RAILWAY OCCURRENCE REPORT
R96W0171

COLLISION AND DERAILMENT

CANADIAN NATIONAL
TRAIN NO. M-358-51-30 AND
TRAIN NO. M-359-41-01
MILE 145.4, ABERDEEN SUBDIVISION
NORTH BATTLEFORD, SASKATCHEWAN
02 JULY 1996

Transportation Safety Board
of Canada

Bureau de la scurit des transports

du 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 Occurrence Report

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Synopsis

On 02 July 1996, at 0351 Central daylight time, eastward Canadian National (CN) freight train No. M-358-51-30 was unintentionally diverted onto a spur track at Mile 145.4 of the Aberdeen Subdivision at North Battleford, Saskatchewan, and collided head-on with stationary and uncrewed CN freight train No. M-359-41-01. The locomotives of both trains were extensively damaged, and 10 freight cars derailed. One crew member sustained minor injuries.

The Board determined that the switch for the spur track was inadvertently left in the reverse position. Contributing factors to the accident were the excessive permissible maximum train speed and the limited safety defence provided by the recognition distance of switch targets. The reversed roles of the locomotive engineer and conductor without adequate crew resource management discipline created a work environment leading to the switch being left in the reverse position.

Ce rapport est également disponible en français.

1.0 Factual Information

1.1 The Accident

1.1.1 Train 359

The crew of westward train No. M-359-41-01 (train 359), consisting of an assigned locomotive engineer and an assigned conductor, came on duty at 1545, 01 July 1996, at Humboldt, Saskatchewan, Mile 0.0 of the Aberdeen Subdivision, to operate the train to North Battleford, Saskatchewan, Mile 147.7.

The train departed Humboldt at 1645 and arrived at East Warman, Saskatchewan, Mile 64.2, at about 1905. At this time, the crew members traded positions, with the conductor (a qualified engineer) operating the locomotives and the locomotive engineer (a former conductor) performing the conductor's duties. The rail traffic controller (RTC) instructed the crew members to yard their train in spur track NB-36 at North Battleford. The switch to track NB-36 is located at Mile 145.4.

At 2100, when the train reached Mile 145.4, the locomotive engineer detrained and the train was pulled beyond the switch. The locomotive engineer unlocked the protecting padlock, lined the switch to the spur, and placed the derail in the non-derailing position. The conductor backed the train into the spur with the locomotive engineer on the leading car of the reverse movement. The crew noted that, although both positioning a person on the leading car and a slow progressing of the movement would be normal practices, these actions were particularly important during this movement since they had concerns about the condition of this infrequently used spur.

The train was stopped at a position which placed the locomotives about 750 feet from the switch to the main track. A taxi ferried the locomotive engineer to the head end of the train. After the locomotives were secured, both crew members took the taxi to rest accommodations. The crew members were off duty at 2205.

1.1.2 Train 358

Eastward train No. M-358-51-30 (train 358), crewed by the same two employees that had positioned train 359 in track NB-36, with the assigned locomotive engineer at the controls, departed North Battleford Station at 0340, destined for Humbolt. The headlights were on full power and the ditch lights were on. When the crew members noticed that the NB-36 switch was

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

in the reverse position, they placed the train brakes into an emergency application and jumped from the moving train after the locomotives negotiated the switch. Train 358 continued into the spur, striking unattended train 359.

A key ring belonging to the locomotive engineer with his padlock key in the open lock was retrieved from the NB-36 switch stand. It was observed that the derail was not in the derailing position.

1.2 Injuries

The locomotive engineer sustained minor injuries when he jumped from the train.

1.3 Personnel Information

The crew members were qualified for their positions and met the fitness and rest requirements established to ensure the safe operation of trains.

1.4 Train Information

Train 359 consisted of 2 diesel locomotives, 4 loaded cars and 36 empty cars. It weighed approximately 1,700 tons and was about 2,800 feet in length.

