TECHNOLOGY DIGEST
TD-16-041
©OCTOBER 2016
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.

A Review of Derail Designs

David D. Davis, Rafael Jimenez, and Benjamin Bakkum

Summary

Transportation Technology Center, Inc. (TTCI) has conducted a review of derails to determine potential ways to improve performance. The review included a representative sample of derails used in North America with an emphasis on those currently being marketed. The results of the review suggest some opportunities to improve the performance and/or reduce the cost of derails. These findings are being used to develop improved performance prototypes.

TTCI's survey, performed under by the Association of American Railroads' Strategic Research Initiatives (SRI) Program, revealed that derails can be classified into two types: short derails and long (i.e., switch type) derails.

Short derails can produce high longitudinal and lateral forces. While this is of little consequence to the car being derailed, it offers the opportunity to improve performance reliability by minimizing these forces and their potential effects on loss of control of the car and component failure in the derail. Development of concepts that lower ramp angles and extend lateral guarding may be warranted, based on failure modes currently seen.

Long derails, essentially switches, produce more reliable results than short derails. They are, however, relatively expensive to build and maintain. The continuous mainline rail switch concept may have good application in further improving the performance and economics of long derails.

The SRI Special Trackwork project will use results of this study to work with track engineers and trackwork suppliers to develop and evaluate improved performance prototypes.

Please contact **David Davis (719) 584-0754**with questions or concerns regarding this *Technology Digest.* E-mail: David_Davis@aar.com.

INTRODUCTION

Transportation Technology Center, Inc. (TTCI) has undertaken a study of currently used derails to determine if improvements in reliability and efficiency could be developed. The results of the review, performed under the Association of American Railroads' Strategic Research Initiatives (SRI) Program, suggest some opportunities to improve the performance and/or reduce the cost of derails.

Derails are a vital component of railroad safety. They protect mainline and yard tracks from inadvertent fouling by unattended equipment and/or trains. As more routes carry passengers and freight, the potential consequences of a potential collision increase in frequency and magnitude.

The study of derails requires the same mindset used to develop improved performance special trackwork: a good design economically minimizes dynamic forces for the vehicle and the track. This is not done to minimize damage to the vehicle or the track; but is done to improve the likelihood that the vehicle behaves in the desired manner.

ANALYSIS OF CURRENT DERAIL DESIGNS

Ideally, derails are only used for their intended purpose of derailing a vehicle on rare occasions. Thus, a low cost design is necessary to assure that all tracks are protected. It is easy to understand why there is a limited amount of data about derail failure rates and modes: failure rate data is not regularly recorded because derail usage is not recorded. However, there is much anecdotal information about failure modes. Derails can be classified into two types: short derails and long (i.e., switch type) derails

Short Derails

Short derails are generally less than 5 feet long and, generally, they are deployed by adding a derailing/ diverting component to the top of one or both rails. Thus, they typically do not carry wheel loads under normal traffic.

The typical short derail design provides a ramp for the tread and flange to climb over one rail. The derail also may act as a crowder device to divert the wheel flange beyond the field side of the rail resulting in loss of wheel/rail contact, and subsequently, the derailment of the wheelset. The crowder may be integral to or separate from the device that raises the wheel that is intended to end up outside of the track gage. Figures 1 through 3 show typical short derails used today.

Figure 1. Typical Hinged Derail: a) Deployed, and b) Retracted

Figure 2. Typical Sliding Derail with Integral Crowder: a) Deployed, and b) Retracted

Figure 3. Typical Sliding Derail with Separate Crowder (Deployed)

This design, however, causes impact loading at the interface where the wheel tread meets the ramp of the derailing device.[1] The derailing ramp can be quite steep, especially for the hinged type of short derail, with angles up to 45 degrees. Figures 1a and 2a show derails from the perspective of the wheels. The impacts can cause wheel unloading and the loss of ability to steer the wheelset off of the track.[1]

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; 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.[1]

Connections to the track can fail due to the degradation of timber crossties and the fasteners that attach the derail to the crossties. Environmental decay and weathering can reduce crosstie strength by more than half of the original value.[2] Additionally, corrosion and crosstie metal sickness can further reduce the strength of metal to wood connections.[3]

Long Derails

Long derails are generally conventional split switches where the diverging route ends just beyond the heel of the switch. A typical switch type derail is 20 to 25 feet in length, depending on the switch point length used.

The split switch derail, which operates like a standard switch, derails the vehicle by terminating the diverging route track. The vehicle simply runs off the ends of the rails. This method increases the likelihood of a car derailing in any given situation. It does have substantial upfront costs, however, directly related to installation of a panelized switchpoint package. This entails specially machined rails (both switch points and stock rails), switch point connecting rods, stock rail braces, slide plates, and extended length crossties. A disadvantage of this type of derail is that all traffic for the track runs on the mainline switch point of the derail. Figure 4 shows a typical split switch derail.

