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Progress Report on Revenue Service Implementation of OWLS Flange Bearing Crossing Diamonds

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Summary

The implementation of One Way Low Speed (OWLS) flange bearing crossing diamonds in heavy haul freight service on North American railroads continues to be successful after two years of monitoring. Under the Association of American Railroads (AAR) sponsorship, the Transportation Technology Center, Inc. (TTCI), Pueblo, Colorado, and AAR member railroads have proven this concept to be beneficial for applications where a heavy tonnage or high speed mainline crosses a low tonnage, low speed line. This Technology Digest is an update to the progress report made in 2004 [1].

The experience gained from three OWLS crossing diamonds being monitored in Chenoa, IL; Crawford, WI, and Mikon, CA can be practically applied for the design of and maintenance on future installations.

Mainline degradation and dynamic loads are reduced with this design, mainline train speeds have been raised, and crossing line vehicle and diamond performance have been measured and found to be acceptable.

Recent findings are:

- The effects of OWLS crossing diamonds on train and locomotive operation have been minimal. No changes in locomotive engineer instructions have been required. Wheel slip has not been a significant issue.
- The effects of flange bearing on locomotive wheels have been minimal. The performance of one locomotive's wheels has been monitored for 84,000 miles and 550 OWLS crossing diamond passes in the last 2 years. No unusual wheel defects have been reported. The average wheel cross section profile rapidly developed a flat facet on the flange tip, with little change in the rest of the wheel profile. At this ratio of 150 miles per OWLS crossing, tread wear has consistently outpaced flange height loss. This means that wheels will wear in the usual manner, with flange height growing over time. No additional wheel profile maintenance due to the OWLS crossing diamond is expected.
- Offset ramps can be used for locations with very low branchline speeds. While offset ramps have been successfully operated at walking speed by trains at two OWLS crossing diamonds, the design is not recommended. The potential for wheel climb is present at speeds above 5 mph. The actual risk is dependent on crossing angle and ramp rate.
- Initial deformation of the flange bearing running surface at flangeway corners has been high. As with conventional frogs, the deformation rate has decreased with tonnage as the running surfaces work harden to more conformal shapes.
- The long term effects of flange bearing on the mainline running surface (cross grooving) needs further study. To date, cross grooves have not adversely affected ride quality. Based on preliminary data, a high ratio of mainline to branch-line traffic (~20:1) will wear away the cross grooves.

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Background

Flange bearing frogs and OWLS crossing diamonds are concepts that have been used for many years specifically in non-heavy haul situations. Flange bearing frogs are used where the railroad requires minimization of impacts, noise, and vibrations due to unsupported wheels crossing flangeway gaps. Street railways and ports are the main users of flange bearing frogs. OWLS crossing diamond designs are popular for locations where transits cross freight lines.

Currently, Federal Railroad Administration (FRA) track safety standards allow flange bearing frogs for freight railroads on Class 1 track (maximum speeds of 10 mph for freight and 15 mph for passenger) and on excepted track [2]. The OWLS crossing diamond concept is thus applicable to many situations where a low speed, low tonnage line crosses a higher speed main line, since only the low-speed line is flange bearing. Use of an OWLS crossing diamond can offer significant life cycle cost savings by providing a longer service life and by eliminating or reducing track speed restrictions for the main line at diamond crossings.

OWLS Crossing Diamond Performance

The characteristics of the three monitored OWLS crossing diamonds demonstrate a wide range of operations and designs and are described in Table 1. The Crawford location is a typical freight mainline crossing a freight branch line with a traffic volume more than 99 percent on the mainline. The Mikon location is also a typical case with freight and passenger trains on the two-track mainline crossing a low tonnage freight short line. The Chenoa location is a high-speed passenger line with low tonnage crossing a freight short line in which the freight branch line has more tonnage than the passenger mainline does.

Train Handling

Train handling and locomotive operations have not been affected by OWLS crossing diamonds. At the monitored branch line locations, trains stop to obtain clearance before crossing the diamond and therefore, most trains are traveling from walking speed to 5 mph when crossing the diamond. As with other crossing diamonds, locomotive engineers traditionally power down locomotives as they cross the diamond to “calm” the DC traction motors before impacting crossing flangeway gaps and reduce the risk of a “flash-over.” With the OWLS crossing diamond ramps, this reduces wheel slip as the wheel transitions from tread bearing to flange bearing. The Toledo, Peoria and Western Railway Corporation (TP&W) reports no train operating problems with the OWLS crossing at Chenoa. Additionally, there is no evidence of engine burns on the running surfaces of any of the diamonds.

Wheel Performance

TP&W is participating in the Chenoa OWLS crossing diamond study by monitoring locomotive truck and wheel performance. Truck component performance has not changed during the first two years of operations.

TTCI measured wheel profiles on one locomotive that regularly crosses the diamond at Chenoa. These profiles were measured after approximately 35, 160, 230, 324, 446, and 552 passes. Measures of flange height, flange thickness, and flange tip shape were extracted from the measured profiles. The monitored wheels have performed well in flange bearing duty. The locomotives are making a crossing of an OWLS diamond at the frequency of once per 150 to 200 miles. This is likely to be similar to the ratio frequency encountered by the North American car fleet, if flange-bearing crossings are fully implemented.

