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# Field Performance of Bainitic Steel Rail Crossing Diamonds

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**Summary**

Initial results from field testing bainitic steel rail crossing diamonds installed in the Gilman and Zeigler, Illinois, test sites have shown that the diamonds have required less maintenance and have less deformation in the first year of revenue service than similar diamonds made with conventional rail steel. CN-IC, Union Pacific (UP), and the Transportation Technology Center, Inc. (TTCI) are monitoring the performance of two three-rail crossing diamonds in revenue service.

The revenue service results are being compared to the previous bainitic steel crossing diamond test conducted at the Transportation Technology Center's Facility for Accelerated Service Testing (FAST) under 39-kip wheel loads. At the CN-IC's Gilman test site, the performance of the bainitic rail diamond is also being compared to the performance of the two previous pearlitic rail diamonds.

Significant findings to date include:

- Running surface height loss rates ("wear" rates) have been very low on the bainitic rail diamonds. The flangeway corners at Gilman and at UP's Zeigler crossing have lost only 0.04 inch in height relative to the running rail in 10 MGT. This compares well to the 0.10 and 0.25 inch of initial deformation typically seen on pearlitic and austenitic manganese steel (AMS) casting frogs.
- Maintenance has also been less on the bainitic rail diamonds. The Gilman diamond was ground for metal flow into the branch line flangeways at 30 MGT. The previous pearlitic diamonds were ground after about 10 MGT and again at about 30 MGT.
- Bainitic running rails are outperforming the previously used pearlitic running rails at the Gilman test site crossing. Less running surface maintenance, such as flow grinding, has been needed. Running surface height loss rate at the flangeway corners is less than half the height loss rate with the previous two pearlitic rail diamonds.
- Running surface height loss rates at the two revenue service sites are similar. The rates at the two revenue service sites after 10 MGT are higher than they were at FAST, even though average wheel loads are less. Comparisons made at 30 MGT between the Gilman and FAST diamonds show similar wear rates.
- Frog corners common to both routes (i.e., common corners) are showing more height loss per MGT than corners that are on only the mainline. The height loss rates are lowest for mainline corners and higher for both common corners and branchline corners. The better running surface profile on mainline corners results in less height loss.

**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

## INTRODUCTION

High hardness, medium carbon bainitic microstructure rail was developed by the Association of American Railroads (AAR) for use as a wear resistant curve rail for heavy axle load (HAL) applications. This rail also has more toughness than pearlitic rail, making it desirable for high impact areas like crossing diamonds and switch points. Comparison testing of various running rails in a high angle crossing diamond under 39-kip wheel loads at FAST showed that bainitic rail was clearly superior to head hardened pearlitic rail in this application.[1] As a result, a program of revenue service tests using modern design prototypes and comparing them to the performance of prototypes used in previous revenue service sites are described here.

### Bainitic Running Rail Crossing Diamond Test Sites

Exhibit 1 lists the bainitic rail crossing diamond test sites. All locations have three rail design crossing diamonds with "RE" section rail. The Gilman diamond has only bainitic running rails. The Zeigler diamond has all bainitic rails, including guard and easer rails.

## PRELIMINARY RESULTS

Exhibit 2 shows the running surface performance of the bainitic rail diamonds in test. The two revenue service crossings are performing similarly to date. At 10 MGT, the two diamonds have averaged 0.04 inch of running surface height loss (labeled as wear) measured at 1 inch from the flangeway. By comparison, the FAST diamond had about 0.01 inch of running surface height loss at 10 MGT.

These deformation rates are very low compared to conventional pearlitic rail diamonds. For comparison, wear at removal from track for the previous two pearlitic diamonds at Gilman is shown in Exhibit 2. At 100 MGT, the pearlitic diamonds averaged about 0.25 inch of wear at the flangeway corners. The FAST bainitic rail diamond had an average of about 0.07 inch under 100 MGT of more severe loading.

Exhibit 3 shows measured running surface hardness for the test diamonds. The running surface hardness for all three test diamonds reached about 470 Bhn

