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Evaluation of a Prototype Flange Bearing Derail

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Summary

Transportation Technology Center, Inc. (TTCI) evaluated a prototype flange bearing design for a low cost and highly reliable derail on the Impact Track of the Facility for Accelerated Service Testing (FAST) at the Transportation Technology Center in Pueblo, Colorado. The prototype design attempted to address the issues with derails used in the industry today and is a departure from typical derail designs in that it is entirely flange bearing. This feature permits the derail to raise the vehicle a shorter distance, thus requiring less work to derail a vehicle.

The results of the prototype flange bearing design tested at FAST have been very promising. The changes in derail design reduce the vertical impact loading from the car striking the derail and require substantially less crowding (diverging) force as a result of the derail bearing on the backside of the flange only. While ride quality in and of itself is not important for derailing a car, it is indicative of the efficiency of the design. This also indicates the potential improvement in the long term reliability of the derail, as lower forces should result in a longer service life.

Proof of concept tests were conducted at FAST with the prototype derail design and with two other derail designs. Vehicle truck accelerations and track deflections measured during the derailing motion of loaded and empty open top hopper cars verify the prototype design has lower dynamic vertical, lateral, and longitudinal forces, which should help in addressing the failure modes of currently used designs. These include:

- Track connection failures: The vehicle strikes the derail with sufficient force to break the connections to the track. The result is that the vehicle pushes the derail down the track.
- Insufficient diverting: The derail raises a wheel so that the flange is above the top of rail, but does not divert it far enough to clear the field side of the rail. The wheelset “climbs over” the derail. One wheel may become flange bearing, but the rolling radius difference with the tread bearing mate wheel will likely cause the wheelset to re-rail itself.



INTRODUCTION

Derails are a vital component of railroad safety. Derails have become a standard safety feature across the freight and transit rail industry. Current derail design, however, is not without limitations.

The traditional low cost derail design practice has been to provide a ramp for the tread to climb up on along with a crowder device to force the flange away from the rail, resulting in loss of wheel/rail contact and subsequently the derailment of the wheelset. This design, however, causes impact loading at the interface where the wheel tread meets the ramp of the derailing device. The impacts can cause wheel unloading and the loss of ability to steer the wheelset off of the track.

Typically, the derail will fail in one of two manners. It will fail materially, i.e., the structure of the derail (especially its connection to the track) fails often following a large impact loading, or given the right conditions, rolling stock will jump or climb over the derail rather than being diverted off of the rails. This latter failure mode is due to insufficient control of or diverting of the wheelset. Steep vertical slopes can cause the wheels to unload vertically (i.e., jump over the derail). This makes diverting the wheel laterally nearly impossible. It is also possible in some instances that during a high force impact or as a result of a steep striking angle the derail will shatter and fail to divert the wheels at all, allowing the rolling stock to continue unimpeded.

Advances have been made in recent years in derail design. Notably, one advance is the vertical lift derail, which operates like a continuous mainline running rail switch (vertical lift switch) but terminates in the closure curve section. Similar to the traditional split switch derail, this design increases the likelihood of a car derailing in any given situation. It does have substantial upfront costs, which are directly related to installation of a panelized switch point package.

Prototype Flange Bearing Derail

TTCI developed the prototype flange bearing derail design to address the issues with current derail models. Considering the typical failure modes of traditional derailing devices, a change to the primary derailing mechanism was proposed. Rather than use a ramp to elevate the tread of the wheel, and then divert the wheelset flange, an attempt to make the flange become bearing was utilized. This was accomplished by using an angled plate that enables the wheelset to become entirely flange bearing as it travels in the direction of the derail. Once the wheelset becomes flange bearing, a built-in crowder is used to guide the wheelset off the rail. Figure 1a shows a

computer aided design (CAD) drawing of the new flange bearing plate design, and Figure 1b shows the prototype flange bearing derail tested at FAST. The prototype design shown in Figure 1b was constructed to facilitate ease of installation and removal during testing. It would have to be further refined and optimized (less material and operable throw mechanism) before being used in a revenue service environment. The goal of this prototype fixture was to prove that the concept of a flange bearing derail would perform adequately.

