TECHNOLOGY DIGEST

Timely Technology Transfer — 99-011

Fuel Savings Resulting from the Use of ECP Brakes on Unit Trains

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Summary

Researchers from Transportation Technology Center, Inc., have used newly obtained revenue-service data to confirm computer-modeling simulations indicating that electronically controlled pneumatic (ECP) brakes significantly reduce fuel consumption in operations that rely on power braking. Saving fuel is one of the potential benefits of ECP brakes developed under the Association of American Railroads (AAR) Advanced Brake Systems Strategic Research Initiative. ECP brakes eliminate the need for power braking, which is often required with conventional air brakes to control train speed on undulating territory and on heavy downgrades.

A 1995 analysis, using the AAR's Train Energy Model (TEM) simulations of a unit coal train on Colorado's Tennessee Pass as the case study, showed that fuel savings could be as high as 10 percent.[1] This is in operations where power braking is a requirement to control speed on undulating downgrades. However, there was no data available at the time to benchmark the simulation results.

Locomotive event tape data was made available by Burlington Northern Santa Fe (BNSF) on its taconite-train operation from Kelly Lake in Eastern Minnesota to Lake Superior. This is one of the services being used by BNSF as an ECP-brake test bed. New TEM simulations have been carried out using the taconite train as the case study because actual fuel consumption data does not exist. The event data was was used to validate model results. In this case, a fuel savings of 7 percent was predicted where ECP brakes eliminated the need for a very modest level of power braking for speed control.

Preliminary information from Quebec Cartier Mining (QCM) indicates fuel savings in the 2 to 3 percent range in their ECP operations. In the coming months, more information will become available from QCM test trains. Like the BNSF taconite service, the QCM operation involves loaded trains on long downgrades, with moderate to heavy power braking required to control train speed when conventional brakes are used. Accurate fueling records have been kept for both ECP and conventional trains since the test began. Since the ECP brake system in use on QCM is of the stand-alone design (no pneumatic back-up), the fuel data should not be distorted by periodic conventional-brake operation.

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

Work performed by TTCI Transportation Technology Center, Inc.
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INTRODUCTION AND CONCLUSIONS

One of the potential cost/benefit components identified in the Association of American Railroads' economic model for Electronically Controlled Pneumatic (ECP) brakes was fuel savings. Transportation Technology Center, Inc. (TTCI) researchers used a combination of train simulations and train-operating data to confirm the hypothesis that ECP brakes can significantly reduce locomotive fuel consumption. Studies on loaded unit trains, operating in heavy-grade territory, show that the fuel savings could be as high as 10 percent. ECP brakes eliminate the need for power braking, which is often required with conventional air brakes to control train speed on undulating territory and on heavy downgrades.

BACKGROUND

ECP-brake-related fuel savings of approximately 10 percent were originally predicted in 1995, by simulations of loaded unit coal trains operating on the heavy downgrade from Tennessee Pass (on the former Southern Pacific Railroad) in Colorado. However, no operational data was available at that time to confirm the simulation results.

In 1997, Burlington Northern Santa Fe (BNSF) released data to TTCI from the taconite train operation from Kelly Lake in Eastern Minnesota to Lake Superior. This was one of the services which formed a part of the ongoing ECP-brake revenue-service evaluation program being carried out by BNSF (see TD 97-008). This operation represented an ideal case study to better quantify the potential fuel savings resulting from the use of ECP brakes.

THE BNSF TACONITE TRAIN OPERATION

The taconite trains consist of up to 164 100-ton capacity ore cars. The cars are relatively short in length, measuring approximately 35 feet over coupler faces. The trains are typically pulled by two SD-60M locomotives.

The route featured in this study is from Kelly Lake in Eastern Minnesota to the ship-loading dock at Allouez on Lake Superior, a distance of a little more than 100 miles. The route elevation and speed limit profile is shown in Exhibit 1. The elevation at Kelly Lake is approximately 900 feet above the lake level, while the storage terminal at Allouez is almost at lake level. The trains are loaded at one of several mines near Kelly Lake, which is the staging point for the loaded move to Allouez. As shown in Exhibit 1, the loaded move is mainly on downgrade, with a maximum gradient of -0.82 percent. The track curvature is moderate, with a maximum curvature of 7.5 degrees. The route is divided into three main gradient sections, separated by two plateaus. The longest sustained downgrade is approximately 30 miles long, with an average gradient of -0.38 percent, varying from almost 0 to -0.82 percent.

