Correcting Adverse High Rail Profiles to Promote Desirable Wheel Contact and Rail Stability

Brad Kerchof

NS Research & Tests

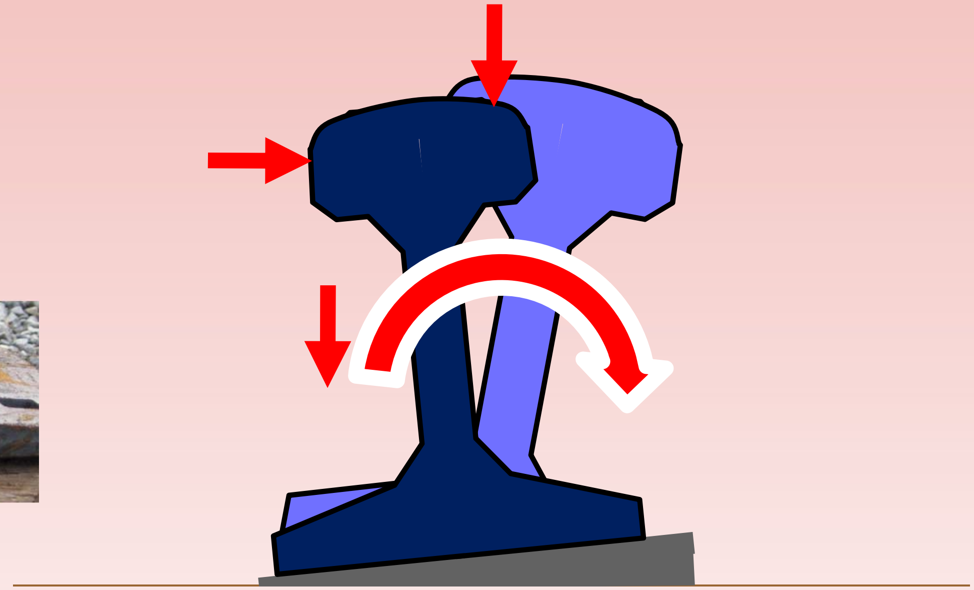
May 21, 2015

Outline

- Rail profile fundamentals (rail cant, B/H, head slope and wheel/rail contact)
- Understanding the impact of rail cant on rail grinding and rail profiles
- How did the importance of rail profiles come to our attention?
- The Cresson subdivision asks permission to gage several high rails
- Loram's grinding plan to modify the high rail profiles
- Next time we do this

Rail cant

Cant is the amount of rail rotation referenced from standard tie plate position (typically 1:40 inward).



Tie plate rail seat wear and plate cutting into the tie can cause ***outward*** cant, as much as 3° from the 1:40 position

Rail profiles can be described by B/H ratio and head slope

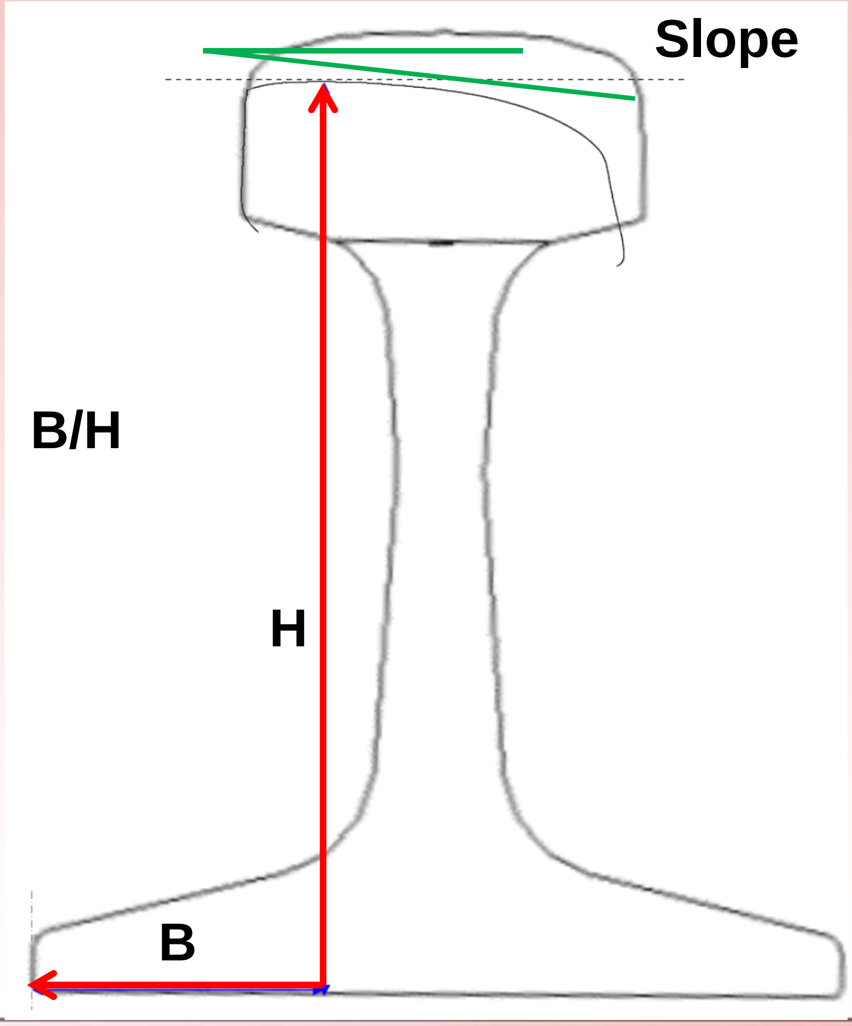
Base / Height (B/H) ratio

- H is the rail height
- B is the horizontal distance from the high point to the field side of the base
- B/H for new 136RE rail = 0.41
- NS uses 0.35 as a threshold for concern

