Cold weather performance of freight car air brake systems

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

National Research Council Canada

Automotive and Surface Transportation Research Centre

Cold Weather Performance of Freight Car Air Brake Systems

E. Toma, S. Mackie, A. Jahagirdar

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Background

- Air brake systems are known to have a loss in performance with a drop in ambient temperature – this is typically attributed to air leakage.
- This performance decrease has been known for as long as the modern railway air brake system has existed.
- Understanding of temperature effect on air brake operations is not well documented – industry practice is to adjust operating conditions, sacrificing productivity, dependant on past experience to maintain safety.

Research Objectives

- What is the performance changes the complete air brake system at low temperatures?
- Include all major air brake system components:
    - service and emergency portions, pipe bracket, and pipe fittings and portion gaskets
    - brake cylinder
    - empty-load valve
    - retainer
    - reservoir tanks (auxiliary and emergency) with fittings

- Objective is to be able to understand <u>all</u> these components operating as a whole system under extreme cold conditions.

NRC Cold Weather Air Brake Research Lab

How do you fit a train

…in here?

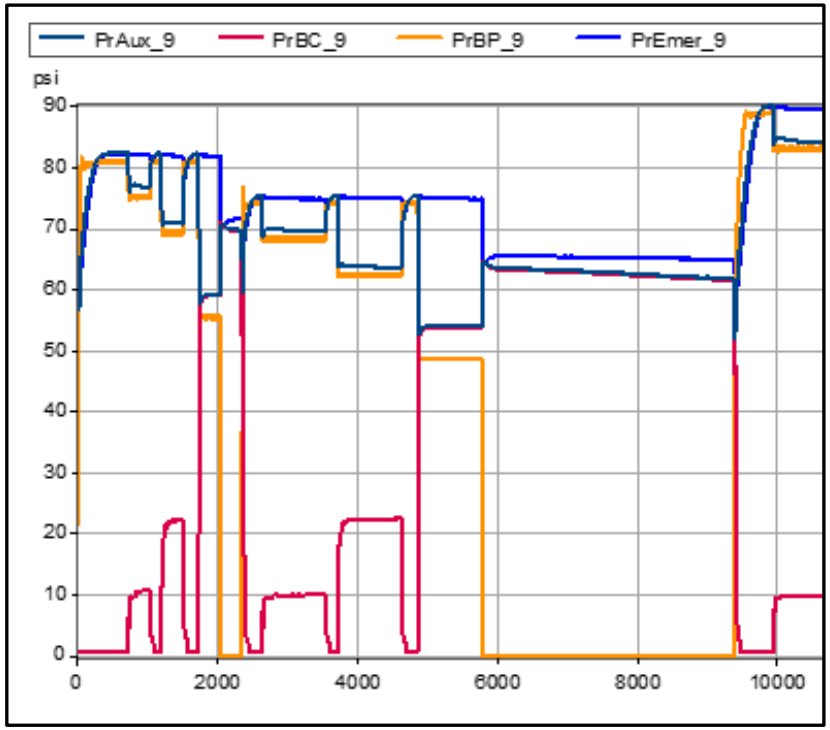
- Goal: *To test multiple freight cars at one time under controlled temperatures.*
- The solution: build a compact arrangement of brake system components.
  - testing of brake systems and understanding of interactions of systems as they would experience in a train.
  - modular system of multiple brake units.

Design: Compact modular brake system

Modular system: compact arrangement of all key brake system components into a compact space:

- air reservoir tank
- brake valve
- EL-valve
- retainer valve
- brake cylinder
- 40 feet of brake pipe
- connecting hoses, angle cocks, gland hands

Design: Fully instrumented



Data recorded throughout testing:

- **brake pipe pressure (PrBP)**
- **Auxiliary reservoir pressure (PrAux)**
- **Emergency reservoir pressure (PrEmer)**
- **brake cylinder pressure (PrBC)**
- **Brake cylinder force**
- **piston displacement**
- **Air flow into test setup (SCFM)**

What this research is intended to be:

This research IS intended to:

- **Learn about the performance capabilities of freight air brake systems in cold temperatures.**
- **Better understand, possibly quantify, the change in operational risk due to cold temperatures.**
- **Discover diagnostic tools to identify when a component should be repaired or replaced.**
- **Report findings to industry to improve safety, reliability and efficiency.**

What this research is NOT

This research is not intended to be or to be used as:

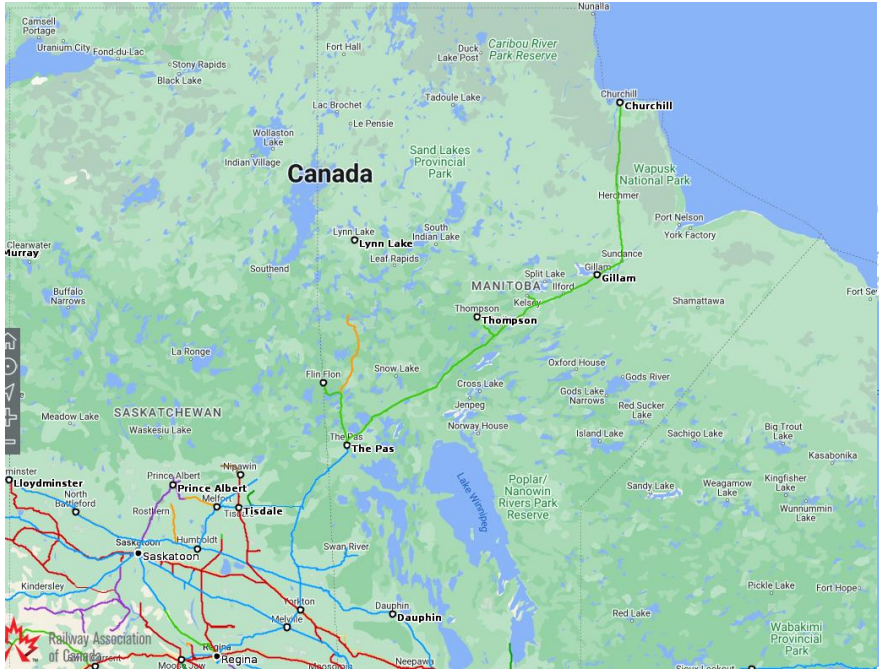
- **An audit of brake component manufacturers.**
- **An audit of brake rebuilding facilities, processes or procedures.**

