Development and Validation of Switch Point Inspection Gauges to Reduce Wheel Climb Derailments

Brad Kerchof
Research & Tests

Outline

1. Switch point inspection - introduction

2. Three conditions (typically) needed for wheel climb

3. History of this project

4. Gauges explained

5. Industry validation

6. Improvements & next steps

Typical track inspector learning process

How does a track inspector learn to identify a high-risk switch point?

➢ Mostly through experience – seeing first-hand which conditions contribute to wheel climb

This is a very expensive way to learn!

(Adding more grease is not the solution to this switch point problem)

FRA's Track Safety Standard

The FRA Track Safety Standard concerning switch points isn't very specific:

§ 213.135 Switches
(h) Unusually chipped or worn switch points shall be repaired or replaced. Metal flow shall be removed to insure proper closure.

What is unusual to one inspector may not be unusual to another inspector. It may depend on their derailment experience!

What three conditions are typically present in most switch point wheel-climb derailments?

1. A gapped, worn or broken switch point

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1. A gapped, worn or broken switch point
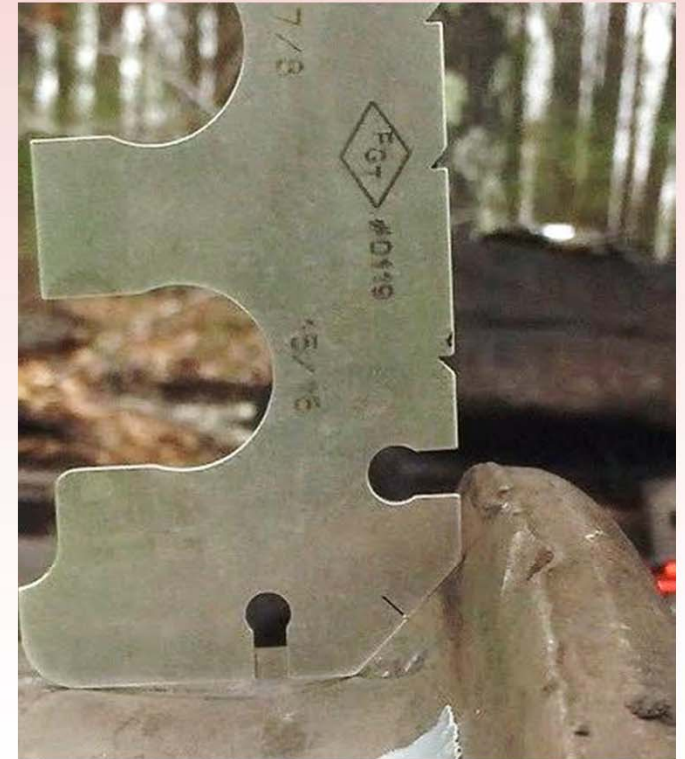
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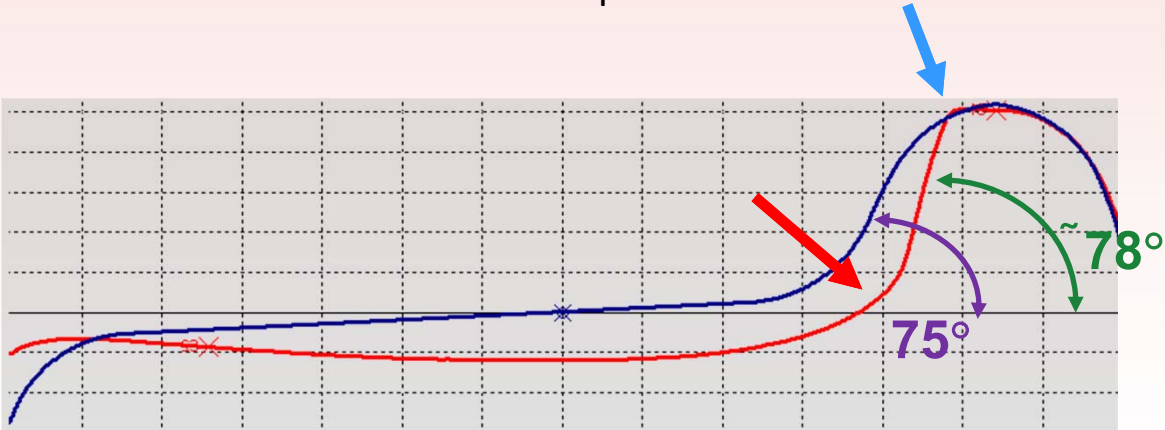
1. A gapped, worn or broken switch point

2. A worn wheel profile – one with a worn flange root (red arrow), and – often – a sharp edge on the tip of the flange (blue arrow).

Why is a worn wheel more likely to climb a switch point?

A worn flange root (red arrow) allows the outside edge of the flange (blue arrow) to move closer to the switch point.