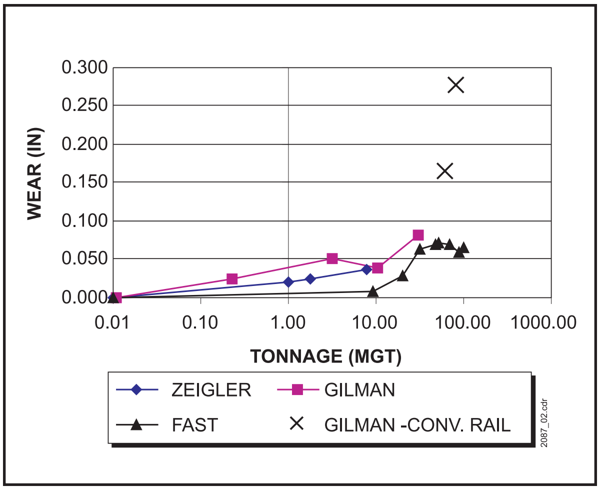


**Exhibit 2. Average Running Surface Height Loss for Bainitic Rail Diamonds**

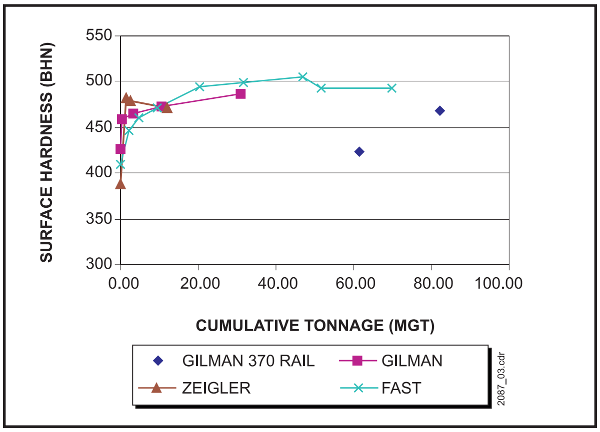


**Exhibit 3. Running Surface Hardness of Bainitic Rail Diamonds**

**Exhibit 1. FAST Crossing Diamond Running Rail Test Summary**

| Test Location | Crossing Angle (degrees) | Owning Railroad | Crossing Railroad | Annual Tonnage Rate (MGT/yr) | Speed Limit (mph) | Crossing Traffic (percent) |
|---|---|---|---|---|---|---|
| Gilman, IL | 78 | CN-IC | TP&W | 37 | 40 | 3 |
| Zeigler, IL | 76 | UP | BNSF | 60 | 40 | 33 |
| TTC/FAST Pueblo, CO | 90 | AAR | No Cross Traffic | 140 | 40 | 0 |

TTCI = Transportation Technology Center, Inc.; AAR = Association of American Railroads at 10 MGT. Hardening is rapid with traffic, as it is with AMS castings. The hardening rate is linear on a logarithmic scale. By comparison, the premium pearlitic rail, with an initial hardness of 370 Bhn, hardens to about 460 Bhn after 80-100 MGT.

Comparison of average wear rate versus percent of crossing traffic was made for the three test diamonds. Exhibit 4 shows this comparison. The better performance of the FAST diamond to some extent is attributed to the lack of crossing traffic. Despite the higher wheel loading and with similar speeds, the FAST diamond had a much lower wear rate than has been seen on the revenue service diamonds. It appears that a small amount of crossing traffic is sufficient to cause considerable wear. The running surface of the crossing track presents two problems on three rail diamonds. The first is that it can be difficult to keep the five different pieces of each frog in alignment. The second is the adverse running surface profiles that are encountered. While the mainline track sees only properly oriented running rail, the crossing track sees three rails at each frog that are rotated to the crossing angle. Exhibit 5 shows the cross track running surface. The running surface longitudinal profile is a series of four dips and three humps. This profile results in impacts and high-contact stresses between non-conformal wheel and rail surfaces, resulting in higher wear rates.

The effects of cross traffic on running surface height loss rates are significant. This is seen in the relative performance of the frogs in the revenue service diamonds. Each diamond's frog corners were segregated into three groups:

1. Corners that have mainline traffic only: main corners

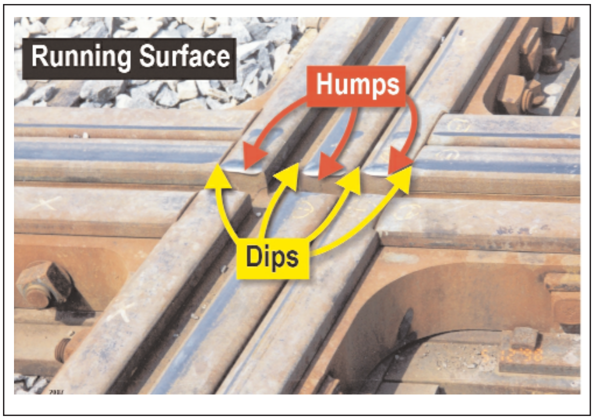


**Exhibit 5. Three-Rail Diamond Crossing Track Running Surfaces**

2. Corners that have branch line traffic only: branch corners
3. Corners with traffic from both lines: common corners

The common corners have the most deformation, as they have the most tonnage. The mainline corners have the lowest deformation rates because the rail running surface is best aligned for the main route.

