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Evaluation of Switch Point and Stock Rail Profiles for Heavy Axle Loads

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Summary

A series of tests were conducted by Transportation Technology Center, Inc. to evaluate methods to reduce stock rail metal flow and switch point fatigue in turnouts.

Preliminary results suggest that it may be possible to limit metal flow on the gage corner of the stock rail. The prototype profiles used during the test series, which altered the gage corner radius, were not successful in greatly affecting the rate of metal flow. However, they did show that the location of contact and resulting metal flow can be affected by changing the stock rail running surface profile. Further design iterations are needed to provide more clearance between the stock rail and the switch point for metal flow.

The tests involved changes to the stock rail cross section profile and the orientation of the stock rail with respect to the vertical plane using plate work. A side by side comparison of flat and canted plate work was conducted for the currently used profiles and for the prototype stock rail running surface profiles. Tests measuring the railhead profile showed that stock rails on canted plates may shift wheel and rail contact from the gage corner to the field side of the rail. This is evident from the higher metal flow rate on the field side of the running surface of stock rails with canted plates and suggests more wheel contacts are occurring on the field side of the stock rail, away from the gage corner. This should result in less metal flow near the gage corner undercut and less interference with the switch point. The risk of rail rollover resulting from the field side contact is small because the stock rail is braced for the lateral forces of diverging route switch entry. Putting the stock rail on canted plates will require changes to either the switch point or the stock rail undercut, so that the two will fit together. The point must remain on flat plates to facilitate throwing the switch. The canted running surface in a stock rail can also be accomplished by reprofiling the stock rail on flat plates. This is the likely method of applying cant to the stock rail.

Many switch points are removed due to chipping (i.e., fatigue of the thin section near the point of switch) caused by excessive metal flow from stock rail gage corners. North American practice is to install switches on flat, rather than canted plates. Flat-plate work makes switch construction and operation simpler. However, it is also known to create a running surface discontinuity as the stock rail is twisted about the longitudinal axis in going from canted plates before a switch to flat plates in a switch.

These tests are being performed to improve the service life of special trackwork and are part of the Association of American Railroads' Strategic Research Initiatives Program.



INTRODUCTION

Normally switch points are replaced together with stock rails to avoid fitting problems. This practice has encouraged more design improvements in switch points than in stock rails. However, there are various potential improvements in stock rail design that may indirectly increase the service life of switch points. These improvements may include better gage corner radius to reduce metal flow, use of canted plates for moving wheel and rail contact away from gage corner, and stock rail alignment changes for better steering. The first two improvements are discussed here, and information on how to improve vehicle steering can be found in a previously published *Technology Digest*, TD-10-013.¹

BACKGROUND

Performance records of existing switch designs were reviewed and show the following top six switch-related accident causes:

1. Gapped switch points
2. Chipped switch points
3. Dragging equipment derailments
4. Track surface and alignment defects
5. Worn switch points
6. Split switches

Five of the failure modes are related to the specific features of split switches. Dragging equipment derailments are largely independent of switch design. However, the other five failure modes are related to the split switch configuration and the knife-edge switch points it utilizes. The thin section of the switch point is susceptible to breakage from vertical loading and torsional bending. The removal of the foot of the switch point makes it unstable under load. Metal flow from the stock rail can make contact with the switch point problematic, because a narrow band of contact is likely located near the top of the switch point. Differential movement of the two components under loading makes the design of the contact surfaces more difficult. These conditions result in the overloading of the switch point and stock rail in the same locations, resulting in cracked and broken switch points, track surface defects near the point of the switch, switches that do not close properly, and worn switch points that raise the likelihood of a wheel climb.

In theory, extending the life of the stock rail may not have an effect on the service life of switch points, since both are replaced together to avoid fitting problems. However, chipping or breakout is the most common failure mode of switch points. Stock rail metal flow and lack of timely maintenance grinding are contributing factors. Consequently, any design feature that can reduce stock rail metal flow also has the potential to increase switch point service life.

The stock rail is a standard rail section with only one additional design feature of undercut, which is provided to fit switch points. This undercut allows switches to fit under the stock railhead before taking any vertical load. An added design feature of higher gage corner radius on the stock rail may be desirable. This may reduce the gage corner metal flow that has the potential to restrict switch point closing and cause switch point chipping.

North American railroads have a long history of installing stock rail and switches on flat plates, even though the exact reason for doing this is not documented. It may be to reduce the difficulty of machining the switch point and to reduce the cost of machining plate work. The train travels over rail with canted plates on standard track and when operating over a turnout (stock rail and switch point) it travels over flat plates and back again to rail with canted plates on standard track. The forces created because of this transition are largely undocumented because the effects of other components are difficult to separate.