Inaugural Research: Hudson Bay Railway

https://www.arcticgateway.com/hudson-bay-railway

Government of Canada Gouvernement du Canada

https://tc.canada.ca/en/programs/funding-programs/rail-safety-improvement-program



https://rac.jmaponline.net/canadianrailatlas/

12 functional service worn systems from HBR

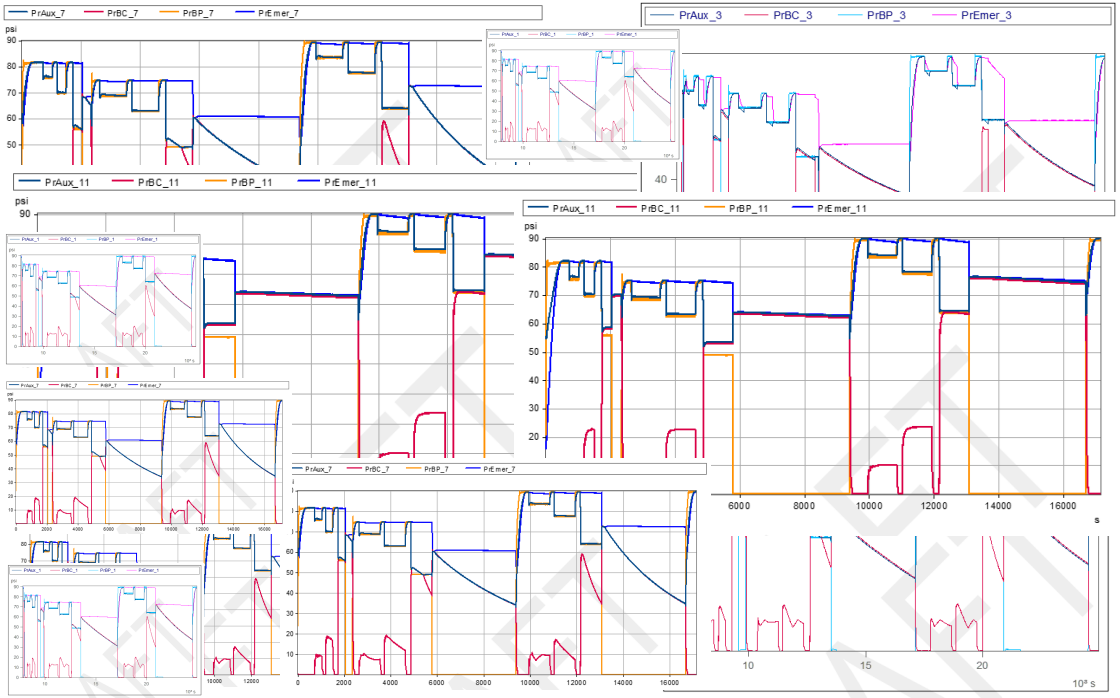
	Unit	visual ("#1")	SCABT	reason	Est. AGE
Group A	1	pass	pass		10
	2	pass	pass		11
	3	pass	pass		6
	4	pass	fail	>225 CIM	9
	5	pass	pass		unknown
	6	pass	pass		13
Group B	7	pass	pass		unknown
	8	pass	fail	>225 CIM	unknown
	9	pass	pass		unknown
	10	pass	pass		5
	11	pass	pass		unknown
	12	pass	fail	retainer	unknown

- **12 functional service worn systems from HBR**
  - Sent in 2 groups of 6 systems
- **All systems pass visual brake inspection: *piston extends with service brake application***
- **SCABT at NRC found 3 'fail':**
  - 2 for excessive leakage (systems function but require more than 225 CIM air flow to charge.
  - 1 system failed during retainer test (with new retainer).

Overview of Test Conditions

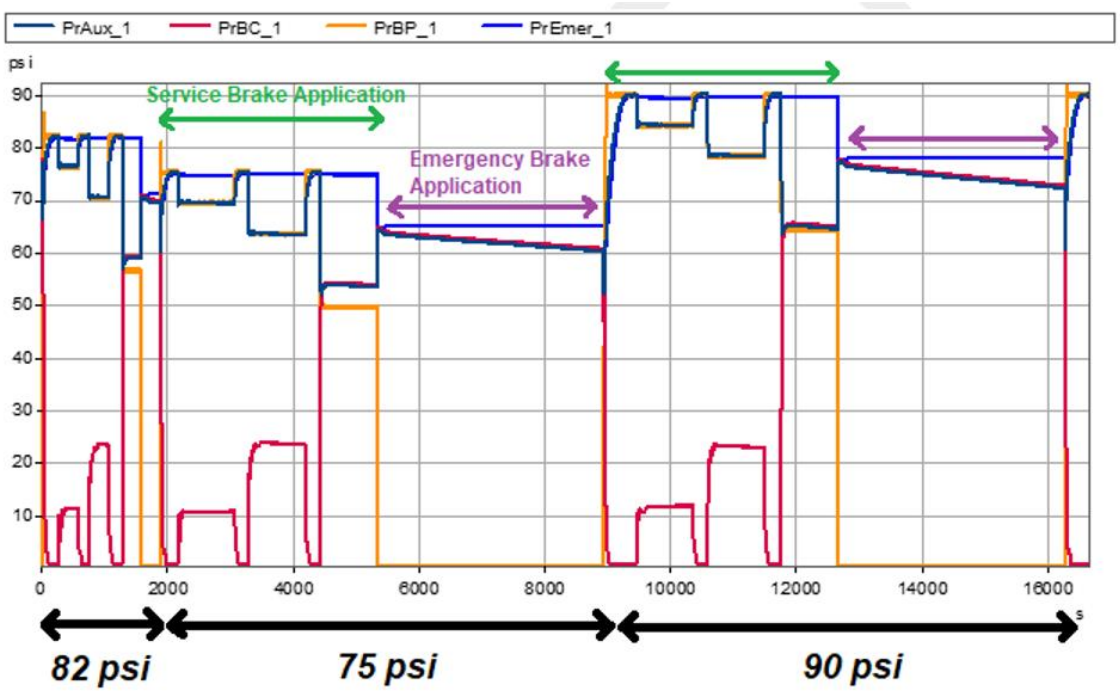
- The systems were tested at temperatures of:
  - +10°C, 0°C, -10°C, -20°C, -30°C, -40°C
- The electronic air control system made consistent and repeatable air brake applications at each test temperature.
- 90 psi representing a front of train brake pipe pressure
- 75 psi representing a rear of train brake pipe pressure (allowable 15 psi loss of pressure to rear of train)

Repeated for all systems, from +10C to -40C



- 288 data cycles
- 82, 75 and 90 psi BPP
- 1872 brake applications
- 1152 brake application data points (75psi and 90psi)
- Qualitative and quantitative look at the data

Brake Application Tests



- At each brake pipe pressure, brake applications resulting from brake pipe reductions of 6, 12 and 26 psi were completed;
- a 26 psi full service application followed by an emergency brake application, held for 1 hour;
- an emergency brake application from fully charged state, held for 6+ hours.