Train 358 consisted of 3 diesel locomotives and 88 loaded cars. It weighed approximately 10,000 tons and was about 6,500 feet in length.

1.5 Immediate Work History of the Crew of Train 358

The locomotive engineer had last worked Saturday, 29 June 1996, and had gone off duty at about 2030 that day. He did not work on 30 June 1996. He indicated that he had had normal rest from his arrival home on 29 June 1996 until he was called to work on the afternoon of 01 July 1996, to take train 359 to North Battleford. He indicated that he had slept until approximately 0800 on 01 July 1996.

The conductor had last worked Sunday, 30 June 1996. He indicated that he had had sufficient rest before being called for duty, 01 July 1996, having slept through the night and waking up in the morning.

Neither crew member had requested rest at North Battleford on arrival. Both were called for train 358 at 0245 after having been off duty for 4 hours 40 minutes. They indicated that they had slept for approximately 2 hours in the rest quarters used by Canadian National (CN) for crew layovers at North Battleford.

1.6 Rest Requirement

The crew's maximum in-duty time was 18 hours in any 24-hour period with no more than 12 hours in one tour of duty. Such employees who go off duty at their objective terminal after working less than 10 hours are not further restricted, other than the requirement to not work more than 18 hours in any 24-hour period. Employees who are off duty for 8 hours are considered fit for 12 hours of work. Employees are expected to report for duty fit and rested.

1.7 Track Information

1.7.1 Aberdeen Subdivision

At Mile 147.7, the track descends in a 0.4 per cent gradient to Mile 145.4. The track is tangent from Mile 147.7 to Mile 146.4. There is a one-degree curve at Mile 146.4, after which the track is tangent to Mile 145.4 and beyond. The maximum permissible speed for freight trains between Mile 147.7 and Mile 138.5 is 45 mph with a speed limit of 10 mph at a crossing at Mile 146.8.

1.7.2 The Switch

The hand-operated switch at Mile 145.4 consists of a No. 10 turnout and a standard switch stand. The switch stand mast is approximately seven feet above the rail head and is equipped with reflective targets conforming to Canadian government standard 62-GP-11, level 1 reflectivity (maximum). An eight-inch square green target to indicate through movement and a small red circular target to indicate a reversed switch top the mast. A red oblong target, measuring approximately 18 inches by 15 inches, also indicating that the switch is reversed, is mounted approximately 15 inches below the top targets.

Switch NB-42 is located approximately nine feet west of switch NB-36. The targets and mast for this switch are located lower than those for switch NB-36, and in such a way so that the respective targets do not overlap. However, train crews approaching the area from either direction with one switch lined in the reverse position can see both a green square target and a red oblong target.

1.8 Switch Handling

Manually operated main track switches are equipped with high-security padlocks, the keys to which are only issued to employees qualified in the Canadian Rail Operating Rules (CROR). After opening the padlock, the key can only be removed if the padlock is re-locked. The proper procedure when leaving switches temporarily in the reverse position is to secure the switch in this position with the padlock and remove the key. It is common practice, however, to leave the key in the open lock pending normalizing the switch.

1.9 Canadian Rail Operating Rules

The CROR pertaining to main track hand-operated switches and derails contain the following:

CROR Rule 104 - Hand Operated Switches

> (a) . . . main track switches must be lined and locked for the main track when not in use.

CROR Rule 104.5 - Derails

> (c) . . . after a derail has been placed in the non-derailing position and the track is no longer in use, such derail must be restored to the derailing position and secured with a lock whether or not there is equipment on the track.

1.10 Method of Train Control

The Aberdeen Subdivision is governed by the Occupancy Control System (OCS) from Humboldt to East Warman, Mile 63, then by the Centralized Traffic Control System (CTC) to Mile 65.1, returning to the OCS from Mile 65.1 to North Battleford, Mile 147.7.

