

AN EXPERIMENTAL ELECTRIC ASSIST BRAKE SYSTEM

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Summary

The AAR Research and Test Department has completed the laboratory testing of an electro-pneumatic assist (EPA) brake system. Results show that the EPA brake is most effective with heavy brake applications and the system's effectiveness increases as the severity of downgrade increases. Results also show that train speeds for existing double stack trains in existing block lengths can be increased by 10 to 20 mph in relatively flat territory.

The AAR EPA system is a conservative overlay system primarily intended to demonstrate the improved stopping ability of electric brake systems on heavily loaded fast trains, i.e. solid articulated double stack trains. This will allow these heavier trains, such as solid double stack trains, to more frequently run at full track speeds. The EPA system was tested on a simulated 25-car double stack train on the AAR Train Braking Research Facility in Chicago.

The EPA system is now ready for test on a train, but further testing has been put on hold. Shortly after completion of these tests, several manufacturers announced more advanced electric brake systems which would allow graduated release and faster brake cylinder pressure build-up. Because of this, AAR R&T is now concentrating on the development of performance requirements for testing of advanced brake systems. These testing requirements will be submitted for consideration by the AAR O&M committees as a specification for future electric braking systems. The performance portion of the testing requirements has been under development since October, 1993 and is nearing completion. Future prototype electric brake systems will hopefully be tested to these performance requirements. These tests will be used to further develop the signal protocol and trainline connector design (if one is used). The advanced brake systems are also intended to work within a total train control and information system which would include such items as distributed power control and hot box detection.



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INTRODUCTION AND CONCLUSIONS

The AAR Research and Test Department (R&T) has successfully completed the evaluation of an electrically assisted brake system on the Freight Train Braking Facility at the Chicago Technical Center. This work was done as part of the Advanced Braking System study, which has the goal of recommending specifications to the AAR O&M committees covering the performance and interchange requirements of advanced brake systems.

There are a number of conclusions which can be drawn from these tests. First, the EPA brake is most effective with heavy applications, and not as effective with 6-10 psi reductions. Second, the EPA system effectiveness increases as the severity of downgrade increases. Third, existing double stack train speeds in the existing block lengths could be increased by 10 to 20 mph when the EPA system is used. Fourth, grade balancing with the air brake is not effected by any "speed-of-light" brake signal propagation other than the fact that the engineer can get his brakes on quicker if he gets into trouble. Grade balancing is strictly a function of the operating brake ratio of the train and the thermal capacity of the wheels and brake shoes. Because of this, the use of the EPA brake system in heavy grade territory would not allow any significant increase in speed.

ELECTRIC-ASSIST BRAKE SYSTEM

AAR R&T contracted with Q-Tron Ltd. to develop an Electro-Pneumatic Assist (EPA) brake system to demonstrate the performance benefits of electric brake signal propagation. The intent of this system was to use it as an overlay system on top of the conventional air brake system. The EPA system provides for a simultaneous brake pipe reduction throughout the train. In case of failure, however, the conventional brake system would continue to operate normally.

The EPA system consists of a head-end control box, which is connected to the brake pipe gage test port on any locomotive in the consist, and is powered by 72 VAC from the locomotive. Each 5-unit double stack car would have one repeater unit connected to the dirt collector bowl of the center brake system control valve. The repeaters would be connected to each other and to the head-end control box with cables.

The AAR used cables originally manufactured for the Canadian Pacific Second Generation Unit Train (SGUT). The cable connectors between every car were designed to pull apart without damage when the cars were uncoupled, yet be water and dust tight. These cables were in successful service on the SGUT for approximately two years. The only problem experienced with these connectors was when moisture condensed inside the connector and froze. This resulted in the plugs or sockets being pulled from the connector body when they were uncoupled in freezing weather. Q-Tron has rebuilt the cables with a redesigned connector which will hopefully eliminate the freezing problem.

The repeaters have a pressure transducer which reads the local brake pipe pressure at the car, and a solenoid valve selected for its low current draw. The head-end control box has a pressure transducer to read brake pipe pressure at the locomotive. The control signal is an FM signal carried on a 30 VAC trainline cable. The signal protocol is 1000 Hz = 100 psi, and 500 Hz = 0 psi. The total current draw for the system with 25 repeater boxes is about 2 amps.

When the locomotive engineer makes a brake pipe reduction, the head-end control box reads the brake pipe pressure and sends an FM signal corresponding to the brake pipe pressure back through the trainline cable. When a repeater sees that the brake pipe pressure signal from the head end is 2 psi lower than the local brake pipe pressure, a solenoid valve is opened to locally vent the brake pipe at a service rate. The solenoid valve remains open until the local brake pipe pressure is reduced to within 0.5 psi of the pressure signal from the head end. The brake release is conventional. With this initial conservative system, there is no provision for an electrically assisted emergency application. The conventional pneumatic emergency remains the fastest way to stop the train. This was done for safety, so that if the EPA system failed just as the engineer braked for a restrictive signal, the train could still be stopped short of that signal with a conventional emergency application.

The Train Braking Research Facility 150-car rack was configured to duplicate as near as possible 25 double stack cars, each with three control valves and 300 feet of brake pipe per car. An EPA repeater was connected to the center control valve on each simulated double



stack. The control valves on each simulated car were two DB60-Ls and one ABDW. The cables were replaced with short jumpers with the same electrical resistance as the actual trainline cables due to space limitations within the lab building. The head-end control box was connected to the racks' 26C brake valve.

