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Mainline Switch Design to Improve Vehicle Steering

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Summary

The Transportation Technology Center, Inc. has developed a switch alignment design intended to improve the performance of frequently used mainline turnouts. The idea of a presteered switch is to steer the wheelset away from the most vulnerable part of the switch point. In this way, the risk of a switch failure is lowered. This is done by separating the start of the switch point from the alignment point of switch; i.e., the location where the diverging route begins to deviate from the main route. By manipulating alignment, gage, and running surface profiles ahead of the point of switch, wheelsets may be positioned to minimize the most severe contact with the switch point. Each axle is presteered to a negative angle-of-attack, so the wheel runs away laterally from the switch point.

Compared to the traditional switch, the proposed presteered switch has the following advantages:

- It is expected to reduce the maximum lateral impact force by 28 and 18 percent for a loaded and empty car with new wheels, respectively, at speeds up to 40 mph for a No. 20 switch.
- It is expected to reduce the maximum lateral impact force by 5 and 9 percent for a loaded and empty car with hollow-worn wheels, respectively, at speeds up to 40 mph for a No. 20 switch.
- It has a thicker (switch point) blade where the maximum lateral impact occurs.
- It is easy to fabricate and implement.

The switch will function by varying the alignment of the stock rail (thus, track gage) ahead of the point of switch. This will create a steering force that will cause the wheelsets to steer away from the switch point and towards the opposite stock rail for each route of the switch. By extending the switch points physically beyond the point of switch, the presteering can be affected for each route of the switch. The longer switch points will also be thicker than with conventional designs. This should provide better resistance to switch tip chipping and wear failures.

These design improvements build on previous work by suppliers to develop presteering switches. They are expected to result in a more robust and reliable switch, capable of handling a wider range of wheel profiles and truck steering characteristics.



INTRODUCTION

Split switches have served the North American freight and passenger railroads well for many years. The standard split switch used today has two moveable switch rails (or points) that are inside the fixed rails (or stock rails) and are connected to each other. Figure 1 shows a schematic of a split switch and a vertical switch, which will be described below.

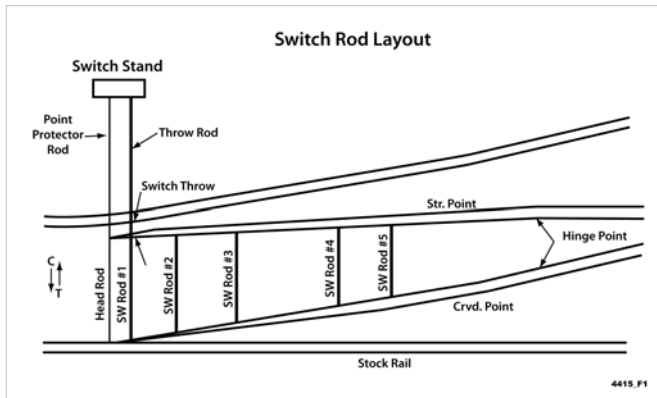


Figure 1. Split Switch Schematic Drawing

An analysis of failure modes of current switch designs was made to determine ways to improve their performance.¹ This analysis was used to guide research and development planning for the Strategic Research Initiative on Special Trackwork.

FAILURE MODES ANALYSIS OF CONVENTIONAL SWITCHES

A review of the performance records of the existing split switch designs was conducted. The top five switch related accident causes were:

- Gapped or chipped switch points
- Dragging equipment derailments
- Track surface & alignment defects
- Worn switch points
- Split switch

Four of these are related to the specific design features of split switches. Dragging equipment derailments are largely independent of switch design. However, the other four causes 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 torsion 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, as a narrow band of contact is likely to develop 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 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 switch,

switches that do not close properly, and worn switch points that raise the likelihood of a wheel climb.

Potential Solutions

A review of potential solutions was conducted. This involved reviewing old switch designs and potential modifications to currently used designs. During this process, it became apparent that there were two categories of solutions. One is applicable only to switches with low traffic volume, low speed (i.e., <1 percent and 10 mph) diverging operations. Switch designs for this application are described in another *Technology Digest* (TD).² Another category of solutions apply to switches with more diverging traffic or higher speed diverging traffic. Designs for this situation are described here.

Presteered Switch Design

The idea behind the presteered switch is to steer the wheelset away from the most vulnerable part of the switch point. In this way, the risk of a switch failure is lowered. This is accomplished by separating the start of the switch point from the alignment point of switch (i.e., the location where the diverging route begins to deviate from the main route). By manipulating alignment, gage, and running surface profiles ahead of the point of switch, wheelsets may be positioned to minimize the most severe contact with the switch point. Each axle is presteered to a negative angle-of-attack (AOA), so the wheel runs away laterally from the switch point. There are two benefits for this design:

- It reduces the AOA from the start of the switch point — lower AOA means lower lateral force.
- The wheel contacts the switch rail on the thicker part of the blade and causes less damage on the switch point.

The Kinematic Gauge Optimization – KGO® (registered trademark of voestalpine BWG) design also steers vehicles through the diverging side of the switch by manipulating track gage. TTCI’s design differs from the previous work by extending the switch points beyond the point of switch. This will provide a more robust switch for heavy axle load applications. The new design will accommodate a wider range of wheel profiles.

