past a Stop Signal indication head-on into eastward train 996. Based on the application of accepted scientific research as it relates to the actions of the crew members of train 819, it is believed that a lack of restorative rest had impaired their ability to perform their duties. The cause and effect of fatigue on the crew of train 819, the current regulatory approach to fatigue, and the method of train control will be explored.

2.2Consideration of the Facts

The locomotive engineer and conductor of train 819 felt that they were not rested when they were called for their train. However, based on their estimation that the trip would take approximately six hours, they believed that they would be able to complete the trip safely. They did not anticipate being held for 4.5 hours at Golden. When they eventually departed, about 22 hours had passed since either had experienced a significant restorative sleep episode.

The locomotive engineer described experiencing increasingly severe symptoms of fatigue as the trip progressed. When the train entered the localized fog bank approaching Greely, he lost situational awareness and experienced accompanying confusion. He was familiar with the area and had operated similar trains in similar visibility conditions, but this time he did not know where he was. Location references such as the next signal did not materialize as he expected. He released the automatic brake at a time when he should have increased brake pressure, even though he had communicated the Clear to Stop indication on Signal 1183S to the conductor and had been reminded of the impending Stop Signal. It was not until he saw the locomotive in the west end of the back track at Greely and recognized where he was relative to train 996, that he regained situational awareness and applied the emergency brakes.

The conductor experienced similar disorientation in the localized fog and, although he reminded the locomotive engineer that a stop was likely imminent, he did not take more forceful action to have the train slowed; slowing would have been usual under the circumstances. He also inexplicably misinterpreted the brake release as an increased brake application, although these activities produce distinctly different sounds and train response.

The behaviour exhibited by both the locomotive engineer and the conductor of train 819 is consistent with extreme fatigue and may indicate that they were experiencing microsleeps. Releasing the brake at the time and location where it was released could also be viewed as consistent with operating the train under the impression that the last signal was clear. Under the circumstances, the more likely scenario, and the one supported by the factual information, is that the crew members experienced a microsleep after having identified and communicated the clear to stop indication on the advance signal. Microsleeps are uncontrollable by the individual, and the perceptual isolation accompanying them can lead to disorientation after the sleep episode.

The operation of the train in excess of maximum permissible speed at times throughout the trip and approaching Greely was indicative of taking shortcuts, a common reaction of fatigued individuals. The

absence of information to support an established history of speeding and other rule non-compliance by the locomotive engineer, combined with the high probability that both crew members were suffering from the symptoms of extreme fatigue, makes the view that a blatant disregard for operating practices propagated this occurrence, most unlikely.

The locomotive engineer and conductor did not gain enough restorative rest to prepare themselves for the trip to Revelstoke. The time allowed to them for restorative rest, between 1440 and 2210, is not an opportune time for sleep, and only sleep can maintain or restore performance capacities to normal alertness levels. Sleep during this period is likely to be difficult, subject to awakenings, and of limited value in restoring alertness over the long term.

Had either the locomotive engineer or conductor declined the trip because of fatigue, or attempted to seek relief en route because of the likelihood of fatigue posing a threat to safety before the end of the trip, that individual would have had to book sick. It is a commonly held perception by some operating crew members that it is not acceptable within the industry for an employee who has commenced duty to request relief en route because of fatigue, outside of exercising negotiated provisions that permit crews to obtain relief after 10 hours on duty. When a crew member accepts a call and reports for duty, implicit in those actions is his confirmation that he is rested, fit for duty, and will remain so throughout the trip. The railways expect train crews in unassigned pool service to be fit for duty at the end of a rest period the same as if they worked a regularly scheduled assignment or a 9-to-5 job.

There were opportunities for both crew members to decline work, but their assessment of their own levels of alertness would not likely have provided much reason to do so. People are poor judges of their own fatigue or alertness levels. At 2210, the locomotive engineer and conductor likely would have felt alert and fit for duty, and the activity following their arrival at Golden and the preparation of their train for departure would have had a stimulating effect, resulting in their assessing their fitness level as good.

