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## Effects of Reducing the Number of Gage Rod Switches under Heavy Axle Load Service

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### Summary

Transportation Technology Center, Inc. (TTCI) conducted a preliminary analysis of the effects of reducing the number of gage rods on No. 20 switches in heavy axle load service. The effects of switch maintenance, switch design, number of spreader rods and traffic were assessed. Initial findings include:

- The stability of AREMA style switch points depend on switch rods holding the points against the stock rail due to the points' deeply undercut base. Switch rods also help maintain the proper orientation of the switch point.
  - Displacement measurements and high-speed video shows that switch points can roll or twist under loading. The switch point's gage rods help limit the amount of switch point roll under traffic. A standard five-rod No. 20 switch had 0.65 degrees of roll at the point of switch. With two rods removed, the same switch point rolled 1.17 degrees under load.
- Reduction in the number of switch rods has increased component wear and maintenance.
- Gage rods assist in closing the heel end of the switch. For the No. 20 seven-rod switch located at the Facility for Accelerated Service Testing (FAST), Transportation Technology Center (TTC), removing gage rods changed the switch point stock rail gap at rod location 5 from 0 to 1/4 inch. Since the switch point bears on the stock rail for lateral support, failure to fully close will result in plate wear and switch point roll.
- A key factor affecting switch throw force is switch maintenance. The throw force required for a typically maintained switch at FAST was about 4 times higher than the force required to throw the same switch after lubrication and adjustment.
- For a properly adjusted and maintained switch:
  - Reducing the number of gage rods from 5 to 3 increases the throw force by a negligible amount.
  - Switch point helper rollers and foot-locks decrease the required throw force by a negligible amount.

#### Suggested Distribution:

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

**INTRODUCTION**

North American railroads have significantly improved the performance of track components under heavy axle load (HAL) traffic in recent years. However, railroads are looking for an improved performance switch. Currently, switches and turnouts require significant track surface and alignment maintenance. This difficulty is a result of the dynamic load environment, the abrupt changes in track structure, and the inaccessibility of the switch to mechanized tamping. The switch rods occupy ballast cribs, preventing access and altering lateral support conditions. Reducing the number of switch spreader rods is one way to lower first costs, to completely fill the cribs with ballast, to prevent mechanical rod damage, to prevent rod-against-tie binding preventing the throwing of the switch, and to improve switch accessibility to surfacing.

Additionally, thermal forces can cause longitudinal movement of the switch points and stock rails relative to the crossties. This can result in warping of the switch or interference between the switch rods and ties. A recent industry survey showed that gage rods binding on ties or ballast is one of the biggest problems with switch throw.<sup>1</sup> Major problems, such as point chipping, can also occur if the switch throw is not adjusted to the proper throw dimension. Switch point chipping can lead to early point failure. Point closure is ultimately the most important factor with switch throw and derailment prevention. Frequent inspections, as prescribed under CFR Title 49, and timely grinding maintenance are essential in preventing early failures.

Switch rods help position the switch points with respect to the stock rails and each other. They help maintain the proper alignment and vertical orientation of the points. The location of gage rods, sometimes called connecting rods, in a turnout is based on the quantity of rods, length of switch points, and length of required stock rail/switch point contact area. The industry has seen an increase in the number of gage rods used on Class I mainline railroads. The increase in rods

seems to address issues of switch throw integrity and track gage maintenance because of the use of longer switch points, floating heel blocks, and the confidence that the points will close from the point-of-switch to the head separation.

**Test Description**

Testing was done on No. 20, 136RE switch turnouts on the High Tonnage Loop at FAST and the Railroad Test Track. Testing consisted of an instrumented gage rod that temporarily replaced the No. 1 head rod to measure force during switch throws (Figure 1). Foot-locks and switch rollers were removed to determine their effects on throw forces. Also, switch gage rods were sequentially removed to determine their contribution to switch throw forces. Service worn or a normal maintained switch verses a fully adjusted and lubricated switch were measured for their switch throw differences and switch torque action under load.

Long-term performance will be monitored with two of the five gage rods removed to determine long-term effects on rail corrugation, gage widening, increased maintenance, and switch components breakage and wear (Figure 2).