Cautionary limits exist from Mile 143.7 to Mile 147.7. Within these limits, caution speed, defined as "a speed that will permit stopping within one-half the range of vision of equipment or a track unit," applies (CROR Rule 94). When the CROR were first issued (1990), the definition of caution speed contained a maximum speed not exceeding 15 mph. Subsequent changes eliminated the reference to the 15 mph speed limitation.

Between Mile 147.7 and Mile 145.4, the applicable timetable (Timetable No. 4) special instructions provide that the requirements of CROR Rule 94.1 apply to switch NB-07 at Mile 146.94. CROR Rule 94.1 states:

> 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.

Timetable No. 4 also instructs all trains not to exceed 10 mph within 500 feet of the crossing at Mile 146.8 (Battleford Road) until the crossing is occupied by the train.

1.11 Recorded Information

The event recorder data depict train 358 approaching the switch at Mile 146.94 at 13 mph and occupying the crossing at Mile 146.8 at 16 mph. The emergency brake application occurred at a speed of 38 mph with the throttle in position No. 8 (maximum). Event recorder data indicate that train 358 struck train 359 at 22 mph, after having travelled 1,462 feet in 41 seconds in an emergency brake application.

1.12 The Weather

At 2105, 01 July 1996, at North Battleford, the recorded weather was 24.6 degrees Celsius with a south-east wind at 7 km/h, and no precipitation.

At 0300, 02 July 1996, at North Battleford, the recorded weather was 16.2 degrees Celsius, with a north-east wind at 19 km/h, and no precipitation.

1.13 The Simulation

At about 0200, 03 July 1996, a simulation of an eastward train approaching the switch for track NB-36 was performed to determine the effective switch target recognition distance. The locomotive used in the simulation was similar to the leading locomotive on train 358 and equipped with double headlights and ditch lights.

The switch was lined for track NB-36 and a track unit was placed on the main track just beyond the switch. The movement proceeded eastward from the station until visual verification of either the track unit and the switch target could be made. Visual verification of the switch target and the track unit could not be made until the engine reached Mile 145.6, approximately 1,000 feet from the switch to track NB-36.

1.14 Reversal of Roles

When the crew exchanged roles at East Warman, no formal job briefing was conducted. Both were familiar with the respective duties and did not discuss their plan of action before shoving the train into the spur. Once this action was completed, the locomotive engineer reverted to his normal responsibilities as a locomotive engineer, including shutting down and securing the locomotives. The conductor assisted the locomotive engineer in the shut-down process, but neither assumed the conductor's duties at this time, which would have included lining the switch for the main track and repositioning the derail.

1.15 Crew Resource Management

Work planning is a critical element of crew resource management (CRM) that helps to ensure that the crew members have a clear understanding of the work to be done, who will be carrying out specific tasks, as well as when and how the task will be performed. Essentially, these factors contribute to crew members developing a shared mental model and common expectations.

Research has shown that the process of information transfer and decision making are prime determinants of crew performance, and that crews that have high levels of communication perform more effectively and commit fewer operational errors.

[2] R. Helmreich and H. Foushee. (1993) "Why crew resource management?" In E. Weiner, B. Kanki and R. Helmreich (Eds.) *Cockpit Resource Management.* Academic Press Inc.: New York, pp. 3-34.

2.0 Analysis

2.1 Introduction

The proximate cause of this accident was the NB-36 switch being inadvertently left in the reverse position by the crew while yarding train 359. As is often the case, however, the unintended diversion of train 358 was the product of a series of intertwined safety-sensitive activities and procedures.

The analysis will discuss factors antecedent to leaving the switch lined for the spur, crew alertness, switch target conspicuity relative to the safety features of caution speed, and the identification of reversed switches in OCS territory.

2.2 General

The crew operated eastward out of North Battleford in a manner consistent with the location. The only factors limiting achievement of the maximum operating speed (45 mph) was the need for switch target identification at Mile 146.94 (limiting train speed to 15 mph and met by the crew) and a speed restriction at the crossing at Mile 146.8 (10 mph maximum speed limitation exceeded by 6 mph). Sight-lines were unrestricted and there was no maintenance-of-way or switching activity in the yard to consider relative to caution speed.

