FROGS: DESIGN FEATURES, REVENUE SERVICE TEST RESULTS & MAINTENANCE ADVICE

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OUTLINE

DESIGN FEATURES

REVENUE SERVICE TEST RESULTS

MAINTENANCE ADVICE

CONCLUSIONS & RECOMMENDATIONS

Frog focus

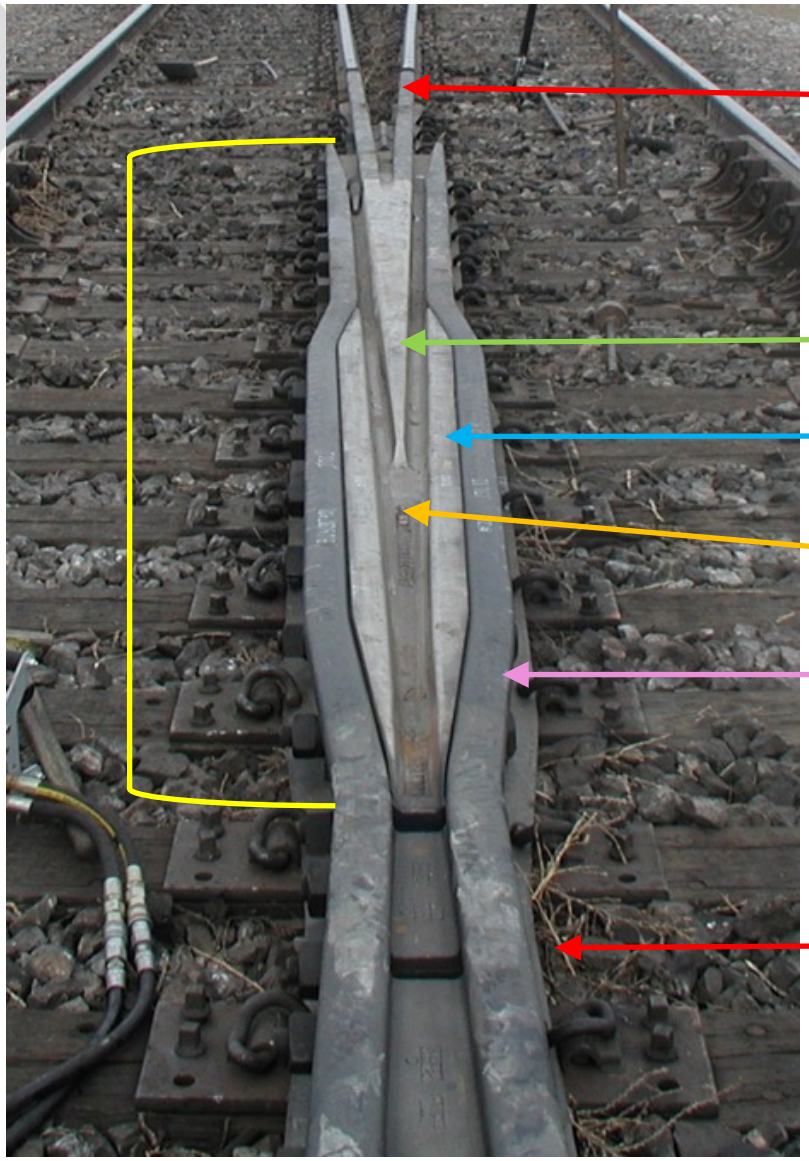
- RBM (rail-bound manganese)
- WBM (welded-bolted manganese)

Characteristics of these two frogs

- Manganese casting
- Open flangeways
- Popular for mainline applications

WBM frog

RBM FROG COMPONENTS

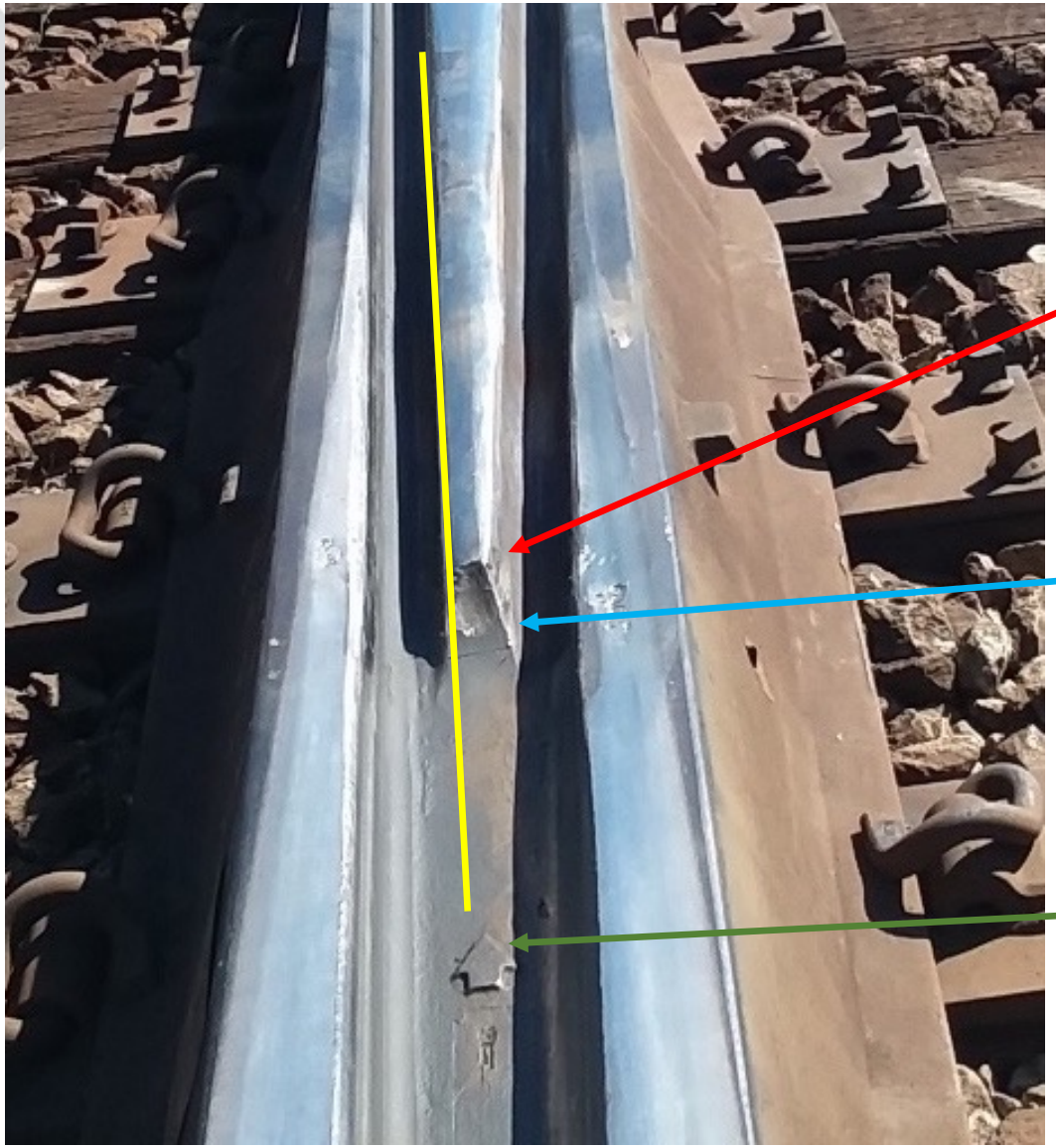


Two impact locations:

1) point/wing transition
2) heel

FROG POINT GEOMETRY

(applies to both RBM and WBM frogs)



5/8” POF

- where the gage lines are 5/8” apart
- where the point reaches full height
- where wheel contact typically begins

1/2” POF

- where the gage lines are 1/2” apart
- often indicated by a mark on the point ramp
- location referenced by design plans and field measurements

Theoretical POF

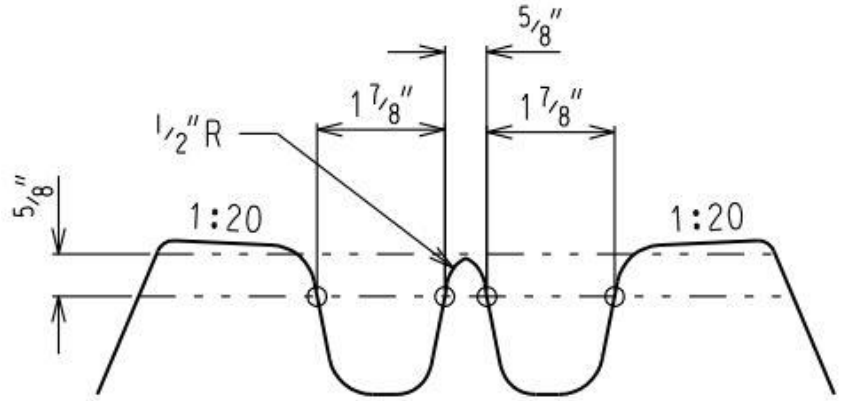
- where the gage lines converge
- often marked on the bottom of the flangeway
- located 1/2 the frog # (inches) ahead of the 1/2” POF

DESIGN FEATURES OF RBM FROGS

What are the design features associated with RBM & WBM frogs?

