Update on the Use of Flange Bearing Technology

In Special Trackwork

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ABSTRACT

Due to high impact loadings and the need to increase reliability, Class I railroads have been turning to flange bearing technology to minimize impacts and increase the life cycle of special trackwork components. Both BNSF and CSX continue to lead the industry in the installation of flange bearing trackwork components and are starting to see benefits in both reduced maintenance and an increased life expectancy.

The primary locations that have been used for flange bearing technology are railroad crossing diamonds. The major railroads been experimenting with different types of flange bearing diamonds in recent years. A popular type of crossing in use in has been the One-Way Low Speed (OWLS). Only one leg of the crossing diamond is flange bearing and the other is uninterrupted rail therefore reducing wheel impacts to only one side.

Another type of diamond that has been installed by CSX and will be installed in of the fall of 2008 on BNSF is a full flange bearing frog (FBF) diamond. In this type of diamond, both directions traverse the diamond on its flanges and there is no speed reduction on either track. CSX installed a test diamond in Ohio in 2006 and it is still evaluating its performance. While there has been virtually no maintenance of its FBF diamond, CSX is seeing a higher than expected wear rate of the diamond components and grinding of the top of rail has been necessary to continue flange bearing.

Expanding on the diamonds, there are several offerings of flange bearing turnout frogs that both BNSF and CSX are testing. Both railroads have found that this type of frog is suitable for turnouts that are seldom used.

UPDATE ON THE USE OF FLANGE BEARING TECHNOLOGY IN SPECIAL TRACKWORK

With the increased loadings and volume of traffic on today's railroads, special trackwork component such as crossing diamonds and turnout frogs have taken increased abuse and shortened life cycles. Various methods to decrease the degree of impact produced by traffic passing on these increased loadings have been explored. One of these methods to reduce impact is to use flange bearing concepts to eliminate the gap in the rail when railcars traverse these special trackwork components.

Over the last several years, many Class I railroads have implemented several flange bearing technologies with technical assistance from the Transportation Technology Center, Inc. (TTCI). In particular, both CSX Transportation (CSXT) in the eastern United States and BNSF Railway (BNSF) in the western United States have embraced flange bearing in several heavy haul applications on their respective territories.

Both railroad companies have installed numerous One Way Low Speed (OWLS) type diamonds across their properties. In July 2006, CSXT installed the first mainline full flange bearing diamond in Ohio and BNSF is planning its first full flange bearing diamond installation in the fall of 2008 in Minnesota. Additionally, both railroads have installed several partial flange bearing turnout frogs in turnouts on their respective systems.

DEVELOPMENT OF FLANGE BEARING TECHNOLOGY

Certain types of special trackwork present significant challenges to track maintenance engineers, often causing bottlenecks in train operations. Due to the high dynamic loads generated by heavy axle load (HAL) service, diamonds and frogs also are frequently associated with train delays for slow orders and maintenance activities. The service lives of diamonds and frogs are greatly affected by wheel loads and speeds of the trains that operate over them.

For many years, track engineers have searched for alternatives to conventional diamonds and frogs. Flange bearing diamonds and frogs offer a simple design that can provide benefits by reducing vertical dynamic loads for most of the traffic traversing them. Flange bearing is accomplished by eliminating the unsupported flangeway gap from the running surface of the frog. As the name implies, flange bearing's functions by supporting the wheel on its flange through the diamond or frog. This is compared to conventional tread bearing diamonds and frogs have unsupported flangeway gaps that wheels must cross. These gaps generate high dynamic loads that adversely affect ride quality, track speed, and component life.

Under the sponsorship of the AAR Engineering Research Committee, Transportation Technology Center, Inc. (TTCI) evaluated the flange bearing concept for HAL operations. The concept was found to be technically sound and the economics are compelling for implementation of flange bearing track components. TTCI conducted a thorough review of potential operations, mechanical, and track issues[1]. The review included input from railroad mechanical and operating officers, wheel and locomotive suppliers, and AAR mechanical committees. This subject was also discussed at the AREA Symposium on Turnouts and Special Trackwork in 1996[2] with additional research and testing continuing since that time.

