TECHNOLOGY DIGEST

Timely Technology Transfer

"ECP BRAKES — CABLE CONNECTORS AND THE RADIO OPTION "

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Summary

The railroad industry may soon realize the many economic and safety benefits of electronically controlled pneumatic brakes, but there is a need among railroad personnel for a better understanding of these systems. Tests performed by the Association of American Railroads indicate that ECP brakes allow for shorter stopping distances through faster signal propagation and uniform braking forces. Current pneumatic brake systems operate at about half the speed of sound, while the new electronic devices have the potential to send out braking messages to every car on the train at the speed of light.

This quick transfer of information allows for a virtual instantaneous braking effect on all cars. Revenue-service tests of trains equipped with ECP brakes readily show the shorter stopping distances these systems provide — 40 to 70 percent shorter than standard pneumatic braking systems, depending on brake application and gradient. Some potential advantages of ECP brake systems include more reliable operation, reduced slack action, reduced fuel consumption and less wear and tear on wheels. Furthermore, a built-in health-monitoring aspect constantly updates the engineer on the status of the braking system. It is hoped that this feature will eliminate 1,000-mile intermediate terminal brake tests and periodic air-brake tests.

Because ECP systems are the wave of the future in railcar braking, it is important that all railroad personnel have at least a working knowledge of these systems. This report will detail how ECP brakes work, and clear up some misunderstandings.

Suggested Distribution:

- ❑ Equipment/Rolling Stock
- ❑ Train Handling
- ❑ Intermodal/Safety
- ❑ Car Department

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INTRODUCTION

The Association of American Railroads, in cooperation with the railroad supply industry, has been developing performance specifications for electronically controlled pneumatic (ECP) brake systems for use on cars in interchange service between railroads. ECP systems are also well suited to captive fleets. While this effort is generally understood among railroad mechanical staff, there is still a lack of knowledge among general railroad personnel as to just what an ECP brake is, and how it works. Furthermore, there is also some confusion concerning the use of the "radio option" and radio repeaters in ECP systems. This paper will attempt to clarify these issues in easily understood terms.

ECP DESCRIPTION

The ECP brake directly and simultaneously controls brake-cylinder pressure on each car in a train. This is unlike conventional brakes, which rely on changes in brake-pipe pressures to cause pneumatic control valves to apply and release the brakes. With ECP brakes, each car is actually a node in a computer network. This means each car can communicate with other cars as well as the head end unit on the locomotive. The car-control devices (CCDs) are capable of reacting to signals, or to the lack of signals, such that the train will either stop on its own, or warn the engineer when a problem arises. The ECP brake uses the present brake pipe as a reservoir-charging pipe only. The present brake cylinders and rigging can be used with the new system. All control of brake-cylinder pressure is through a computer-controlled network. Each car is equipped with one or more CCDs, which act to fill and exhaust the brake cylinder. Brake-cylinder pressure is directly controlled by each CCD according to a brake command from the engineer. Each CCD monitors its own brake-cylinder pressure. This enables the CCD to maintain brake-cylinder pressure against small amounts of brake-cylinder leakage. Unlike conventional brake systems, the final brake-cylinder pressure is independent of brake-cylinder piston travel.

Because the signal speed from the first car to last car is instantaneous with ECP systems, the rate of brake-cylinder pressure build-up is higher. In conventional systems, the brake-cylinder pressure build-up time has been carefully retarded in order to prevent the last cars of a train, where the brakes have not yet engaged, from ramming the front cars having fully developed brake-cylinder pressure. The ECP brake-cylinder pressure build-up rate will be approximately 6 to 10 psi/sec for both emergency and service brake applications.

ECP systems allow the graduated release of the brakes because the brake-cylinder pressure is now under direct control of the engineer. The brakes can be applied, partially released, then reapplied as often as necessary to negotiate a changing grade, within the ability of the locomotive compressors to replenish air reservoirs at the rear of a long train. Under virtually any operating scenario, it will be difficult to "run out of air."

RADIO OPTION VS. CABLE/CONNECTOR

In an ECP train there are two ways to pass information from the locomotive to the cars, and from car to car — train-line cables and radios. All ECP trains currently operating employ a train-line cable with connectors between each car. While this scheme can cause a single-point failure if a connector should part, experience to date has shown that connectors are very reliable. All revenue-service operations to date have used a temporary connector, the reliability of which has far exceeded all expectations. After more than 55 million car miles of revenue-service testing on four railroads, there have been only three connector separations causing a train delay. The AAR is currently working with a number of manufacturers to develop an AAR standard connector, which is expected to be extremely reliable.

