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Demonstration of a Continuous Mainline Rail Turnout

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Summary

Progress Rail Services, BNSF Railway, and Transportation Technology Center, Inc. have developed a continuous mainline rail turnout for low speed and low volume diverging traffic. The prototype was evaluated under 39-ton axle load traffic at the Facility for Accelerated Service Testing, Pueblo, Colo. After a proof of concept test and some minor modifications, the same turnout has been installed in revenue service.

Tests on the prototype consisted of mainline and diverging operations, track strength measurements, and running surface wear measurements. The prototype turnout performed successfully in low speed diverging operations with loaded and empty 315,000-pound capacity cars. In mainline operations, train dynamic performance is significantly better than with conventional split switch turnouts. As expected, elimination of a switch point to stock rail transition for the main line resulted in decreases in both vertical and lateral forces. Diverging route vertical forces are higher for the prototype turnout because of the elevation change inherent in the design.

Suggested improvements from the tests will improve safety and reduce first cost, and include:

- Lateral strengthening of the field-side point
- Reconfiguring the points for improved guarding and ease of construction
- Reconfiguring switch heels and rollers to reduce switch throw effort
- Using more conformal running profiles on the points

The switch configuration of the new design differs from conventional design by having both fixed stock rails on the mainline route, thus its name “continuous mainline rail turnout.” The moveable switch points are both on the diverging route. In the right-handed switch prototype, one switch point is located on the gage side of the left stock rail, whereas the other switch point is located on the field side of the right stock rail.

The continuous mainline rail turnout design is also called a “vertical switch” because it functions by lifting wheels over the mainline rails, instead of providing a gap in the mainline rail for wheel flanges to pass through. This switch is the functional counterpart of the lift frog design that has been successfully implemented by North American freight railways. The design strongly favors the main line in terms of ride quality and allowable speeds. This type of switch has potential applications for set-out tracks and industrial sidings accessed from the main line.



INTRODUCTION

Progress Rail Services, BNSF Railway, and Transportation Technology Center, Inc. have developed a prototype continuous mainline rail turnout for low speed and low volume diverging traffic. The prototype was evaluated under 39-ton axle load traffic at the Facility for Accelerated Service Testing (FAST). After a proof of concept test and some minor modifications, the same turnout has been installed in revenue service.

The design of the switch configuration differs from conventional design by having both fixed stock rails on the mainline route, thus the name “continuous mainline rail turnout.” The moveable switch points are both on the diverging route. Figure 1 shows the continuous mainline switch configuration. Note that one switch point is located on the gage side of the left stock rail, whereas the other one is located on the field side of the right stock rail.

Because the new design functions by lifting wheels over the mainline rails, instead of providing a gap in the mainline rail for wheel flanges to pass through, it is also called a vertical switch. This switch is the functional counterpart of the lift frog design that has been successfully implemented by North American freight railways. This design strongly favors the main line in terms of ride quality and allowable speeds. This type of switch has potential applications for set-out tracks and industrial sidings accessed from the main line.



Figure 1. Prototype Continuous Rail Turnout at FAST

Conventional switches have one fixed stock rail and one moveable switch point on each route. The name “split switch” is applied to this design. Figure 2 shows a conventional split switch. Both routes have running surface discontinuities on one rail. Wheels transition from stock rail to switch point on one rail of each route.

The continuous mainline rail concept described here was developed to address the common failure modes of a split switch. These failure modes are related to the thin section switch point design used.¹ During the project literature search, several “vertical switch” concepts were reviewed to develop the basis for the heavy axle load service concept presented here. A feasibility study was conducted, using vehicle/track dynamic modeling.¹ Promising results from the simulations led to the development of a prototype by BNSF and Progress Rail Services.



Figure 2. Conventional Split Switch Turnout at FAST

Proof of Concept Test

The developing team conducted a series of proof tests to evaluate the prototype design. These tests consisted of mainline and diverging operations, track strength measurements, and running surface wear measurements.

Operations consisted of 40 mph mainline operations of 315,000-pound cars. Approximately 20 MGT was accumulated. Diverging operations consisted of spotting loaded and empty cars in the 350-foot set-out track. These operations were made at speeds ranging from 2 mph to 10 mph. Approximately 0.03 MGT (275 cars and locomotives) were operated over the switch.

