NORFOLK SOUTHERN

Measuring Rail Cracks Using Eddy Current

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Rohmann LP

RCF cracks on high and low rails

Rail cracks develop into spalls

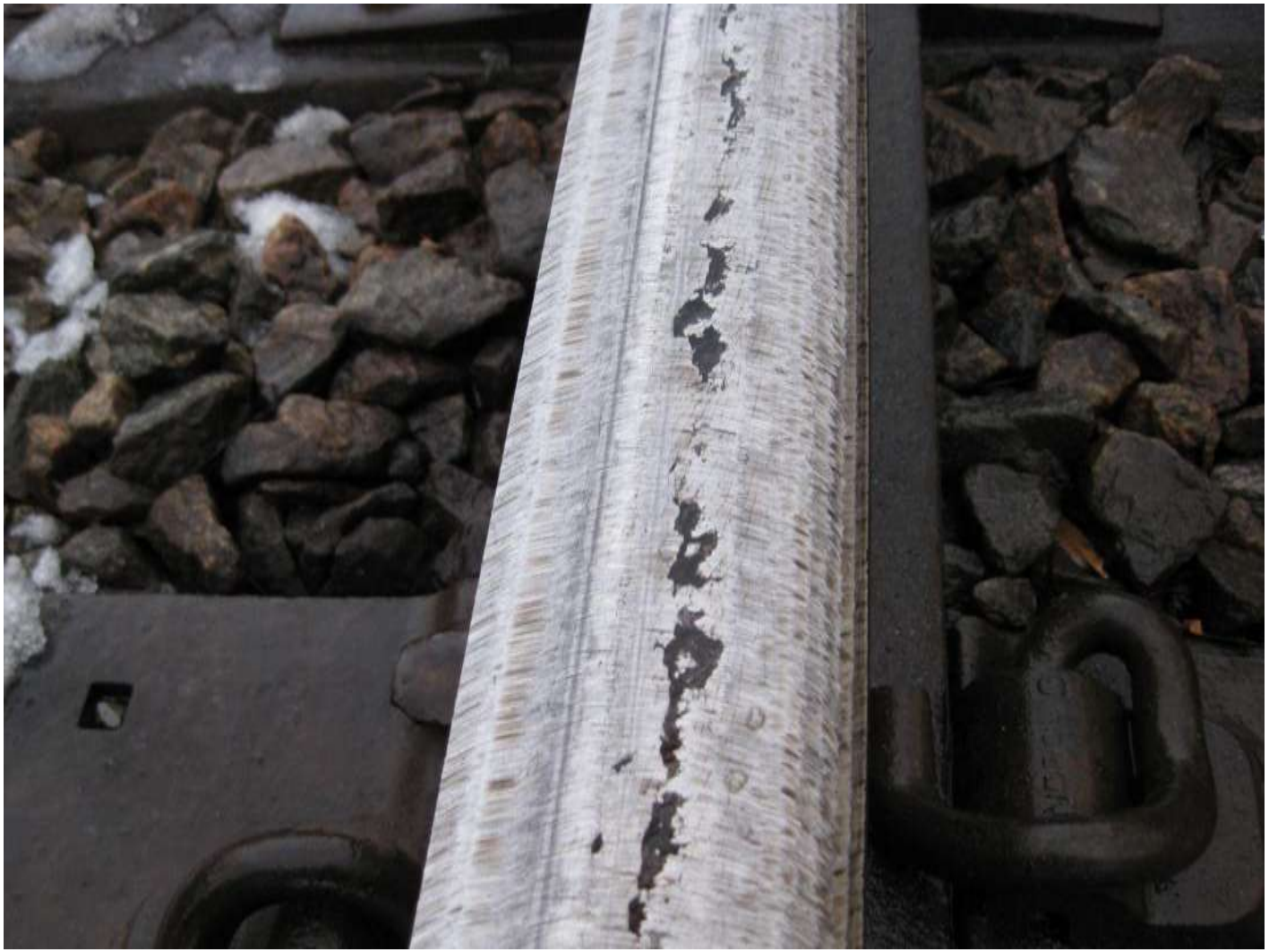
Cracks, spalls and plastic flow and spalls

Cracks can develop into transverse defects

2012 data: a third of NS's defects and service failures are TDs, and a high percentage of these originate at the running surface

Low rail before grinding

Low rail after pass 1



Low rail after pass 2

Low rail after pass 3

Low rail after pass 4

Low rail after pass 5

Even after 5 passes, cracks are still visible!

Should we have made additional grinding passes to remove the cracks?

Why do we grind?

1. Remove RCF defects, including spalls, corrugations and fatigued metal
2. Maintain a clean surface for ultra-sonic testing
3. Restore a rail profile that improves axle steering

High rail pre-grind (gage side right)

High rail post-grind

Why do we grind?

Low rail pre-grind (gage side left)

Low rail post-grind

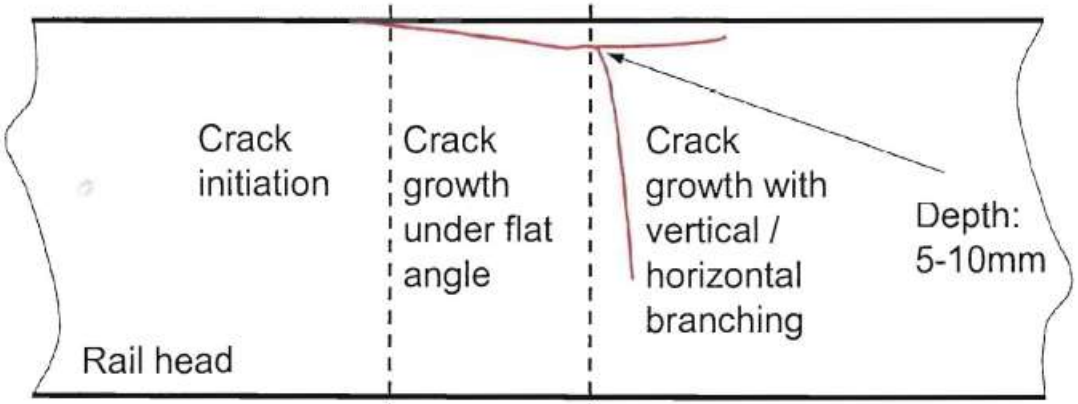
Should we have made additional grinding passes to remove the spalls and cracks?

Deutsche Bahn Crack Growth Model

Crack growth divides into three stages

DB NETZE

Head Checks – Path of crack and speed of crack growth



Rate of crack growth (steel grade R260)	after 5-10 Mio Lt	1 to 2 mm 100 Mio Lt	~1 mm / 1 Mio Lt
ZfP-system for evaluation	VT, ET (St>0.2mm)	VT, ET (St≤2.7mm)	VT, UT

St = damaging depth
VT = visual check
ET = eddy-current text
UT = ultrasonic check

Source: project IOS, TP 1, Dr. René Heyder, VTZ 35, 08.04.2008

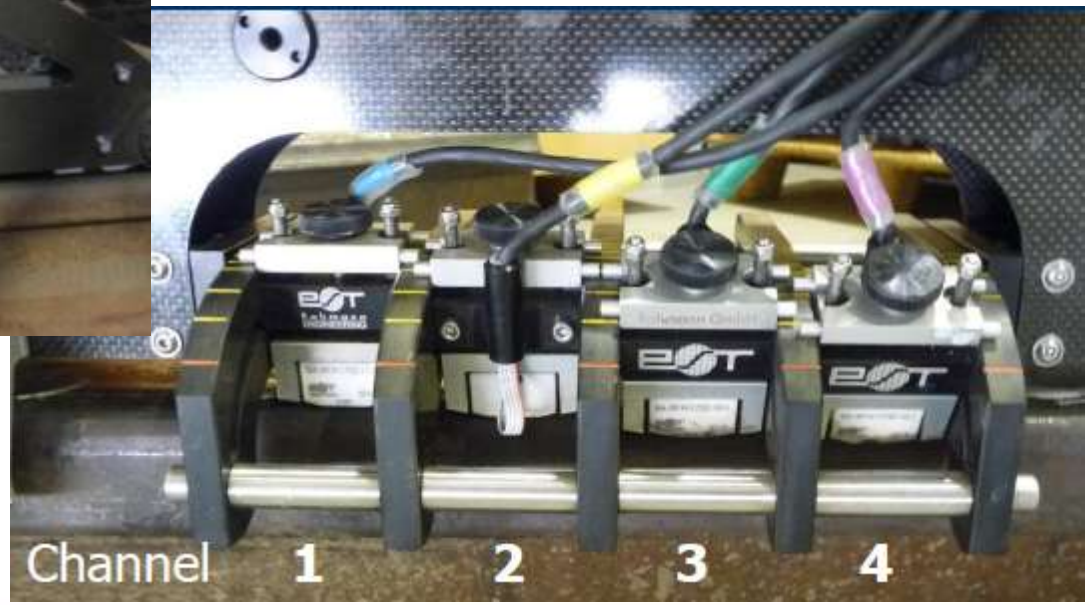
Can we measure crack depth?

- Knowing crack depth can improve the effectiveness of grinding program.
- The Rohmann “Draisine”
- Walk-behind
- Measures one rail at a time

Draisine measurement head

Four eddy current probes:

- probes 1 and 2 cover the head
- probes 3 and 4 cover the gage corner
- each probe covers a 7 mm “active area”

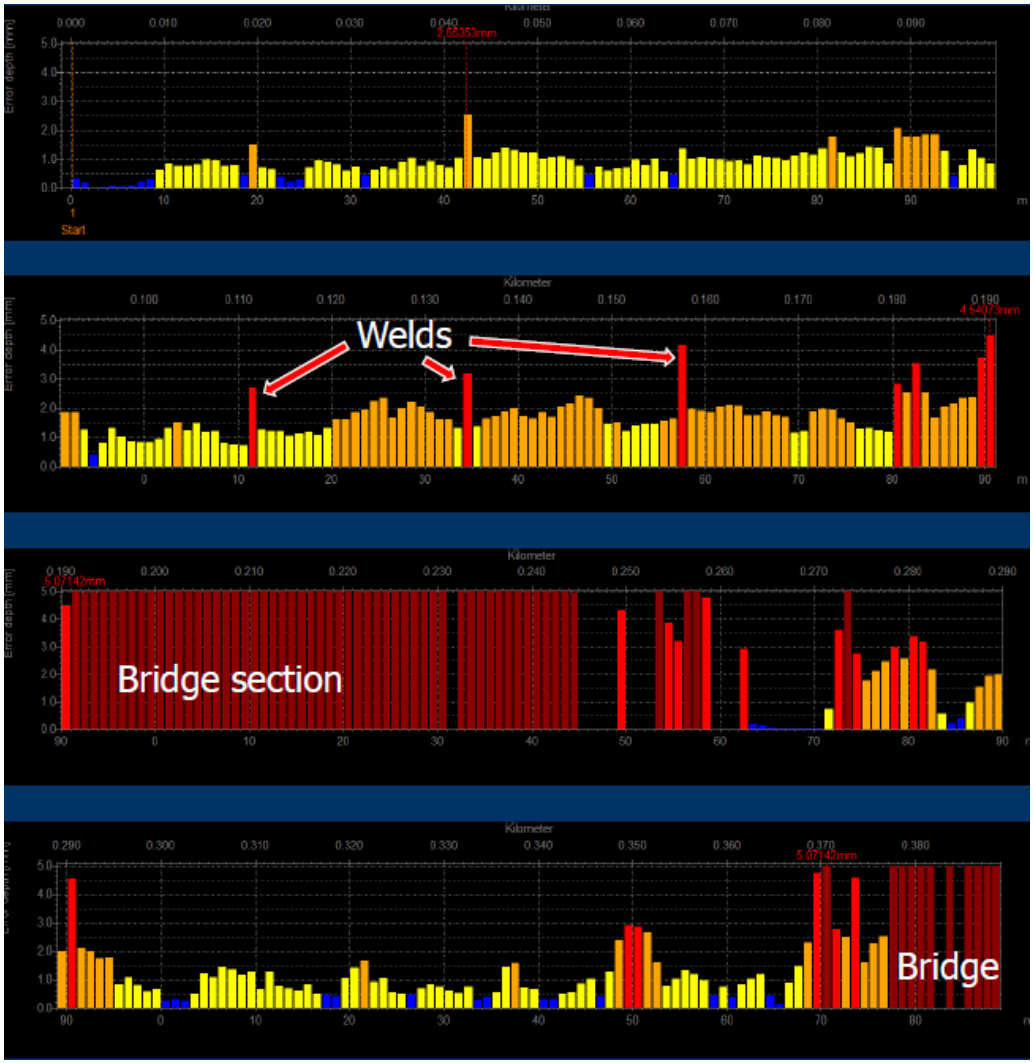


Phase 1– Measurement pre- and post-grind

- Will the Draisine measure a change in crack dimension?
- Will grinding stone marks interfere with the eddy current signal?

Draisine pre-grind crack measurements

- Low rail
- Horizontal scale: 100 m per graph
- Vertical scale: 0 – 5 mm; different mm are color-coded, and each bar represents the worst cracks found in 1 m
- Cracks were measured between 1 and 3 mm on ground track, and over 5 mm on the two bridges



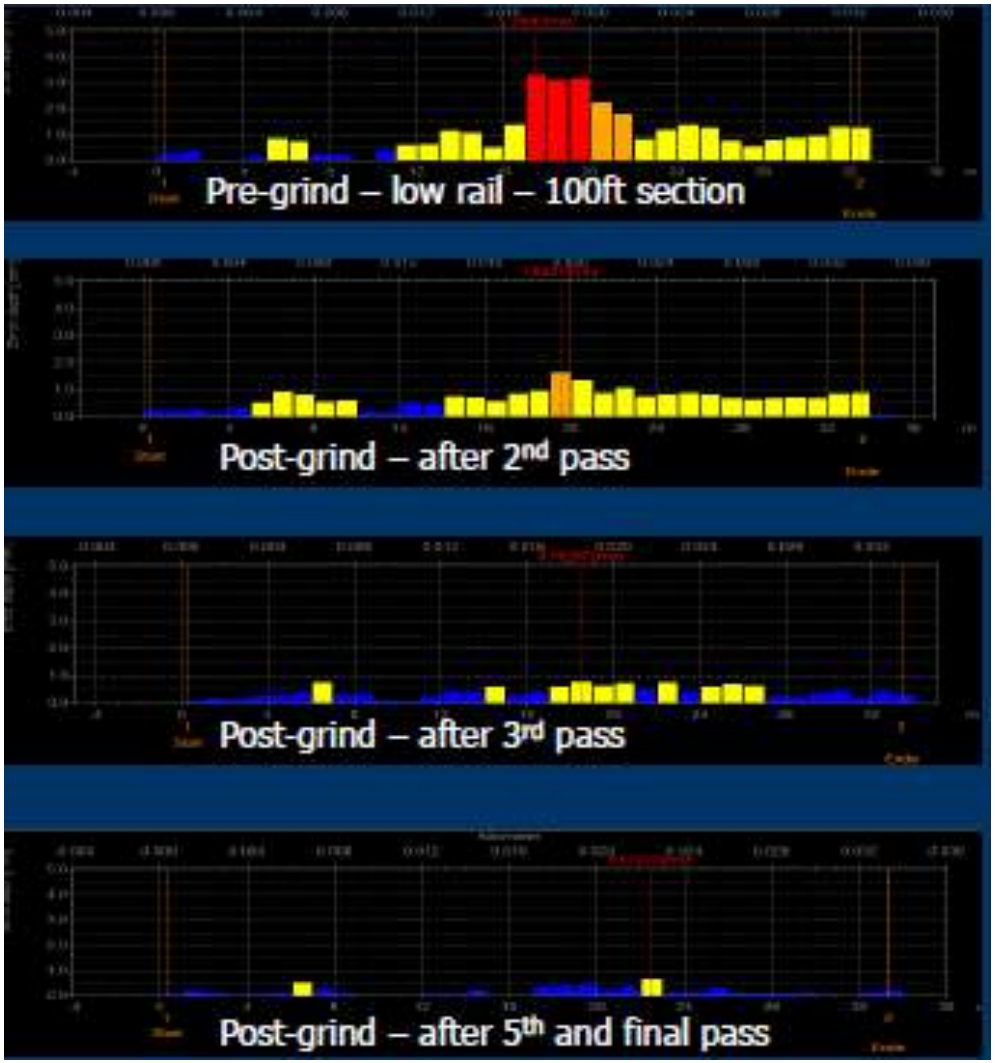
Draisine post-grind crack measurements

- After 5 grinding passes, results show a significant reduction in crack size (especially over the 2 bridges)
- Grinding marks do not appear to be a problem

Draisine measurements during grinding

We collected crack data over a 35-meter long section of low rail after each grinding pass. Results shown are pre-grind and post-grind after 2nd, 3rd and 5th passes.

- Crack size decreased with grinding, and this decrease was captured by the Draisine.



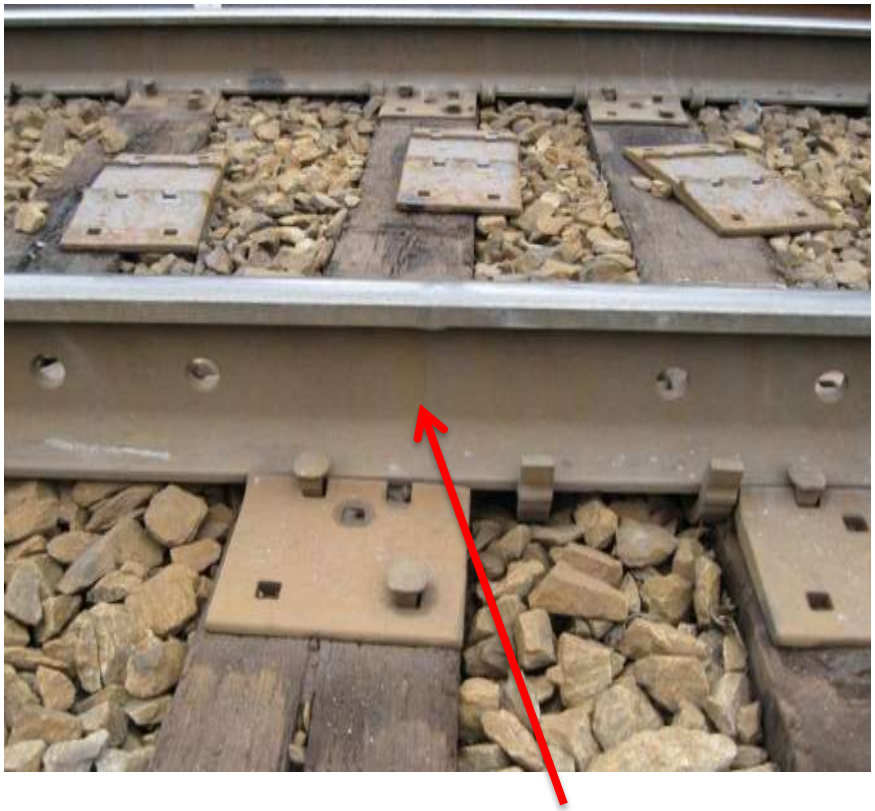
Phase 2 – Describe the measurements

- Determine what the Draisine is measuring – is it crack length, depth, or some combination?
- Quantify crack depth – that is what is needed for rail maintenance!

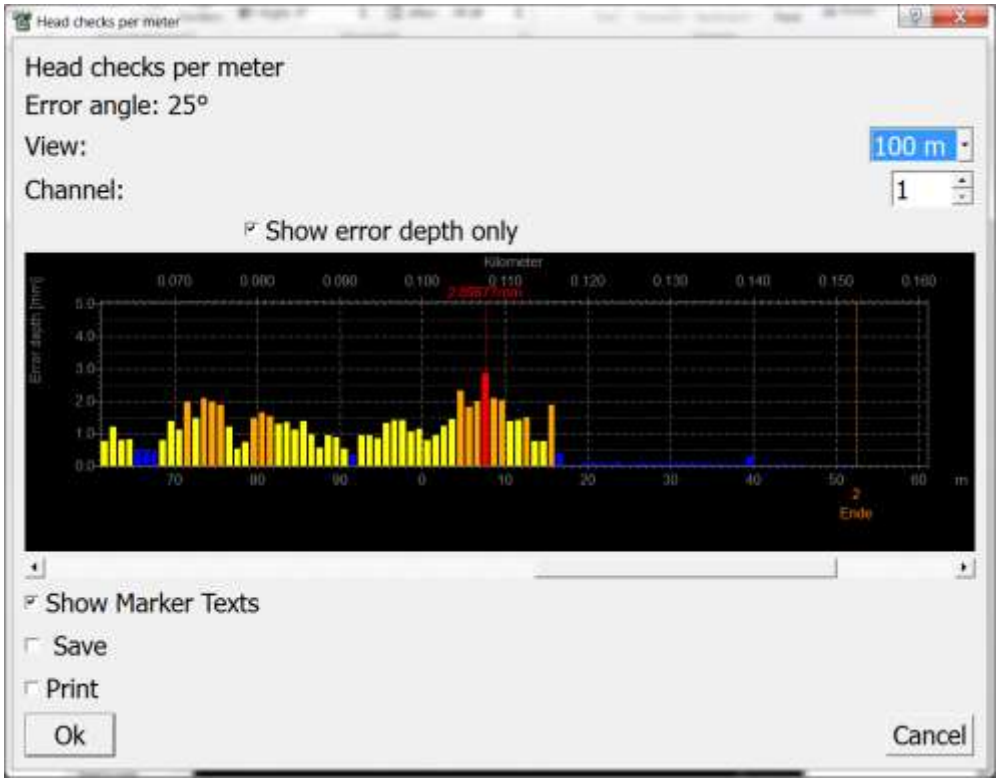
Crack verification, rail sample no.107

1. Collect crack measurement data (high rail of 2°curve)
2. Identify three one-foot samples that have RCF cracks rail)
3. Cut out the samples and perform a cross-section analysis

