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Initial Wear Performance Evaluation of Partial Flange Bearing Frogs for Turnouts in Heavy Axle Load Service

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Summary

Partial flange bearing frogs for turnouts offer significant benefits in reduced maintenance and increased service life for applications where the great majority of traffic travels on the mainline route of the frog. As part of the program to improve the performance of special trackwork, Transportation Technology Center, Inc., (TTCI) conducted experiments using prototype frogs at the Facility for Accelerated Service Testing (FAST). These experiments help determine the operating envelope for this type of frog, as well as provide data on wear rates under known conditions.

Initial revenue service prototype test results indicate that partial flange bearing frogs offer performance benefits over conventional fixed point (i.e., rail bound manganese) or movable wing (i.e., spring) frogs for low volume turnouts in mainlines. The elimination of a flangeway gap in the mainline route is accomplished by raising the diverging route so that wheels travel over (not through) the mainline rail. The tests conducted evaluated the dynamic performance and wear of flange bearing surfaces of two prototype frogs. This *Technology Digest* describes the results of the wear tests during the first 240 million gross tons (MGT) of heavy axle load traffic at FAST. An earlier TD described the results of the dynamic performance evaluations.¹

The following conclusions can be drawn from the test results:

- Successful operation – 240 MGT mainline, 3 MGT diverging traffic without accident or speed restriction
- The flange bearing vertical height loss (i.e., wear) rate of the austenitic manganese steel frog castings exceeds the tread bearing wear rate for the same traffic.
 - The flange bearing wear rate is exceeding the tread bearing wear rate by 10 to 25 times. Thus, the best application for this frog design is a location with a low percentage of diverging traffic (e.g., 1 percent diverging)
- A cross groove has developed where the diverging traffic runs over the mainline rail in flange bearing.
 - To date, this has had no noticeable effect on mainline ride quality.
- Lateral alignment defects have occurred for the mainline route.
 - The cause has been determined to be strikes on the frog casting short guard flare by mainline trains operating in trailing point moves.



INTRODUCTION

Partial flange bearing turnout frogs function by lifting the diverging route wheels over the mainline running rail. This allows the mainline running rail to be continuous with no flangeway gap. The benefits for mainline traffic are significant in that the frog will perform like open track. Revenue service applications include mainline industrial sidings and bad order set-out tracks. These are locations where diverging traffic is less than 1 percent of the total mainline traffic. TTCI is evaluating the performance of two prototype frogs for diverging traffic in heavy axle load (HAL) service. In this regard, the test at FAST is more severe than revenue service, due to 2 percent diverging HAL car traffic.

Figures 1 and 2 show the prototype frogs installed in test tracks at FAST in Pueblo, Colorado. Figure 1 shows the Progress Rail Services “Lift Frog,” being sold to railroads today. Figure 2 shows the VAE Nortrak “Jump Frog,” which is similar to those being purchased by railroads today. Based on TTCI and railroad test experience, the guard side parallel ramp has been added.

Usually, partial flange bearing frogs function by providing ramps for diverging route wheels to climb over the mainline rail and descend back to nominal track level. Both test frogs do this with a combination of tread bearing and flange bearing ramps. Both frogs use a tread bearing ramp (i.e., they raise the diverging running surface so that the wheel flange tip will be at the same elevation as the top of the mainline rail) on the toe end of the frog. Also, they both use a flange bearing ramp on the heel end of the frog (i.e., from the point of frog and beyond). Figures 1 and 2 show the locations where wheels make contact with the frog running surfaces. Each frog surface was painted before the same train operated. Note that both frogs have flange bearing contact on the ramps and on the mainline running rails. Not evident from the photographs is that both frogs carry some wheels across the mainline rail without making contact. These wheels have shorter flanges and are tread bearing across the mainline rail.



Figure 1. Progress Rail Services Lift Frog in Test at FAST



Figure 2. VAE Nortrak Jump Frog in Test at FAST

The two frogs function similarly, but vary in specific details of the ramping and guarding of wheels through the frog. Table 1 provides more detail about each frog.

Table 1. Partial Flange Bearing Frog Dimensions

Frog	Toe End Ramp Rate	Heel End Ramp Rate	Running Rail Ramp	Guarding
Lift Frog	1:30	1:30	Yes	Conventional guard rail, Toe ramp self guard
Jump Frog	1:36	1:36	No	Conventional guard rail

Mainline Route Performance

The continuous mainline rail through each frog performed well in most respects. Some rolling contact fatigue was seen in areas where the wheelsets may move laterally due to the guard flares. The mainline rail opposite the frog did not show any unusual performance.

The Lift Frog in mainline service at FAST has required frequent maintenance (i.e., 25 MGT intervals) for alignment on the mainline route. The cause of the lateral alignment deviations was determined to be mainline flangeway guard strikes on the frog castings. These strikes would move the frog panel laterally, eventually exceeding class 4 maintenance limits. Figure 3 shows the alignment of the frog prior to maintenance. At FAST, the frog is in a short tangent between curves of opposite direction. Thus, in one direction, the

wheelsets may still be flanging the rail opposite the frog, and they would more likely come in contact with the flangeway guard.

In addition, the guard flare on the heel end of the mainline route casting is shorter than modern mainline standards. The flare, from 3-1/2 inches to flangeway width of 1-7/8 inches, occurs in about 24 inches. As a result of this test, the railway track standards engineers and the frog suppliers are redesigning the guard flare to decrease the angle of attack wheels will encounter. The new design will reflect entry designs used on frog guard rails,² with longer flares and curved shapes. Additional analysis is being conducted to determine if the lateral alignment issue is wholly or partially related to the particular configuration of test location at FAST. This will guide designers about any future changes needed for lateral panel stability. An additional *Technology Digest* is being planned.