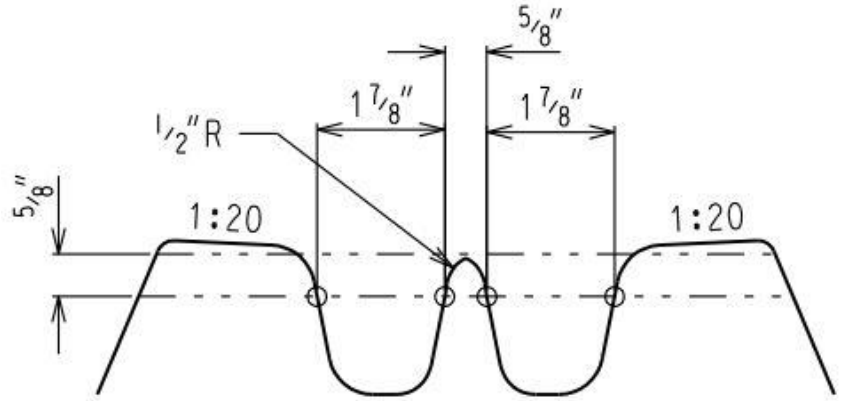
or……

What decisions do you need to make when you buy a frog from a supplier?



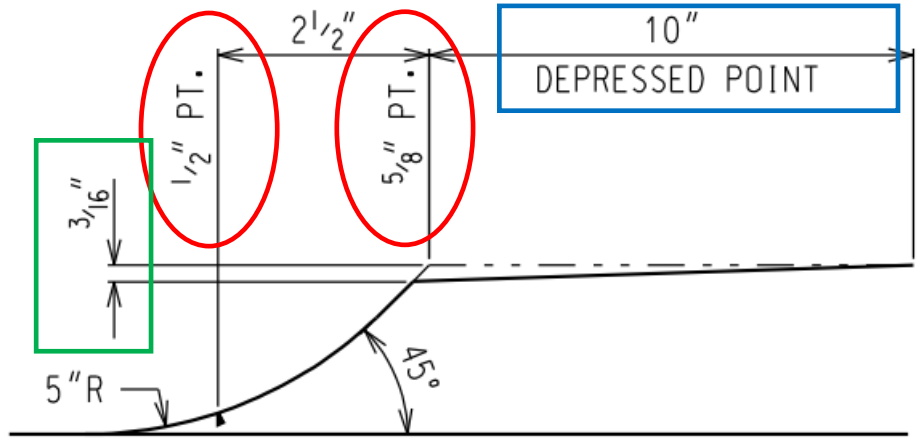
DESIGN FEATURES OF RBM FROGS

1) Point slope
2) Heavy point vs. standard point
3) Rubber pads under plates
4) Heel design
5) Profile – conformal vs. flat top
6) Wing slope



1) POINT SLOPE (DEPRESSED POINT)

- Slope length, in inches, is typically equal to either 1/2 or 3/4 the frog number
- Depth, at the 5/8” POF, is typically 3/16” but can be 1/4”
- The slope allows wheels to make a smooth transition between wing and point without damaging the tip of the point



POINT SLOPE VARIES WITH FROG NUMBER

- This photo reflects point slopes equal to 3/4 x frog number
- At the tall end of the slope, the point and wing are level

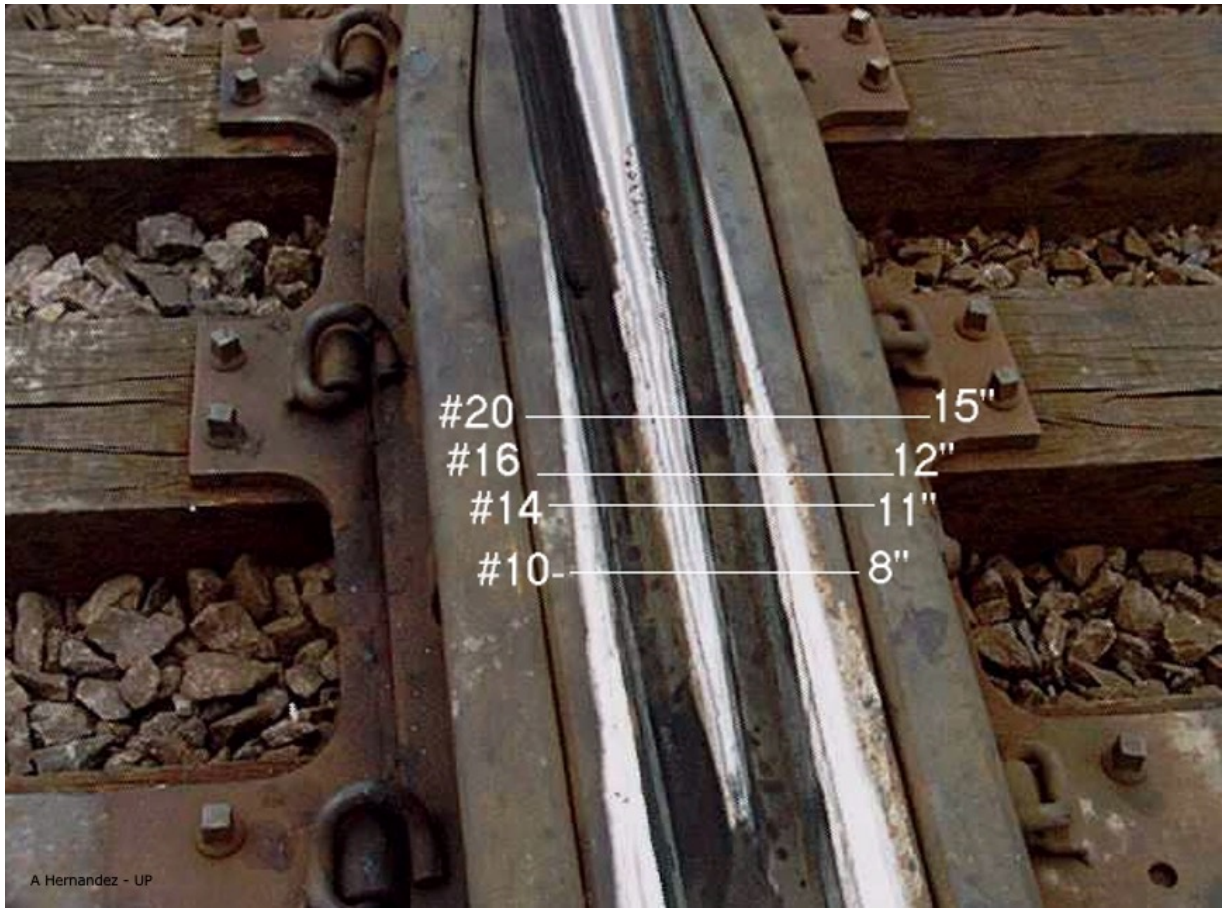


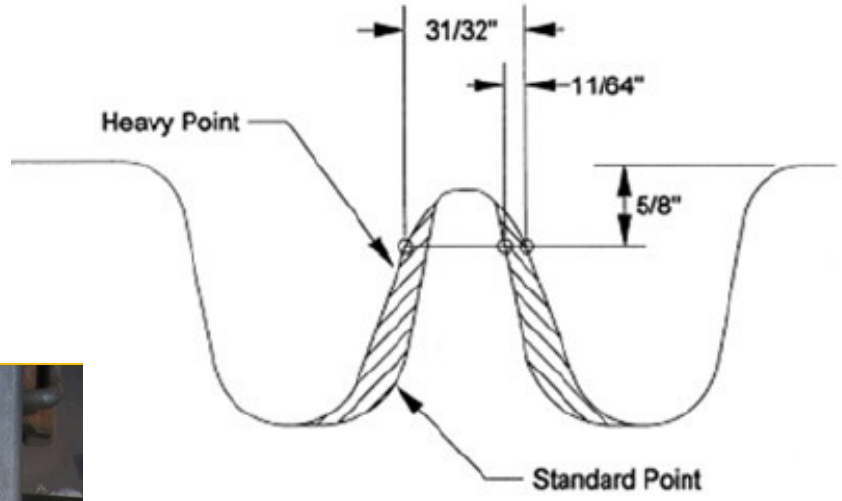
Photo: Aaron Hernandez, UP
"RBM Frog" presentation

2) HEAVY POINT VS. STANDARD POINT

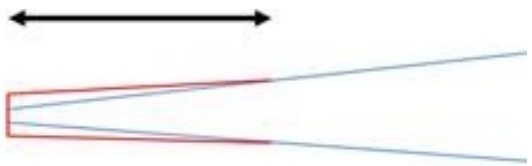
A heavy point is approximately 3/8” wider than a standard point (close to 3/16” on each side). The wider point results in narrower flangeways. A heavy point will typically show less wear (and deformation) because of its increased width.