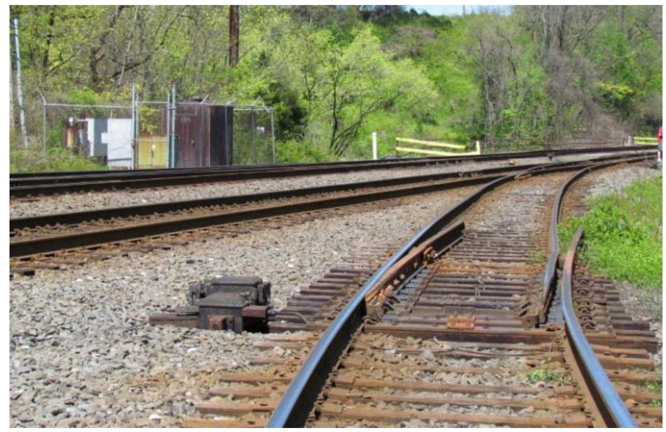

Figure 4. Typical Split Switch Derail

This type of derail can fail by the modes associated with split switches. Failure for a derail is defined as failure to keep the guarded track free of obstructions. Thus, a failure would be a split switch type derailment where the mainline is fouled by the derailment.

A recent refinement of the long derail is the vertical switch type derail. This design is based on the recently re-introduced continuous mainline rail turnout.[4] As the name implies, this design of switch has continuous mainline rails; thus, like short derail designs, the derail components carry no load when retracted. Figure 5 shows a prototype undergoing proof testing at Transportation Technology Center (TTC), Pueblo, CO.

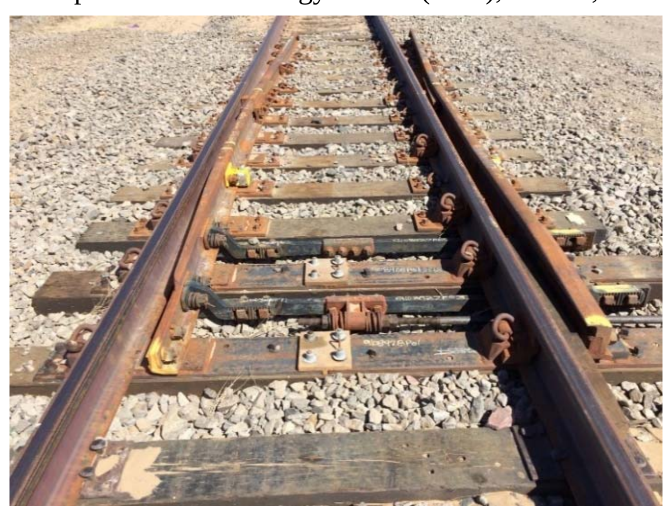

Figure 5. Prototype Vertical Switch Derail in Track

DIMENSIONS SURVEY

A survey of dimensions was conducted from product literature, engineering drawings, and measurements of derails in use at TTC. Angles were measured in three planes:

1. Gradient (with respect to horizontal in the longitudinal direction).
2. Diverging angle (with respect to track centreline in the lateral direction).
3. Gage face angle (with respect to vertical perpendicular to gage line).

Table 1 lists the three angles for each derail type. The table gives an idea of the average and ranges of values for each derail type.

Table 1. Derail Design Parameters

Parameter	Short Derail Average (Range)	Long Derail Average (Range)
Length (ft)	1.78 (0.56 – 3.64)	31.27 (NA*)
Ramp angle (degrees with respect to horizontal)	20.40 (14.0 – 28.0)	1.09 (NA*)
Ramp rate (grade)	29 percent (20.8 – 53.8)	0.4 percent (NA*)
Diversion angle (degrees with respect to track center line)	19.60 (8.3 – 30.0)	2.1 (NA*)
Gage face angle (degrees)	58.10 (46.0 – 90.0)	78.0 (NA*)

*Very small range of values due to manufacturing tolerances from standard switch designs

Based on the ramp and diverging angles, the longitudinal and lateral forces on the short derails are likely orders of magnitude higher than those on long derails or conventional turnouts. These high forces can result in the track connection failures seen in short derails. They can also result in wheel unloading and loss of control of the wheelset. This can result in cars "climbing over" the derail or one wheel becoming flange bearing on the rail. The rolling radius difference this causes on the wheelset makes it likely the wheelset will re-rail itself. Most derails lift wheels well above the top of the running rail; which would appear to be unnecessary. Therefore, ramp angles can be reduced without lengthening the current derails.

CONCLUSIONS

A survey of derails was conducted to determine potential ways to improve performance. The survey revealed that short derails can produce high longitudinal and lateral forces. While this is of little consequence to the car being derailed, it offers the opportunity to improve performance reliability by minimizing these forces and their potential effects on loss of control of the car and component failure in the derail.

FUTURE WORK

Under the SRI program, TTCI will develop and evaluate new concepts for derails that offer improved reliability as compared to currently used short derails, or lower first cost as compared to currently used long derails.

REFERENCES

1. Bakkum, Benjamin, Rafael Jimenez, David D. Davis, and Beatrice Rael. "Evaluation of a Prototype Flange Bearing Derail." *Technology Digest* TD-16-033, Association of American Railroads, Transportation Technology Center, Inc. Pueblo, CO. August 2016.
2. Davis, David, Poo Chow, and Roger Meimban. "The Effects of Weathering on Wooden Crossties." Research Report R-915, Association of American Railroads, Transportation Technology Center, Pueblo, CO. December 1997.
3. Choros, J. et al. "Iron Degradation of Wood Crossties." Research Report R-767, Association of American Railroads, Technical Center, Chicago, IL. December 1990.
4. Davis, David D. et al. "Demonstration of a Continuous Mainline Rail Turnout." *Technology Digest* TD-13-006, Association of American Railroads, Transportation Technology Center, Inc. Pueblo, CO. April 2013.