TECHNOLOGY DIGEST

TD-05-019

©AUGUST 2005

TIMELY TECHNOLOGY TRANSFER

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Economic Analysis of Top of Rail Friction Control – Walong, CA

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Summary

The Transportation Technology Center, Inc., (TTCI), Pueblo, Colorado, has performed an economic analysis to evaluate the costs and benefits of the application of the top-of-rail (TOR) friction modifier as an addition to existing gage face friction control. This analysis is based on the results of a TOR friction control system installation at Walong, California, detailed in TTCI TD-05-018 *Implementation Demonstration of Wayside Based Top of Rail Friction Control, Union Pacific Railroad – Walong, CA.*[1]

In 2005 an economic analysis was performed using TTCI's Friction Control Benefits Cost Model. This model assesses the impact of friction control on rail wear, tie and wheel life, and fuel consumption. The model uses the coefficients of friction before and after installation of the TOR friction control systems to estimate the change in the life expectancy of components and the change in fuel consumption. The results of this analysis conclude the following:

- The model results compared well with the measured 58 percent reduction in TOR/low rail wear rate.
- The results are very sensitive to the impact of the TOR friction modifier on high rail gage face wear. Additional testing is necessary to fully evaluate the affect of the TOR friction modifier on gage face wear rates. If gage face wear rates increase with the application of the TOR friction control, this economic analysis would be invalid.
- For the five and a half mile segment actually involved in the demonstration project, the implementation of the TOR friction control has a net present value (NPV) of $366,000. That is, the NPV benefits of the installation of the TOR friction modifier exceed the NPV costs by $366,000 over ten years.
- The economics of the TOR friction modifier consider site sensitivity to curvature, traffic, and required spacing of TOR friction control systems. Each potential TOR friction control site should be carefully considered with these sensitivities in mind.

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Introduction

In 2005, six Top of Rail (TOR) friction modifier systems were implemented on the Union Pacific Railroad (UP) at a site near Walong, California, to evaluate the costs and benefits of the application of the TOR friction modifier as an addition to existing gage face friction control.

The six TOR friction modifier systems were installed between mile post (MP) 349.5 and MP 355. UP chose this 5.5-mile long section of track with existing gage face friction control because of its severe terrain.

The following data was collected for economic analysis during the 120 MGT test period:

- Rail wear measurements were successfully measured at four curves in this section.
- Curving forces were measured by a load station at MP 352.0.
- Friction was measured using a handheld tribometer before and during the test period.

Economic Model

TTCI developed an economic model to evaluate the costs and benefits of rail friction control. This model has the capability to evaluate both gage face and TOR friction control systems.

To develop this model, TTCI researchers used the Association of American Railroad's NUCARS™ software to model the effects of rail-friction control on steady-state curving performance of freight cars. The NUCARS™ software provided wear-indices and lateral loads for a broad range of levels of coefficients of friction on the gage face, top of both rails, curvatures, and car weights. The wear indices were then processed through the Railway Track Lifecycle Model to determine wear rates under this myriad of conditions.

The Friction Control Model then translates the wear rates and lateral loads into component life cycles and finally into cash flows. The cash flows for the costs and benefits are then discounted back to the present to determine the net present value of the investment in friction control systems.

The model limits maximum rail lives based on a survey of the six largest railroads in North America performed in 2001. The purpose of the maximum rail lives is to prevent the model from predicting very long rail life based on the low wear rates that are often associated with well lubricated rail. Rail life is capped to recognize that if the wear is lowered enough, another failure mechanism such as fatigue will become the causal factor for rail replacement. Table 1 shows the maximum rail lives used in the TTCI study. For this section of railroad, the result of these maximum rail lives is to allow the life in ten-degree curves to increase by approximately 65 percent.

Table 1. Maximum Rail Lives in Million Gross Tones (MGT) In the TTCI Friction Control Model

Degrees of Curvature	Rail Life Limit [MGT]
Tangent	1,460
1	1,050
2	640
3	540
4	510
5	440
6	390
7	380
8	370
9	350
10	330

Route

The route characteristics were obtained from UP track charts. The 5.5 mile section in the UP demonstration project had a profile as shown in Table 2. This is a mountainous route with two percent grades and with a very high percentage of curvature overall and a high percentage of curves of eight degrees or greater.

Table 2. Distribution of Curves Demonstration Site

Degrees of Curvature	Percentage of Rail
Tangent	22.75
1	0.00
2	0.00
3	1.84
4	6.42
5	4.13
6	8.66
7	4.60
8	5.75
9	21.33
10	24.53

This route carries 80 to 85 million gross tons (MGT) of traffic annually. The traffic is primarily 286,000-pound cars in 110-car consists.

