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Evaluation of Prototype Switch Point Running Surface Profiles for Heavy Axle Loads

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Summary

Prototypes of a conformal running surface switch point profile (reported in TD-10-011)[1] have been tested in revenue service on Union Pacific Railroad (UP) and BNSF Railway (BNSF) mainline track, and preliminary test results indicate they are expected to increase switch point life by reducing wear and delaying the initiation of rolling contact fatigue (RCF). The revenue service tests also indicate that both prototypes of switch point profiles moved the wheel contact positions away from the rail gage corner. After approximately 200 and 100 MGT respectively, both prototypes provided significant improvement over the currently used profile, but the prototype that was closer to the recommended shape produced better wear patterns, lower wear rates, and less rail surface damage.

Transportation Technology Center, Inc. (TTCI) conducted an investigation to determine the causes of running surface fatigue or RCF on switch points. This project, funded under the Association of American Railroads' Strategic Research Initiatives Program, is intended to develop strategies to mitigate RCF at switch points. The investigation results led to the development of new running surface cross section profile designs and the installation of prototypes in revenue service tests on UP and BNSF sites in Kansas and Missouri.

The track tests conducted on revenue service lines confirm the previous observations on the current standard switch point profile, showing it produces concentrated wear at the switch point gage corner, which causes surface damage in the early stages of service life.

The new design switch point running surface profiles can improve wheel/rail interface conditions by producing larger contact areas with new and worn wheel profile shapes, which lead to lower contact stresses. The new profile is much closer to the shape of a canted rail — the shape wheels encounter on the rest of the track.

The current switch point running surface design[2] tends to experience a relatively high rate of wear and early onset of RCF, resulting from high contact stress and concentrated contact at the rail gage corner. The current design worked better when rails were much softer than those used today, enabling the switch point to wear into a conformal shape. The non conformal shape was a result of planing a point slope into the switch point.

The two revenue service tests each used a slightly different version of the prototype profile design. The one tested on UP was very close to the design profile. The profile tested on BNSF had the same gage corner radius, but it was rotated toward the center of the track, as compared to the first profile. The prototypes on UP produced more conformal wheel contact and significantly lower wear rates (as compared to the standard profile) than did the profile tested on BNSF.

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INTRODUCTION

TTCI's investigation to determine the causes of RCF on switch points and to develop strategies for mitigating RCF at switch points has led to the development of new running surface cross section profile designs and prototypes, which have been tested in revenue service. This *Technology Digest* describes the performance of the prototypes tested on UP and BNSF mainline track.

PROTOTYPE DESIGNS

The new three circular arc design was shown in TD-10-011.[1] In order to simplify the machining process and use an existing cutting tool, a simplified design was also provided, as Figure 1 shows. This profile has a 1-inch radius at the switch point gage corner. It maintains the 78-degree gage side cut and has a flat top (or 1:20 slope) cut that is tangential to the 1-inch radius arc. Because the 1-inch radius arc is not tangential to the 78-degree line, it creates a visible intersection of the curved and flat surfaces that can be smoothed during production. This switch point should quickly wear into a conformal shape with the commonly worn wheel profiles. The new profile is intended to approximate the gage corner of a canted rail. This running surface profile is similar to what the wheel encounters on the rest of the track outside of turnouts. Figure 2 shows a comparison of the current design and the new design.

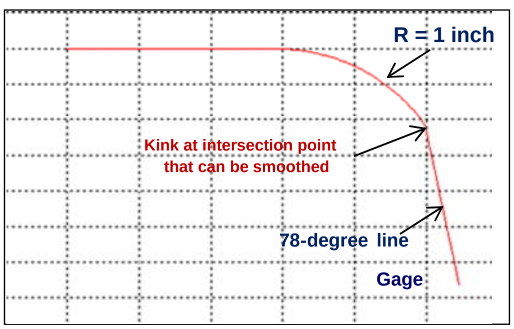


Figure 1. New Switch Point Profile Design 2

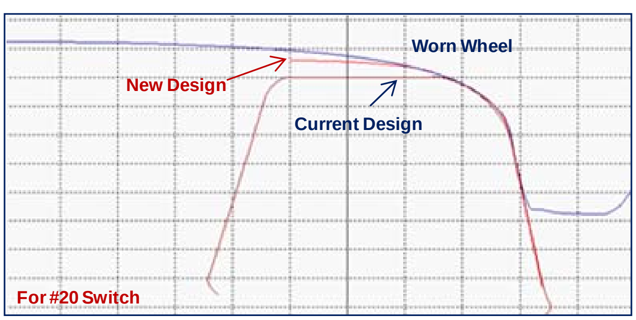


Figure 2. Comparison of the Current Switch Point Design and the New Switch Point Profile Design

