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Implementation Guidelines for Flange Bearing Frogs

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Summary

Flange Bearing Frogs (FBFs) add another tool for the track engineer to employ to improve railway performance; however, locations and operations should be selected to provide optimum FBF performance. With the issuance to the Association of American Railroads (AAR) of a waiver of Federal Railroad Administration (FRA) track safety standards that will allow widespread implementation, Transportation Technology Center, Inc. (TTCI) has prepared the implementation guidelines for FBFs presented in this *Technology Digest* (TD).

FBFs offer the potential to greatly reduce the dynamic loading generated at conventional tread bearing frogs. The following are expected benefits of FBF implementation:

- Longer component service life
- Less frog maintenance per tonnage
- Fewer condition related speed restrictions
- Elimination of the highest dynamic loads on wheels

FBF Crossing Diamonds

FBF crossing diamonds can be installed in FRA class 1 tracks without restriction. For FRA Class 2 to Class 5 tracks, FBF crossing diamonds may be installed under a waiver that was granted to AAR in 2010. This waiver requires additional inspection and reporting to FRA. Without this waiver, FBF crossing diamonds are not permitted in tracks with speeds above FRA Class 1.

In this TD, TTCI provides the following guidance on FBF implementation:

- Waiver requirements
  - Vehicle monitoring
  - FBF monitoring
- Selection of FBF candidate locations
  - Full FBF crossing diamonds
  - One way low speed flange bearing crossing diamonds
- FBF design guidelines
  - General design considerations
  - Ramp rates

Use of flange bearing in turnout frogs, which is not a subject of the FRA waiver, is also discussed.

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INTRODUCTION

FBF crossing diamonds offer the potential to greatly reduce the dynamic loading generated by conventional tread bearing frogs, with the following expected benefits of FBF implementation:

- Longer component service life
- Less frog maintenance per tonnage
- Fewer condition related speed restrictions
- Elimination of the highest dynamic loads on wheels

Now, track engineers can use FBFs to improve railway performance; however, locations and operations should be selected to provide optimum FBF performance. With the issuance of a waiver of FRA track safety standards that will allow widespread implementation, TTCI has prepared the implementation guidelines for FBFs presented in this TD.

FBFs support wheels through the point of the frog on their flanges. Conventional tread bearing frogs with high angles may leave the wheel unsupported across flangeways. This can result in high dynamic loads for all vehicles negotiating the frog. Figure 1 shows typical tread bearing and flange bearing crossing diamonds. Note the FBF diamond has wear marks in the flangeway floor in the frogs.

Figure 1. Tread Bearing (Left) and Flange Bearing Crossing Diamonds

One way low speed (OWLS) FBF crossing diamonds are a hybrid design used when a low tonnage secondary line crosses a high tonnage or high speed main line. The mainline route flangeways are eliminated, resulting in a smoother ride for mainline traffic. This niche product is effective at removing speed restrictions in mainline track. Figure 2 shows an OWLS flange bearing diamond crossing.

Figure 2. OWLS Flange Bearing Crossing Diamond

FBF Waiver Requirements

Railways are allowed to install FBF crossing diamonds (flange bearing in both directions) in Class1 track without a waiver. For installations in Class 2 to 5 track, the AAR's waiver of 213.137(d) must be used.[1] For OWLS diamonds (flange bearing in one direction), the main line side can be any speeds, but traffic on the low speed flange bearing side cannot be above Class 1 track speeds without using the AAR waiver.

Only five of the FBFs will require any checks on vehicles using the FBF diamonds, and even on these diamonds only five vehicles need to be inspected after six passes over the diamond in a year, and the inspection will not require a truck rollout.

To install a FBF diamond, the diamond must be included in a list submitted to the FRA by the AAR. The list will be a document showing all the FBFs intended to be installed by AAR railroads in the following calendar quarter. For example, each railroad intending to install FBF crossing diamonds in a given quarter will inform AAR by letter a month before that quarter begins. Then, AAR will send the list of the combined intended FBF installations to FRA.