Table 3. Coefficients of Friction without TOR Friction Control

Degress of Curvature	Coefficients of Friction Before Friction Control		
	Top of High Rail	Top of Low Rail	Gage Face
Tangent	0.450	0.450	0.250
1	0.450	0.450	0.250
2	0.450	0.450	0.250
3	0.450	0.450	0.250
4	0.450	0.450	0.250
5	0.450	0.450	0.250
6	0.450	0.450	0.250
7	0.450	0.450	0.250
8	0.450	0.450	0.250
9	0.450	0.450	0.250
10	0.450	0.450	0.250

Table 4, Coefficients of Friction with TOR Friction Control

Degress of Curvature	Coefficients of Friction After Friction Control		
	Top of High Rail	Top of Low Rail	Gage Face
Tangent	0.350	0.350	0.250
1	0.350	0.350	0.250
2	0.350	0.350	0.250
3	0.350	0.350	0.250
4	0.350	0.350	0.250
5	0.350	0.350	0.250
6	0.350	0.350	0.250
7	0.350	0.350	0.250
8	0.350	0.350	0.250
9	0.350	0.350	0.250
10	0.350	0.350	0.250

In both cases the gage face coefficient is held constant at 0.250. This carries the important assumption in this analysis that the gage face was consistently well lubricated. In the course of the actual demonstration, there were periods when the gage face friction control was not held constant in the range of 0.250. The TOR friction control was measured in the range of 0.34 to 0.37 at all six locations. This is well within the goal level of friction of 0.30 to 0.40 suggested by the equipment manufacturer.

The gage face friction control was in the range of 0.19 to 0.31 for the nine sites where measurements were taken. The 0.25 coefficient of friction used in this analysis is the average of those sites and at the top of the range suggested by TTCI researchers in TD-99-018 *Evaluation of Industry Practices for Wheel/Rail Friction Control*.[2] The gage face friction control was maintained at the same level with and without the TOR friction control.

Results

The economic analysis was performed for three scenarios.

1. The UP demonstration site, as tested.
2. A 20-mile segment including the UP demonstration site that approximates the limits of this mountainous section of railroad, assuming 1.0-mile spacing of TOR friction control units.
3. The same 20-mile segment as above, assuming a 1.5-mile spacing of the TOR friction control units.

Figure 1 shows the expected benefits for the three scenarios. These are net present benefits over the entire segment for 15 years.

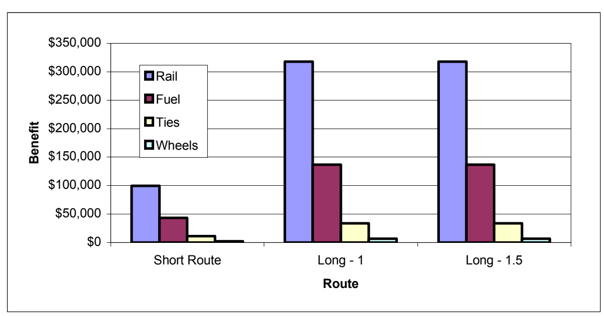

Figure 1. Benefits of TOR Friction Control UP Demonstration Site Near Walong, CA

The NPV benefit for the two longer routes is greater than the actual demonstration site, only because these are longer track segments.

The overall NPV for the sites requires consideration of the costs of implementing the TOR units. The results for the three scenarios considered are shown in Table 5.

Table 5. Net Present Value of Implementing TOR Friction Control at the Walong, CA Demonstration Site

	Short Route 1-mile Unit Spacing	Long Route 1-mile Unit Spacing	Long Route 1.5-mile Unit Spacing
5-year NPV	$183,000	$339,000	$557,000
10-year NPV	$366,000	$699,000	$1,030,000
IRR	90%	70%	95%

For each of these scenarios, the benefits exceed the costs. The Internal Rate of Return is also very attractive. For this specific site, TOR friction modifier systems appear to be an attractive investment. These results, however, assume that consistent gage face friction control is achieved and that high rail gage face wear does not increase with the installation of TOR friction control. See TD05-018 for test results.[1]

Summary and Conclusions

The TOR friction control results from the demonstration site near Walong, California show that the application of TOR friction modifier systems can be economically attractive. During this demonstration, however, inconsistent friction control of the high rail gage face indicated the possibility of increased gage face wear if adequate gage face friction control is not maintained.[1] Follow-up testing is required to assure that the gage face wear will not increase with TOR friction control.

The maximum rail lives used in this study may be lower than what can be achieved in actual service. As these maximum lives are increased, the NPVs for all cases will increase. To test the sensitivity of this analysis to these assumed maximum lives, the anlysis was redone with the maximum lives increased by 10 percent. This increase resulted in a nearly 20 percent increase in the net present values for all three scenarios. Thus, to the extent these maximum rail lives are underestimated, the economic results achievable are also underestimated.

The economics of installation of TOR friction control systems are highly route and service dependent. Each location should be individually evaluated.

References

1. Richard Reiff, "Implementation Demonstration of Wayside Based Top of Rail Friction Control: Union Pacific Railroad – Walong, California," TTCI Technical Digest TD05-018, June 2005.
2. Duane Otter, R. Sweeny, and S. Dick, "Evaluation of Industry Practices for Wheel/Rail Friction Control," TTCI Technical Digest, TD99-018, May 1999.