Event recorder data show that the emergency brake application occurred approximately 700 feet before the switch. Under test conditions, the switch target was visible from about 1,000 feet. It would seem, therefore, that the switch target would have been visible for about 5 seconds at the recorded approach speed of 38 mph, indicating that the crew members were vigilant to train operation and aware of the condition of the track ahead.

2.3 Yarding of Train 359

Since the locomotive engineer and the conductor were very familiar with each other's duties, they did not formally discuss their respective responsibilities before shoving the train into the spur. Once the portion of the action sequence involving the reversing of the train into the spur had been completed, neither crew member carried out the duties of the conductor, which included lining the switch for the main track and placing the derail in the derailing position. It is apparent that the train crew did not take steps to manage their team resources adequately by way of a work plan and job briefing. The absence of effective CRM in terms of work planning increased the potential for elements of the work to be overlooked. An effective work plan would have included a discussion of the job requirements, a review of specific responsibilities and the verification of the successful completion of tasks. As a result of this inadequate preparation, the conductor's tasks were not performed.

The lack of an effective work plan may have left the crew members more susceptible to unintentional errors. Since the location of the switch and derail was removed from the final position of the locomotives, their

presence would not have acted as a reminder to the crew; this physical separation, especially at night, may have led to an out-of-sight, out-of-mind situation for the crew.

The design of the padlock, in that the key is held until it is returned to the locked position, is intended to heighten employee awareness while handling main track switches. The practice of leaving keys in open padlocks of reversed switches has apparently evolved to help to remind employees of their need to re-line a switch. As this accident has demonstrated, this practice is not always successful.

2.4 Crew Alertness

The crew met the mandatory rest requirements. While no case can be made to indicate that fatigue played a direct role in the failure of the crew to re-line the NB-36 switch or operate their train in a more cautious manner when leaving North Battleford, identifiable fatigue issues, including sleep needs, sleep deprivation and working through a period or circadian rhythm most likely to induce sleep, were present.

At the time of yarding train 359 (2105 to 2205), both crew members were approaching the time of maximum sustained wakefulness before the onset of degraded alertness due to fatigue (13 hours). The sleep/wake cycle can be thought of as a "credit" and "deficit" system in which a person receives 2 points for every hour asleep up to a maximum of 16 points with one point deducted for every hour awake. An 8-hour sleep (16 points) will be followed by a wakeful period of about 16 hours (16 points). When the sleep balance is low, the pressure to sleep may be extreme.

At the time of the accident (0350), the crew had been up most of the night and had been awake for approximately 20 hours with only 2 hours of restorative rest. Research has shown that performance on cognitive and mental problem solving, vigilance and communication tasks show a 30 per cent decrement after 18 hours of wakefulness. In normal conditions, the sleep/wake cycle follows a 24-hour rhythm with approximately 1/3 of the time spent sleeping. Although individual rhythms vary, everyone's cycle has two distinct alertness peaks and dips. The time of lowest alertness is in the dip just before dawn (0300-0500). During dips, it can be particularly difficult to maintain alertness.

It is probable, therefore, that crew alertness was affected by fatigue and, although fatigue cannot be viewed as causal, train crews working in similar circumstances could be expected to experience performance degradation.

2.5 Rest Requirements

Had the train not been diverted into the siding but continued to Humboldt, the crew would have booked off duty at approximately 0800. At this point, they would have been awake for approximately 24 hours, with 2

[3] 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), pp. 217-241.

hours of restorative rest, and yet, been in compliance with the mandatory rest requirements. Mandatory rest requirements neither recognize the time awake before reporting for duty nor performance degradation generated by short turn-around scheduling schemes.