ONE WAY LOW SPEED DIAMONDS

Full flange bearing diamonds (FBF) have been used for many railroad applications such as transit and crane use. Unfortunately, full flange bearing diamonds' use in freight applications has been limited due to various regulatory issues. While concerns about the effect of heavy axle loads have been addressed by AAR research and testing, the requirement for a waiver to the FRA

Track Safety Standards (Code of Federal Regulations 49, Part 213.137)[3] has thus far limited the full implementation of FBFs in revenue service. While the standard was written to prevent wheel flange impacts on excessively worn tread bearing frogs, the rules have inadvertently prevented application of flange bearing designs to other tracks above Class 1 speeds (10 MPH freight and 15 MPH passenger) that could benefit from flange bearing.

The OWLS partial flange bearing diamonds were created to take advantage of flange bearing technology, but still remain within the confines of the FRA Track Safety Standards without a special waiver. OWLS diamonds are well suited for numerous locations where two railroad lines cross each other and one have a predominance of traffic. A typical situation for an OWLS diamond would be where a lightly used branchline crosses a heavy used mainline. In the case of the OWLS diamond, the lower speed and tonnage branchline crosses the higher speed and tonnage mainline by ramping up the wheels of the cars to cross the mainline rails in their flangetips. The primary advantage of the OWLS diamond is to remove the gap from the higher speed and tonnage track virtually eliminating any increased impact loading at the diamond due to the gap.

There are two methods of accomplishing the OWLS diamond currently in use. One of these methods is to use special castings that bolt inline with the rails of both approaching tracks. These castings include the ramping and guarding required to successfully crossing one track over the other. The second method is to use continuous running rails for the mainline track and bolt on ramp castings to the field and gage sides of the rails that create the required branchline ramping. Both of these methods leave a flangeway gap open for the mainline, and therefore do not leave a gap for mainline wheels to cross the branchline flangeway running paths.

Certainly there is a concern with the wear or grooving in the running rails created by the crossing flangetips. Research by Davis, et al, has indicated that “a high ratio of mainline to branch-line traffic will wear away the cross groves”. Further research also has indicated that flange bearing diamonds do not negatively impact the performance of condition of freight car or locomotive wheels.[4] The freight railroads’ experience and increasing use of OWLS diamonds further implies the lack of negative impacts on the equipment that operates over flange bearing special trackwork.

CSXT Experience with OWLS

CSXT will have installed a total of thirteen OWLS crossing diamonds through its system by the end of 2008. Although a few of these diamonds have been installed in lower tonnage single track routes, many have been installed in heavy tonnage double track territory and have dramatically reduced the maintenance required at these diamond locations. In several communities where the OWLS diamonds have been installed, citizens have inquired with maintenance personnel concerning the reduction in noise levels created by the diamonds. CSXT’s most unique OWLS installation is in Darby, Pennsylvania, crossing with an imbedded SEPTA street trolley track.

Overall CSX has enjoyed significant savings in diamond maintenance and related costs with its OWLS installations. This savings appears to be related to the decreased impact loading on the components within the diamond. Generally, the number of broken bolts and other parts in the OWLS diamond compare to conventional diamond designs has dramatically reduced. In certain high tonnage area, the life cycle between replacement of components and the entire diamond has increased considerably.

BNSF Experience with OWLS

BNSF also has had a good experience with OWLS crossings. The track engineers from BNSF have seen some indentation on the top of the running rail on all installations due to flangeway contact, however, if the metal flow to the main track side is kept ground, most of the time this flow has not become a concern even for crossings that have been in track for five years. BNSF has seen an increase in the amount of maintenance needed on the older style diamond crossings due to increased tonnages and the use of splice bars in the design which the OWLS diamonds mitigates. In order to protect for potential emergency failures, extra castings and insulated joint rails are being ordered along with new conventional diamond crossings.

FULL FLANGE BEARING DIAMOND CROSSINGS

CSXT installed the first full flange bearing diamond in high speed revenue service on July 31, 2006, in Shelby, Ohio. Due to the condition of the FRA waiver on flangeway depth of trackwork components, the location was limited to 40 MPH speed. The 24º50’ diamond is located in CSXT’s mainline between Cleveland and Indianapolis and has seen approximately 60 MGT per year. The VAE Nortrak supplied crossing diamond uses manganese castings to form ramps that meet at the intersection points. These ramps bring the wheels into flange bearing so that both intersecting lines cross on a level surface.

