

Improved Running Surface Profile for No. 20 Frogs

by Charity Sasaoka, David Davis, Satya Singh, Don Guillen

Summary

Four prototype No. 20 frogs, each with an improved performance running surface, have been developed and are currently being tested under heavy axle loads by Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads (AAR). Each frog is characterized by a specific modification to its surface profile. This will allow TTCI to evaluate which “new” features will best minimize impacts at transition points, minimize the occurrence of high contact stresses due to edge loads and contacts with small radius frog surfaces, and minimize elevation changes for wheels traversing the frog. The prototype frogs are currently in test at the Federal Railroad Administration’s (FRA) Transportation Technology Center (TTC), Pueblo, Colorado, under the cooperative AAR/FRA Heavy Axle Load (HAL) program.

Frog number 1 (conventional) and Frog number 2 (conformal) include changes to their cross-sectional profile. The goal of these changes is to lower contact stresses and minimize grinding maintenance. Frog number 3 (wing and point riser) and Frog number 4 (wing anti-riser) include changes to their longitudinal profiles. The goal of these changes is to eliminate impacts from running surface discontinuities.

Frogs 1 and 2 have been tested on No. 20 turnouts at TTC’s Facility for Accelerated Service Testing (FAST) since April 2001 and have accumulated over 100 million gross tons (MGT). Frogs 3 and 4 have been tested at FAST in conventional track since September 2001. All traffic runs on one side of the frog. Both frogs have accumulated over 50 MGT.

More tonnage will be accumulated to determine long-term results, but initial observations are listed:

- The larger, 9/16-inch flangeway corner radii have been effective in reducing maintenance requirements.
- The conformal wing profile, with a 1:20 taper, is an effective means of spreading wheel contacts across the wing.
- Both longitudinal profiles are effective in controlling wheel wing-point transfer location by:
 - Protecting the point tip from impacts from new wheels.
 - Protecting the wing and point from hollow tread wheel impacts beyond the top of the point slope

The running surface profile frogs tested are typical No. 20, rail-bound, manganese casting frogs. They were built to current railroad standards in all other respects. The frogs have been tested under the controlled conditions at FAST’s High Tonnage Loop located at TTC. The test facility applies loads with a 39-kip wheel load train operating at 40 mph.

Suggested Distribution:

- Maintenance of Way
- Planning & Analysis
- Track Maintenance
- Safety



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BACKGROUND

Current No. 20 mainline frog running surface designs do not minimize required metal flow maintenance; nor do they provide optimal dynamic performance. Most frogs are built with flat running surfaces and flangeway corner radii of less than 1/2 inch. A cone-shaped wheel on this running surface profile will produce contact on the gage (flangeway) corner. This produces high contact stresses, which lead to metal flow into the flangeway and the need for maintenance grinding. Further, the typical 3/16-inch point depression is not sufficient to prevent a new 1:20 taper wheel from bluntly striking the point for facing point moves. The elevation difference between the point and wing is not sufficient to raise false flanges above the wings and results in the interference between the wheel and wing on trailing point moves.

The currently flat running surface profile and shallow point depression frog design is used because of the ease of manufacturing it offers and the way it minimizes dynamic loads with typical worn wheels. With advances in manufacturing capabilities, it is practical to design a surface profile that accommodates a wider range of wheel profiles without impacts and yet still benefits dynamic performance. With this in mind, TTCI developed four prototypes that are currently being tested at FAST.

The first two prototypes have changes to their cross-sectional profile. Frog number 1 (conventional) has a conventional flat running surface but a larger gage corner radius (9/16 inch vs. typical 3/8 or 7/16 inch). The larger radius is used to keep the wheel-rail contact off of the gage corner, thereby reducing the expected metal flow. Frog number 2 (conformal) has the larger gage corner radius, but also has a 1:20 taper slope on the frog wings and a railhead profile on the frog point. These changes make the running surface more conformal to the wheel, allowing contact to occur over a larger area of the running surface cross-section.