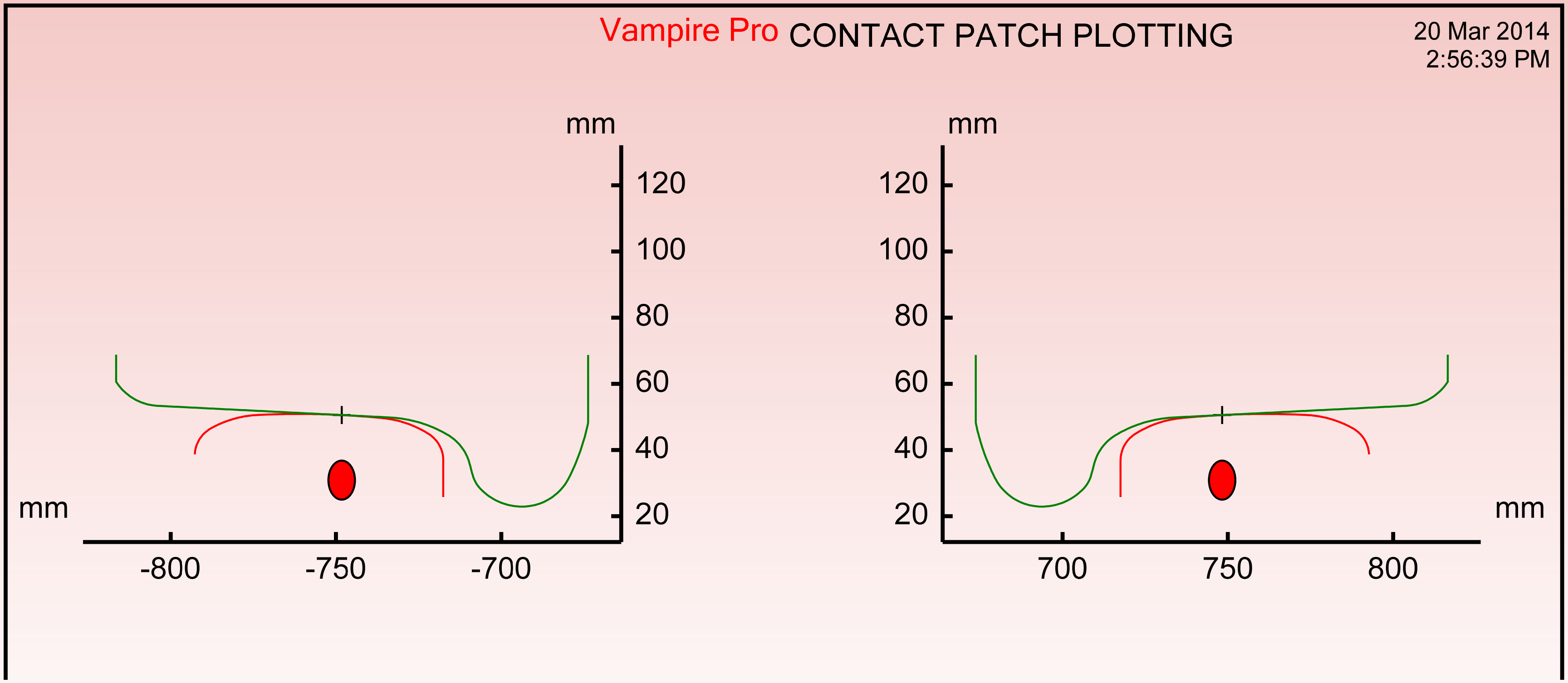
Head slope is the angle defined by two points ½ inch on either side of rail head center