CSXT’s experience with Shelby has been good overall. Initial ride reports indicate that the diamond was very smooth and quiet. It was apparent that the impact loading had been eliminated this location. Because of the decrease in loading, the diamond has required virtually no maintenance activity directly related to the diamond in the first 22 months of service. Of the 168 1-3/8” heavy track bolts in the diamond, only one had failed after 20 months of service with all other track components remaining unfailed.

Despite the excellent early performance, running trough in the manganese castings have deformed underneath the weight of the passing trains to form a deep quarter-inch grove in what began as a flat surface. This grove had created a partial flange bearing condition at the diamond which had been leading to increased impact and loading on the flange guarding that lies beneath the wheel treads. In May 2008, using a main track switch grinder, CSXT ground away approximately one-quarter inch of the guarding that lies under the wheel treads to restore the diamond to a full flange bearing condition.

As part of the waiver for operating a full flange bearing diamond, additional inspections of the diamond and a representative sample of wheels operating over the diamond. The additional inspections have not revealed any particular trouble spots in the diamond. On the mechanical side, in order to better capture data for the wheel inspections, CSX is operating a fleet of twelve non-revenue covered hoppers in a looping service over the diamond. TTCI and CSX inspect the wheels on these cars on a quarterly basis pursuant to the waiver requirements. The findings have supported previous research by TTCI in that there are no detrimental effects to the wheels created by flange bearing operations. The reports also show that wear in the wheel treads far exceed that of the flangetips.

In addition to CSXT’s location, BNSF is planning on a full flange bearing double track crossing installation of a Progress Rail design in the fall of 2008. The design of the diamond will use a different ramping method as compared to CSX’s diamond. The ramping will consist of a tool steel grade material that can be replaced for wear if needed.

PARTIAL FLANGE BEARING TURNOUT FROG

Another offshoot of the OWLS diamond concept is a partial flange bearing turnout frog. Several Class Is have sampled these turnout frogs, which eliminate the gap in the mainline running rail by ramping the diverging running rail over the mainline rail. Both CSXT and BNSF have installed these types of turnout frogs in various locations on their respective systems.

The partial flange bearing turnout frog, referenced generically in the industry as the leap frog, has significant advantages over rail bound manganese (RBM) and spring frogs under certain conditions. Due to the nature of this type of frog, the lift frog use should be limited to those tracks that see very light use on the diverging side of the turnout. Common locations for the lift frog would be hotbox setout tracks, team tracks, and seldomly used industry tracks that come out of the mainline.

When used in the proper application, the lift frog is superious to a typical spring from insomuch as it eliminates the moving parts and the additional monthly inspection and lubrication that a spring frog requires. Due to the lift frog's design, the guardrail on the mainline can be eliminated which further reduces the total overall cost of the turnout. It appears that this type of frog will have a greatly extended life compared to RBM and spring frogs installed in similar locations.

CSXT Experience with Partial Flange Bearing Turnout Frogs

CSXT has installed two of these types of frogs on the Chicago to Cleveland corridor. Thus far, these frogs have performed well and have significantly reduced the maintenance required for these locations. Other locations where lift frogs are being used is to replace aging spring frogs. To date, CSX has installed one #10 lift frog supplied by Progress Rail Service; three more are planned to be installed later in 2008.

BNSF Experience with Partial Flange Bearing Turnout Frogs

BNSF has more than thirty lift frogs in service on its system currently. The railroad has combined the lift frog with other test items such as thick web switch points, over the tie rods and

Ultra High Molecular Weight Polyethylene (UHMWPE) switch plates and has been pleased with the results of the testing. BNSF is still concerned about the height of the guard on the frog and have had it lowered by one-quarter inch since the first installation. BNSF also requires a sign to be posted next to frog to warn of a possible height problem with MOW and testing equipment employed by contractors. BNSF currently has #11 lift frogs in service and will be adding the # 10 size to its standard plans in the near future.

CONCLUSION

Flange bearing diamonds and improved frog technology has shown great results to date and reduces the impact loading of special trackwork. Reducing the impact leads to decreased maintenance and increase life cycles of these expensive special trackwork components. Class Is have been employing various flange bearing technologies in diamonds and turnout frogs with great success. Building on current successes, it is expected that additional development of improved materials, flange bearing technology will continue to keep maintenance low and reduce expenses in special trackwork situations.