Figure 2 shows the presteered switch design and its differences compared to the traditional switch design. The wheelset is presteered through the contact on the extended switch blade (A-D) on the left rail before it enters the switch point where kink angle starts. The maximum gage increase between the left and right stock rail is 1.25 inches. The stock rail gage widening gives more room to design a thicker switch blade. The thickness on the switch point is also increased by 1.25 inches to allow more material to wear than the traditional switch. The extended blade (A-D) is about 4~5 feet long for speeds up to 45 mph. Its length (A-D) and thickness slopes (A+B and B-C) depend on the running speed.

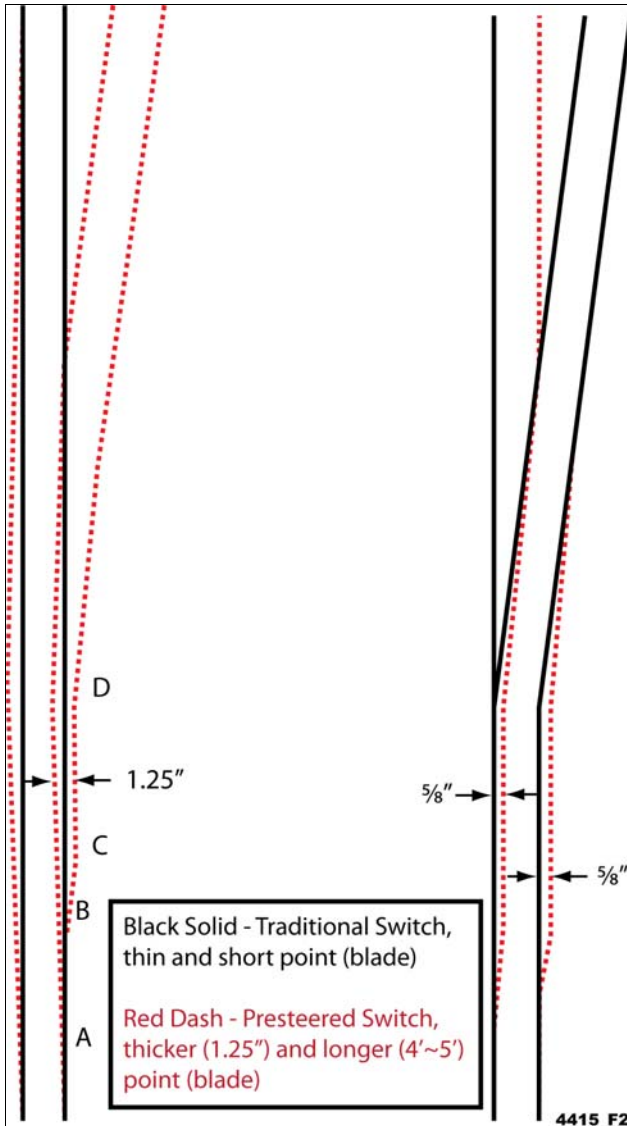


Figure 2. Presteered Switch (showing both main line and branch line switch points closed)

Presteered Switch Dynamic Simulations

A series of dynamic simulations was conducted using TTCI's dynamic vehicle modeling program NUCARS® to develop the presteered switch alignment. These simulations used an empty (63,000 pounds GRL) and a loaded (263,000 pounds GRL) coal hopper car traveling at 40 mph over a No. 20 turnout. Figure 3 shows the wheelset was steered to a negative AOA before it entered the switch point, D, (see Figure 2). This negative AOA is seen at distances 28-30 feet in the figure. The point of switch occurs at a distance of 30 feet. This negative AOA means the leading edge of the wheel is pointing towards the center of the track. The flange is likely not making contact with the rail on this leading edge.

Correspondingly, the wheelset moves laterally towards the right rail (away from the diverging switch point), as Figure 4 shows. This will likely keep loads off of the switch point for a greater distance on facing point moves. The expected effect of

these changes is extension of service life by reduction of early switch point chipping failures.

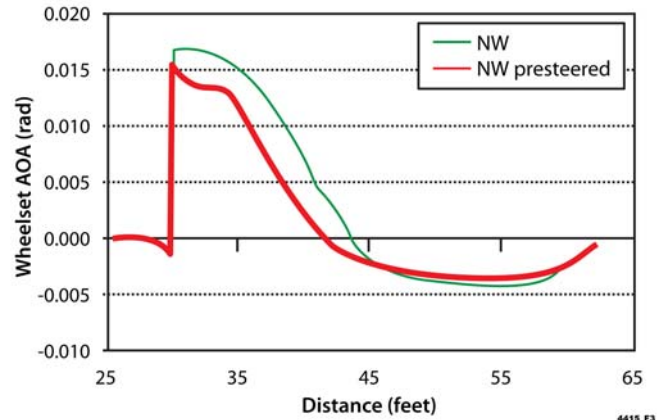


Figure 3. AOA Comparison between a Presteered Switch and a Traditional Switch (empty car)

