CONCRETE TURNOUT TIE DESIGN FOR LIGHT RAIL TRANSIT

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ABSTRACT

Portland TriMet opened its Interstate Max (IMAX) line for revenue service May 1, 2004. This line marks the first of its kind where concrete turnout ties were optimized specifically for a light rail transit operation. These turnout ties are installed at wider than traditional spacing and are also shorter in height. These changes allow for a cost effective design without sacrificing track structure performance, while simultaneously providing compatible track stiffness with adjacent concrete tie track.

Construction of these turnouts was simplified since the geometry was preset except for the tie spacing. Even though the ties are heavier than wood, the contractor was able to install the concrete turnouts more efficiently and proper gauge and line was easier to control.

INTRODUCTION

TriMet currently operates 44 miles of track between Gresham in the east, Hillsboro in the west, the Expo in the north, and the Portland International Airport. The original line to Gresham utilized wood ties and wood turnout ties. The extension to Hillsboro and the extension to the Airport utilized concrete ties in open track, but wood ties in all turnouts (see figures 1). For the Interstate MAX Light Rail Project, TriMet installed 11 No. 6 and No. 8 concrete turnout tie sets that were specifically optimized for transit use. Test trains began running on this line in July, 2003 and the line opened for service May 1, 2004.

Although other transit agencies have utilized concrete turnout ties, the ties have always been similar in height and width as those used on freight railroads and also have been typically spaced at standard wood tie turnout spacing (see figures 2, 3, and 4). A different approach was taken for the IMAX project turnout ties, the tie size and spacing was optimized to more closely match the light rail load environment.

TRANSIT OPTIMIZED DESIGN

Light rail loading is significantly less than Class 1 freight loading because the wheel loads are lighter and the wheel maintenance is more tightly controlled. The maximum expected static freight wheel load is between 33,500 and 39,000 pounds, whereas the maximum expected static light rail wheel load is around 13,000 pounds. Since most light rail lines have a captive fleet and aggressive wheel maintenance for out-of-round and flat wheels to ensure quality of ride, dynamic impact loading is less of an issue than can occur on freight tracks.

Whether standard ties for open track or turnout ties, each must be designed to withstand the load environment. For standard ties, light rail track structure has been optimized over the years such that the typical design now uses 115 RE rail on concrete ties spaced at 30 inches. As further optimization, the ties are also typically designed with less bending strength than is used for freight due to the lighter static and dynamic light rail wheel loading. Transit agencies nationwide have found that track built in this manner using standard concrete ties provides consistent and dependable track gauge, excellent stray current isolation, and improved ride quality. Turnout tie light rail track structure has historically not been optimized. It has been either wood spaced between 18 and 22 inches (see figures 5 and 6) or freight depth concrete also spaced between 18 and 22 inches (see figure 4).

Whether wood or concrete, the tighter spacing causes a stiffness difference between the turnout ties and adjacent standard ties. The tighter spacing also requires more ties, special trackwork plates, and rail fastenings per turnout than if the ties are spaced further apart (see table 1). The optimized turnout tie for transit use is spaced at the 30 inch spacing similar to that used for standard ties (see figures 7, 8, and 9). The cross section of the optimized turnout ties has also been made similar to that of the standard ties without sacrificing the AREMA Chapter 30 required bending strength (see figure 10). This is accomplished by manufacturing the ties with more prestress than is used for standard transit ties. The resulting turnout ties provide adequate flexural strength, closer matched track modulus to open track than with previous designs, and reduced tie weight versus previous concrete turnout designs for transit.

INSTALLATION

Two contractors; Stacy and Witbeck, Inc. and MRC COMPANY installed the turnout ties on the IMAX line. The track construction foreman of both companies reported that this was their first experience installing concrete turnout ties. The contractors were furnished shop drawings of the concrete tie layouts showing the tie numbering and spacing. Installation of the ties and turnout material was scheduled based on previous experience with wood ties. Concrete turnout tie and turnout installation progressed faster than scheduled for both contractors. Both contractors indicated they preferred the concrete tie turnout installation over timber ties. The advantages they pointed out include the following:

- No creosote burns reported by employees and no creosote stained clothing and gloves.
- The job site was not as noisy because air compressors and spike drivers were not used as often.
- Installation was quicker because the ties did not require detailed pre-drilling and plate placement.
- Once the ties are properly spaced, there is little chance for error. Tie plates are never spiked so close to the edge of a tie that it splits out. The turnout material sets in place easily and is clipped to the ties.
- All concrete ties were straight and uniform. Plates have full bearing with the rail base. No warped ties to deal with.

