

NRC Publications Archive Archives des publications du CNRC

Automatic parking brake (APB) technical brief

Mackie, S.; Jahagirdar, A.; Toma, E.

For the publisher's version, please access the DOI link below./ Pour consulter la version de l'éditeur, utilisez le lien DOI ci-dessous.

<https://doi.org/10.4224/40004054>

NRC Publications Archive Record / Notice des Archives des publications du CNRC :

<https://nrc-publications.canada.ca/eng/view/object/?id=dd8f9beb-baff-437d-b512-08f0b525ae47>

<https://publications-cnrc.canada.ca/fra/voir/objet/?id=dd8f9beb-baff-437d-b512-08f0b525ae47>

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at

<https://nrc-publications.canada.ca/eng/copyright>

READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site

<https://publications-cnrc.canada.ca/fra/droits>

LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at

PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.

Automatic Parking Brake (APB) Technical Brief

S. Mackie, A. Jahagirdar & E. Toma
National Research Council of Canada

© 2026 His Majesty the King in right of Canada, as represented by the National Research Council of Canada.

ABSTRACT: With funding from Transport Canada (TC), the National Research Council of Canada (NRC) previously performed cold-weather air brake research which included multiple separate testing programs. This technical brief presents the results from controlled testing of two pre-production freight railway air brake cylinders with built-in automatic parking brake (APB) capability. The APB function is seen by the railway industry as providing an additional means of securement beyond that provided by the handbrakes, as APBs offer the ability to mechanically lock the brake piston in an extended position without manual intervention following a pneumatic brake application. The APB systems were installed on a freight railcar in direct replacement of the standard brake cylinder and subjected to both service and emergency brake applications at nominal brake pipe pressures of 90 psi. Additionally, the same APB-equipped cylinders were tested in an individual railcar air brake test rig. Findings show that the APB-equipped cylinders are effective at maintaining brake force following emergency brake applications, even after all air was evacuated from the brake cylinders, with minimal performance degradation in routine brake functions and no significant impact on handbrake operation.

Results demonstrate that implementation of the APB equipment into interchange operations has the potential to improve railway safety. However, the practical implementation may present integration challenges with railway operations that should be addressed prior to deployment into service by the railway industry. Additional field trials in a railway interchange operation would provide data to better understand how likely the APB-equipped cylinder is to retain braking force, and what benefits this provides during routine and emergency air brake applications.

1 BACKGROUND

A derailment in Canada in February 2019 brought attention to an operational problem that North American railways have experienced since the advent and adoption of pneumatically controlled train braking systems: the loss of air brake effectiveness in cold weather. The final investigation report prepared by the Transportation Safety Board of Canada (TSB) provided several recommendations to Transport Canada (TC) to prevent uncontrolled movements, including TSB Recommendation R22-02 on APB technology [1].

These recommendations highlighted the need for the North American railway industry to explore an automatic parking brake that would enable brake force retention to prevent uncontrolled movements of stopped trains.

2 AUTOMATIC PARKING BRAKE

The Automatic Parking Brake (APB) is seen by the railway industry as providing an additional means of securement beyond that provided by the handbrakes. A handbrake is applied mechanically, without air pressure, when a railcar is required to be parked or secured. This is currently done manually by rotating a handbrake wheel to force the brake shoes against the wheels to secure the railcar. An APB offers the ability to mimic this function automatically, without manual intervention, by mechanically locking the brake piston in an extended position after a pneumatic brake application, and when the brake pipe pressure drops below a set threshold. The APB requires the piston to be extended prior to securement; as such, it cannot act as a replacement for handbrakes.

The concept of the APB is novel, and multiple manufacturers have proposed proprietary design solutions to address the need for APB functionality as a direct replacement for the carbody-mounted brake cylinders that are approved for all North American railcars for interchange service. The Association of American Railroads (AAR), the industry body that sets standards for all North American railroad equipment, does not currently approve an APB-equipped brake cylinder design for interchange service.