Heavy point

Standard point



Cross-sections of standard & heavy point at the 5/8” POF



Heavy point runout

WHAT IS THE IMPACT OF A HEAVY POINT…

on flangeway width?

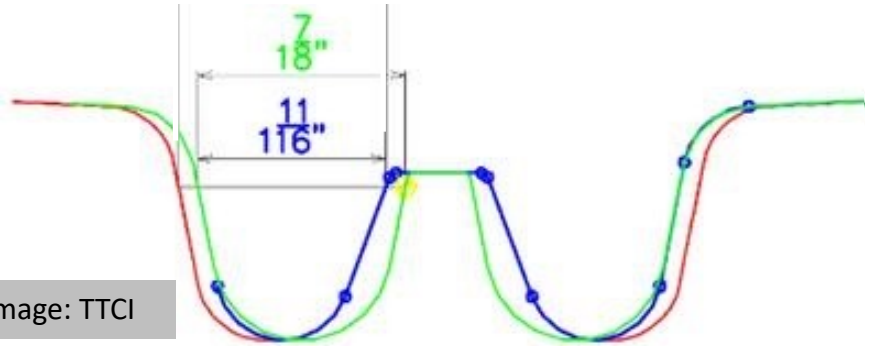


Image: TTCI

Cross sections at the 5/8” POF:

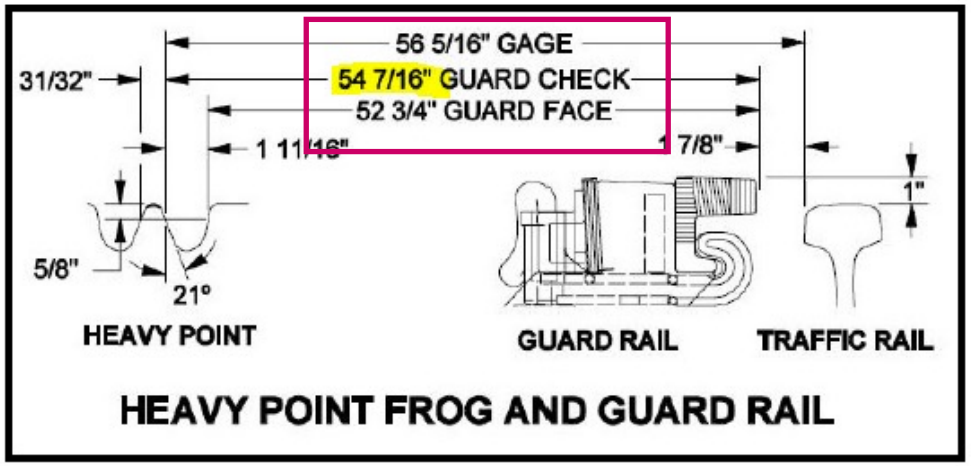
- Green = standard point
- Blue + green = heavy point (note narrow flangeways)
- Red = modification to wing to maintain 1=7/8” flange width

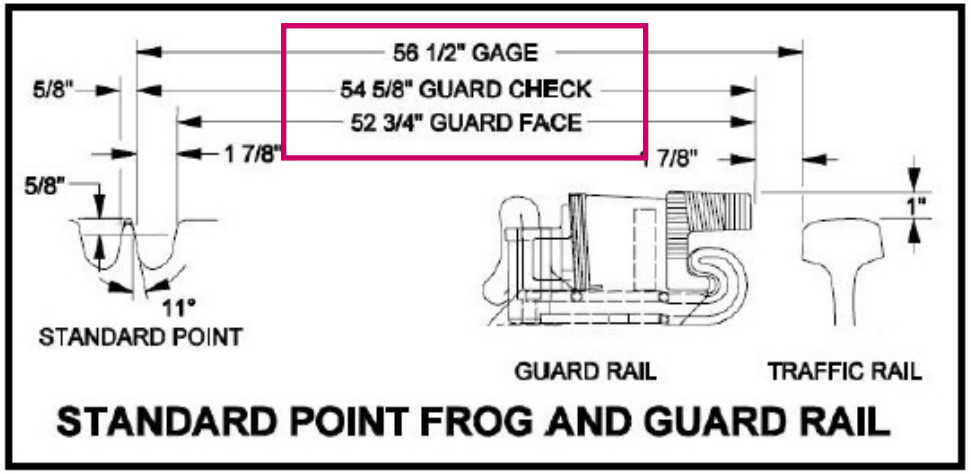
A heavy point is 3/16” wider on each side, reducing the frog’s flangeway width from 1-7/8” to 1-11/16”.

The modified flangeway still complies with FRA §213.133, which requires a minimum width of 1-1/2”.

WHAT IS THE IMPACT OF A HEAVY POINT…

on track gage, guard check gage and guard face gage?



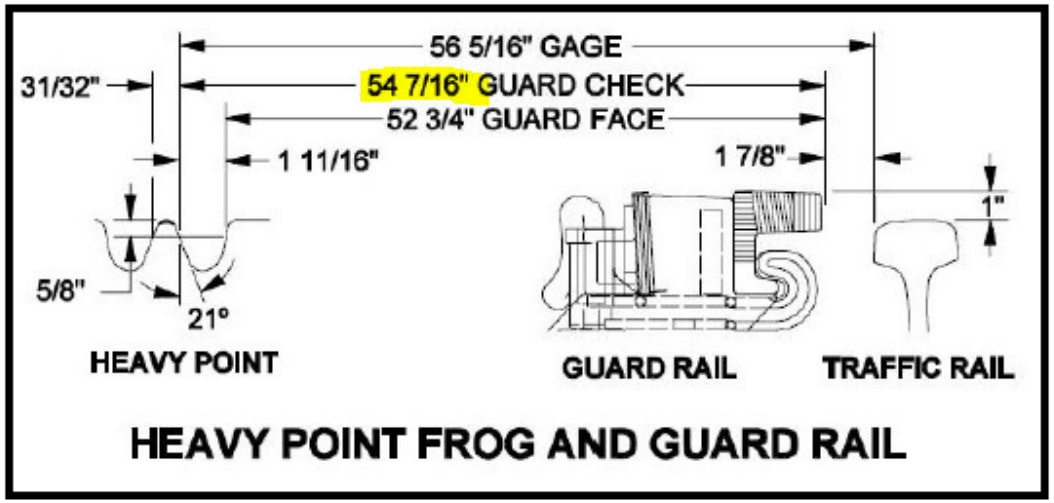


FRA 213.143 Frog guard rails and guard faces; gage		
Class of Track	*Guard Check Gage (not less than)*	*Guard Face Gage (not more than)*
1	54-1/8"	53-1/4"
2	54-1/4"	53-1/8"
3 & 4	54-3/8"	53-1/8"
5	54-1/2"	53"

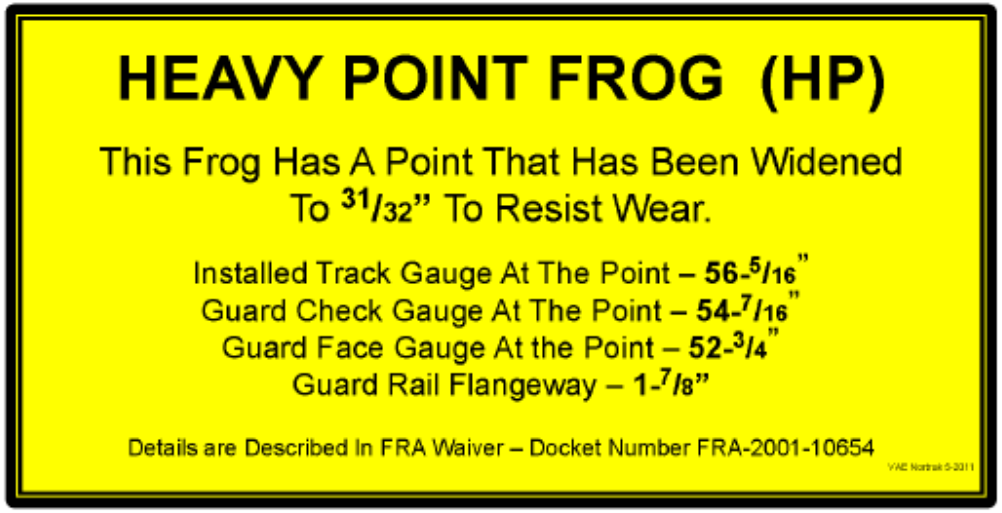
Guard check gage of 54-7/16” complies with Class 1 – 4, but not Class 5.

In 2003, FRA granted an industry waiver allowing operation of trains at Class 5 speeds over a heavy point frog with guard check gage meeting the Class 4 standard.

