

Dynamic Performance Evaluation of Two Switch Points

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Summary

Two switch points, one engineered for the Association of American Railroads (AAR) and the other following design recommendations by the American Railway Engineering and Maintenance of Way Association (AREMA), were evaluated by Transportation Technology Center, Inc., Pueblo, Colorado. The AAR prototype showed dynamic performance benefits over the conventional AREMA design switch point.

Measurements of the dynamic loads generated by 39-kip wheel load cars operating through No. 20 switches at the Facility for Accelerated Testing (FAST) were made and analyzed by TTCI. The AAR switch point differs from the AREMA design in the cross-section. The AAR's switch point has a flat base and a larger area head. The AAR prototype was designed to provide a smoother ride by maintaining the railhead section throughout the stock rail to the switch point transition area. It features a switch geometry that has a theoretical entry angle that is twice the entry angle of the AREMA curved point switch. Preliminary performance results indicate:

- Initial maintenance was minimal with negligible metal flow on the switch point and stock rail. A reduction in initial wear-in maintenance compared with the AREMA design was noted.
- On average, the lateral wheel loads for the AAR prototype were about 14 percent lower than the AREMA switch point for trailing point 40 mph runs.
- On average, lateral wheel loads for the AAR prototype were about 7 percent lower than the AREMA switch point for facing point 40 mph runs.
- A substantial decrease in lateral loads at the point of switch (PS) was observed. The highest lateral load at the pos was about 3.6 kips for a facing point 40 mph run. In contrast, lateral loads of approximately 8 kips are generally seen at the point of switch for AREMA type switches. This reduction is attributed to the housing of the prototype point allowing a smooth transition to occur at the PS.
- Lateral wheel loads for the AAR prototype increased linearly with speed. Lateral loads were about 10 percent lower in the facing point runs compared with the trailing point runs at higher speeds.
- After 148.4 MGT of heavy axle load traffic (63.3 MGT on the switch point and 85.1 MGT on the stock rail) on the AAR prototype, a 3/16-inch deep longitudinal fatigue defect ("chipping out") occurred 6 to 9 inches from the PS on the stock rail face of the switch point. The chipping out resulted from the typical stock rail flow induced fit problem at the head contact between the two components.
- The thickness of the AAR prototype point was about 5/16 inch in the area where chipping out occurred. After grinding the flow to restore the undercut angle, deburring the chipped section, and providing a larger "flow relief" radius on the stock rail near the undercut, the prototype switch point was continued in service.

Any negative aspects of the new switch points, including increased stock rail-base stress, will be covered in future reports.



Suggested Distribution:

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

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INTRODUCTION

Switch points are the key traffic control elements in turnouts, allowing trains to move from one track to another. The consequences of diverging traffic, under heavy axle load (HAL) environment make them a relatively short-lived track component in the track system. The desirability of a more durable switch point is supported by the following field observations of switch performance: (1) generally switch points wear out before stock rails, (2) the stock rail is often replaced with the switch point to avoid fit problems, (3) switches are a cause of track related accidents, with worn or broken points being the leading cause among switch caused accidents.

Goals therefore were to increase the life of the switch point and to decrease the likelihood of a derailment on the switch. The AAR's prototype switch point/stock rail pair was designed to reduce stresses on the switch point, prolong component life, restore stability in the switch point as a result of a larger flat base, decrease the chance of splitting the switch, and create a smoother transition at the point of switch (PS) by "housing" the point. The prototype switch point/stock rail pair was fabricated by machining the switch point and stock rail from 136 RE rail to ensure interchangeability (as a pair) with existing switch designs within the AREMA lead length. The prototype switch point has its own flat base and about a 40 percent larger cross-sectional head area at the PS compared with the conventional AREMA design. The prototype was fabricated with no point slope. The intent was to allow traffic to create a conformal point slope during the initial wear in period. The resulting point slope was a 5/16-inch rise over 36 inches. This slope is steeper and shorter compared with typical manufactured point slopes. For example, an AREMA type point slope and top cut may have a total rise of 3/4 inch over 20 feet. The prototype stock rail required additional machining to remove the switch-point side of stock rail base to provide room for the switch point's flat base. The prototype was installed at FAST in the beginning of September 2001 for testing under HAL environment.

RESULTS AND ANALYSIS

Load data was collected using instrumented wheelsets (IWS). The prototype load data was analyzed and compared with the existing IWS data for the AREMA switch point to determine how well the goal of load and stress reduction on the switch point was met. Exhibit 1 shows a comparison of turnout properties.

