TECHNOLOGY DIGEST

Timely Technology Transfer — 98-008

ECP Brake Tests on Conrail Unit Coal Trains

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Summary

A cooperative test with Consolidated Rail Corporation (Conrail) has provided valuable data on equipment and system design, as well as environmental requirements for electronically controlled pneumatic (ECP) brake systems. However, due to equipment and operational limitations encountered during this test, the original goal of quantifying the economic benefits of ECP brakes was not as conclusive as expected. The test also reinforced the need for adequate training of both operations and maintenance personnel as a new and radical technology is being implemented. In addition, the findings supported the need to move towards stand-alone ECP brake systems, rather than overlay systems, as quickly as possible.

The test was conducted on a dedicated pair of Conrail coal trains on a mainline route through Pennsylvania between June 1996 and May 1997. The main participants in this cooperative project were: Conrail, Technical Services and Marketing Inc. (TSM), the Association of American Railroads, and the Federal Railroad Administration (as partial sponsor of the project). The study compared the service and maintenance experience of a unit coal train equipped with TSM s latest electronic air-brake overlay ECP brake system with an identical conventionally braked train, operating in the same service. These trains operated a dedicated service between the coal fields of Southwestern Pennsylvania and two power-generating stations in the Philadelphia area.

A complete record of comparative maintenance was kept over the test period. In addition, measurements were made of fuel consumption and coupler forces for multiple trips of each of the trains in an attempt to quantify any benefits in train handling that may result from the use of ECP brakes.

Suggested Distribution:
- o Equipment/Rolling Stock
- o Train Handling
- o Intermodal/Safety
- o Car Department

Work performed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

April 1998

INTRODUCTION AND CONCLUSIONS

A comparative test performed between June 1996 and April 1997 on a dedicated pair of Conrail coal trains has provided valuable data on equipment and system design, as well as environmental requirements for electronically controlled pneumatic (ECP) brake systems. Unfortunately, due to equipment and operational limitations encountered during the test, the original goal of quantifying the economic benefits of ECP brakes was not as conclusive as expected. This Technology Digest presents the results and findings of this test as follows.

- The service experience on Conrail has continued to confirm the viability of ECP brake technology in service.
- The harsh operating environment experienced by these particular cars, coupled with Car Control Device (CCD) manufacturing problems during initial assembly, led to a higher-than-expected ECP brake-failure rate, and may have tainted the comparative component maintenance data.
- In the ECP brake overlay design (i.e., when brake technology is overlayed on the existing air-brake system), sticking brakes can occur on cars near the back of the train when the ECP brakes are cut out.
- The average coupler force and the round-trip drawbar energy measurements indicated that the energy requirements for the ECP-braked trains were higher than the conventionally braked train. Differences in train makeup and train-handling techniques may have jeopardized the integrity of the energy-comparison test data.
- The coupler-force data indicated that the ECP-braked trains exhibited less dynamic-coupler forces than their conventionally braked counterparts.
- The number of wheel-set change-outs on the ECP-braked trains compared with the conventionally braked trains was significantly lower, although the brake-shoe usage was higher.

BACKGROUND

The focus of the industry cooperative ECP brake research program has moved towards establishing the economic benefits of this technology. However, the widespread implementation of a technology as radically different as this requires strong economic justification.

In early 1995, the Association of American Railroads (AAR) entered into a cooperative agreement with Conrail and Technical Services and Marketing Inc. (TSM, now a subsidiary of Rockwell International) to conduct an extended-service comparison test. Part of the funding for this effort was provided by the Office for Research and Development of the Federal Railroad Administration (FRA), as part of the AAR/FRA joint research agreement. The objectives of this test were to evaluate the long-term service reliability of the technology and quantify economic benefits.

RECOMMENDATION

Based on test results, it is recommended that:

- Changes should be made to the ECP brake-overlay system design to ensure that sticking brakes cannot occur when the electronic control is cut out.
- A high priority should continue to be given to the development of pure ECP brake systems.
- The shock and vibration environmental requirements for electronic equipment mounted on freight cars should be increased (already implemented, see TD 97-022).
- A more robust intercar connector design with positive mechanical latching should be adopted, particularly when frequent coupling and uncoupling operations are involved. (A new AAR standard intercar connector design meeting these requirements has been adopted by the industry)

TEST OPERATION OVERVIEW

The operation moves coal from two mines located near Conrail s Shire Oaks yard, which is south of Pittsburgh, to two power plants in the greater Philadelphia area. Three train sets, each consisting of 115 cars, are used to service this operation. During the spring of 1996 one of these train sets was equipped with ECP brakes, the main objective being

to quantify the economic benefits of this technology compared with conventionally braked equipment in identical service.

After a train is loaded at one of the two mines, it is moved to Shire Oaks yard in preparation for the trip to the power stations. The loaded train is routed over Conrail mainline trackage on its way to Philadelphia. After being unloaded, the empty train is then returned to Shire Oaks for loading at one of the two mines. The round-trip sequence, including loading and unloading, is accomplished in approximately five days. The distance covered in a round trip is approximately 750 miles.

The section of the service route west of Altoona is classified as mountainous, reaching a peak of 2,180 ft at Gallitzin (see Exhibit 1). The eastern section of the route, which descends to approximately sea level at Eddystone, is classified as undulating territory. Since the braking-duty cycle on this route is relatively high, it was considered to be ideal for the ECP brake-comparison test.

Two alternative routes were utilized at the west end of the operation during this test. The loaded trains were generally routed through Pittsburgh over the Conemaugh line, which is a longer route with milder grades. The empty trains were generally operated over the more direct route, which has more severe grades, but were less significant for the empty train. Helper service was provided for the loaded trains from Johnstown or Pitcairn to Altoona.