~78°

75°

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2. A worn wheel profile

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1. A gapped, worn or broken switch point

2. A worn wheel profile

3. Tracking position – the worn wheel is shifted toward the switch point

Worn (or gapped) point + worn wheel + tracking position =
wheel climb derailment
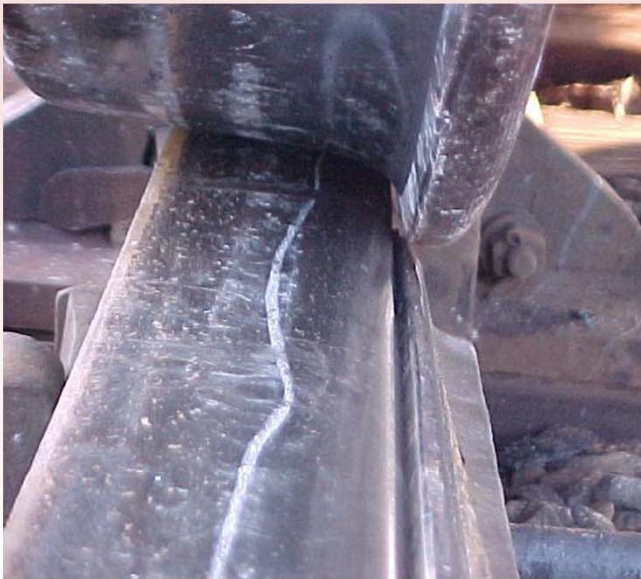
"Investigation of Wheel Climb Safety and Maintenance Practices for Switch Points"

A TRB IDEA* proposal submitted by Dr. Allan Zarembski (University of Delaware) in 2012

* Innovations Deserving Exploratory Analysis, funded by FRA Office of R&D

Gauge from the Swiss Federal Railway

Objective

- Reduce wheel-climb derailments at switch points by improving the quality of switch inspection

Proposed Methodology

- Review switch inspection practices used by European railroads
- Evaluate the potential for application of these practices to North American railways

TRB accepted this proposal

Phase 1 accomplishments

- Established an advisory team of industry track experts

- Evaluated the switch inspection process of two European railroads - Network Rail (UK) and SBB (Swiss Federal Railway), and recognized their reliance on switch point gauges

- Duplicated a set of four Network Rail gauges and tested them on NA switches

- Modified two of the gauges, and developed a third (new) gauge, for further testing

- Determined that we should apply for a second grant to continue gauge development & testing

WRI 2016
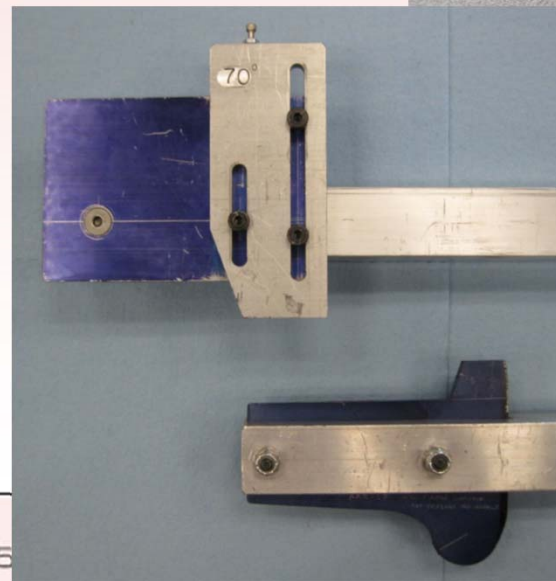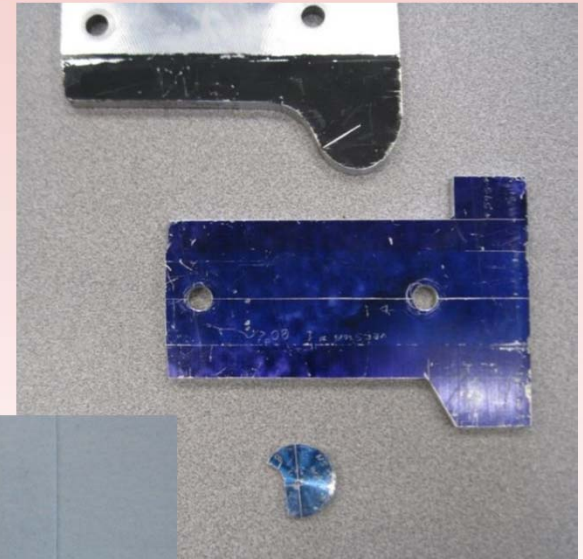
"Field Validation of Inspection Gauges for Wheel Climb Safety at Switch Points"

Dr. Zarembski submitted a second proposal to the TRB IDEA committee in 2014


Safe

Objectives

- Complete development of a set of gauges that identifies switch points that are at risk for wheel climb

- Validate the performance of these gauges through field testing on several railroads