DESIGN ANALYSIS

There are several scenarios about how wheels may contact the location of a stock rail at switch points, such as a worn switch with a worn wheel, worn switch with new wheels, and at turnouts on curves and tangents. Figure 1 shows the location in a worst-case scenario on the gage corner of a stock rail where relatively newer wheels are likely to make contact. This model assumes that wheel lateral load is high enough to cause gage corner contact. Figure 1 also shows the metal that is likely to flow down to the top of switch point. As the flange root and wheel tread wears, the potential location for metal can move down farther.

AREMA standard 136RE head corner has 0.3740- and 0.5625-inch radius. A larger radius, as suggested in Figure 2, may increase contact area reducing the metal flow.

Also, using stock rail over canted plates may reduce flow because wheel and rail contact is likely to move away from the gage corner.

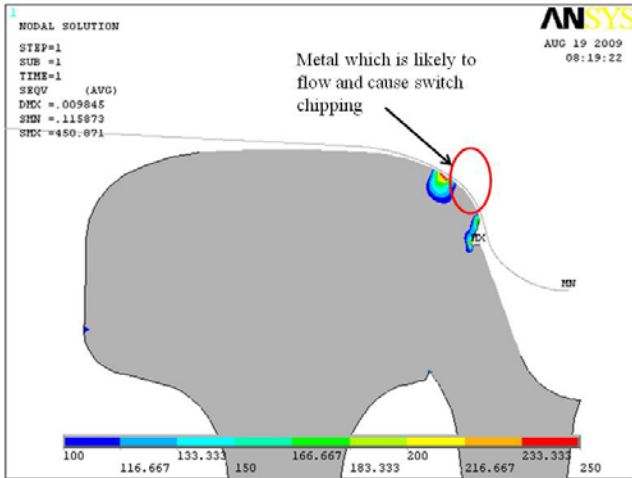


Figure 1. Modeled Metal Flow on Gage Corner of Stock Rail

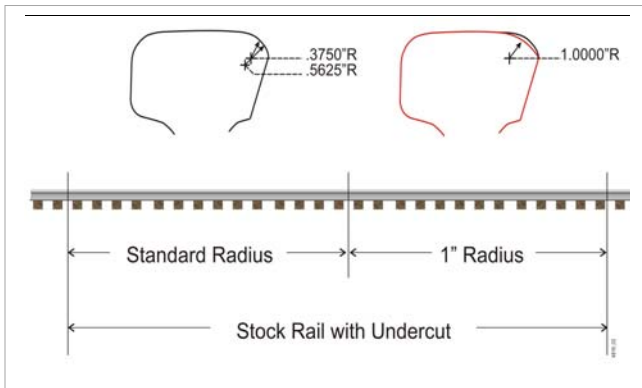


Figure 2. Standard and Proposed Gage Corner Radius on a Test Stock Rail

METHODOLOGY

Two 39-foot-long stock rails were machined with an undercut. Half of the length of the 136RE rail, with undercut, had AREMA standard radius (0.3740 inch and 0.5625 inch) at the corner. The other half had 1-inch radius, as Figure 2 shows. This arrangement was expected to provide direct comparison of the effects of standard radius and suggested radius (1 inch) on metal flow.

One stock rail was installed on canted plates with screw spikes as hold-down devices and Pandrol e-clips. The other rail was installed on flat Pandrol hook plates and Pandrol e-clips. Both stock rails were installed outside of the turnout on tangent track on the outside rail. The inside rail had a standard 136RE profile and

was anchored with canted plates. Thus, there were no switch rails on either stock rail. This arrangement allowed comparison of the stock rail performance on canted and flat plates.

Cross-section profiles of railheads using MiniProf™ were measured at every 30 MGT, starting at 0 MGT and ending between 180-188 MGT.

Effects of Canted/Flat Plates

Contrary to standard installation practice of rail on canted plates in open track, normal practice in North America is to install stock rails, switch points, closure rails, and frogs in turnouts on flat plates. This is likely to simplify construction of the switch and frog. Some railroads create a cant transition by using plates with less cant (such as 1:80) in front of the point of switch. The practice of using flay plates in switches creates three types of issues. First, it changes wheel and rail profile match by rotating the rail relative to the wheels operating on the line. Second, resistance to lateral wheel loads, which a rail base with 1:40 cant provides, is not available. Thus, in order to provide lateral resistance, braces on stock rail on the field side are provided. Third, change of rail profile due to change in cant (1:40 to 0 to 1:40) may trigger some undesirable vehicle response.

As Figure 3 shows, the metal flow on stock rail with canted plates was doubled compared to the stock rail on flat plates, a possible sign of more severe contact on the field side than on the gage side. Area loss due to wear on the railhead was similar on both stock rails. (More tonnage is needed to see if wheel and rail contact intensity was reduced on the gage side.) This suggests more wheel contacts are occurring on the field side of the stock rail, away from the gage corner undercut and less interference with the switch point. The risk of rail rollover resulting from the field side contact is small because the stock rail is braced for the lateral forces of diverging route switch entry.