Multiple brake component manufacturers have developed different forms of APB mechanisms that can integrate into the housing of the carbody-mounted brake cylinder to provide additional securement when brake pipe pressure, detected using a pressure-sensing airline, drops below a defined threshold. The APB mechanism contains no electronic systems; it uses air pressure as a trigger signal to engage an internal mechanical stop which prevents the brake cylinder piston from retracting, thus retaining brake force. The pressure thresholds are currently defined by the manufacturers.

By engaging a locking mechanism when a brake application is made, the APB will retain a portion of the applied braking force even if the brake cylinder air pressure drops or reaches 0 psi. It retains this hold until the brake pipe pressure is recharged or the APB is intentionally released through a manual release function.

3 COLD WEATHER AIR BRAKE (CWAB) RESEARCH APPROACH

The Cold Weather Air Brake (CWAB) research program was initiated in response to long-standing industry concerns and TSB recommendations following incidents of uncontrolled train movements attributed to loss of brake effectiveness in extreme cold. With funding from TC, the NRC executed multiple separate testing programs spanning four calendar years (2021–2024) and was conducted under controlled climatic conditions at the NRC CWAB facility in Ottawa, Canada.

The CWAB facility (Figure 1) was developed by the NRC to enable the testing of multiple freight car air brake systems in a modular arrangement. The configuration shown in Figure 1 operates up to 12 complete freight railcar air brake systems simultaneously; additionally, the two individual railcar

air brake test rigs (one of which is shown in Figure 3) and a freight railcar can be coupled inline to make a total consist of 15 air brake systems. The air brake systems are installed in a compact configuration where each system has approximately 45 feet of brake piping to represent an individual freight car brake pipe. The systems are connected using standard AAR-approved end-of-car hoses and gladhands, as used in the railway industry, to represent a total train length of approximately 660 feet.



Figure 1. The NRC's CWAB facility staged inside the Climatic Testing Research Facility.

The CWAB facility has been used to evaluate the performance of freight car air brake systems operating in cold weather conditions to quantify the performance loss observed in cold temperatures. While testing conventional freight car brake systems in the CWAB facility, the NRC also tested pre-production APB-equipped brake cylinders from multiple manufacturers to understand and compare their function with that of standard brake cylinders.

3.1 APB Climatic Test Procedures

Testing was performed inside the Climatic Testing Research Facility at three temperatures: +5°C, -20°C, and -40°C. The APB units under test (UUT) received brake applications intermittently throughout two weeks of climatic testing, where three complete test days were specifically allotted to test the APB functionality (one test day per temperature).

Testing was executed in four phases: handbrake testing, APB performance testing, APB engagement testing, and internal friction testing. This methodology also permitted APB testing to occur in two different testing arrangements: one with the UUT installed in a freight railcar (Figure 2) and another with the UUT installed in an individual test rig, as shown in Figure 3.

3.1.1 APB Handbrake Testing

Stationary handbrake tests were performed to verify that the APB did not interfere with the operation of the handbrake, and to quantify the brake retention ability of the APB when the brake cylinder pressure is at 0 psi. Tests consisted of applying handbrakes upon air brakes, and releasing the air brakes to allow for the brake cylinder pressure to be 0 psi with the piston retracted while the push rod remained extended due to the handbrake chain force. This was followed by observations of the residual effects on the handbrake force output.

3.1.2 APB Performance Testing

To understand the APB's baseline performance during typical brake applications, four brake applications were repeated three times, providing 12 brake applications at each of the three test temperatures:

- minimum-service application (6 psi drop)
- intermediate-service application (15 psi drop)
- full-service application (30 psi drop)
- emergency application.

Between applications, forces were allowed to stabilize before recharging.

3.1.3 APB Engagement Testing

To understand the circumstances under which the APB mechanism would engage, a leak in the brake pipe was triggered following a brake application to simulate the intended field service function of the APB.

3.1.4 APB Internal Friction Testing

APB-equipped brake cylinders provide a mechanical means of keeping the brake piston extended; however, there is internal friction within this mechanism that resists extension. This test was undertaken to study whether the APB mechanism introduces any frictional resistance that has a quantifiable impact on the resulting brake output force.

