TECHNOLOGY DIGEST

Timely Technology Transfer

COMPARATIVE PERFORMANCE OF TWO TURNOUT DESIGNS IN REVENUE SERVICE

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Summary

The Association of American Railroads is comparing the performance of an American Railway Engineering Association (AREA) geometry turnout to that of a tangential-geometry turnout in its Advanced Turnout Evaluation Program. Tests show the lower-entry-angle tangential-geometry turnouts are subjected to lower damaging lateral forces than the higher-entry-angle AREA-geometry frogs.

The dynamic performance of the turnouts, as measured by strain-gaged wheel sets on a 100-ton car, reflected the differences in switch and guard-rail design and similarities in frog design between the two turnouts. The initial measurements at 20 million gross tons (MGT) showed the design advantages of the tangential turnout: lower maximum lateral and vertical forces at the switch.

The effect of speed on maximum dynamic loads was also determined from the test runs. They varied with the particular movement through the turnout.

Static measurements of gage and cross level show that the turnouts are quite stable. Both are performing well with little change in maximum or average deviations. Average gage error for both turnouts was virtually unchanged over a 100 MGT monitoring period.

These findings result from a field test conducted on the Burlington Northern Santa Fe's Clovis Subdivision at Buchanan, New Mexico. The test site consists of two turnouts at the ends of a controlled mainline siding.

Suggested Distribution:

- ❑ Train Handling
- ❑ Maintenance of Way
- ❑ Planning and Analysis
- ❑ Track Maintenance

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INTRODUCTION AND CONCLUSIONS

Special track work (turnouts and crossing diamonds) is a vital link in the track system and a key component in train operations, affecting more than one track. Special track work is also the most expensive and complicated track component used, and it consumes a disproportionately large part of the track maintenance budget. About $98 million is spent on turnout maintenance annually. Additionally, 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. Improved performance is needed from special track work to improve system reliability and efficiency.

Preliminary technical analysis of the advanced design turnouts submitted to the Association of American Railroads under the Advanced Turnout Evaluation Project suggested that significant reductions in maximum forces — as compared to those experienced on standard American Railway Engineering Association (AREA) designs — applied by vehicles traversing these turnouts could be achieved. This test, with a back-to-back comparison of non-tangential AREA and tangential switches, will provide a long-term performance comparison of the two designs under high-tonnage revenue-service traffic.

Monitoring the performance of this turnout in track includes the replacement and maintenance of components. To date, after about 122 million gross tons (MGT) of traffic, neither turnout has required much maintenance.

The test turnouts are a tangential-geometry, fixed-point rail-bound manganese (RBM) frog No. 20 turnout, and a standard AREA-geometry, fixed-point RBM frog No. 20 turnout. The Tangential turnout was built by Nortrak-VAE, purchased and installed by the Burlington Northern Santa Fe at the west end of the Buchanan, New Mexico, siding in June 1995. The AREA turnout was installed at the east end of the Buchanan siding at the same time. The line is single track with controlled sidings spaced at 10-mile intervals. Approximately 20 percent of the traffic uses the Buchanan passing siding. The traffic on this line consists of high-speed freight traffic. A significant portion of the traffic is intermodal container and trailer traffic. The typical train is relatively short and fast. The mainline timetable speed is 65 miles per hour at the test site. The annual traffic rate has been quite high on this line for many years, with 90 MGT in 1995.

FINDINGS:

- The turnouts have survived more than 122 MGT of freight traffic. To date the switch points, stock rails, and closure rails all have survived. The tangential switch's curved point had an initial chipping and spalling problem. Corrective grinding was done at 40 MGT.
- Static measurements of unloaded track geometry show that the turnouts are performing well under the high-tonnage rate traffic. Unloaded gage and cross level are fairly stable. The gage deterioration rates are very low at 0.01 and 0.03 inch per 100 MGT, for the AREA and Tangential turnouts respectively. No difference in gage performance can be attributed to switch design at this point; neither has required gage or cross level-related maintenance. The cross-level deterioration rates are 0.02 and 0.10 inch per 100 MGT for the same turnouts. The Tangential turnout had a lower cross-level error at the start of the test; both have about the same average error after 122 MGT.

RESULTS

In special tests conducted in September 1995, the test turnouts were subjected to a series of runs by a test train at various speeds. The test train had a loaded 100-ton car with load-measuring strain-gaged wheel sets. All four train

	Tangential	AREA
Lead Length (feet)	172	156
Entry Angle	0.18	0.46
Maximum Allowable Speed with 3" cant deficiency (FRA crtieria)	49	49
Fasteners	Elastic	Elastic
Guard Rails	22' Raised	22' Conventional
Forces (Kips)		
Maximum Lateral Force- Switch @ 10 mph	6	8
Maximum Vertical Force-Frog @ 10 mph	39	39
Maximum Lateral Force-Switch @ 40 mph	10	21
Maximum Vertical Force-Frog @ 40 mph	51	49
Maximum Vertical Force-Frog @ 65 mph	67	65
Average Peak Lateral Force-Frog @ 10 mph	5.0	8.2
Average Peak Lateral Force-Frog @ 40 mph	5.2	16.1

Exhibit 1 — Turnout Physical and Performance Characteristics

movements (i.e. facing point straight, facing point diverging, trailing point straight, and trailing point diverging) were made through the test turnouts at speeds of 10 and 40 mph. Selected runs were also made at 25 and 65 mph. Exhibit 1 compares the two designs and shows the effect of switch design on the lateral forces measured. Note that at the typical 40 mph diverging route speed, the tangential design produced maximum lateral forces that are only one half as large as those of the AREA design.