GUARD CHECK GAGE FIX: FRA REVISED §213.143



HEAVY POINT FROG AND GUARD RAIL



FRA published a final rule addressing HP frogs in October 2020:

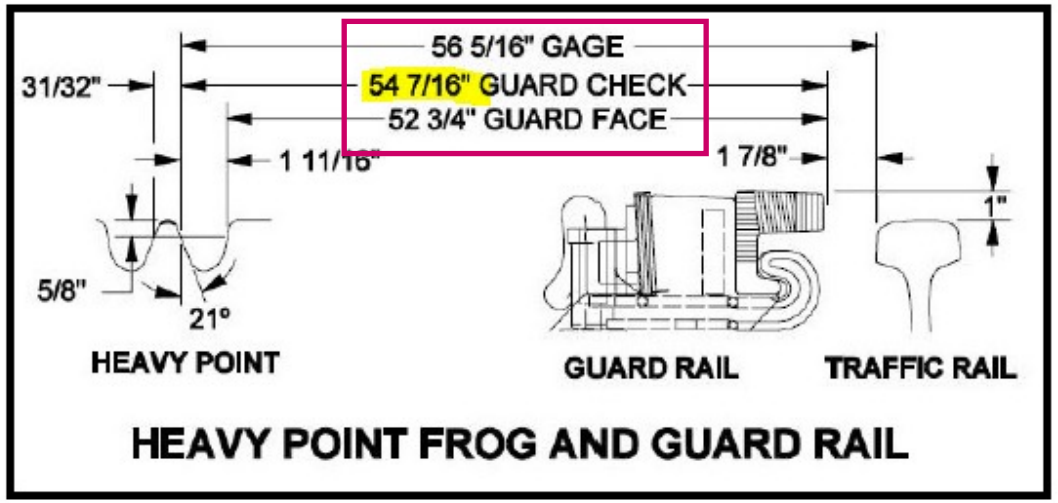
§213.143 was revised to include this addition:

(b) For any heavy-point frog (HPF) on Class 5 track, the guard check gage may be less than 4' 6-1/2" but not less than 4' 6-3/8", provided that:

(1) Each HPF and guard rails on both rails through the turnout are equipped with at least three serviceable through-gage plates with elastic rail fasteners and guard rail braces that permit adjustment of the guard check gage without removing spikes or other fasteners from the crossties.

Photo: Aaron Hernandez, UP
"RBM Frog" presentation

IS THERE AN ALTERNATIVE TO THE THRU-GAGE PLATE REQUIREMENT?



Yes. UP's solution:

- Adjusting the guard rail by 1/8" which narrows the guard rail flangeway to 1-3/4", and
- Reducing track gage by 1/16", to 56-1/4"…..

➢ Increases guard rail check gage 1/16", to 54-1/2" (the Class 5 standard)

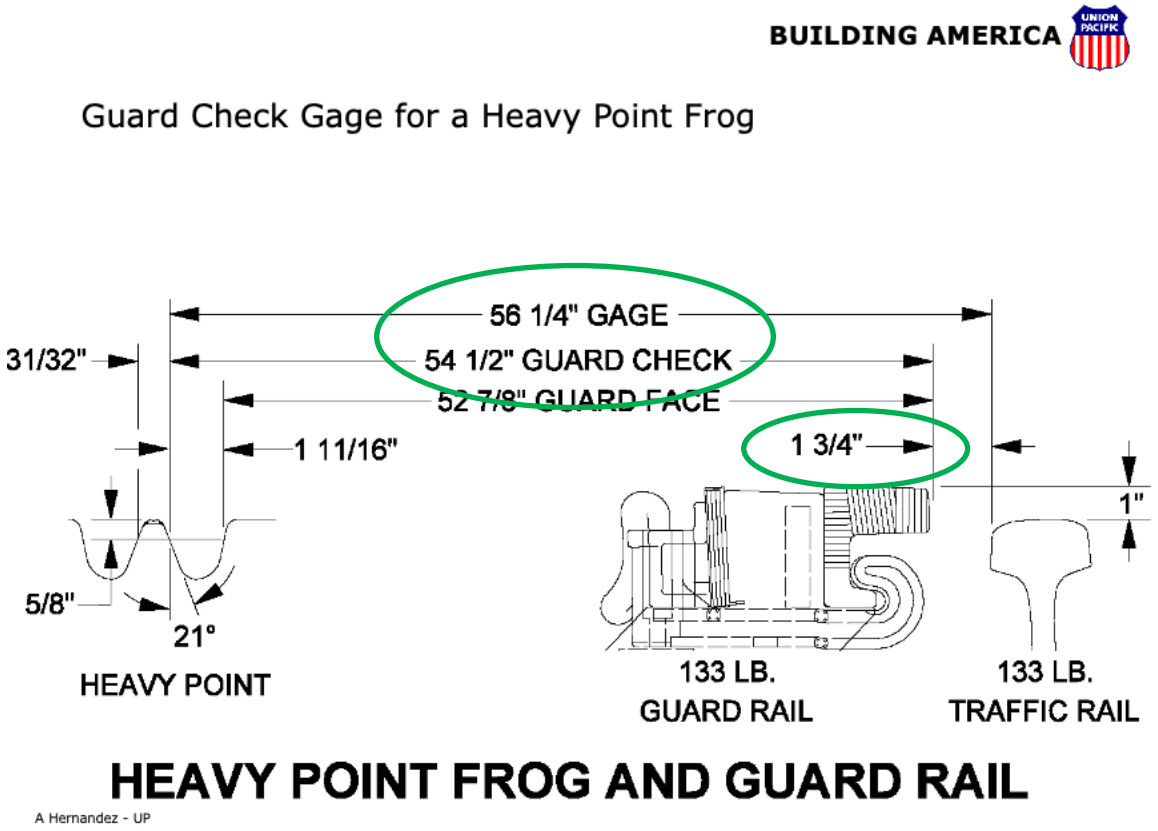
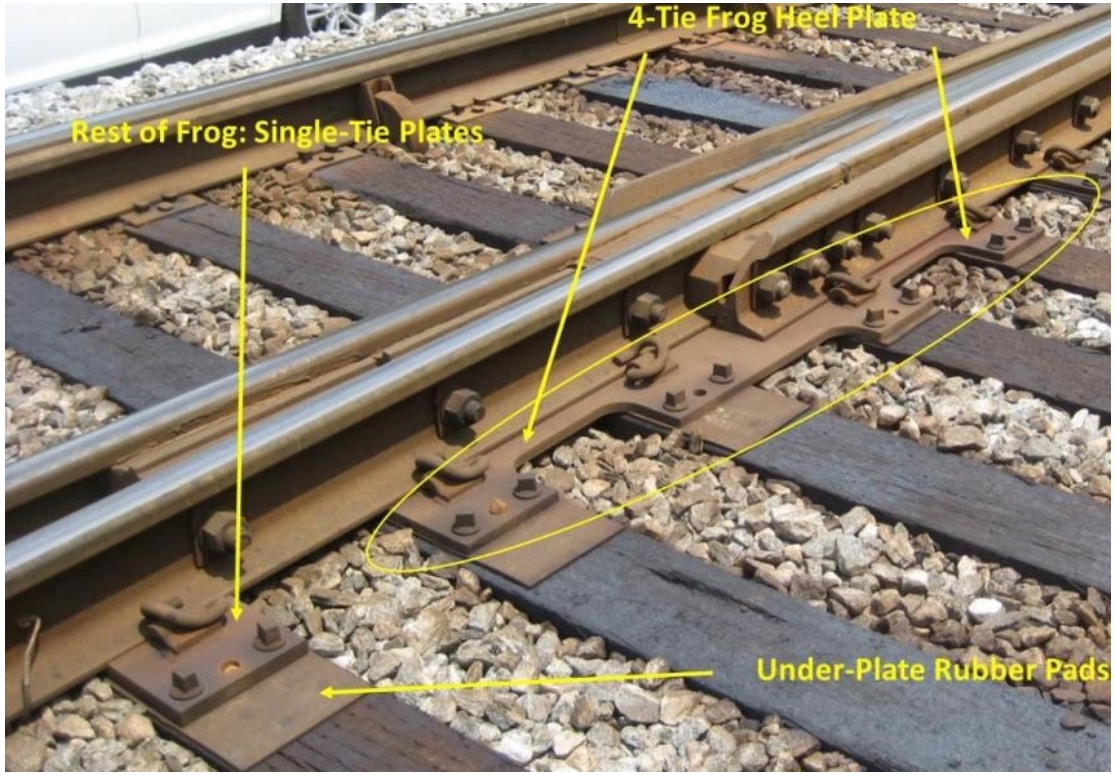


Image: Aaron Hernandez, UP
"RBM Frog" presentation

3) RUBBER PADS UNDER FROG PLATES



Rubber pads are not a supplier specification; they are a construction specification. Included here because we have revenue service test results.

4) HEEL DESIGN

RBM - Standard heel (30°)

RBM - Low impact (75°) heel

WBM - welded heel

5) RUNNING SURFACE PROFILE: FLAT TOP

RBM frog with flat top profile. Both wings and the point are machined flat and are the same height.

