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Performance Evaluation of an Advanced Design Turnout with Spiral Geometry, Hollow Switch Ties, and Welded Heel Frog

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Summary

Initial performance evaluations of an advanced design turnout under Heavy Axle Load (HAL) traffic were conducted at the Transportation Technology Center's (TTC) Facility for Accelerated Service Testing (FAST) in 2004. This new turnout has several features intended to enhance performance and reduce maintenance under HAL traffic.

Initial performance results from the 39 kip wheel load FAST test are encouraging. While life cycle costing will require significantly more tonnage to answer, several findings were made. These include:

- A reduction in initial maintenance. The switch was stable, requiring little surfacing and no alignment maintenance.
- After a 25-MGT break-in period, the measured dynamic forces in the turnout are low as compared to previously tested number 20 turnouts at FAST.
- Maximum lateral forces of 11-kips were measured under a 39-kip wheel load hopper car at 40 mph. About 20-kips were measured on The American Railway Engineering and Maintenance of Way Association (AREMA) style switches.
- Maximum vertical forces of 55-kips were measured under a 39-kip wheel load hopper car at 40 mph. About 72-kips was measured on the railbound manganese (RBM) style frogs.
- The hollow switch ties are performing well to date with no unexpected problems.
- The switch required higher than typical force to throw. Attempts to adjust the switch since installation did not improve its operation. As ambient temperatures decreased, this condition has become worse. Longitudinal movement of the switch points relative to the ties caused the rods to bind on the angle bracket type rod guides in the ties.

The switch and frog used were donated by VAE–Nortrak for evaluation under 39-kip wheel load traffic at FAST. A total of 55-MGT was accumulated during testing sponsored by Federal Railroad Administration (FRA) and the Association of American Railroads (AAR) under HAL and Special Trackwork Strategic Research Initiatives (SRI). To date, the turnout performed well with relatively little maintenance being required.

Some of the design features of the turnout being evaluated include:

- Low entry angle, tangential switch design with double spiral switch alignment – reducing lateral forces and accelerations in the switch.
- Kinematic Gage Optimization™ (KGO™) – this allows for a larger cross section switch point potentially resulting in a longer service life. KGO™ will also help steer cars with good (i.e. cone shaped) wheel profiles through the diverging route of the turnout.
- Hollow switch ties –are intended to provide uniform support conditions and make surfacing easier
- Non-metallic "blue composite" switch rods – These should minimize track circuit shorting through the switch rods.
- "Solid" AMS casting frog with welded heel rails –design eliminating all running surface discontinuities except the wing to point transfer and should result in lower vertical forces than an RBM frog.

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INTRODUCTION

Turnouts influence many aspects of the performance of the railroad, as they are the instruments of train control – the junction points that keep traffic flowing. They are a major maintenance cost. More than $200 million per year is spent on turnout maintenance.

Recent efforts to address these costs include work on optimizing switch geometry.[1] This effort was successful in reducing the maximum lateral forces generated by diverging route vehicles. However, switch point service life was also reduced on these "low-entry angle" designs due to the thin cross sections on the switch points.[2]

Additional efforts focused on developing a more stable switch point by redesigning its cross section. The AAR design[3] re-apportioned material between the stock rail and switch point providing a smoother gage face transition from stock rail to switch point. This design shows promise for situations where the percentage of diverging traffic is relatively high. While the switch point was significantly more stable (showed less roll under load), switch point chipping seen in HAL service was not completely eliminated.

Use of a modified running surface elevation profile (or switch point slope) provided significant service life benefits for low entry angle switches tested at FAST. The Union Pacific-style, 60-inch "second cut" point slope increased the service life of low entry angle switch points by 50 percent. While this reduced some of the performance benefits of the low entry designs, it also raised the service life from 20 percent below to about 20 percent above that of AREMA style switch points.

The latest test turnout installed in FAST embodies commercially available design improvements that address the issues previously discussed. Some of the design features of the turnout being evaluated include:

- Low entry angle, tangential switch design with double spiral switch alignment – this should reduce lateral forces and accelerations in the switch
- KGO™ – this allows for a larger cross section switch point and may result in a longer service life. KGO™ will also help steer cars with good (i.e. cone shaped) wheel profiles through the diverging route of the turnout.
- Hollow switch ties – these are intended to provide uniform support conditions and make surfacing easier.
- Non-metallic switch rods – these should minimize track circuit shorting through the switch rods.
- "Solid" AMS casting frog with welded heel rails – this design eliminates all running surface discontinuities except the wing to point transfer and should result in lower vertical forces than rail bound manganese RBM frog.