EVENT TAPE ANALYSIS

Event tape records were provided by BNSF for eight round-trip train operations (Allouez-Kelly Lake-Allouez), all for conventionally braked trains. After preliminary analysis, one of the tapes was selected as the basis for train-simulation study, on the grounds that it represented an "average" operation. Three other tapes, containing complete loaded-train operations, were used to support the selection. The speed profile for the selected baseline train (ALLBRM 201) is shown in Exhibit 2, while the train performance data is summarized in Exhibit 3. The fuel consumption for the service train was estimated from the event tape throttle channel, using the "time at throttle" method.

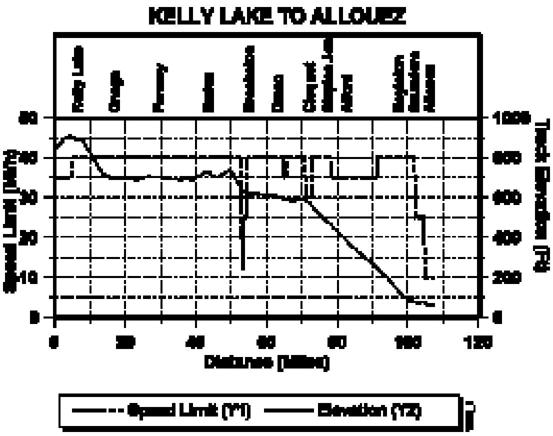

Exhibit 1. Taconite Train Route Profile

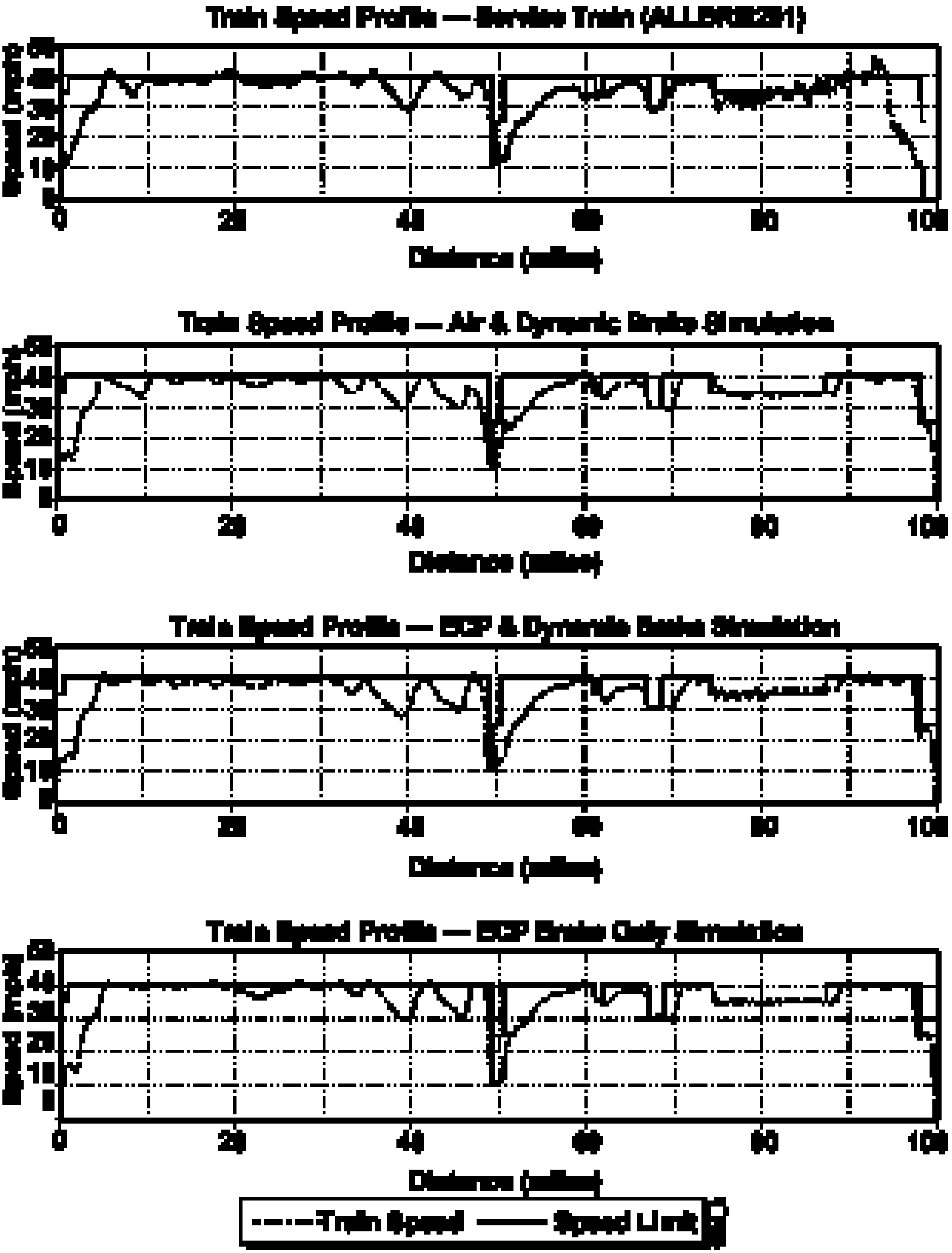

Exhibit 2. Kelly Lake to Allouez (Loaded Train) — Train-Speed Profile Comparisons

Train or Simulation Label	Distance		Trip Time			Total Fuel (gals)	Comments
	Mi	Ft	H	M	S		
ALLBRM 201	99	4250	3	7	44	670	Service Train Event Tape Data, Conventional Braking. Service train fuel estimated by"time at throttle notch" method.
KELAADST	99	3744	3	3	27	670	Simulation — Air & Dynamic Braking
KELAEDST	99	3153	3	4	32	622	Simulation — ECP & Dynamic Braking
KELAEPST	99	3112	2	59	30	648	Simulation — ECP Braking Only

Exhibit 3. Comparison of Service Train and TEM Simulation Results — Loaded Train Operation

Analysis of the event tape data clearly showed that good speed control for the conventionally braked trains depended on the use of dynamic braking. In two of the four cases studied, it was necessary to use modest power braking to maintain control at some of the gradient transitions on the track.

TRAIN SIMULATIONS