REFERENCES

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2. Proceedings: Symposium on Turnouts and Special Trackwork – American Railway Engineering Association, August 14-15, 1996
3. Davis, D.; D. Guillen; R. Reiff and S. Kalay. “Initial Performance Evaluation of Flange-Bearing Frog Crossing Diamonds at FAST”; *Technology Digest* TD99-012; Transportation Technology Center, Inc; Pueblo, CO, April 1999.
4. Davis, D.; C. Sasaoka, D. McNeely, E. Kohake, and M. Armstrong. “Progress Report on Revenue Service Implementation of OWLS Flange Bearing Crossing Diamonds”; *Technology Digest* TD05-031; Transportation Technology Center, Inc; Pueblo, CO, December 2005.

FIGURES

Figure 1. Conventional 3 rail diamond in place nearing end of life cycle. Plant City, Florida.

Figure 2. Table of OWLS and Full Flange Bearing Diamonds

Location	# of diamonds	Angle	Owner Railroad	Crossing Railroad	Year Installed
Athens, GA	1	67°23’	CSX	Hartwell	2006
Ocala, GA	1	65°40’	CSX	Florida Northern	2006
Humboldt, TN	1	73°23’	CSX	WTRR	2007
Walkerton, IN	2	57°38’	CSX	NS	2007
Darby, PA	2	42°25’	CSX	SEPTA	2007
Grafton, OH	2	81°45’	CSX	CSX	2008
Indianapolis, IN	2	79°22’	CSX	CSX	2008†
Springfield, MA	2	90°00’	CSX	Amtrak	2008†
Shelby, OH (Full)	1	24°50’	CSX	Ashland RR	2006
Emporia, VA	1	57°39’	NS	CSX	2007
Crawford, WI	1	51 13’	BNSF	WSOR	<2005
Kansas City, KS	1	64 04’	BNSF	BNSF	?
Park Junction, MN	2	56 55’	BNSF	MN. COMM	2007
Tower 60 Ft Worth, TX	1	47 04’	BNSF	BNSF	2006
Earlville, IL	2	56 05’	BNSF	UP	2005
Bushnell, IL	2	90	BNSF	KJRR	2005
Superior, WI	1	73 38’	BNSF	BNSF	2003
Beaumont, TX	3	56 57’23”	BNSF		2004
Merced, CA	1	36 12’ 53”	BNSF	BNSF	2004
Plainview, TX	1	61 05’	BNSF	BNSF	2005
Galveston, TX	2	47 03’	BNSF		2005
Shabbona, IL	1	54 07’	BNSF	UP	2005
Los Nientos, CA	2	37 15’ 12”	BNSF	UP	2005
Moorhead Jct, MN (Full)	2	27 44’	BNSF	BNSF	2008†
Various	9	Various	UP	Various	Various
Various	2	Various	CNIC	Various	Various