The train-line cable provides the means to charge the battery on each car with power from the head-end locomotives, or from locomotives distributed throughout the train. The cable also allows any node to transmit at any time, and the signal transmissions are instantaneous throughout the train. The cable can also "jump start" batteries on cars that have been stored for long periods of time. The AAR is in the final testing phase of a method to automatically test the integrity of the connectors and transceivers in a train, and to order the cars from front to back.

Exhibit 1 — Comparison of Brake Systems

Feature	Conventional Repeater	Radio	ECP Cable	ECP Radio
Reservoir charging while brakes applied	NO	NO	YES	YES
Simultaneous control of B.C. pressure within ± 2 psi on all cars	NO	NO	YES	YES
"Speed-of-Light" brake signal propogation	NO	NO	YES	YES*
FCC license required for radio	N/A	YES	N/A	NO
Maintain B.C. pressure against light leakage	NO	NO	YES	YES
Maximum resistance to signal interface	N/A	NO	YES	YES
Individual intelligence on each car which allows for onboard health-monitoring such as bearing temperature and ride quality	NO	NO	YES	YES
Shorter stop distances	NO	YES**	YES	YES
Graduated release	NO	NO	YES	YES

* The radio systems are slightly slower than cable systems. The radio commands from the locomotive to the EOT and back again can take anywhere from a few tenths of a second to two seconds, depending on weather and track-side conditions.

** Use of a radio repeater does provide shorter stopping distances; however, the radio repeater will never equal the performance of the ECP systems. This is due to the slower brake-cylinder pressure build-up using the conventional control valves and because the brake signal must still be propagated pneumatically from the repeaters to the remaining cars.

The radio option uses radio transceivers and onboard power generators on each car to take the place of the connectors and the train-line power/signal cable. Unlike the cable systems, which transmit signals at the speed of light, the radio system uses a short-range radio which does not require an Federal Communications Commission license. The radio signal is relayed from transceiver to transceiver until the signal reaches the End of TRain (EOT). The EOT then transmits a return message that is relayed back to the locomotive. While this method is not "speed of light," it is much faster than the present pneumatic signal speed of about 500 feet per second. Depending on weather conditions, and on-track side environments (tunnels, cuts, trains on adjacent tracks, noise sources) the signal may travel anywhere from 300 to 5,000 feet before it loses strength and must be retransmitted. This means that the signal may take from a few tenths of a second to two seconds to travel from the locomotive to the EOT and back again depending on conditions and train length.

In addition, should a cut of cars be stored for a long period of time (grain hoppers, for instance), the batteries could become discharged. The options for bringing the brake systems back to life would be to individually recharge, or change the battery on each car. There are also potential difficulties in forming the train network in train yards, and it could prove difficult to automatically and reliably obtain the car order from front to back.

ECP BRAKES AND RADIO REPEATER VALVES

The introduction of a radio repeater has caused some confusion in the industry. There are those who think that the radio repeater offers a means to equip a few cars at a time and thereby migrate gradually to full ECP operation. This is not true. The hardware and software used in radio repeaters is not transferable to ECP operation. The repeater allows conventional service and emergency brake applications to be made at remote locations in a train, such as at the last car or at several cars with repeaters spaced throughout the train. But the actual control of the brakes on each car is still pneumatic. This is a laudable concept, and will certainly help the operations of conventionally braked trains. But it is no substitute for ECP brakes.

It is believed in some quarters that the radio repeater will provide all of the advantages of ECP brakes without having to rely on an electric trainline cable. This also is not true. The repeater does not provide graduated release. It does not provide constant reservoir charging. It is not capable of maintaining brake-cylinder leakage. It does not provide for onboard health monitoring. And it does not provide constant brake-system health monitoring. The latter feature is the key to reducing mandatory air-brake testing requirements and eliminating intermediate terminal air-brake tests. The repeater will provide shorter stopping distances, but they will never be as short as ECP brake stopping distances due to the conventional brake-cylinder build-up time and the necessity of sending an air signal over some portion of the train's length. Incidentally, the radio repeater concept was considered and tested by the AAR in 1993 and rejected when it became obvious that a better solution was possible. Exhibit 1 compares features of the present and radio-repeater brake systems with both the cable and radio ECP brake systems.

CONCLUSION

The ECP brake system is a train-control network encompassing not only brakes but distributed motive power and train-health monitoring. The operating principles of the system are essentially alike regardless of using cables and connectors or short-range radio and on-board power. In either case, all cars in a train would have to be ECP-equipped to gain the full benefits of this new technology. While it may be technically possible to mix ECP and conventional cars in the same train, all of the benefits of ECP braking would be lost with the exception of somewhat shorter stopping distances. The same holds true for radio repeaters. The AAR is pressing ahead with the ECP performance specifications based on a cable system. Should a viable radio option system prove more reliable and cost-effective than the cable system, then the industry could switch. However, at this point the cable system appears to be the most reliable and cost effective way to implement ECP brake technology.

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