Figure 1 shows the measured average flange heights for five wheelsets on the TP&W locomotive versus mileage since OWLS crossing diamond installation. As can be seen in Figure 1, the average flange height has increased at each interval. This means that wheel tread wear has been greater than flange vertical wear (a combination of wear and plastic flow). Thus, wheels will wear in the usual manner with flanges getting taller over time.

Table 1. OWLS Crossing Diamond Design and Operating Characteristics

Location	Ramp Length	Ramp Design	Allowable speed (mph)	Mainline Traffic	Branchline Traffic	Ratio Main/ Branch Traffic	Comments
Chenoa, IL (UP-TPW)	10 feet	Parallel	UP – 79 (pass) TP&W – 10	0.4 MGT Passenger 79 mph 0.1 MGT Mixed Freight 60 mph	1.5 MGT Mixed Freight 10- 25 mph	1:3	Frogs are AMS castings
Mikon, CA (UP-Yolo)	4 feet	Parallel	UP – 79 (pass) Yolo – 10	30 MGT Mixed Freight 60 mph 2 MGT Passenger 79 mph	2 MGT Mixed Freight 10-25 mph	30:1	Frogs are running rails with bolt-on AMS castings
Crawford, WI (BNSF-WSOR)	2 feet (within frog casting)	Staggered	BNSF – 50 WSOR – 10	40 MGT Mixed Freight 50 mph	0.2 MGT Mixed Freight 10-25 mph	200:1	Frogs are AMS castings

FLANGE HEIGHT (mm)

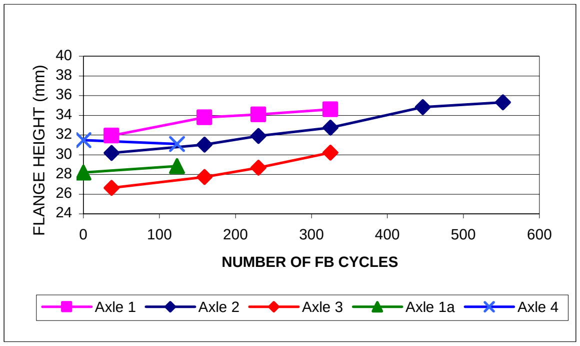

Figure 1. Locomotive Wheel Flange Height versus OWLS Flange Bearing Diamond Passes

Figure 2 shows a time series of wheel flange profiles for one locomotive wheel being monitored and is typical of the group. Note that the flange height is still increasing with time, indicating that tread wear is exceeding flange height loss. Also note the relative stability of the cross section profile shape over time. As was measured during tests at FAST [3], the flange tip flattens rapidly to become conformal to the diamond running surface. The gage side corner of the flange tip may also sharpen (decrease in radius).

Ramp Design

The performance of the flange bearing ramps has been good to date. Austenitic Manganese Steel bar and castings have been used for OWLS crossing diamond ramps. The material has performed well under flange tip loading. Confinement of the running surface, that is, minimizing unsupported edges, has helped. Unsupported edges at joints and flangeways show more deformation and plastic flow.

Ramp Slopes

Parallel ramps with 1:96 slope have been stable, providing good transitions from tread bearing to flange bearing. The result compare favorably to the simulation modeling done for 1:120 ramps. These were recommended as the maximum rate allowed limiting dynamic forces to 150 percent of static wheel loads for freight traffic up to 40 mph [4]. The transition zones are about 24 inches long, indicating a range of wheel flange heights from about 1.125 to 1.437 inches, travel over the crossing diamond.

Short staggered (non-parallel) ramps are used at the Crawford crossing diamond. Train operations over the ramps at walking speed have been uneventful. However, based on simulation modeling, staggered ramps are not recommended for speeds above 5 mph. The ramp stagger causes a large rolling radius difference for each wheelset due to one wheel being flange bearing and one being tread bearing in the distance of the ramp stagger. This rolling radius difference (equal to the flange height of the flange bearing wheel) is predicted to cause the wheelset to steer in the direction of the tread bearing wheel, causing high lateral forces and a high angle of attack.