Figures 1a, 1b, and 1c show these features on the test turnout as installed in the FAST High Tonnage Loop (HTL).

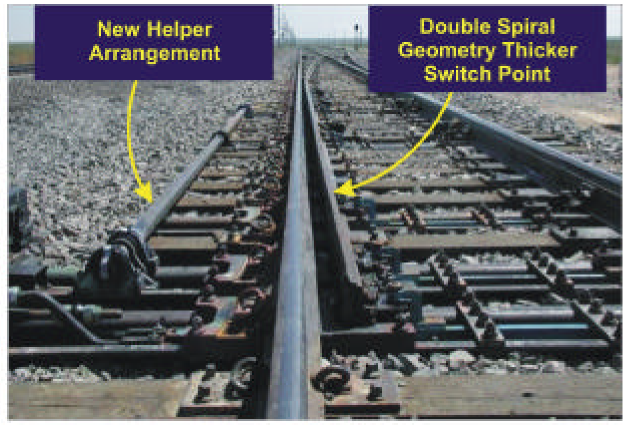

Figure 1a: View of VAE-Nortrak FAST Test Turnout Double Spiral Geometry Thicker Switch Point with Helper

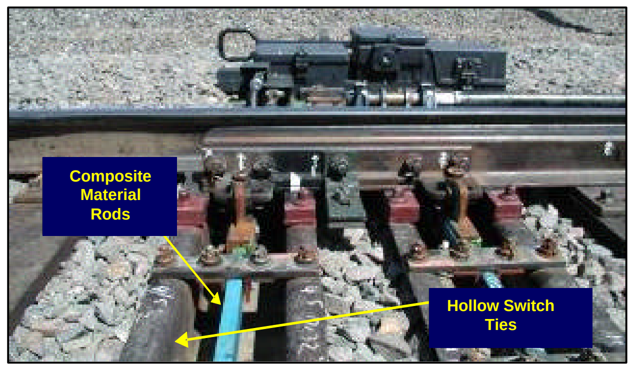

Figure 1b: View of VAE-Nortrak FAST Test Turnout Composite Rods and Hollow Switch Ties

Figure 1c: View of VAE-Nortrak FAST Test Turnout Joint-Less Frog

TURNOUT PERFORMANCE

Initial performance shows promise. A total of 55 MGT was accumulated during testing sponsored by FRA and AAR under the HAL and Special Trackwork Strategic Research Initiatives (SRI). To date, the turnout has performed well with relatively little maintenance being required.

Surfacing Maintenance: Surface maintenance was minimal with tamping required after the first day and week of operations. No work was needed to restore alignment through the switch.

Failed or Broken Components: Track pumping occurred at the frog. Some plate hold down screw spikes worked up.

Figure 2: FAST Turnout Switch Rod Binding on Transit Clip and Rod Guides in Cold Weather

Switch Throw: The effort required to throw this switch was higher than that needed for AREMA style switches. The switch was built in June 2004 during relatively hot weather. As temperatures decreased, the switch became harder to throw. In November and December 2004, the switch point longitudinal movement allowance in the rod clips was completely used up (i.e. the switch points moved back toward the frog due to thermal contraction). Thus, the rods were binding on the guides. Figure 2 shows the position of the rod and clip in cold weather. As the switch points pulled the rods, it also bent them; causing the point tips to move away from the stock rails. This design, with angle bracket rod guides in the ties, appears to be less forgiving of rail longitudinal stress (temperature) effects than standard designs.

Dynamic Loads: The initial performance of the switch was measured with strain gaged wheelsets. Maximum lateral loads of 11 kips were measured for 40 mph diverging runs under 315 kip cars. These forces were measured for both facing point and trailing point runs. Figure 3 shows a comparison of the lateral forces measured in various number 20 switches tested at FAST. The forces measured in the VAE – Nortrak switch are low compared to AREMA style and low entry angle switches previously testing under the same cars. Thus, the spiral geometry and KGO™ features are providing dynamic performance (with turnout in new condition) as good as, or better than any switch tested at FAST.

