TECHNOLOGY DIGEST
TD-15-033
©OCTOBER 2015
TIMELY TECHNOLOGY TRANSFER

The work described in this document was performed by Transportation Technology Center, Inc.,
a wholly owned subsidiary of the Association of American Railroads.

Flange Bearing Frog Crossing Diamond Waiver Five-Year Report

David Davis, Rafael Jimenez, and Chris Pinney

Summary

Full flange bearing frog (FBF) diamonds have been operated safely for more than 8 years under two waivers of the Federal Railroad Administration (FRA) Track Safety Standards for minimum flangeway depth (CFR 49, Part 213.137). This digest describes the performance of six FBF diamonds operating under an FRA waiver issued to the Association of American Railroads, October 5, 2010, as part of docket number FRA-1999-5104. The diamonds reported on include five full FBF diamonds and one 15 mph One Way Low Speed flange-bearing crossing diamond. There have been no accidents on or near the diamonds during the waiver period. Findings from the analysis of waiver diamond performance include:

- In general, the FBF waiver diamonds have been successful in greatly reducing dynamic loading of the crossing diamond and the vehicles going over them.
- There has been a significant reduction in impact related degradation modes typically seen in tread bearing diamonds.
  - Running surface fatigue has been largely suppressed.
  - Flangeway corner cracking has not been seen on these diamonds.
  - Track surface degradation is much less per unit of traffic than on conventional diamonds.

Observations of the FBF diamonds over time have revealed several degradation modes. The following list was compiled from these observations:

- Flange bearing surface wear (metal flow and wear)
- Insulated joint electrical failures
- Insulated joint deflection
- Uneven wear of the flange bearing surface (longitudinally)

The service lives of the diamonds have been less than expected because of high wear rates on the flange bearing running surfaces. Wear rates were anticipated to decrease as the running surfaces and wheel flanges became more conformal. However, this may not happen until there are a sufficiently large number of flange-bearing crossing diamonds in service to condition a large portion of the North American car fleet wheels.

Please contact **David Davis (719) 584-0754** with questions or concerns regarding this *Technology Digest.* E-mail: David_Davis@ttci.aar.com.
©2015 Transportation Technology Center, Inc. Unauthorized duplication or distribution prohibited.

INTRODUCTION

Full FBF diamonds have been operated safely for more than 8 years under two waivers of the FRA Track Safety Standards for minimum flangeway depth (CFR 49, Part 213.137). This digest describes the performance of six diamonds operated, owned, and maintained by BNSF Railway under the current waiver. The diamonds covered in this report include five full FBF diamonds and one 15 mph One Way Low Speed (OWLS) flange-bearing crossing diamond. There have been no accidents on or near the diamonds during the waiver period. A comprehensive report was prepared in fulfilment of provision 10 of the FRA waiver issued to the AAR October 5, 2010, as part of docket number FRA-1999-5104.[1]

Crossing Diamond Performance

Figure 1 shows the full FBF crossing diamond at Milano, Texas, and Table 1 lists the waiver diamonds. The lack of shiny running rails through the frogs and the shiny flangeway bottoms in the frogs are indicators that the diamond is flange bearing. The basic design of the five full FBF diamonds does not vary significantly. Each diamond has a set of flange bearing ramps that raise the flangeway floor from a conventional depth of at least 1 7/8 inches below the running (tread bearing) rail to less than 1 inch below the tread rail.

Figure 1. Full FBF Crossing Diamond Milano, TX

Figure 2 shows the OWLS flange-bearing crossing diamond at DT Junction, California. It differs from the full FBF diamonds in several respects. There are no frogs in the traditional sense. The wheels of the crossing track use flange bearing ramps to go over the mainline rails. The mainline rails (and a set of flangeway gaps) are part of the running surface of the crossing track. For the mainline route, the design is very similar to a three-rail diamond, except there are no flangeways cut for the crossing track. There is a running rail, a field side easer rail, and a gage side guardrail. In function, the diamond is similar to the Lift Frog (Progress Rail Services) used for low diverging traffic volume turnout frogs. There are well over 1,000 lift frogs in service in the USA. Each frog consists of two flange bearing ramp castings bolted to a mainline running rail of the other track.

Figure 2. OWLS FBF Diamond at DT Junction, CA
The flanges of crossing traffic run on the top of the mainline rails.

In general, the FBF waiver diamonds have been successful in greatly reducing dynamic loading of the crossing diamond and the vehicles going over them. There has been a significant reduction in impact related degradation modes typically seen in tread bearing diamonds. Running surface fatigue has been largely suppressed. Flangeway corner cracking has not been seen on these diamonds. Track surface degradation is much less per unit of traffic than on conventional diamonds.