Exhibit 6 shows wear rate versus location for the bainitic three rail diamonds. The revenue service diamonds are showing the highest wear rates on the common corners. The mainline corners are showing lower wear rates than the common corners. The branchline corner rates are about the same as the mainline rates on the two revenue service diamonds (somewhat lower in the case of Gilman and somewhat higher in the case of Zeigler). The relatively small amount of tonnage and wear seen on these corners makes the data uncertain.

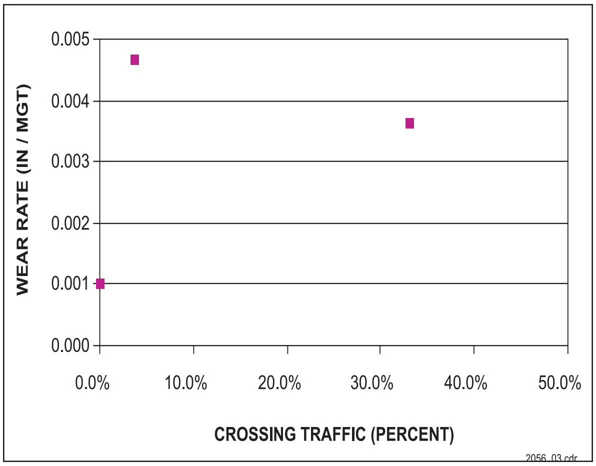


**Exhibit 4. Running Surface Wear Rate vs. Percent Crossing Traffic**

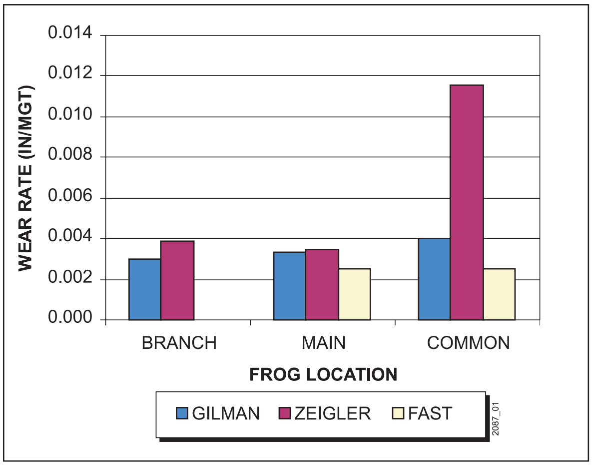


**Exhibit 6. Wear Rate vs. Frog Location**

### Measurement Methods

Running surface height loss, a combination of metal deformation and wear, is measured with respect to the rail running surface height using a depth gage device. Exhibit 7 shows how flangeway running surface wear is determined. All frog measurements are made relative to the rail running surface away from the frog. Thus, the reported wear is mostly the additional deformation that occurs at the frog.

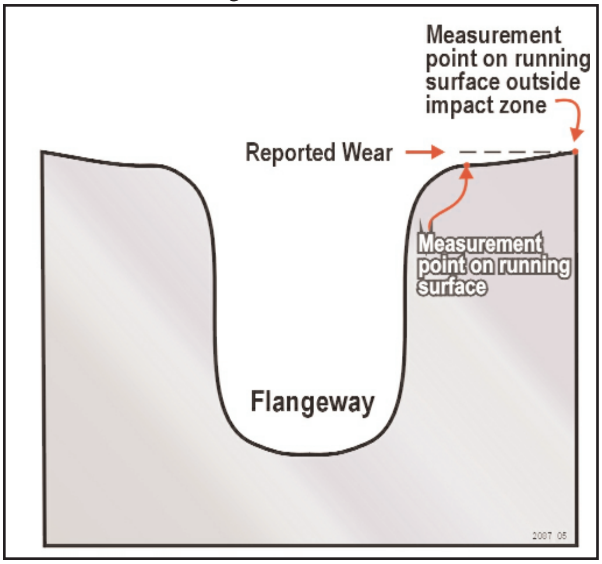


**Exhibit 7. Flangeway Running Surface Wear**

### FUTURE WORK

These and additional test crossings will continue to be monitored until life cycle costs for bainitic rail products can be determined. A pair of thick web rail crossing diamonds will be installed in late 2001. These diamonds will also have a reconfigured arrangement of rails at the frog corners, to make a smoother running surface for cross traffic. One diamond will be installed in revenue service, and the other one will be installed at FAST.

### REFERENCES

1. Davis, David and Don Guillen. August 2000. "Evaluation of Bainitic Rail for Crossing Diamond Applications," *Technology Digest* TD00-016, Transportation Technology Center, Inc., Pueblo, CO

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