Since people cannot accurately estimate their current fatigue level, their ability to predict what their alertness level will be in several hours must be even less valid. They anticipated finishing the trip around 0500, and likely would not have had much reason to doubt their ability to complete the job. While at Golden, the conductor had requested relief to take effect after 10 hours on duty, as per the negotiated rest provision. As railway practice is to relieve all crew members when one crew member requests relief, it is not unusual that the locomotive engineer did not individually request relief. Under this provision, the crew would not have been relieved until 0810. Given the time of the collision at 0640 and the time relief was scheduled to have taken effect, 0810, the negotiated rest provision had no bearing on this occurrence other than to demonstrate that the train crew anticipated they would require relief hours after they had already assessed themselves as tired.

The 4.5-hour wait in the yard at Golden changed the situation for the operating crew. At 2300, a five- or six-hour trip probably seemed manageable. When the trip did not start until 0320, however, it was not . Two crew members, subjected to fatiguing conditions, were now required to work through the period of maximum sleepiness (0300 to 0500) without having had any significant restorative rest in the previous 24 hours.

The crew of train 819 were within the parameters of mandatory time off duty and maximum hours of service prescribed for operating crews, yet, at the time of the collision, the locomotive engineer had had about 1 hour of sleep in the previous 24 hours and the conductor had had no sleep in the same period. The current mandatory time off duty and maximum hours of service requirements no doubt are intended to

ensure that railway employees in train service are rested and fit prior to duty and do not continue on duty for excessive periods of time. Time off duty is not necessarily restorative rest, and the fact that the person least likely to make an accurate assessment of his condition, the individual, is charged with the task of making that assessment makes it possible for dangerously fatigued employees to be operating trains while in full compliance with the current regulatory requirements and while under the impression that they are fit to perform their duties.

Past regulatory action on hours of service and off-duty time were intended to serve only as interim measures while the industry came up with a means to address the issues completely. The railways have recently completed the *CANALERT '95* study into the effects of railway work patterns on their employees. The study tested a number of fatigue countermeasures and found some of them to be successful. CP has elected to further study the effectiveness of the countermeasures before implementing them.

Part II of the CLC gives employees the right to refuse work whenever the employee perceives a danger. However, these provisions have been interpreted by the CLRB as not allowing a safety officer to support an employee's refusal to work based on the assertion that their condition constitutes a danger.

CTC has been the method of train control in use on the Mountain Subdivision for 25 years. The system does not allow for intervention to stop a train or control train speed in the event that it becomes necessary to do so. A train control system capable of intervening to stop a train or of providing a passive warning to crews in advance of areas of restriction might have prevented this collision. The absence of a secondary line of defence to compensate in the event that a crew does not respond to a signal demonstrates a system that has no backup safety mechanism built in; a single point failure system.

3.0Conclusions

3.1Findings

1.Train 996 was operated in accordance with regulatory and company requirements.

2.The crew members of train 819 were in compliance with current regulatory requirements respecting mandatory time off duty and maximum hours of service.

3.Both crew members of train 819 were impaired by fatigue as they approached the Stop Signal at Greely and operated their train past the signal and into train 996.

4.The current regulatory requirements respecting mandatory time off duty and maximum hours of service do not adequately address the cumulative effects of sleep debt and do not ensure that employees in train service have had sufficient restorative rest before reporting for duty.

5.There is currently no secondary defence mechanism associated with the Centralized Traffic Control System (CTC) that is capable of stopping or slowing a train neither is there a secondary warning system associated with the CTC that would alert a crew of their proximity to areas of restriction or rolling stock.

3.2Causes

The collision occurred when the crew of train 819 did not take appropriate action in response to the Clear to Stop Signal approaching Greely and the Stop Signal at Greely, and operated head-on into train 996. The crew had become impaired by fatigue due to excessive waking hours without a restorative rest period. Localized dense fog present at the time of the collision restricted the visibility of the signal at Greely.