This design has several advantages. It potentially eliminates impact loading from the contact point between derail and wheelset. The flange bearing plate functions in a similar manner to a switch point in that the wheel rides up the plate. The built-in crowder removes the need for a separate crowding device and eliminates additional material and equipment typically required to derail a car.

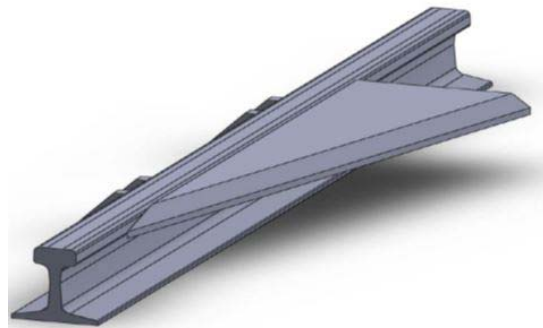


Figure 1a. CAD Drawing of Flange Bearing Plate Design



Figure 1b. Flange Bearing Prototype Derail

CSX Vertical Lift Derail

Progress Rail designed a derail that was based on the principles of a vertical lift switch for CSX who then requested evaluation testing be performed. As described by Davis and Akhtar, “A vertical switch requires diverging route wheels to climb over the mainline rail. This is done by lifting the wheels over the stock rail on a field side switch point.”¹ The vertical lift derail utilizes that principle to create a variation on a traditional split switch derail.

As Figure 2 shows, the vertical lift derail panel consists of a knife style switch point in combination with an outer diverging rail that lifts the wheelset. Once the wheelset is lifted above the rail, the switch point pushes the wheelset towards the diverging rail.¹

The vertical lift design eliminates the issues resulting from noncontiguous mainline running rail seen in traditional split switch derails. Similar to the TTCI prototype flange bearing derail, it has the potential to minimize impact loading at the point of derailment. It does, however, have higher costs to install than alternative derail equipment.



Figure 2. Vertical Lift Derail Panel

Traditional Slider/Crowder Derail

Figure 3 shows a two-way configuration of a traditional slider/crowder derail tested as part of this project. It was selected to provide a data baseline for derails that would be typically encountered in revenue service.

The slider/crowder derail consists of a tread ramp style derail paired with a wheel crowder that applies to the opposite rail simultaneously (as shown in Figure 3). As previously discussed, this derail lifts the tread of the wheel and then diverts the wheelset off of the rail. Out of the three derails investigated, the slider/crowder derail is one of the more common derails seen in revenue service. It

has moderate installation costs compared with a vertical lift derail or a split switch style derail).



Photo courtesy of Western-Cullen-Hayes
Figure 3. Traditional Slider/Crowder Derail (Two-way configuration model.)

Field Tests

Field tests of the three derail designs were conducted on the Impact Track at FAST using two open top hopper cars, one loaded and one empty. The derails were tested at two different speeds, 4 mph and 10 mph with both cars. The angle of attack of the leading wheelset was also altered to create a worst-case scenario for derailling. Cars derailed at 4 mph were pushed by the locomotive unit as one train, while at 10 mph the cars were pushed individually in the direction of the derail. Instrumentation rigged to the leading truck of the car gathered data on accelerations and displacement as the car struck the derails. Simultaneously, instrumentation set up at wayside collected data on the displacement present in the rails at the location of each derail during the same event. Figure 4 shows the prototype flange bearing derail and the railcar passing over it on the Impact Track at FAST.



Figure 4. Video of Prototype Flange Bearing Derail at FAST and Railcar Passing over it at 4 mph

Profile measurements were taken of all four wheels on both cars to document the condition of the wheels used during testing. In an attempt to keep the data consistent, special consideration for the speed at impact had to be made. Every effort was taken to ensure that the car struck each derail as close to the specified speed as possible. Speed measurements were made using the locomotive’s speedometer and a handheld radar gun.