Results

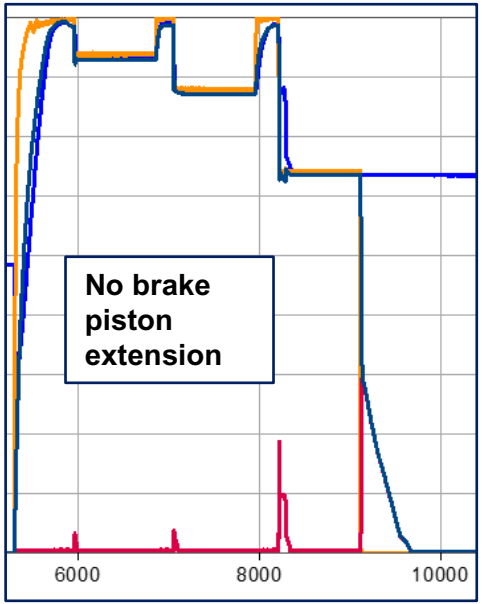
Qualitative analysis: assign a pass, pass/fail, or fail to a system based on what an inspector would see

Pass: brake piston extended and remained extended

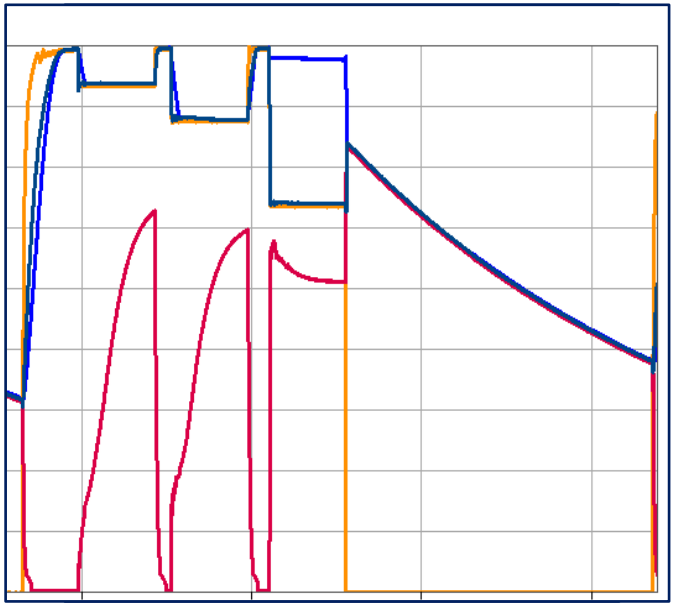
Pass/fail: brake extended, but data shows an issue, or possible fault

Fail: visual inspection shows no brake piston extension (“#1” brake test)

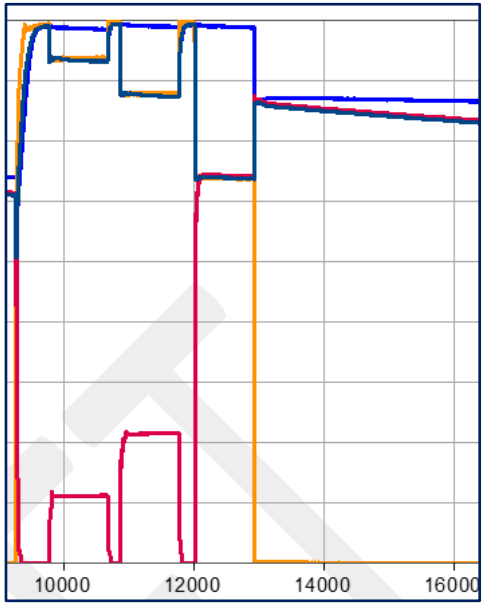
Qualitative analysis: grading system



Fail



Pass/Fail



Pass

		Service-Worn								Refurbished							
		75 psi Tests				90 psi Tests				75 psi Tests				90 psi Tests			
		Brake Pipe Drop (psi)				Brake Pipe Drop (psi)				Brake Pipe Drop (psi)				Brake Pipe Drop (psi)			
Temp. (°C)	Module	6	12	26	E	6	12	26	E	6	12	26	E	6	12	26	E
-40	1	F	P	PF	PF	P	P	PF	PF	P	P	P	P	P	P	P	P
	2	F	P	P	PF	P	P	P	P	P	P	P	P	P	P	P	P
	3	F	F	PF	PF	F	F	F	PF	P	P	PF	P	F	P	P	P
	4	P	P	P	P	P	P	P	P	F	P	P	P	F	P	P	P
	5	F	F	F	F	F	F	P	F	P	P	P	P	P	P	P	P
	6	F	P	P	P	P	P	P	P	PF	PF	PF	PF	F	P	P	PF
-30	1	P	P	PF	P	P	P	PF	P	P	P	P	P	P	P	P	P
	2	P	P	P	PF	P	P	P	P	P	P	P	P	P	P	P	P
	3	F	F	F	PF	F	F	F	PF	P	P	P	P	P	P	P	P
	4	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	5	F	F	F	PF	F	P	P	PF	P	P	P	P	P	P	P	P
	6	P	P	P	P	P	P	P	P	PF	PF	P	PF	PF	PF	PF	P
-20	1	P	PF	PF	PF	P	PF	PF	P	P	P	P	P	P	P	P	P
	2	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	3	F	F	F	P	F	F	F	P	P	P	P	P	P	P	P	P
	4	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	5	F	F	P	PF	P	P	P	PF	P	P	P	P	P	P	P	P
	6	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
-10	1	P	PF	P	PF	P	PF	PF	P	P	P	P	P	P	P	P	P
	2	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	3	F	F	P	P	F	F	F	P	P	P	P	P	P	P	P	P
	4	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	5	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	6	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
0*	1	P	P	PF	PF	P	P	PF	P	P	P	P	P	P	P	P	P
	2	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	3	F	F	P	P	F	F	P	P	P	P	P	P	P	P	P	P
	4	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	5	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	6	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
10	1	P	P	PF	P	P	PF	PF	P	P	P	P	P	P	P	P	P
	2	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	3	F	F	P	P	F	F	P	P	P	P	P	P	P	P	P	P
	4	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	5	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	6	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