† Planned Installation


Figure 3. OWLS Diamond in place, Walkerton, Indiana


Figure 4. Shelby FBF Following Installation

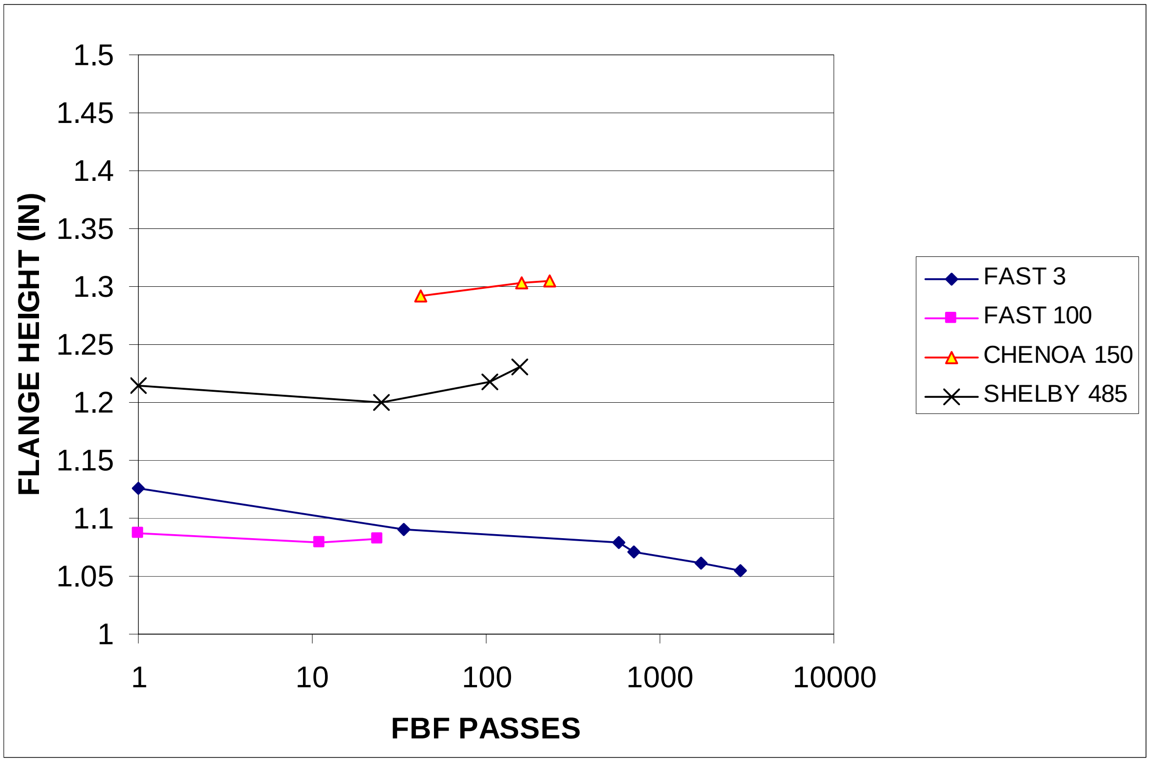

Figure 5. Flange Height vs. Flange Bearing Diamond Passes for Various FBFs

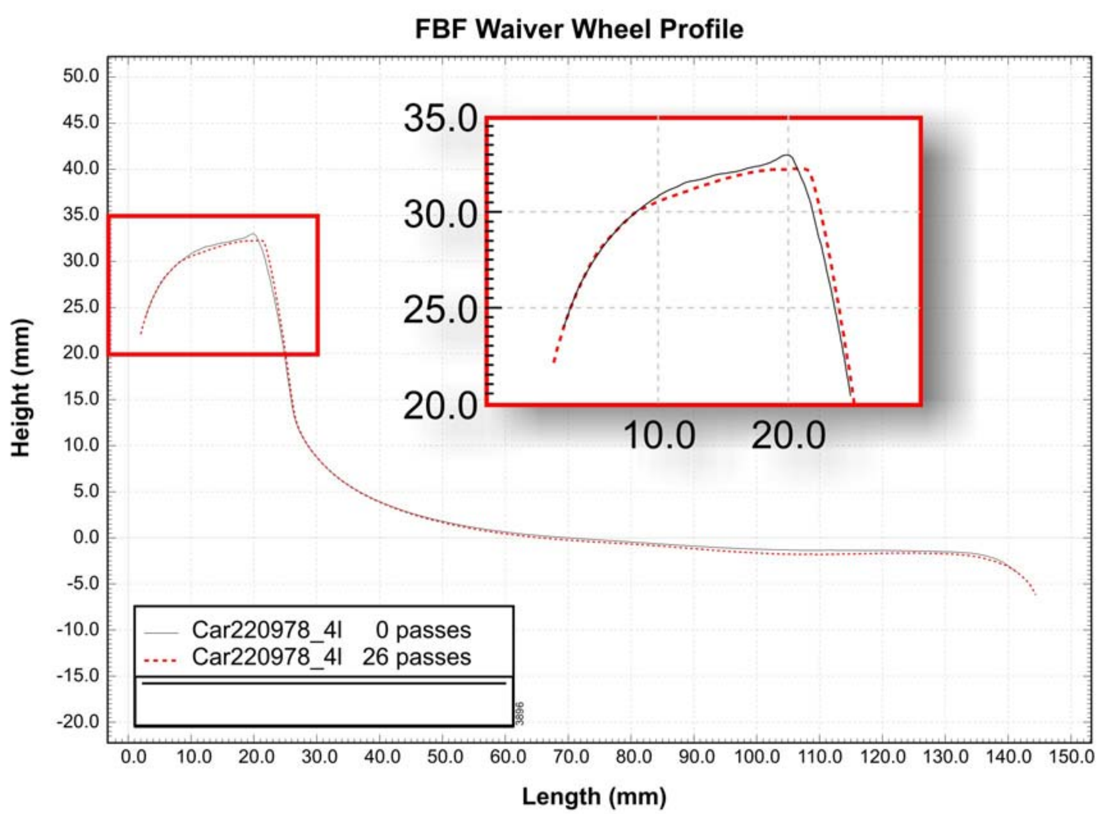