- Promote the use of these gauges as an aid to switch inspection

TRB accepted this proposal, as well

Phase 2 accomplishments

- Settled on the design of four gauges

- Developed a validation plan

- Sent gauges and instructions to six industry volunteers

- Processed their feedback

- Modified gauges & instructions

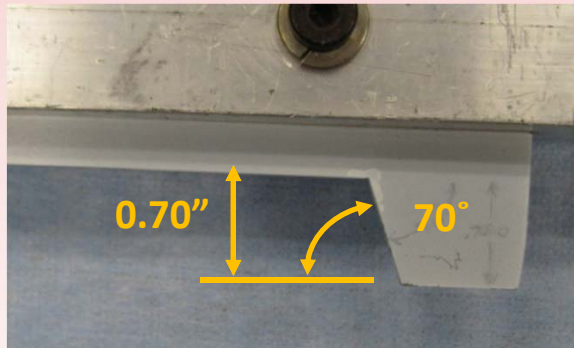- Proposed next steps
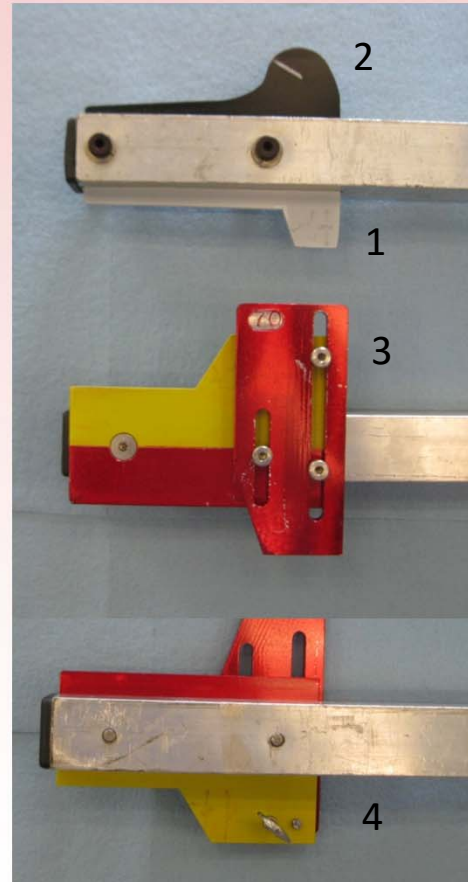
G2. AAR 1B wheel contact

G1. Chipped point
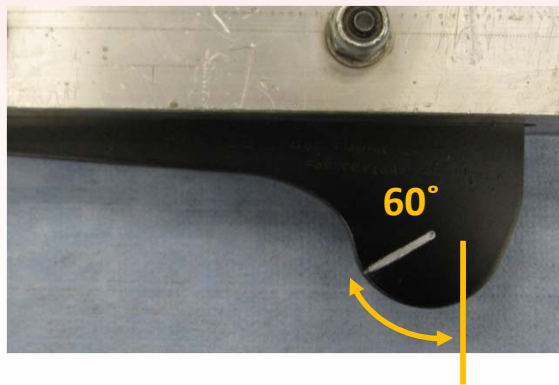
G3. Severely worn wheel profile

G4. Gage-face wear angle

Gauges described & instructions for use

G1. Chipped point - paddle depth 0.70", paddle angle 70°

G3. Severely worn wheel profile – sliding gauge simulates 70° wheel flange angle

G2. AAR 1B wheel contact – uses the profile of a new AAR 1B wheel; hash mark at 60°
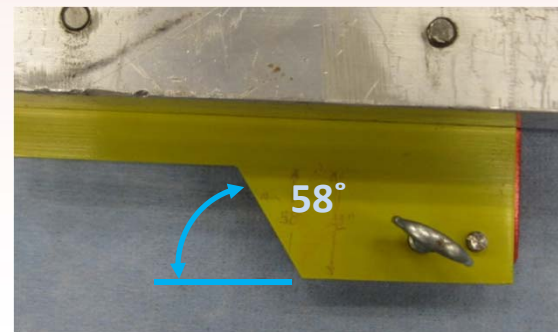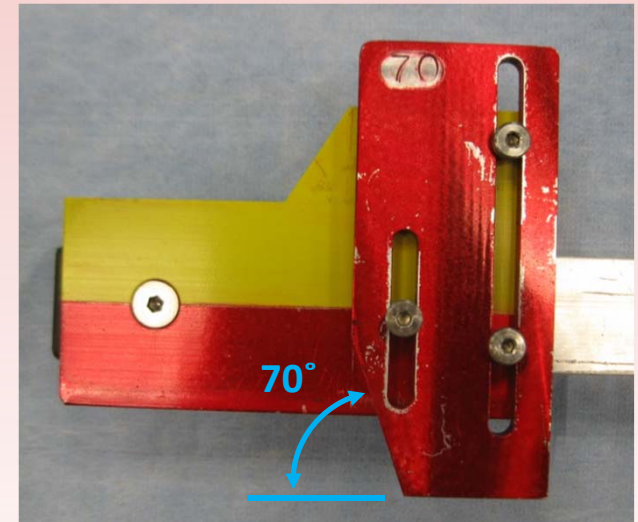
G4. Gage-face wear angle, 58° (depth of paddle not important)

G1. Chipped point gauge
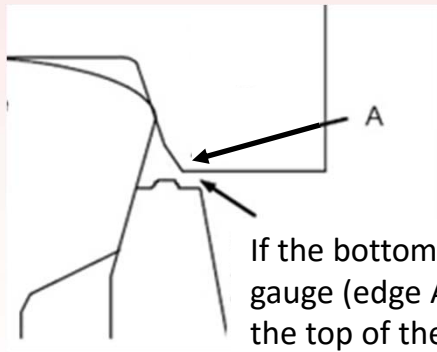
If the bottom edge of gauge (edge A) is over the top of the damaged switch point , **Fail**
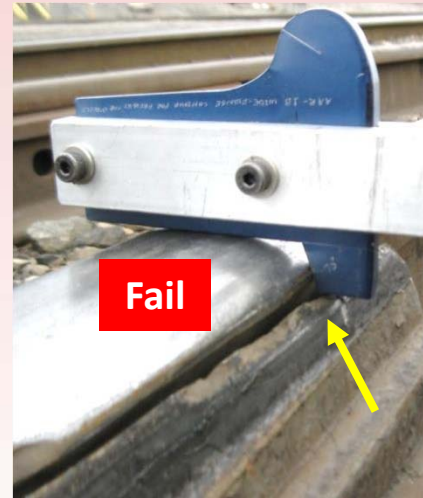
Apply this gauge within 12 inches of the tip of the point.

- If the bottom edge slides <u>over</u> the top of a broken or worn point, **Fail**

- Otherwise, **Pass**

G2. AAR 1B wheel contact gauge

Apply this gauge within 12 inches of the tip of the switch point.

If contact with the switch point is…

- above the 60˚ mark, **Pass**
- below the 60˚ mark, **Fail**

G3. Severely worn wheel profile gauge

Pass

Fail
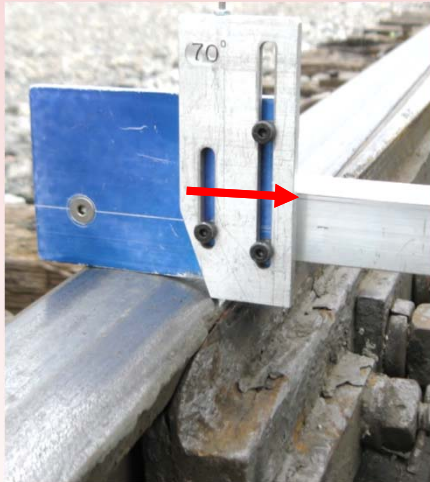
This gauge can be used to identify gapping points, broken points and points that are exposed due to a worn stock rail.

Apply this gauge within 2 inches of the tip of the point, where straight-on contact with a worn flange is most likely. Start with the gauge on top of the stock rail, then slowly shift the gauge toward the point until the it slides off.

- If the slider slides down the gage face of the switch point, **Pass**
- If the corner of the slider lands on top of the switch point, **Fail**

G4. Gage-face wear angle gauge

At Limit

Pass

At Limit
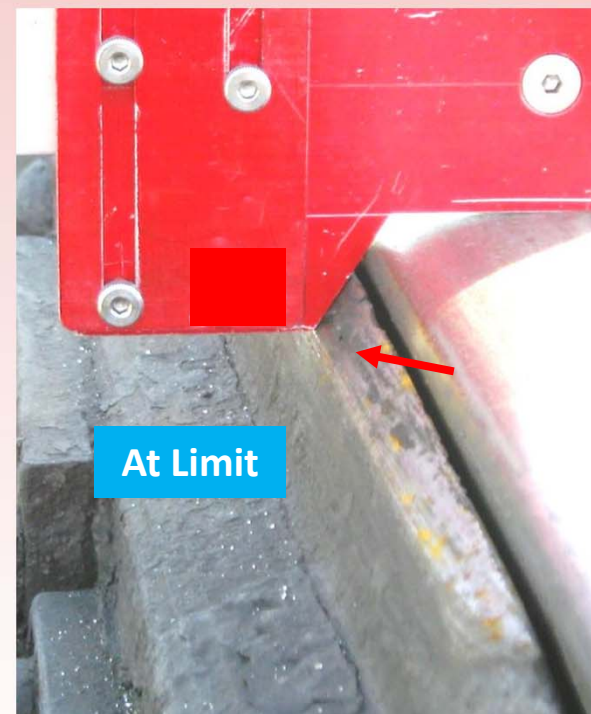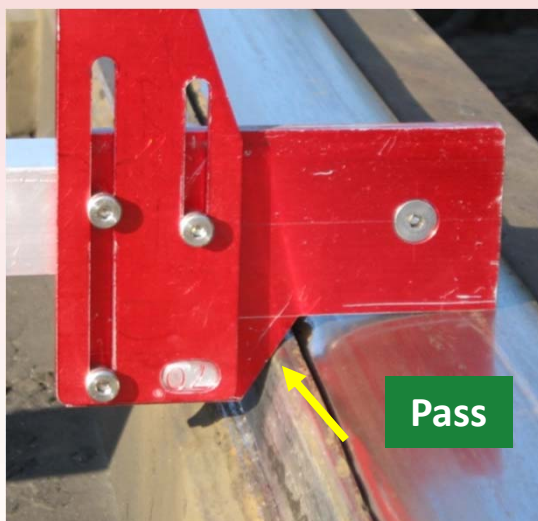
Apply this gauge within 24 inches of the tip of the point.