- NS uses 5° as a threshold for concern

Low B/H and high head slope tend to move wheel contact toward field side

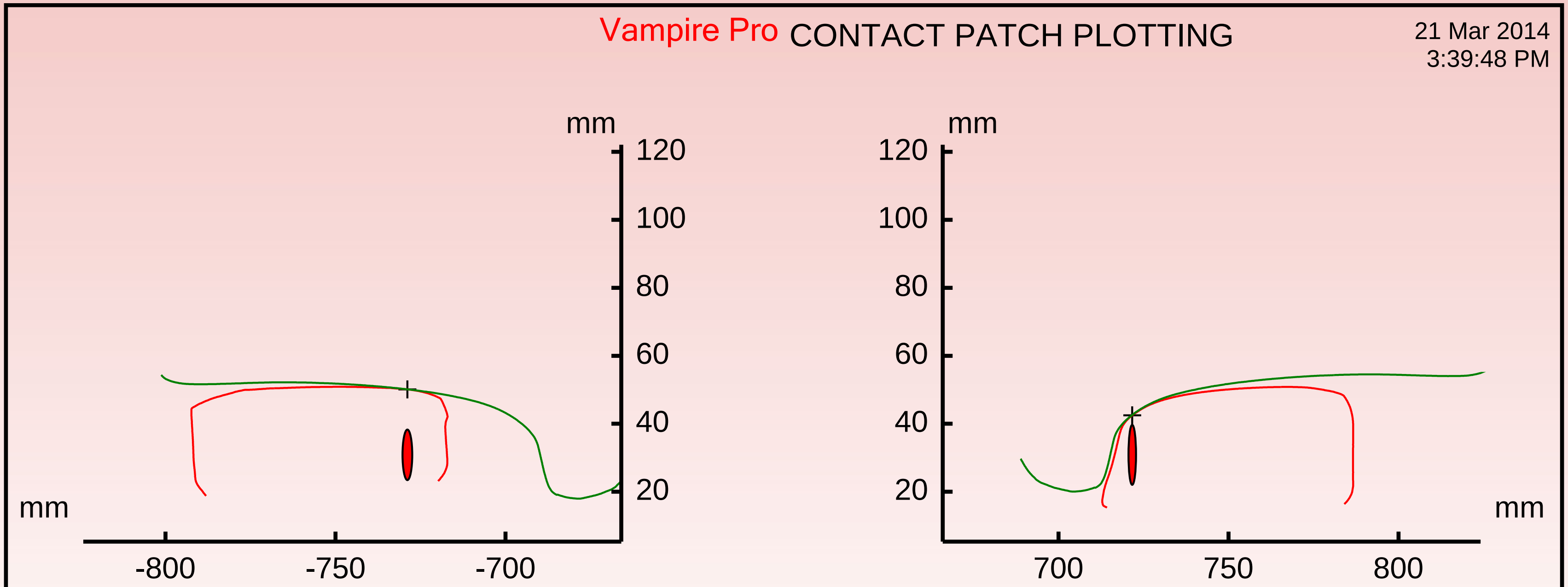


Wheel / rail contact patch plot on tangent



$$RR_{left} = RR_{right}$$

Wheel / rail contact patch plot on curve, conformal contact



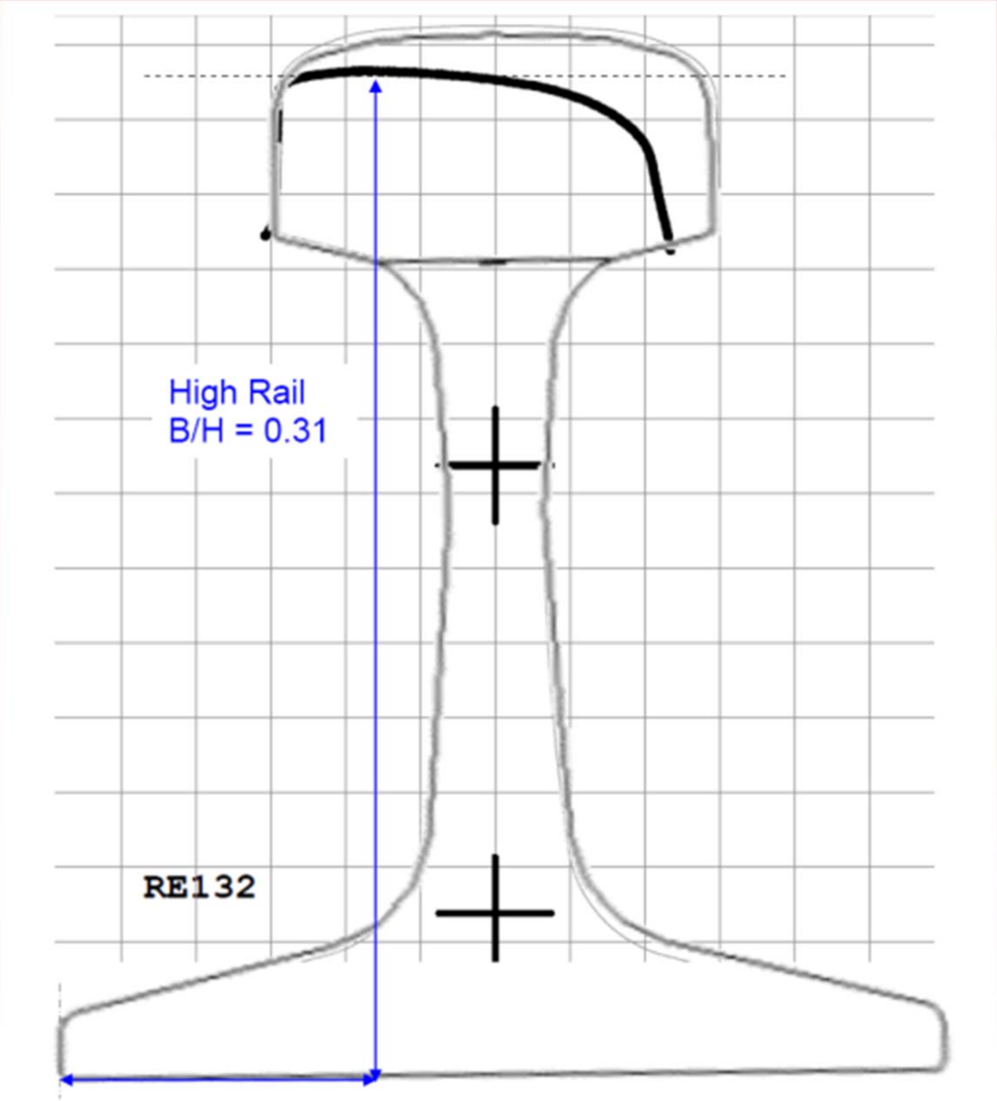
$RR_{high} > RR_{low}$

- conformal contact on high rail
- good steering geometry

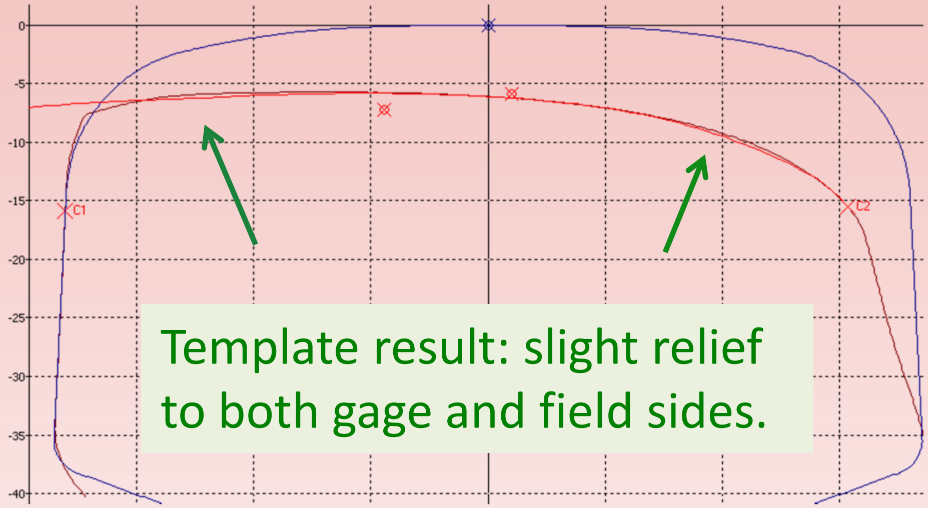
Understanding the impact of rail cant on rail grinding and rail profiles

Result of grinding canted rail

Grinding canted rail over the course of many years has given us high rail profiles that look like this!



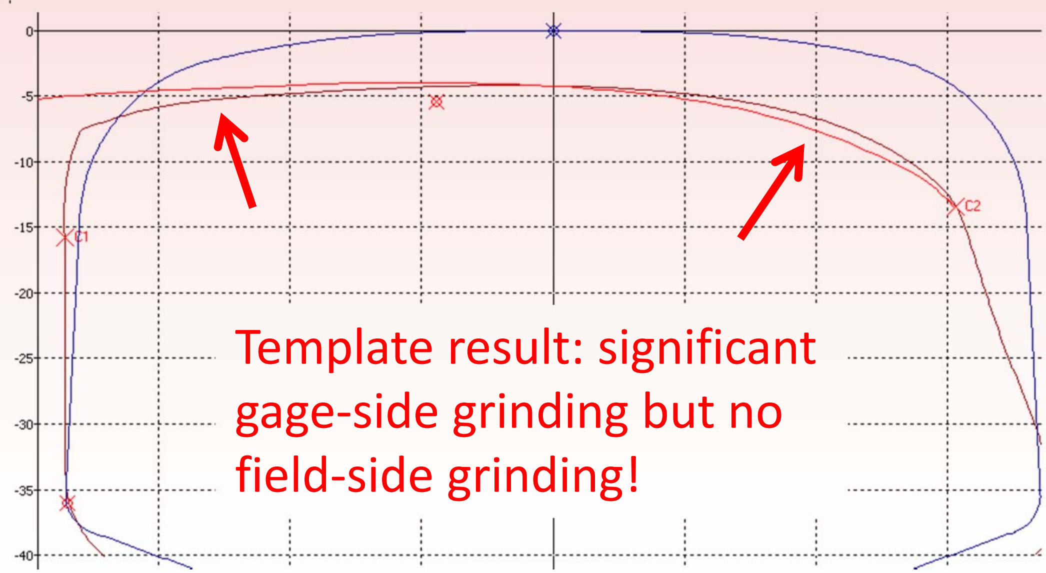
Grinding template applied to rails with 0° and 3° cant



