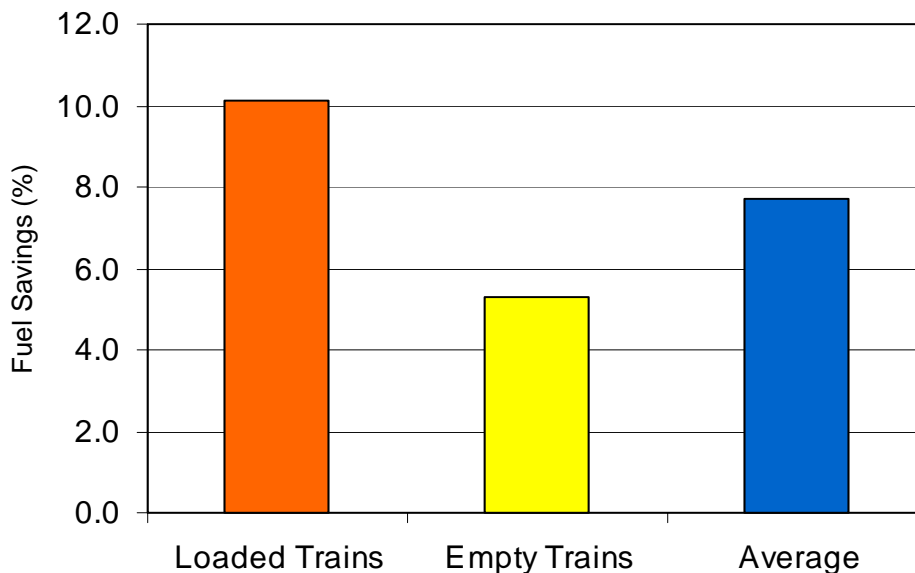




## Evaluation of a Top-of-Rail Lubrication System

### SUMMARY

An average fuel savings of 7.7% was achieved in tests of a top-of-rail lubricant and application system on CSX between Corbin, KY and Cartersville, GA. The test measurements were made during six round trips of a typical 90-car coal unit train. No adverse effects on braking or train handling were observed during the tests. Figure 1 shows the fuel savings achieved for test runs with all coal cars fully loaded, with all coal cars empty, and the average of these.



**Figure 1.** Fuel savings achieved in tests of a top-of-rail lubrication system.



## BACKGROUND

In pursuit of a common goal of reducing transportation energy consumption, the Federal Railroad Administration (FRA) and the United States Department of Energy (DOE) have participated with the railroad industry in evaluating top-of-rail lubrication systems. These systems apply a consumable lubricant to the top of both rails behind the last locomotive axle to lower the wheel to rail friction of the following cars, thus reducing the energy needed to pull the train. To prevent adverse effects on the locomotive traction of following trains, the lubricant is applied in controlled quantities and is designed to be used up (or consumed) as the train passes.

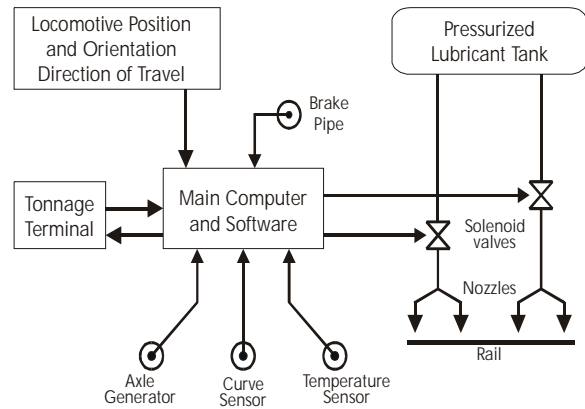
In late February and early March of 1998, the SENTRAEN 2000 top-of-rail (TOR) lubrication system was tested on a 243-mile segment of CSX Transportation (CSX). The testing was jointly sponsored by the FRA's Office of Research and Development, DOE, CSX, and Tranergy Corporation – the TOR developer. CSXT, Tranergy, and ENSCO, Inc. (under contract from the FRA) designed the tests and analyzed the data.

## THE LUBRICATION SYSTEM

The basic elements of the SENTRAEN 2000 TOR lubrication system are shown in Figure 2. The system is designed to apply the TOR lubricant in controlled quantities with the intent that none will be left on the rail after the train has passed. The rate of lubricant application is controlled by an on-board computer and is based on the following train and track parameters:

- # Train speed
- # Train tonnage
- # Degree of track curvature
- # Ambient temperature
- # Brake application
- # Direction of travel
- # Locomotive position and orientation

These parameters are measured continuously during train operation, with input feeding the TOR system, as indicated in Figure 2. The computer determines when the solenoid valves are opened, allowing the lubricant to flow from the pressurized storage tank. The solenoid valves close if system power is interrupted.