The other two prototypes have changes to their longitudinal profiles. The goal of these changes is to reduce the impacts due to running surface discontinuities. Frogs 3 and 4 (Exhibit 1) have the following features:

- Depressed point to accommodate cone shaped wheels. The frog point running surface is 0.30 inch lower than wings at the 1/2-inch point.
- Depressed wings to accommodate hollow worn wheels. At the typical point to wing transfer area (at about 15 inches from the 1/2-inch point on a No. 20 frog) the elevation of the point is 0.05 inch above the wings to avoid impacts and assure that all wheels are running on the point in facing point moves.



Exhibit 1. Frog No. 3 Installed in Conventional Track

TEST RESULTS

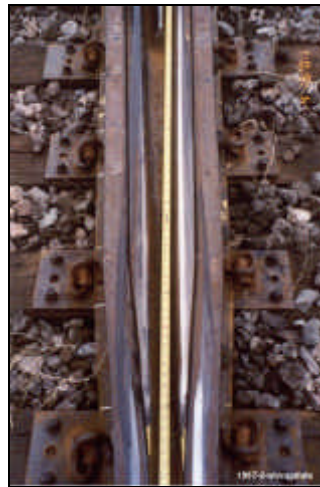
Cross-Sectional Profiles

Since their installation in April 2001, Frogs 1 and 2 have accumulated over 100 million gross tons (MGT) of traffic (56.61 MGT on mainline and 51.35 MGT on branch line). The first maintenance grinding was done at approximately 62 MGT. Typical rail-bound manganese (RBM) frogs at FAST would have required grinding at least twice in this interval. This improvement is due to the larger 9/16-inch radius moving the wheel-rail contact off of the gage corner. Exhibit 2 shows the wear pattern of each frog after 10 MGT. Frog number 2 has a wider wheel contact band centered on the running surfaces.

Exhibit 3 shows the cumulative running surface wear for Frogs 1 and 2. Frog 2 has approximately twice the height loss of Frog 1.



Conformal



Conventional

Exhibit 2. Wear Pattern of Frogs 1 and 2

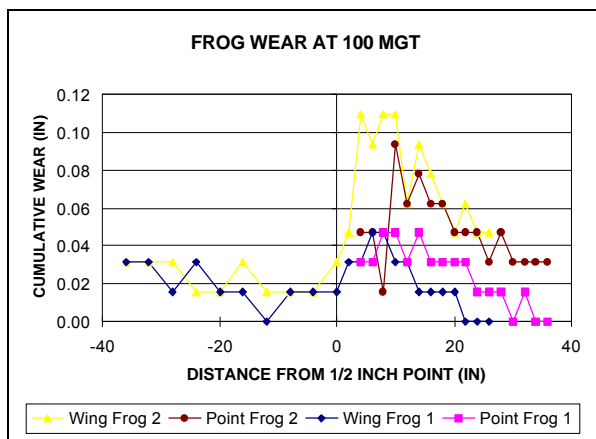


Exhibit 3. Frog Running Surface Wear

Running surface hardness (see Exhibit 4) for Frog 1 increased from a range of 403-415 Bhn to

a range of 512-532 Bhn. The running surface hardness for Frog 2 increased from a range of 415-460 Bhn to a range of 530-571 Bhn.

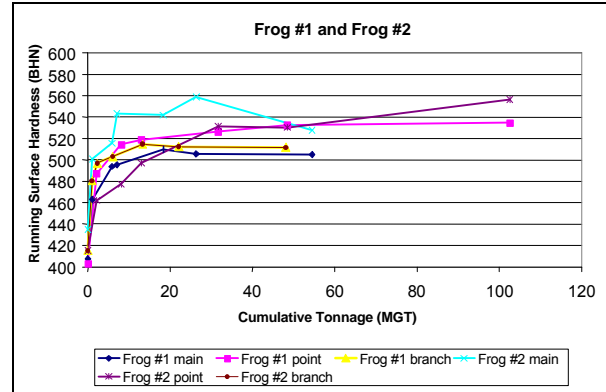


Exhibit 4. Frog Running Surface Hardness

Longitudinal Profiles

Frogs 3 and 4 have accumulated over 50 MGT of traffic since installation in September 2001. Both frogs appear to have been successful in reducing some of the impact due to running surface discontinuities. As can be seen in Exhibit 5, the point of transition for Frog 3 occurs approximately 7 inches from the 1/2-inch point. The point of transition for Frog 4 occurs approximately 5.5 inches from the 1/2-inch point.