The follow on signal contractor, Mass Electric, installed power switch machines on the concrete headblock ties (see figures 11 and 12). Coordination with CXT and Mass Electric regarding the switch machine mounting details occurred as part of the design of the concrete headblocks. Inserts were installed to match the hold-down holes on the switch machine. The elevation of the machine mounting surface was depressed from the top of the concrete tie gauge plate bearing surface. The concrete headblocks provided an easier installation of the switch machine. Advantages reported by Mass Electric include the following:

- No wood tie adzing to get proper elevation and uniform bearing surface.

- Concrete headblocks provide a cleaner work environment, no creosote stains.
- Bolting machine to tie does not require excavation beneath the tie for fastening nuts and bolts.

MAINTENANCE

Although most of the original wood turnout ties on the TriMet system remain in good condition, some have cracked and weathered to the point that they will need to be replaced in the near future. A recent power switch installation project in the yard resulted in several wood tie headblocks that needed replacement due to cracks in the switch machine mounting area. With concrete turnout ties, problems with loose spikes or spike killing are avoided.

STRAY CURRENT ISOLATION

In 2002 TriMet received the "Revenue Utility Stray Current Study" on the Airport Extension Project. This line was constructed with concrete tie track and wood turnout ties. The rail is used for the negative return of current to the substations. Stray current testing found higher levels of stray current in the turnout areas and attributed that to the timber turnout tie construction. The report recommended installation of elastomeric pads and insulated screw spikes (see figure 13) or an alternative of periodically removing and inspecting spikes for deterioration from corrosion.

The Interstate MAX line has also been tested for stray current. The track that includes the concrete turnout ties tested well above our rail to earth criteria. The electrical isolation between rail and earth in a concrete turnout tie is provided through elastomeric pads and insulated plate anchor bolts for plated ties within switch and frog areas (see figure 14) and through standard resilient fastener assemblies for all of the remaining ties (see figure 15). This isolation has proved to be superior to TriMet's former design of spiking turnout plates to wood turnout ties.

SUMMARY AND CONCLUSIONS

Optimized concrete turnout tie sets are a cost competitive and effective solution for light rail turnouts. Expectations are that train movement from mainline standard concrete tie track to concrete turnout ties will remain smooth due to the uniform track stiffness through the transition area. It is also expected that the concrete turnouts will also provide greater longevity and require less maintenance than wood turnout ties.

TriMet has been operating light rail trains for 18 years. Although the concrete turnout ties on the IMAX extension are a new installation, the turnout line and grade has remained good and the ride over the turnouts is smooth.

The ties installed on the IMAX extension have met or exceeded all expectations in providing matched track support, aesthetics, constructability, stray current isolation, and ride quality. The transit optimized concrete turnout tie has been adopted as a TriMet track design standard for all future new track construction.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Stacy and Witbeck, MRC COMPANY, and Mass Electric for their contributions regarding installation.