The prototype performed very well in most aspects. The dynamic forces, measured using strain-gaged wheelsets, for mainline moves were quite low, similar to what is normally measured on open track. Maximum dynamic forces on diverging moves, as Table 1 shows, were acceptable. A comparison was made with a nearby split switch turnout. Even though the split switch turnout is larger (No. 20 vs. No. 11), the lateral forces were comparable. Remember, the prototype is intended for low volume, low speed diverging route moves. Maximum vertical loads are somewhat higher for the vertical switch because of the ramping in the switch, where wheels are raised above the stock rails (see Figure 3). Also, the wheel climbs a step as it encounters the end of the switch point (which rests on the surface of the stock rail).

The measured diverging forces agree well with the modeled forces from the feasibility study.

Table 1. Comparison of Measured Wheel/rail Forces for Diverging Moves in the Prototype and Conventional Switches

Test Route	Speed (mph)	Maximum Lateral Force (kips)	Maximum Vertical Force (kips)
Prototype Facing Point, Diverging	2	15	56
Prototype Trailing Point, Diverging	5	20	58
No. 20 Split Switch Facing Point, Diverging	2	14	49
No. 20 Split Switch Trailing Point, Diverging	5	20	50



Figure 3. Vertical Ramping in Prototype Switch Points

Table 2 lists the measured maximum dynamic loads for mainline moves through the two turnouts. The data here is split between the switch and the frog on each turnout. Note that in each location, the continuous rail turnout produced lower maximum lateral forces. There were similar drops in average lateral forces, as well. The changes in running surface in the conventional switch and frog generate lateral forces above those seen in open track. Maximum vertical forces at higher speeds should be similar to open track with continuous welded rail. Previous tests of a lift frog at FAST showed 95-percent vertical forces of 47 and 76 kips for lift and railbound manganese frogs (RBM), respectively, at 40 mph.²

Track strength tests were conducted on the diverging route of the prototype turnout. In conventional split switches, the switch points are supported laterally by the stock rails and the field side braces. In most cases, this provides a track that resists gage widening. In the prototype, one switch point is on the field side of the stock rail. Thus, switch rods are required to hold gage and provide rotation resistance for the switch point.

Gage strength tests were conducted using the Association of American Railroads' Track Loading Vehicle (TLV). The TLV was operated at walking speed through the switch with vertical and lateral loads of 33 and 18 kips applied using a single split axle wheelset. These test runs, intended to simulate a damaged or poorly steering truck, revealed a weakness in the prototype between the last switch rod and the fixed heel joint. This location, in the middle of an 8-tie span of laterally unsupported switch point length was too flexible for the loading applied. Figure 4 shows the location from a longitudinal and profile view of the switch. The proposed remedy is to add an additional switch rod in the middle of the span.

Table 2. Comparison of Measured Wheel/rail Forces for Mainline Moves in the Prototype and Conventional Switch Turnouts

Test Route	Speed (mph)	Maximum Lateral Force (kips)	Maximum Vertical Force (kips)
Prototype Switch (Facing & Trailing Point) Main Line	10	8.8	43
Prototype Lift Frog (Facing & Trailing Point) Main Line	10	2.0	43
No. 20 Split Switch (Facing & Trailing Point) Main Line	10	13.5	43
No. 20 RBM Frog (Facing & Trailing Point) Main Line	10	6.5	47

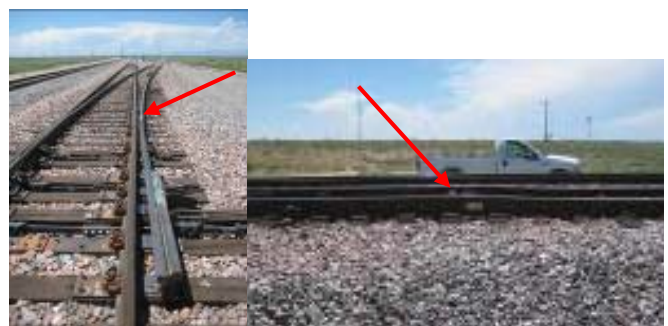


Figure 4. Laterally Weak Location in Prototype Switch Diverging Route

Wear of the stock rails and switch points was also measured. The switch points, with their nonconformal shapes and short vertical ramps, wore at a much higher rate (per MGT) than the stock rails. Table 3 shows wear rates for each of the four running rails in the prototype switch. The switch point wear rates are 2-3 orders of magnitude higher. Note, however, that the initial wear in the first measurement interval of 0.11 MGT was about 50 and 90 percent of the total wear of the gage-

and field-side points, respectively. The wear rate is expected to continue decreasing as the points reach shapes that are conformal to wheels. Figures 5 and 6 show the switch point wear versus location for three accumulated tonnages.