Exhibit 1: Comparison of Turnout Properties

Switch Design Feature	AAR-prototype	Conventional AREMA
Turnout Description	No. 20-136RE Left Hand	No. 20-136RE Left Hand
Manufactured Standard	BNSF Standard	Bethlehem Premium Standard
Lead Length	153' 5 1/2"	156'
Switch Point	Prototype	AREMA
Switch Point Length	43'6"	39'
Switch Point Entry Angle	0.99°	0.46°
Switch Point Radius	Straight to 30' (then 3280.44' radius)	3300'

Lateral Load Environment in Turnouts

Data was collected for both trailing and facing point moves for speeds ranging from 20 mph to 40 mph. Exhibits 2 and 3 show typical dynamic load data for the AAR prototype and conventional AREMA turnout, for both trailing and facing point moves at 40 mph.

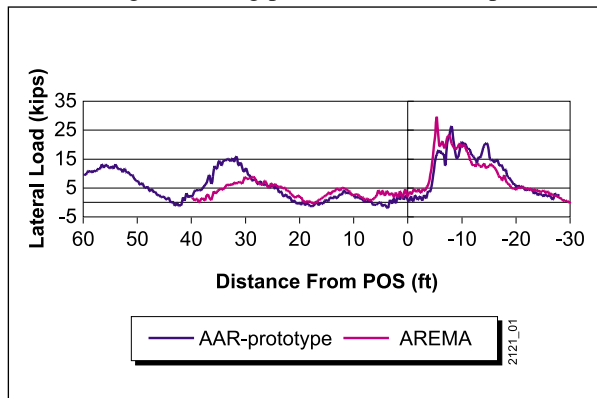


Exhibit 2: Typical Lateral Loads for Trailing Point Diverging Moves at 40 mph

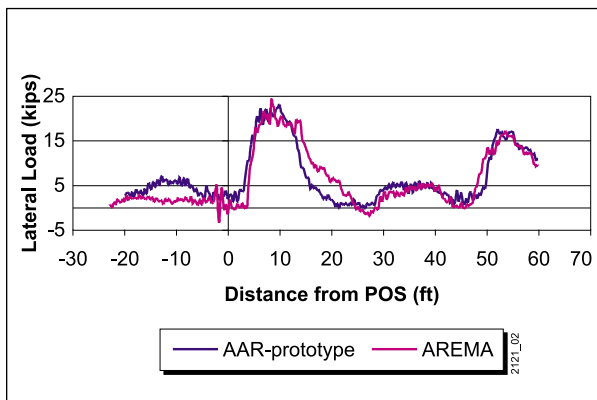


Exhibit 3: Typical Lateral Loads for Facing Point Diverging Moves at 40 mph

Peak lateral load of approximately 26 kips for a typical trailing point move occurred 8 feet in front of the PS for the AAR prototype. The peak location compares well with peak location for the AREMA switch. In a trailing point move, the change in radius of curvature is from a finite radius in the turnout to an infinite radius of curvature of the track in front of the PS. Peak lateral load occurs in this transition area in front of the PS as a result of the curving forces.

Peak lateral load of approximately 23 kips for a typical facing point move occurred 10 feet inside of the turnout for the AAR prototype. This peak location compares well with the peak location for the AREMA switch. Once the peak transverse reaction-curving forces are fully established at this location, lateral loads decrease over the length of the switch point. Data also suggests a rocking of the cars as they travel through the turnout.

Maximum Lateral Loads in Prototype Turnout

Exhibit 4 shows maximum lateral loads for the prototype and AREMA geometry turnouts. The lateral wheel loads on the AAR prototype increase linearly with speed. Lateral load for trailing point runs are approximately 10 percent higher than those for facing point runs. The highest lateral loads for facing and trailing point runs occurred at 40 mph. They were 23.1 kips for facing point runs and 25.3 kips for trailing point runs.

The prototype switch point provides, on average, a 14-percent improvement in lateral loads compared with the conventional AREMA switch point for trailing point runs. A 7-percent improvement was achieved for facing point runs. This is a result of the smoother transition of wheels to the prototype switch point due to the housed switch point.

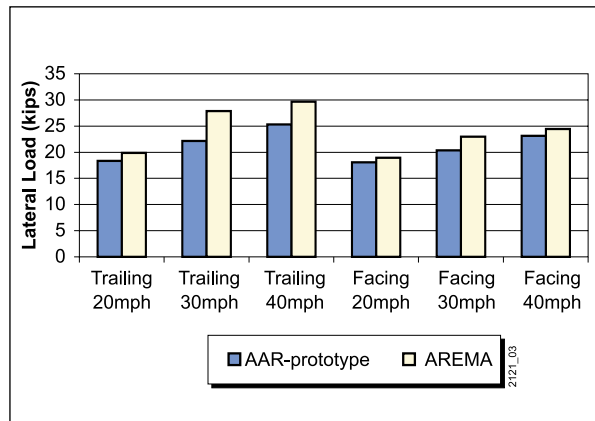


Exhibit 4. Comparison of Maximum Lateral Loads in Different Turnouts

Lateral Loads at the Point of Switch

Exhibit 5 shows lateral loads occurring at POS recorded by the IWS. The lateral loads for the prototype switch point range from approximately 2 kips to 3.5 kips. The AAR prototype provides a substantial decrease in lateral loads for trailing point moves compared with the AREMA switch point. This reduction is attributed to the housing of the switch point creating a smoother transition.