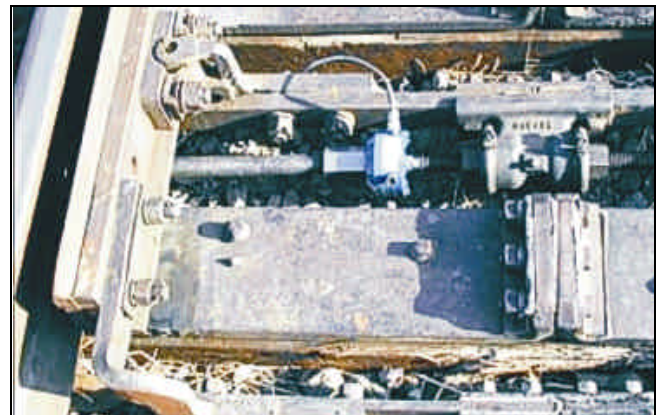


Figure 1. 10-k Load Cell Throw Rod

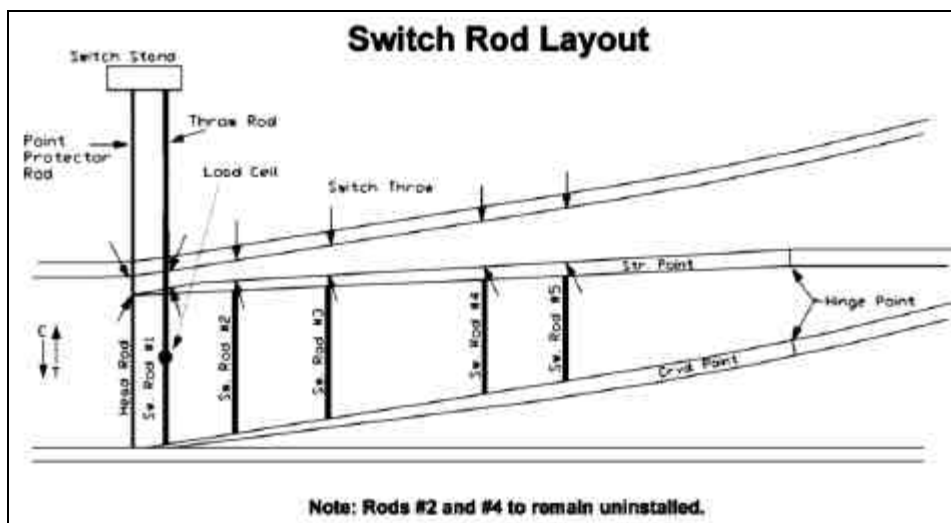


Figure 2. Sketch of Switch Turnout Gage Rods and Load Cell Throw Rod

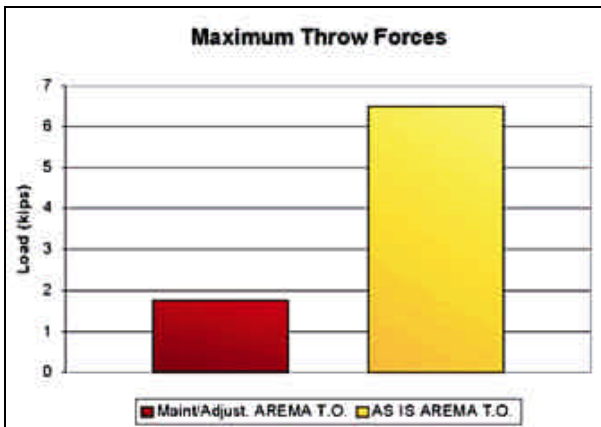
For measurement purposes TTCI defined “fully maintained and adjusted” versus “as is” switch as:

- The fully maintained and adjusted switch is defined by: transit clips lubed and tight, switch plates lubricated, switch rollers adjusted, foot-locks working, essentially all relevant components working, and ballast and debris in the cribs do not obstruct the gage rod when thrown.
- The term “as is” or service worn switches are switches maintained to normal FAST maintenance schedules.

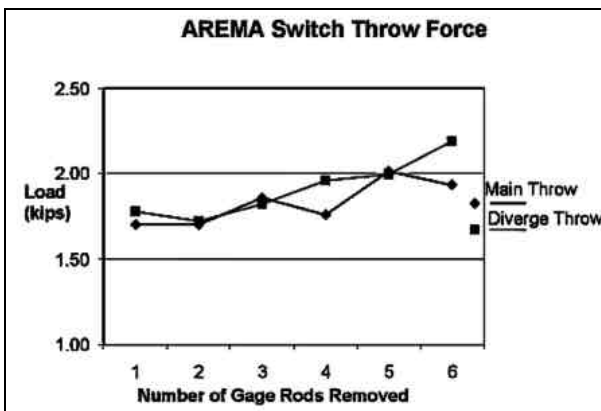
**TEST RESULTS**

A properly adjusted and lubricated switch decreases throw force by 4.7 times of a normal service worn switch (Figure 3), which suggests that switches should be maintained to their minimum specifications on a regular preventative maintenance schedule.

Removing switch rods had minimal effect on switch throw force for a properly adjusted and lubricated turnout (Figure 4). The increase in force required to throw switches is negligible with the reduction of gage rods.



**Figure 3. Throw Force**



**Figure 4. Minimal Effect with Gage Rods Removed**

A slight increase in switch maintenance was noticed when several gage rods were removed from the turnout. Several broken and loose transit clip bolts, on the curved switch points, were noted (Figure 5). Two rivets in one of the curved switch point’s reinforcing D-bars sheared off at the button head. These two types of fastener failures have never been identified before in the maintenance log books at FAST prior to removal of the gage rods for this test. TTCI cannot contribute these fastener failures to gage rod removal, because one of the two curved switch points received some damage in a previous derailment at FAST. The derailment caused an impact at the point-of-switch section that may have warped or twisted the point. Inspections for broken components and wear are scheduled at close intervals.