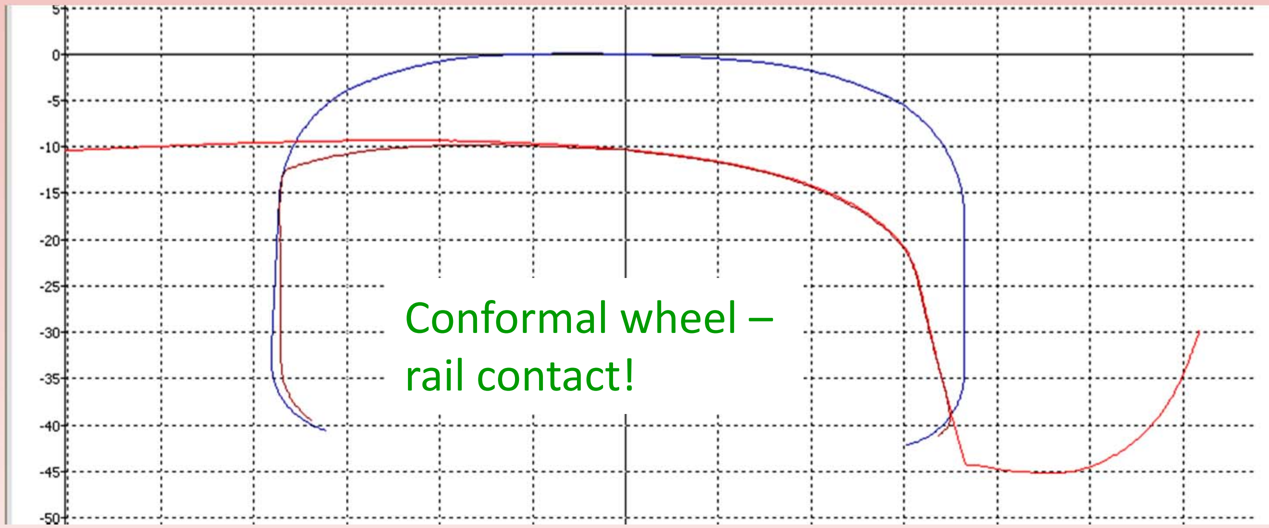
- Brown – worn rail
- Red – template

High rail with 0˚ cant

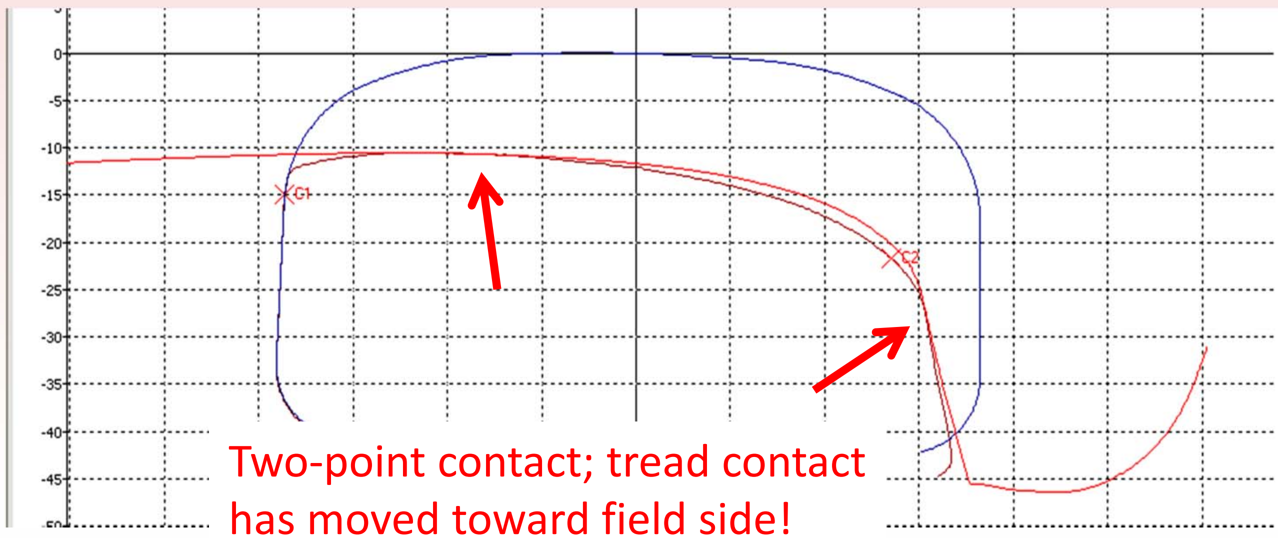
High rail with 3˚ cant



Worn wheels applied to rails with 3° and 0° cant



- Brown – 3˚ canted rail
- Red – worn wheel



- Brown – 0˚ canted rail
- Red – worn wheel

How did the importance of rail profiles come to our attention?

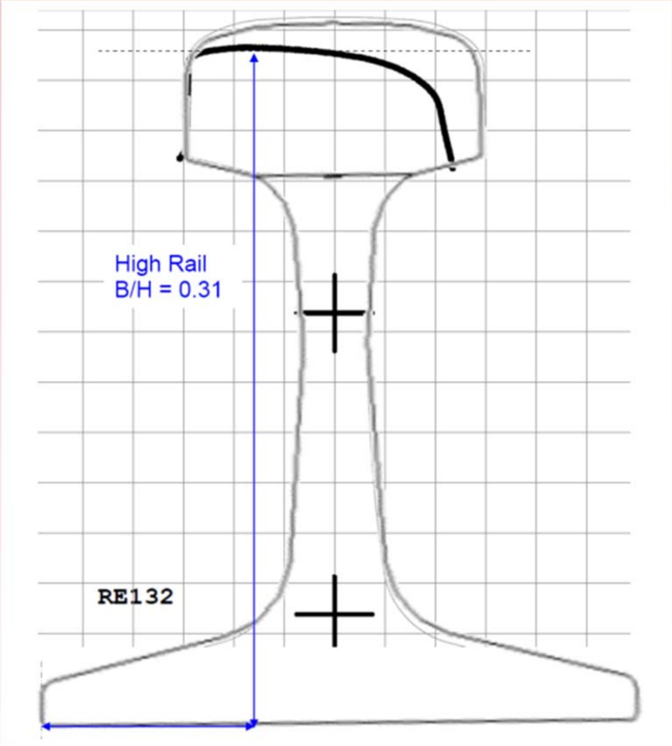
Because of rail roll-over derailments in curves with these characteristics:

- Curvature of 6˚ to 9˚
- Previously canted rail, up to 3˚
- Currently, excellent tie condition (new ties installed or high rail gaged)
- Gage < 57” (sometimes < 56-1/2”)

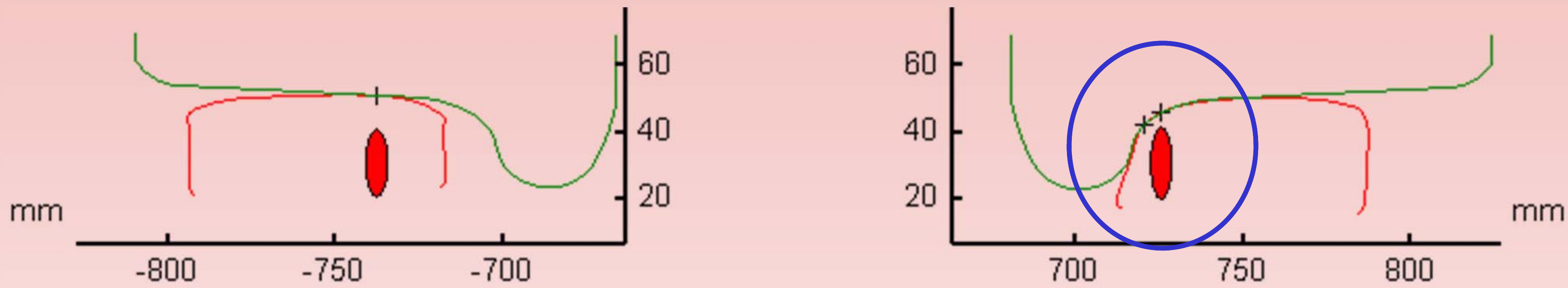
Rail rollover derailment at Waco, GA

High rail rollover restraint was exceeded in 6.8° curve account:

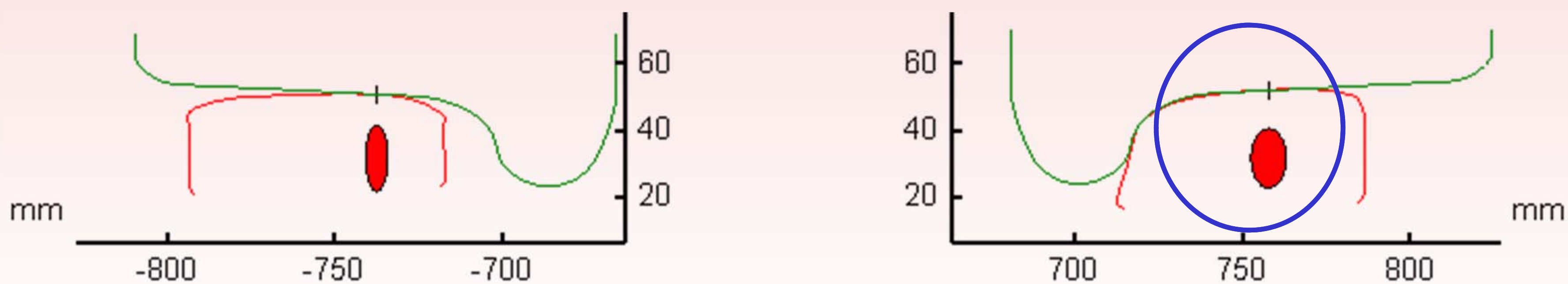
- worn rail profile developed from reverse cant,
- setting the rail up on new ties generated severe 2-point contact,
- vertical wheel loads were biased towards field side of rail, and
- high lateral forces from compromised wheelset steering.



Rail rollover derailment at Waco, GA



Contact patch plot for new AAR-1B wheel on high rail with 3˚ cant



Contact patch plot for new AAR-1B wheel on high rail set up to 0˚ cant

Following a number of rail rollover derailments, NS established this process

- Before gaging or tie replacement, curves with worn high rails are identified for further analysis

- High rails that have
  - B/H < 0.35
  - Head slope > 5˚
  - Cant close to 3˚

  are likely to have wheel contact move to the field side if the cant is corrected

- We use a rail grinder to change the rail profile so that desirable wheel contact will continue after the rail is “set up”

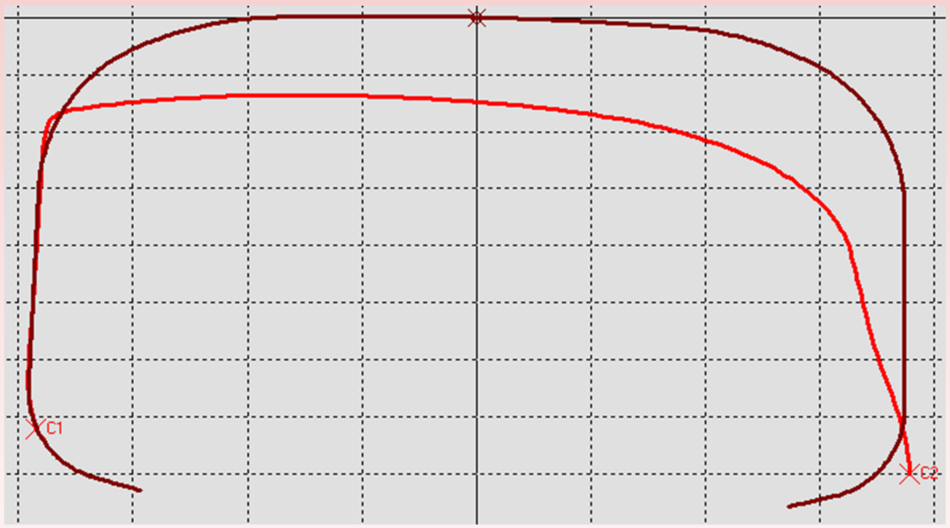
The Cresson (PA) subdivision wanted to gage the high rail of several curves

From a recent track geometry car test, we found these curves to have:

- significant tie plate cutting resulting 2˚ to 3˚ of cant
- B/H ratios between 0.33 and 0.35
- head slopes between 5˚ and 7˚

These are conditions that would result in a significant shift in wheel contact position if the high rail were to be set up.

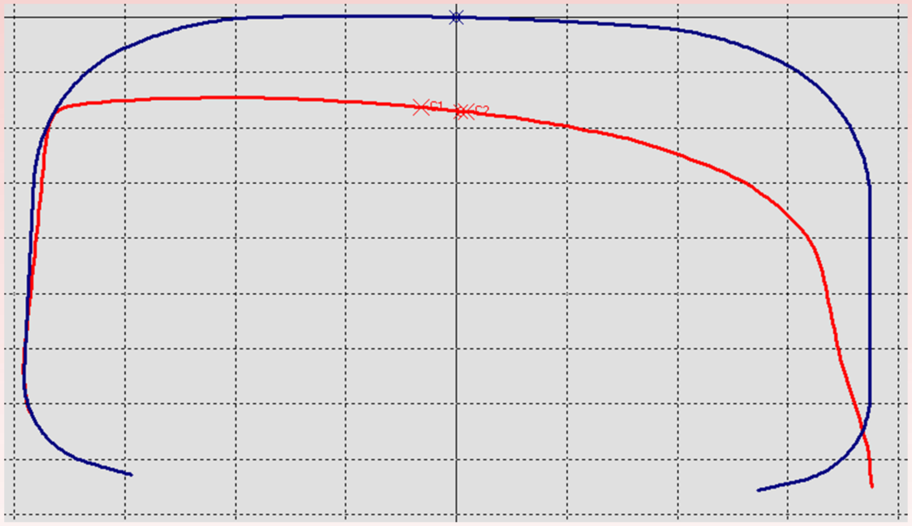
We asked Loram for rail profiling assistance



The RG 405 had operated one month earlier; its KLD laser-camera system had recorded the post-grind profiles (data which includes rail cant)

Loram developed a grinding plan

- Bob Harris of Loram was able to manipulate the KLD images to orient the rail at 1:40 inward, simulating how the rail would rotate as a result of gaging or a tie job.
- He then applied NS's high rail template to the re-oriented rail to determine how much metal to remove.