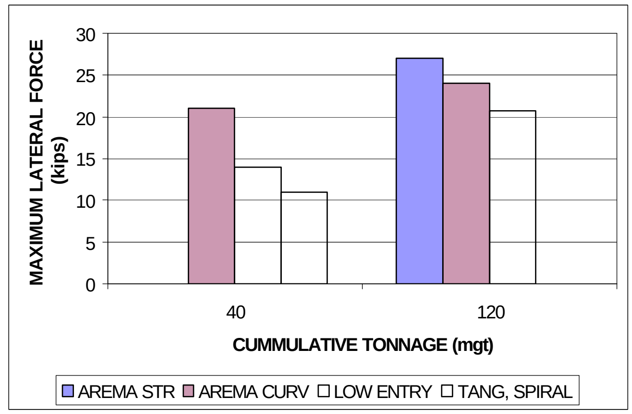

Figure 3: Comparison of Maximum Lateral Forces in FAST Test Turnouts

At the frog, this "solid" design eliminates the usual running surface transitions from running rail to frog casting at the toe and heel ends. The smaller than typical point depression is suited to the wheel conditions at FAST, where minimal tread hollowing exists. Dynamic load measurements at the frog show that it is performing very well. Maximum average wheel loads over the frog at 40 mph were 55 kips. This is a dynamic load factor (measured load/ static load) of 1.4. The dynamic performance of the frog has been better than traditional Rail Bound Manganese RBM casting designs and equal to improved running surface –Longitudinal Profile (LP) designs developed by AAR. Figure 4 compares the dynamic vertical load performance of these designs.

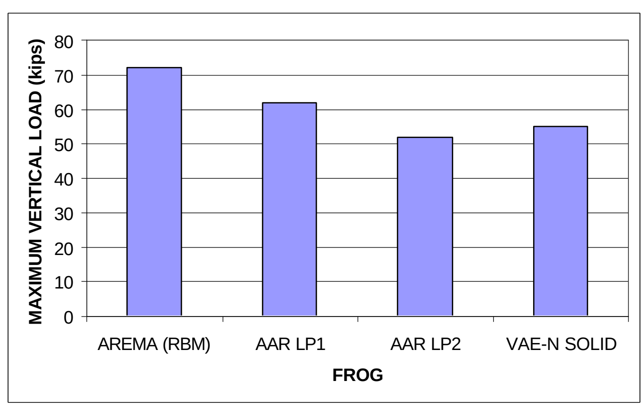

Figure 4: Comparison of Dynamic Performance of FAST Test Frogs

Ride Quality: The lower dynamic loads reflect the superior ride quality of the turnout to date. Feedback from the FAST train crews (a form of qualitative measurement) confirm visual trackside observations that the train rides smoothly through the turnout.

Areas for Improvement: The Transportation Technology Center, Inc., (TTCI) is also working with the turnout supplier and member railroads to remedy the longitudinal stress related switch point movement problems. The Nortrak design has less allowance for longitudinal switch point movement. This design intends to keep the rods centered in the hollow steel ties. Switch points can move relative to the rods along longitudinal slots cut in the rod clips. Longitudinal movement is limited to a total of about 2-1/2 inches. By comparison, a typical switch with the rods in tie cribs, allows longitudinal movement up to the full space between ties. This is plus or minus 5 inches.

Experience at FAST and in revenue service suggests that switch point longitudinal movement exceeds 3-inches over the year at many locations. Thus, allowance for more movement of the switch points relative to the ties is needed. This is also more movement than one would expect from thermal expansion and contraction of the switch point alone.

The uniqueness of FAST operations and their potential effects on rail longitudinal movement should be recalled. FAST uses large scale fleeting of trains. For example, as many as 300 trains operate in one direction before operating a similar number in the opposite direction. This operating pattern tends to cause wider ranges of rail movement than typical on single line routes. It may well be representative of some double track routes.

FUTURE WORK

Additional tonnage will be needed to fully evaluate the life cycle performance of these design features. Of particular interest will be how the dynamic performance of the turnout degrades and eventually fails with additional tonnage.

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