**Figure 5. Broken Transit Clip Bolt**

TTCI recently filmed the train at FAST going through special track work at 40 mph. At 30-frames/second, the high-speed footage showed the switch point rolling to some extent under load. The rolling or twisting of the switch point under load may enhance point chipping and excessive wear on the gage corners. The film footage showed the switch point’s undercut has contact with the stock rail’s undercut at the top edge verses the entire surface area of the undercut.

To quantify switch point roll under load, measurements were taken to determine the amount of roll movement with all five gage rods installed and with two of the gage rods (numbers 3 and 5) removed. Roll was determined near the point of switch by measuring lateral movement at the head and base of the switch point, as Figure 6 shows. Under traffic the switch point rolled: 1) 0.65 degree with five rods installed and 2) 1.17 degrees with three rods installed.



**Figure 6. Measuring Switch Point Roll under Traffic**

Figure 7 shows the effects of the number of axles on the switch point on switch point roll. The data shows average roll values for facing point moves.

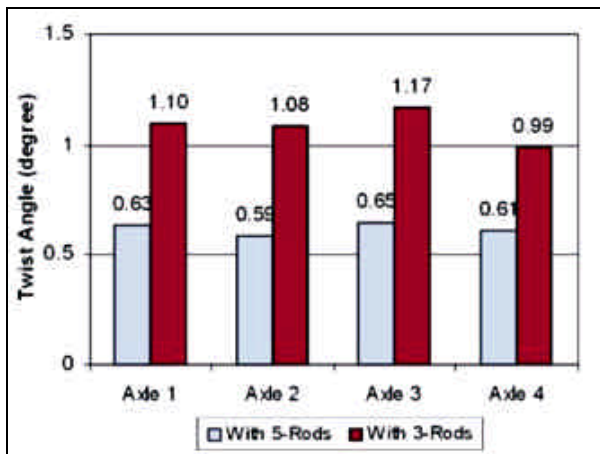


Figure 7. AAR Prototype Switch Point Roll or Twist under Traffic

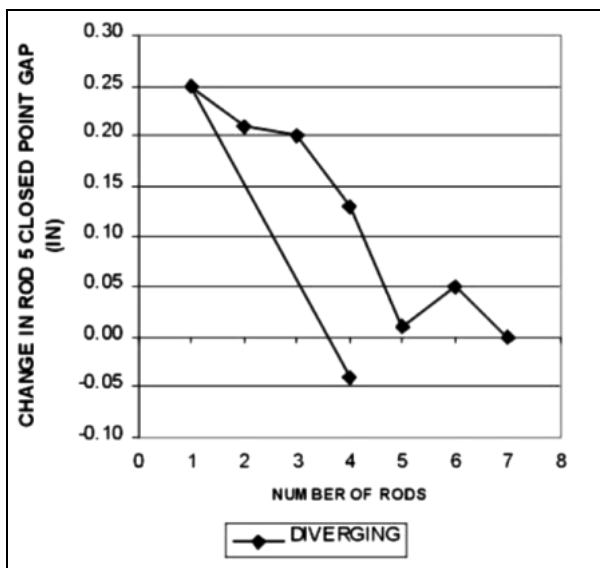


Figure 8. Switch Throw Alignment

Reducing the number of gage rods affects switch point throw alignment. Figure 8 shows throw gap alignment degradation with each gage rod removed. The gap distances shown are the measured distances from stock rail to switch point at the 5<sup>th</sup> rod location. A perfectly lined switch will have no gap between stock rail and switch point. A switch with switch point-stock rail gaps will have geometry deviations and a higher likelihood of point chipping failures.

**FUTURE TESTING**

Long-term performance will be monitored to evaluate the effects of the reduced number of gage rods. Rail corrugation, gage widening, increased maintenance, switch components breakage will be monitored regularly to determine affects and operation safety. Long-term assessment will be to determine if removing gage rods is a viable option in terms of safety and economics.

**RECOMMENDED RESEARCH AND DEVELOPMENT**

This work is intended to help determine the optimal number of switch spreader rods. Additional industry efforts are devoted to relocating the spreader rods from the ballast cribs. Hollow ties and rods above solid ties are being tried. Both will make it easier to surface the switch. This should also reduce the relative movement problems that can cause the switch rods to bind on the ties in current designs.

**Acknowledgements**

Ed Kohake, Methods & Research, Union Pacific Railroad supplied information related to their field tests. Ira Kalb, Instrumentation Technician, TTCI, designed the load cell gage rod used in these tests.

**Reference**

1. D. D. Davis, V. R. Terrill, D. B. Mesnick, "Railroad Switch Design and Failure Analysis," *Technology Digest* TD02-015, Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colorado, July 2002.