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# Analysis of Contact Issues between Locomotive Wheels and Switch Point Guards

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**Summary**

Due to concerns about wheel climb at switch point guards (i.e., field side guardrails used in low speed switches), the Association of American Railroads (AAR) funded the Transportation Technology Center, Inc. (TTCI) to investigate the wheel/rail contact issues between locomotive wheels and switch point guards. The analysis showed some potential wheel/rail and track specification compatibility issues. Potential solutions to these issues are presented in this *Technology Digest*.

The following is a brief summary of TTCI researchers' conclusions:

- A field side switch point guard is a simple way to accomplish the objective of guarding switch points. However, a guardrail in the gage of the track would be preferable (from the wheel/rail interaction point of view). The solutions to clearance issues identified below would be simpler if the point guard was a guard in the gage of the track.
- Track maintenance handbooks do not specify track gage for use with switch point guards.
- Current mechanical and track tolerances allow situations where the envelope between the point guard and the opposite rail is too small to allow wheelsets meeting AAR mechanical requirements to pass. While this situation is not likely unless track gage is narrow, it can be worse for locomotive wheels, because they can have wider spacing than freight car wheels.
- The sloped flares on the switch point guards allow the possibility for wheels to climb the point guard.
  - The wheel rim chamfer, a 45-degree cut on the field side of locomotive wheels, makes this situation worse and allows wheels to more easily climb the point guard. In 2007, a reduced size of allowable chamfer was implemented by AAR.
  - The cylindrical locomotive wheel profile used by some railroads for locomotive wheels produces the worst-case wheel climb scenario. Care should be taken to use the current 2009 profile dimensions.[1] The previous version had an error that made the analysis incorrect.

Recommendations for the track engineers are:

1. Develop a "design" wheelset for trackwork. Determine the width of wheels and wheelsets used on the railway. This may be a locomotive wheelset.
2. Specify minimum track gage allowed based on item 1. This may be larger than FRA Track Safety Standards allow.
3. Increase the slope on the point guard flare. The slope should be 90 degrees or slightly less, as is the practice for the body of conventional guardrails.
4. Raise the existing point guards to engage the wheel on a vertical face. Chamfered locomotive wheels require the guard to be raised about 3/16 inch.

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## INTRODUCTION

Due to concerns about wheel climb at switch point guards (i.e.. field side guardrails used in low speed switches), TTCI analyzed the wheel/rail contact issues between locomotives and switch point guards. The analysis has shown some potential wheel/rail and track specification compatibility issues. Potential solutions to these issues are presented in this *Technology Digest.*

Switch point guards (i.e., switch point protectors) are used to keep wheels away from switch points at the point of switch of low speed turnouts. They are commonly used to protect the diverging route switch points of heavily used turnouts in yard lead tracks, curved turnouts, and locations where there is a curve immediately before the switch points.

Figure 1 shows a typical field side switch point guard. This type of guard is popular because it is easy to install and maintain. The guard does not interfere with access to the switch points or the switch throw mechanism.

**Figure 1. Typical Field Side Switch Point Guards**

This type of switch point guard functions by guiding the wheel away from the switch point near the point of switch. The guard engages the wheel on its outer (i.e., the side away from the flange) vertical face. The guard bar is flared, like frog guardrails, to guide the wheelset laterally away from the point of switch.

Recently, concerns have been raised about wheel climb derailments on this type of switch point guard. Common elements in these incidents include:

- Curved track in front of the point of switch
- An existing (i.e., relatively well worn) switch point guard
- A locomotive with recently turned wheels

The first common element practically assures that the switch point guard will come in contact with passing wheels. The guards will wear in a way that lowers the slope on the flares, lowering the wheel/rail contact angle. Thus, the wheelsets will be more likely to climb the guard under the same operating conditions. Figure 2 shows a worn switch point guard.

