TECHOLOGY DIGEST

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# Comparison Performance of AREMA and Intermediate Geometry Design Turnouts

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**Summary**

Transportation Technology Center Inc. (TTCI) is comparing the dynamic performance of a “standard” American Railway Engineering and Maintenance of Way Association (AREMA) geometry design turnout to an “intermediate” geometry turnout designed for improved performance. The intermediate geometry design features a lower entry angle switch and a No. 20 spring frog. The performance evaluation was done at the Federal Railroad Administration’s Transportation Technology Center near Pueblo, Colorado, under sponsorship of the Association of American Railroads. Results show that:

- Load-measuring wheel-set tests show that the intermediate design (low entry angle) switch reduces the maximum lateral force in a No. 20 turnout by about 33 percent over the range of typical operating speeds. Maximum lateral forces on diverging moves of HAL cars at 40 mph were 14 kips in the intermediate-geometry-design turnout versus 21 kips in the AREMA-geometry-design turnout. The AREMA geometry turnout has a higher allowable diverging speed (50 mph vs. 45 mph) than the intermediate geometry turnout.
- Load-measuring wheel-set tests show that the spring, or moveable-wing, frog in the intermediate-geometry-design turnout does not reduce maximum vertical forces at 40 mph compared to the standard AREMA fixed-point, or rail-bound manganese, frog in the AREMA-geometry-design turnout. The vertical and lateral test does not necessarily represent other possible benefits of the spring frog.
- The field results are comparable to the NUCARS vehicle/track dynamics model predictions made for similar vehicles. The model results predict somewhat lower forces than actual for both turnouts. The differences are attributed to actual track conditions versus ideal track in the model.
- 315,000-pound heavy-axle-load (HAL) car was instrumented with 38-inch load-measuring wheel sets to measure minimum and maximum dynamic loads at the Facility for Accelerated Service Testing. Vertical and lateral measurements were taken over two No. 20 turnouts at speeds of 30, 40, 45, and 50 mph, with facing-point and trailing-point directions on the mainline and diverging routes.

**Suggested Distribution:**

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

Work performed by TTCI Transportation Technology Center, Inc.
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## INTRODUCTION

Special track work (turnouts and crossing diamonds) is a vital link in the track system and a key component in train operation, affecting more than one track. Special track work also includes the most expensive and complicated track components used, and it consumes a disproportionately large part of the track-maintenance budget.

About $220 million is spent on turnout maintenance annually. Of this amount, 6,800 frogs are replaced at a cost of $120 million per year. The load environment on these components is quite severe, making them the shortest-lived in the track system, except for crossing diamonds. Improved performance is needed from special track work to improve system reliability and efficiencies.

## RESULTS

Preliminary technical analysis of the advanced-design turnouts submitted to the Association of American Railroads (AAR) suggested that significant reduction in maximum forces as compared to those experienced on standard AREMA designs applied by vehicles traversing these turnouts could be achieved. This test, with a back-to-back comparison of an AREMA turnout and an intermediate-geometry turnout, provides a long-term performance comparison of the two designs under high-tonnage revenue traffic. The load-measuring wheel-set data and modeling shows the effect of turnout geometry differences for both turnouts and the comparison shows differences in maximum lateral forces on the two frogs and turnouts (see Exhibits 1 and 2).

## MAXIMUM LATERAL FORCE ON TURNOUTS

Modeling shows that maximum loads for the intermediate-design turnout were 50 percent lower than the AREMA-design turnout. The No. 20 intermediate-geometry turnout has a 0.29-degree entry angle and the No. 20 AREMA design is a 0.46-degree entry-angle turnout. Maximum lateral forces occur at the switch entry and are directly related to the effective entry angle of the switch. Exhibit 3 shows this effect from FAST test results. The AREMA-design turnout, with a larger entry angle, generates higher maximum lateral forces and accelerations over the range of typical operating speeds including the allowable maximum speed. Load measuring

| Component | No. 20 Turnout Designs | |
|---|---|---|
| | **AREMA** | **Intermediate** |
| Entry Angle | 0.46$^{N}$ | 0.29$^{N}$ |
| Lead Length | 156' | 156' |
| Closure Curve Radius | 3100' | 2850' |
| Allowable Diverging Speed (3-inch cant deficiency) | 50 mph | 45 mph |
| Frog Type | RBM | Spring Frog, extended w/ AMS Casting |
| Switch Type | Under-Cut | Under-Cut, extended w/ rollers |
| Fasteners | Standard | Premium: grade 8 bolts., screw spikes |
| Plate-work | Standard | Multi-tie, riser plates, frog gage plates |