Figure 6. Time Series of Wheel Profiles from Loaded Car Operating Over FBF

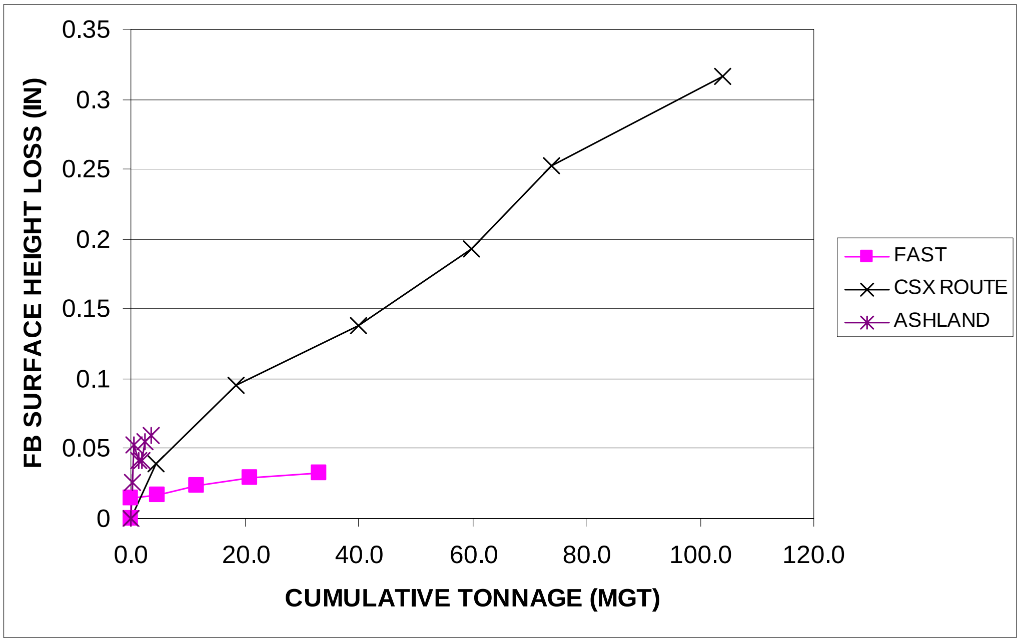

Figure 7. Flange Bearing Surface Height Loss vs. Tonnage

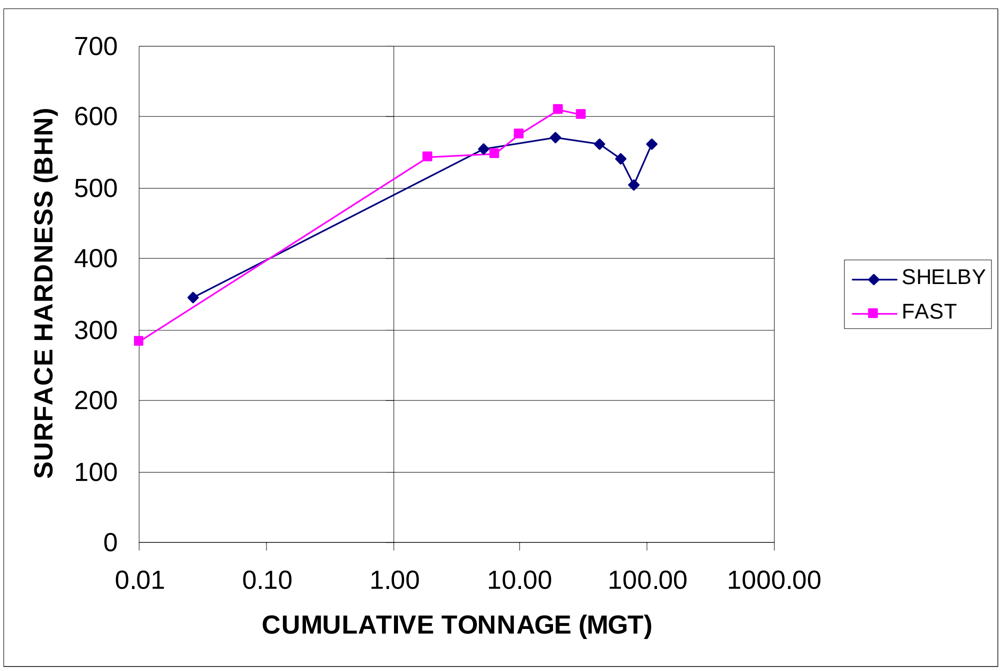

Figure 8. Flange Bearing Running Surface Hardness vs. Tonnage

