TECHNOLOGY DIGEST

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Tie Conditions Leading to Dynamic Gage Widening Exceptions Under TLV Loads

by Richard Reiff

Summary

Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads, inspected a typical mainline track using the Track Loading Vehicle (TLV) to apply loads of 33 kips vertical and 19 kips lateral. Dynamic gage widening under these loads was measured, marking locations of 1-inch or wider gage widening. Locations where 1 inch or greater wide dynamic gage occurred were visually inspected to document tie conditions.

Locations that exhibited dynamic wide gage of 1-inch or greater under TLV loads were found mostly on curves, and were associated with ties that exhibited one or more of the following characteristics: excessive splitting, spike-killed but plugged, negative cant plate cutting, or hidden tie plate cutting under direct fixation fasteners. Several segments of such track contained ties that had been previously marked for renewal.

During the two-day inspection, approximately 40 locations were marked for follow-up inspection. For this *Technology Digest*, an individual curve is considered a location, whether it contained one or several (2 to 10) separate, distinct segments of dynamic gage widening of 1 inch or more under TLV loads. Results suggest:

- Local knowledge of maintenance history is useful in marking ties for replacement.
- Most locations in curves, where wide dynamic gage was measured, already contained a number of ties marked for replacement.
- Not all locations with marked ties exhibited wide TLV-loaded gage.
- Areas where spikes were broken off in the tie did not have ties with the usual visual indications. Close inspection of spike heads provided limited warning.
- Most locations on curves exhibited more plate cutting on the field side of the high rail, rather than plate cutting on the low rail.
- Sites with elastic fasteners that exhibited wide dynamic gage under TLV loading required close inspection to show plate cutting under fasteners suspending the plate.
- Locations of lower gage restraint capacity on tangent track typically were associated with grade crossings or at lubricator sites where cloth mats inhibited routine tie replacement.

Overall, the areas inspected did not exhibit significant segments of stressed track. Ramifications of high stress that were, however, noted included short, isolated segments exhibiting broken spikes, severe plate cutting, and tie splitting. The source(s) of high loads leading to localized degradation should be investigated, thus allowing measures to be taken that could lead to a reduction in the overall stress state of the track.

Suggested Distribution:

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

Work performed by TTCI Transportation Technology Center, Inc.
a subsidiary of the Association of American Railroads

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INTRODUCTION AND CONCLUSIONS

An evaluation of a typical mainline track was performed by TTCI using the Track Loading Vehicle (TLV) to apply loads of 33 kips vertical and 18 kips lateral.

A 50-mile stretch of a typical wood tie, Class 4 mainline was inspected using the TLV with applied vertical and horizontal loads. This line has 40 MGT (primarily loaded coal traffic) annually. The test team monitored continuous measurements of unloaded and loaded gage.

The TLV can be configured to evaluate vertical track modulus, panel shift, and gage restraint. For this project, the TLV was configured to inspect dynamic gage widening, thus determining what conditions might be created under a vehicle with poor curving performance. Isolated areas of track that may be weak can produce wide gage and could be susceptible to rail spreading, rolling, and subsequent derailment. Data was obtained to determine what tie conditions are associated with weak gage restraint and to determine if present tie inspection procedures are adequate in locating these areas.

The TLV provides production testing by controlled simulation of load environments as may be applied by trains to quantify the dynamic response of track. By applying controlled loads, the amount of gage widening experienced by a passing train can be obtained and measured. Data is displayed on board and is stored for subsequent statistical analysis. [1, 2, 3]

TEST/INSPECTION PROCEDURE

As seen in Exhibit 1, the TLV was configured to mark with a yellow paint stripe those locations where (dynamic) gage under TLV test loads exceeded 1 inch (57.5 inches). The division engineer, a local track engineer, and a TTCI engineer followed the TLV in a hi-rail truck and inspected each marked site to determine the cause for this dynamic gage. In addition, the host railroad dispatched a stand-by track crew to those locations that warranted repairs. Inspection consisted of walking the suspect area, observing tie and fastener conditions, measuring unloaded gage, and striking fasteners with a hammer to determine if broken spikes were present.

While the TLV proceeded at 15 to 20 mph, a railroad representative would advise the hi-rail crew by radio of the approximate location of the track segments where gage under TLV test loads exceeded 57.5 inches. Multiple sites around a curve were treated as one location. However, each site was inspected on foot to determine cause and remedy. The TLV was operated for five days.

Exhibit 1. Yellow Paint Mark at Site Exhibiting a Broken Spike and Field Side Cant

RESULTS

The results presented here summarize two days of inspection, but are representative of the entire inspection.

Approximately 40 locations were marked, most of which were associated with curves of 4 to 8 degrees. All marked locations were on wood ties, most of which used cut spikes and 18-inch plates. Most tangent locations used two spikes per plate, while most curves were equipped with five spikes per plate (three gage and two field). A limited number of locations were on tangent track or used direct fixation (DF) fasteners.

With a few notable exceptions, most locations where dynamic wide gage under TLV loads was marked also contained a number of previously marked ties intended for removal during an upcoming tie program. However, the corollary did not always hold — when a wide dynamic gage site was inspected, the adjacent, unmarked areas usually exhibited similar tie conditions. In addition, some sections marked by the TLV as weak contained "blacked out" ties, which were previously marked but eliminated from the maintenance program and not replaced. This suggests that the tie inspectors are performing a credible evaluation of tie conditions in most areas by selecting the least strong ties within a group of ties with similar appearance. Areas where this was not true included ties that were not previously marked and were shown to have been re-spiked. In these cases, the tie plugs did not provide restraint sufficient to prevent 1-inch diameter dynamic wide gage under the TLV. The track had not been re-gaged and no significant damage or poor tie condition was observed. Local knowledge of maintenance history could help an inspector decide to mark such ties.