In the initial rack tests the EPA signal propagation rate was disappointingly slow. The solenoid valves chosen were too small, and difficulties with pressure transducer resolution occasionally resulted in unintended brake applications. Selection of a bigger solenoid valve and some fine tuning of the control software resulted in much improved performance. Full service, 20 psi, 15 psi, 10 psi, minimum service and 5 psi reductions were

made both with the conventional baseline braking system and with the EPA system. The results are shown in Table 1. Comparisons of traditional propagation times are meaningless because with the EPA brake, the propagation time is very close to zero. For Table 1, the time from the start of the application to 70% and 90% of full brake cylinder pressure is used for comparison.

Note that the data for minimum service and the 5 psi reductions are not in the table. This is because the effect of the faster EPA propagation diminishes with lighter brake applications. The EPA has the biggest effect with heavier brake pipe reductions. Exhibit 1 shows the train average brake cylinder pressure build-up for a full service reduction.

TABLE 1

Brake Appl.	Time (sec) to 70%		Time (sec) to 90%		% Improvement to	
	CONV	EPA	CONV	EPA	70%	90
	50	19	89	27.5	62	69
20 psi	57.5	26	104	85	55	18
15 psi	50	22.5	99.5	83	55	17
10 psi	48.5	47	169	108	3	36

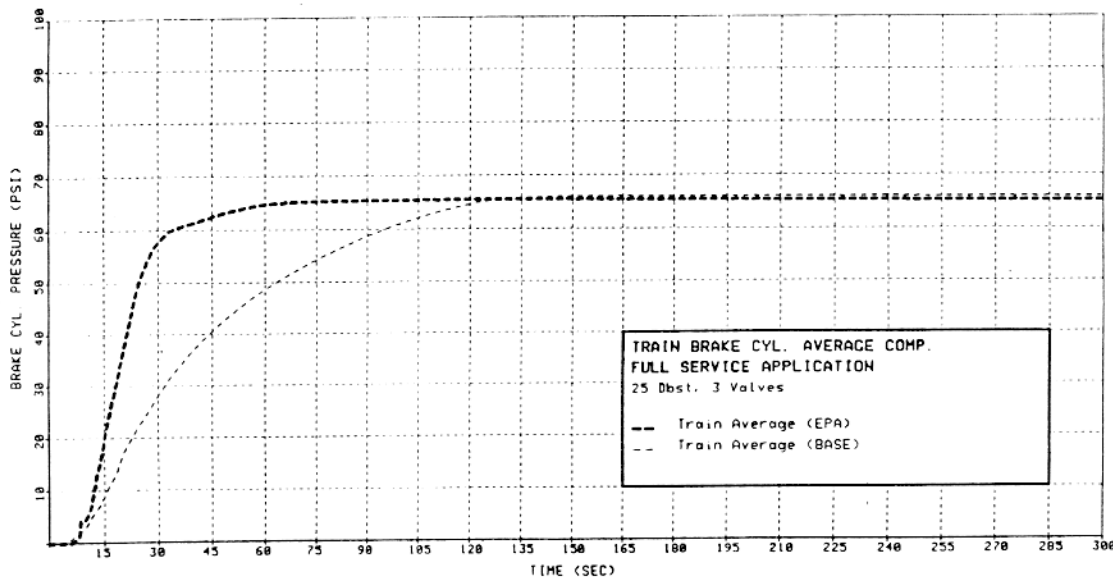


Exhibit 1. Full Service Train Average B.C. Pressure, EPA vs. Conventional



Using these train average brake cylinder pressures in a stop distance calculation for a double stack train yields the results shown in Table 2. The train in question has twenty seven 125-ton 5-unit double stack cars braked at 8.5% net brake ratio with 50 psi brake cylinder pressure. The locomotive consist is five 200-ton 6-axle units with brakes bailed off. The total train weight is 9000 tons and the total tons per operative brake for this simulated train is 120. The stop distances (Table 2) are for straight away full service applications from a 90 psi brake pipe pressure. The train average brake cylinder build-up used for the emergency calculations came from an FTABS computer simulation.

The next step was to be a functional test of the EPA equipment on a train, but that has been put on hold. Following the completion of these tests, several

manufacturers announced more advanced electric brake systems which include graduated release. One of these systems has already been tested on a 30-car train. The AAR will now concentrate on the development of an electric brake performance specification, which will be used to test future advanced brake systems for AAR interchange approval. At the time of this writing, two meetings have been held to begin the development of this specification. The meetings have been attended by railroad and supply industry representatives. Two draft specifications have been developed; one for dedicated service only, and one which would allow an electric brake equipped car to operate in a conventional train. These specifications call for faster brake cylinder pressure build-up and an electric emergency application. Table 3 shows the improvement in stopping distance with the advanced electric brake systems with the same train simulated in Table 2.

TABLE 2

SPEED mph	% GRADE	STOP DISTANCE (Feet)			REQ'D BLOCK LENGTH	
		CONV.	EPA	EMERG.	CONV.	EPA
80	0	8980	7151	5648	11973	9535
70	0	7368	5735	4417	9824	7647
70	-1.0%	10450	7899	5689	13933	10532
30	-2.2%	6748	3614	1860	8997	4818
20	-3.0%	10389 *	3906	1349	13852	5208

Speed increased from 20 mph to 38 mph before brakes began to decelerate the train.

TABLE 3

SPEED MPH	% GRADE	CONV. F.S.	CONV. EMERG.	AAR EPA F.S.	ADVANCED F.S.	ADVANCED EMERG.
90	0	----	----	----	7400	6449
80	0	8980	5648	7151	5966	5191
80	-1.0	----	----	----	8184	6757
70	-1.0	10450	5689	7899	6388	5262

Note: Contact Fred Carlson at (312) 808-5832 with questions or comments about this document.

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