TEST PREPARATIONS

The preparation of the 240 cars (120 conventional and 120 ECP brake-equipped) was carried out at Conrail s Enola Car and Locomotive Shops near Harrisburg. The ECP brake equipment was installed on the cars selected for that purpose. All cars were then subjected to a single-car pneumatic air-brake test and a thorough wheel inspection. Any wheel set that, from a wear point of view, would not last the length of the study was replaced, and all known defects were corrected.

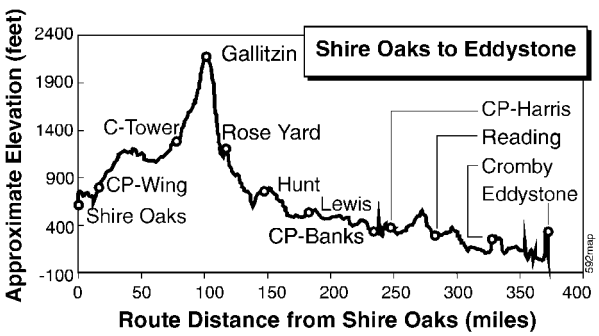

Exhibit 1. Elevation Profile of Test Route

Trainline cabling and provision for the installation of the Head End Unit and the power supply for electronic brake control was incorporated into four SD60M locomotives, of which three were utilized at any one time to operate the ECP brake train. In addition, two SD40-2 locomotives were equipped with special hardware to provide power knock-down in response to an electronic emergency brake signal. These units were used as the rear-of-train helpers for moving the loaded ECP-braked train from Pitcairn or Johnstown to Gallitzen.

IN-TRAIN TEST DATA

Conrail s Instrumentation Car, CR-19, was inserted directly behind the locomotives for several round trips of both trains. The instrumentation car was equipped with an instrumented coupler to measure the locomotive drawbar force and a Somat 2100 programmable data-collection system to collect the data. The instrumentation system also monitored train speed, brake-pipe pressure, and time, together with track curvature and over-/under-balance condition. A GPS system also provided track location and altitude data to the data-collection system. The test data was processed en route to provide a measure of drawbar energy and coupler-force standard deviation.

After the test was completed, the data for all of the runs of each train type was consolidated to provide an average for each train type. The results of this comparison showed that the energy required to operate the ECP-braked train was consistently higher than that required for the conventional train. However, post-test analysis showed that basing energy consumption conclusions on an instrumented coupler measurement behind the lead locomotives alone may not be practical, since this measurement does not take into account the effect of the helpers or of the differences in train-braking techniques with the two systems. It was noted that the locomotive engineers were more inclined to use train braking on the ECP-braked trains and dynamic brakes on the conventional trains. Another major difference affecting the drawbar force data was that the ECP trains were operated with three lead locomotives, while the conventional trains were only dispatched with two.

The loaded train-coupler force data was analyzed for variation on the heavy grade sections before and after Gallitzin. The data showed the coupler-force variations were reduced by approximately 40 percent under heavy draft conditions, and by approximately 60 percent under heavy buff conditions. However, the caveats applied to the drawbar energy results apply equally to these.

MAINTENANCE DATA

The comparative maintenance data records, which are summarized in Exhibit 3, were diligently maintained by the Conrail engineers. The maintenance shows some promising trends in wheel change-outs, although the brake-shoe replacement rate on the ECP train was higher than that observed on the other unit trains monitored. Several of the shoes from both car types were replaced due to the keys falling out in the rotary dumper. Also the increased shoe usage on the ECP brake trains may have been due to the aggressive braking techniques employed by the train crews, as noted earlier.

The ECP brake-component replacements were the result of a series of CCD failures early in the test and of a general deterioration of the temporary intercar connector design used for this test. The connector problem was exacerbated by the frequent coupling and uncoupling required for the coal-dumping operation. In the meantime, a more robust design of intercar connector, with a positive mechanical latching system, has been adopted by the industry as an AAR standard. This is expected to alleviate the connector problem.

The CCD failures occurred early in the test and were attributed to a faulty procedure used to mount the electronic circuit boards during initial assembly at the manufacturing plant. The faulty manufacture, together with the high shock loads sustained during the coal unloading operation, led to an unacceptably high initial failure rate. The manufacturing problems were corrected and the problem solved. The shock and vibration issue was addressed in a special test, conducted by TSM and the AAR. As a result, the shock and vibration requirements for electronic equipment mounted on freight cars contained in the AAR ECP brake specification have been strengthened (see TD 97-022).

During the period of the CCD failures, it was discovered that a sticking brake situation could result from cutting out a single ECP-braked car, when the rest of the system remained operational. This was found to be a problem of using an overlay arrangement. It was found that the small pressure variations in brake-pipe pressure, caused by the adjacent cars operating in the ECP brake mode, could cause the now-active service portion of the cut-out ECP car to set up. However, the pressure recovery was not sufficient to cause the same portion to fully release. This problem was particularly noticeable at the rear of the train. This effect was confirmed by a special test conducted at the Conrail Enola Shops. In retrospect, it is now thought that this effect may have tainted the energy measurements made early in the test program. It certainly provides another incentive to move toward a stand-alone ECP system.

	Conventional	ECP
CCDs	n/a	9
Other ECP Components	n/a	7
Control Valve Portions	4	n.a.
Wheel-set Change-outs	11	2
Brake Shoes Renewed	19	57
Other Brake Components	33	29

Exhibit 3. Summary of Maintenance Data

Note: Contact Fred Carlson at (719) 584-0718 with questions or comments about this document.

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