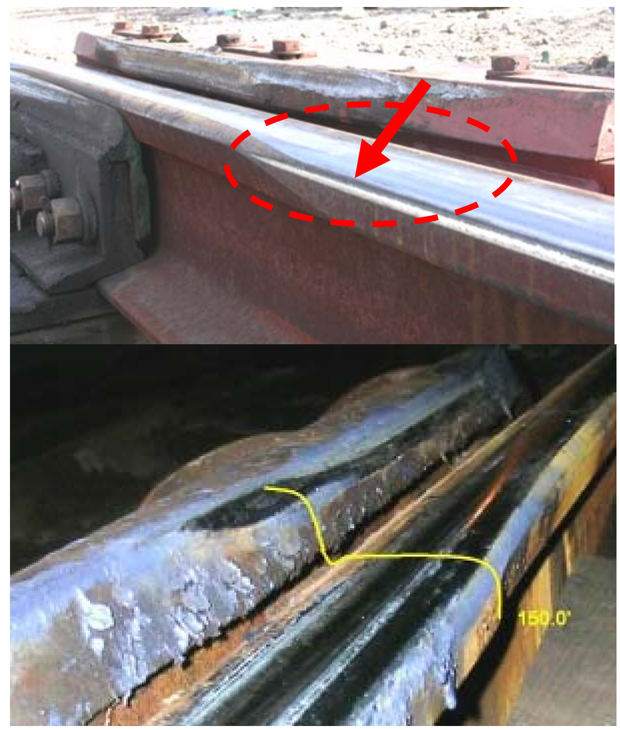


**Figure 2. Worn Switch Point Guard**

Recently turned locomotive wheels often have a wheel tread chamfer. This is a cut made at 45 degrees to the vertical at the field side of the wheel tread. The chamfer is likely the first part of the wheel to make contact with the flare of a field side switch point guard. The contact angle between these two surfaces is low, making it more likely for the wheel to climb the guard. Figure 3 shows the maximum allowable chamfer (0.4375-inch long) permitted by the AAR Wheel Standard M-107.[1] AAR M-107 no longer permits the large chamfer shown in Figure 3. New wheels normally have a 5/8-inch radius instead of the chamfer. However, cutting a chamfer is allowed when turning locomotive wheels because of limitations of some wheel cutting lathes.

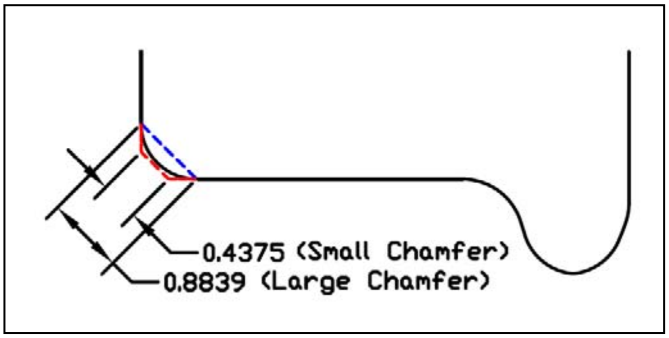


**Figure 3. Locomotive Wheel Profile with Chamfer**

## Wheel/Rail Contact Geometry

A contact wheel/rail contact geometry analysis was conducted using the likely worst-case scenario wheel and track conditions. The locomotive wheel was selected due to its history of problems derailing on switch point guards. The maximum AAR allowable wheel back-to-back spacing of 53 3/8 inches was selected for the analysis. It created a situation where the wheelset was likely to come into contact with the switch point guard. Also, minimum allowable track gage was likely to be the worst case, because it can create a situation where the wheelset is most likely to come into contact with the switch point field side guard.

Three wheel chamfers were used in the analysis:

- No chamfer (5/8-inch radius)
- Small chamfer (0.4375-inch long), currently allowed in AAR M-107
- Large chamfer (0.8839-inch long), a typical 5/8-inch depth chamfer permitted prior to 2007

The 1979 version drawing of an AAR Cylindrical Tread Contour for Narrow Flange Wheels drawing was used in the analysis rather than the 1997 version drawing due to some errors in the 1997 drawing of the flange shape. The 1997 drawing flange is 3/64-inch wider than the flange in the 1979 drawing. The current drawing (2009) is similar to the 1979 version used in this study. Note that some railroads no longer use a cylindrical tread profile on locomotives, but continue to cut the chamfers due to the limitations of the wheel cutting machines.

Figure 4 shows the switch point guard configured with nominal spacing to the gage face of the rail it is protecting. Wheel/rail contact geometry analyses were conducted for several locations along the switch point guard shown in Figure 4, with critical locations identified between cross sections A to C, as Figure 5 shows.