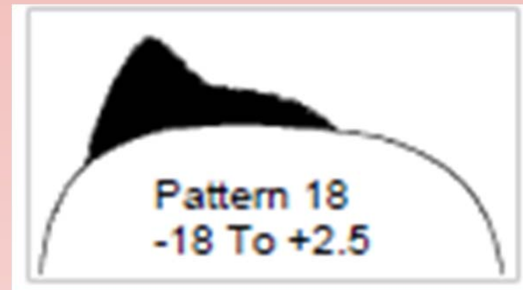
Switch grinder instead of big grinder

- If we were using a big grinder, Loram could have used its pre-grind rail inspection program to determine patterns, passes and speeds…. automatically. But a big grinder was not close by.
- We did have the RGS2 switch grinder two days away.

The grinding program

Bob Harris developed a grinding program for each curve using the switch grinder. He created 2 patterns (or pattern sequences):

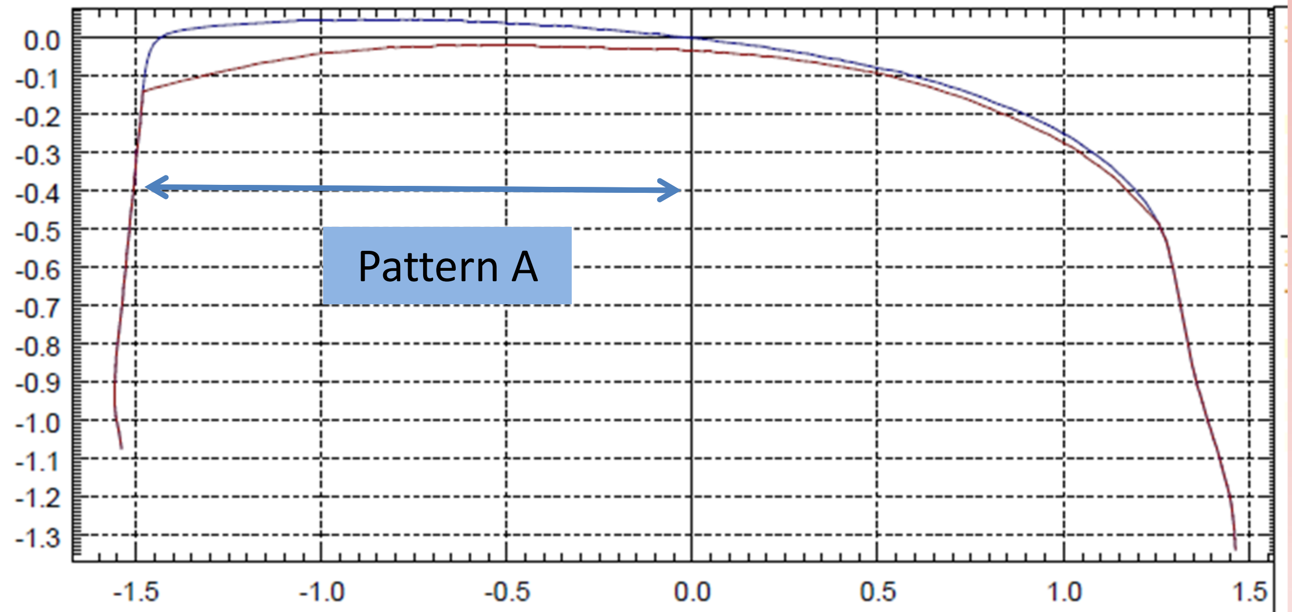
- Pattern A provided field-side relief (stone angles from -18˚ to 1˚)
- Patterns B1, B2, B3 & B4 provided full ball coverage (-16˚ to 45˚)

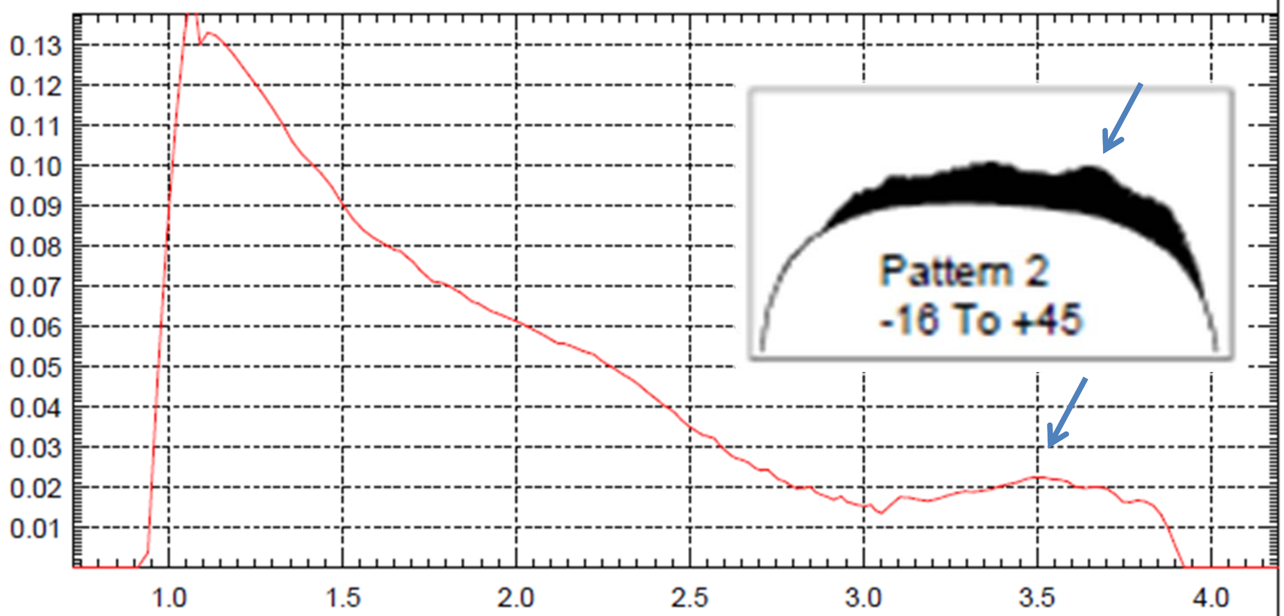


Field RG 401 Gage

For Scotch Run, the curve needing the most work, Bob specified:

- 8 passes with Pattern A at 5 mph
- 1 pass each with Patterns B1 – B4 at 5 mph





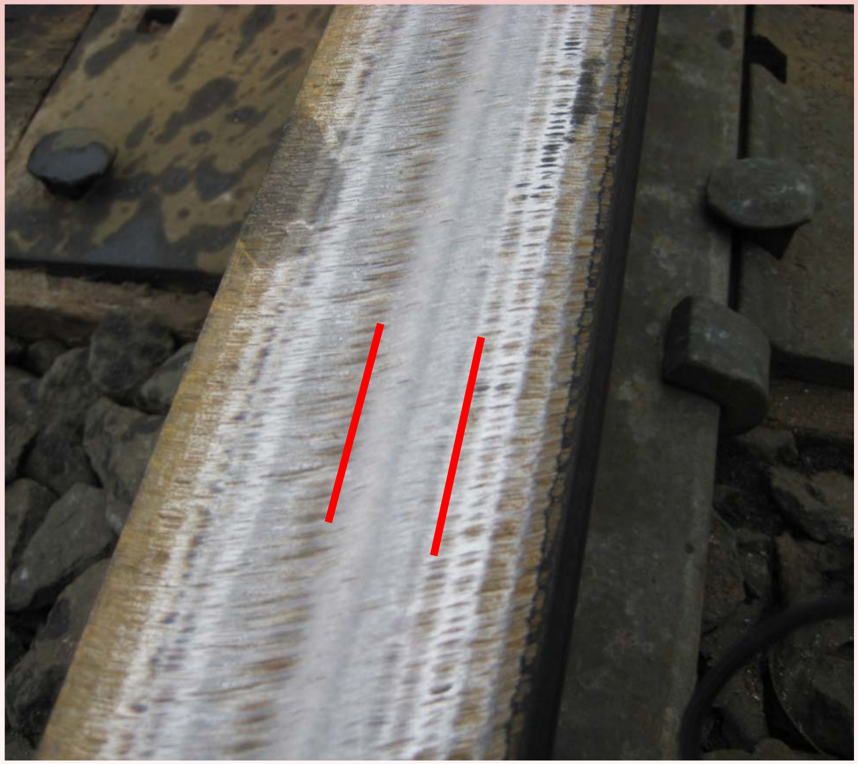
- Actual (pre-grind) rail profile set up to the 1:40 position (blue)
- Expected profile after grinding and gaging (brown)
- Expected metal removal, max is 0.14 inches (3mm+) at the field corner
- Insert is RG 401 pattern 2, which reflects an increase in metal removal near the gage corner

RGS2 switch grinder

- The RGS2 worked six curves during one night shift
- The number of passes on the high rails ranged from 6 to 12

- RGS2 has 24 stones – 8 six-inch and 16 ten-inch (a big grinder has 96 ten-inch stones)
- The smaller stones are meant for close clearance work (road xings, guard rails)
- For this project, Loram replaced the small six-inch stones with ten-inch stones

Results after grinding, before gaging



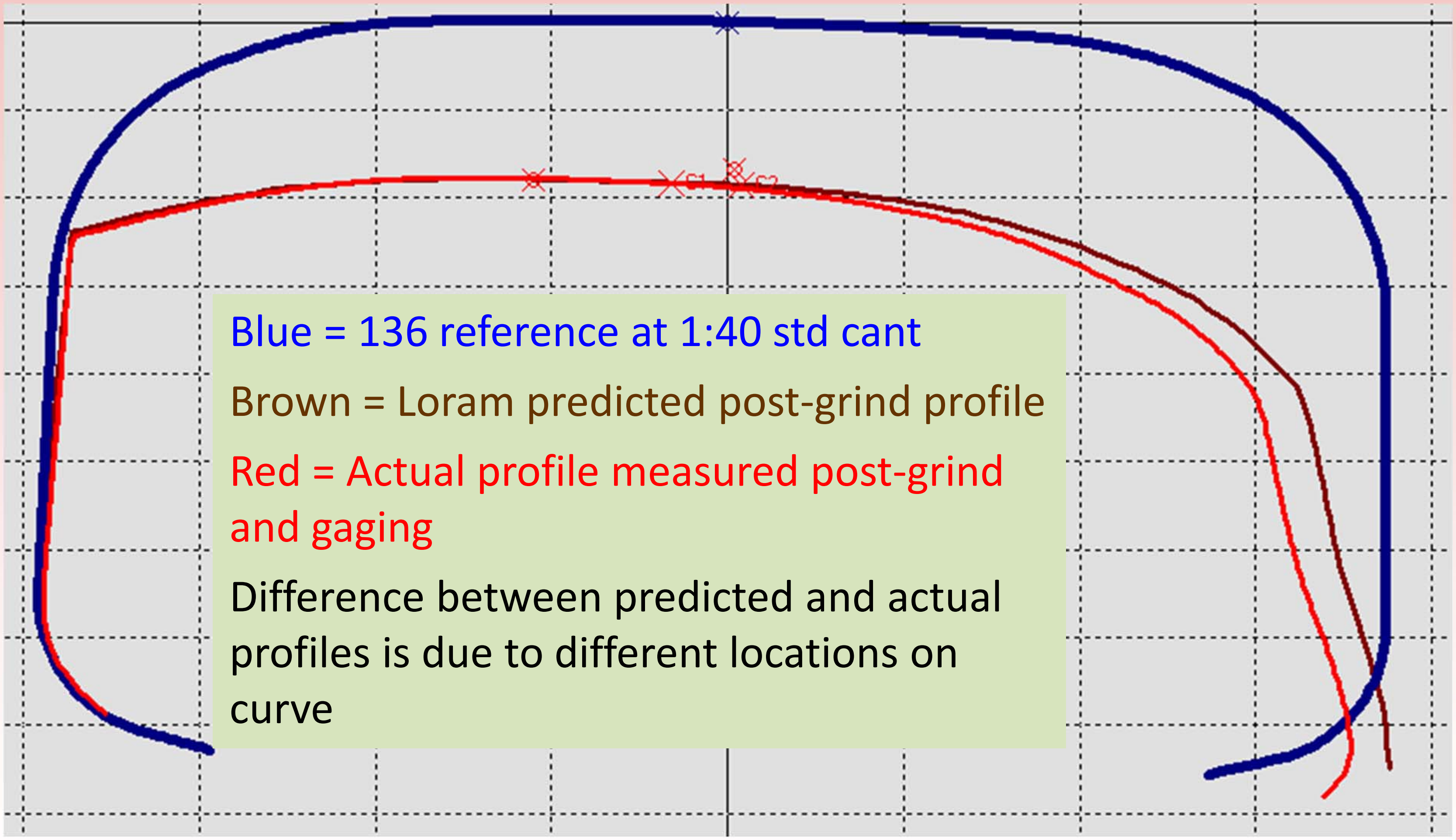
Grinding complete and several trains have run; note primary contact band is on the gage side of center

Results after grinding and gaging

High rail shows wheel tread contact band on the gage side of center (desirable); but it also shows two-point contact (undesirable). Photos taken one week after grinding and gaging.