REFERENCES

1. TriMet's 2002 "Revenue Utility Stray Current Study".

Figure 1 – Wood turnout ties within standard concrete tie track

Figure 2 – Previous concrete turnout ties for transit at tighter spacing

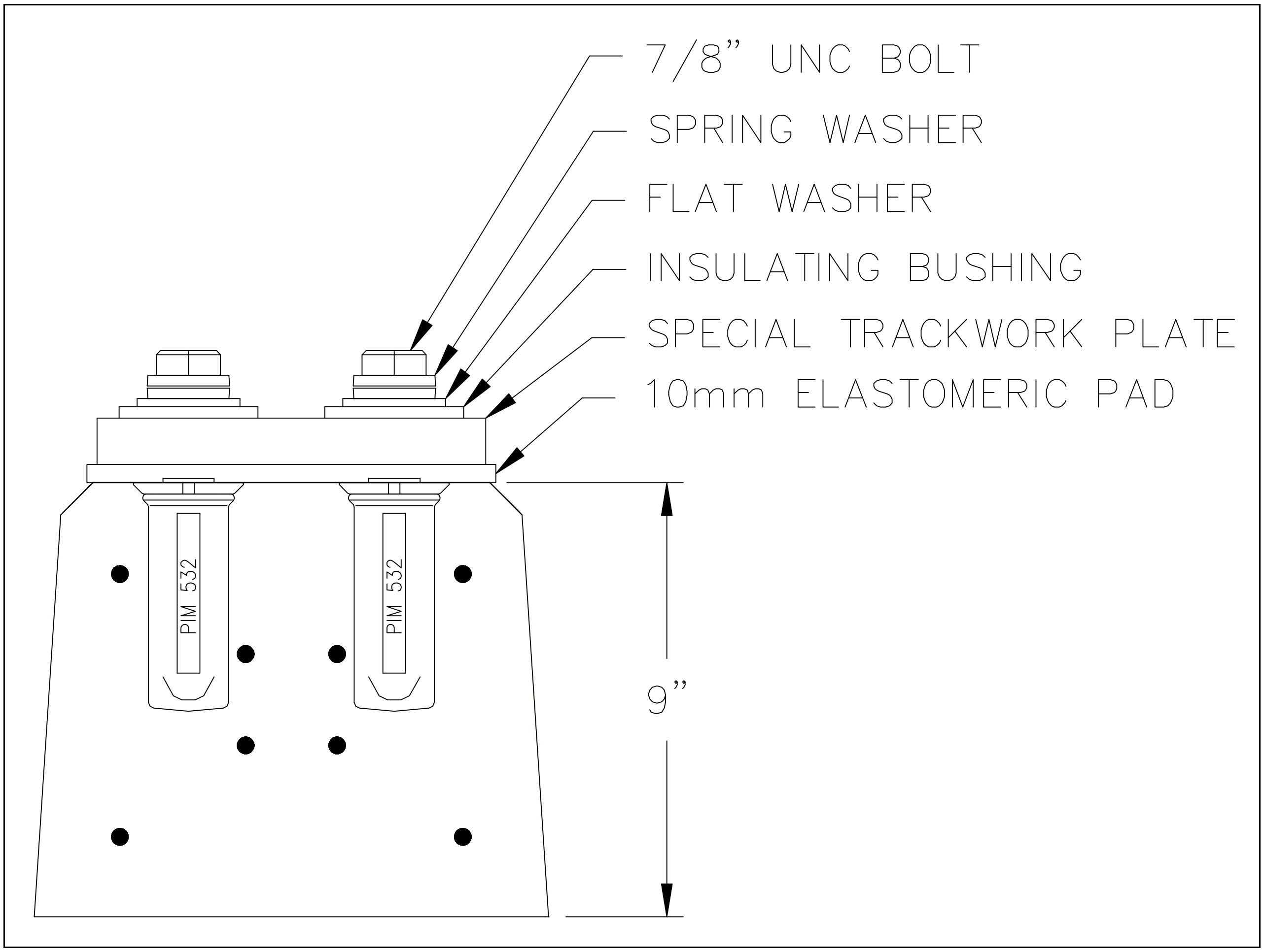

Figure 3 – Historically used freight depth turnout tie cross section

