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RESEARCH RESULTS

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PERFORMANCE OF NO. 20 FROGS OF VARIOUS DESIGNS IN REVENUE SERVICE

SUMMARY

Transportation Technology Center, Inc. (TTCI) tested and evaluated the performance of four No. 20 fixed-point frogs on the Norfolk Southern Railway (NS) track as part of the jointly funded Association of American Railroads (AAR) and Federal Railroad Administration (FRA) Heavy Axle Load (HAL) Revenue Service Test Program (Jimenez, Davis, Shu, & Aragona, 2016).

Two standard frog systems used by the host railroad and two premium frog systems were installed specifically for this test within a 54-mile section of track south of Lexington, Kentucky, between March and August, 2013 (Figure 1). Each frog is defined as a system due to several noteworthy differences (e.g., point thickness, under-plate pads) among them. As of April 1, 2016, the frogs have accumulated between 226 and 234 million gross tons (MGT) of traffic.

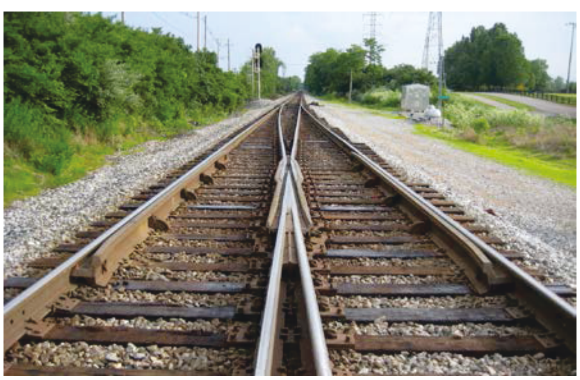

Figure 1. No. 20 Turnout at Bishop Location Near Lexington, Kentucky

Performance of the four frog systems was evaluated based on the following criteria: periodic visual inspections, wear/deformation of the running surfaces over time/tonnage, and reporting of any required maintenance over the course of the test. In addition, the dynamic service environment was characterized by way of dynamic response measurements under train traffic.

The wider heavy points of the premium frogs had approximately 50 percent less deformation than the points of the standard frogs under the same traffic as of September 2015. The mainline route wings of the premium frogs had approximately 33 percent less deformation than the mainline route wings of the standard frogs. The design of the frog heel/frog heel-rail interface on the premium frogs reduced running surface deformation by approximately 50 percent as compared to the standard frog heel designs.

The dynamic service environment measurements indicated a generally less severe condition over the premium frogs. Results from this test suggested that safety will be improved through lower wear and fatigue rates with improved performance frogs. The decreased dynamic loads should also contribute to fewer vehicle component failures.

The four frogs, located in turnouts that control passing sidings in a single-track railroad, remained in service for continued performance monitoring.

BACKGROUND

Each frog is defined as a system because there are several differences among them, including: type of plates, under-plate pads, heel connections, design of frog point, and others. The frogs were installed as panels in new ballast.

Table 1 lists the four frogs and their corresponding features and components at four locations near Lexington, Kentucky: The frogs installed at Bishop and Corman are of the NS standard design; the frogs installed at South Fork and Kings Mountain are commonly referred to as "premium" frogs. All the frogs were produced by the same manufacturer.

OBJECTIVES

The primary determination of performance is based on visual inspection, required maintenance, and wear/deformation of the running surfaces as a function of tonnage. These three parameters were observed and measured during each of the six trips to the test sites. Dynamic response measurements were also taken at selected locations of each of the frogs under multiple passing trains during the week of September 29, 2015, to characterize the dynamic service environment.

METHODS

Static

The wear/deformation of the running surfaces on the wings and points of the four frogs was monitored using the transverse running surface profile measurements, taken with a rail profilometer. A total of 49 profile measurements, mostly at 2-inch increments, were taken at each frog during six inspection trips (16 along each of the two wings and 17 along the point).

Dynamic

Test setup, data collection and teardowns for the dynamic characterization of the four frogs were conducted over four consecutive days, one frog per day. Each frog, therefore, was measured under a different set of trains.

RESULTS

Figure 2 shows the total height loss at the tip of the frog point between 14 inches and 46 inches past the theoretical point of frog (between 4 inches and 36 inches past ½-inch point of frog) as of the last measurements taken on September 30, 2015. The results indicate about 3.5 times more wear on the standard frogs than on the premium frogs at 16 inches past the ½-inch point of frog. The majority of wear (not shown here) on

Table 1. Features and Components of Frog Systems in Test

Location	Bishop (MP 85.6) Northbound: Facing Point	Corman (MP 95.7) Northbound: Trailing Point	South Fork (MP 134.8) Northbound: Facing Point	Kings Mountain (MP 139.1) Northbound: Trailing Point
Design Feature	NS-Standard Frogs		Premium Frogs	
Installation Date	4/1/13	3/18/13	8/26/13	
Point Thickness	Standard	Standard	Heavy point 31/32@ 5/8	Heavy point 31/32@ 5/8
Under-Plate Rubber Pads	No	Yes	No	No
Point Slope	10"	10"	15"	15"
Frog Running Surface Profile	Flat	Flat	Conformal	Conformal
Heel Design	30" cut, bolted	30" cut, bolted	Miter cut, low impact	Welded heel rails
Frog Heel Plates	4-tie	4-tie	4-tie	4-tie
Frog Plates (Rest)	Single	Single	2-tie	2-tie
Gage Plates	None	None	3	None
Guard Rail Type	C-clamp	C-clamp	Independent, raised 1-1/2"	Independent, raised 2"
Guard Rail Length	26'	26'	26'	26'

the wings of the four frogs on the mainline route occurred at 14 inches past the ½-inch point of frog. The average total height loss measured on the premium frogs at this location is ~0.09 inch; the average total height loss measured on the standard frogs is ~0.14 inch, which is ~1.5 times more than the premium frogs.