Train simulations were carried out using the Train Energy Model (TEM). First, the "average" train, selected from the event tape data, was modeled with conventional brakes as the baseline. The control parameters in TEM were adjusted to match the event tape speed profile as closely as possible. The same train was then modeled as an ECP-braked train, using two alternative control strategies, namely: ECP brake with dynamic brakes, and ECP with the dynamic brakes cut out. The resultant train-speed profiles are compared with the service-train event recorder data in Exhibit 2 and the train performance compared in Exhibit 3.

Using the conventional air and dynamic brake simulation as baseline, a fuel savings of approximately 7 percent is predicted for the use of an ECP and dynamic brake strategy. Comparing these two cases, the speed profile and journey times are very similar. In the case of the ECP-brake-only strategy, the fuel savings were less (3 percent) but the journey time was five minutes shorter. The use of ECP-brake-only strategy permits the locomotive engineer to operate closer to the speed limit if necessary. In unit-train service this is probably of little benefit, unless time make-up is required to make a train meet.

The fuel consumption (670 gallons) for the conventional brake simulation matched the "time at throttle" estimate for the service train. This match should be considered a coincidence and not a measure of accuracy of the simulation. To support this conclusion, the fuel consumption estimates for the four complete service-train operations were averaged. The average of the four samples was 675 gallons, but the standard deviation was 58 gallons.

Reference

1. Carlson, Fred. "Update Status of AAR Electric Brake Specification," presented to the Air Brake Association, Sept. 1995.

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

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A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE, MD, 21279-0780.