TECHNOLOGY DIGEST

Timely Technology Transfer — 99-030

Estimating Rail-Wear Effects of Warp-Resistant, Self-Steering Trucks with TRACS*

by Steven L. Clark and Nick Wilson

Summary

Beneficial effects on rail wear from improved suspension trucks can now be estimated using a comprehensive set of track-degradation and costing models designed to assist railroads in the analysis, planning, and budgeting of track right-of-way maintenance activities, operational changes, and alternative technologies. Rail-wear index values for improved-suspension HAL trucks with high warp restraint and self-steering capabilities have been calculated using *NUCARS, and incorporated into the **TRACS rail-wear model.

Sample simulations were performed using improved-suspension truck "wear-index" numbers generated from the NUCARS vehicle/track dynamic interaction computer model. The wear-index number, derived from NUCARS simulations, is a measure of the mechanical work being performed at the wheel/rail interface.The resulting rail-wear values were compared to data collected from the Facility for Accelerated Service Testing (FAST) located at the Federal Railroad Administration's Transportation Technology Center in Pueblo, Colorado. Under assumed "dry rail" conditions, TRACS produced gage-face rail-wear rates in curves higher than the average rail-wear rates experienced at FAST. However, FAST is operated under a variety of lubrication conditions. Therefore, rail lubrication conditions in TRACS were adjusted to characterize rail-wear outputs to the rail-wear experienced at FAST with standard trucks. Improved suspension trucks were then implemented in the TRACS model and new rail wear estimates generated. The improvements in rail-wear estimated by TRACS are somewhat less than those experienced at FAST with improved trucks. In this analysis, TRACS produces a more conservative rail wear improvement which may be a more realistic assessment of what would be experienced in the revenue service environment under less controlled conditions.

- When compared to standard trucks, the percent of rail-wear reduction due to the implementation of improved-suspension trucks as estimated by TRACS is slightly understated relative to FAST experience (71.8% vs. 75.3%).
- Based on data obtained from FAST, with field characterization, TRACS can provide a reasonable and conservative estimate of rail-wear improvement expected from implementing improved-suspension trucks in revenue service.

*New and Untried Car Analytic Regime Simulation
**Total Right-of-Way Analysis and Costing System

Suggested Distribution:

- ❑ Mechanical Purchasing
- ❑ Planning & Analysis
- ❑ Track Maintenance
- ❑ Safety

Work performed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads
August 1999©

INTRODUCTION

Transportation Technology Center, Inc. has used NUCARS to calculate rail-wear index values for improved-suspension heavy-axle-load (HAL) trucks with high warp restraint and self-steering capabilities. These values have been incorporated into the TRACS rail-wear model, and the beneficial effects on rail wear from these types of trucks can now be estimated using this comprehensive set of track-degradation and costing models. TRACS is designed to assist railroads in the analysis, planning, and budgeting of track right-of-way maintenance activities, operational changes, and alternative technologies.

The TRACS Rail Wear Model estimates rail wear in two wear regimes: mild and severe wear. Mild wear is characterized as being proportional to the normal forces (vehicle wheel loads), and the number of passes of the wheels, measured in million gross tons (MGT). Severe wear is characterized as being proportional to the normal force (wheel load), the conditions of lubrication (coefficient of friction), and the creepage that occurs between the wheel/rail interface. Severe wear is modeled as being linearly proportional to the "wear-index number" which is a non-linear value. The wear-index number is derived from NUCARS simulations and is a measure of the mechanical work being performed at the wheel/rail interface.

METHODOLOGY

A number of NUCARS simulations were made for "generic" representations of standard trucks and improved-suspension trucks negotiating curves ranging from 0 to 10 degrees. Simulations were made with conditions representative of dry track and track with gage face lubrication. Wheel/rail interaction forces and wear indices were calculated for input to the TRACS model. The NUCARS input data was as follows:

- Loaded and empty 125-ton cars were equipped with "standard" three-piece trucks with constant-contact side bearings. The car body was modeled to be representative of the 125-ton coal gondolas used in the heavy-axle-load (HAL) train at the Facility for Accelerated Service Testing (FAST). The steering characteristics and warp restraint were modeled to be representative of normal 125-ton trucks that have no added features to resist truck warp or aid in axle steering.
- Loaded and empty 125-ton cars were equipped with "improved-suspension" three-piece trucks with roller side bearings, primary rubber shear pads, and braces that connect the two side frames together to resist truck warp. The axle-steering and truck warp characteristics were based on the Standard Car Truck FRAME BRACE™ trucks in the FAST/HAL train. The car body was modeled to be representative of the 125-ton coal gondola used in the FAST/HAL train.
- Wheel profiles were representative of "average" service worn wheels. These wheels, which have a slight amount of tread hollowing, were generated from the database of wheel profiles measured as a part of the Association of American Railroads' (AAR) wheel/rail profile research (TD98-003).
- Rail profiles were representative of "average"curve worn rails. These rails, which have a moderate amount of gage-face wear, were generated from the database of rail profiles measured as a part of the AAR's wheel/rail profile research (TD98-003).

Coal-haul consists with 100 cars and four locomotives were assumed. Vehicle load values are shown in Exhibit 1.

TTCI = Transportation Technology Center, Inc.; AAR = Association of American Railroads

Exhibit 1. Loaded Values for Test Trains

Trains	Net Lading	Car Axle Axle Load	Locomotive Axle Load
Loaded Cars	125 tons	39.2 tons	33.3 tons

Under dry track conditions, TRACS produced gage-face rail wear values higher than those measured at the FAST facility. In order to use TRACS to estimate rail wear reductions for a change of equipment on FAST, which rarely operates under purely dry track conditions, TRACS must be characterized to the FAST conditions. It must be noted, however, that the selection of one value for the coefficient of friction for FAST is difficult due to the variable lubrication conditions. Consequently, to characterize TRACS to the FAST conditions, it was assumed that a coefficient of friction of 0.32 would closely approximate the average coefficient of friction of the FAST facility. This was based on a combination of wayside lubrication and "contaminated" dry rail base-case conditions (TD99-018), with a bias towards the latter.

The NUCARS wear indices were input to the TRACS program with lubrication conditions as detailed in Exhibit 2.

Then, by applying the new wear-index numbers for improved suspension trucks, a new estimate of rail wear is generated. The percent improvement in rail wear can be used to assess the estimated rail wear improvement achieved by the implementation of improved suspension trucks.

As a model, TRACS cannot be expected to produce results exactly as experienced in the field. Differences between estimated rail wear values and actual values can be attributed to the infinite number of variables found in the field operating environment, as opposed to the limited number of variables possible in computer modeling. Such variations can be individual wheel and rail profiles, actual car loadings, suspension component wear, and track geometry.

Exhibit 2. Lubrication Conditions Input to NUCARS

Track Condition	Coefficient of Friction		
	High Rail	Low Rail	High Rail Gage Face
Dry	0.40	0.40	0.40
Lubricated	0.32	0.32	0.32

RESULTS

The data presented in Exhibit 3 comes from Section 7 on the High Tonnage Loop at FAST and is a curve of 5 degrees with improved rail (nominal 370 Bhn). No grinding is assumed.

Exhibit 4 presents the percent improvement in rail wear for the 5-degree curve at FAST, and the estimated improvements estimated with TRACS.

Exhibit 5 presents gage-face rail wear for standard and improved trucks under lubricated-track conditions, as estimated by TRACS for curves from 2-degrees to 10-degrees.

Exhibit 5 also shows the difference between the "mild" wear regime and the "severe" wear regime. Recall that both "mild" wear and "severe" wear are characterized by the normal forces and number of passes, but the severe wear regime also assumes creepage in the wheel/rail interface. In Exhibit 5, TRACS is estimating wear from the improved suspension trucks in the mild regime for the gage face in curves of two degrees and three degrees. Between 3 and 4 degrees, the wear regime converts to severe wear and the gage face wear begins to climb. Consequently, it can be assumed from this that TRACS is estimating flanging of the wheel (wheel/rail creepage) to occur somewhere between 3 and 4 degrees of track curvature when using improved suspension trucks. The gage-face wear from standard trucks is estimated in the severe wear regime for all curves 2 degrees and higher.

CONCLUDING REMARKS

Using TRACS with its default settings is an excellent way to perform quick order-of-magnitude studies of the incremental effects of changes in traffic or track technologies. To perform more in-depth studies to a specific route

Exhibit 3. Rail Wear for 5-Degree Curve at FAST (inches/100 MGT) under Lubricated Conditions

	Standard Trucks			Improved Suspension Trucks		
	Top of High Rail	Top of Low Rail	High Rail Gage Face	Top of High Rail	Top of Low Rail	High Rail Gage Face
FAST	0.0200	0.0260	0.1340	0.0043	0.0047	0.0331
TRACS	0.0192	0.0376	0.1320	0.0078	0.0164	0.0387

Exhibit 4. Percent Improvement in Rail Wear for 5-Degree Curve at FAST under Lubricated Conditions

	Top of High Rail	Top of Low Rail	High Rail Gage Face
FAST	76.7%	82.0%	75.3%
TRACS	59.2%	56.3%	71.8%

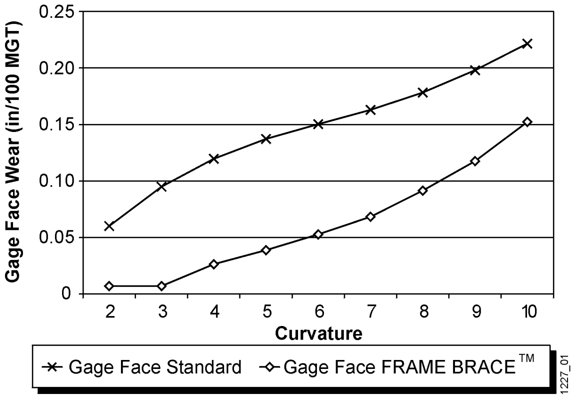

Exhibit 5. TRACS-Estimated Gage-Face Rail Wear for Standard and Improved Trucks on Lubricated Track with 2- to 10-Degree Curves

or track structure requires route characterization of the various models residing within the TRACS structure. A previous Technology Digest (TD-99-001) discusses the methodology to "field characterize" the TRACS rail wear model to a specific railroad route and traffic.

Any TRACS user can now perform quick incremental analyses of the rail wear effects of improved suspension trucks. Should such incremental analysis indicate positive benefits, more route- and traffic-specific, detailed and accurate analyses may be performed by applying the field characterization technique to a specific route and traffic.

Two additional files are required for TRACS users to perform analyses of improved suspension trucks. These are the "wearfb.wer" and the "railmatf.rma" files. These files are located in the "data" sub-directory. When performing analyses, the user will select these two files within the "file selection" routine that operates in the "run analysis" function. Licensed TRACS users should contact TTCI for these files.

REFERENCES

TD98-003, "North American Wheel Profile Study," Kevin Sawley and Ned Parker.

TD99-001, "Applying the TRACS Rail Wear Model," Steve Clark, Randy Bowman, and Carl Martland.

TD99-018, "Evaluation of Industry Practices for Wheel/Rail Friction Control," Richard P. Reiff, Scott E. Gage, and Corey T. Pasta

Note: Please contact Steve Clark at (719) 584-0729 with questions or comments about this document.
E-mail: steve_clark@ttci.aar.com

Web site: www.ttci.aar.com

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.