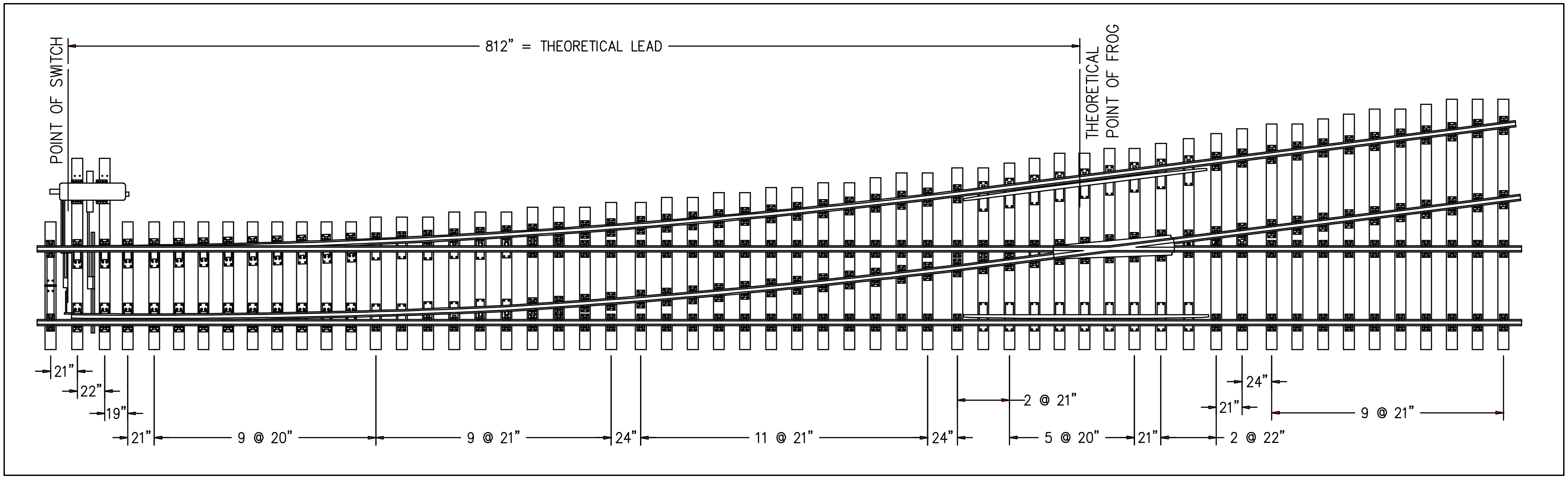

Figure 4 – Historically used concrete turnout tie spacing and layout

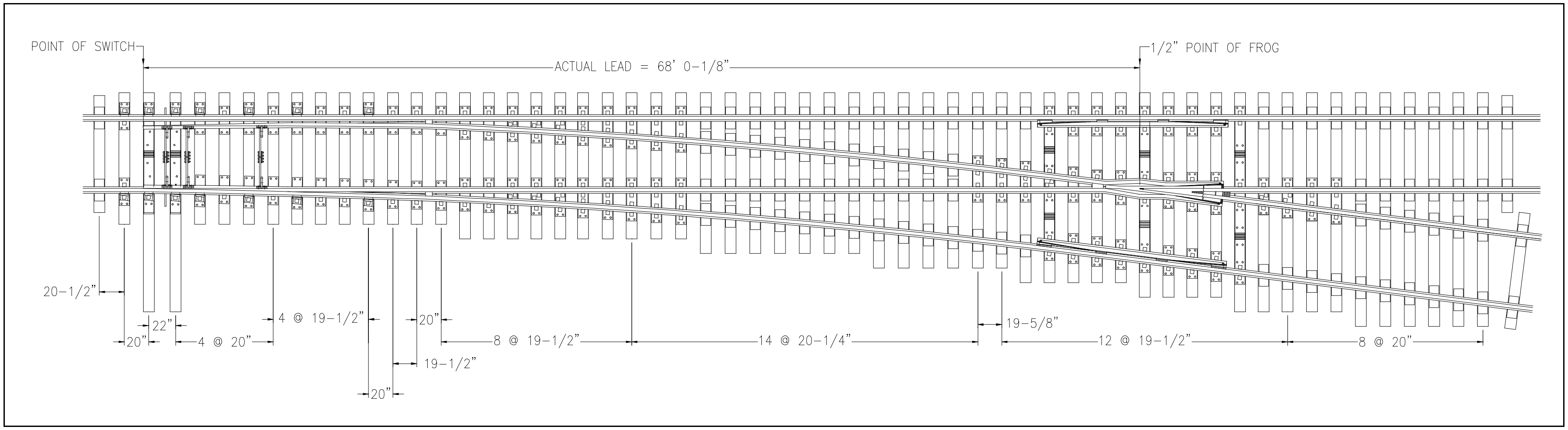

Figure 5 – Typical No. 8 turnout wood tie spacing

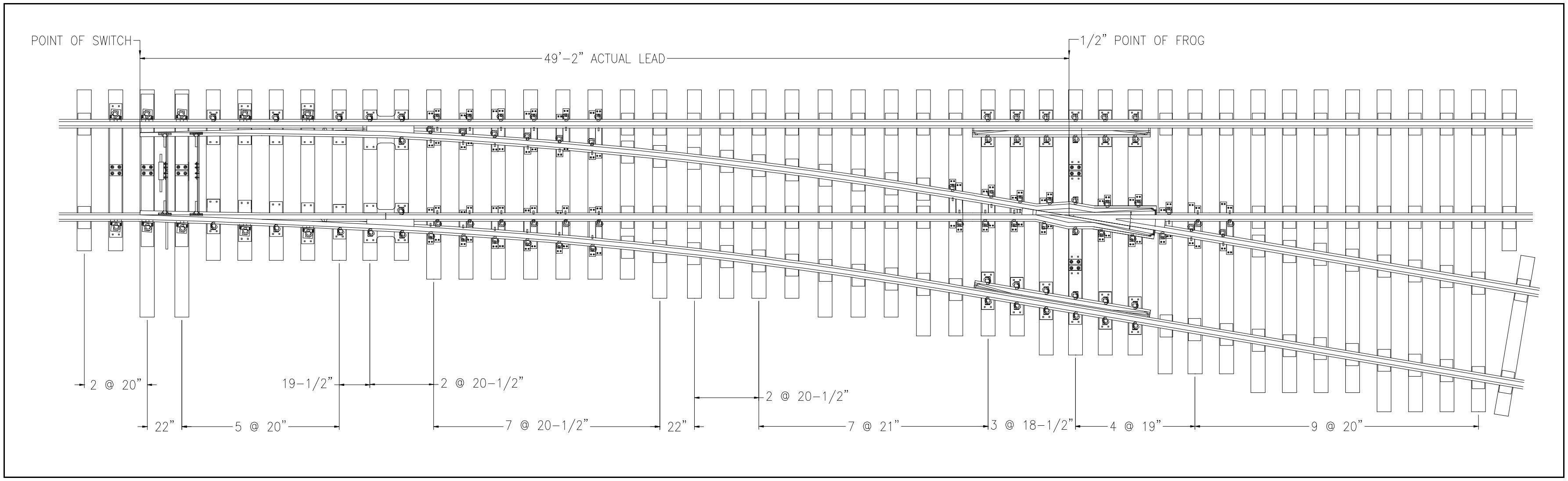