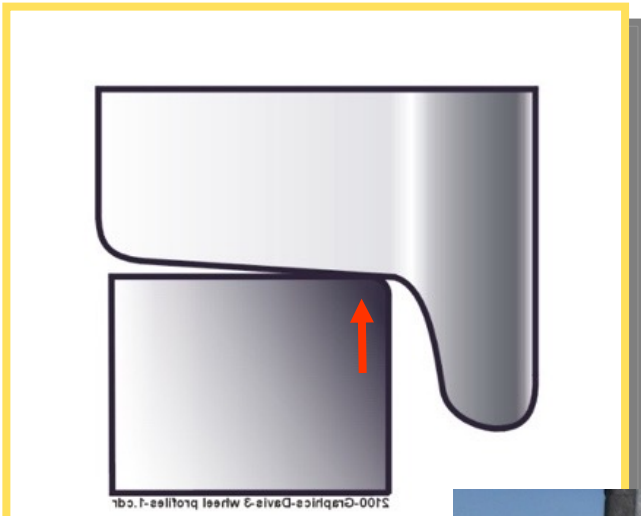
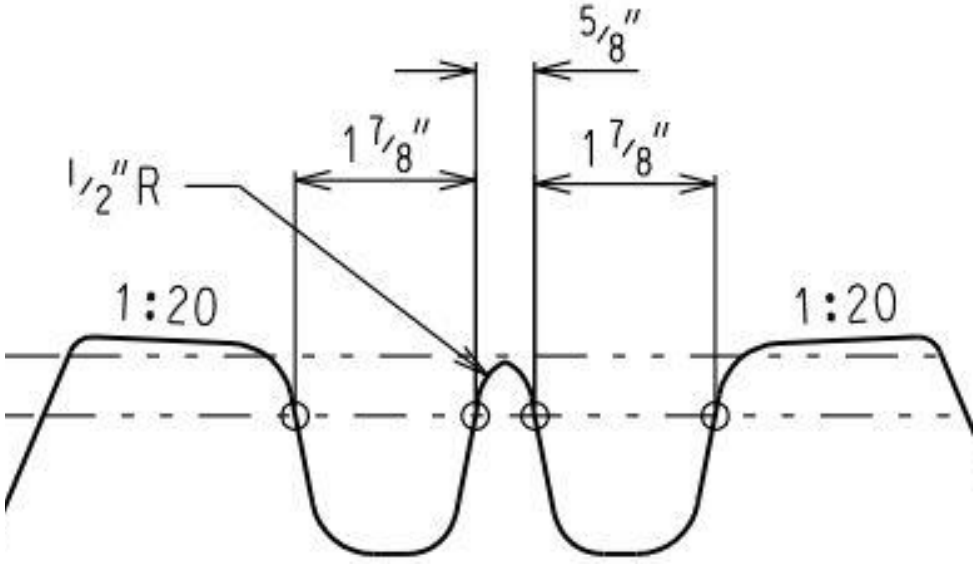


Image: Dave Davis, TTCI presentation Jan 15, 2014

Image & photo: New wheel on wing with flat top profile (and very small corner radius)

5) RUNNING SURFACE PROFILE: CONFORMAL



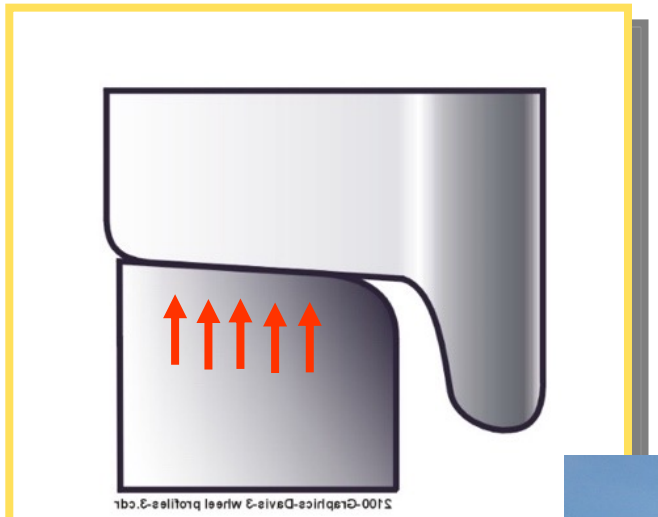


Image: Dave Davis, TTCI presentation Jan 15, 2014

New wheel on wing with conformal profile

The wings have a 1:20 transverse taper which provide “conformal” contact with new wheels, resulting in lower contact stresses due to a larger contact area. The point also has a conformal profile.

6) LONGITUDINAL WING SLOPE

- Wing slopes are meant to produce a smoother transition from point to wing by hollow-tread wheels.
- Machining begins at the 5/8” POF and lowers the wing 1/8” over (typically) 24”

Left: The straight edge is 12” behind the 5/8” POF

A 1-mm hollow wheel clears the wing.

A 1/8” wing slope should allow wheels up to 3 mm (0.120”) hollow to clear the gage corner of the wing.

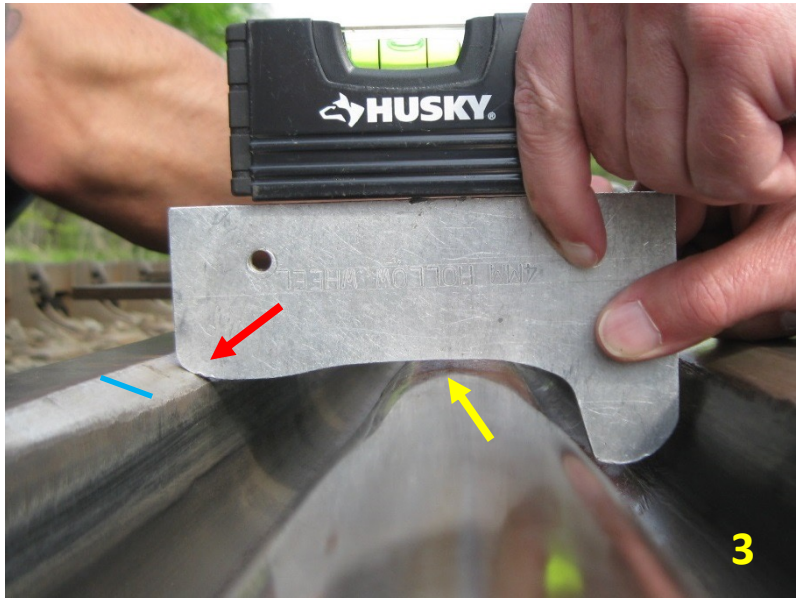
POINT-TO-WING TRANSITION - DIFFERENT WHEEL PROFILES

A new wheel has full bearing on point, with clearance between the wheel rim and wing.

- Frog - no. 20 WBM with some wear (to wings and point)
- Wheel location - 18” behind the POF (close to the point-to-wing transition)

A 1-mm hollow-tread wheel is riding on both the point and the wing.

A 4-mm hollow-tread wheel rides on the edge of the wing. This wheel profile is very destructive to a frog wing.



DAMAGE CAUSED BY HOLLOW-TREAD WHEELS


TTCI fil photo

Contact by wheel rim outside edge is evident at the point-to-wing transition on all three of these WBM frogs

REVENUE SERVICE TESTING

Test objective

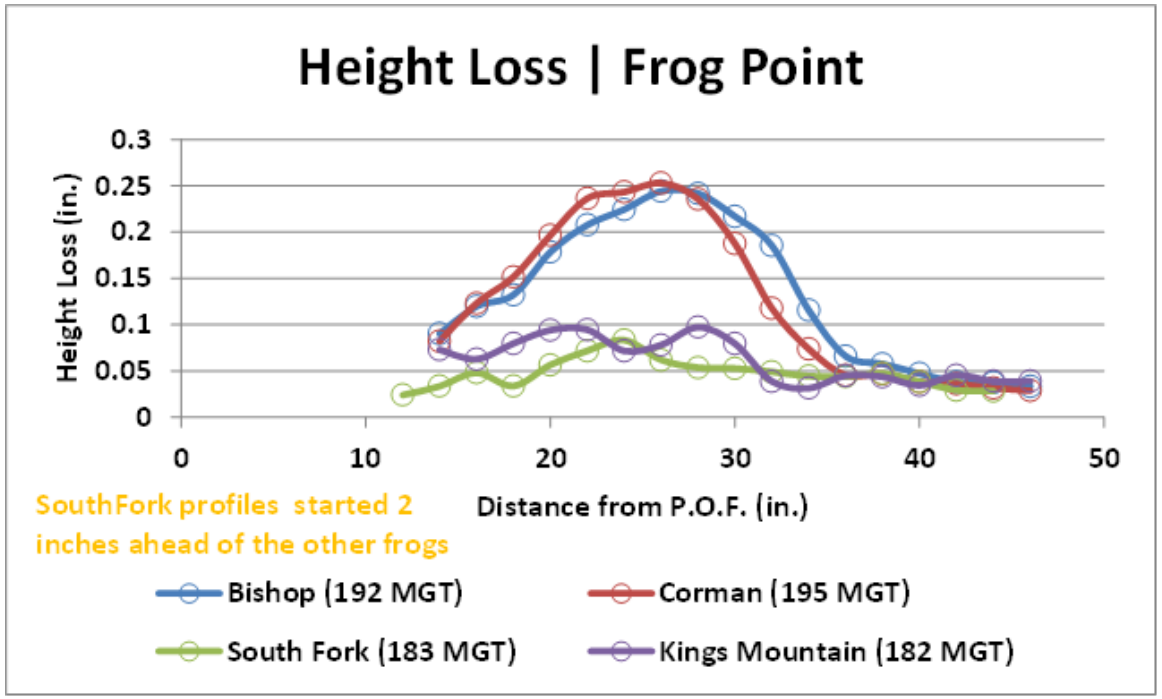
Compare performance of frogs with different design features:

1) Standard point vs. heavy point
2) Rubber pads vs. no rubber pads
3) Standard heel vs. low-impact heel vs. welded heel
4) Conformal profile vs. flat top profile
5) Longitudinal wing slope

Test location

NS's Cincinnati – Chattanooga Line; 90 MGT, 60 mph, all frogs installed at single-track to double-track control points

2) STANDARD POINT VS. HEAVY POINT



1: Standard point. Note the overflow, and, in the distance, a depressed section. A reverse view of the same point is shown in Photo 3.

