TECHNOLOGY DIGEST
Timely Technology Transfer

Two Standard-Component Crossing Diamonds Tested Under HAL Traffic,

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TD 93-005

Summary

Railroad crossing diamonds are a major maintenance concern of railroads. Crossing maintenance items include welding and grinding of running surfaces, component failure, loss of track geometry, and loss of rail fastener restraint. To date, two crossing diamonds have been tested at the Facility for Accelerated Service Testing (FAST), Transportation Test Center, Pueblo, Colorado. These tests indicate that standard-component crossings suffer tremendous damage under Heavy Axle Load (HAL) traffic. It is anticipated that more crossings will be tested as warranted by the results of these tests.

The first crossing was an 89-degree diamond with manganese steel frog inserts. It survived only 1.9 million gross tons (MGT) of HAL traffic before failing due to excessive batter and geometry loss. A batter rate of about 1/8-inch per MGT was observed on the flangeway wall of one of the manganese steel insert castings.

The second crossing was a 62-degree three-rail bolted diamond that was removed from track after 4.6 MGT of HAL traffic because of rail end damage due to traffic and repeated repair welding. There was not a significant loss of track geometry under this crossing compared to the 89-degree crossing. It is likely that the crossing angle has a significant influence on this behavior.

More testing is recommended using premium-component crossings. Tests of manganese insert crossings should include use of explosion hardened castings and high-integrity castings. Testing is also recommended to determine the effects of factors such as rail hardness, tie support, and crossing angle.

Association of American Railroads
Research and Test Department
August 1993

INTRODUCTION AND CONCLUSIONS

89-DEGREE MANGANESE STEEL INSERT CROSSING – PERFORMANCE RESULTS

The 89-degree manganese insert crossing was subjected to 1.9 MGT of HAL train traffic at FAST before being removed from track. The crossing battered at a very rapid rate. Vertical track geometry degraded rapidly as well. The train operating crew reported a very rough ride through the diamond. After the equivalent of only about two days of operation over the crossing, train traffic was stopped and the diamond was removed from track.

Exhibit 1 shows the excessive amount of batter and metal flow, on both the insert castings and the wing rails, after 1.9 MGT of 39-ton axle load traffic. The batter rate was about 1/8 inch per MGT. Exhibit 2 shows that the plastic deformation and metal flow resulted in a narrowing of the cross-direction flangeway to less than the American Railroad Engineering Association (AREA) allowable. The deformation included yielding of the manganese steel casting walls, as measured using strain gages applied at various locations on the castings. This indicates that more than just a harder casting surface is necessary to withstand HAL traffic. In addition, there was a significant loss of vertical track geometry, as the crossing settled with accumulating tonnage.