Figure 6 – Typical No. 6 turnout wood tie spacing

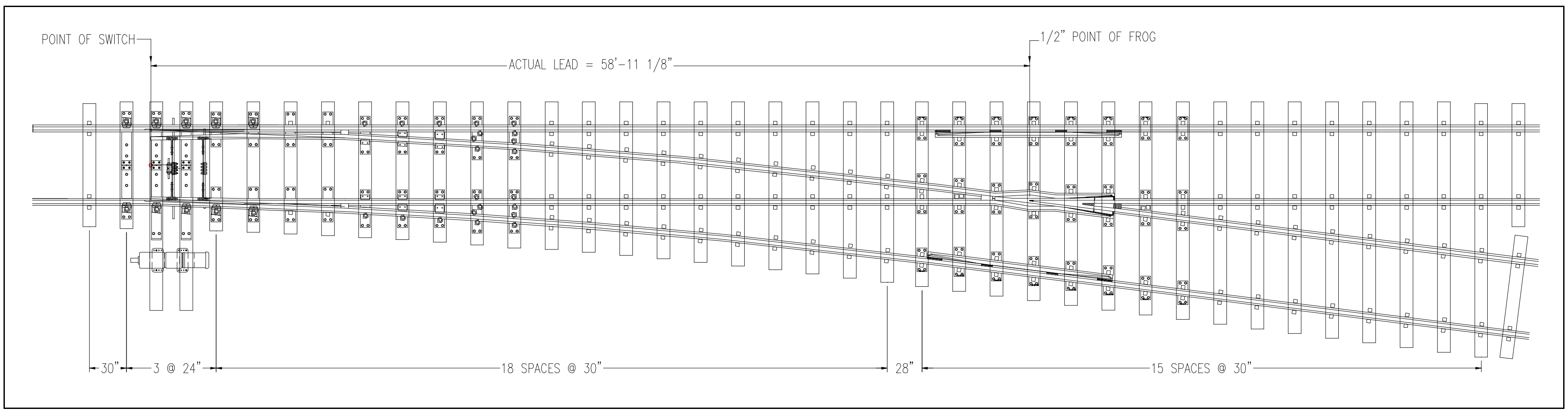

Figure 7 – Optimized No. 8 transit concrete turnout spacing and layout

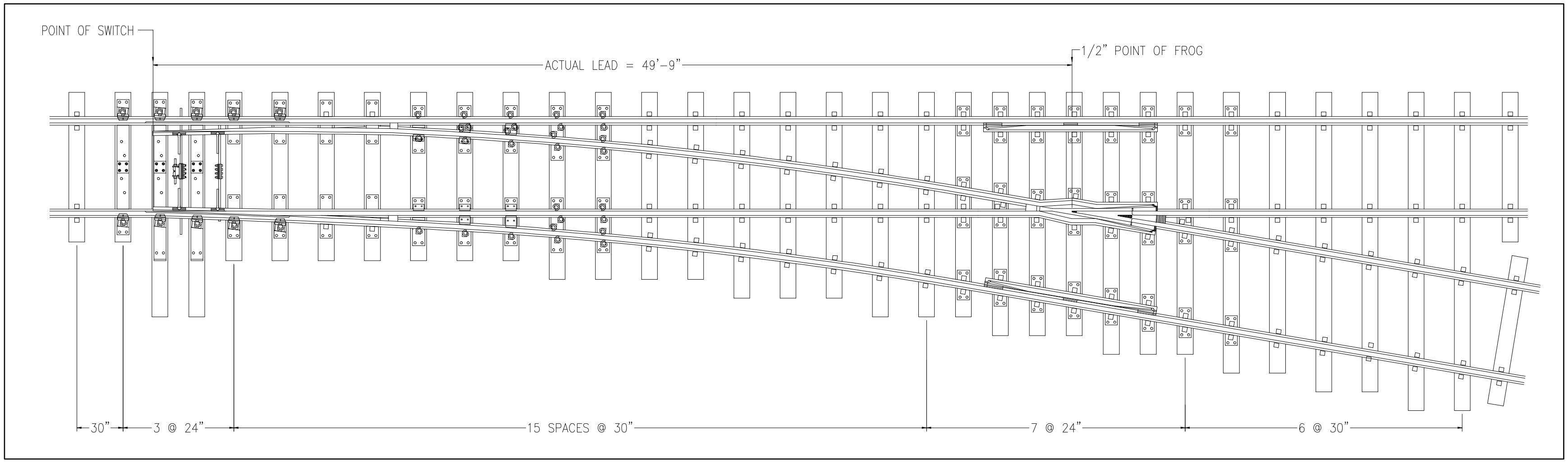

Figure 8 – Optimized No. 6 transit concrete turnout spacing and layout

Figure 9 – RH No. 6 transit optimized concrete turnout tie set

