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PERFORMANCE OF PROTOTYPE NO. 20 FROGS IN REVENUE SERVICE

SUMMARY

Transportation Technology Center, Inc. (TTCI) evaluated the performance of several No. 20 fixed-point frogs on Norfolk Southern Railway (NS) in Kentucky. This effort was part of the Heavy Axle Load (HAL) Revenue Service Test Program jointly supported by the Federal Railroad Administration (FRA) and Association of American Railroads (AAR). Research was conducted between 2017 and 2022.

The NS line used in this research had previously hosted revenue service frog studies [1]. In 2017, a second generation of frog testing was initiated to evaluate the performance of prototype heavy point frogs that had been modified with wider flangeways. The new design met the pre-2020 FRA track safety standard requirements for check gage and face gage for Class 5 track without requiring a waiver [2, 3]. Prototype modified heavy point frogs were installed at three locations along the NS line. Figure 1 shows one of these frogs at Kings Mountain, KY. Both prototype modified heavy point frogs were welded boltless manganese (WBM) with flattop running-surface profiles. As of June 21, 2022, these two frogs had accumulated approximately 358 million gross tons (MGT) of traffic.

The performance of the frog systems was evaluated based on periodic visual inspections, wear/deformation of the running surface over time/tonnage, and maintenance reported by NS track personnel over the course of the test.

The measurements from these inspections indicate that the prototype modified heavy point frog systems did not perform as well as the original heavy point frogs installed on this line. Compared to the earlier test, the prototype modified heavy point frogs installed in 2017 exhibited greater amounts of point deformation. The 2017 frogs featured flat (versus conformal) running surface profiles and wider flangeways. It is likely that both of these features contributed to the greater amounts of point deformation observed. The wider flangeways (an additional 3/16 inch of flangeway width) resulted in shorter wheel transfer zones on the point and wing, as well as higher loading pressures. NS chose the flattop profiles to protect the wings from impacts made by false flange wheels during trailing point moves.

Figure 1. No. 20 frog at Kings Mountain, KY

BACKGROUND

In the course of a long-term evaluation that began in 2013 [1], frog systems of various design were installed along the NS line. In the first installations, two standard frog systems (standard points, flat profiles, standard heels, and standard guard rails) were compared with two premium frog systems (heavy points, conformal profiles, low impact or welded heels, and raised guard bars). The previous study [1] included the improved safety and performance benefits of the premium systems. All the frogs in the previous study have now been removed from service.

Table 1 lists the various test frogs from three locations on the NS line south of Lexington, KY, along with their corresponding features and components.

Table 1. Features of frogs tested through June 2022

MP	Location	Northbound	Type	Point
134.8	South Fork	Facing Point	RBM	Heavy
130.2	Palm	Trailing Point	WBM	Modified Heavy
139.2	Kings Mountain	Trailing Point	WBM	Heavy
139.2	Kings Mountain	Trailing Point	WBM	Modified Heavy

MP	Running Surface Profile	Installed	Removed	MGT
134.8	Conformal	2013 Aug	2021 Dec	663
130.2	Flat	2017 Dec	--	358+
139.2	Conformal	2013 Aug	2017 Dec	342
139.2	Flat	2017 Dec	--	358+

The frogs installed at South Fork and Kings Mountain in 2013 were the original "premium" frogs installed as part of the 2013 test program [1]; the frogs installed in 2017 at Palm and Kings Mountain were the prototype modified heavy point frogs that are the primary focus of this publication.

Figure 2 compares the transverse profiles of standard, heavy point, and prototype modified heavy point frogs. The prototype frogs differ from conventional heavy point frogs in that the prototype frog flangeways are 1-7/8 inch wide over the length of the heavy point. The difference between frog types is accomplished by removing some metal from the wings over a 60-inch transition zone. The wider flangeways of the prototype modified heavy point frogs were employed to simultaneously satisfy face gage and check gage requirements of Section 213.143 in the pre-2020 FRA track safety standards.

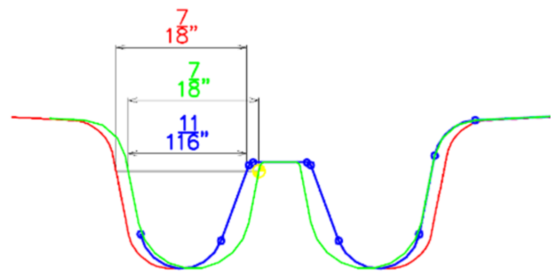

Figure 2. Frog transverse profiles: standard (green), heavy point (blue), modified heavy point (red)

OBJECTIVES

The primary objective of this portion of the study was to evaluate the performance of the prototype modified heavy point frog design. The previous study verified the improved safety and reduced maintenance of the heavy point frog design [1]. The prototype modified heavy point frog design was an attempt to provide some of the benefits of the heavy point frog design while also meeting all provisions of the pre-2020 FRA track safety standards for Class 5 track.