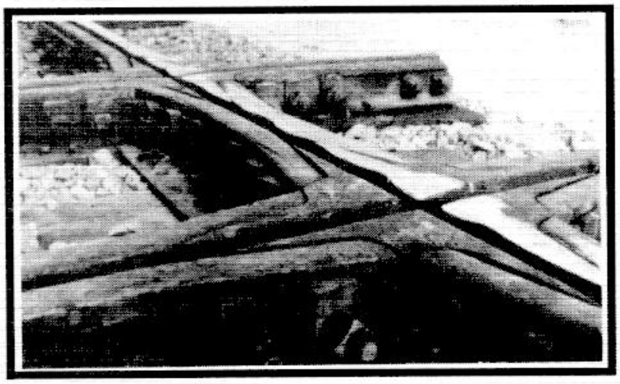

Exhibit 1. 89-Degree Crossing after 1.9 MGT of HAL Traffic

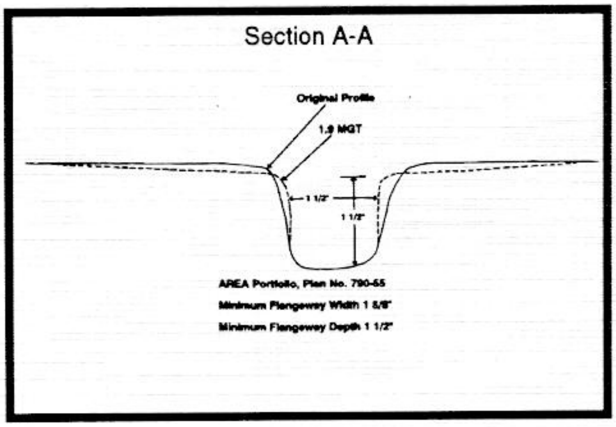

Exhibit 2. 89-Degree Crossing Profile after 1.9 MGT of HAL Traffic

Given the extent of the damage to both the castings and the wing rails, and the rapid rate at which it occured, it was deemed impractical and prohibitively expensive to attempt to repair the crossing and maintain it in track for any length of time.

62-DEGREE THREE-RAIL BOLTED CROSSING – PERFORMANCE RESULTS

The 62-degree crossing was subjected to 4.6 MGT of HAL traffic at FAST before being removed from track. The reason for removing the diamond from track was excessive damage to the rail ends at the gaps in the crossing. As might be expected, the rail ends downstream of the gap suffered the most severe damage after a day of train operation in one particular direction. Exhibit 3 shows a damaged rail end after 4.6 MGT of HAL traffic. Notice the extensive plastic flow and cracking. The cracks went so deep that very little of the original railhead material would have been left if the cracks were ground. Perhaps this rail end might have lasted longer if train operations were stopped before the damage had progressed this far, and a repair could still be made.

The rail ends at the crossing gaps required frequent repairs, particularly the downstream ends. Most of the damage was in the form of plastic flow which needed to be ground off. Weld material was then used to build up the surface.

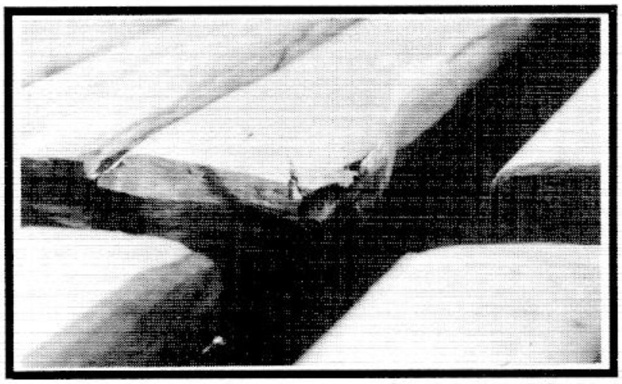

Exhibit 3. Crossing Rail End after 4.6 MGT of HAL Traffic

There was little loss of track geometry over the diamond as tonnage was accumulated. The train operating crew reported no noticeable ride problems or geometry degradation through the diamond.

COMPARISON

In comparison to the 89-degree manganese steel insert crossing, the 62-degree three-rail bolted crossing performed much better. There may be several reasons for this. First of all, the rail surface of the 62-degree crossing was much harder, with an average hardness of about 350 Brinell as compared to about 280 for the manganese castings and 300 for the wing rails of the 89-degree crossing. The harder rail prevented corrugations from developing and propogating rapidly as occurred in the 89-degree diamond. Secondly, the three-rail bolted crossing design has a smoother running surface with no transitions, whereas, the manganese insert design includes four transitions between wing rails and castings per running rail. The only rail surface anomalies on the mainline route of the three-rail design are the gaps at the frog points. Thirdly, the crossing angle was almost certainly a factor. In a 62-degree crossing, only one wheel of a wheel set negotiates a rail gap at a time, while in an 89-degree crossing, both wheels of a wheel set negotiate gaps nearly simultaneously. Lastly, the timber work was different for the two diamonds. The more continuous support of each running rail provided for the 62-degree diamond may have helped in maintaining a good rail surface condition. Because of the many differences between the two diamonds, it is not possible to differentiate the extent of each of these effects without further testing.

