TSB Recommendation R22-02

Reducing the risk of uncontrolled movements through the implementation of automatic parking brake technology

The Transportation Safety Board of Canada recommends that the Department of Transport require Canadian freight railways to develop and implement a schedule for the installation of automatic parking brakes on freight cars, prioritizing the retrofit of cars used in bulk commodity unit trains in mountain grade territory.

Rail transportation safety investigation report	R19C0015
Date the recommendation was issued	31 March 2022
Date of the latest response	June 2022
Date of the latest assessment	August 2022
Rating of the latest response	Satisfactory in Part
File status	Active

Summary of the occurrence

On 04 February 2019, the Canadian Pacific Railway Company (CP) freight train 301-349 being operated by a relief crew derailed on Field Hill near Field, British Columbia, on a 13.5-mile section of track with a steep descending grade (average 2.2%) and several sharp curves. The 3 crew members—a locomotive engineer, a conductor, and a conductor trainee—were fatally injured in the derailment.

Rationale for the recommendation

The issue of uncontrolled movements of railway equipment is not a new one. The TSB has pointed out the need for robust defences to prevent uncontrolled movements since 1996. On 12 August of that year, all 3 occupants in the operating cab of a locomotive were fatally injured when their train collided head-on with a cut of 20 runaway cars near Edson, Alberta.[1] In its investigation report, the TSB indicated that the facts surrounding this occurrence raised some concerns, notably with respect to the secondary defences against runaways.

1 TSB Railway Investigation Report R96C0172.

The issue came to the forefront again in 2013 when, on 06 July, a runaway train derailed in the centre of the town of Lac-Mégantic, Quebec, destroying the town's core and main business area, and causing the death of 47 people.[2] In its investigation report, the TSB indicated that equipment runaways are low-probability events that can have extreme consequences, and the cost to human life and our communities can be incalculable. For this reason, the Board recommended that

> the Department of Transport require Canadian railways to put in place additional physical defences to prevent runaway equipment.
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> **TSB Recommendation R14-04**

Since then, the trend in the number of uncontrolled movements has been on an upward trajectory. In 2014, the year after the Lac-Mégantic accident, there were 59 occurrences; in 2019, there were 78, including this one. Unplanned/uncontrolled movements of railway equipment remains a current issue and is included in the TSB's Watchlist 2020, a list of issues that need to be addressed to make Canada's transportation system even safer.

In the years since Recommendation R14-04 was issued, in an effort to address these concerns, Transport Canada (TC) has implemented several initiatives aimed at reinforcing and clarifying requirements in the *Canadian Rail Operating Rules* (CROR) governing the application of hand brakes. These initiatives included a revision to Rule 112 in 2015, which provided the industry with a comprehensive hand brake application chart to respond to various operating situations when securing unattended equipment.

Following the occurrence at Field, TC again modified the CROR with new requirements for the use of hand brakes. It introduced Rule 66 (Securing Equipment after an Emergency Brake Application on Grade) for the securement of trains stopped in emergency on heavy grades and mountain grades.[3] The new rule also includes a comprehensive hand brake application chart. It came into effect on 24 June 2020.

A hand brake is a mechanical device used to secure railway equipment and prevent uncontrolled movements. Hand brakes are installed on all railway rolling stock. They are manually applied and tightened by turning the hand brake wheel. This causes the brake shoes to be pressed against the wheel tread surface to prevent the wheels from moving or to retard their motion.

For hand brakes to securely hold a train, the right number of them must be applied to generate the needed brake force.

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[2] TSB Railway Investigation Report R13D0054.

[3] CP defines heavy grades as grades between 1.0% and 1.8% inclusive. Grades exceeding 1.8% are defined as mountain grades.

The hand brake application chart in Rule 66 indicates the number of hand brakes that must be applied on a train based on train tonnage and descending grade. For instance, given the occurrence train's weight of approximately 15 000 tons and the average 2.2% grade on Field Hill, to meet the requirements of Rule 66, it would have been necessary to apply 75 hand brakes on the train after it had stopped in emergency.