METHODS

Performance evaluation was based on visual inspection, required maintenance, and wear/deformation of the running surfaces as a function of tonnage. TTCI engineers observed and measured these parameters during several trips to the test sites.

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. Up to 40 profile measurements, in 2- to 4-inch increments, were taken at each frog during each inspection trip (up to 16 measurements along each of the two wings and up to 8 measurements along the point).

RESULTS

Figure 3 compares the frog point height loss measurements for the original heavy point frogs (2013 Kings Mountain and South Fork) and modified heavy point frogs (2017 Kings Mountain and Palm) at similar tonnages of approximately 150 MGT. For both 2017 frogs, the frog point height loss was considerably higher at most locations. After approximately 150 MGT, some of the frogs underwent grinding and weld repairs, making comparisons less relevant.

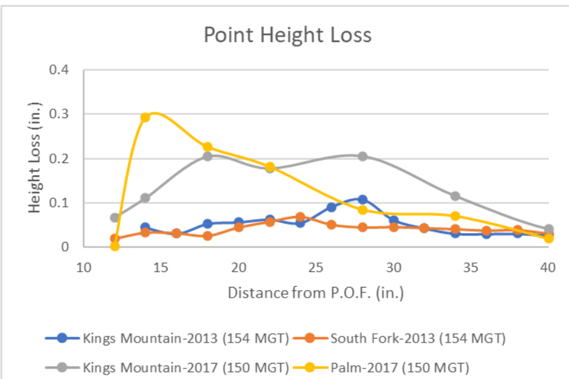

Figure 3. Point height loss for original (2013) and modified (2017) heavy point frogs

There are two reasons for the greater point height loss in the modified heavy point frogs. First, these frogs have a flangeway that is 3/16 inch wider than the original heavy point frogs. This wider flangeway resulted in shorter transfer zones for the wheel to transition between wing and point and higher static stresses for wheel-rail contact [2]. The wider flangeway also resulted in higher dynamic stresses as the wheels negotiated the flangeway gap.

Second, the modified heavy point frogs were delivered with flat rather than conformal profiles. Previous analysis showed that flat profiles resulted in a higher initial wear rate for the point, particularly close to the point of frog [4]. This effect is most obvious in the data from the Palm frog, where the greatest measured height loss is approximately 14 inches from the point of frog.

Figure 4 shows the comparative wing rail height loss for original and modified heavy point frogs at approximately 150 MGT. Generally, the measured height losses were under 0.1 inch maximum along the wings. The largest exception was the diverging wing of the Palm frog, which exhibited approximately 0.2 inch of height loss as early as 150 MGT.

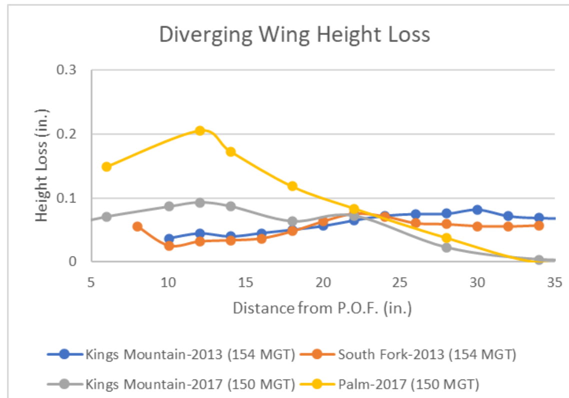

Figure 4. Diverging wing height loss for original (2013) and modified (2017) heavy point frogs

The maximum wing height loss for the Palm frog was near the same location as the maximum-point height loss. The area near the point is where the wider flangeway most reduces the width of the wings in the prototype modified heavy point frogs. This width reduction is likely the reason the prototype frogs had significantly more wing height loss in the first 20 inches from the point of frog when compared with the 2013 original heavy point frogs. It is likely that the shorter transfer zone and higher wheel-rail stresses were the primary causes of the increased amount of wing deformation near the points of the prototype modified heavy point frogs.

Visual inspections and maintenance were also used to determine performance. Initially, the flattop profiles protected the wings from false flange wheel impacts and shifted the transfer zone toward the heel end of the frog, as compared to a frog with a conformal profile. The result was more deformation on the frog points. NS personnel reported that the prototype frog castings required increased maintenance sooner than the previous heavy point frogs. NS personnel also noted that the wider flangeways of the prototype frogs could be felt while traversing them in a hi-rail vehicle.

CONCLUSIONS

Based on the measurements of point and wing deformation, the performance of the prototype modified heavy point frog systems was not as favorable as what was experienced by the original heavy point frogs installed on this line. The wider flangeway that was used to meet pre-2020 requirements for both check gage and face gage resulted in higher loading pressures.

In October 2020, FRA modified the track safety standards to allow the use of the original heavy point frog geometry, provided it meets Class 4 dimensions for check gage and face gage, as well as additional requirements for gage plates, guard rail braces, and elastic rail fasteners. Considering the results of this test, that rule change seems prudent and should help promote improved safety and maintenance of fixed-point frogs.

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