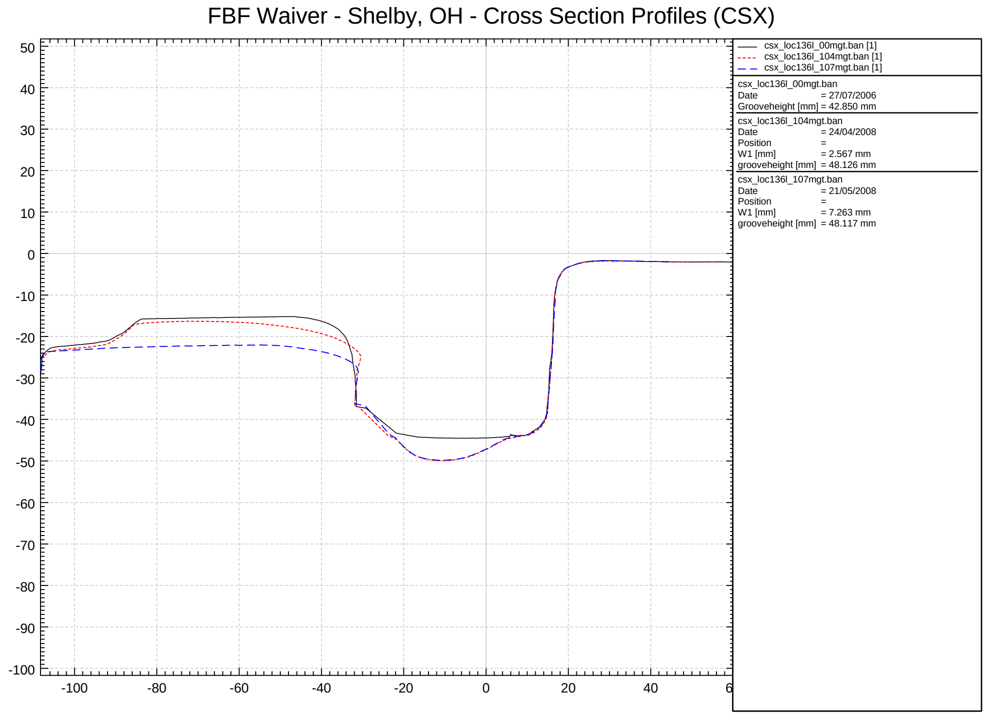

Figure 9. Frog Cross Section Profiles Showing Mainline Wear Groove at the top of the ramp. The black line is the original section, the red line if the pre-grind section, and the blue section is the post grind section.

