

TECHNOLOGY DIGEST

Timely Technology Transfer

"FULL SCALE EVALUATION OF A BONDED FILM LUBRICANT"

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Summary

Bonded film lubricants have been shown to reduce wheel/rail friction without migrating to the top of the rail. Tests conducted by the Association of American Railroads (AAR), Transportation Test Center (TTC), Pueblo, Colorado, indicate that durability of the films evaluated was higher than a single application of conventional grease. However, the bonded films evaluated exhibited insufficient durability, in their current form, to provide long lasting friction reduction at the desired location on rail/wheel contact interface for a reasonable interval between application cycles.

Performance of the bonded film indicated that if application can be reliably controlled, undesirable top of rail contamination will be reduced while still obtaining benefits of reduced energy and wear.

Bonded film lubricants characteristically do not migrate and therefore were selected for evaluation. The performance of several bonded film lubricants was evaluated by first screening potential candidates through laboratory tests. One of the bonded films that had encouraging laboratory results was then utilized to coat a short (19') section of rail for full scale demonstration at TTC's Facility for Accelerated Service Testing/High Tonnage Loop (FAST/HTL). Finally, a prototype field application was demonstrated for a 1,000-foot curve to determine durability and migration performance of a product that was deposited on the rail only at a location where friction reduction was desired.

This was a preliminary test to determine if such films could be applied under field conditions and still provide necessary energy and wear savings. Additional developmental work in material durability and application system configuration is required.



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INTRODUCTION AND CONCLUSIONS

Significant savings in train energy and rail/wheel wear can be obtained by the proper application of lubrication. However with certain wheel/rail profile configurations, truck steering is affected generating undesirable high lateral forces.

Traditional lubricants are viscous, generally between a heavy grease to light oil. Locomotive flange lubricators and hy-rail systems apply lubricant to the wheel flanges or rail, while wayside applicators apply lubricant to be picked up by passing wheel flanges. A wide range of lubricants can generally be applied by all systems, with the wayside applicators limited to thicker greases. These application systems can, under certain conditions, apply lubricant in such a quantity that excess material tends to migrate to top of rail running surfaces or is flung and wasted into the ballast.

In an effort to reduce waste and migration of lubricant to undesirable locations, the AAR investigated the use of bonded film materials for the rail/wheel interface.

Laboratory Test Selection Process

Laboratory screening was done to select a candidate bonded film for field testing. For laboratory testing, AAR selected the Amsler wear machine, which uses relatively small metal disks that simulate wheel/rail contact loads and creepages. Amsler wear data from dry disks provided similar rankings when compared to FAST dry rail wear data of various metallurgies and heat treated rails.

A series of tests using the Amsler wear machine conducted by the Oregon Graduate Institute, with a variety of conventional (liquid) track lubricants, indicated that exact rankings based on Amsler results did not follow FAST findings as closely as the dry wear results. However gross differences between "good" and "poor" performing lubricants indicated that the Amsler machine could be used to provide "screening" of alternative lubricants.

For this evaluation, the total disk revolutions between "lubricated" and "dry" was used for comparing conventional track lubricant and various bonded film lubricants. Two Amsler roller configurations were tested: one with both rollers smooth, and the other with one smooth and one rough roller. These represent simulated "smooth rail/smooth wheel" and "smooth wheel/rough rail" gage interface conditions.

Texaco 904 (calcium/graphite) grease was used as a typical track lubricant. Exhibit 1 summarizes Amsler results, showing revolutions to reach a friction level of 0.2 for different products and roller smoothness conditions.