Approval in advance from FRA is not required, but the letter from the railroad to AAR stating the intended FBF installation is required by FRA and must contain the following information:

- Railroad Name
- Location, including names of each of the two lines intersecting
- Whether full FBF (flange bearing in both directions) or OWLS diamond (flange bearing in only one direction) with speed in the flange bearing direction(s) over Class 1 track. (See following paragraph for details)
- Traffic volume (tonnage and axle passes) and types (passenger, hazardous material, and other), including the frequency at which captive stock unit trains will encounter the crossing

- Criteria that was used for selection of location
  - Train speeds
  - Track conditions
  - Location of the nearest automatic equipment identification tag reader likely to record a large proportion of the cars passing over the FBF diamond
  - Other relevant factors
- Description of diamond design, including plans and specifications

There are additional inspection regulations for each new FBF crossing diamond, requiring on-foot inspection daily for the first two weeks, weekly for the next six months, once every other week for the second six months, and then the regular monthly inspection required of any diamond. For the first two years after the FBF is installed, the signed inspection records must be submitted to FRA. Also, all maintenance and repair work performed on FBFs must be documented in detail and reported by the railroad to FRA yearly.

Manuals and proper training for individuals responsible for inspecting and repairing FBF diamonds are also required.

FBF Location Guidelines

FBF crossing diamonds may be installed in most locations where tread bearing crossing diamonds are currently installed.

Traffic rate is an important consideration for FBF applications. Due to the increased material (for flange bearing ramps) and the relative novelty of the designs, FBFs may have a higher initial cost than conventional designs. Thus, sufficient tonnage rates are needed to generate payback in lower maintenance and/or higher reliability to produce lower life cycle costs.

In addition, the relative rates of traffic on the two crossing lines will affect the selection of frog type. Locations with nearly equal traffic on each route are candidates for full FBFs. Locations with traffic predominately on one route are candidates for OWLS FBFs.

Based on a limited sample of OWLS diamonds, a traffic ratio of 30 to 1 (main line to secondary line) will effectively wear away any cross grooving of the mainline running surface.[2] At ratios less than this, cross grooving of 1 to 1.25 inches wide can be expected, compared to much wider flangeways (1 7/8 inches plus casting radii) on conventional diamonds.

For the same guarding protection, FBF diamonds will have a higher minimum allowable angle. This is due to the larger treadway opening (as compared to a flangeway on a tread bearing frog) that must be left unguarded at frog points. Below this minimum angle, a moveable point frog is the preferred design. Depending on the minimum radius wheel used and the height of the guarding, the minimum angle recommended for flange bearing is about 22 degrees. American Railway Engineering and Maintenance-of-Way Association recommends 14 degrees for tread bearing frogs.

The major benefit of flange bearing is the elimination of high dynamic loading from unsupported flangeway gaps. The effects of flangeway gaps are greatest for frogs with angles above 50 degrees.

FBF diamonds would not be recommended at the following two locations:

1. Locations where full-service braking is expected: Due to accumulation of track lubricant, FBF diamonds are more likely to cause empty cars to slide wheels.
2. Diamonds on curves: Due to the lack of rolling radius variation on flanges, a vehicle in flange bearing is unable to steer through curves, but it can steer through them in tread bearing. The change from tread bearing to flange bearing while curving causes poor steering and high lateral forces. In the same regard, curved turnout frogs are not good candidates for flange bearing.

General Design Guidelines

Inside guarding (i.e., within the gage of the track) should be raised above nominal rail height, as is done by many railways in tread bearing frogs. This allows a smooth guarding surface through the tread to flange transition zone.

For additional risk mitigation, it is recommended that field side guarding be employed throughout the flange bearing zones. This guard can be the tread bearing rail. Its purpose is to help guide the wheelsets and to contain the flange bearing running surface, laterally. This will reduce metal flow of the flange bearing surface.

Ramp rates for flange bearing running surfaces should be determined for the likely maximum speed of the vehicles. A vehicle-track dynamics analysis of ramp operation was conducted to determine acceptable ramp rates.[3]

The criterion limited maximum dynamic loading to 1.5 times static wheel loading in operating over the bump. For example, Figure 3 shows the force ramp rate relationship for 20, 40, and 60 mph freight vehicle operations. An appropriate ramp design can be selected using this chart.