**Exhibit 1. FAST Test Turnout Characteristics**

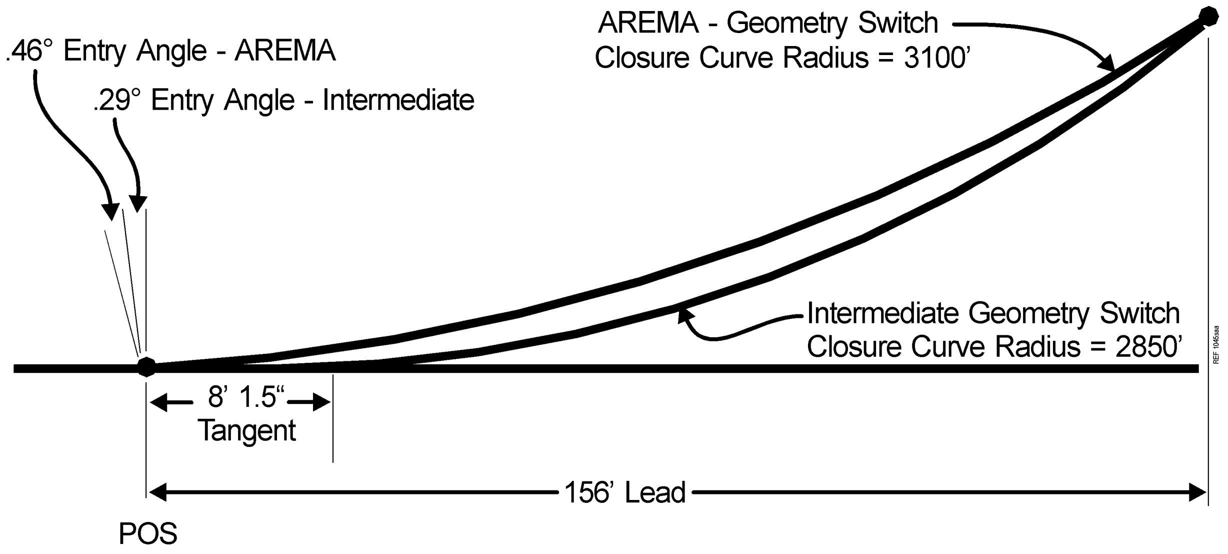


**Exhibit 2. FAST Test Turnout Characteristics**

wheel-set test results show that the lower entry angle reduces maximum lateral forces at 40 mph and increases performance with lower maximum lateral forces as speed increases to 50 mph, as shown in Exhibit 3.

Comparison of NUCARS predictions with the measured lateral forces shows that the model consistently predicted lower forces than actually measured at the Facility for Accelerated Service Testing (FAST). There are some logical reasons for this result. NUCARS used nominal geometry; FAST results reflect actual geometry. Thus, the NUCARS results represent the theoretical best-possible performance.

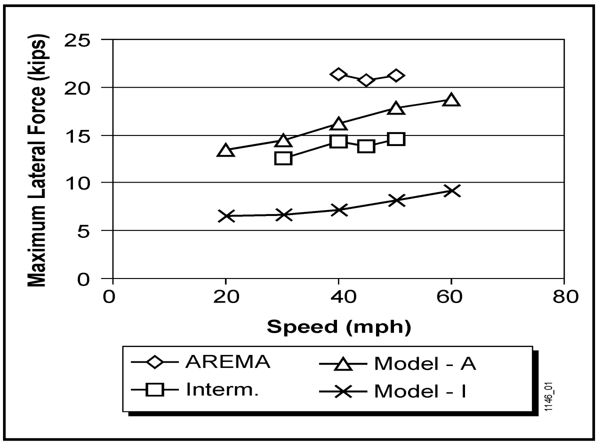


**Exhibit 3. Maximum Lateral Forces for FAST Turnouts (Loaded HAL Car on Diverging Route)**

In addition, the FAST intermediate turnout had a kink in front of the switch point. This effectively increased the entry angle of the switch and increased the lateral forces. This accounts for the smaller performance difference between the intermediate turnout and the AREMA turnout (33 percent actual versus 50 percent predicted) at FAST.