There are several factors, however, that can reduce the effectiveness of hand brakes, most notably low input torque (the amount of force applied by the operator at the hand brake wheel), service wear, and reduced coefficient of friction (COF) of the brake shoes from rail conditions such as the presence of ice or snow. When some of the hand brakes on a train are not fully effective, more hand brakes are needed to achieve the brake force necessary to hold it stationary.

In practice, operators do not know how much force they are applying at the hand brake wheel, as hand brakes do not provide this type of feedback. Nor do they know the coefficient of friction of the brake shoes, or whether a hand brake's effectiveness is reduced due to service wear. The only available means to determine whether a sufficient number of hand brakes has been applied, therefore, is to perform a hand brake effectiveness test. This test involves releasing the air brakes to confirm that the train does not begin to roll. If the train does roll, more hand brakes must be applied, and the test performed again. In the operating scenarios covered by Rule 66, however, this test is not feasible for a train stopped on a heavy or mountain grade. In such circumstances it would be highly risky to release the air brakes, as the train could begin to roll quite quickly and it may not be possible to stop it again. Therefore, operators must rely on the pre-determined number of hand brakes mandated by the rule. If some hand brakes on the train are not fully effective, this number may not be enough, and there is a risk of uncontrolled movement.

Applying hand brakes is physically demanding and time consuming. Operators must board the car by climbing the side ladder, position themselves safely at the hand brake wheel, and crank the wheel clockwise to take up chain slack before applying maximum force on the crank. They must then dismount, walk to the next car, and repeat the manoeuvre. Applying a large number of hand brakes requires a sustained effort over several hours. As fatigue sets in, the force that operators are able to exert at each hand brake wheel may diminish over time; with lower input torque, the effectiveness of the hand brakes is reduced, requiring more hand brakes to be applied.

Table 1 shows how many hand brakes would be needed to hold a 15 000-ton train on a 2.2% descending grade, assuming 55 foot-pounds input torque (the force achieved by the participants in the human performance assessment),[4] and a coefficient of friction in the range of 0.3 to 0.4. In the presence of brake cylinder leakage, an increasingly higher number of hand brakes would be needed as the pressure drops. According to this table, the 75 hand brakes mandated by Rule 66 would be sufficient, based on a COF of 0.39, and a BCP of 10 psi.

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4 See Appendix E in TSB Rail Transportation Investigation Report R19C0015.

As the table shows, the number of hand brakes needed to hold a train varies greatly based on several variables, over which train crews have no control.

Table 1. Number of hand brakes required at an input torque of 55 foot-pounds to hold a 15 000-ton train on a 2.2% descending grade, based on the coefficient of friction of the brake shoes and the average brake cylinder pressure*

Coefficient of friction	Number of hand brakes required based on average brake cylinder pressure						
	77 psi**	65 psi	50 psi	35 psi	25 psi	10 psi	0 psi
0.30	42	40	46	55	67	102	162
0.31	40	39	44	53	64	98	156
0.32	39	37	43	51	62	95	151
0.33	37	36	41	50	60	92	146
0.34	36	35	40	48	58	88	141
0.35	35	34	38	46	56	86	136
0.36	34	33	37	45	54	83	132
0.37	33	32	36	44	52	80	128
0.38	32	31	35	42	51	78	124
0.39	31	30	34	41	49	75	120
0.40	30	29	33	40	48	73	116

* The numbers in this table assume a net hand brake ratio of 6.5%.

** A brake cylinder pressure of 77 psi corresponds to the pressure after an emergency brake application, when there is no brake cylinder leakage.

There is AAR-approved technology available for securing trains, which takes most of these variables out of the equation: automatic parking brakes for rail vehicles (APBs), such as Wabtec's Automatic Park Brake and New York Air Brake's ParkLoc. APB technology has been tested and approved for use on North American railways, but it has not been widely adopted.

APBs are brake cylinders equipped with an automatic, mechanically operated latch that locks the brake cylinder piston as needed depending on the pressure in the brake pipe. When the brake pipe pressure is depleted (e.g., after a penalty or an emergency brake application), the system automatically locks the brake cylinder piston in the extended position, thereby retaining the brake force. This occurs without any specific intervention or action by the train crew. Once the brake pipe pressure increases again, the system automatically releases the lock and retracts the brake cylinder piston, which releases the brake force. APBs can be configured for use on both truck-mounted and body-mounted brake systems, and they can be retrofitted on existing freight cars with no need to make modifications to the air brake system.

Because APBs lock the brake cylinder piston into position on the cars, their effectiveness is independent of input torque, and it is not affected by brake cylinder leakage. APBs, therefore, can hold a train on a steep grade indefinitely.

Uncontrolled movements of railway equipment, while low frequency events, can create high-risk situations that may have catastrophic consequences. TSB investigations into uncontrolled movements have revealed that the sequence of events almost always included inadequate train securement. TC has made several improvements to the rules governing the application of hand brakes. However, even with a comprehensive set of rules, it has been demonstrated over the years that depending solely on the correct application of rules is not sufficient to maintain safety in a complex transportation system. The concept of “defence in depth” has shaped the thinking in the safety world for many years. Layers of defences, or safety redundancy, have proven to be a successful approach in many industries, to ensuring that a single-point failure does not lead to catastrophic consequences.

Better and more numerous administrative defences have not been successful in establishing safety redundancy against uncontrolled movements. To date, the Canadian railway industry and the regulator have yet to look beyond strengthening an administrative defense such as the use of hand brakes.

Until physical defences such as automatic parking brakes are implemented across the Canadian railway network, the risk of uncontrolled movements due to inadequate train securement will persist, especially on steep grades where the effectiveness of hand brakes cannot be tested.

Therefore, the Board recommended that the Department of Transport require Canadian freight railways to develop and implement a schedule for the installation of automatic parking brakes on freight cars, prioritizing the retrofit of cars used in bulk commodity unit trains in mountain grade territory (TSB Recommendation R22-02).

Previous responses and assessments

N/A

Latest response and assessment

June 2022: Transport Canada’s response

Transport Canada (TC) agrees with recommendation R22-02. As noted in the TSB’s report, uncontrolled movements of railway equipment can create high-risk situations that may have catastrophic consequences, and Transport Canada has made several improvements to the rules and regulations to help prevent uncontrolled movements. The TSB’s report also notes that maintaining safety in a complex transportation system requires layers of safety, including additional physical defences such as automatic parking brakes.

Aligned with the TSB’s recommendation in this area, automatic parking brakes require no action from the train crew to be applied. Because the automatic brakes can only be released with an increase in air pressure from the locomotive, even if there is a leak in the air brakes, the train will remain secured indefinitely.

It is important to note that automatic parking brakes are not currently used by freight railway companies in North America. Although there are a limited number of examples currently available, automatic parking brake technology has not yet been tested, nor assessed, to ensure safe operations in Canada. Of note, the technology has not yet been approved by Transport Canada, the U.S. Federal Railroad Administration, nor the American Association of Railways. Instead, hand brakes are required by regulation by Transport Canada and the Federal Railroad Administration, and represent an essential safety measure to prevent uncontrolled movements. As such, it will be important to carefully assess the readiness, effectiveness and safety implications of automatic parking brakes, especially in the context of cold weather operations.

With this context, Transport Canada will undertake a series of actions involving due diligence and cold-weather testing:

- Transport Canada will assess the safety implications of automatic parking technology, by engaging with an expert consultant, the Volpe National Transportation Systems Center, which provides multidisciplinary, multimodal transportation expertise to government and industry worldwide. Working with Volpe, the department will assess technology effectiveness, operability in various weather considerations, implementation factors, and recommended regulatory approaches. It is anticipated that a contract will be in place with Volpe by September 2022, with a final report completed by March 2023.
- The department will conduct testing of automatic braking technology in a laboratory cold chamber to verify safety and performance in simulated mountainous terrain under real world operating conditions. Cold-weather testing will start in September 2022 and be completed by March 2023.
- Transport Canada will form a working group with railway companies to consider the design and safety parameters of automatic parking brake technology, including exploring options to test the technology under safe operating conditions (September 2022 – June 2023).
- Transport Canada will also conduct testing of air brake performance in cold weather, which was also highlighted in the TSB's report. This testing will enable the department and railway companies to explore further improvements to air brake performance in cold weather conditions.