2: Heavy point.

The graph compares point height loss of four test frogs. The two heavy point frogs show significantly less height loss.

3) RUBBER PADS UNDER FROG PLATES

These two RBM frogs were identical in all respects but one – the frog on the right had rubber pads under the frog plates.

Frog without pads lasted 350 MGT and was removed because of a deteriorated heel and repeated casting failures

Frog with pads lasted 450 MGT and was removed because of a casting failure

4) STANDARD, LOW IMPACT & WBM WELDED HEELS

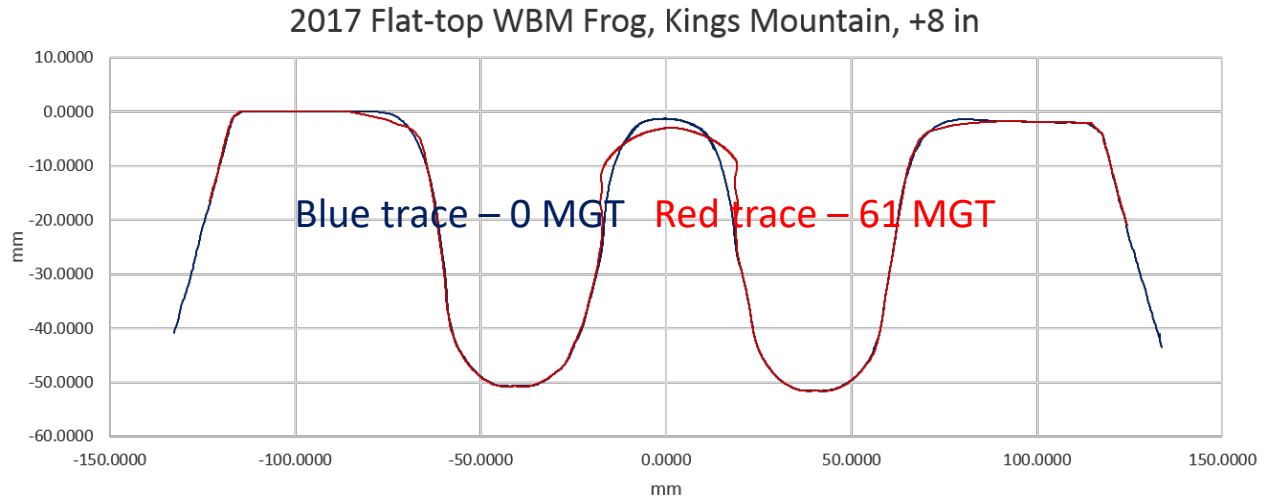
A standard 30° heel is secured with 4 bolts. This test frog (shown at 310 MGT) failed at the heel after 350 MGT.

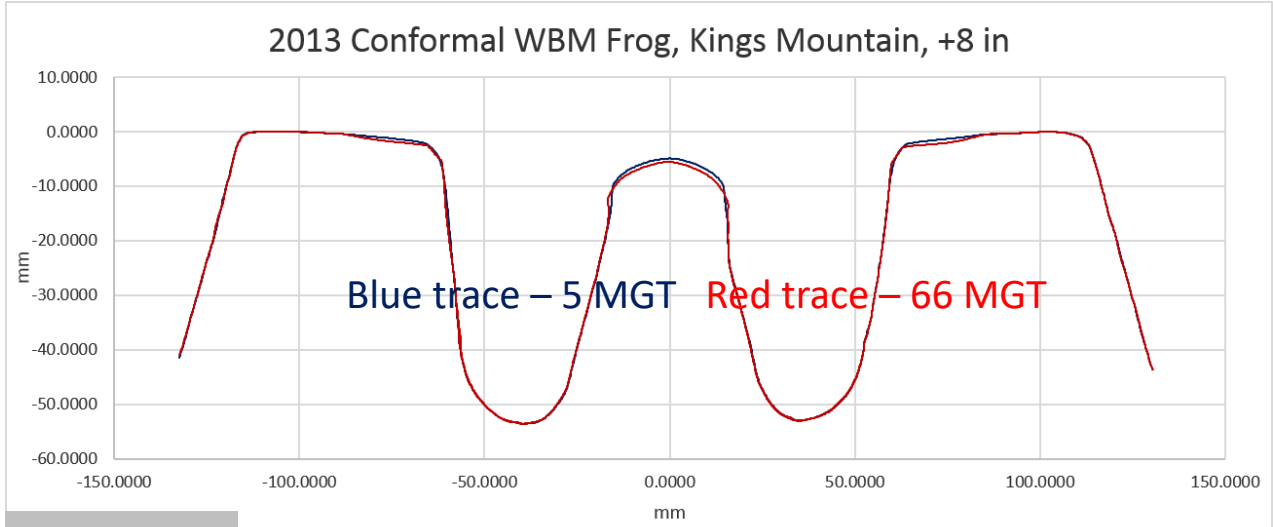
A low impact heel is secured with 5 bolts. This test frog (shown at 520 MGT) was removed after 650 MGT due to casting failure at the point/wing transition.

The life of this WBM heel could not be measured; the frog casting failed at the point/wing transition after 350 MGT

5) FLAT TOP VS. CONFORMAL PROFILES

- Measurement location 8” behind the 5/8” POF
- Flat top: Point shows significant deformation. Wings show a little wear. Both point and wings are wearing toward a conformal profile.
- Conformal: Both point and wings show very little wear; they are maintaining their conformal profiles.





Images: TTCI

6) WING SLOPES

Nortrak RBM frog with standard point, flat top profile and no wing slopes (148 GT)

Nortrak WBM frog with heavy point, flat top profile and 24” x 1/8” wing slopes (135 MGT); wheel tread contact on wings begins much closer to point.

File photos TTCI

6) WING SLOPES – RESULTS FROM TTC HEAVY AXLE LOOP

Two no. 20 RBM frogs on the HAL loop

Without wing slopes; wheel contact begins 36” from the POF (162 MGT)

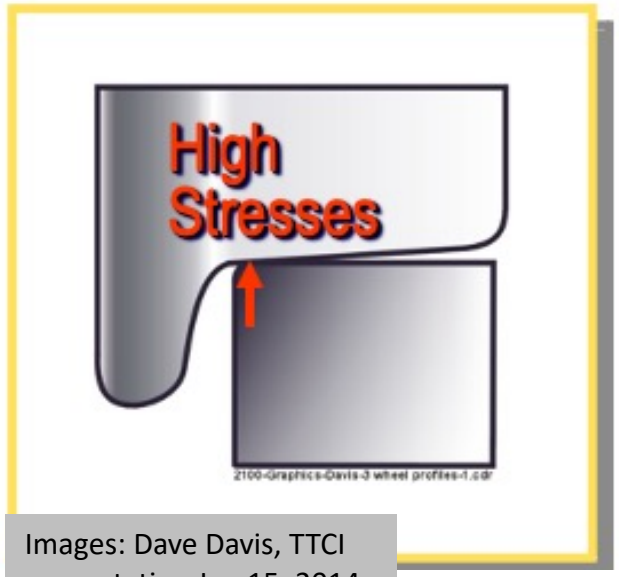
With wing slopes, wheel contact begins 18” from the POF (40 MGT); damage to the wings’ gage corner is reduced.