3.2 Freight Railcar Arrangement

The test railcar, shown in Figure 2, was a 4,550 ft³ covered hopper car owned by the NRC and normally used at the NRC's Rail Vehicle Impact Ramp Test Facility. The car was loaded with crushed stone, and had a gross rail load (GRL) of approximately 265,300 lbs. The car was built in 1980, and, although it is not

suitable for revenue service, it was outfitted with a new AAR-approved car control valve (service and emergency portion) and a refurbished AAR-approved standard 10-inch by 12-inch brake cylinder. All new components were dated 2020.



Figure 2. NRC 100-ton loaded covered hopper car (AVL 003).

3.3 Individual Railcar Air Brake Test Rig

The individual railcar air brake test rig was purpose-built by the NRC as a compact means to evaluate the performance of freight car air brake systems (Figure 3). In this compact arrangement, the main components of a typical freight railcar system are present: the car control valve, an empty/load valve, a retainer valve, the auxiliary and emergency reservoirs, 50 feet of brake pipe, and the brake cylinder. The NRC modified the individual test rig by adding a spring bumper to replicate the brake rigging stiffness required to maintain force for the proper APB engagement. On a railcar, this would typically be provided through the brake beams and other components of the brake system rigging.



Figure 3. Individual railcar air brake test rig.

3.4 Instrumentation and Data Acquisition

The freight railcar arrangement was instrumented to automatically record the following data using a digital data acquisition system (DAS):

- eight brake shoe/wheel tread normal forces
- handbrake chain tension force
- brake pipe pressure
- emergency reservoir pressure
- auxiliary reservoir pressure
- brake cylinder pressure
- brake piston displacement

Separately, the individual railcar air brake test rig measured and recorded the following parameters:

- brake pipe pressure
- auxiliary reservoir pressure
- emergency reservoir pressure
- brake cylinder pressure
- brake piston force
- brake piston displacement

In addition, the CWAB system as a whole, measures and records the following, at various locations:

- control system air flow (nominal ‘locomotive’ air flow)
- additional flow meters (not related to the APB testing)
- temperature

Signals from instrumentation transducers were recorded using the DAS, that provided a 16-bit final resolution. All channels were simultaneously sampled, and filtered using a low-pass analog 8-pole Butterworth anti-alias filter. The DAS control software was used to configure the DAS and record data during all tests. All signal channels were sampled at 100 Hz and filtered at a cut-off frequency of 50 Hz.

4 RESULTS

For confidentiality purposes, manufacturer identities have been anonymized and their individual results combined into a single aggregated dataset. The data presented has been averaged from three repeat applications for a majority of the tabulated results.

4.1 APB Installed in the Freight Railcar

4.1.1 APB Handbrake Testing

At ambient room temperatures, handbrake tests were performed by applying a full-service air brake application, then applying the handbrake to the required chain force, and finally releasing the air brake. This procedure was repeated three times. The total brake shoe force and piston displacement were measured at each phase. Table 1 shows the average results of the standard and APB-equipped cylinder tests. Note that the APB was not engaged during the handbrake tests, as the brake pipe pressure did not fall below the trigger signal.

Table 1. Handbrake results, freight car arrangement, all units

UUT	Handbrake plus air brake		Following air brake release		
	Avg. piston disp. (in.)	Avg. force (lbf)	Avg. piston disp. (in.)	Avg. force (lbf)	Avg. % force remaining
Std. cylinder	9.5	37,500	0	36,400	97
APB-equipped	9.4	38,050	0.3	36,800	97

4.1.2 APB Performance Testing

Table 2 shows the test results of the brake applications for the APB-equipped cylinder. Note that the APB was engaged during the emergency brake applications, but not the full-service brake applications, as the brake pipe pressure did not fall below the trigger signal.

Table 2. Performance results, freight car arrangement, APB-equipped cylinder

Temp. (°C)	Full-service		Emergency	
	Avg. piston disp. (in.)	Avg. force (lbf)	Avg. piston disp. (in.)	Avg. force (lbf)
+5	8.2	25,500	8.6	30,500
-20	8.1	25,700	8.5	30,500
-40	8.1	25,000	8.5	29,800

4.1.3 APB Engagement Testing

All instances of the emergency application were held by the APB upon air brake release, as summarized in Table 3.