The new design switch point profile provides a large wheel/rail contact area to carry the vertical load and tangential force and will more quickly wear into a conformal shape. To increase the size of the wheel/rail contact area, the switch point top of the new design is slightly higher than the current design in the load-carrying zone from 9 to 19 feet from the switch point tip. The new switch point maintained the slope for the two side cuts. It adjusted the slopes for the first and second top cuts and the length of the second cut to accommodate the new profile and to keep the switch point tip elevation the same as in the current design.

PROTOTYPE TESTS

The prototype switch points were tested on BNSF and UP high tonnage rate mainline track.

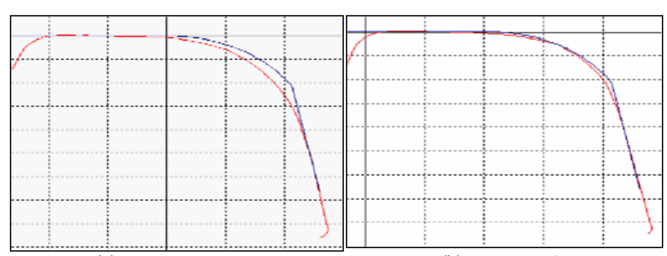
The BNSF test consists of a No. 20 crossover at East Marceline, MO. One turnout has prototype switch points, and the other has AREMA style[2] profile switch points. Traffic at Marceline consists of intermodal, mixed freight, unit grain, and passenger trains. Traffic levels are approximately 60 MGT per year on each track.

The UP test consists of four No. 20 turnouts at Bonner Springs, and Linn, KS. These are installed in three crossovers. At Linn, one crossover has two turnouts: one with a prototype switch profile point and one with an AREMA style switch profile point. A second turnout with prototype switch profile points is installed near Bonner Springs. The second turnout with AREMA style profile points is installed at the control point west of Linn. Traffic at Bonner Springs consists of unit coal, intermodal, unit grain, and mixed freight trains. Main 1 is mainly for westbound trains (including empty coal trains) and Main 2 is mainly for the eastbound trains (including loaded coal). Traffic on the two tracks is 45 MGT and 140 MGT per year, respectively.

PROTOTYPE SWITCH POINT PROFILES ACTUALLY TESTED

The tested switch points were manufactured by two switch suppliers. The concept drawing as shown in Figure 1 was interpreted differently by each supplier. Thus, the prototype points were made with somewhat different shapes and show some differences in performance.

Figure 3 compares the manufactured switch point profiles with the recommended shape (Figure 1). The prototype switch points (Prototype 1, Figure 3a) at Marceline, were produced simply using a cutter with 1-inch radius to tangentially connect the two straight sections at the rail top and the gage side, respectively. Compared to the intended profile, too much metal was removed at the rail gage corner, resulting in strong two-point contact. The prototype switch point profile (Prototype 2, Figure 3b) installed at Bonner Springs, although not in complete agreement with the recommended shape, was reasonably close to the intended profile.



(a) Prototype 1 (b) Prototype 2

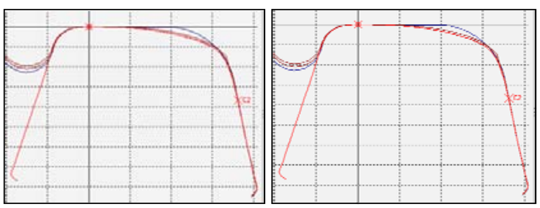
Figure 3. Prototype Switch profiles from Two Switch Suppliers (Design shape is shown in blue for reference)

PERFORMANCE MEASUREMENTS

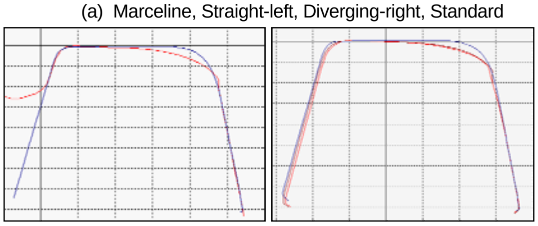
The performance of the switch points was quantified by measuring the running surface cross section at the test locations over time**.** By overlaying the profiles, the amount of wear and metal flow was determined**.** Profiles were taken from a few feet in front of the point of switch to the location where the switch point is a full railhead section again**.** Thirty profiles per switch point were taken. In addition, qualitative assessment of the surface condition by visual inspection and records of running surface maintenance grinding were used to determine the effect of the profiles on RCF occurrence.