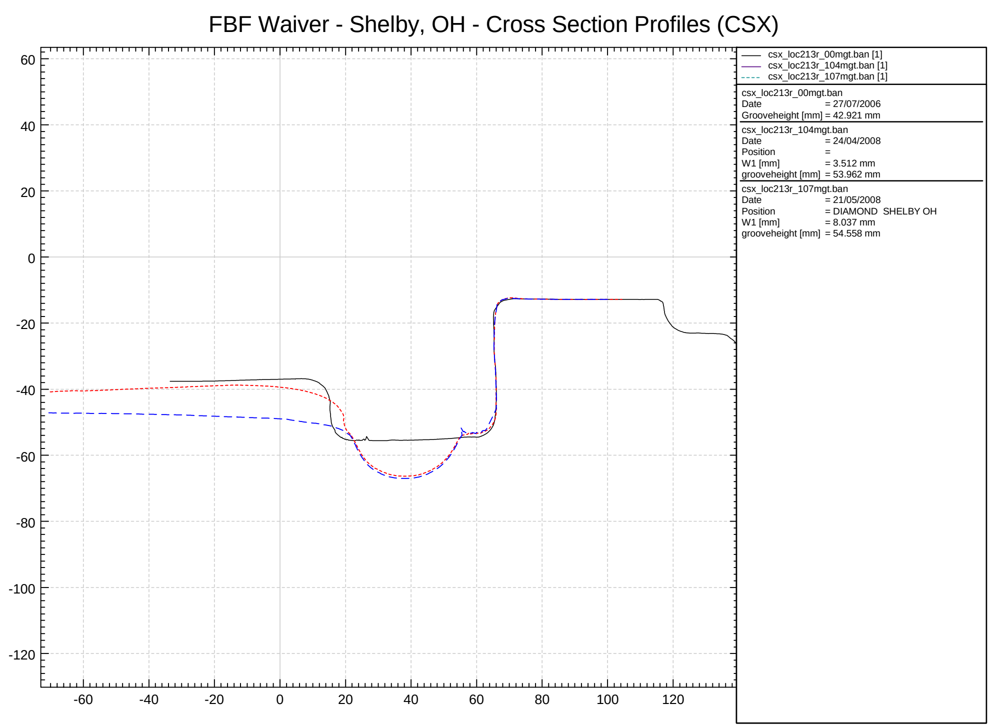

Figure 10. Frog Cross Section Profiles Showing Mainline Wear Groove in the crossing casting. The black line is the original section, the red line if the pre-grind section, and the blue section is the post grind section.

Figure 11. Shelby Flange Bearing Diamond During Grinding

Figure 12. Shelby Flange Bearing Diamond Following Grinding

Figure 13. Lift Frog Locations

Location	Frog Angle	Owning Road	Year Installed
Tracy, IN	10	CSX	2007
McCool, IN	10	CSX	2008†
Wellington, IL	10	CSX	2008†
Space Park, TN	10	CSX	2008†
Mayfield, KS	11	BNSF	2006
Tulsa, OK	11	BNSF	2007
West Quincy, MO (2)	11	BNSF	2006
Mountain Grove, MO	11	BNSF	2006
Kansas City, KS	11	BNSF	2007
Kiowa, KS	11	BNSF	2007
Galesburg, IL	11	BNSF	2007
Pampa, TX (3)	11	BNSF	2007
Douglas, WY (6)	11	BNSF	2007 and 2008
Neosho, MO	11	BNSF	2007
Fort Scott, KS	11	BNSF	2007
Barstow, CA	11	BNSF	2007
Fort Sumner, NM (2)	11	BNSF	2007
Joliet, IL (2)	11	BNSF	2007
Vaughn, NM	11	BNSF	2007
Lubbock, TX	11	BNSF	2007
Vancouver, WA	11	BNSF	2008
Amarillo, TX	11	BNSF	2008
Holbrook, AZ	11	BNSF	2008
Rochelle, IL (2)	11	BNSF	2008
Lind, WA	11	BNSF	2008
Unknown (2)	10	CNIC	Unknown
Lisbon, NM	11	UP	2006

† Planned Installation

Figure 14. Typical Lift Frog Following Installation, Tracy, Indiana.

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David Clark is Engineer Maintenance of Way Standards for CSX Transportation in Jacksonville, Florida. David joined CSX in 1996 and has held a variety of positions including Trainmaster, Project Engineer, Director Engineering Service, and Manager System Production Operations. Prior to joining CSX, David earned his bachelors and masters degrees in Civil Engineering from the University of Kentucky, earned his MBA from the University of Phoenix and is a licensed professional engineer. He serves on AREMA Committee 4 Rail and Committee 5 Track on which he serves as Vice-Chairman of Subcommittee 5 on Turnout and Crossing Design

Tom O'Connor

Tom O'Connor is Assistant Manager Track Standards for BNSF railroad in Fort Worth, Texas. Tom hired on the former Burlington Northern railroad in 1976 and has worked most of the positions in the MOW department including Foreman, Welding Foreman, and on various crews. While employed at BNSF, Tom earned his bachelors degree in Organization Leadership at Bethel College in St. Paul, Minnesota. In 2004 he accepted a position in Manpower planning and in February of 2005 moved in to his present position. He is a member of AREMA Committee 5 track and Chairman of Subcommittee 9 road crossings.

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Dave Davis is a Senior Scientist for the Transportation Technology Center, Inc. in Pueblo, CO. His duties include AAR Strategic Research Initiatives program management and project leadership of Special Trackwork and Technology Scanning research. Dave holds BS and MS degrees in Civil Engineering from the University of Illinois. He is a professional engineer in the state of Illinois and a member of the AREMA committee on track. Dave began his railroad career as a track laborer for the Chicago and North Western Railroad.