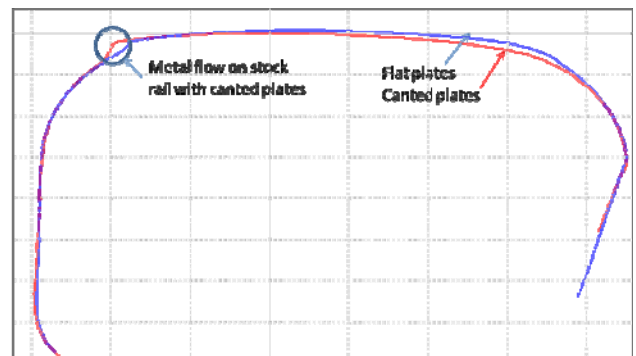


Figure 3. Stock Rail Profiles after approximately 180 MGT

Putting the stock rail on canted plates will require changes to either the switch point or the stock rail undercut, so that the two will fit together. The point must remain on flat plates to facilitate throwing the switch. The canted running surface in a stock rail can also be accomplished by reprofiling the stock rail on flat plates. This is the likely method of applying cant to the stock rail.

Effects of Standard vs. Proposed Gage Corner Radius

Figure 4 shows that the difference in metal flow with both types of corner radii is not noticeable. The location of stock rails was close to a 6-degree curve where the train runs at overbalanced speed. This speed may have the tendency to reduce wheel root and rail gage corner contact.

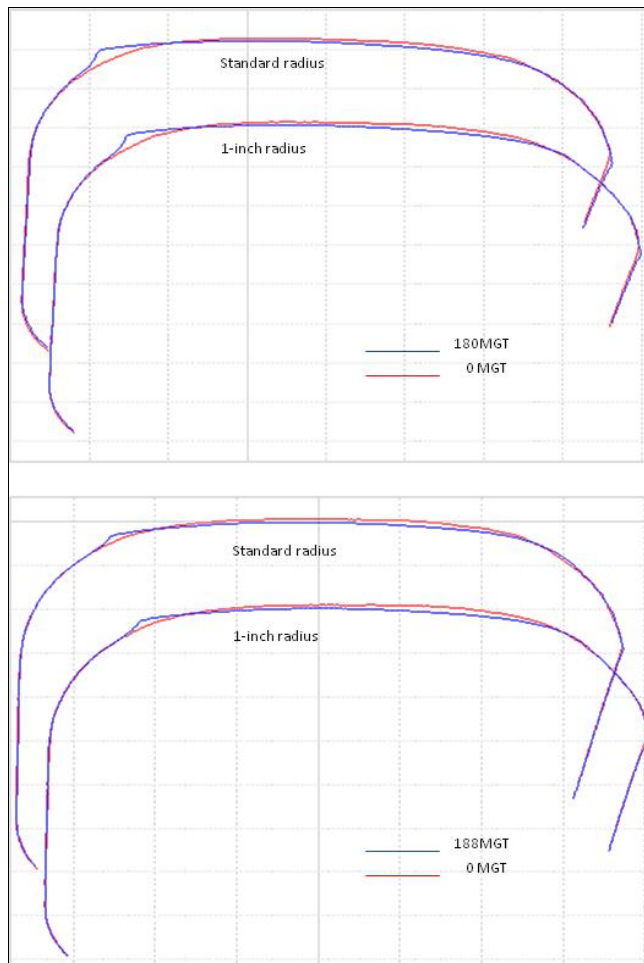


Figure 4. Effects of Gage Corner Radius – Stock Rail on Canted Plates (top) and Flat Plates (bottom)

FUTURE WORK

The tests of the prototype stock rail running surface profile and plate cant will continue with some modifications. The results to date are encouraging, but inconclusive. There is evidence to suggest that the prototype profile will protect switch points from adverse contact due to stock rail flow. The prototype has accumulated about 200 MGT with very little metal flow. However, more tonnage is needed to reach a definitive answer, as the base case profile is also performing well. Similarly, the use of canted plates shifts more wheel contacts to the field side of the stock rail, but metal flow on the gage corner has been largely unchanged.

Some uncontrolled variables are likely affecting the results of the experiment. These include vehicle dynamic behavior from nearby rail joints and harmonic roll motion of railcars on the test train at the Facility for Accelerated Service Testing. These factors are affecting wheel contact position and dynamic wheel loads in the test zones. To reduce or eliminate the effects of these factors, rail joints will be repaired or eliminated, and track gage will be adjusted to produce more consistent gage corner contact in the test zones.

REFERENCES

1. Shu, Xinggao and David D. Davis. May 2010. "Mainline Switch Design to Improve Vehicle Steering." *Technology Digest* TD-10-013. Association of American Railroads, Transportation Technology Center, Inc., Pueblo, CO.