Wear Pattern Results

Standard Switch Points The standard switch points from two switch suppliers at the two test sites produced similar wear patterns as in the previous survey.[1] Figure 4 shows the switch point profiles at the two test sites, measured at 14 feet from the point of switch after about 7 months and after 18 months since the switch points were installed, overlaid with the new profiles (blue lines in plots)**.** The actual Marceline points were measured before installation, whereas representative new profiles were used for the Bonner Springs turnouts**.** Two main observations are: (1) High rates of wear occurred in the first 7 months, and (2) The wear was concentrated at the rail gage corner.



(a) Marceline, Straight-left, Diverging-right, Standard



(b) Bonner Springs, Main 1- mostly empty trains , Straight-left, Diverging-right, Standard

Figure 4. Standard Switch Point Wear Pattern

Figure 5 is a photo of the standard switch point taken 7 months after the installation at Marceline, which shows the surface damage at the rail gage corner. Rail grinding (using a hand grinder) had been conducted a few days before to remove the plastic flow at the gage corner.

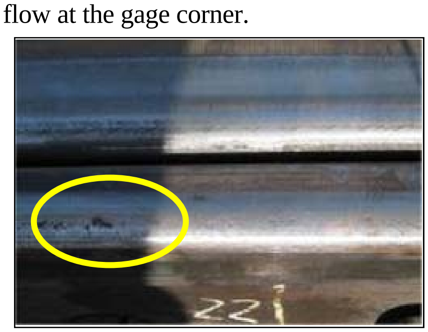
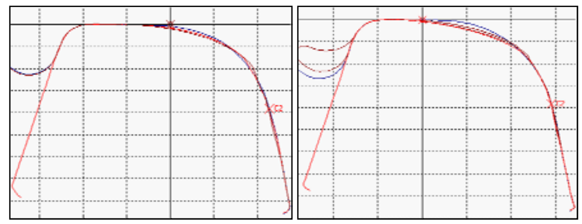


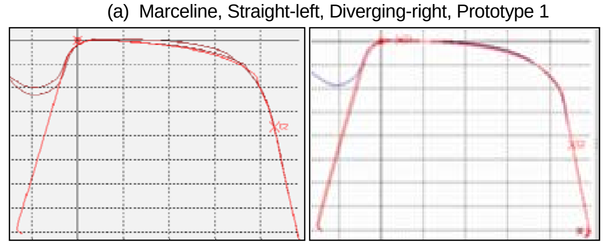
Figure 5. Standard, Straight, about 14 feet (measurement position 22) from Point of Switch – April 2011, Marceline

Prototype Switch Points Figure 6 shows the wear patterns for two variations of the prototype switch point profile at a similar distance from the switch point as that shown in Figure 3 and during the same time. Compared to the standard switch point profile, performance results from the prototype profiles show the following features:

- Both versions of the prototype profile did not show the concentrated wear at the rail gage corner as seen on the standard profile. The wear was mainly spread at the rail top, indicating a larger wheel/rail contact area.
- The wear at this location during the same service period was lower than that on the standard profile.



(a) Marceline, Straight-left, Diverging-right, Prototype 1



(b) Bonner Springs, Main 2 – mostly loaded trains, Straight-left, Diverging-right, Prototype 2

Figure 6. Prototypes Wear Patterns, (a) BNSF (b) UP

Figure 7 is a photo of the prototype switch point taken at 7 months after the installation at Marceline. Compared to Figure 5, the rail surface condition was much better and the contact band was located on the top of the rail, which agreed with the measured profiles**.** Local forces that maintain the switches also noted less RCF occurred and less grinding was needed on the prototypes.

Figure 7. Prototype, Straight, 15 feet (measurement position 23) from the Point of the Switch – April 2011, Marceline

The measured profiles show that Prototype 1 (see Figure 3a) tends to have more gage face wear in the switch entry section and in the beginning of the load carrying section, especially for the diverging route.