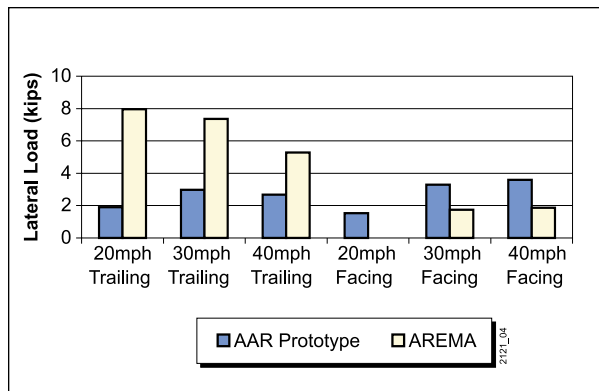


Exhibit 5: Comparison of Lateral Loads at the Point of Switch

Vertical Load Environment

Exhibit 6 shows maximum vertical loads for the AAR prototype and AREMA switch points. The vertical loads for the AAR prototype range from 37 kips to 43 kips. The highest vertical load of about 43 kips occurs at 30 mph for a facing point run. This is approximately 10 percent higher than the static wheel load of the car. This 10 percent increase over the static wheel load is expected to be carried easily by the combined action of the switch point with its own base and the stock rail.

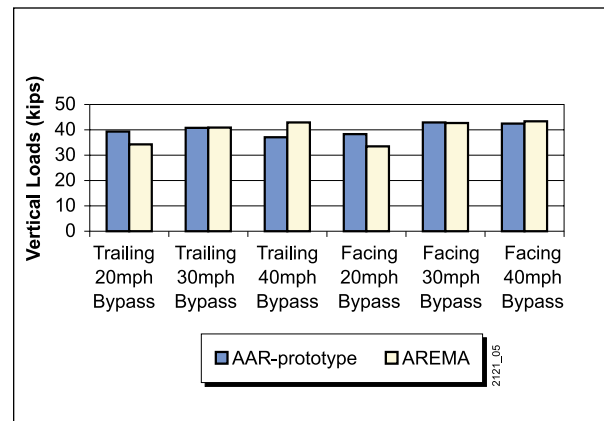


Exhibit 6: Comparison of Maximum Vertical Loads at Point of Switch



ASSESSMENT OF DESIGN AND FUTURE WORK

Stock rail flow was found to create a fit problem at the head contact between the switch point and the stock rail for about 2 feet from the PS. This problem did not result in shorter component life; rather the prototype was continued in service after grinding the flow from the stock rail and the switch point. The minimal point slope and the housed design of the switch point resulted in the damage occurring near the top of the rail. Thus, it could be ground off without affecting the safe operation of the switch. While the AAR-prototype design was not completely successful in eliminating stock rail flow related to switch point "chipping," it minimized the damaging effects of the dynamic environment. Additional tonnage will be accumulated to determine more about the long-term performance of the prototype. Production of the first prototype pair was accomplished with the expertise of the track-work supplier. The first cost of this design was similar to the AREMA design.²

The AAR prototype was a groundbreaking experiment for a turnout in North America. The HAL tests at FAST are intended to learn about the service related pitfalls of the initial design. This information will be used to improve upon a "second generation" design. Mainly, these design changes will include providing for flow of the stock railhead by reconfiguring the point slope of the switch point. The goal of the re-design is to keep the good features of the prototype, but improve the performance of the switch point/stock rail under low or no maintenance conditions. The key is to

prevent the adverse contact between switch point and stock railhead that results from running surface flow.

It is realized that the new switch-point design has drawbacks in that the stresses in the base of the stock rail are increased due to a reduction in the area and the introduction of stress risers in the cutout section, which is not present in the AREMA design. These aspects will be discussed in future reports.

REFERENCE

1. Singh, S.; Davis, D. and Guillen, D. "Development of an Improved Switch Point for Heavy Axle Load Service," *Technology Digest* TD00-005, March 2000.
2. Robeda, J., Singh, S., Guillen, D., Davis, D. "Performance Evaluation of Prototype Switch Point and Stock Rail for HAL Service," *Technology Digest* TD01-014, July 2001.

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