Table 1. FBF Waiver Crossing Diamonds Characteristics

Location Name	Number of Diamonds	Railway 1 Tonnage	Railway 2 Tonnage	Ramp Rate 1 (1/X)	Ramp Rate 2 (1/X)	Railway 1 Speed MPH	Railway 2 Speed MPH
Moorhead Jct 1	2	60	20	240	180	40	25
Moorhead Jct 2	2	90	20	240	180	40	25
Lamar	1	54	10	180	180	40	40
Christopher	1	10	5	180	180	25	25
DT Junction	1 of 3	48	2	0	72	70	15
Milano	1	85	55	180	180	40	40

Observation of the FBF diamonds over time has revealed several degradation modes. The following list was compiled from these observations:

- Flange bearing surface wear (metal flow and wear)
- Insulated joint electrical failures
- Insulated joint deflection
- Uneven wear of the flange bearing surface (longitudinally)

Flange bearing surface wear and flow has resulted in relatively short service lives for the FBF waiver diamonds. While dynamic loads have been significantly reduced, this has not resulted in a longer wear life for the frog running surfaces, as compared to conventional tread bearing diamonds. The BNSF full FBF diamonds have a high hardness alloyed die steel for the flange bearing running surface. The OWLS flange-bearing diamond uses an austenitic manganese steel casting, as did the previous full FBF diamond tested at Shelby, OH. The running surface height loss rates at the waiver diamonds are relatively steady over time. Test engineers expected the rates would diminish with time, as the running surfaces harden with deformation. The deformation rates do greatly decrease when the tread bearing rails begin to share load with the flange bearing surfaces. Figures 3 and 4 show the predicted running surface wear life of the waiver diamonds in tonnage and years (at current tonnage rates). This is not necessarily the service life of the crossing diamond. It is the wear life of the flange bearing running surface, defined as the point when the shortest flange wheels will remain tread bearing while traveling across the diamond. The wide range of wear lives seen is related to the range of service environments for the diamonds, as seen in the range of traffic (rate and load), train speeds, and ramp rates as Table 1 shows.

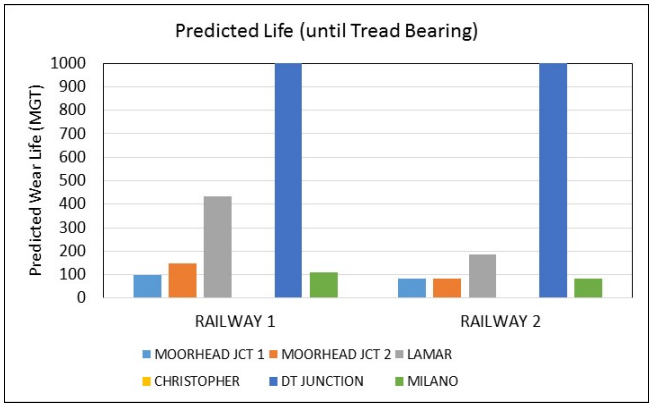

Figure 3. Predicted Wear Life (MGT) until Tread Bearing

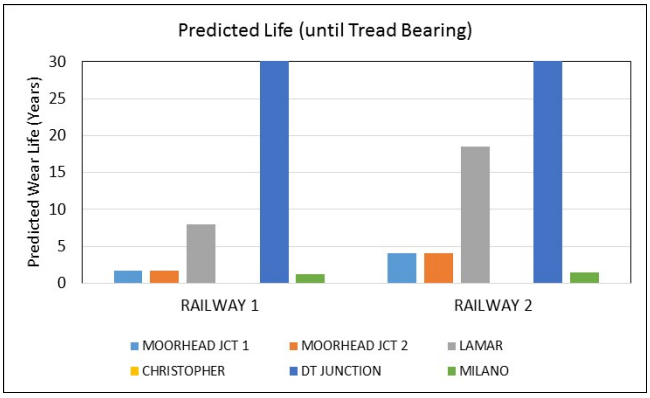

Figure 4. Predicted Wear Life (Years) until Tread Bearing

Wheel Performance

Wheel performance in flange bearing has been monitored in two ways. First, monitoring of the North American car fleet wheel failure and repair trends is ongoing. In 2013, flange related defect rates increased, after many years of declines. An analysis of the statistics showed that the increase in flange defects largely comes from the railways with the fewest FBF diamonds and frogs. The increase can be located in the northwest of North America and is not likely related to waiver diamonds. The second method of determining wheel performance in flange bearing is by monitoring a small fleet of cars that routinely operate over the FBF waiver diamonds. The performance of the waiver fleet wheels has been documented with periodic inspections under two waivers since FBF operations began on BNSF. The current waiver fleet consists of five ballast cars. They are in service hauling company materials for BNSF. They make at least six passes across each FBF waiver diamond each year. The cars average around 13,000 miles per year, with an increasing number of FBF passes as more diamonds were installed. In 2014, the fleet averaged 42 FBF diamond passes and 16,826 miles. Figure 5 shows waiver fleet operation statistics.