Specific Causes for Wide Dynamic Gage

Many locations exhibiting wide dynamic gage under

TLV loads were located on curves where rail wear was contributing at least 1/2 inch to the unloaded wide gage. Unloaded gage in these areas was generally 0.5 to 0.75 inch wide. Thus, under loading, only an additional 0.25-0.5 inch of movement was needed to exceed the 1-inch wide gage. In these cases, measurement of 1-inch wide gage under TLV loadings might not indicate any lessening of gage restraint capability.

In curve areas, the degradation mode most commonly noted was high rail, negative cant plate cutting (Exhibit 1). In these areas, the field side of the plate could be seen digging into the tie, while for the most part, the low rail did not exhibit such cutting. It was suggested that this high rail cutting was due in part to high lateral loads being generated by the two to three unit helpers operating in full throttle mode that are used by every uphill loaded coal train over this territory.

A few isolated areas of dynamic TLV gage widening over 1 inch were discovered in tangents. These were associated with grade crossings and lubricator sites (Exhibit 2). Ties may not have been properly visually inspected at these locations because the roadway or lubricant absorption pads cover them. In the case of wayside lubricators, evidence of recent tie renewals could be seen each side of the lubricator. This suggests that the inconvenience and difficulty of removing the lubricator and its associated equipment may have caused these sites to not be handled by production work gangs.

Exhibit 2. Yellow Paint Mark on Tangent Track at a Wayside Lubricator Location

Direct fixation fasteners offered an unusual situation. At first glance at locations identified by the TLV, the ties and plates appeared to be in excellent condition, with no cutting or negative cant. Closer examination revealed that the ties were cut significantly (Exhibit 3). Plates were actually suspended over a depression in the tie by the action of the clips. A passing train would push the plate into the cavity and often would result in the wide gage. Only close inspection, often including the investigation of unused holes, would reveal this condition.

Exhibit 3. Elastic Fastener on an Open Deck Bridge Exhibiting Hidden Plate Cutting

Exhibit 4 summarizes the number of locations for each of the major tie conditions determined to cause wide gage. Note that many sites had mixtures of causes, especially re-spiked ties. Only one site was documented as being associated solely with re-spiking and no other degradation mode.

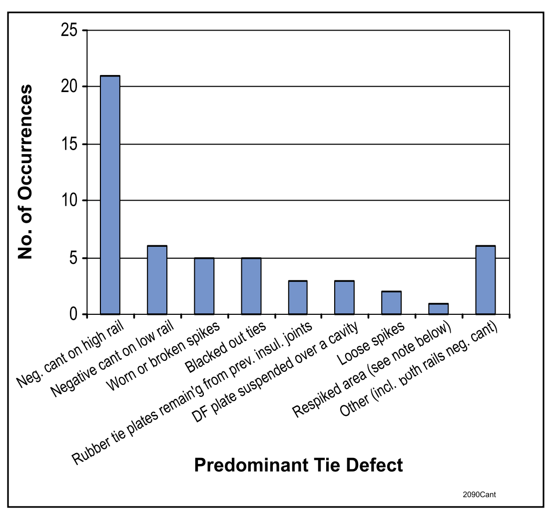

Exhibit 4. Number of Occurrences for Predominate Tie Conditions Leading to Wide Loaded Gage

Data suggests that most of the gage (TLV loaded) over 1-inch wide marked by this TLV run was associated with negative tie plate cant. These sites contained tie plates where the field side exhibited significantly more cutting than the gage side. In most cases, the gage side of the plate exhibited no visible cutting; thus, overall rail seat degradation was not the issue. This suggests that high lateral loads may have been the predominate factor. Additional evaluations to determine root causes and solutions for these higher loads are suggested for resolving average stress to the track structure.

SUMMARY

TLV loading values and marking of gage over 1-inch wide correlated well with sites previously marked by track inspectors. Several locations of blacked out ties (ties previously marked but not replaced) still exhibited weaker gage restraint, suggesting that the tie inspectors had properly identified these ties as candidates for renewal. The DF fasteners can "hide" poor tie conditions by lifting plates out of depressed areas, causing these ties to be skipped unless appropriate inspections and examinations are conducted or devices like the TLV are used. Inspections that skip ties due to visual obstructions (grade crossings and lubricator pads) can miss weak areas.

RECOMMENDATIONS FOR FUTURE WORK

Most of the wood-tie railseat degradation observed in this territory was from high rail negative cant rather than low rail cant/cutting. This pattern is not typically seen on other mountain territories where upgrade freight trains are operated at well below balance speed, and low rail tie plate cutting is a major issue. Two obvious causes for the excessive high rail plate cutting include:

- Many trains operating with high balance speeds below FRA maximums but above equilibrium;
- Pushers applying forces, thus causing high outward lateral loads.

Only a few locations inspected also contained significant low rail surface degradation. Therefore, simply reducing speed may lead to increased surface degradation to the low rail. The potential of high lateral forces from use of two to three rear-end helpers should be investigated.

A wayside instrumented site to measure lateral loads could evaluate current operations in various scenarios: using fewer helpers, using helpers operating in throttle positions less than Run 8, and operating trains at slower speeds. The information could be used to determine where lateral loads are coming from, and to revise operating conditions to optimize track degradation and costs.

Future plans include using the TLV to re-examine this track in order to evaluate the effectiveness of repairs. Additionally, this will provide information of further strength degradation of track in this area that is not subject to a tie renewal program.

References:

1. Singh, "Revenue Track Gage Widening Tests Using the Track Loading Vehicle," Report R-886, Association of American Railroads, Washington, D.C., August 1995.

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