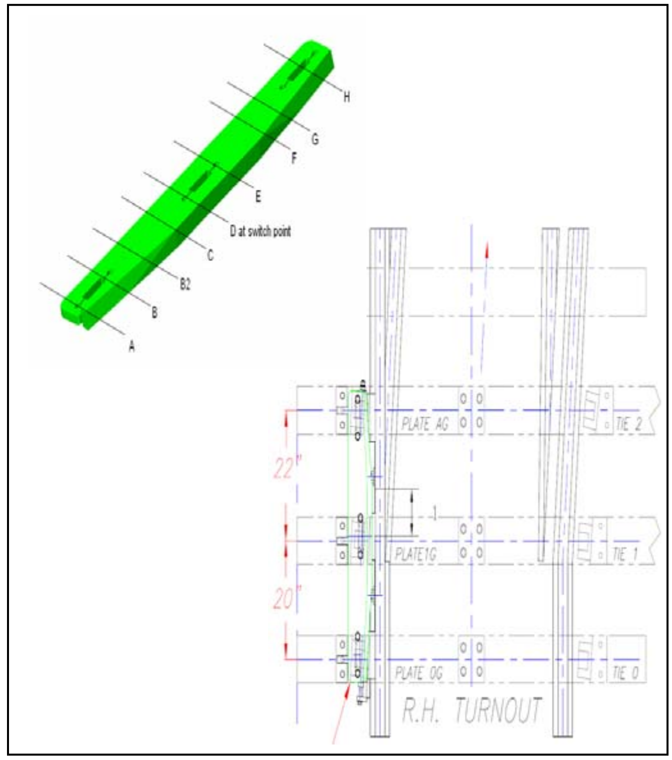


**Figure 4. Switch Point Guard Layout**

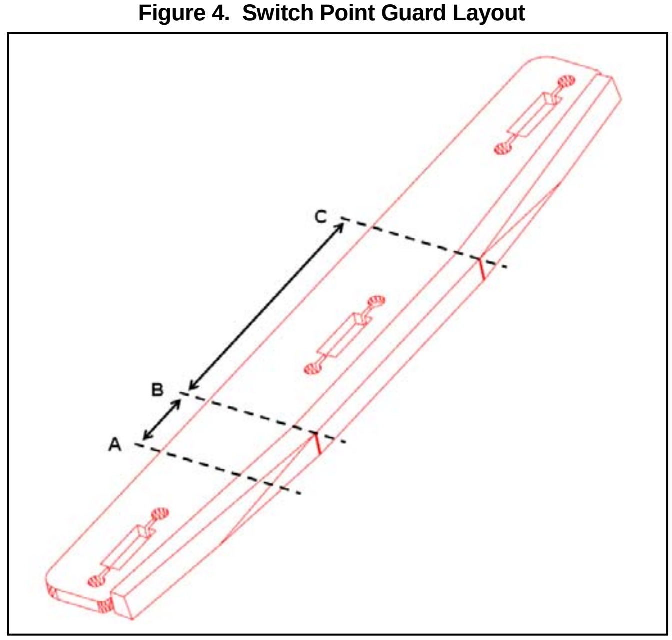


**Figure 5. Switch Point Guard Cross Section at Critical Locations**

Figures 6 and 7 show the results of the contact geometry analysis using a minimum allowable track gage of 56 inches.