Table 3. Comparison of Wear on Vertical Switch Points and Stock Rails

Component	Average Wear Rate (sq in/MGT)	Maximum Wear Rate (sq in/MGT)
Gage Side Switch Point	0.665	4.550
Matching Stock Rail	0.001	0.002
Field Side Switch Point	2.248	4.354
Matching Stock Rail	0.002	0.003

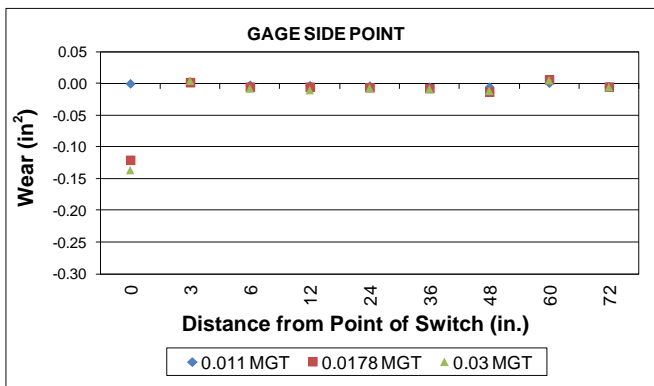


Figure 5. Gage Side Switch Point Wear vs. Distance

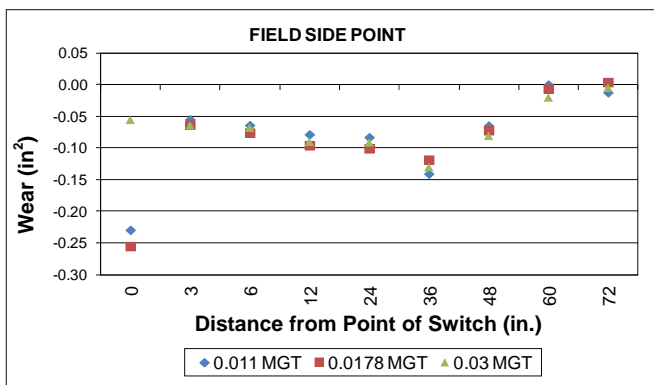


Figure 6. Field Side Switch Point Wear vs. Distance

Note the similarities and differences in wear of the two switch points. In both cases, the locations of highest wear rate are at the point ends. This is where the wheel impacts the end of the point as it rolls in a facing point move. Somewhat higher wear is also noted at the top of the point ramps.

The effect of running surface profile may explain the higher wear rate (reported as cross section area loss) on the field-side point. Both points started with the same rectangular shape. The running surface available to the wheel on the field-side point is much smaller and perhaps less conformal, as well. In addition, the field-side point is a composite structure consisting of three pieces. Shifting of the pieces relative to each other may cause some of the reported wear for this switch point.

CONCLUSIONS

The turnout has undergone proof of concept testing at FAST. The prototype has performed successfully in low speed diverging operations with loaded and empty 315,000-pound capacity cars. In mainline operations, train dynamic performance is significantly better than with conventional split switch turnouts.

From the initial operations, the project team will be making several design improvements, including:

- Lateral stiffening of the field-side point to prevent gage widening. Reconfiguration of the switch heels to reduce switch throw effort. Cutting the switch rails at the heel made them much easier to throw for the diverging route. Additional switch point rollers will further reduce the required throw effort.
- Reconfiguration of the point guard to enhance safety and simplify construction. Moving the guard, currently located on the field-side point, to the gage-side point will allow the guard to contact more of the wheel surface. It will also eliminate the wheel/rail contact issues inherent with field-side point guards.
- Use of more conformal running profiles on the points. An initial shape closer to a rail will reduce the high initial wear rates.

The turnout was modified to incorporate some of the suggested improvements before being installed in revenue service.

REFERENCES

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2. Davis, David, Xinggao Shu, and Rafael Jimenez, December 2009, "Initial Performance Evaluation of Partial Flange Bearing Frogs for Turnouts in Heavy Axle Load Service," *Technology Digest* TD-09-031, Association of American Railroads, Transportation Technology Center, Inc. Pueblo, CO.