TECHOLOGY DIGEST

Timely Technology Transfer

GEOMETRY FOR AN IMPROVED PERFORMANCE NO. 20 TURNOUT

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Summary

As part of its special track work research program, the Association of American Railroads (AAR) has developed an improved No. 20 turnout geometry. Turnouts are one of the most expensive and maintenance intensive parts of the track. Many railroads are using expensive alternative designs in high-traffic applications. AAR's goal is to provide an alternative turnout design with a lower cost premium which could be cost effective over a much wider range of applications.

This AAR effort improves the turnout geometry for better vehicle performance through the turnout, with reduced lateral impact forces. This results in less wear and maintenance for both the turnout and the vehicles. Features of the new AAR turnout design include:

- Reduced peak lateral forces to about half those for the current AREA No. 20 design
- Improved safety as a result of reduced lateral to vertical (L/V) force ratio
- Fits in same space as current AREA No. 20
- Potential for safe operation at higher speeds than for the AREA No. 20
- Provides smoother ride for sensitive cargo
- More uniform lateral force through switch point area to reduce uneven wear
- Reduced life-cycle costs

The new turnout design was developed using AAR's vehicle dynamics simulation model NUCARS. This study demonstrates the capabilities of NUCARS to evaluate and/or design switch geometries. NUCARS can be used to develop designs that optimize selected performance characteristics. This lateral turnout geometry was developed for optimum vehicle performance through the diverging route, while retaining a tangent alignment for the straight route. Lateral wheel/rail forces and L/V ratio are minimized while keeping the design within the space limitations of the current AREA No. 20 turnout, as well as the speed requirements in the Federal Railroad Administration track safety standards. By staying within the space limitations of the existing design, installation and signal costs for the new design are held constant, making this design much more attractive than longer designs.

Suggested Distribution:
- ❑ R&D Track Maintenance
- ❑ Maintenance of Way
- ❑ Train Operations

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INTRODUCTION AND CONCLUSIONS

Turnouts are vital links in the railway track system. They are key components in train operations, affecting more than one track. They are also the most expensive and complicated track components used. U.S. railroads spend about $320 million annually on turnouts. They consume a disproportinately large part of the track maintenance budget, about $98 million annually. The load environment on turnout components is severe, making them the shortest lived in the track stystem. Improved turnout performance is needed to improve system reliability and efficiency.

The Association of American Railroads (AAR) research is working on improving turnouts to better withstand the current loadings and improving turnout designs to reduce the loadings from current and future traffic. As an example of what can be done to improve switch geometry, we used NUCARS to develop a new turnout geometry that reduces the peak dynamic lateral loadings, while staying within the dimensions of the current American Railway Engineering Association (AREA) turnout design, will be used by the AAR to construct a No. 20 turnout. The turnout will be placed in the High Tonnage Loop at the Facility for Accelerated Service Testing to provide a rigorous test of the design to determine its life-cycle costs.

Design Constraints

The primary constraint for the new turnout geometry was that it retain the lead length of the current AREA Curved Point No. 20 turnout (156' 0-1/2"). By retaining the lead length of the current design, installation and signaling costs are minimized, particularly at crossovers. In addition, the new design will fit anywhere that an existing No. 20 is located, which is particularly important in congested trackage and urban areas where space is at a premium.

A second constraint was that it provide an allowable speed of at least 45 mph through the diverging route, as per Federal Railroad Administration (FRA) track safety standards. The maximum diverging route speed of the existing AREA No. 20 turnout is typically set at 45 mph or less. From a maintenance standpoint, wear increases and alignment deteriorates rapidly as speed increases over the current design. By keeping the allowable speed for the new design at 45 mph, no additional train delay costs will be incurred as compared to the existing No. 20. In fact, the analyses suggest that the new design can be safely operated with much less wear and deterioration even at higher speeds.

Improved Turnout Design

Exhibit 1 shows the improved No. 20 turnout design. Design parameters, as compared to the current AREA No. 20, are listed in Exhibit 2. The key to the improved design is the smaller entry angle at the point of switch, which is 0.280 degrees as compared to 0.455 degrees. The smaller point angle reduces the impact force as a car enters the turnout. Additionally, the improved design has a 7-foot-long tangent section at the end of the switch point before the start of the switch curve. The use of the short tangent section improves vehicle performance at switch entry.

In order to accommodate the smaller point angle within the given lead length, the switch and closure curves have a smaller radius of 2,733 feet as compared to 3,606 and 3,330 feet, respectively, for the AREA design. This curve is still large enough to accommodate 45 mph train operations in accordance with FRA standards. The smaller radius curve of the improved design provides for a longer, tangent section at the toe of the frog (14.80 feet compared to 2.03 feet in the AREA design). This may also improve vehicle performance through the frog by aligning trucks on the facing point moves. The new design also uses the same curve throughout the switch point and closure rail, eliminating the compound curve used in the AREA design. The improved design requires a longer 46.9-foot point (calculated assuming a 6.25-inch heel spread), as compared to the current AREA design, which has a 39.0-foot point. This extra point length (nearly 8 feet) may require the use of rollers and/or helpers to throw properly.

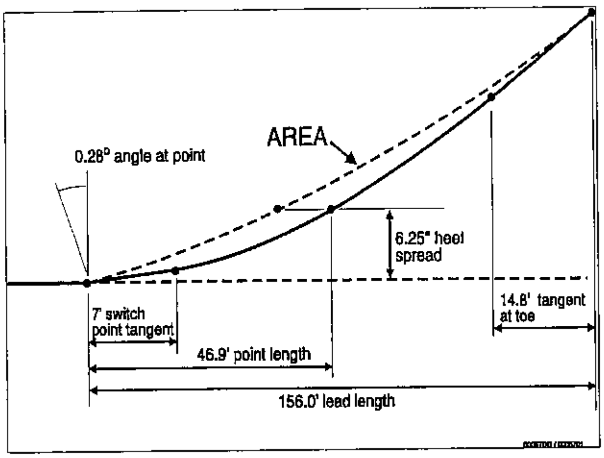

Exhibit 1. Improved No. 20 Turnout Geometry

Exhibit 2. Comparisons of Improved Turnout

Dimension	Improved Design	AREA No. 20
Lead Length (feet)	156.0	156.0
FRA Speed (mph)	45.2	49.9
Angle at Point (degrees)	0.280	0.455
Switch Point Tangent (feet)	7.0	0.0
Switch Radius (feet)	2733	3606
Closure Radius (feet)	2733	3330
Tangent at Toe (feet)	14.80	2.03
Point Length (feet)	46.9	39.0
Heel Angle (degrees)	1.117	1.075

The improved vehicle performance at switch entry is illustrated in Exhibit 3. Note the large lateral force impact just beyond the point of switch for a 100-ton loaded hopper on the diverging route of an AREA No. 20 at 40 mph. The geometry of the new AAR design was developed to minimize this peak impact and spread the lateral steering forces over a longer distance along the switch point, promoting more uniform wear. As shown in Exhibit 3, the peak lateral force for the improved geometry design is about half that of the AREA design. This new design should not experience the concentrated switch point wear that is so common on AREA switch points.

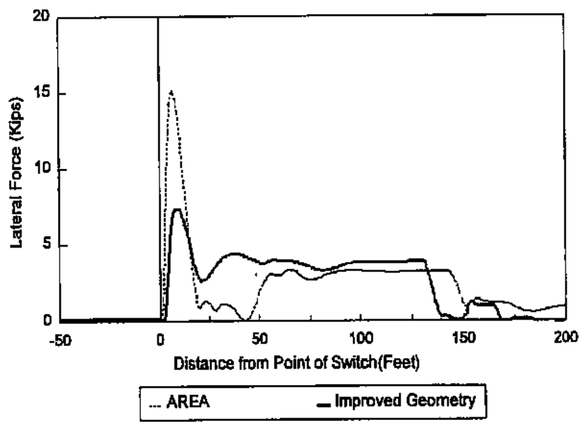

Exhibit 3. Lead Axle Flanging Wheel Lateral Force Comparison for 100-ton Hopper Car at 40 mph

The reduced lateral impact force for the AAR design holds true over a wide range of speeds, as shown in Exhibit 4. Over the speed range of 20 mph to 60 mph, the peak lateral forces for the new design are roughly half of those for the AREA No. 20 for the lead axle flanging wheel of a loaded 100-ton hopper car on the diverging route.

Similarly, the lateral to vertical (L/V) force ratio for the new AAR design is about half of that for the AREA No. 20 (Exhibit 5). The L/V ratio is an indication of the propensity for rail rollover and flange climb. Clearly, the new design improves turnout safety by reducing the L/V ratio throughout the wide range of operating speeds. This data also suggests that it might be safe to operate over the new design turnout at higher speeds while still benefiting from reduced wear and degradation. For sensitive cargo, such as automobiles, the ride quality through the turnout would need to be investigated before operating at higher speeds.

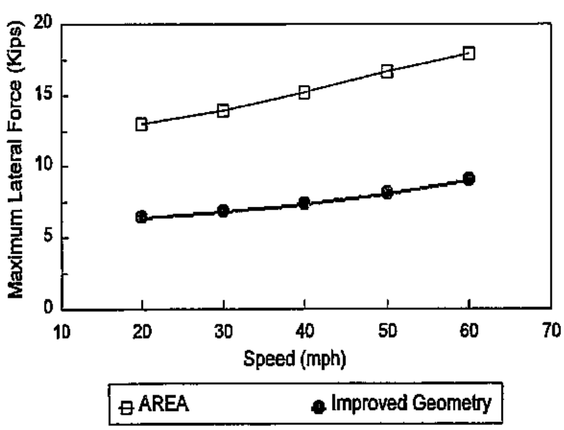

Exhibit 4. Comparison of Peak Lateral Forces from 20 mph to 60 mph

Design Methodology

The AAR developed this new turnout design using its vehicle performance simulation model NUCARS. First, a generic turnout geometry was developed based on the design constraints. Then parameters such as the angle at point-of-switch and length of switch point tangent were varied to get the best vehicle performance within the design constraints. To quickly narrow down to the optimal range for the design parameters, NUCARS runs were made using a loaded 100-ton hopper car at 40 mph. To further refine the designs, runs were made for both loaded and empty cars at various speeds to make sure the designs produced consistent results over the entire range. All results shown have been generated using the NUCARS model. This model is a valuable tool to optimize and refine special track work designs.

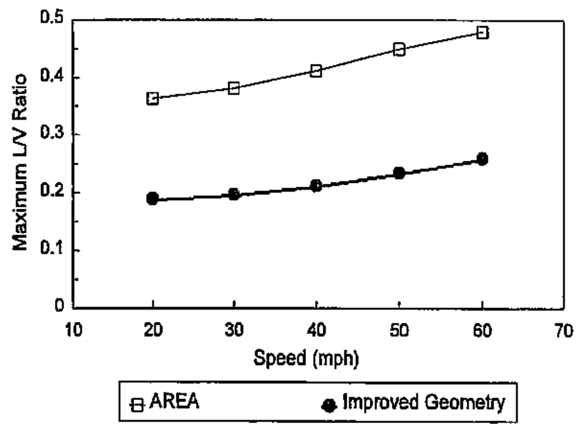

Exhibit 5. Comparison of L/V Ratio from 20 mph to 60 mph

Field Testing

A No. 20 turnout, using a switch geometry similar to the one described in this TD and a spring frog, will be tested under heavy axle load (HAL) conditions at FAST. The performance of this turnout will be monitored and compared to the adjacent AREA design No. 20 turnout already in track. The AREA design turnout has had relatively short average switch point life compared to that seen in revenue service under 33-kip wheel load traffic. An improved switch point design (e.g., switch angle and/or cross-section) may be needed to support HAL operations.

The life of components and the amount of maintenance needed to keep the turnout operating will be recorded. The life-cycle cost of this design will be determined and compared to the AREA design.

Note: Contact Duane Otter (719) 584-0594 or Dave Davis (719) 584-0754 with questions or comments on this document.

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A MORE DETAILED REPORT, WHICH MAY CONTAIN REVISED INFORMATION, MAY BE AVAILABLE AT A LATER DATE THROUGH THE AAR, PUBLICATION ORDER PROCESSING, 50 F STREET, NW, 5TH FLOOR, COG, WASHINGTON, D.C.,20001