**Figure 2. Top-of-rail lubrication system elements.**

The TOR lubricant used in these tests is an environmentally safe, biodegradable, non-toxic liquid lubricant developed by Tranergy, in collaboration with Texaco. The lubricant is water-based, containing no solids commonly used in conventional lubricating compounds (such as graphite or molybdenum disulfide) and is designed to function over a wide range of temperatures. The material can be described as a friction modifier which provides a reduction in friction under normal rolling conditions and an increase in friction under braking conditions. The lubricant is produced and sold by Equilon Enterprises LLC, a joint venture of Texaco and Shell.

## HOW THE TESTS WERE CONDUCTED

The test train consisted of 3 locomotives followed by an instrumentation car and 90 coal hoppers. The same consist was used during each test run. The test series was comprised of six round trips on a 243-mile segment between Corbin, KY and Cartersville, GA. The unit train was operated in normal fashion, except for the added instrumentation car. Three round trips were instrumented with the TOR lubrication system turned on and three with the system turned off.

In addition to fuel consumption, electrical and mechanical energy measurements were made for comparison and validation of the test results. Stopping distance tests were conducted with and without TOR lubrication, with full service and emergency brake applications. Lateral and vertical forces were also measured in one curve of approximately 6 degrees.



To determine the amount of TOR lubrication which may have remained after train passage, friction coefficient measurements were made with a tribometer on the top of both rails in one curve before and after the passage of test trains as well as regular revenue trains.

TOR lubricant was applied from the trailing end of the trailing locomotive at a rate determined by the SENTRAEN 2000 system. Lubrication was stopped during application of the automatic brake but not during dynamic or independent braking. The amount of lubricant consumed was measured visually by marking and recording lubricant levels on a sight glass at the start and end of each trip and at designated locations during the trip.

Throughout the test effort, both wayside curve lubrication devices and wheel flange lubricators were fully operational. Of the three locomotives within the consist, the lead and middle locomotives were applying flange lubricant continually in all tests. The TOR lubrication system was turned on for three complete round trips and off for three other round trips.

**TEST RESULTS**

- # *Fuel Savings:* When using TOR lubrication, on average, fully loaded trains consumed 10.1% less fuel, empty trains consumed 5.3% less fuel, with an average reduction of 7.7% for both loaded and empty trains.
- # *TOR Lubricant Distribution and Consumption:* As shown in Table 1, top-of-rail friction measurements indicated no significant adverse effects of TOR lubrication behind the test train. The range of friction coefficients measured before and after the passage of lubrication test trains. Engineers on pusher locomotives used for a fifteen-mile 1% grade reported the operation to be normal when assisting the test trains using the TOR lubricant. While reports from following trains were not routinely gathered, no reports were received of any unusual conditions experienced following the TOR test runs.
- # *Braking Performance:* Stopping distances with the TOR lubrication system turned on and off were nearly the same. This was true for both full service and emergency braking

**Table 1. Top-of-rail coefficient of friction measurements before and after the passage of trains with and without TOR lubrication.**

	Top-of-Rail Friction Coefficient			
	Before Train		After Train	
	Low	High	Low	High
Regular Trains	0.37	0.56	0.21	0.48
TOR Lub.Test Trains	0.31	0.51	0.27	0.45

and for loaded and empty trains. No indications of wheel slip occurred during any of the 13 braking tests.

- # *Train Handling:* No adverse effects on train handling or speed control were observed by train crews when the TOR lubrication system was in use. The average speeds, throttle notch dwell times, and the number of throttle position changes did not differ significantly between TOR lubrication and non-TOR lubrication test runs.
- # *Wheel/Rail Interaction:* A detailed evaluation of the effect of TOR lubricant on curving forces was beyond the scope of this test, and therefore, no specific conclusions could be drawn. With respect to truck hunting, no evidence of truck instability was observed during the tests, however operating speeds were lower than the point at which truck hunting usually occurs.

**FOR FURTHER RESEARCH**

Below is a partial list of TOR lubrication performance aspects which were beyond the scope of these tests, but which will need further examination.

- # *Lubrication Delivery Rates:* Effect of applying too little or too much lubrication, including possible short or long term buildup of excess lubrication. Also, the ability to match TOR



lubrication delivery rate with changing conditions.

- # *Truck Performance:* Effect of TOR on truck steering and lateral forces in curves.
- # *Lubrication on One Rail Only:* Train performance effects if TOR lubricant is applied to one rail only due to line or nozzle blockage or other system failure.
- # *Temperature Effects:* Behavior of TOR lubrication system and train performance when ambient and rail temperatures are very high or low.

**KEYWORDS:** energy savings, fuel savings, top of rail lubrication, friction modifier

### WANT MORE INFORMATION?

Details on this test and additional data can be found in the following FRA report:

Davis, Kenneth, W. Strickland, and E. Sherrock, "Evaluation of a Top Of Rail Lubrication System," Final Report, August, 1999. DOT/FRA/ORD-99/13.

### ACKNOWLEDGMENTS

Assistance from the CSX Road Foremen and train crews operating between Corbin, KY, and Cartersville, GA was essential to the success of these tests, as were the efforts of Instrumentation Services, Inc. in the implementation of the wayside instrumentation sites. Leading the tests and analyses were Ken Davis and Wain Strickland from CSX and Eric Sherrock from ENSCO, Inc.

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