TECHNOLOGY DIGEST

Timely Technology Transfer

The Effect of Axle Load on an Advanced Design Turnout

by

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Summary

Initial field evaluation of one advanced design turnout showed that the major components (e.g. the switch points and swingnose frog) have survived 315 MGT of unit coal train traffic. The turnout is a number 20 size, tangential geometry design, with a swingnose frog. The tangential geometry should reduce maximum lateral forces by lowering the entry angle. The swingnose frog should reduce maximum vertical forces by eliminating a flangeway gap from the running surface. These components have already exceeded the average lives of conventional turnout components in similar service. However, until all major components have been replaced, complete life cycle cost comparisons cannot be made.

Experimental load measurement results show maximum vertical wheel loads of up to 80,000 pounds. At 43 mph, the difference in vertical wheel loads between the 110- and 100-ton cars was about 20 percent or twice the approximately 10 percent static wheel load difference. Maximum lateral loads of 28,000 and 22,000 pounds were measured for the two cars, respectively.

The effect of speed on maximum dynamic loads varied with the particular movement through the turnout. The effect on maximum vertical load is significant, with an average 33 percent increase over speeds ranging from 20 to 43 mph. The average maximum vertical load at the track speed limit (43 mph) was approximately double the static load for the 110-ton car.

These findings are from field tests conducted on the Burlington Northern 's Powder River Division and the Chicago & Northwestern's Powder River Subdivision coal lines (the "joint" coal line) in Wyoming. The data is used as part of the Association of American Railroads Advanced Turnout Evaluation and Heavy Axle Load Revenue Service Evaluation programs.

Suggested Distribution:

Operating/Engineering Department —
- ❑ Maintenance of Way/Planning
- ❑ Track Planning

Research and Development/Test Dept.

Operations Department —
- ❑ Equipment Maintenance

Association of American Railroads
Research and Test Department

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INTRODUCTION AND CONCLUSIONS

Turnouts are the most complicated and one of the most expensive track components. About $98 million is spent annually on turnout maintenance. Improvement in other track components over time has left the turnout as a major consumer of track maintenance resources. While constituting only two percent of the track mileage, turnouts require up to 20 percent of the track maintenance budget.

Preliminary technical analysis of the advanced design turnouts submitted to AAR under the Advanced Turnout Evaluation Project suggested that significant reductions in maximum forces (as compared to standard AREA designs) applied by vehicles traversing these turnouts could be achieved. A report on this is currently in production.

Monitoring the performance of advanced turnouts in track has shown that they do provide the life benefits suggested. To date, they have proven to be viable in terms of maintenance required. No weld repairs and little spot grinding has been required on the test turnout. Complete life cycle cost comparisons must await the replacement of the turnouts or their main components.

The turnout that is the subject of this report, one of four in the AAR project, is a tangential geometry, swingnose frog #20 turnout. The turnout was manufactured by Nortrak-VAE and purchased and installed by Burlington Northern at East Nacco, WY. The location of the turnout is at the end of a section of double track. Traffic is almost exclusively unit coal trains. The facing point moves are the loaded moves through the turnout. Approximately one third of the tonnage makes a diverging move through the turnout.

The annual traffic has been quite high on this line for many years. It was 100-150 MGT/yr in the mid- 1980's; and it is increasing rapidly from about 200 MGT/yr in 1993 to an estimated 240 MGT/yr in 1994. A sample of wheel loads measured on the CNW portion of the traffic showed that approximately 10 percent of the current traffic is in 110-ton cars.

Findings and Conclusions to date include:

- The turnout, its switch points and swingnose frog, has survived 315 MGT of unit coal train traffic. Little maintenanceh as been performed. This frog has already outlived the typical railbound manganese frog in similar service.

- The effect of 36,000 pound wheel loads (the nominal 110-ton car) vs 33,000 pound wheel loads (the nominal 100-ton car) was determined. The nine percent increase in static wheel load results in a 10 to 24 percent increase in maximum vertical loads. The larger increases occurred at higher speeds. Lateral force increases for the 110-ton car ranged from -24 to +87 percent. The largest increases occurred on the diverging moves.