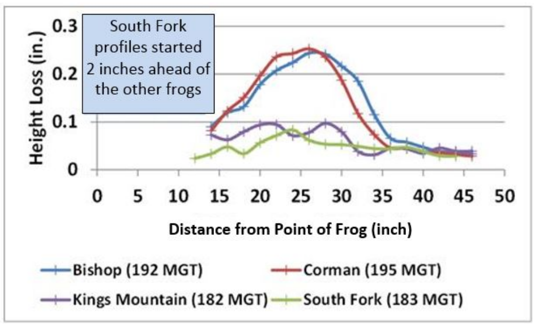

Figure 2. Total Height Loss Along the Frog Points

The longitudinal profiles measured at the wheel transfer zone over the frog heel indicated that the smoothest transition was the welded connection of the premium frog at Kings Mountain, where the dip along the 37-inch zone was about 0.06 inch. The dip at the miter-cut, low-impact, bolted connection of the premium frog at South Fork was about 0.08 inch. The 30-degree cut, bolted connections of the standard frogs dipped about 0.17-inch at Bishop and about 0.15-inch at Corman. The longitudinal profiles are illustrated in Figure 3, which shows the curves separated vertically for clarity.

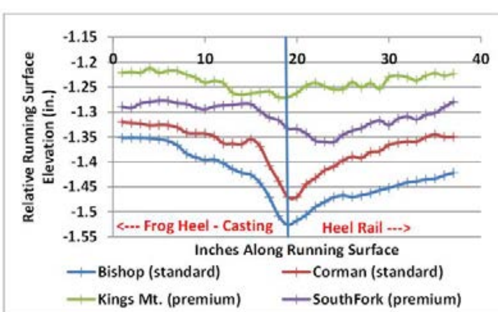

Figure 3. Longitudinal Profiles and the Frog Heel/Frog Heel-Rail Interface

Dynamic Service-Environment Characterization

The dynamic response from the more consistently loaded six-axle locomotive wheels, as compared to those of mixed-freight cars, was used to derive the results presented here. In total, the results represent the response from 134 locomotive wheels from 15 trains (some wheel data was not usable). The comparison of standard and premium frogs' acceleration responses measured at the wheel transfer zone over the frog point is shown in Figure 4. The graph indicates a generally less severe dynamic environment was measured on the premium frogs. In four of the five cases where a premium frog acceleration dataset corresponds with a standard frog dataset at the same speed or occurs at a higher speed, the median premium frog acceleration measured was from 7 g to 20 g lower. The highest median acceleration measured on standard frogs was 96 g at 44 mph; the highest acceleration measured on premium frogs was 56 g at 43 mph.

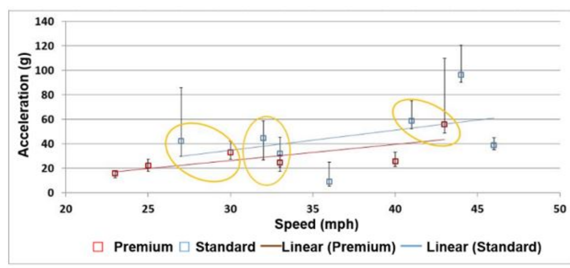

Figure 4. Acceleration Wheel Transfer Zone Over the Frog Point of the Standard and Premium Frogs on the Mainline Route

Surface Degradation

Over time, the location of maximum running surface height loss on the standard frog wings moved in the same direction (away from the point of frog) and at the same rate (about 6.5 inches per 100 MGT) as their point slopes. On the premium frog at South Fork, maximum height loss occurred between 12 and 14 inches past the point of frog in three of the four measurement cycles. Maximum height loss on the premium frog at Kings Mountain occurred more randomly between 16 and 24 inches past the point of frog.

The migrational behavior of the point slopes and wings of the standard frogs, where the effective wheel transfer zone moved away from the point of frog as a function of tonnage, may diminish the chances of either the point or wing suffering a fatigue failure. Conversely, the rapid wear may lead to a wear vehicle component failure.

Safety Implications

Results from this test suggest that safety can be improved through lower wear and fatigue rates with improved performance frogs. The decreased dynamic loads that result should also contribute to fewer vehicle component failures.

CONCLUSION

Data analyzed indicates that premium heavy point frogs wear less and produce less severe dynamic loading environments than standard frogs in a HAL service environment.

REFERENCES

Jimenez, R., Davis, D., Shu, X., & Aragona, I. (2016, June). Performance of No. 20 Frogs in Revenue Service. *Technology Digest*, 16-028. AAR/TTC.

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KEYWORDS

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