If the switch point gage-face angle is...
- greater than 58°, **Pass**
- less than 58°, **Fail**

This gauge protects against a low gage face angle, which is more likely to contribute to wheel climb.

Industry validation

Volunteers who offered to field-test a set of gauges and provide feedback:

- ✓ Amtrak
- ✓ BNSF
- ✓ CN
- ✓ Gary Wolf
- ✓ Long Island Railroad
- ✓ NS

Seven sets of gauges were produced and sent out in October, 2015 (2 sets to NS)

Industry validation

Validation instructions

➤ Use gauges on 40 – 50 switch points, many of which are in marginal, poor or failed condition

➤ Complete a switch point inspection data form for each point

➤ Take a photograph of each switch point

➤ Provide feedback on the usefulness and design of the gauges

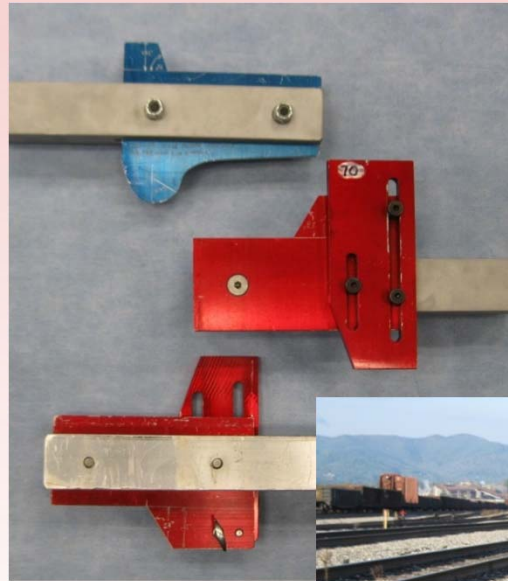Field Validation of Switch Point Inspection Gauges: IDEA Safety - 28

[1] Inspector's Name _____ [2] Date __/__/____
[3] Railroad _____

Switch Point Information (one form per switch point)

[4] Yard Name/Location _____ OR [5] Mile Post/Track No. _____
[6] Switch ID/Name _____ [7] Turnout size _____
[8] Switch point length _____ [9] Rail size _____
[10] Switch point side ☐ Straight ☐ Diverging (Curved)
[11] Switch point type ☐ Samson/Undercut ☐ Plain
[12] Turnout ☐ Left hand ☐ Right hand ☐ Equilateral
[13] Prevailing traffic ☐ Facing ☐ Trailing ☐ Balanced
[14] Is the turnout on or at end of curve? ☐ No ☐ Yes; Degree _____
[15] Inspector Assessment of Switch Point Condition (prior to measurement with gauges)
☐ Good ☐ Marginal ☐ Poor ☐ Failed

Gauge 1: Chipped point gauge
[16] ☐ Pass ☐ Fail ☐ Can't determine (reason) _____

Gauge 2: AAR 1B wheel contact gauge
[17] ☐ Pass ☐ Fail ☐ Can't determine (reason) _____

Gauge 3: Severely worn wheel profile gauge
[18] ☐ Pass ☐ Fail ☐ Can't determine (reason) _____

Gauge 4: Gage-face wear angle gauge
[19] ☐ Pass ☐ Fail ☐ Can't determine (reason) _____

Comments
[20] _____

Industry validation

- Field validation was conducted over five months, from Oct 2015 through Feb 2016.

- Measurements were taken by MW people on four railroads plus an independent consultant; they looked at a total of 285 switch points.

	Switches inspected
NS	22
LIRR	45
CN	135
Wolf	41
BNSF	42
Total	285

Typical data response

Photos of switch point &
completed data form

Field Validation of Switch Point Inspection Gauges: IDEA Safety - 28

[1] Inspector's Name Y. MAO, A. PAOLO, R. LEGGIO   [2] Date 1/13/2016

[3] Railroad LIRR

Switch Point Information (one form per switch point)

[4] Yard Name/Location BELMONT   OR   [5] Mile Post/Track No. YARD WEST LEAD - EAST

[6] Switch ID/Name 1 E   [7] Turnout size PRR #10 T/O

[8] Switch point length 18'-0"   [9] Rail size 100# P.S.

[10] Switch point side   ☑ Straight   ☐ Diverging (Curved)

[11] Switch point type   ☐ Samson/Undercut   ☑ Plain * PRR SW. PT.

[12] Turnout   ☑ Left hand   ☐ Right hand   ☐ Equilateral

[13] Prevailing traffic   ☐ Facing   ☐ Trailing   ☑ Balanced

[14] Is the turnout on or at end of curve? ☐ No   ☑ Yes; Degree N/A

[15] Inspector Assessment of Switch Point Condition (prior to measurement with gauges)

☐ Good   ☑ Marginal   ☐ Poor   ☐ Failed

Gauge 1: Chipped point gauge

[16] ☑ Pass   ☐ Fail   ☐ Can't determine (reason) _____

Gauge 2: AAR 1B wheel contact gauge

[17] ☑ Pass   ☐ Fail   ☐ Can't determine (reason) _____

Gauge 3: Severely worn wheel profile gauge

[18] ☐ Pass   ☑ Fail   ☐ Can't determine (reason) _____

Gauge 4: Gage-face wear angle gauge

[29] ☑ Pass   ☐ Fail   ☐ Can't determine (reason) _____

Comments

[33] * SW. PT. CHIPPED AND WAS GROUNDED BACK ;

*Attach digital photo of switch point and send form and photos digitally to Dr. Allan Zarembski; <dramz@udel.edu>

Sample Color-Coded Data (NS and CN)

ID	Gauge1 Chipped Point	Gauge2- AAR 1B	Gauge3- Thin Flange	Gauge4- Gage Face angle	RR Inspector Assessment
NS 3	F	P	F	P	Failed
NS 6	P	F	P	P	Poor
NS 7	F	F	can't determine	F	failed
NS 8	P	P	P	P	Failed
NS 9	P	P	F	P	Failed
NS 10	P	P	P	P	Failed
NS 14	P	P	F	P	Failed
NS 20	P	P	P	P	Poor
CN 9	F	P	P	P	Poor
CN 28	P	P	P	P	Poor
CN 29	F	F	P	P	Poor

Agreement between inspector and the gauges is achieved when

- The inspector assesses the point as good or marginal and <u>all four</u> of the gauges show **Pass**, or

- The inspector assesses the point as poor or failed and <u>any one</u> of the gauges shows **Fail**

Very few switch points had the inspector assess the point as poor or failed while all four gauges showed **Pass**

Summary: Correlation Analysis

Railroad	No. of Inspections	% Agree	% Disagree
1: All inspections	272	58%	42%
2: CN	135	49%	51%
3: BNSF	41	44%	56%
4: LIRR	45	84%	16%
5: NS	16	50%	50%
6: Gary Wolf	35	77%	23%

Agreement between inspector and the gauges is achieved when

- The inspector assesses the point as good or marginal and all four of the gauges show **Pass**, or

- The inspector assesses the point as poor or failed and any one of the gauges shows **Fail**

Summary: Correlation Analysis

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Explanation for variation in agreement %

- A difference in inspection standards between railroads.

- A difference in interpretation of the instructions (which were not as accurate as they could have been).

- A difference in experience among the inspectors (in particular, derailment investigation experience).

Summary: Failed Gauge Analysis

This graph shows the relative percentage of failed assessments for each gauge on each RR.

For example

- On CN, the chipped point gauge counted for 60% of all CN failed gauge assessments.

- On the LIRR, the severely worn wheel gauge counted for 60% of all LIRR failed assessments.

Railroad	No. of Inspections	Gauge 1	Gauge 2	Gauge 3	Gauge 4
1: All inspections	272	44%	21%	28%	7%
2: CN	135	60%	19%	11%	10%
3: BNSF	41	28%	32%	38%	2%
4: LIRR	45	30%	10%	60%	0%
5: NS	16	29%	21%	36%	14%
6: Gary Wolf	35	29%	7%	64%	0%

Field validation included these four questions

1. How easy were the gauges to use?

2. Are the instructions clear? (If not, what changes to you recommend?)

3. Do the gauges provide useful information on switch point condition? (Did the gauge correlate with the inspector's assessment of switch point condition?)

4. Do the gauges need further refinement?

1. How easy were the gauges to use?

- All of the gauges were easy to use, however they were cumbersome, and thus unlikely to be taken out of the truck during a regular inspection.

- Why can't the gauge be one bar, with the gauges on opposite sides and orientation; possibly interchangeable on a single rod.

- AAR 1B wheel contact gauge – difficult to see point-gauge contact

2. Are the instructions clear?

- Fairly clear (however instructions are generally not read).

- I did read the instructions but the most difficult thing to follow was the wide range of locations for the gauges to be used. I forgot the distances almost immediately.