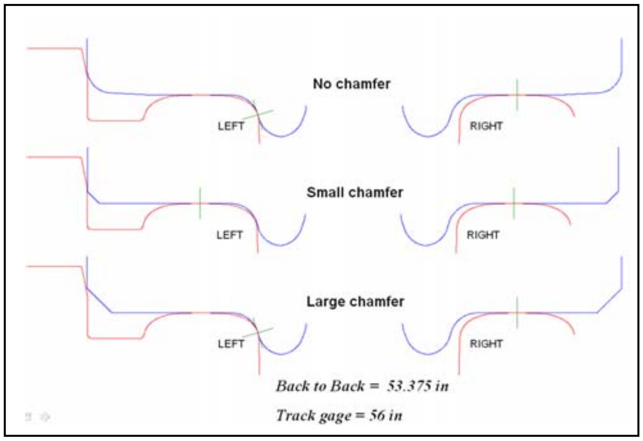


**Figure 6. Wheel/ Guard Contact in Entry Flare for Narrow Track Gage and Wide Wheelset Spacing at Cross Section A**

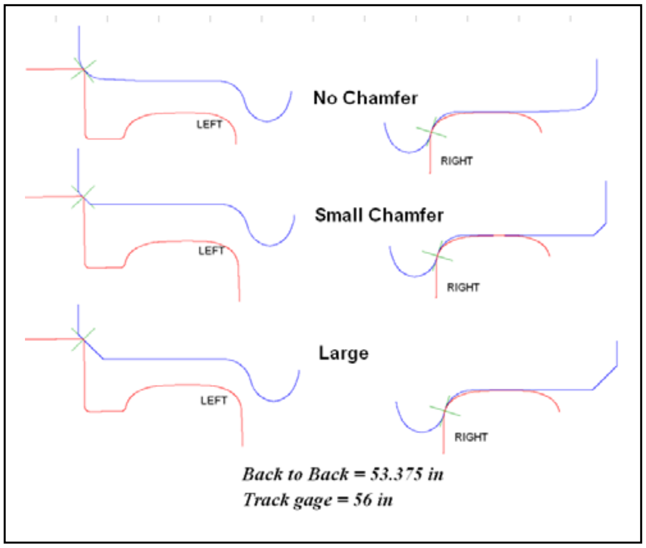


**Figure 7. Wheel/ Guard Contact in Full Body of Guard for Narrow Track Gage and Wide Wheelset Spacing at any Cross Section between B and C**

The wheel/guard contact angle in the guard flares (Figure 6 shows cross section A as an example) depends on the height of the wheel chamfer and the 78.8-degree slope of the flare cut. Over time, this slope angle can decrease due to wear. For the case described, the large chamfer and the radius wheels will contact the guard on the flare cut. This sharp corner can "catch" on the slope face leading to wheel climb. The small chamfer will cause the corner of the chamfer to contact on the guard vertical face. Note that as the slope face of the guard wears, it will extend farther downward and allow the corner of the smaller chamfer to catch on the slope. Angles of attack between the wheelset and the rails will exacerbate the problem for both chamfer conditions.

Figure 7 illustrates another potential problem with field side switch point guards. The center length of the guardrail can pinch the wheelset between the guard and the opposite rail when the track gage is narrow, and the wheelsets have the maximum allowable back-to-back spacing. This condition will force track gage spreading and/or wheel climb. Current track maintenance guidelines do not specify how this dimension (running rail to field side guard face) is checked to determine whether wheelsets have sufficient clearance. However, for minimum track gage and maximum wheel back-to-back spacing, there is insufficient clearance, regardless of wheel tread profile or chamfer. FRA standards allow even wider wheel back-to-back spacing on locomotives (53 ½ inches), which exacerbates the clearance problem.[2]

The above situation is unlikely to happen for nominal track gage and AAR interchange wheels. But, it can happen for nominal track gage situations where there are wider tread wheels and/or wider wheel back-to-back spacing. Except for the rim chamfer issues noted above, the shapes of the wheel tread and flange profile will have little effect on contact with the switch point guard.

## Exacerbating Conditions

The following will affect the wheel/guard contact conditions:

- Wheel width — a wider rim makes the potential for wheelset pinching at wider track gages more likely. A wider wheel causes the wheel to contact the guard sooner (i.e., closer to the end of the flare) and will result in a lower contact angle and more risk of wheel climb.[3.4]
- Flange width — a wider wheel flange also makes the potential for wheelset pinching at wider track gages more likely.
- Flange wear — a worn flange will allow the wheel to contact the guard sooner (i.e., closer to the end of the flare). This will result in a lower contact angle and more risk of wheel climb.[3.4]
- Guard wear — a worn guard will reduce the wheel/guard contact angle for most wheels. This condition can be especially harmful for chamfered wheels.
- Wheelset angle of attack — Switches in curves or just beyond curves are most vulnerable to wheel climb because of the likelihood of wheelsets operating with high angles of attack. The wheels are already in gage face contact when they enter the switch. The angle of attack decreases the wheel/guard contact angle, making wheelset climb more likely.[3.4]

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