Complementing these due diligence measures, Transport Canada will begin engaging with industry stakeholders on a phased approach to deploying this important technology. It is anticipated that this engagement work will begin in July 2022, and will be completed by June 2023, allowing time for industry to review the assessment of the automatic parking brake technology and to assess any implementation challenges. The timeline for technology deployment will be established based on the outcomes of the research and consultations.

August 2022 : TSB assessment of the response (Satisfactory in Part)

Transport Canada (TC) agrees with the recommendation. TC notes that automatic parking brake (APB) technology is not currently used by freight railway companies in North America as there are a limited number of available technologies. In addition, TC states that APB technology has not yet been tested, nor assessed, to ensure safe operations in Canada. The technology has also not yet been approved by Transport Canada,[5] the U.S. Federal Railroad Administration, or the Association of American Railroads (AAR).

In Canada and the U.S., the AAR develops specifications and provides approval for all rolling stock equipment used in interchange service. AAR approval is a multi-step process. For APB technology, this process includes a detailed review of the technical drawings and specifications for the technology, laboratory cycle and environmental testing, and field testing.

AAR conditional approval is provided following the successful completion of laboratory cycle and environmental testing. This permits a manufacturer to proceed with field testing, where a specific quantity of units can be installed and used on certain operational freight cars over a set period of time, in accordance with an approved test plan.

AAR unconditional approval is granted following the successful completion of field testing. Once APB technology obtains AAR unconditional approval, it can then be installed on operational freight cars where permitted, or as required, by regulations.

While APB technology has not yet received AAR unconditional approval, there are two manufacturers (Wabtec and New York Air Brake) that have been granted AAR conditional approval.[6] To date, both manufacturers have not been successful in partnering with railway companies to perform the field testing that is required to achieve AAR unconditional approval.

TC will undertake a series of actions to evaluate APB technology, including performing cold-weather testing. Specifically, TC has committed to assess the safety implications of APB technology by engaging an expert consultant, the Volpe National Transportation Systems Center, to assess technology effectiveness, operability in various weather considerations, implementation factors, and recommended regulatory approaches . The final report is scheduled to be completed by March 2023. In addition, TC will conduct laboratory cold chamber testing of APB technology between September 2022 and March 2023 and also test air brake performance in cold weather. Finally, between September 2022 and June 2023, TC will form a working group with railway companies to consider the design and safety parameters for APB technology, including exploring options to test the technology under safe operating conditions.

The Board is encouraged that TC recognizes and acknowledges that uncontrolled movements of railway equipment can create high-risk situations that may have catastrophic consequences. TC also acknowledges that maintaining safety in a complex transportation system requires layers of safety, including additional physical defences such as APBs. To this end, TC has set out a plan

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[5] However, TC permits the use of parking brakes as an alternative to hand brakes to secure equipment that is left unattended to prevent it from moving unintentionally. See CROR 112 (ii), Securing Unattended Equipment, which states "Parking brakes are considered to be hand brakes."

[6] The New York Air Brake APB technology was introduced in 2006 for Wabash National Road-Railer. Over 3500 units were in service. However, the AAR does not recognize the Road-Railer as a freight car for the purpose of satisfying the field testing requirements.

to evaluate APB technology, test its cold-weather effectiveness, and assess any implementation challenges. However, a commitment to field test and implement APB technology is contingent on the results of TC's planned actions, including consulting with railway companies to consider the associated design and safety parameters of the technology. Therefore, the Board considers TC's response to Recommendation R22-02 to be **Satisfactory in Part**.

File status

The TSB will monitor TC's progress on its planned actions.

This deficiency file is **Active**.