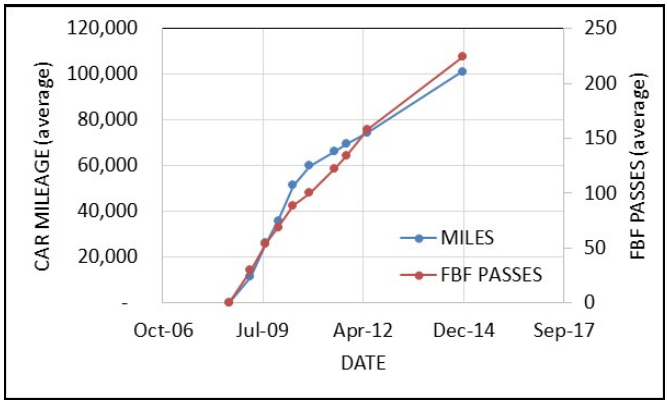

Figure 5. FBF Waiver Fleet mileage and FBF Passes

The predominant failure modes of wheels in the waiver fleet include:

- High dynamic loads (found by Wheel Impact Load Detectors). These are AAR removal code WM 61.
- Tread wear (e.g., high flanges). These are AAR removal code WM 64.
- Tread defects (including spalls, shells). These are AAR removal codes WM 74, 75.
- Non-wheel defects (e.g., bearing and axle defects and mate wheels from the above defects). These are AAR removal code WM 11.

These are the predominant failure modes of the North American fleet, as well. Thus, the effect of flange bearing on wheel degradation is nil.

An important consideration for train operations is the relative wear rates of the wheel treads and flanges (e.g., height loss). This height loss race determines whether wheel flanges will increase or decrease in height above the tread over time. Wheel flanges that decrease in height over their lifetime would be problematic, because track work is designed for the currently allowed range of flange heights. New wheels have the minimum allowable flange height. If they were to lose flange height, the potential exists for wheel climb at switch and frog points. Thus, an analysis of wheel wear under flange bearing operations was conducted.

Analysis of profiles taken on the waiver car fleet show that flange heights are growing with the current ratio of 400 miles per FBF diamond pass. Thus, flange height loss is not likely to be a concern nor a new failure mode for wheels in flange bearing. Figure 6 shows waiver fleet average wheel flange height versus mileage and FBF passes. Original wheels are ones that were in the cars when the waiver began.

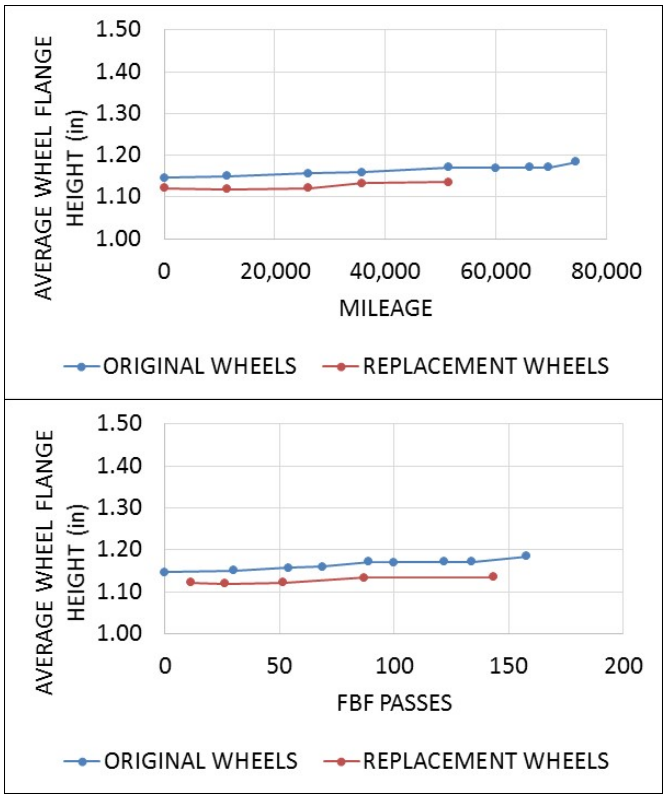

Figure 6. FBF Waiver Fleet mileage and FBF Passes

CONCLUSIONS

The results in this digest show that both full FBF and OWLS flange-bearing crossing diamonds have been operated successfully in revenue service. Further improvements in materials and running surface profile designs are needed to realize the full economic benefits of flange bearing technology.

REFERENCE

1. Federal Railroad Administration. "Petition for Waiver of Compliance, Petition Docket Number FRA-1999-5104. https://www.federalregister.gov/articles/2015/06/04/2015-13638/petition-for-waiver-of-compliance

Visit our website at http://www.ttci.aar.com

Disclaimer: Preliminary results in this document are disseminated by the AAR/TTCI for information purposes only and are given to, and are accepted by, the recipient at the recipient's sole risk. The AAR/TTCI makes no representations or warranties, either expressed or implied, with respect to this document or its contents. The AAR/TTCI assumes no liability to anyone for special, collateral, exemplary, indirect, incidental, consequential or any other kind of damage resulting from the use or application of this document or its content. Any attempt to apply the information contained in this document is done at the recipient's own risk.