Exhibit 1.
Amsler Results Comparing Dry Film and Grease

LUBRICANT	REVOLUTIONS TO REACH $\mu = 0.2$	
	SMOOTH LOWER ROLLER	ROUGH LOWER ROLLER
Air Cured Dry Film	22180	2000 (2570 to $\mu = 0.5$)
Oven Cured Dry Film	73280; 67340	(1150 to $\mu = 0.5$)
Phosphate/Oven Cured Dry Film	160680; 213530	90 (260 to $\mu = 0.5$)
Texaco 904	(~10000 to $\mu = 0.37$)	(1670 to $\mu = 0.5$)

Smooth/smooth roller results indicate that the various dry/bonded films lasted between 2 and 21 times longer than conventional lubricant. Under smooth/rough roller conditions, the results of the bonded films were less encouraging, with the same or less life.

These results indicate that under smooth wheel/rail conditions bonded films should last longer than grease, while under rough/smooth conditions no improvement or a reduction in performance should be seen.

Initial Field Test Evaluation

Bonded film performance in full railroad service is still unknown. A short field trial was conducted to determine if additional work was warranted. For this evaluation, two short (19') pieces of curve worn



rail were removed from FAST: one featuring a very rough gage face, and the other featuring a smooth gage face. The rail sections were shipped to a facility where oven-cured dry film was applied. This film process was selected because of its potential future transfer capability for application in the field.

In-track testing was performed on these two rails in late 1993. Exhibit 2 shows data results. Each rail was tested as follows:

1. Normal operation of the FAST train was conducted, with the inside gage rail of the HTL not lubricated. Before testing, a plug of rail the exact length of the coated rails was installed into Section 07, a 5-degree curve. See Exhibit 3, FAST/HTL map.
2. The train was stopped, and the rough rail with dry film coating was installed.
3. The train operation was restarted, and gage face and top of rail tribometer data collected. Data was collected after each train pass until gage face friction of 0.35 was obtained.
4. The same process was repeated with the other smooth rail.
5. Finally a coating of Chevron RF (calcium/graphite) track grease was manually brushed onto the gage face, and friction was measured as before.

Evaluation of this limited data indicates that the dry film on rough rail lasted about twice as long as on the smooth rail. The opposite trend was found from the Amsler laboratory tests. The dry film on both rails, however, did last considerably longer than the brushed on track grease. Field observations of the smooth and rough rails indicated lubricant was being trapped in large surface cavities on the rough rail gage face, creating a large number of miniature lubricant reservoirs. The difference in surface roughness between Amsler disks and field rail conditions may have been the primary reason that the rough rail performed better than the smooth rail, compared to performance observed in the Amsler laboratory tests. In both dry film test cases, the limited length

(19') of rail did not provide adequate simulation to determine tendency for migration to top of rail. Therefore, it was decided to test a dry film over the length of a full curve.

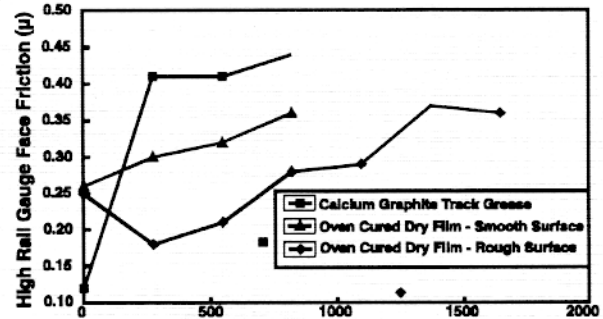


Exhibit 2. Comparison of Conventional Grease to Bonded Film Performance on 5-degree Curve.

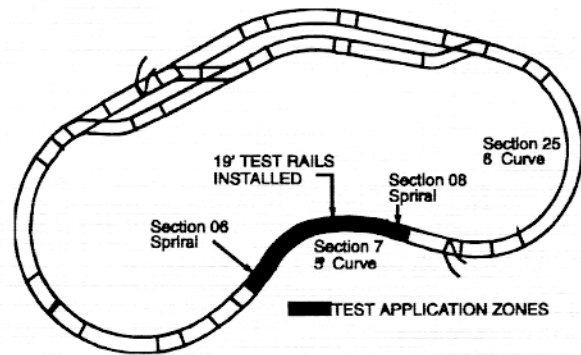


Exhibit 3. FAST/HTL Map

Full Curve Field Test Evaluation

Full length of curve testing was conducted on the FAST/HTL loop by coating the gage face of Section 07, reverse curve, with a liquid film that was bonded using air cure. Three separate application test cases were conducted.

A prototype application method was used where bonded lubricant in liquid form was "painted" onto the gage face surface. This was followed by a cure time to allow the transfer agent to evaporate, followed by the train's operation period. Air dry cure time was used as a means of simulating a more rapid forced cure (such as by application of heat), which would be part of a production application system. The gage face for about 1,400 feet of Sections 06-08 was coated for each test. See Exhibit 3 for application area.



The primary data base consisted of gage face and top of rail friction measurements collected after each train pass. Data was collected near the beginning of the curve until dry rail was obtained, at which time a different lubricant formula was evaluated. Exhibit 4 shows friction data for gage face and top of rail near the beginning of the curve where application was made for one product. Gage corner data also was collected and those results will be reported in the research report.

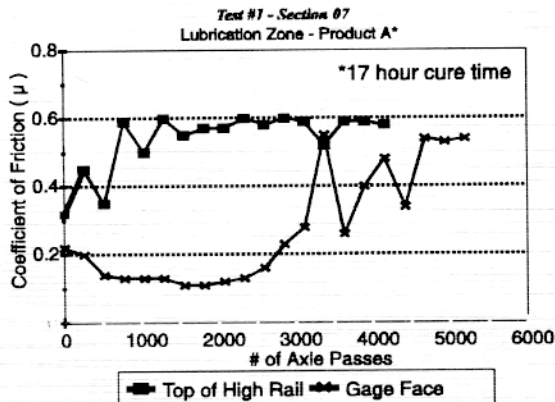


Exhibit 4. Friction Data for Gage Face and Top of Rail where Application was made.

Results show that the gage face remained well lubricated until after at least 3000-4500 axle passes, while the top of rail remained dry the entire period. To determine if lubricant was being transferred along the rail, tribometer data was also taken in Section 06, immediately BEFORE the location of where the dry film was applied. This data, for the second product evaluated, is shown in Exhibit 5.

Results show that while the gage face in Section 07 starts out lubricated and gradually becomes dry, the rail in Section 06 starts out dry (due to no lubricant being applied at this location)

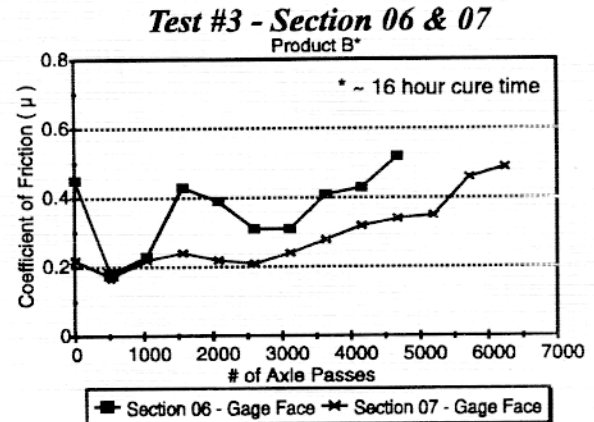


Exhibit 5. Data from 2nd Product

and becomes lubricated from bonded film that was transferred from the rail in Section 07 to the wheels, carried around the loop, and deposited on the gage face of Section 06. Although lubricant did not migrate to the top of rail, it did migrate along the rail from passing flanges.

Recommendations for Future Product Development

This was a limited scope test conducted to determine if bonded films could provide a reduction in rail/wheel friction while preventing lubricant migration and contamination at the top of rail. The dry film compared well with grease, and at no time did lubrication migrate to where it was not desired. However, increased durability of the bonded films is needed before they can replace grease.

Acknowledgements

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Contact Richard P. Reiff at (719) 584-0581 with question or comments about this document.

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