89-DEGREE MANGANESE STEEL INSERT CROSSING – DESIGN AND INSTALLATION

The 89-degree crossing diamond was donated by the Atchison, Topeka, and Santa Fe Railway Company (ATSF). The diamond was constructed with 133 RE rail and manganese steel inserts by the Conley Frog and Switch Company. The insert castings were not explosive depth hardened. The crossing was designed for installation at Bonner Springs, Kansas, where ATSF tangent track crossed a 3-degree curve on the Union Pacific Railroad. The crossing angle is 89 degrees, 20 minutes. The design follows AREA Plans No. 700F-80, 746-82, and 749-73. The ATSF abandoned their line prior to installation of the new diamond, making the unused crossing available for testing.

The installation at FAST followed the manufacturer's recommendations. The crossing was designed with the intent of the 3-degree curve route having heavier traffic than the tangent route. Ties are ordinarily laid in the direction of the heavier traffic; however, only the tangent route of the crossing could be installed at FAST, so the ties were perpendicular to the direction of traffic. The crossing was installed on the manufacturer's own plates with cut spikes.

The diamond was installed with bolted joints into track with 133 RE rail, as intended by the manufacturer. The rail surrounding the diamond was continuously welded. The ballast section had 12- to 15-inch shoulders, 2:1 slopes, and cribs full to the tops of the ties. The ballast was a mixture of granite, traprock, and slag.

Trains were run only in two of the four possible directions of traffic to which the diamonds would normally be exposed due to track configuration at FAST and no crossing track.

62-DEGREE THREE-RAIL BOLTED CROSSING – DESIGN AND INSTALLATION

The 62-degree crossing diamond was donated by CSX Transportation. This diamond was constructed by the Conley Frog and Switch Company using Bethlehem 136 RE fully heat-treated rail. The steelwork closely follows AREA Plans No. 700F-80 and No. 701-80. AAR personnel performed the timber work following the AREA plans. Exhibit 4 shows the crossing installation.

This crossing is a three-rail bolted frog type. There are no manganese castings. According to the AREA manual, this crossing design is recommended for use where speed does not exceed 60 mph and annual tonnage does not exceed 10 MGT.

The crossing was originally installed at Sampson City, Florida, where CSX tangent track crossed a tangent on the Norfolk Southern (NS). The crossing angle is 62 degrees, 14 minutes. The diamond was oriented with the CSX as the line of heavier traffic (main line) and the NS as the branch line. It was in service for approximately 2 years before the NS abandoned their line, making the crossing unnecessary. Revenue service tonnage over this crossing was about 14 MGT total on the CSX and less than 1 MGT total on the NS. Maximum train speed over the diamond was 40 mph on the CSX.

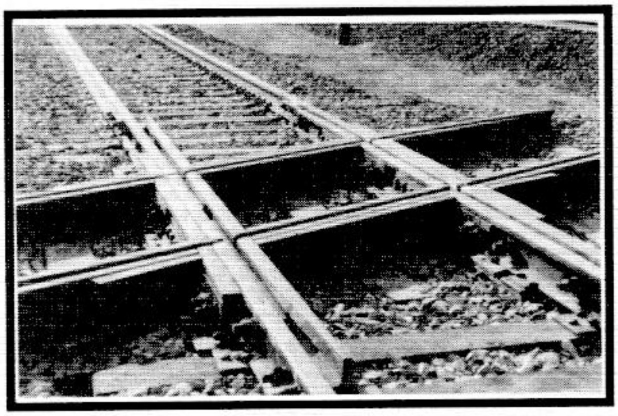

Exhibit 4. 62-Degree Three-Rail Crossing Diamond

Before installing the crossing in track at FAST, the rail ends on the mainline running rails were built up to repair the damage sustained during the 2 years of revenue service traffic over the diamond.

The crossing was installed for FAST train operations over the route designed for heavier traffic. The branch line route was not connected to any other tracks. The crossing was installed on the manufacturer's own plates with cut spikes. Hook twin tie plates were used for the skewed ties on the branch line stubs. The diamond was installed with bolted joints into track with 136 RE rail. The rail surrounding the diamond was continuously welded. The ballast section had 12- to 15-inch shoulders, 2:1 slopes, and cribs full to the tops of the ties. A granite ballast was used.

Note: Contact Duane E. Otter at (719) 584-0594 with questions or comments about this document.

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