- The effect of speed on vertical loads measured for both cars is relatively linear. For example, at 43 mph, the average maximum vertical load was 96 and 85 percent above the static loads for the 110- and 100-ton cars respectively. Over the range of speeds tested (20-43 mph) the average maximum vertical load increased 35 and 20 percent for the 110-ton and 100-ton cars, respectively.

- The design of the turnout, with tangential geometry and swingnose frog, gives the turnout different performance characteristics as compared to an AREA design. This design reduces lateral forces at the switch points and vertical forces at the frog to levels equivalent to those produced by ordinary track perturbations.

DYNAMIC PERFORMANCE TESTS

In November of 1994 a special test consist made a series of runs across the test turnout at various speeds. The test consist had loaded 100-ton and 110-ton cars with load measuring strain-gaged wheelsets. Exhibit 1 shows the lateral and vertical force vs. distance plots for the lead wheel (stock rail side) of each car on a facing point straight movement through the turnout.

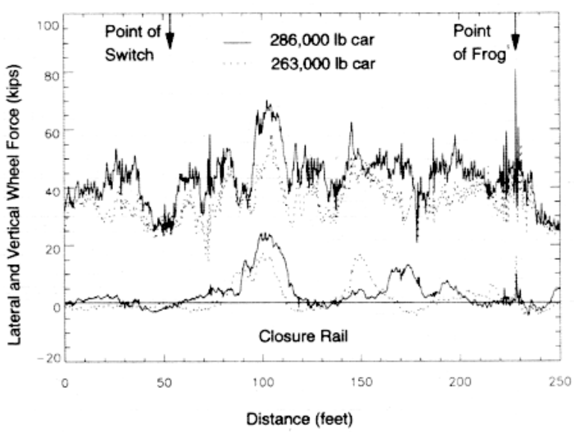

Exhibit 1. Lateral & Vertical Force vs. Distance: Facing Point, Straight @ 43 mph

Exhibit 2 shows the load vs. distance plot for the diverging facing point movement at 43 mph. The large lateral force peaks about 50 feet into the turnout are due to the car entering the curve on the diverging route. The straight move has a similar force peak at about the same distance. We believe that this is due to the dynamic response of the vehicles to alignment and crosslevel faults.

On the straight move, the lateral force drops to near zero after the bump. Whereas, the lateral force on the diverging run remains somewhat higher through the turnout. Here, the higher forces result from the curving forces as well as the track geometry faults on the diverging route.

The vertical force plots show peaks at the same locations as the lateral peaks. There is a load spike at the frog that is similar to those associated with the flange gap in a conventional frog. As one can see from the vertical force plots, the cars are bouncing 50 feet before the turnout and continue through the turnout. They appear to "settle down" past the frog. The two cars behave similarly, but not exactly the same. Differences in performance are probably due to differences in suspension characteristics; the two cars had different types of side bearings. About 180 feet in front of the switch points is a 300 foot ballasted single track bridge spanning Antelope Creek. The stiffness changes in going from bridge to embankment to turnout have caused a chronic track profile and alignment problem here.

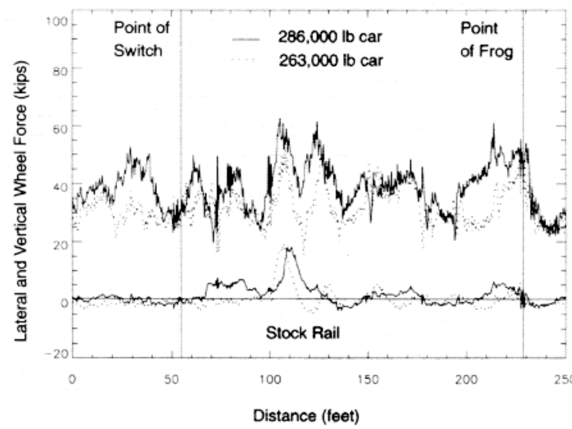

Exhibit 2. Lateral & Vertical Force vs. Distance: Facing Point, Diverging @ 43 mph.