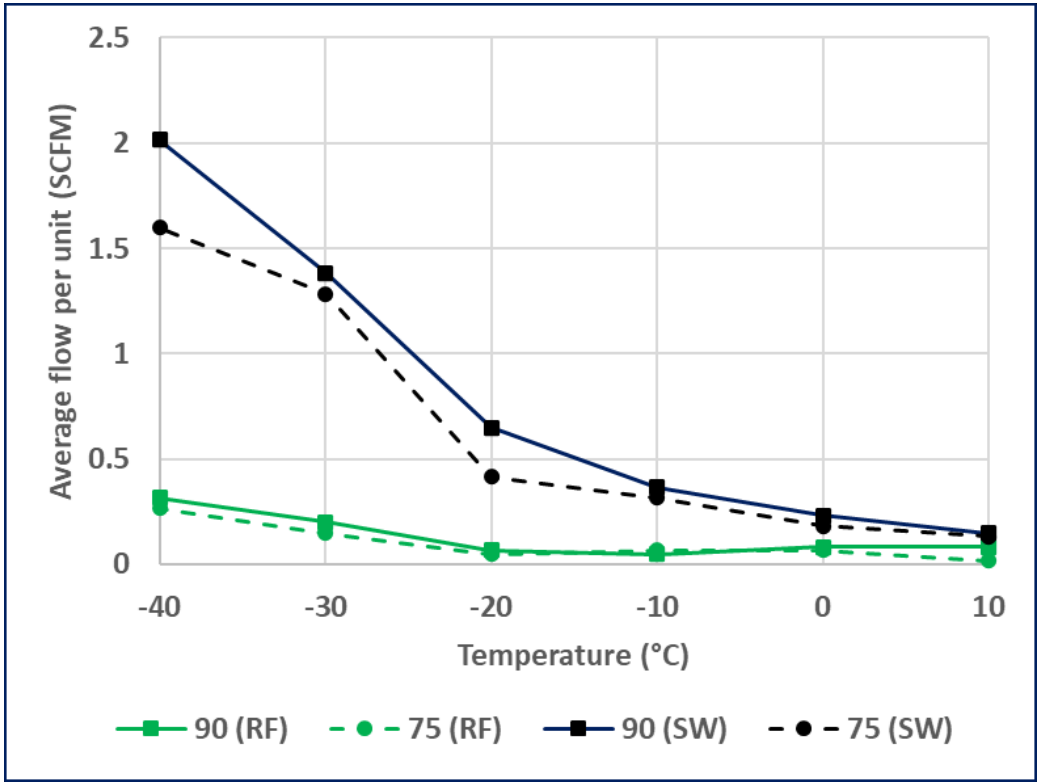
		Service-Worn								Refurbished							
		75 psi Tests				90 psi Tests				75 psi Tests				90 psi Tests			
		Brake Pipe Drop (psi)				Brake Pipe Drop (psi)				Brake Pipe Drop (psi)				Brake Pipe Drop (psi)			
Temp. (°C)	Module	6	12	26	E	6	12	26	E	6	12	26	E	6	12	26	E
-40	7	PF	PF	PF	PF	F	PF	PF	PF	P	P	P	P	P	P	P	P
	8	F	F	F	F	F	F	F	F	P	P	P	P	P	P	P	P
	9	F	PF	PF	F	F	F	PF	F	P	P	P	P	P	P	P	P
	10	F	P	P	F	F	PF	P	PF	P	P	P	P	P	P	P	P
	11	F	PF	PF	PF	F	F	PF	PF	P	P	P	P	P	P	P	P
	12	F	F	F	F	F	F	F	F	P	P	P	P	P	P	P	P
-30	7	PF	PF	PF	F	PF	PF	PF	PF	P	P	P	P	P	P	P	P
	8	PF	PF	PF	P	PF	PF	PF	P	P	P	P	P	P	P	P	P
	9	P	PF	P	F	P	PF	PF	PF	P	P	P	P	P	P	P	P
	10	PF	PF	P	PF	PF	PF	P	P	P	P	P	P	P	P	P	P
	11	F	PF	PF	PF	F	F	F	PF	P	P	P	P	P	P	P	P
	12	F	F	F	F	F	F	F	F	P	P	P	P	P	P	P	P
-20	7	P	PF	PF	F	P	PF	PF	P	P	P	P	P	P	P	P	P
	8	PF	P	PF	P	P	P	PF	P	P	P	P	P	P	P	P	P
	9	PF	PF	PF	F	F	PF	PF	PF	P	P	P	P	P	P	P	P
	10	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	11	PF	PF	PF	PF	PF	PF	PF	PF	P	P	P	P	P	P	P	P
	12	PF	PF	P	F	PF	PF	P	F	P	P	P	P	P	P	P	P
-10	7	P	PF	PF	P	P	PF	PF	P	P	P	P	P	P	P	P	P
	8	PF	P	PF	P	P	P	PF	P	P	P	P	P	P	P	P	P
	9	PF	PF	PF	F	PF	PF	PF	PF	P	P	P	P	P	P	P	P
	10	P	P	P	P	P	PF	P	P	P	P	P	P	P	P	P	P
	11	PF	PF	PF	PF	PF	PF	PF	PF	P	P	P	P	P	P	P	P
	12	PF	PF	P	F	PF	PF	PF	F	P	P	P	P	P	P	P	P
0*	7	P	PF	PF	P	P	NA	PF	P	P	P	P	P	P	P	P	P
	8	PF	P	PF	P	PF	NA	PF	P	P	P	P	P	P	P	P	P
	9	PF	PF	PF	PF	P	NA	PF	F	P	P	P	P	P	P	P	P
	10	P	PF	PF	P	P	NA	PF	P	P	P	P	P	P	P	P	P
	11	PF	PF	PF	PF	PF	NA	PF	PF	P	P	P	P	P	P	P	P
	12	PF	PF	P	F	PF	NA	P	F	P	P	P	P	P	P	P	P
10	7	P	PF	P	P	P	PF	PF	P	P	P	P	P	P	P	P	P
	8	PF	PF	PF	P	PF	PF	PF	P	P	P	P	P	P	P	P	P
	9	P	PF	PF	PF	P	PF	PF	PF	P	P	P	P	P	P	P	P
	10	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	11	PF	PF	PF	PF	PF	PF	PF	PF	P	P	P	P	P	P	P	P
	12	PF	PF	P	F	PF	PF	P	F	P	P	P	P	P	P	P	P

*Note: The 12 psi drop at 0°C on the 90 psi tests was improperly applied by the air delivery system

Quantitative

- Air flow into the system (6 units)
- Full service brake forces
- Emergency brake forces
- Emergency brake 60 minute pressure loss