Table 3. APB engagement emergency force results, freight car arrangement, APB-equipped cylinder

Temp. (°C)	Avg. % force remaining	Number of APB engagements held
+5	96	6/6
-20	96	8/8
-40	96	6/6

4.1.4 APB Internal Friction Testing

Internal friction testing showed that the APB-equipped cylinders had minimal impact on braking output force. After examining a select number of brake applications, the data indicated that, on average, a force of approximately 300 lbf is required to overcome the frictional resistance inside the built-in mechanism as measured at the brake piston.

4.2 APB Installed in the Individual Railcar Air Brake Test Rig

As the individual test rig does not simulate the handbrake, only air brake performance results are reported for this test.

4.2.1 Full-service & Emergency Brake Applications

Table 4 shows the results for the standard brake cylinder and the APB-equipped units in the individual railcar air brake test rig. Average brake cylinder piston force, displacement, and brake cylinder pressure (BCP) for the brake applications are shown. Temperature varied between the three UUTs, however, all tests were conducted at ambient temperatures of 5°C or above. A comparative analysis is shown in Section 5.2.

Table 4. Performance results, individual test rig, all units

UUT	Full-service			Emergency		
	Avg. piston disp. (in.)	Avg. force (lbf)	Avg. BCP (psi)	Avg. piston disp. (in.)	Avg. force (lbf)	Avg. BCP (psi)
Std. cylinder	7.9	4,680	65	8.2	5,570	77
APB-equipped	7.9	4,310	66	8.2	5,080	77

5 COMPARATIVE PERFORMANCE ANALYSIS

Testing on the APB-equipped cylinders and the standard brake cylinder was conducted in two different testing arrangements: one involving installation on the freight railcar, and another involving installation in the individual railcar air brake test rig. The following headings demonstrate the performance variations from the introduction of the built-in APB mechanism.

5.1 Freight Railcar Installation: APB vs. Standard Cylinder

During freight railcar testing, performance was measured primarily through the use of brake shoe force transducers. A comparison of the APB-equipped cylinders against the standard brake cylinder for full-service and emergency brake applications is shown in Table 5. The net brake ratio (NBR) is the ratio of total brake shoe force to the railcar’s GRL, and is presented in the table as the percentage difference between the APB and the standard cylinder.

Table 5. Percent difference of APB vs. standard cylinder performance results: freight car arrangement

Full-service			Emergency		
Avg. % diff. piston disp.	Avg. % diff. force	Avg. % diff. NBR	Avg. % diff. piston disp.	Avg. % diff. force	Avg. % diff. NBR
-1	-3	0.3	-2	-5	0.5

5.2 Individual Railcar Air Brake Test Rig Installation: APB vs. Standard Cylinder

The test rig measured brake cylinder piston force through a spring bumper apparatus to simulate brake rigging stiffness. This simulated stiffness is required for the APB mechanism to properly engage. Table 6 shows the percentage change between the APB-equipped cylinders and the standard brake cylinder for full-service and emergency brake applications conducted in the individual railcar air brake test rig.

Table 6. Percent difference of APB vs. standard cylinder performance results: individual test rig

Full-service			Emergency		
Avg. % diff. piston disp.	Avg. % diff. force	Avg. % diff. BCP	Avg. % diff. piston disp.	Avg. % diff. force	Avg. % diff. BCP
0	-8	-2	0	-8	0

6 DISCUSSION

6.1 APB Functional Performance

Handbrake tests were performed only with the freight railcar and involved the application of the handbrake upon a full-service air brake application, followed by the release of the air brake. Results showed that, following handbrake application and air brake release, the relative force held by the handbrake on the APB-equipped cylinders was repeatable (96%). It was found that the APB mechanisms did not affect handbrake operations during these tests. Additionally, the force held by the APB was consistent with the force held by the handbrake, showing that the APB functioned as intended.

Full-service and emergency air brake applications were conducted with the standard brake cylinder installed on the freight railcar, and these were compared to the same applications conducted with the APB-equipped cylinders. The net brake ratio shows a slightly lesser force when compared to the standard brake cylinder.