Figure 3. View of FAST No. 11 Lift Frog Mainline Alignment Deviation

A groove has been worn in the mainline rail from the diverging traffic. The diverging traffic in this test consists of 315,000-pound cars operating at 10-15 mph. Diverging traffic is about 2 percent of the mainline traffic. Figure 4 shows the running surface groove. The groove is from flange bearing metal flow and wear. As the photo shows, the groove extends to about the middle third of the railhead from the field side. In trailing point diverging moves, most wheels have transitioned onto their treads, riding on the sloped running surface to the right of the flangeway (in this photo) beyond that point. The groove has had minimal effect on ride quality over the mainline side of the frog. The mainline running surface wear rate is high enough to erase the groove worn by any wheels still flange bearing beyond this point. Thus, cone shaped profile wheels running on the mainline have the properly shaped rail (from centerline to gage corner) to run on. The train at FAST has few wheels with revenue service hollow worn profiles. If a wheel was riding on the field side false flange of a hollow worn profile, it may experience some

dynamic forces in crossing this groove. Of course, the same wheels experience dynamic forces at the easers on the ends of most conventional frogs now.



Figure 4. Cross Grooving in Flange Bearing Turnout Frog

Diverging Route Performance

Diverging route performance has been successful to date with 315,000-pound car unit trains operating over the frogs at 10 mph. Locomotives and freight cars can easily operate over the frogs; however, equipment with less capable suspensions (e.g., track maintenance machines) have potential issues with wheel load equalization (within a truck) on frogs where there is a significant design cross level. Proof testing of the parallel tread bearing ramp on the rail opposite the frog was conducted at FAST. This design feature is now standard on all flange bearing turnout frogs.

A time series of running surface profiles were taken on each frog to determine the vertical height loss rates of each frog. The flange bearing vertical height loss (i.e., wear) rate of the austenitic manganese steel frog castings exceeds the tread bearing wear rate for the same traffic. A cross groove has developed where the diverging traffic runs over the mainline rail in flange bearing. The 2 percent diverging traffic is sufficient to wear a groove in the mainline running rail field side. The mainline traffic tread bearing wear is insufficient to remove this groove entirely.

To date, the groove has had no noticeable effect on mainline ride quality. The groove is not present on the gage side of the mainline rail, see Figure 4. In this area, where most mainline wheels make tread contact, the tread bearing wear rate is sufficient to remove the wear caused by flange bearing.

For the case where only diverging route moves were operated at 10 mph, the running surface height loss rates were compared. The flange bearing surface height loss rate is 10-25 times higher than the tread bearing rate. Figure 5 shows the calculated vertical height loss of flange and tread bearing running surfaces of each frog.

Further analysis of the running surface profiles shows that flange bearing wear rate is highest in the ramp portions of the frogs. Figure 6 shows a comparison of running surface height loss on the ramped and flat portions of the flange bearing running surfaces on the Lift Frog. Note that the wear rate is about 50 to 80 percent higher in the ramped portion. It also appears the flat portion wear rate decreased after about 2 MGT of diverging traffic.

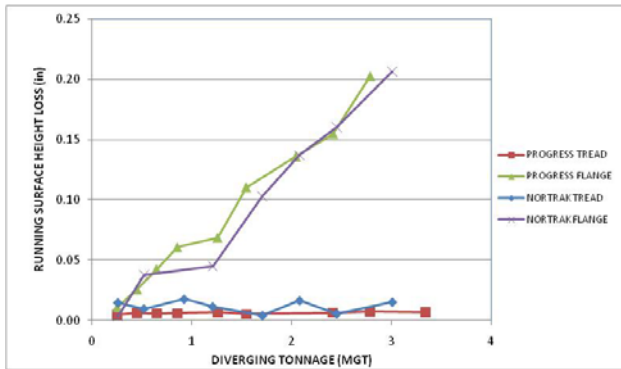


Figure 5. Comparison of Tread and Flange Bearing Running Surface Wear Rates on Turnout Frogs at FAST

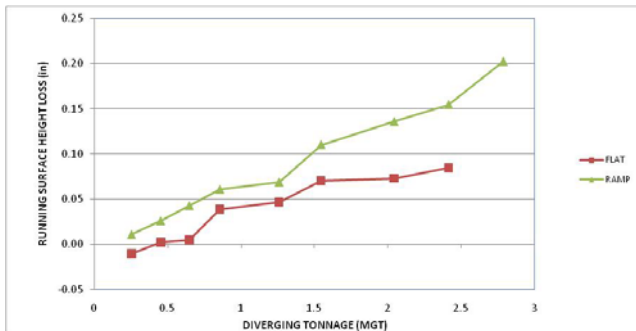


Figure 6. Flange Bearing Wear Rates: Ramp and Flat Sections

Future Work

Additional testing will be conducted to observe the full life cycle of the frog in FAST HAL service. This will allow time to determine long term wear rates and, ultimately, failure modes. Life cycle cost analysis will be conducted after the service life of the frog is established. Further, remedies to the lateral alignment issue will be evaluated.

References

1. Davis, D., X. Shu, and R. Jimenez. December 2010. "Initial Performance Evaluation of Partial Flange Bearing Frogs for Turnouts in Heavy Axle Load Service." *Technology Digest* TD-09-031, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO
2. Davis, D. et al. 2007. "Performance Evaluation of Premium Turnout Components under 39,000-pound Wheel Loads." Research Summary RS-07-003, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO