Reducing Wheel/Rail Forces in Turnouts

Because of the high costs associated with turnout maintenance, attention is being focused on alternate turnout designs aimed at improving the dynamic interaction between freight vehicles and the turnout. An improvement in dynamic interaction, and the resulting reduction in dynamic wheel/rail forces, is expected to reduce turnout loadings and corresponding turnout-maintenance costs, while allowing for an increase in operating speeds through the turnouts.

One advanced-turnout design, which has been the subject of several recent studies, is the tangential-geometry turnout. In this design, the switch-entry angle is virtually eliminated, which significantly reduces the dynamic loads that occur when a vehicle enters the turnout (1). This, in turn, allows for higher speeds through the curved, or turnout, side. As observed in Figure 1, the tangential-geometry turnout eliminates large switch-entry angles and lateral impacts. This eliminates the need for

manganese tips, results in easier maintenance of switch alignment (due to reduced impact) and permits easier design, construction and maintenance of turnouts in curves. On the other hand, these turnouts require switch points approximately 80 feet long and an increased lead length to achieve the desired radius (1).

Computer-modeling

The reduction in wheel/rail dynamic forces, and the corresponding potential reduction in turnout maintenance, was observed in an examination of a freight vehicle's behavior through a turnout. Making use of an AAR-developed computer model, AAR researchers studied the dynamic behavior of freight cars negotiating two No. 20 turnouts, one of conventional AREA geometry and one of more-advanced tangential geometry (2).

The study examined safety and performance criteria in the turnouts' designs. An examination of key safety

MAXIMUM SPEEDS THROUGH LATERAL # 20 TURNOUTS (SPEEDS ARE FOR FREIGHT TRAFFIC)							
	BN	BN-TANGENTIAL GEOMETRY	CN	CONRAIL	UP	AMTRAK	AREA
SPEED	35 / 25	50	45	40	40	40	45
SWITCH ENTRY ANGLE	0° 41'	0° 06'	0° 25'	0° 25'	0° 25'	0° 25'	0° 25'
RADIUS	3527'	3280'	3330'	3289'	3330'	3289'	3330'

Figure 1 — Comparison of various No. 20 turnout designs (1).
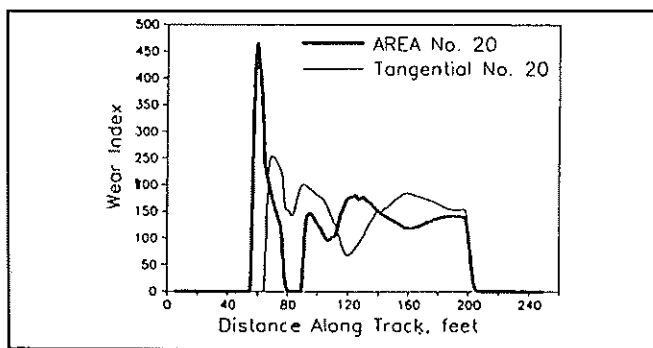

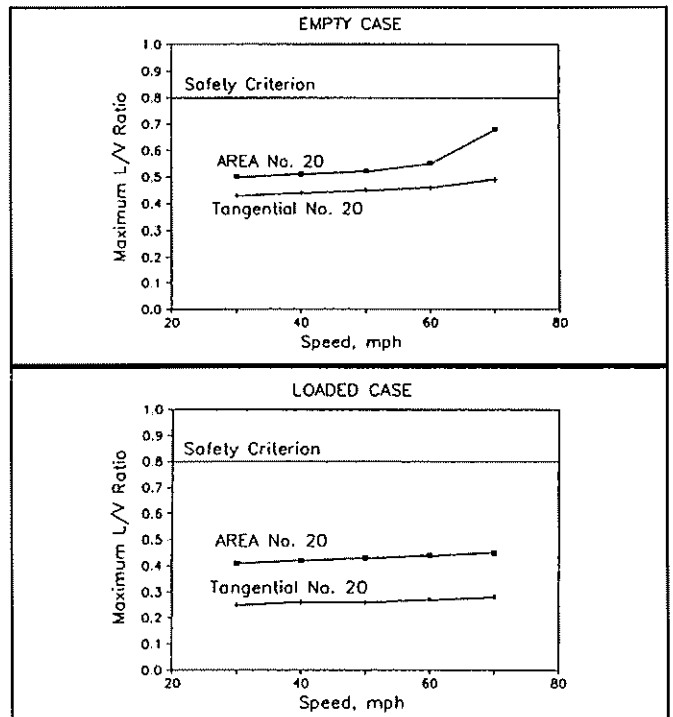*Figure 3 — Predicted lateral force on the outside rail (2).*