Overall, these series of tests suggest that a minimal force difference (less than 5%) would be experienced by railcars in the field for full-service and emergency brake applications if an APB-equipped cylinder was installed as a direct replacement for the standard brake cylinder. However, these results do not account for the service wear or equipment degradation observed in air brake systems over long periods of time.

In the test rig, brake applications for APB-equipped cylinders were compared to the standard brake cylinder, and, on average, had 8% lower force than the standard cylinder for both full-service and emergency brake applications. The lower relative forces observed in the test rig compared to the freight car are likely due to the simulated brake rigging stiffness interacting with the APB mechanism, as confirmed by the freight car test results.

6.2 Rail Safety Implications

For safety reasons, locomotive engineers and conductors on freight trains are required to apply handbrakes on freight cars when a train is stopped in certain situations, such as following an emergency brake application on a grade. In some cases, as per regulations, a large number of handbrakes must be applied, and for a crew of two people, this task may be made more difficult due to cold temperatures, snow, and ice conditions. When the train is ready to travel

again, these handbrakes must also be manually released by the crew.

A train with all cars equipped with automatic parking brakes, which mimic handbrake application, could allow the freight train to meet the regulated number of applied handbrakes required for securement automatically by mechanically locking the brake piston in an extended position following an emergency brake application, or for a service brake application if the brake pipe pressure subsequently fell below a threshold. When secured, the APB on each car would be releasable without requiring manual intervention by the crew, and, if handbrakes were applied, would not interfere with the handbrake application or holding force.

6.3 Potential Operational Challenges

The widespread implementation of APB-equipped cylinders in existing rolling stock would require seamless integration with existing current freight railcar braking systems. To facilitate rapid installation, the cylinders should allow for direct replacement with minimal effort and minimal disruption to standard railcar brake system maintenance practices.

The NRC observed a number of qualitative challenges related to the various APB installations and operation that would be worthwhile to state, as they should not be overlooked when comparing the APB-equipped cylinder with standard cylinders:

1. Integration into the carbody as direct replacements
– A carbody-mounted air brake cylinder is typically pedestal mounted to the top side of the carbody bolster near the draft sill at the B-end of the car. This arrangement varies depending on the type of freight railcar. However, the arrangement on the railcar used at the NRC during testing is typical for a standard covered hopper car. It was observed that the installation of the APB-equipped cylinders did result in interference with the carbody structure from the additional locking mechanism. The impact of potential structural modifications to car bodies should be taken into consideration when evaluating the ease and cost of installing the APB-equipped cylinders as direct replacements for existing rolling stock equipment.

2. Integration into existing air brake system accessories – During the installation of the APB-equipped cylinder, the bleed rod, which is accessible from both the left and right side of the railcar, required rework to allow attachment at the car control valve. This bleed rod is required to allow the railway personnel to manually drain air from the brake cylinder. The rework was minor but should be noted to understand the implications on direct replacement components.
3. Integration of APB mechanism into brake pipe – To enable the APB functionality, the APB-equipped cylinder requires a pressure sensing airline to be installed from the brake pipe on the railcar to the APB system to sense the brake pipe pressure as a trigger signal.
4. Manual release of the APB-equipped cylinder – Railway operations would require the ability to easily release the APB-equipped cylinders after engagement when railcar movement is required. Manual release functionality would be necessary to allow for car movement when not connected to the locomotive air supply such as when the railcar is not part of a train, and when the brake pipe pressure is at 0 psi, which would require the mechanism to be easily released. The APB-equipped cylinders would require a manual release mechanism that is easily accessible from either side of the railcar without the use of additional tools. The ease of use will prevent potential exposure of railway personnel to the risks associated with unplanned/uncontrolled railcar movements if they were required to mount a railcar to release an APB-equipped cylinder.
5. Visual identifier of the engaged APB-equipped cylinder – For ease of operation, it would be helpful to railway personnel for the APB-equipped cylinders to have a visual indication of APB engagement. This indication would allow personnel to make informed railway operational decisions related to proper brake releases and the coupling of standing cars.

6.4 Technology Readiness Review

In 2023, TC retained the United States Department of Transportation’s John A. Volpe National Transportation Systems Center to review the APB technology by assessing the current state of the technology, assigning a Technology Readiness Level (TRL), and proposing

actions towards implementation. At the time, there were three manufacturers whose products were assigned a TRL, which corresponded to a prototype that had been reasonably demonstrated in an operational environment but had yet to be proven in the representative revenue service environment.

The review considered the APB technology as “premature to begin implementation”, and the recommendations were to develop a test requirement under extreme conditions such as steepest grade and cold temperatures, then perform testing to inform technology development prior to the adoption of regulations and standards. [2]

6.5 Interchange Service Design Considerations

The NRC observed minor differences in the solution-based designs of the APB mechanism, including variations in:

- mechanical packaging,
- defined pneumatic thresholds for engagement and release,
- the ability to manually release the mechanism engagement, and
- brake force reductions (minor but measurable) at the cylinder and at the wheel treads

These variations would be solved through the implementation of a mechanical design and operational standard to define performance requirements for the APB function in the Association of American Railroads (AAR) *Manual of Standards and Recommended Practices (MSRP)*. It is envisioned that an equipment specification for the APB Mechanism would be added to Section E: *Brakes and Brake Equipment*, last released in 2019 [3].

In addition to performance-based standards, the AAR has developed extensive approval standards that detail the requirements to achieve AAR approval prior to the serial deployment of equipment across the North American railway industry, where both safety and interchangeability are required for effective railway operation. All equipment for railway operation is required to undergo an intensive multi-faceted process detailed within AAR *MSRP* Section J: *Specification for Quality Assurance*, last released in 2024 [4]. The APB-equipped cylinder would be required to follow the same process, including design review, certification testing, field service trials and auditing prior to approval.

6.6 Future Field Testing

Following the NRC's temperature-controlled laboratory-based approach to understand and evaluate the novel function of the APB-equipped cylinders, the NRC determined that the development of the APB equipment would benefit from further field tests in a railway interchange service environment. A preliminary field-testing plan would include several APB-equipped direct replacement cylinders placed in revenue service and monitored for occurrences of brake holding ability, to better understand the likelihood and benefits of the APB-equipped cylinder to retain braking forces during routine and emergency air brake applications. Revenue service field testing could also yield results with regard to not only the extreme cold operations tested by the NRC in the CWAB facility, but also to a wide range of weather phenomena such as snow, ice, and freezing rain build-up, along with longer-term exposures to water, dust, heat, and vibration and shock from railroad use.

Finally, additional field cyclic testing could provide insight into the endurance of service-worn APB units.

7 CONCLUSION

The APB-equipped cylinders evaluated during testing at the NRC were effective at maintaining brake force following an emergency brake application, even after air had been completely removed from the brake cylinder. Furthermore, they were effective at maintaining brake force during routine brake applications with little performance degradation resulting from the APB mechanism. Additionally, the APB-equipped cylinders showed no significant impact on handbrake operation.

Results demonstrate that the implementation of the APB equipment into interchange operations has the potential to improve railway safety. However, implementation may present integration challenges with railway operations. These challenges should be addressed prior to serial deployment into service by the North American railway industry.

The analysis presented in this document is limited to technical considerations. Assessment of implementation costs, economic feasibility, and return-on-investment was intentionally excluded from the scope of this work.

8 REFERENCES

- [1] The Transportation Safety Board of Canada. *TSB Recommendation R22-02, Reducing the risk of uncontrolled movements through the implementation of automatic parking brake technology. Rail transportation safety investigation report R19C0015*, issued March 2022.
- [2] U.S. DOT John A. Volpe National Transportation Systems Center. *Automatic Parking Brakes for Freight Train Securement: Technology Review*, October 2023.
- [3] Association of American Railroads. *Manual of Standards and Recommended Practices, Section E: Brakes and Brake Equipment*, released in 2019.
- [4] Association of American Railroads. *Manual of Standards and Recommended Practices, Section J: Specification for Quality Assurance*, released in 2024.