The effect of switch design is evident in the maximum lateral load data shown in Exhibit 2. The AREA design switch point has a high entry angle that results in a large lateral force spike as the vehicles encounter the switch rail. The tangential design has a lower entry angle that allows the vehicles more time to transition into the curve of the switch. The lateral force pulse is longer and of lower maximum value. The results seen in testing the turnouts at 40 mph agree closely with New and Untried Car Analytic Regime Simulation vehicle dynamics modeling work done. The total amount of work done in turning the car is the same for both switches. It is merely distributed more evenly in the tangential design.

The effect of speed on maximum vertical force was the same for both turnouts. The two frogs are similar in design and performance. There was a larger difference between routes over a frog than between frogs. The facing point moves produced larger vertical loads than the trailing point moves. The relationship between maximum vertical force and speed is linear from 10 mph to 40 mph. Between 40 and 65 mph, maximum vertical load increases at a higher rate, reaching 67 kips (i.e. 2 times the static load).

There is a difference in the guard-rail design between the two frogs. The frog in the tangential turnout has raised guard rails with a taper of 1:62 where the back of flange contacts the guard rail. The AREA turnout has conventional guard rails with a taper of 1:18 in the contact area. This may account for the higher lateral forces measured in the frog of the AREA turnout shown in Exhibit 1.

Observed effects which may be a result of the higher lateral forces include:

- Increased guard-rail wear in the contact area,
- More screw spikes breaking and working loose, and
- Frog misalignment.

A time series of static track measurements shows how the turnout geometry deteriorates. Measurements were made with a gage and cross-level bar with a precision of 0.01 inch. Approximately 120 to 150 measurements (depending on the length of the turnout) were made during each inspection. Unloaded gage and cross level, measured through the diverging route of the turnout, show similar trends. The unloaded gage error of both turnouts shows little change over the 122 MGT monitoring period. The average value increased from 0.16 to 0.18 for the AREA design and from 0.08 to 0.11 inch for the Tangential design over the period from 22 MGT to 122 MGT. This is a gage-widening rate of 0.01 inch/100 MGT for the AREA turnout and 0.03 inch/100 MGT for the Tangential design. Thus, the plate work, fasteners and hardwood ties are doing an excellent job of holding gage under the lateral forces of the turnouts.

Unloaded cross-level error, measured in the same manner as unloaded gage, has increased at a faster rate. The average values increased from 0.24 and 0.18 inch at 22 MGT to 0.26 and 0.28 inch at 122 MGT for the two turnouts respectively. The cross-level deterioration rates were 0.02 and 0.10 inch/100 MGT during this period. Neither turnout has required maintenance resulting from gage or cross level-related deterioration.

LOAD STATION DATA

A load station was installed at the turnout test site during September, 1995. The load station consists of wheel detectors on the south rail of each of the three legs of the east end turnout and one set of rail strain gages east of the turnout. This setup allows us to determine the count, route, speed and tonnage of each train. The results are shown in Exhibit 3.

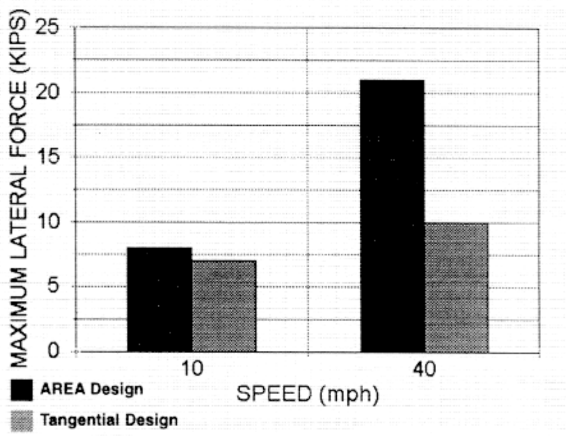

Exhibit 3. Measured Maximum Lateral Force vs. Speed at Buchanan Test Turnouts

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

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Trains/day		50	
Average Trailing Tonnage		4500–5000	
Route	**Direction**	**Tangential (percent of traffic)**	**AREA (percent of traffic)**
Main	Facing Point	44	37
Main	Trailing Point	37	44
Siding	Facing Point	12	8
Siding	Trailing Point	8	12

Exhibit 2. Load Station Data

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