Figure 8 shows an example. This wear pattern is likely due to the orientation of the 1-inch radius cut at the rail gage (Figure 3a), which caused a small contact area at the gage face and a strong two-point wheel/rail contact condition that has a negative effect on curving.

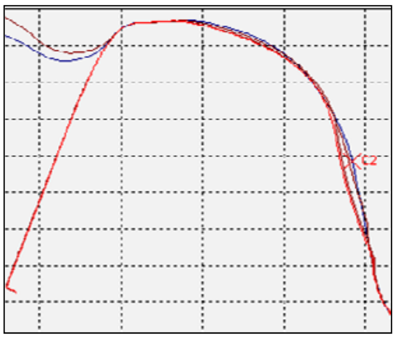


Figure 8. Gage Face Wear, Prototype 1, Diverging

This gage face wear pattern did not occur on the Prototype 2 switch point (Figure 3b), because the gage corner was oriented to be more conformal to wheel flange root – tread profiles. This recommended shape (Prototype 2) provides a larger wheel/rail gage face contact area.

Performance Measurement Results – Wear (Cross section area loss)

The straight prototype and standard switch points are separately installed on Main 1 and Main 2 on both BNSF and UP lines. Bonner Springs, Main 1 (with the standard switch point) has mostly empty coal trains and Main 2 (with the prototype switch point) has mostly loaded coal trains. At Marceline, the loaded trains run on both lines. The actual traffic distribution between two lines is unknown, making it difficult to make a direct comparison of wear on the straight prototype and on the standard switch points. The diverging switch points likely experience similar traffic, but the distributions of facing and trailing traffic are unknown.

Figure 9 compares the wear in terms of rail cross section area loss for the prototype and standard diverging switch point profiles at 13 feet from the switch point after 18 months of wear. Compared to the standard switch, the prototype at Bonner Springs showed about 50 percent less area loss, but at Marceline the prototype had slightly more area loss.

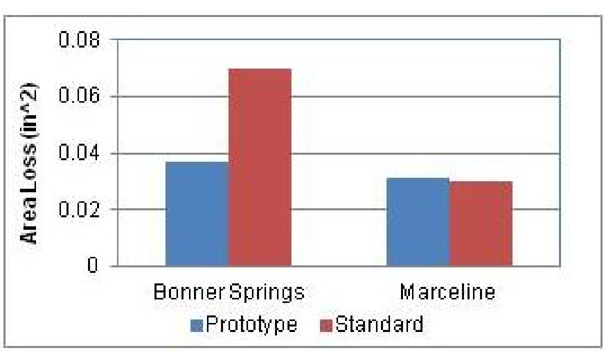


Figure 9. Wear Comparison of Prototypes, Diverging Route, 13 feet from the Point of Switch

As discussed above, the prototype switch point profiles at Bonner Springs were made closer to the recommended design**.** However, the profiles at Marceline were made quite different from the recommended shape and caused strong two-point contact, which has a negative effect on curving (diverging route)**.** Figure 8 clearly shows the wear at the rail gage face**.**

CONCLUSION

The current switch point running surface design tends to experience a high rate of wear and severe RCF resulting from high contact stress and concentrated contact at the rail gage corner. The new design switch point rail profiles can improve wheel/rail interface conditions by producing larger contact areas with new and worn wheel profile shapes, which lead to lower contact stresses.

The track tests conducted on revenue service lines confirm the previous observations on the current standard switch point profile,[1] showing it produces concentrated wear and causes surface damage in the early stages of service life. The track tests also indicate that the contact positions for both prototypes of switch point profiles moved away from the rail gage corner. Although both provided significant improvement over the currently used profile, the prototype that was closer to the recommended shape produced better wear patterns, lower wear rates, and less rail surface damage.

Therefore, the new designed switch point profiles are expected to increase switch point life by reducing wear and delaying the initiation of RCF.

WAY FORWARD

The prototype switch points have provided benefits in terms of decreased wear and running surface maintenance in two heavy haul revenue service tests. Further monitoring of the prototypes will establish the life cycle cost improvements likely to be derived. With no adverse effects noted in the prototype tests, a wider scale implementation is warranted. Additional effort is needed to perfect the manufacturing processes for the new design. Care should be taken to orient the profile properly (with respect to vertical), so that a nearly conformal match to worn wheels is achieved.

ACKNOWLEDGEMENTS

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