Results of Field Tests

Figure 5 shows the measured leading truck accelerations for a loaded and empty car over each derail. Shown are the maximum accelerations for each side frame in the lateral (x), longitudinal (y), and vertical (z) directions. The CSX/Progress Rail vertical lift derail panel and TTCI’s prototype flange bearing derail created similar acceleration effects at 10 mph in the loaded and empty cars. The traditional slider/crowder derail created higher accelerations due to the impact loading experienced as the wheel struck the derail ramp. The prototype derail was broken during the last test run at 10 mph with the loaded car. This caused a spike in the acceleration data in the vertical direction and skewed the data point for the prototype as noted in Figure 4.

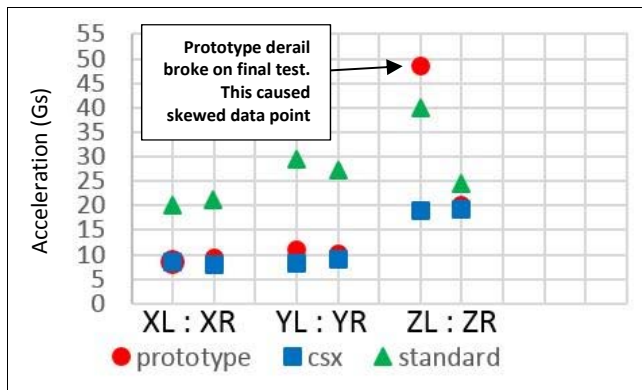


Figure 5. Average Acceleration at 10 mph Derailment by Rail

Figure 6 shows measured rail displacements for each derail during loaded and empty car tests at 10 mph. When comparing lateral displacement of the running rails, the CSX/Progress Rail vertical lift derail panel experienced the least displacement. The prototype flange bearing derail and the traditional slider/crowder derail experienced similar displacements, which were notably higher than the vertical lift derail panel. The TTCI prototype flange bearing derail’s creation of lower lateral

rail movement is an improvement over the traditional design. When installed using a similar throw mechanism as opposed to being bolted to the rail, the prototype flange bearing derail should result in even lower lateral movements. The prototype derail also creates lower acceleration forces in the railcar during derailment when compared with the traditional slider/crowder derail.

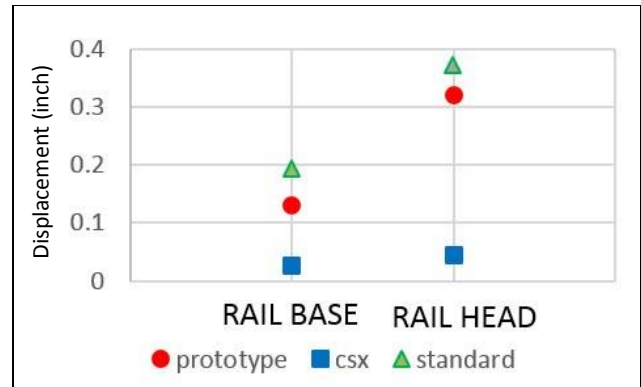


Figure 6. Average Lateral Displacement of Running Rails at 10 mph Derailment

CONCLUSIONS

Test results indicate the flange bearing derail concept is a viable alternative to traditional derail designs. It requires less equipment and material to accomplish the same task as traditional slider/crowder derails in use today. The vertical lift derail designed for CSX is extremely effective and creates low displacements and acceleration forces as a car derails. It provides a continuous mainline running rail requiring minimal maintenance, which is an advantage over traditional split switch point derails.

TTCI would like to further explore optimal derail designs in future years of SRI 9A research work to determine an optimal derail design that is superior in both cost and performance to derails available on the market today. TTCI would also like to conduct derail tests at speeds greater than 10 mph to study the performance of derails at higher speeds than typical.

REFERENCES

1. Davis, David and Muhammad Akhtar. “Development of a Vertical Switch Design.” *Technology Digest* TD-10-014. Association of American Railroads, Transportation Technology Center, Inc., Pueblo, Colorado, May 2010.

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