## MAXIMUM VERTICAL FORCES ON FROGS

Lower vertical forces were expected for the spring frog than the standard AREMA rail-bound manganese (RBM) frog. The spring frog has a shorter transition, gap opening, and distance in the running surface than the standard RBM frog due to the spring wing, which is closed while running on mainline. However, the load-measuring wheel-set tests indicate the intermediate-geometry turnout with the spring frog did not reduce maximum vertical loads at 40 mph versus the AREMA turnout, as shown in Exhibit 4. There also appears to be no significant difference in maximum vertical force between

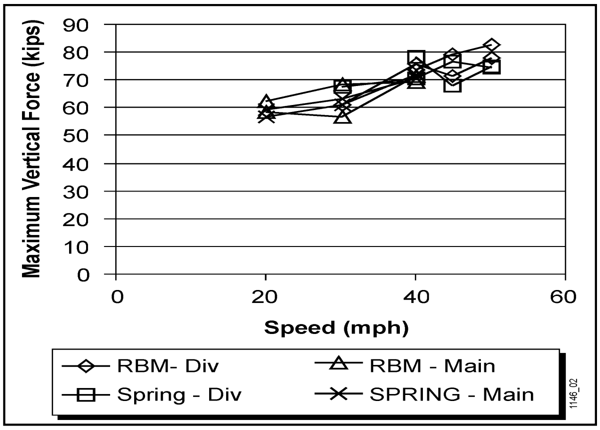


**Exhibit 4. Measured Maximum Vertical Forces on FAST No. 20 Turnouts (Loaded HAL Car)**

routes on the spring frog. The continuous running surface on the mainline side of the spring frog should significantly reduce impact forces. However, the wheels are still seeing a discontinuity under load that results in an impact with about the same maximum as operating over a fixed-point frog. This is not to imply that the spring frog provides no benefit at all. While the maximum loads are the same, the load time histories of two frogs are somewhat different. Long-term monitoring of the service life and required maintenance of each frog type will provide a better determination of the benefits which can be attributed to a No. 20 spring frog.

## TURNOUT SPECIFICATIONS

The intermediate geometry turnout is a No. 20-136RE right-hand turnout with the switch-half manufactured by Cleveland Track Material, Inc., and the frog-half supplied by ABC Rail Corporation. This turnout consists of the supplier's latest designs in component parts. The switch-half consists of a compound-point switch and has extended points with undercuts, rollers with roller-riser plates, extra track-gage plates and gage rods. The frog-half consists of a manganese-casting spring frog with false-flange grooves to accommodate hollow wheels, two springs, extended and adjustable guard rails, insulated and welded frog-gauge plates, cast horns, and hold-downs. The AREMA-geometry design is a No. 20-132RE left-hand turnout with a standard RBM frog and switch points with undercut machining.

## FUTURE WORK

On November 2, 1998, a derailment occurred at FAST in which the AREMA turnout (switch 408) was damaged and removed from track. The derailment was caused by a mechanical component failure that began several hundred feet before the turnout. The AREMA turnout had approximately 700 million gross tons (MGT) of traffic. The turnout was on its third frog and third curved switch point. The damaged AREMA-design turnout was replaced with an AREMA-geometry design turnout manufactured to BNSF standards. The intermediate turnout (switch 407) has about 140 MGT of traffic. Prior to the derailment neither turnout required much maintenance.

Monitoring will continue with performance measurements on the new standard and intermediate turnouts. Comparison of component life and maintenance data will allow life-cycle cost comparisons of the two designs in the future.

**Note: Contact Dave Davis at (719) 584-0754 or Don Guillen at (719) 584-0709, with questions or comments about this document.**

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A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH AAR/TTCI, PUBLICATIONS, P.O. Box 79780, BALTIMORE, MD, 21279-0780.