Photos - Dave Davis TTCI

MAINTENANCE ADVICE

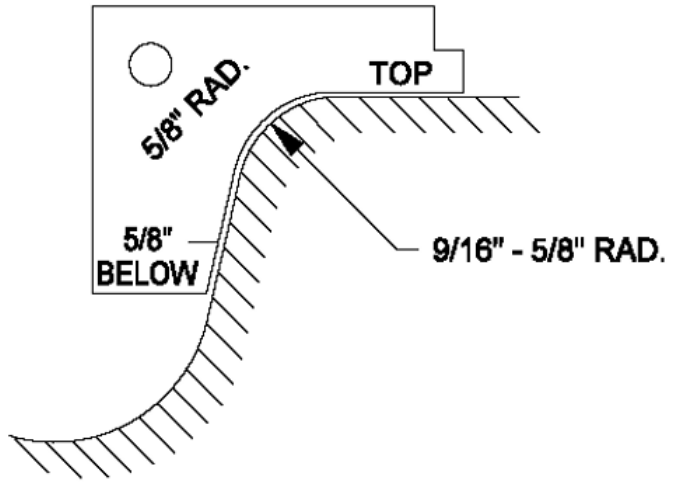
- Maintenance grinding
- Maintaining point height relative to wings

MAINTENANCE GRINDING



Images: Dave Davis, TTCI presentation Jan 15, 2014

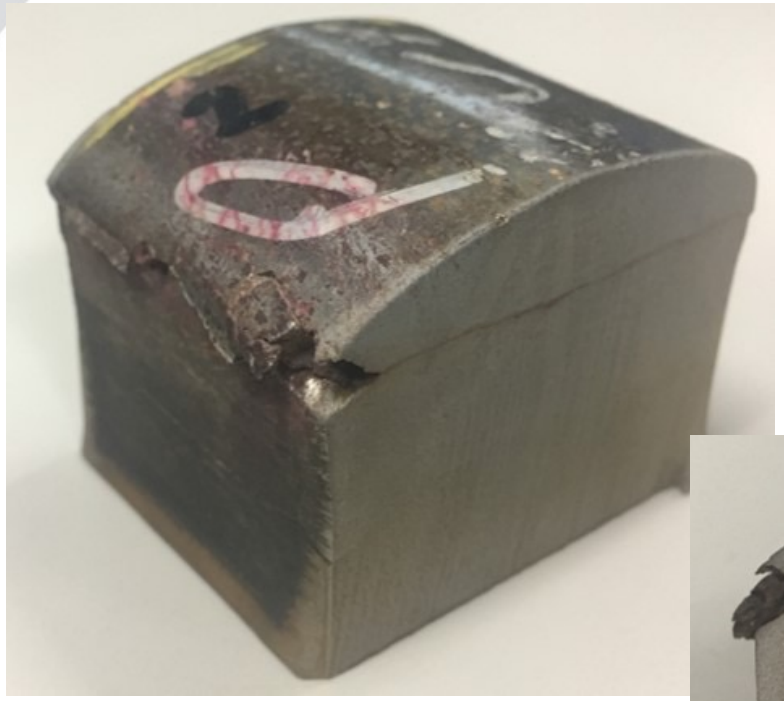
- Maintaining a radius on wing & point corners will prolong casting life by positioning wheel contact over the body of the casting and away from the corner where wheel loading can cause metal flow.
- Radius between 3/8” and 5/8”



NEW CONTOUR & RESTORED CONTOUR

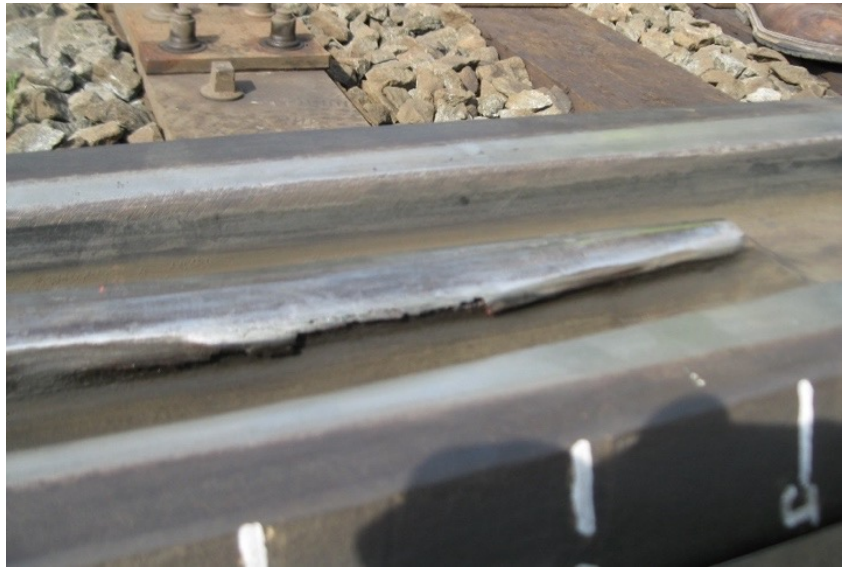
Image & photo: Aaron Hernandez, UP, “RBM Frog” presentation

MAINTENANCE GRINDING



Photos - EWI

- Deformed metal, (plastic flow) represents a change in cross section and a stress concentrator.
- This is where cracks often initiate.
- Maintenance grinding removes deformed metal and will reduce crack initiation.



WELD REPAIR - FLAT TOP FROG

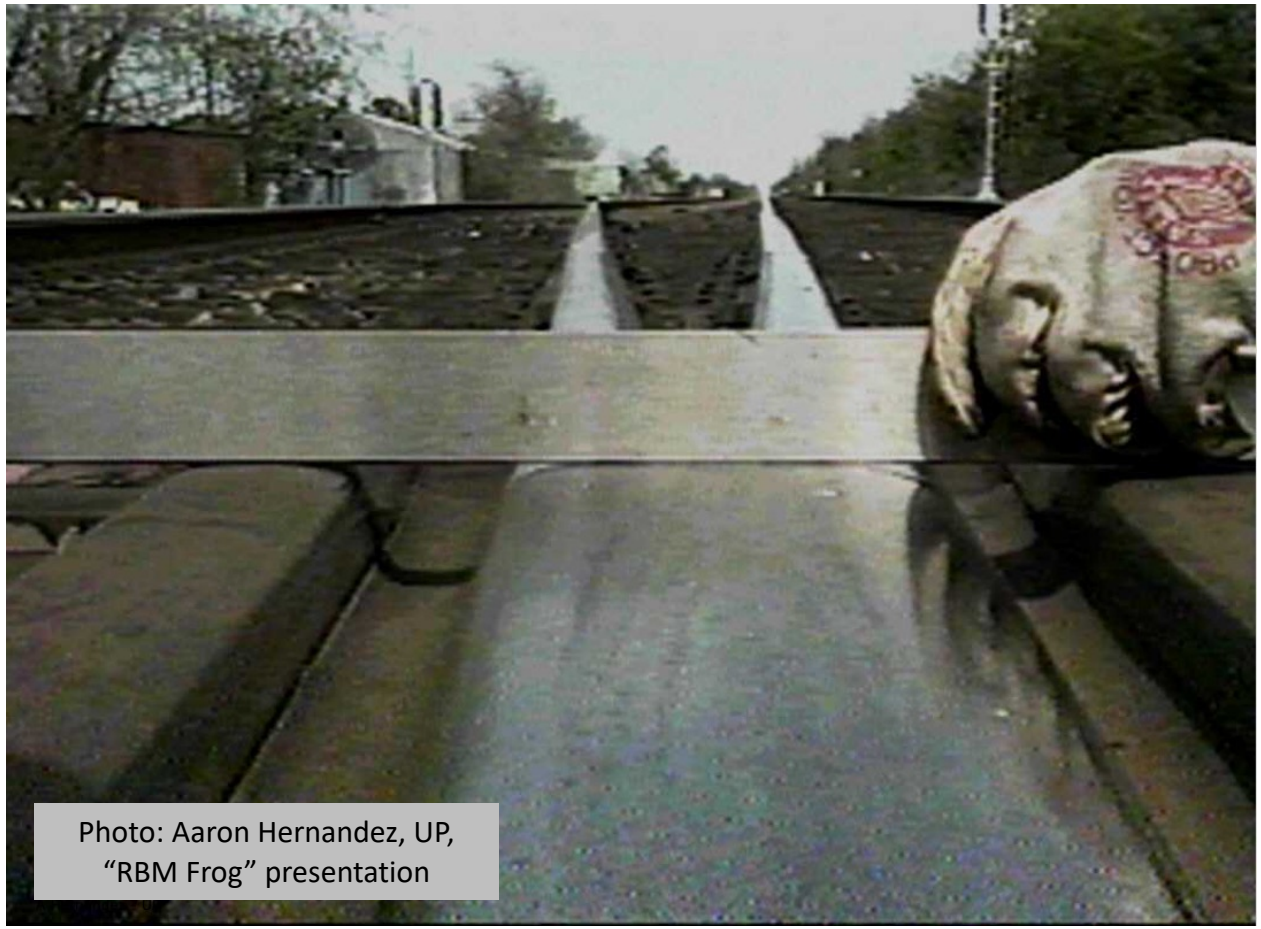


Photo: Aaron Hernandez, UP, "RBM Frog" presentation

- Set a straight edge across the wrap rails to determine the amount of point and wing wear.
- Weld-repair point and wing to original height.