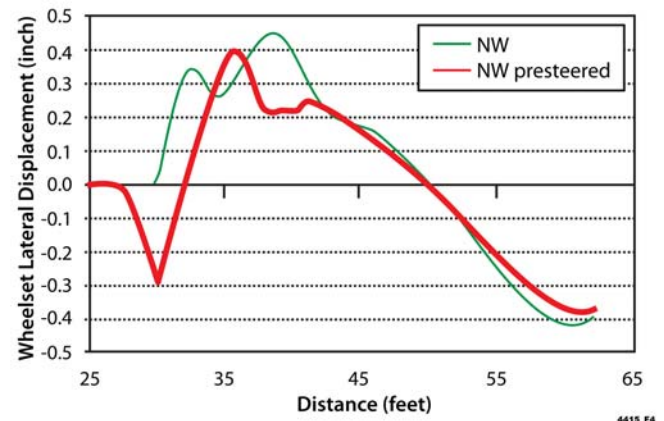


Figure 4. Lateral Displacement Comparison between a Presteered Switch and a Traditional Switch (empty car)

Figures 5 and 6 compare the predicted dynamic lateral forces generated by an empty and a loaded coal hopper car in facing point diverging moves across a No. 20 switch. The variables in the simulation are the switch alignment (base case AREMA versus Presteered) and the wheel tread profile (New Wheel versus 3 mm Hollow Worn Wheel).

Figures 5 and 6 show:

- The new wheel's first lateral impacts (occurring on the thinner part of the blade) on the presteered switch are reduced by 28 and 18 percent for a loaded and empty car, respectively, compared to the traditional switch.
- The hollow tread profile wheel's (3mm hollow) first lateral impacts on the presteered switch are reduced by 5 and 9 percent for a loaded and empty car, respectively, compared to the traditional switch.
- The hollow-worn wheel's first lateral impact occurs on the thick blade of the presteered switch instead of the thin part of the traditional switch because of better steering performance.

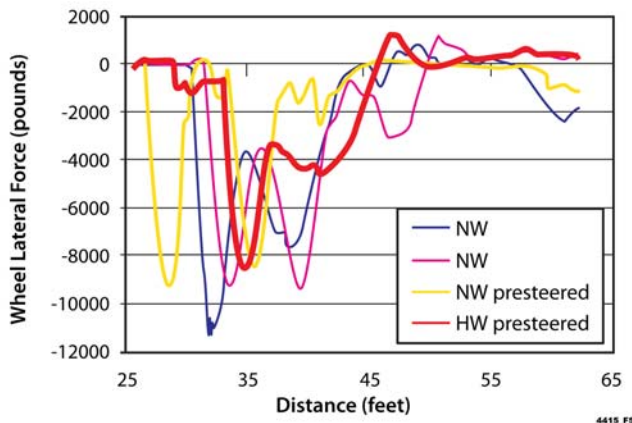


Figure 5. Lateral Force Comparison between a Presteered Switch and a Traditional Switch (empty car)

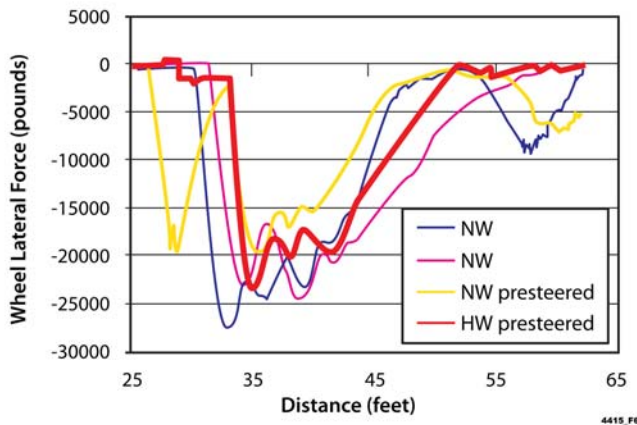


Figure 6. Lateral Force Comparison between a Presteered Switch and a Traditional Switch (loaded car)

CONCLUSIONS

The proposed presteered switch has the following advantages compared to a traditional switch:

- It is expected to reduce the maximum lateral impact force by 28 and 18 percent for a loaded and empty car with new wheels, respectively, at speeds up to 40 mph.
- It is expected to reduce the maximum lateral impact force by 5 and 9 percent for a loaded and empty car with hollow-worn wheels, respectively, at speeds up to 40 mph.
- It has a thicker blade where the maximum lateral impact occurs.
- It is easy to fabricate and implement.

FUTURE WORK

A prototype switch, incorporating the presteered alignment and other running surface profile changes, will be built for evaluation under heavy axle load service. Test results, if promising, will be used to further refine the design.

REFERENCES

1. Davis, D.D., D.B. Mesnick, and V.R. Terrill. July 2002. "Railroad Switch Design and Failure Mode Analysis," *Technology Digest* TD02-015, Association of American Railroads, Transportation Technology Center, Pueblo, CO
2. Davis, D.D., M.N. Akhtar and C.D. Duran. May 2010. "Development of a Vertical Switch Design," *Technology Digest* TD-10-014, Association of American Railroads, Transportation Technology Center, Pueblo, CO