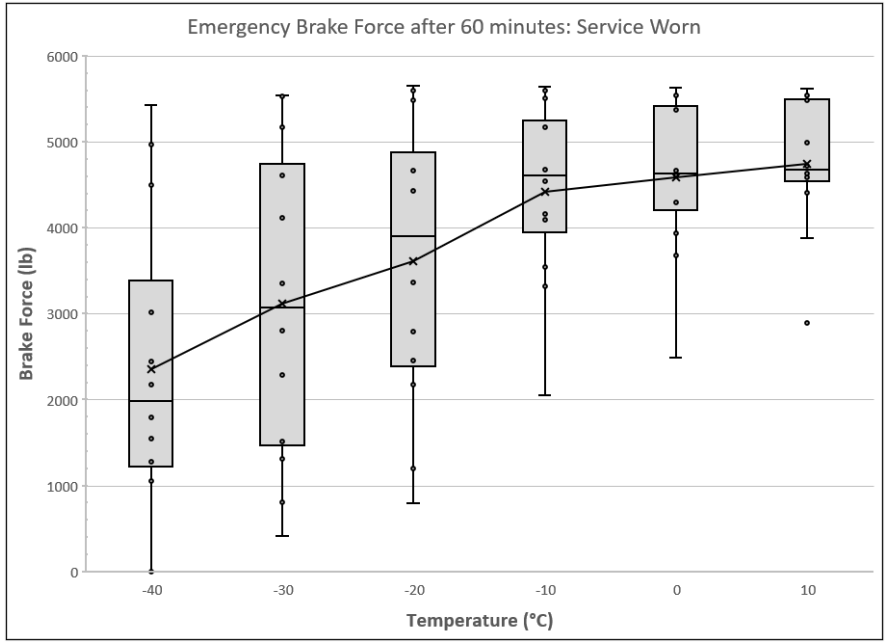
Air Flow



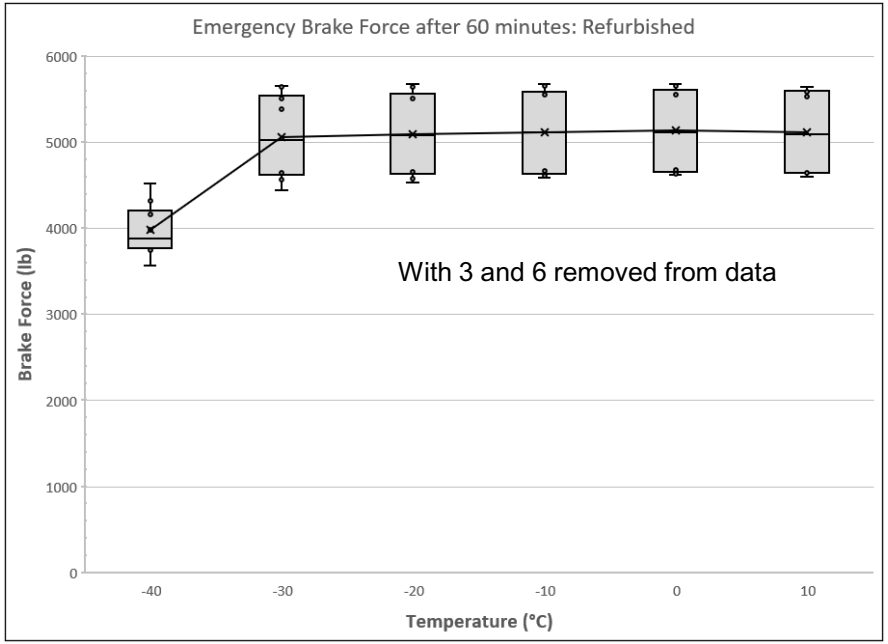
- **Air flow entering the brake pipe for 6 systems**
- **Air flow is measured at the fully charged state (90 and 75 psi)**
- ***all air hoses are new***
- ***new gland hand gaskets***

Effect of Temperature on Emergency Brake Force
(Group A 6 units, 75 and 90 psi BPP)