2.6 Switch Target Conspicuity and Caution Speed

The distance required to stop a 10,000-ton train, such as train 358, operating at 45 mph (the maximum speed within cautionary limits at North Battleford), is in the vicinity of 2,750 feet. Since the simulation revealed that equipment on the track could be first seen from a distance of approximately 1,000 feet, caution speed for train 359 would have been a speed at which the train could have been stopped in 500 feet. Such a speed would be in the vicinity of 20 mph. The caution speed was therefore much slower than the allowable maximum speed under night-time conditions. It is also evident that, in daylight conditions, at 45 mph, caution speed requirements would involve seeing and identifying a hazard from over a mile away. The caution speed limit for this size of train may therefore also be much less than the authorized maximum, in daylight conditions.

Misaligned switches are a threat to safe train operation. Switch targets cannot be viewed as a means for train crews to identify and react to misaligned switches for heavy trains operating at other than slow speeds (15 mph or less).

2.7 Identification of Reversed Main Track Switches in OCS Territory

In OCS territory, railway operating practices rely solely on employees complying with CROR requirements to ensure that switches are left lined for the main track after use. There are no electronic or procedural means to ensure or verify compliance.

3.0 Conclusions

3.1 Findings

1. The crew inadvertently left the NB-36 switch in the reverse position.

2. The crew members were attentive to the operation of train 358.

3. The crew did not develop an effective work plan for the yarding of train 359.

4. While fatigue is not considered to have played a direct role in the switch being left in the reverse position or the operation of train 358 in a more cautious manner, the crew's tour of duty made them vulnerable to sleep need performance degradation.

5. Mandatory rest requirements do not account for time awake before duty nor short turn-around scheduling schemes.

6. Switch target recognition distance does not provide train crews of heavy trains with the means to safely identify and react to misaligned switches when operating at other than slow speeds.

7. The caution speed restriction did not impose a safe maximum speed limit in either daylight or night-time operating conditions for train 358.

8. There are no electronic or procedural means to verify that switches in OCS territory are left lined for the main track.

3.2 Causes and Contributing Factors

The switch for the spur track was inadvertently left in the reverse position. Contributing factors to the accident were the excessive permissible maximum train speed and the limited safety defence provided by the recognition distance of switch targets. The reversed roles of the locomotive engineer and conductor without adequate crew resource management discipline created a work environment leading to the switch being left in the reverse position.

4.0 Safety Action

4.1 Action Taken

CN installed a high-reflectivity switch target at NB-36 switch; however, in July 1997, the spur was removed from service.

CN developed a job aid called "Trip Safety Check List." The list requires that listed crew duties and responsibilities be checked off at pre-departure, departure, en route, arrival and tie-up times. Crews are required to verify their possession of switch keys in the "Personal Equipment" section of the list.

The Railway Association of Canada is drafting a new rule to regulate both the minimum hours off duty and the maximum hours on duty. The new rule will address the fatigue-related issues raised in this report. The new rule is expected to be approved by Transport Canada in 1999.

4.2 Safety Concern

The Board recognizes the concerted effort by the railways and the regulatory body to resolve fatigue and alertness issues. The new rule will undoubtedly assist in reducing those occasions where fatigue-induced crew performance degradation played a role in an accident. The Board, however, believes that implementation of initiatives such as CANALERT, coupled with a comprehensive hours of work rule, is necessary to alleviate the problem of fatigue in the railway operating environment. The Board is concerned that, although certain elements of CANALERT have been implemented, there has not been widespread application of the CANALERT concepts.

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

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 09 April 1999.

[4] M. Moore-Ed et al. *CANALERT '95: Alertness Assurance in the Canadian Railways*, Circadian Technologies Inc. 1996

Appendix A - Glossary

CN	Canadian National
CRM	crew resource management
CROR	Canadian Rail Operating Rules
CTC	Centralized Traffic Control System
OCS	Occupancy Control System
RTC	rail traffic controller
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time