- Putting the distances on the gauges would greatly reduce the number of erred readings.
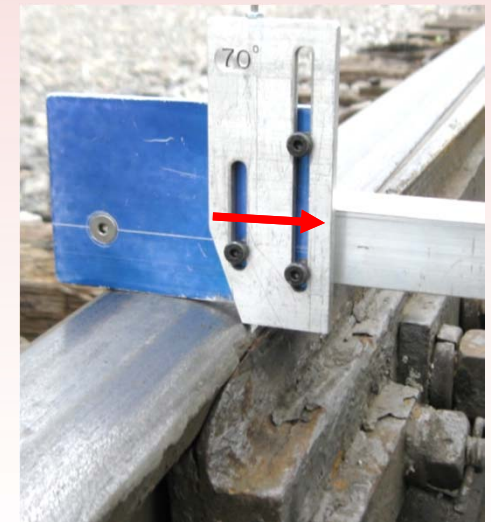
3. Did the gauges provide useful information on switch point condition?

- Yes. It reinforces the Track Inspector's judgment when maintenance is necessary.

- Chipped point gauge - Where does the 0.7-inch depth come from? We use 0.875-inch depth to define a chip. Curious to learn if 0.7 inch is critical.

- AAR 1B was the most insightful gauge.

- We do not currently measure the gage-face wear angle or have a tool to visualize where a wheel contacts the point. These gauges indicate both worn point and worn stock rail.

4. Do the gauges need further refinement?

- One cosmetic suggestion – paint each of the gauges a different color.

- G2 AAR 1B - would like line on gauge easier to see.

- Larger handle for when wearing gloves.

- Can gauges be attached to the Geismar level board?
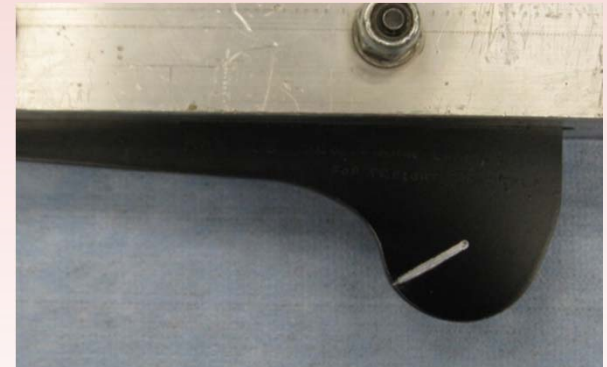
Modifications to gauges

- Chipped point gauge – increased paddle depth from 0.70" to 0.75"

- Gage-face angle gauge – increased angle from 58° to 60°

- Larger handle will be used

- Gauge number (G1 – G4) added

- Instruction sticker will be applied

0.75"

60°
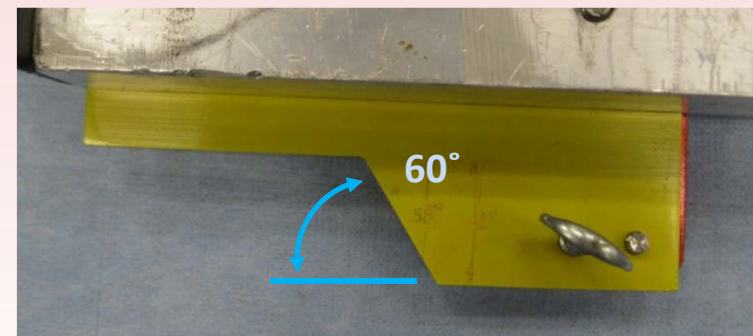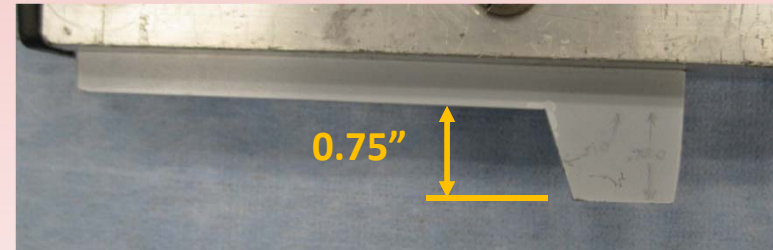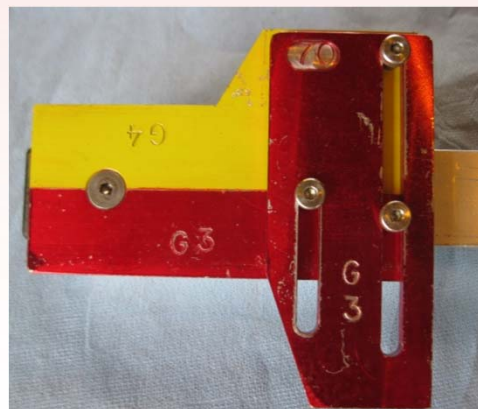
Modifications to instructions

When evaluating a switch point that has been ground back

Apply gauge starting at the ground-back tip.

Gauge applied incorrectly

Modifications to instructions

Chipped point (G1) & AAR 1B (G2)

Apply this gauge where the point is worn or broken. This is typically within 24 inches of the tip, but could be anywhere along the point.

Chipped area 3 to 5 feet behind tip

Modifications to instructions

Severely worn wheel profile (G3)

Apply this gauge within the first inch of the tip of the point, or where wheel flange contact is first evident.