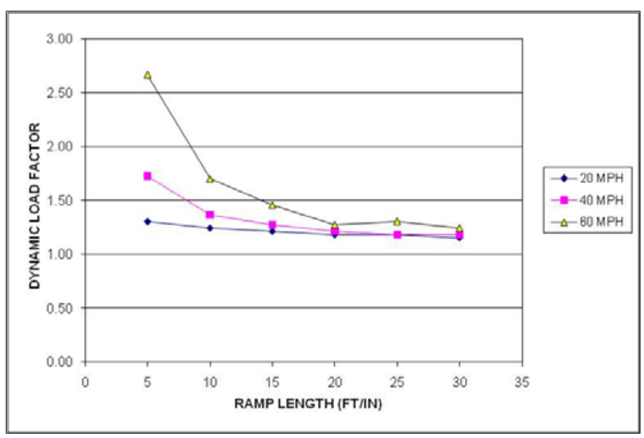

Figure 3. Predicted Maximum Wheel Force versus Ramp Length

Ramp design can be further improved by minimizing the elevation change of the vehicle going across the diamond. The AAR-TTCI ramp design accomplishes this by putting the flangeway floor elevation at the vehicle fleet average flange height below the nominal running rail surface. The tread bearing rail is then ramped down to provide clearance. Figure 4 shows a schematic of this concept.

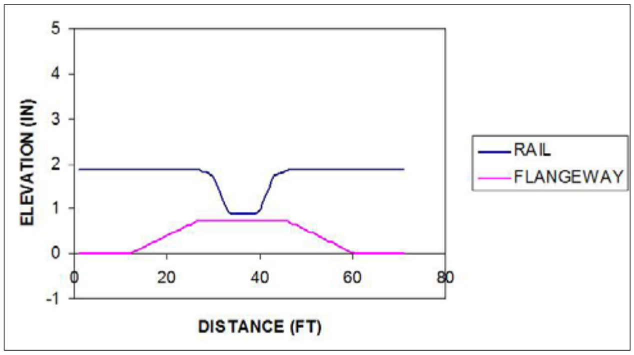

Figure 4. AAR-TTCI FBF Ramp Design Concept

A parallel ramp design is essential for higher speed applications on crossing diamonds. While non-parallel designs are acceptable for operations below 10 mph, parallel ramps will minimize wheelset angle of attack and lateral forces. For lift style turnout frogs (Figure 5), it is suggested that a parallel tread bearing ramp be used for the guard side rail (diverging route) of the frog. This ramp does not eliminate rolling radius differences on the wheelset, but it does help equalize loading within a vehicle truck.[4] This feature is most important for rigid frame maintenance vehicles.

Figure 5. Partial FB Turnout Frog (Lift Frog)

FBF running surface cross section profiles should be slightly concave to minimize contact stresses. A wide concave shape across the flangeway floor is suggested, with a radius of perhaps 8 inches to 10 inches. A conformal groove (i.e., 1-inch radius) is not recommended for an initial cross section profile in the flangeway, because it may apply large lateral forces to wheels on wheelsets that have wheel back-to-back spacing, which differs from conformal groove spacing in the diamond.

Flange Bearing in Turnout Frogs

Turnout frogs are not the subject of the FRA waiver. Flange bearing may also be used on turnout frogs to improve the operating performance of one of the two routes through the frog. This is done by elevating the wheels of the crossing track to become flange bearing across the mainline rails.

For turnout frogs, flange bearing designs can be used to improve performance of the mainline route in the same manner as OWLS crossing diamonds. In addition, they can be configured to share loading on both routes between flange bearing and tread bearing. These low speed frogs are configured to allow tall flange wheels to be flange bearing, while wheels with shorter flanges will be tread bearing. This is expected to reduce impact loading, wear rates, and extend the service lives of frog components.

Installation of turnout frogs in FRA Class 2 and above track is currently not allowed by the FRA track safety standards.

The ratio of flange bearing to tread bearing wear was measured to be 50 to 1 on turnout frogs at the Facility for Accelerated Service Testing.[5] This suggests that the diverging route tonnage on a lift type turnout frog should be no more than 1 to 2 percent of the mainline traffic.

Future Work

Additional research and development is required to reduce the wear rates of flange bearing running surface materials. Improvement is needed to fully take advantage of the superior dynamic performance of FBFs. With the elimination of high dynamic loading, further design effort is required to reduce large changes in dynamic properties for FBF diamonds. The stiffness and damping changes should be minimized to prolong service life.

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