Service Worn Systems

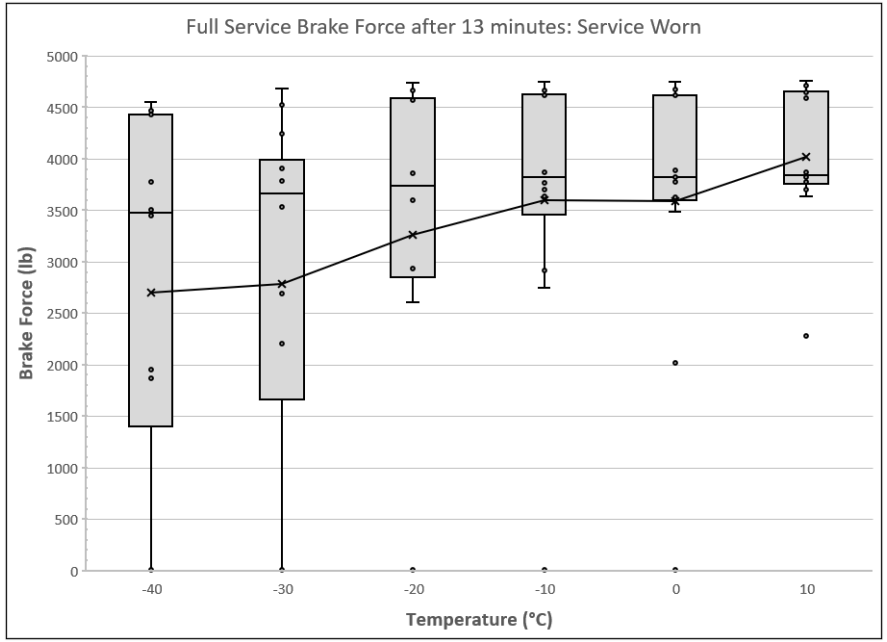


Refurbished Systems

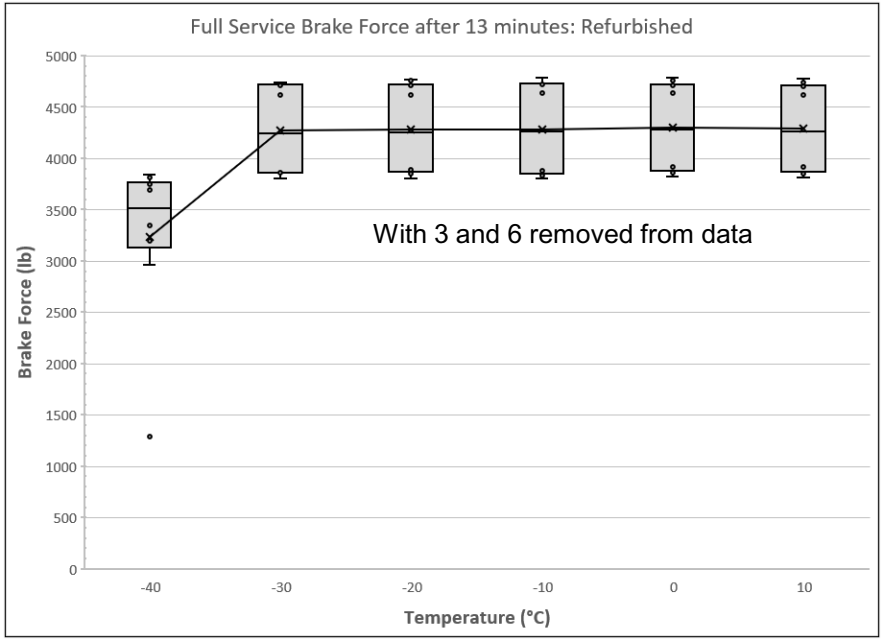


Effect of Temperature on Full Service Brake Force
(Group A 6 units, 75 and 90 psi BPP)

Service Worn Systems

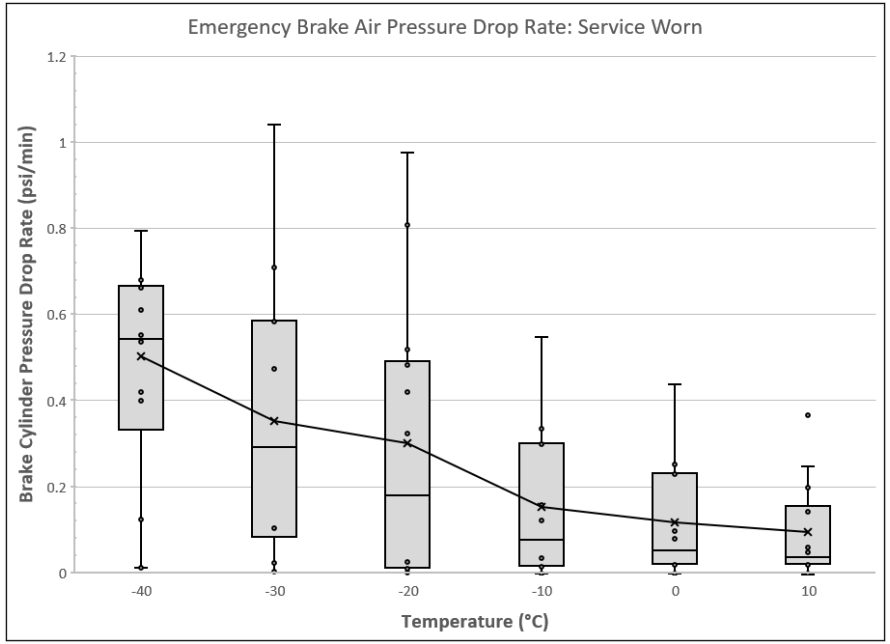


Refurbished Systems

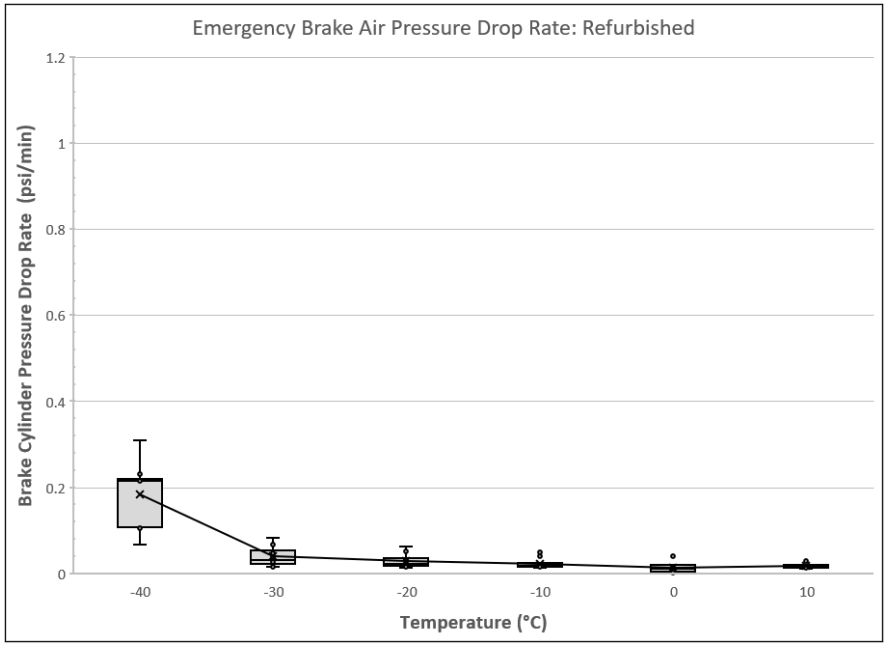


Effect of Temperature on Emergency Brake Cylinder Pressure Loss Rate
(Group A 6 units, 75 and 90 psi BPP)