Gage-face angle (G4)

Apply this gauge where gage-face wear is evident anywhere along the point.

Purpose of the switch point gauges (how we see them being used)

- The gauges will allow a track inspector to
  - ➤ see the wheel flange contact is possible with both new and worn wheels, and thus
  - ➤ identify switch points that are at risk for wheel climb

- We see the gauges being used by an inspector until he can predict how the gauges will evaluate a switch point.

- Once this capability has been achieved, the gauges need not be carried.

Next steps

- Modify gauges
- Provide modified gauges, modified instructions and reporting forms for a second field test to:
  - ➢ Original volunteers: BNSF, CN, Gary Wolf, NS
  - ➢ New volunteer: TTCI
  - ➢ Request volunteers inspect 15-20 switch points
- If the second field test is successful (if it shows improved agreement between gauge & inspector assessment)
  - ➢ Publicize project in an RT&S article
  - ➢ Offer presentations to TRB and AREMA
 - ➢ Gain support from AREMA committee 5

Acknowledgements

- Dr. Allan Zarembski, U of Delaware, originated and led the project

- Advisory committee
  - Bob Kollmar
  - Joe Smak
  - Tony Bahara
  - Yifeng Mao
  - Steve Abramopaulos
  - Brad Kerchof

- Ali Alsahli , graduate student, U of Delaware, processed the validation data

- Guy Kagaels (NS) machined the gauges

- Scott Cummings (TTCI) & Jason Trompeter (NS) helped with gauge design and field testing

- Railroads who used the gauges in the field and provided invaluable feedback:
  - BNSF, Zach Dombrow
  - CN, Dan Voelkerding
  - LIRR, Yifeng Mao & Steve Abramopaulos
  - Gary Wolf
  - NS, Dane Parks & Matt Wince

Questions?
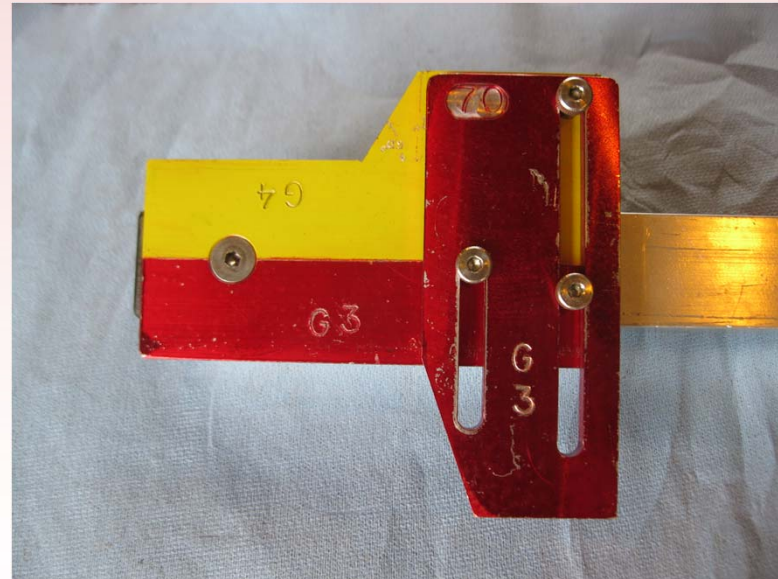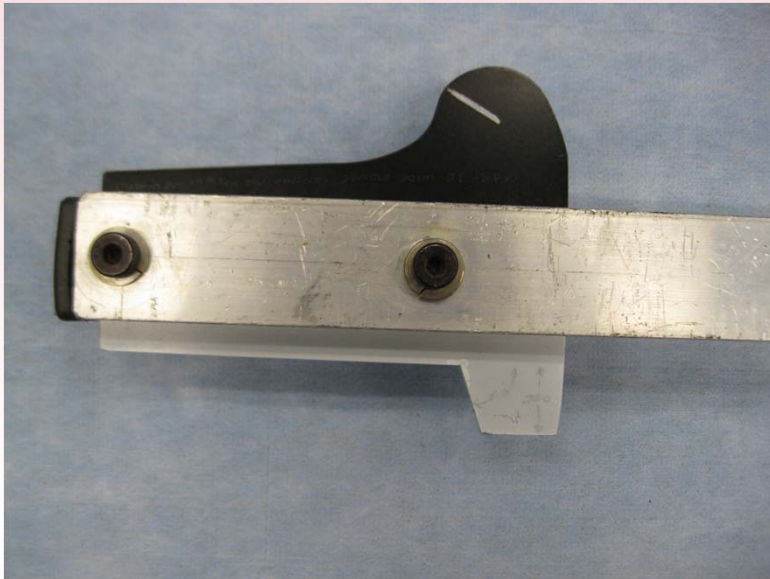
What is the 2nd myth of track maintenance?

- More elevation is better. I can fix my rail wear and gage-widening problems by adding more elevation!

Track

Center of Gravity

W = Weight of Car or Locomotive

R = Resultant Force

C = Centrifugal Force

90°