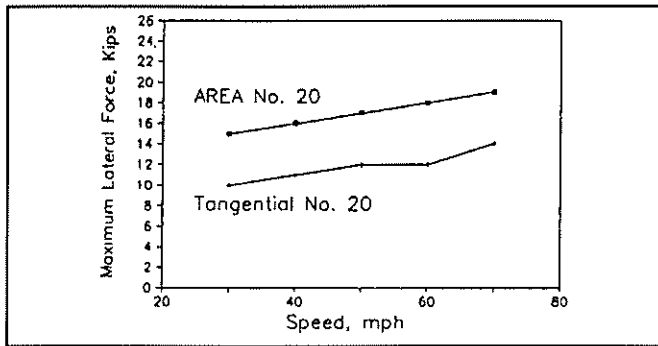
Figure 2 — Maximum wheel L/V predicted for switch entry (2).

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Figure 4 — Variation in maximum lateral force (2).

Figure 5 — Wear index predictions for turnouts at 50 mph. (2).

parameters, such as maximum wheel L/V ratio (the ratio of the lateral wheel load to the vertical wheel load through the turnout), showed that although both turnouts were within the required safety envelope for the speed range studied, the tangential-geometry turnout exhibited a consistently lower L/V ratio at all speeds for both loaded and empty vehicles (Figure 2). Similar behavior was reported for other safety criteria such as truck L/V and minimum wheel load/lift (2).

Examination of the lateral forces generated by the vehicle through the turnouts — an important measure of the performance of the system — also showed an improvement in dynamic performance for the tangential-geometry turnout. This is illustrated in Figures 3 and 4, which show a comparison of the lateral forces predicted by the model for the two turnout types. As can be seen in Figure 3, the largest lateral force is experienced at switch entry, with a noticeable reduction in force levels beyond that point. The maximum force at switch entry is significantly reduced by the tangential-geometry design. Figure 4 shows that the maximum lateral force is reduced for the full range of operating speeds, with the maximum forces in the AREA turnout approximately 50% higher than those for the tangential-geometry turnout (2).

Reduced rail wear

The same behavior was observed when the model was used to calculate predicted rail wear through the turnout. This is illustrated in Figure 5, which compares a
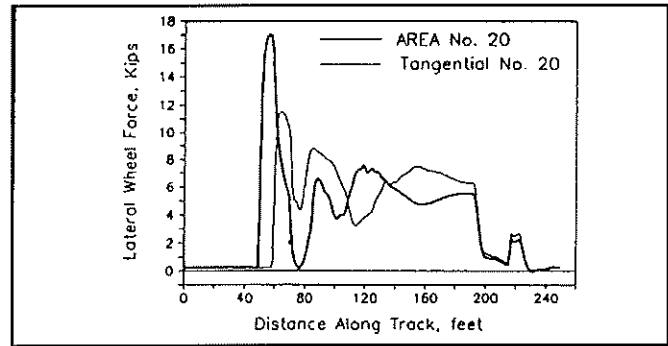
"wear index," a measure of the wheel/rail contact patch energy per unit distance (which has been correlated with wheel/rail wear) along the turnout length for the two turnout designs. Noting the close similarity between the wear index and the lateral force measurement (Figure 3), it can again be observed that the wear in the switch area is significantly lower for the tangential-geometry turnout. However, once in the body of the turnout, the wear indices are somewhat higher for the tangential-geometry turnout. This may be due to its slightly smaller radius of curvature.

Noting that these theoretical results appear to correspond with reported field observations, it appears that use of alternate turnout designs, such as the one discussed here, can reduce the dynamic effects and corresponding maintenance costs associated with high-maintenance turnout locations. Since alternate turnout designs are generally more expensive than the conventional designs, these advantages must be weighed against the additional costs. However, alternate designs appear to offer a potential for improving performance while reducing maintenance costs in a key maintenance-of-way area, and should be carefully examined by railroad maintenance officers.

References

(1) Sauer, S. J., "Swing Nose Frogs and Tangential Geometry turnouts on the Burlington Northern Railroad," Bulletin of the American Railway Engineering Association, Bulletin 726, Volume 91, May 1990.
(2) Handal, Stephen N., "Modeling of Improvements in Turnout Performance," AREA/ASME Joint Railroad Conference, Jacksonville, Fla., October 1990.