Service Worn Systems

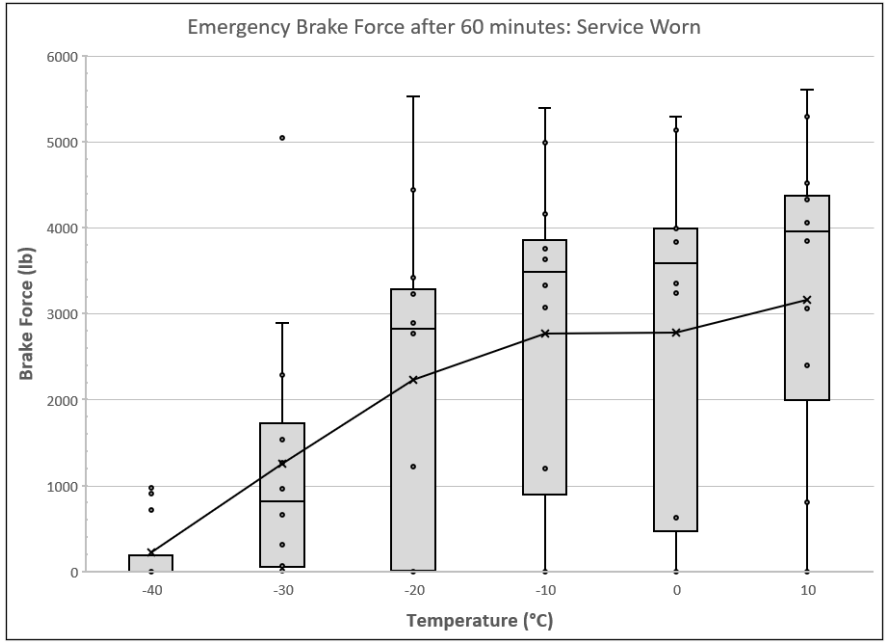


Refurbished Systems

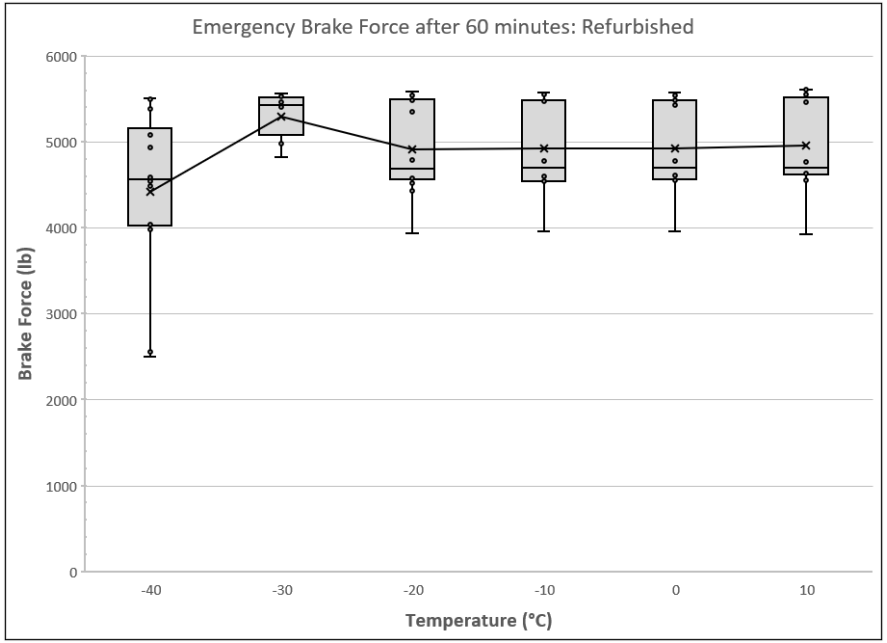


Effect of Temperature on Emergency Brake Force
(Group B 6 units, 75 and 90 psi BPP)

Service Worn Systems

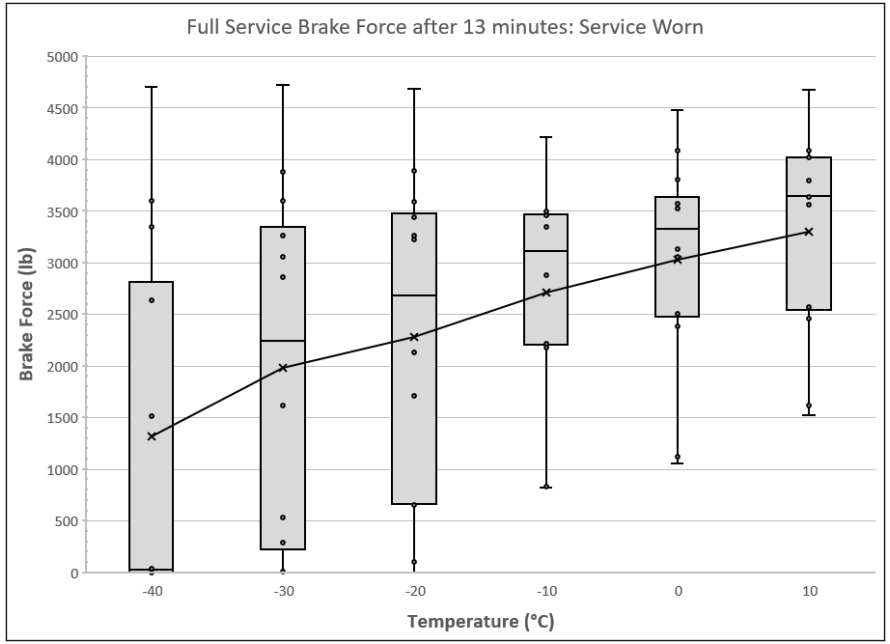


Refurbished Systems

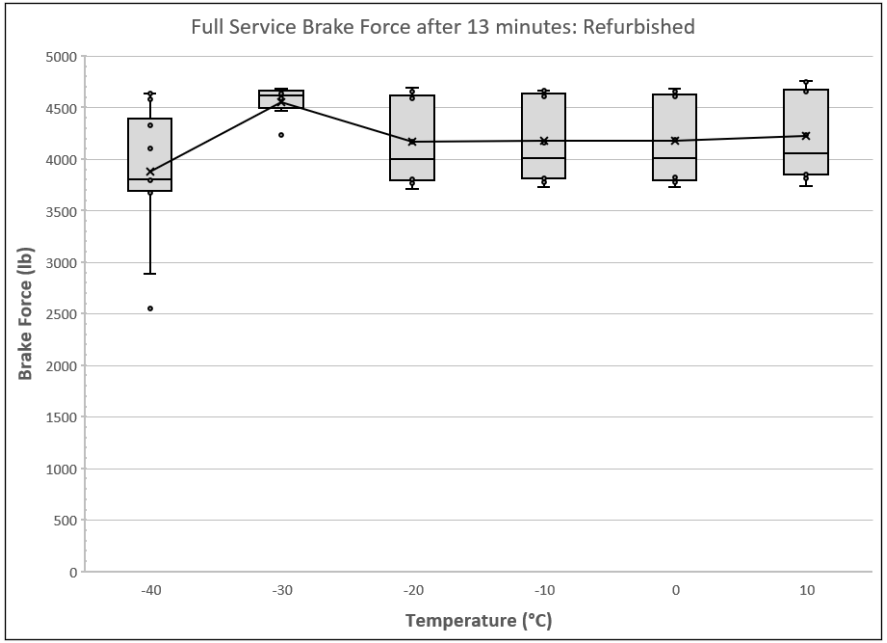


Effect of Temperature on Full Service Brake Force
(Group B 6 units, 75 and 90 psi BPP)