The maximum lateral load for each car on each movement through the turnout at 43 mph is shown in Exhibit 3. The straight moves have lower maximum forces than the diverging moves. The maximum force seen in the facing point straight move is much higher than expected for both cars. The actual forces and relative magnitudes of the other three moves are more in line with model predictions and previous measurements. The large force peak is attributed to the location of track geometry deviations. The 110-ton car is a relatively poor performer compared to the 100-ton car with large increases in the maximum force on the diverging moves.

The maximum vertical loads on all movements at 43 mph are shown in Exhibit 4. Both cars show significant dynamic force on all four movements. The straight moves were somewhat lower (5 percent) than the diverging moves. The 110-ton car had maximum vertical forces that averaged 11 percent higher than the 100-ton car. This is roughly equivalent to the difference in static wheel load between the two cars.

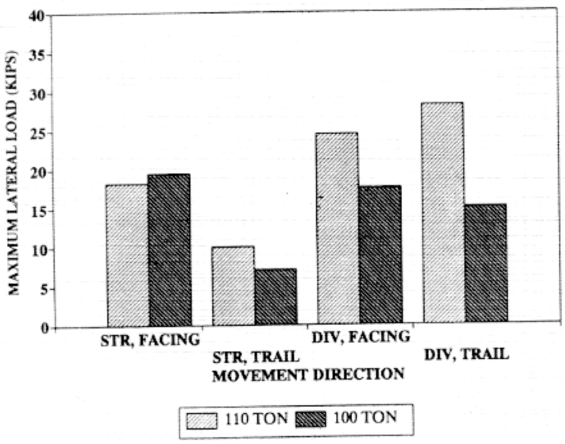

Exhibit 3. Maximum Lateral Loads at 43 mph.

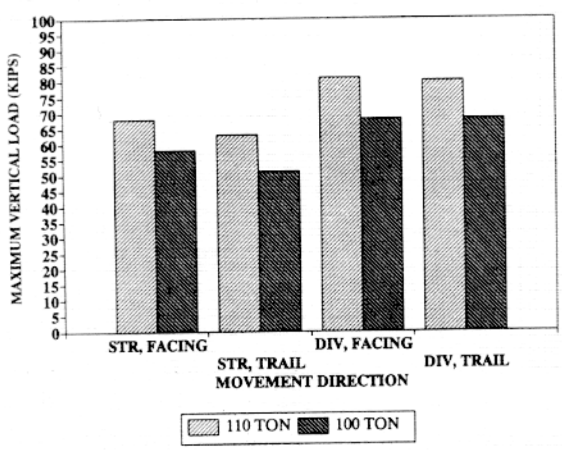

Exhibit 4. Maximum Vertical Loads at 43 mph.

The effect of speed on maximum lateral forces can be seen in Exhibit 5. Each data point represents the average of the maximum values of the four movements through the turnout for each car. The relationship between average maximum force and speed appears to be linear over the range tested.

There is a substantial difference between the maximum forces measured on each movement (as seen in Exhibits 3 and 4). There can also be significant variability in maximum forces measured on repeated runs of the same movement. Thus, the mean value of the four movements provides a better basis for car and speed performance comparisons.

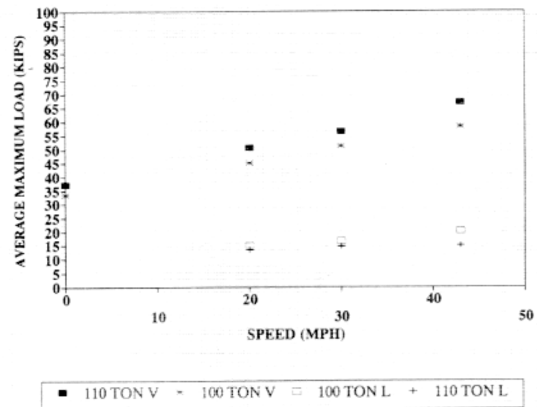

Exhibit 5. The Effects of Speed & Wheel Load on Maximum Vertical & Lateral Loads.

Exhibit 5 also shows the effect of speed on the average maximum vertical wheel loads measured at the frog for each car. The effect is again fairly linear over the range of speeds tested. The maximum load increases about 33 percent for the 110-ton car and 29 percent for the 100-ton car in that range.

ACKNOWLEDGEMENT

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Note: Contact David D. Davis at (312) 808-5851 with questions or comments about this document.