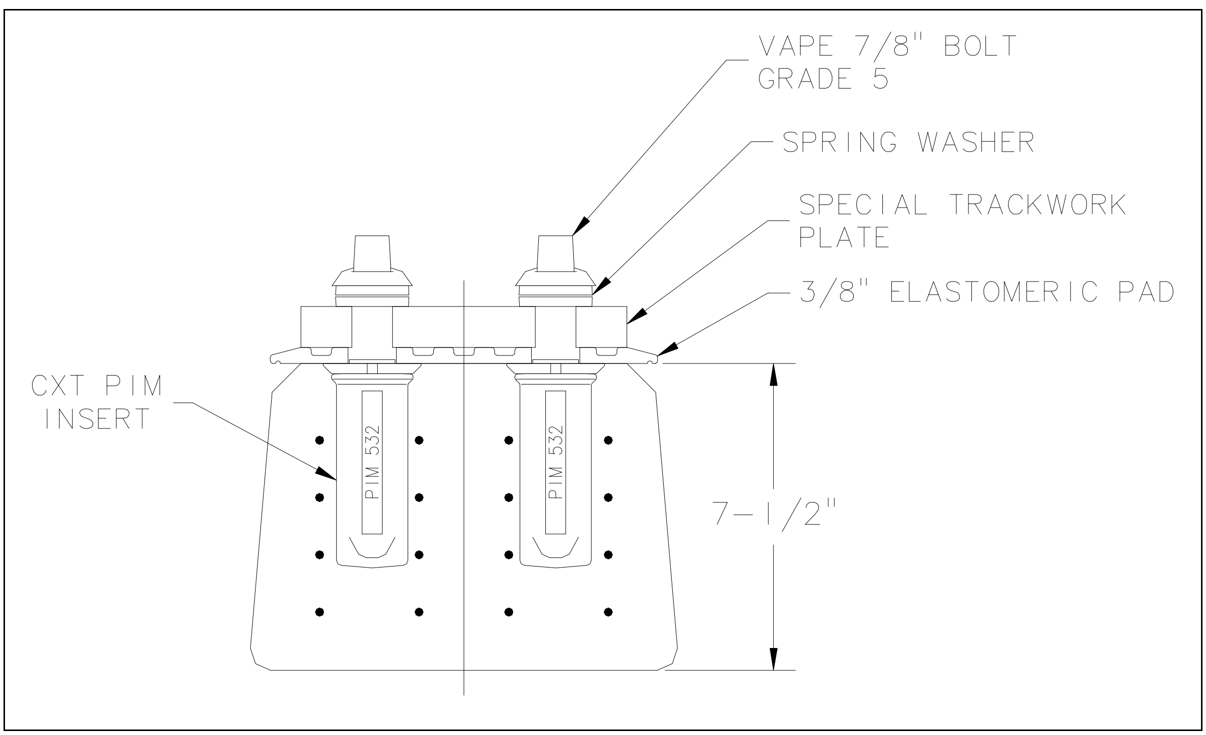

Figure 10 – Transit optimized turnout tie cross section

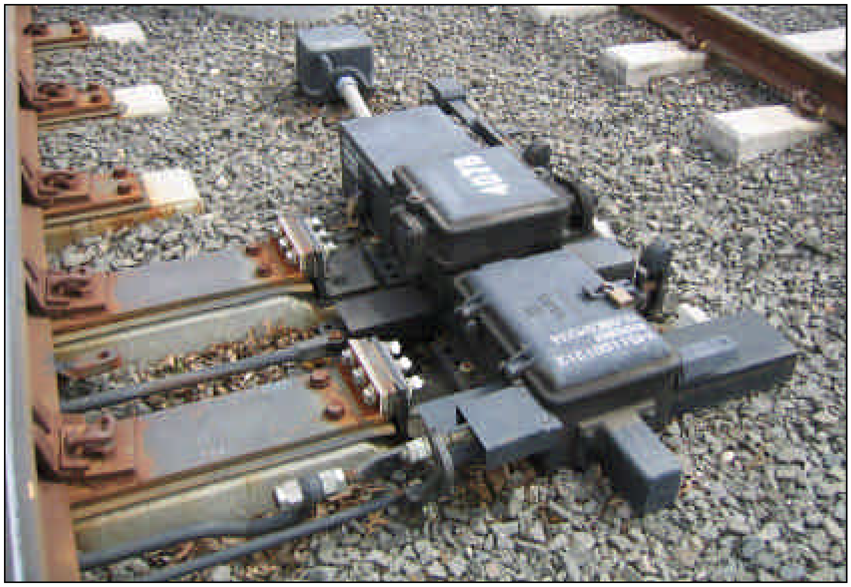

Figure 11 – Headblock ties with switch machine installed

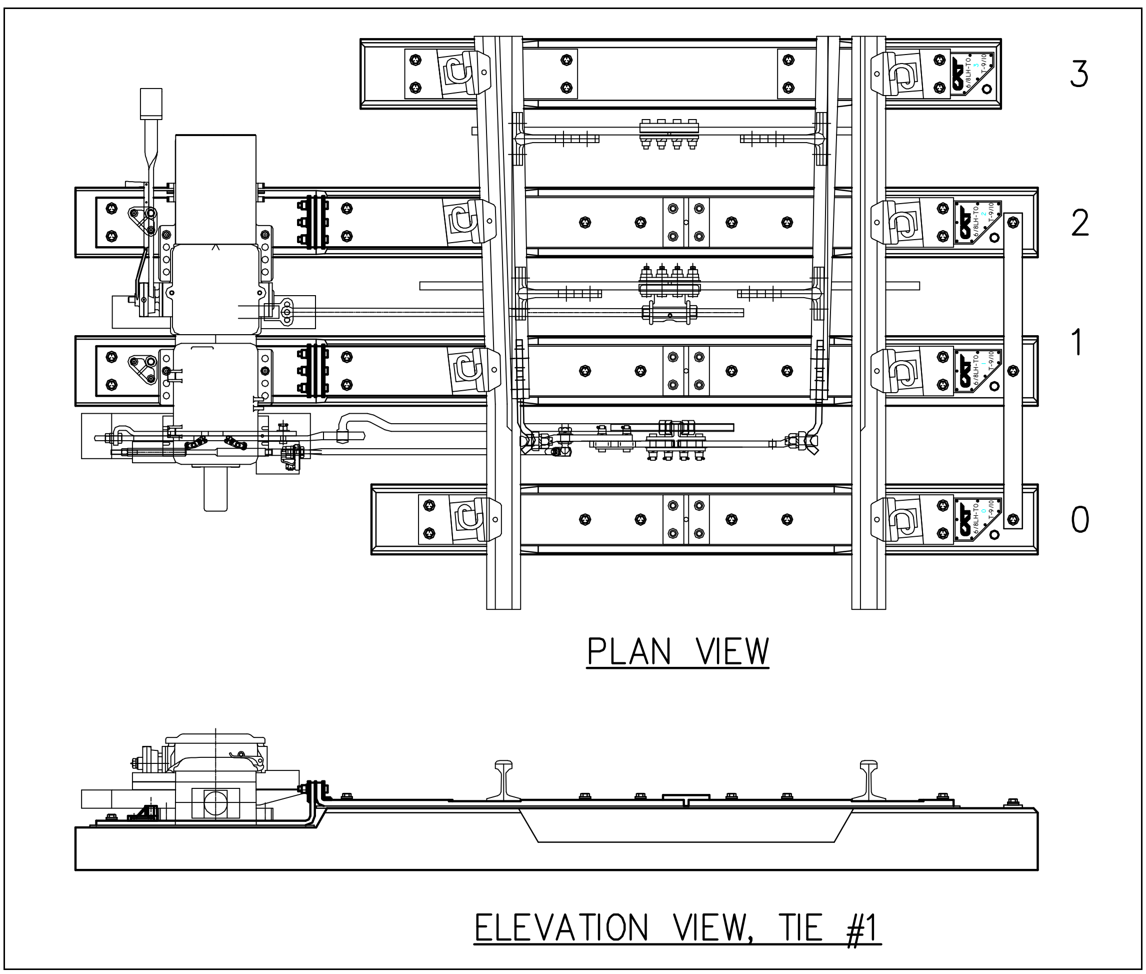