Service Worn Systems

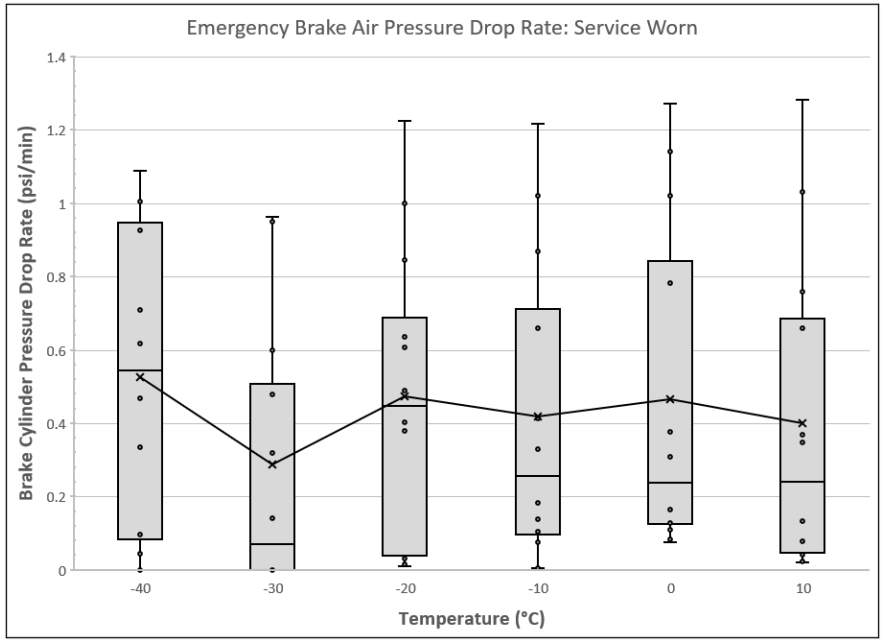


Refurbished Systems

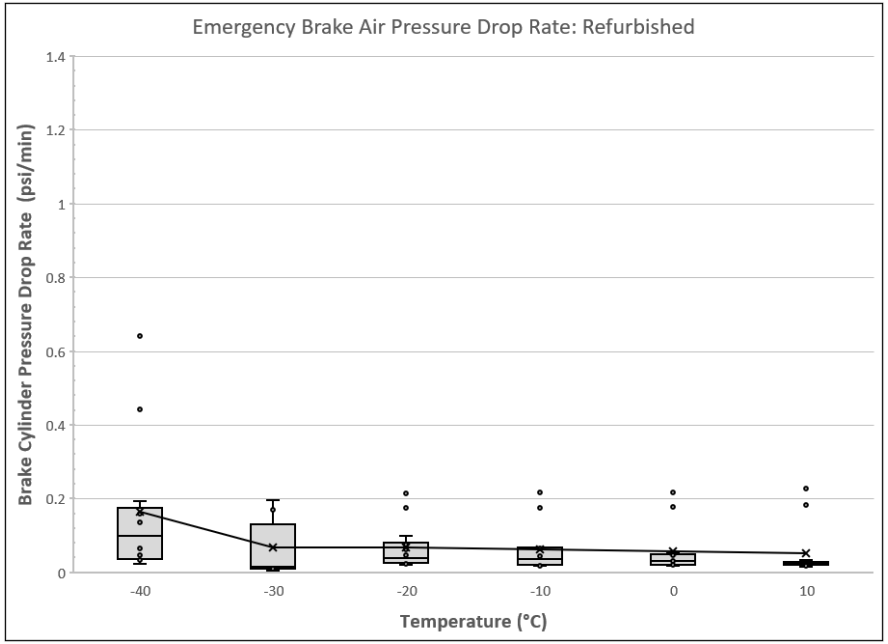


Effect of Temperature on Emergency Brake Cylinder Pressure Loss Rate
(Group B 6 units, 75 and 90 psi BPP)

Service Worn Systems



Refurbished Systems



Summary

- Refurbished brake systems performed as well at colder temperatures as warm.
- For service-worn systems, air flow demands were high, and when below -30°C were over 10x greater than at 10°C.
- In contrast, air flow demands of refurbished systems were low and rose only slightly with lower temperatures.
- Service worn systems (of various ages) showed drop of in performance with temperature, without a distinct cut-off or break point temperature.
- As temperatures dropped, new leaks occurred at flanges and connections – tightening fasteners would remove of reduce these leaks.

Conclusions

Recommendations to HBR that resulted from these tests:

- **Even when cars pass the SCABT (at temperatures above -20°C), replace older brake systems that exhibit poor performance in extreme cold with new or refurbished systems.**
- **Follow all AAR maintenance practices: replace gaskets, filters, etc. as required when replacing portions. (eg, do not re-use portion gaskets.)**
- **Maintain the locomotive air compressor system: clean dry air is a requirement in cold conditions.**
- **Do not rely on service or emergency brake to hold cars or trains – always apply hand brakes.**

Thanks to:

Brett Young, General Manager, Hudson Bay Railway

Albert Wahba, Program Leader, Resilient Ground Transportation Program at NRC

Transport Canada, Rail Safety Improvement Program

Thank You!

National Research Council Canada

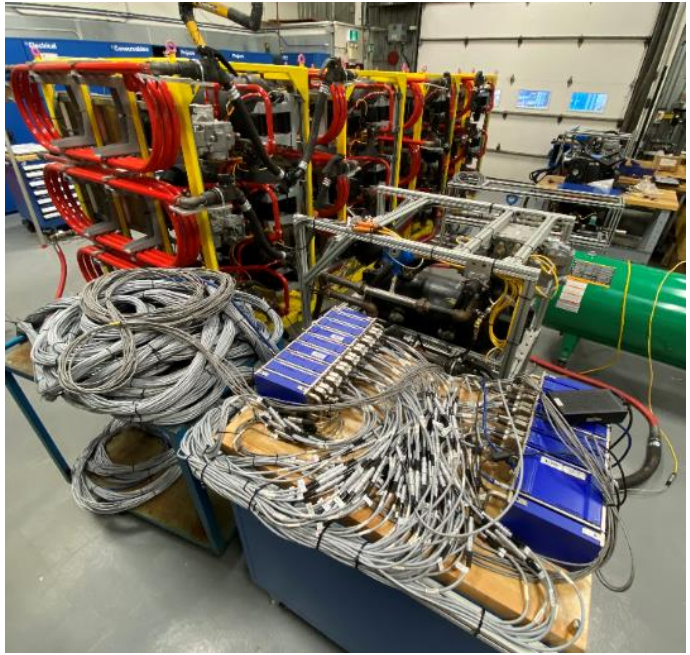
Automotive and Surface Transportation Research Centre

2320 Lester Road, Ottawa, ON

Dr. Elton Toma

Elton.Toma@nrc-cnrc.gc.ca

343-999-9726



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