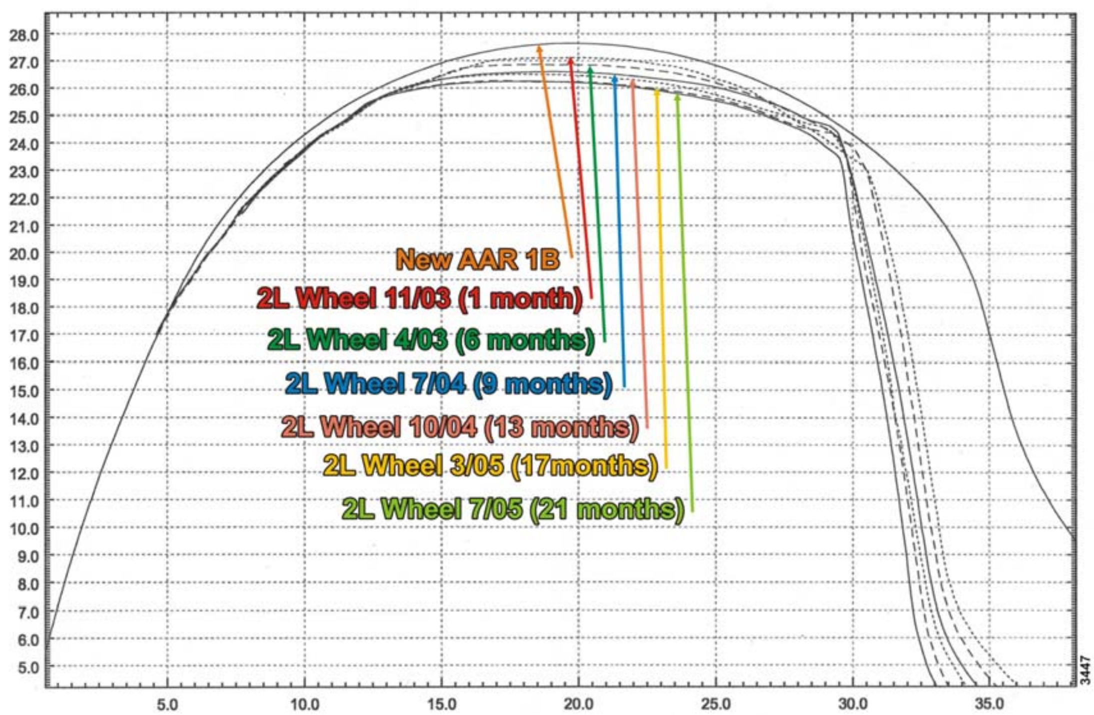

Figure 2. Time Series of Wheel Flange Profiles from Locomotive Operating over an OWLS Crossing Diamond

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Frog Running Surface Performance

The flange bearing running surfaces of the diamonds have been monitored for deformation and rolling contact fatigue (RCF). To date the running surfaces have performed well. As with tread bearing AMS diamonds, initial deformation was relatively large. The rate of running surface height loss has decreased with tonnage at each test location. Absolute measurements of flange bearing running surface height loss measurements were made near the flangeways, but away from the tread bearing running surfaces. The Chenoa crossing diamond had initial height loss rates of 0.1 inch/MGT. The current rate is almost zero. The projected wear life (until a weld repair build up is needed) has increased from a few years to 20 years. The other crossing diamonds with less flange bearing traffic show similar trends.

No RCF is present at any crossing diamond. Measurements of surface hardness in the common flange and tread bearing areas have increased at each measurement interval from about 400 BHN when new to 600 BHN after 2 years in service.

A significant issue for flange bearing frogs is how well the running surface at the flangeway intersections will perform. This area is analogous to the common corner on a tread bearing diamond in that it is where the traffic from both tracks runs on a common running surface. Concerns revolve around the potential for the branchline traffic to wear a cross groove into the mainline running surface. If this wear is severe enough, the dynamic equivalent of flangeway gaps will begin to reappear as cross grooves. The maximum depth of the cross groove was measured at each frog using a straight edge and taper gauge. The maximum value typically occurred near the mainline flangeway. Figure 3 shows the relationship between maximum cross groove depth and flange bearing tonnage for each diamond. What becomes apparent from this graph is the effect of the ratio of mainline to branchline traffic.

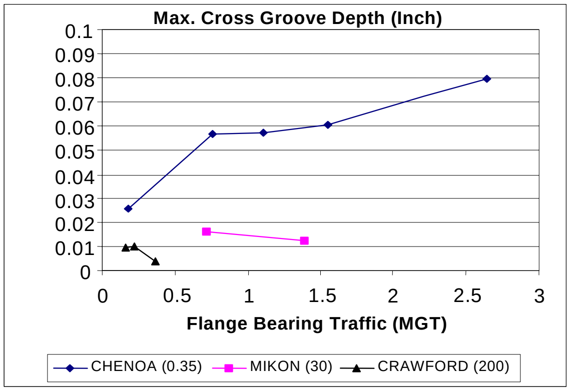

Figure 3. Cross Groove Depth versus Flange Bearing Tonnage

At two of the test sites, the maximum cross groove is decreasing with time. These sites have relatively high ratios of main to branch tonnage. As the rate of flange bearing surface wear has decreased, the rate of tread bearing running surface wear is now higher. Thus, the grooves are being worn away by the mainline traffic. At Chenoa, where branchline traffic is heavier than the mainline traffic, the cross grooves continue to increase with tonnage. Thus, we are beginning to define the range of conditions upon which the cross grooves will require maintenance. It appears that mainline to branchline tonnage ratios above ~ 20:1 will control the occurrence of cross grooves. Measurements at additional sites will be needed to define the relationship further.

FUTURE WORK

TTCI will continue to monitor OWLS crossing diamonds to determine the economics of their design. Additionally, TTCI will support the AAR and its member railroads to implement flange-bearing diamonds in higher speed track.

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