Figure 12 – Headblock ties customized for switch machine for easy installation

Figure 13 – Fastening system on wood ties used for isolating stray current

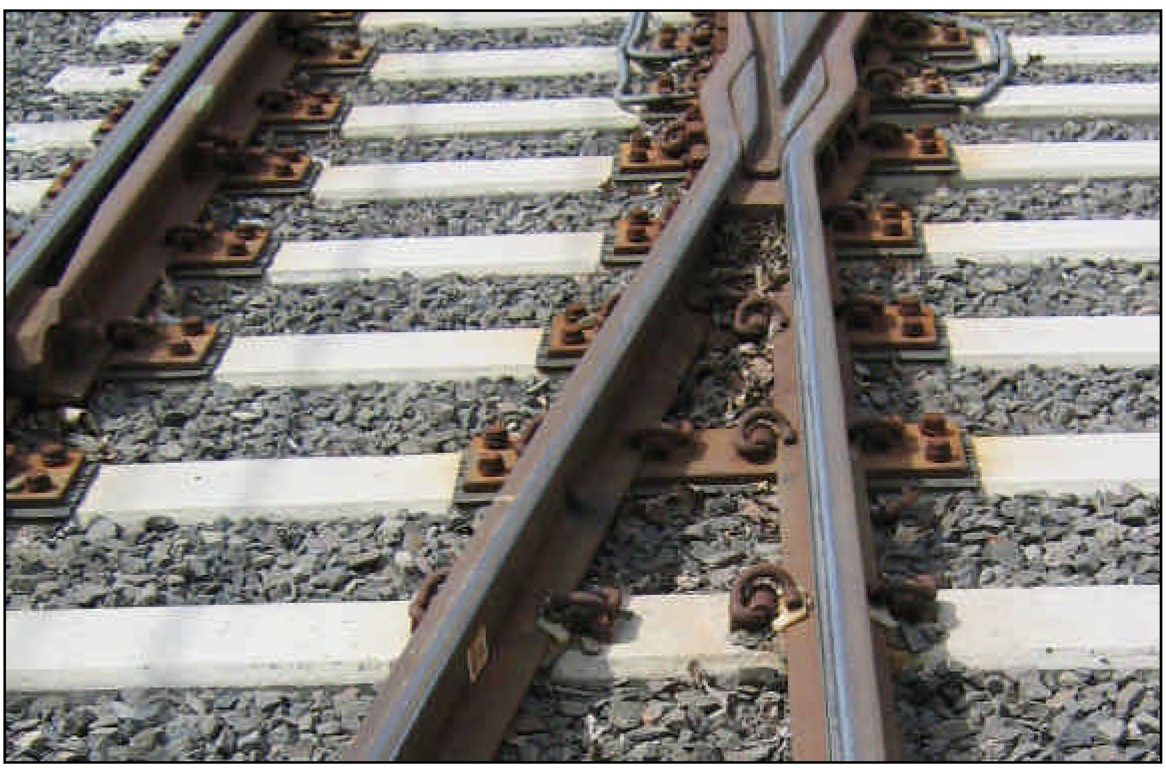

Figure 14 – Example fastening systems on plated concrete turnout ties

Figure 15 – Example fastening system on non-plated concrete turnout ties

	No. 6 Wood	No. 6 Conc	No. 8 Wood	No. 8 Conc
Total Tie Footage	541 LF	408 LF	679 LF	465 LF
Qty switch and frog plates	51	45	80	45
Qty of standard rail fastening assemblies	80	48	82	72

Table 1 – Comparison of quantities for typical wood Vs. transit optimized design