MAINTAINING POINT HEIGHT RELATIVE TO WING HEIGHT

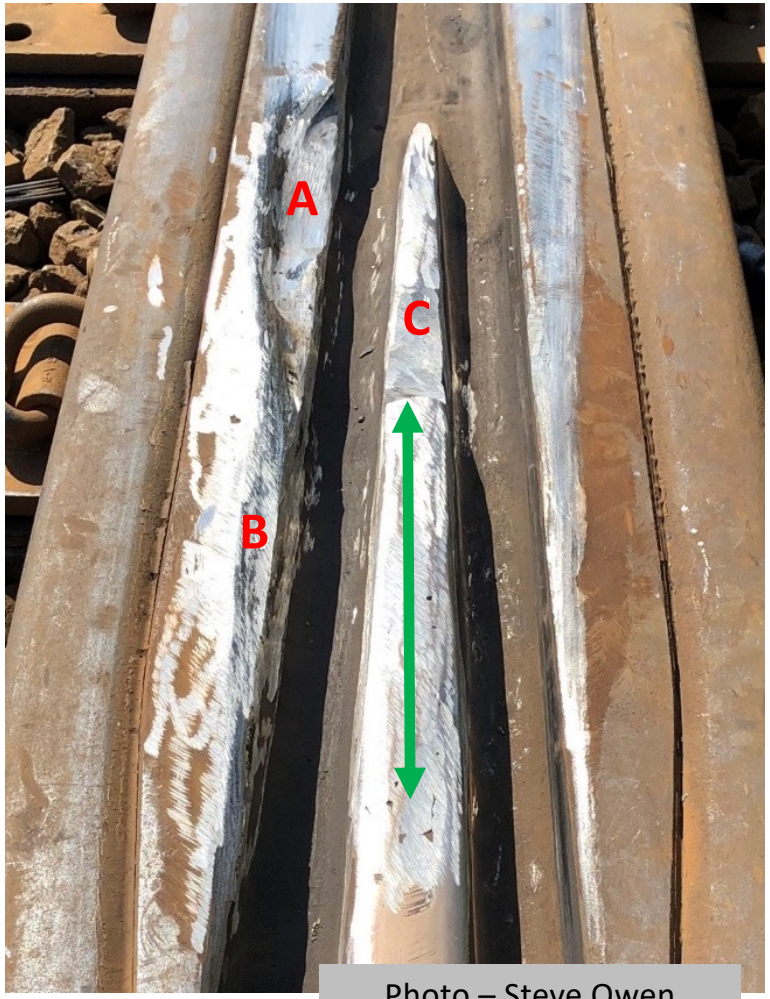


Photo – Steve Owen

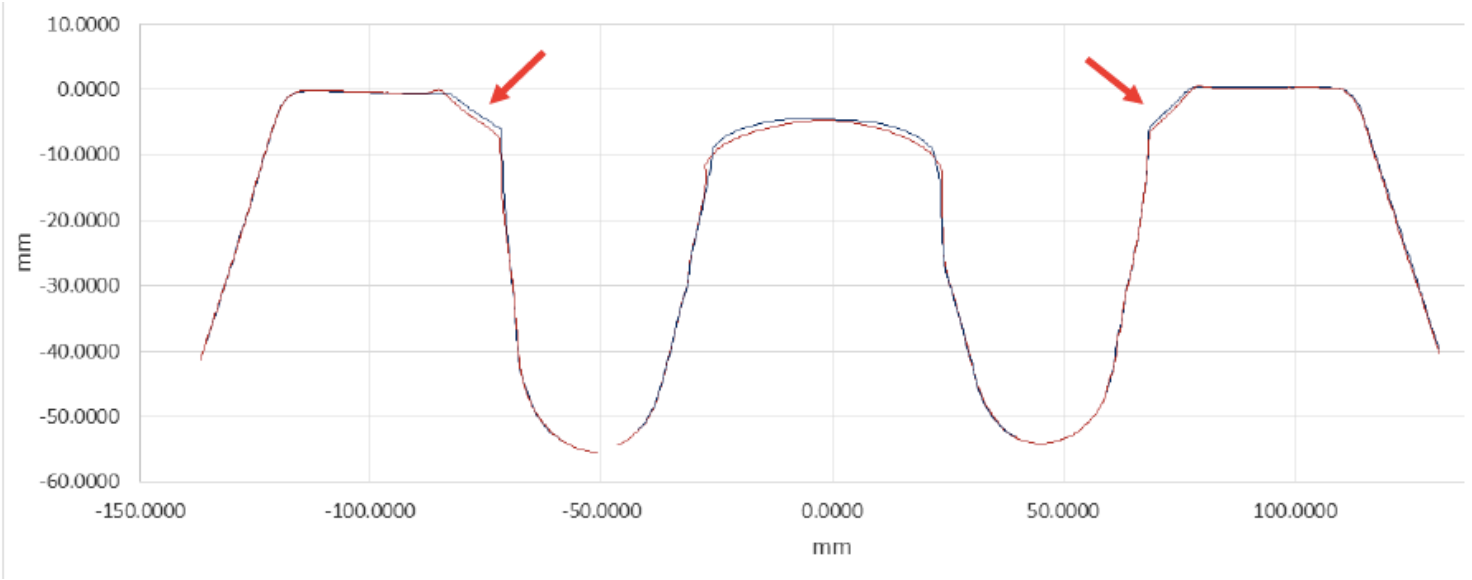
What is the likely repair plan for this frog?

- Wings: Damaged metal has been cut out of two spots, at A & B.
- Point:
  - Damaged metal has been cut out of one spot - C, which is within the limits of the point slope
  - No work is planned for the section of point marked by the green arrow

Worth noting: The damage at B was caused by a point that was worn below wing height, allowing hollow-tread wheels to strike the wing's gage corner.

Beyond the point slope, the point needs to be built up to the same height as the wings.

A COMMON FROG WELD-REPAIR MISTAKE



Simply restoring the wings to their original profile is not a long-term fix for this frog. The point is 1/4” below the wings; the point should be raised to insure a smooth transition of hollow-tread wheels.

WELD REPAIR - CONFORMAL FROG, USING CONFORMAL GAUGES

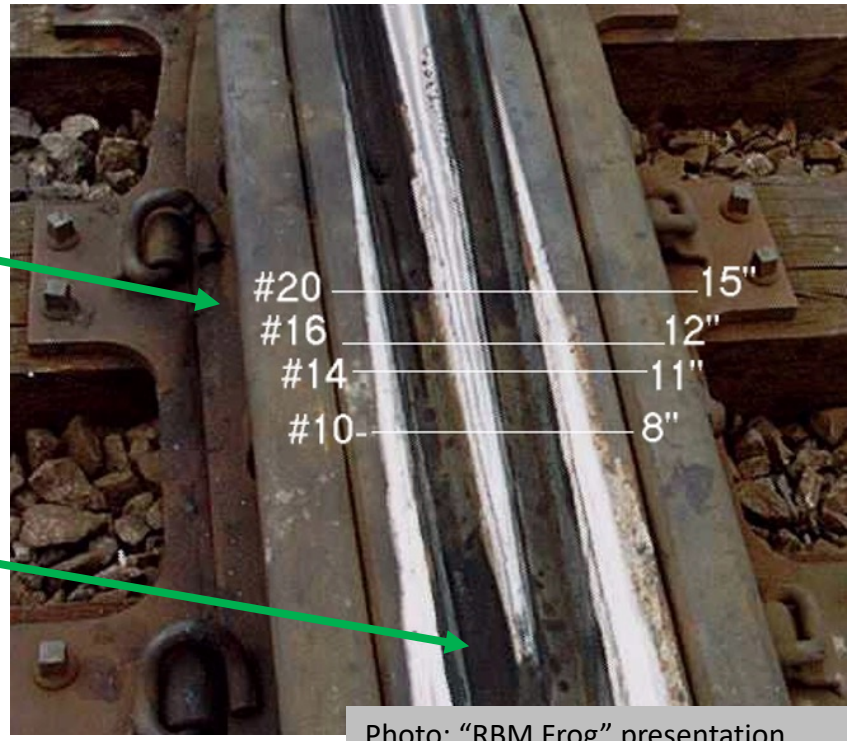


Photo: "RBM Frog" presentation
Aaron Hernandez, UP

What do you notice about the 1-9/16" spread gauge?

If you maintain the Gauge #2 profile for the point beyond the point slope, you will have a frog that:

- Works well with new wheels (that have a matching 1:20 tread profile)
- Does not work well with hollow-tread wheels (the point will be a tad low)

WELD REPAIR – CONFORMAL FROG

Gauge #2 – gaps between gauge and running surface (both wing and point) show amount of weld repair required.

CONCLUSIONS

1. Heavy points perform better than standard points
2. The RBM frog with rubber pads lasted longer than the RBM frog without rubber pads
3. The low-impact heel frog performed better than the standard 30^{o} wing rail design
4. A flat-top profile wears to a conformal profile
5. Wing slopes – we are optimistic that this design feature will reduce wing damage caused by hollow-worn wheels

RECOMMENDATIONS

A. Grind overflow when it appears; maintenance grinding is essential to minimizing casting cracks

B. Maintain a radius on all casting corners (both point and wing)

C. When performing a weld repair, build the point up (behind the point slope) to the same height as the wings; this geometry is essential for a smooth wheel transition. (Applies to both flat top and conformal profiles.)

QUESTIONS?

Photo: Aaron Hernandez, UP, "RBM Frog" presentation