4.0Safety Action

4.1Action Taken

In 1995, Canadian Pacific Limited (CP), Canadian National (CN), VIA Rail Canada Inc. (VIA), the Brotherhood of Locomotive Engineers, and Circadian Technologies Inc. co-operated on a program that developed, implemented and tested an Alertness Assurance Process entitled *CANALERT '95*. The goals of the *CANALERT '95* program were:

- to develop a set of fatigue countermeasures to be used to enhance alertness levels among a group of locomotive engineers, without adversely affecting operations;
- to validate the effectiveness of these countermeasures;
- to determine the relative alertness and mental workload stress levels of locomotive engineers operating high-speed passenger trains as compared to engineers operating trains in freight service; and
- to perform an analysis of the schedule-induced fatigue level which might exist in passenger operations.

The sites selected for testing *CANALERT '95* were between Calgary, Alberta, and Field, British Columbia (CP); Jasper, Alberta, and Blue River, British Columbia (CN); and Montreal, Quebec, and Québec, Quebec (VIA).

A general analysis of alertness, sleep, and mental workload characteristics was conducted to address the issues of fatigue or "impaired alertness" in the Canadian railway system. As a result, specific fatigue countermeasures were developed for railway freight operations. These measures included circadian time pools for establishing a more regular and predictable work-rest pattern, napping practices both on and off duty, improved sleeping accommodations, headsets with music and intercom, and a railway lifestyle training program. Based on the experience gained in the implementation of these fatigue countermeasures and the results obtained from the general analysis, the *CANALERT '95* program recommendations, in May 1996, included the following:

a)scheduling systems be adopted to provide regular and predictable duty periods for crews;
b)a significant period of time be available for rest after outbound night runs and prior to overnight return runs;
c)strategies be developed to permit both en route and terminal napping as an alertness recovery program;
d)bunkhouse rooms be modified for improved daytime sleep;
e)locomotive cab audio systems be installed;
f)a lifestyle training program be conducted and extended;
g)rail traffic controllers (RTC) be trained and crew caller-in strategies be developed; and
h)problem schedules be investigated and rectified at VIA.

CP has recently established a CANALERT pilot project using the time pool arrangement with train crews operating out of Calgary. CP has received ratification of a new contract with the operating unions, which contains a letter of understanding to develop an implementation timetable of the CANALERT initiatives.

4.2Safety Concerns

4.2.1Train Crews Work Hours

In 1965, the *Canada Labour Code* came into effect establishing rules regarding the maximum hours of work in industries under federal jurisdiction. A deferment of the application of the rules was granted for the railway running trades. This exemption resulted from representations made by railways and unions that the application of the rules to railway operations and employees would be prejudicial, detrimental and incompatible with the existing wage structure and system.

In 1986, Dr. Alison Smiley, a consultant retained by the Foisy Commission to analyse the work hours of train crews, emphatically agreed with the conclusion of the study completed by the Canadian Institute of Guided Ground Transport that "the work hours of railway trainmen are both too variable and lengthy to result in anything but sub-optimal vigilance under certain conditions, particularly in the case of returning freight trains."

In April 1987, the Railway Transport Committee issued, as an interim measure, orders regulating mandatory off-duty time for running trades employees. The orders mandated that running trade employees who have been on duty for between 8 and 10 hours must not be called for duty for at least 6 hours, and also if on duty for over 10 hours, must not be called for duty for at least 8 hours.

At Greely, train 819 was operated by employees who were in compliance with the mandatory off-duty and maximum hours of service prescribed for operating crews although they did not have sufficient restorative rest. At the time of the collision, the locomotive engineer had had about 1 hour of sleep in the previous 24 hours. The crew accepted the call, assuming that they were fit for duty, and did not request any rest later because it is a commonly held perception by operating crew members that it is not acceptable within the industry to request relief en route because of fatigue.

In completing the CANALERT project, the railway industry has developed fatigue countermeasures toward enhancing alertness levels in railway running trades. The CANALERT initiatives have been recognized as promising steps in alleviating the problem of fatigue in the railway operating environment. The Board recognizes the concerted effort by the industry and the regulatory body and also acknowledges that Transport Canada continues to be supportive of studies involving fatigue and alertness issues. Notwithstanding these initiatives, the Board is concerned that the hours of duty and fatigue problems are still confronting the railway industry.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 16 December 1997.

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ers Nos. R40385 and R40386.