Mini-prof profiles after grinding & gaging

Predicted post-grind profile compared to Mini-prof post-grind profile, Scotch Run Curve



Blue = 136 reference at 1:40 std cant

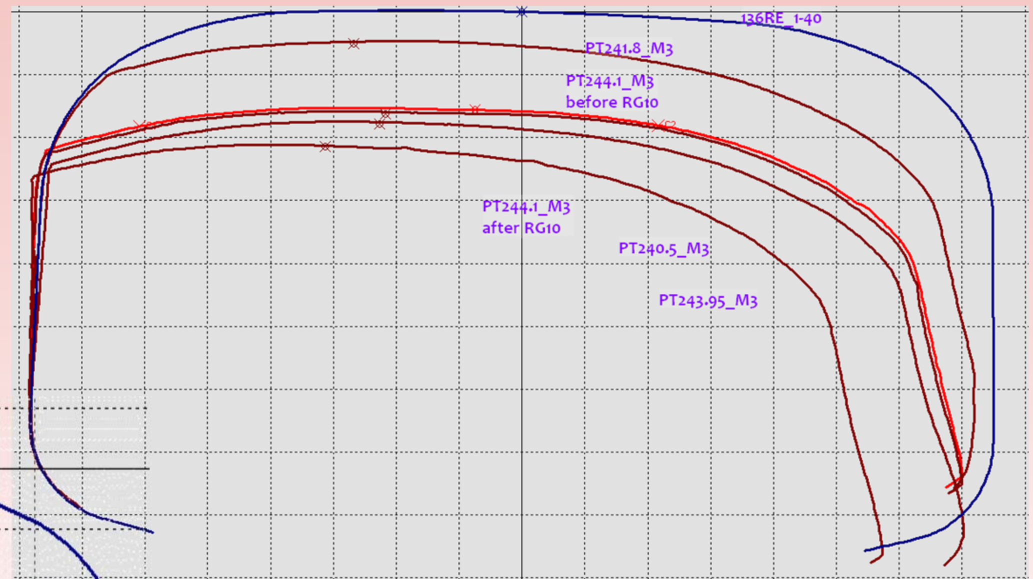
Brown = Loram predicted post-grind profile

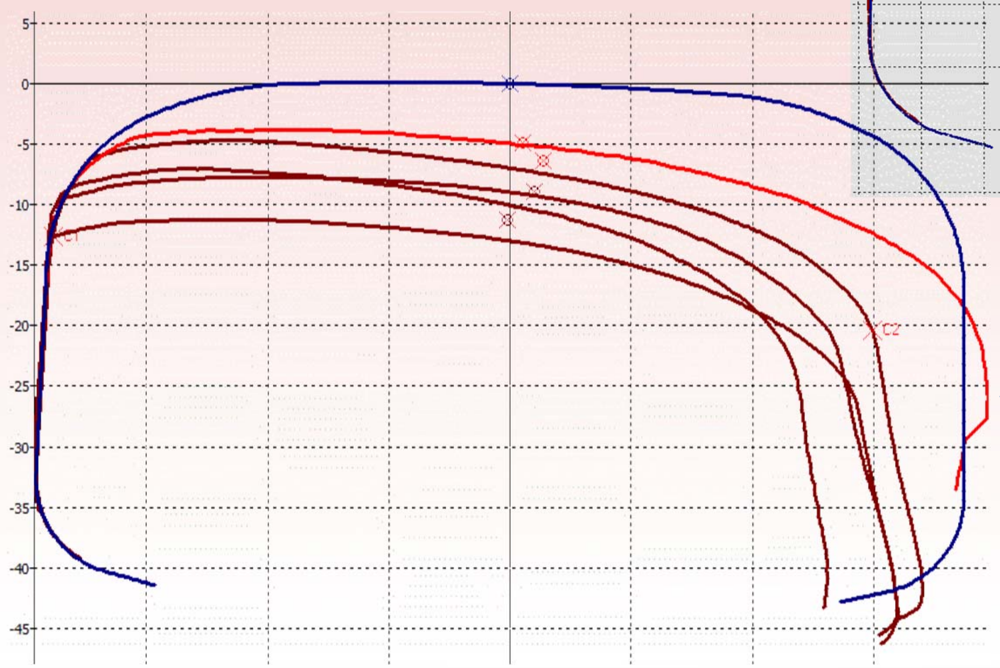
Red = Actual profile measured post-grind and gaging

Difference between predicted and actual profiles is due to different locations on curve

Profiles of high rails from Cresson compared with high rails from recent NS derailments

Mini-prof high rail profiles from four curves after grinding and gaging

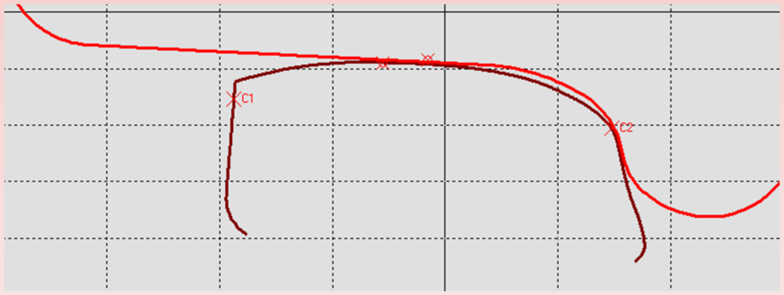




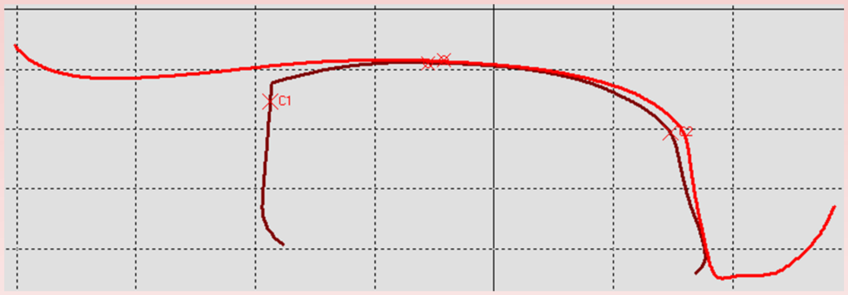
High rail profiles from five NS rail rollover derailments. All have been oriented to the 1:40 standard cant.

Mini-prof profiles matched with several common wheel profiles, Scotch Run Curve

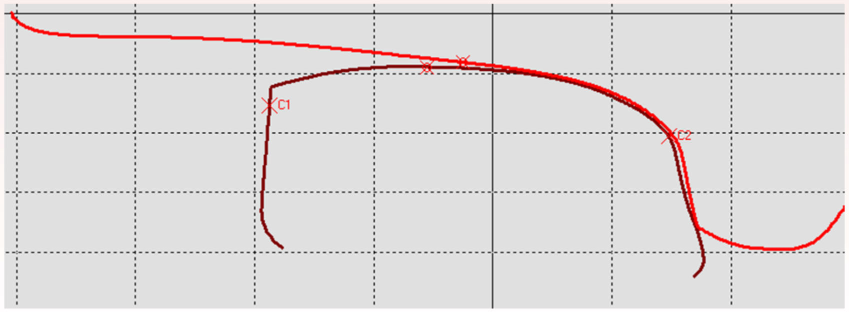
New AAR 1B (two point)



Typical hollow-worn (two point)



“High conicity” (nearly conformal)



Next time we do this

- We made the right decision to change the profile of the high rails in advance of gaging; otherwise, the gaging and tie installation work would have resulted in field-side tread contact.
- We need to plan our work better, so that the profile adjustment is made by the big grinder during its normal cycle (dead-heading a switch grinder was expensive).
- Pattern development needs to be refined to produce more conformal contact.

Rail profiles do matter, and they can be controlled!

Questions?