Frog 3



Frog 4

Exhibit 5. Wear Band on Frogs 3 and 4

The change in the transition zone is due to the depressed point. This allows cone-shaped wheels to transverse the frog without impacting the point on facing point moves. The point riser accommodates hollow tread wheels by raising the false flange above the wing elevation preventing interference between the wheel and the wing. The wing risers also help to minimize elevation changes throughout the frog, thus reducing impacts. Also evident in the exhibit is the flow at the point of transition for each frog. Maintenance grinding was done at approximately 15 MGT.

Exhibit 6 shows the cumulative wear for Frogs 3 and 4 at approximately 50 MGT. The cumulative wear on the point is similar for both frogs, with a maximum of 0.06 inch at about 8-10 inches from the 1/2-inch point. This corresponds closely to the transition zone. The cumulative wear on the wing for Frog 4 has a maximum of 0.06 inch at 2 inches from the 1/2-inch point. The cumulative wear on the wing for Frog 3 has a maximum of 0.08 inch at approximately 6 inches from the 1/2-inch point. Frog 3 has more wear due to the wing riser. There is more material to flow and wear down.

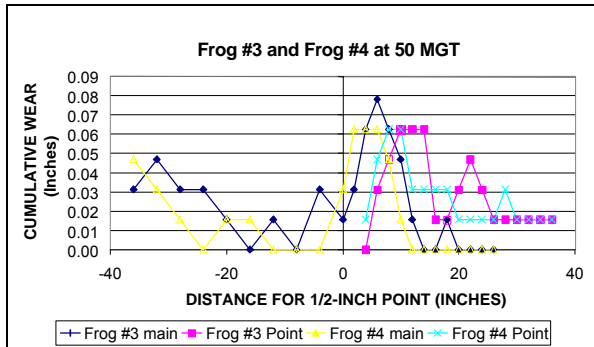


Exhibit 6. Frogs 3 and 4 Running Surface Wear

Exhibit 7 shows running surface hardness. The running surface hardness for Frog 3 increased from a range of 403-431 Bhn to a range of 499-516 Bhn. The running surface hardness for Frog 4

increased from a range of 449-461 Bhn to a range of 501-506 Bhn.

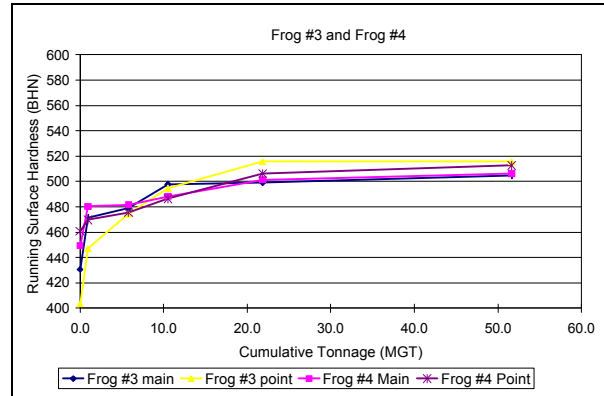


Exhibit 7. Frogs 3 and 4 Running Surface Hardness

ASSESSMENT OF DESIGN AND FUTURE WORK

It is clear from the preliminary results of this test that a larger gage corner radius is effective at reducing the initial maintenance required, the sloped wings are effective for spreading the wheel/rail contact over a wider area, and the longitudinal profile changes are effective in minimizing the impacts on the point as the wheel traverses through the frog. The frogs will continue to accumulate tonnage and long-term results will be evaluated. It will be determined which “new” features contribute the most to improving overall dynamic performance. A second-generation prototype with those features will then be designed and tested.

Note: Contact Charity Sasaoka at (719) 584-7176 with questions or comments about this document. E-mail: charity_sasaoka@ttci.aar.com

Visit TTCI's website: <http://www.ttci.aar.com>