Crack verification, rail sample no.115

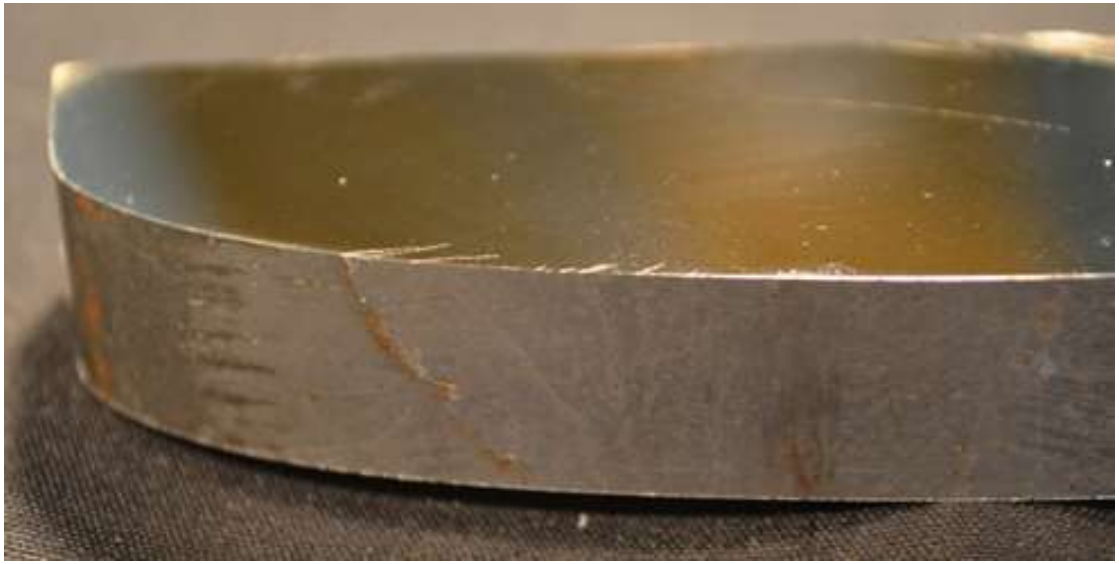


Flashbutt weld separating Steelton & Nippon rails

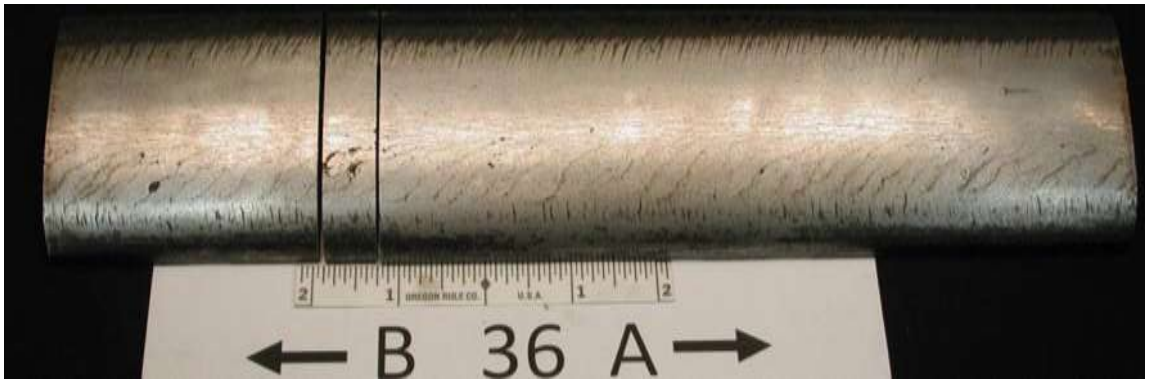


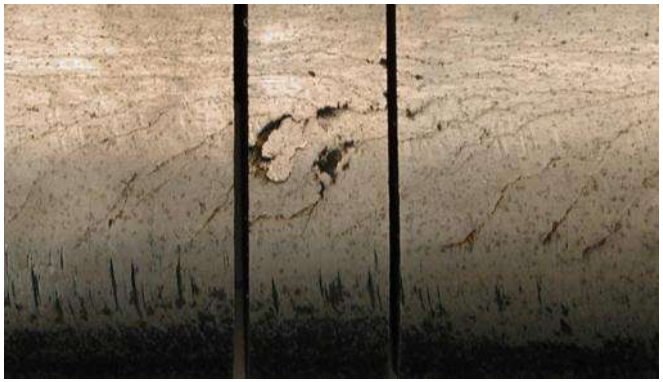
Steelton 1989 rail on left, Nippon 1990 rail on right

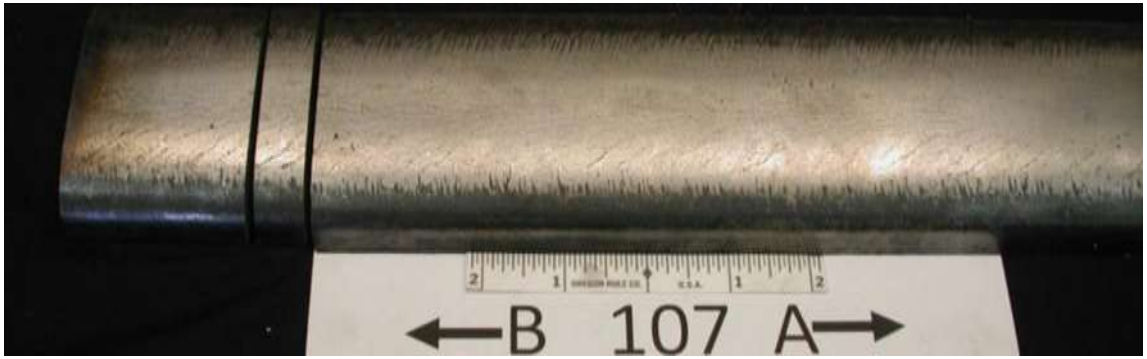
Cross-sections from two of the samples

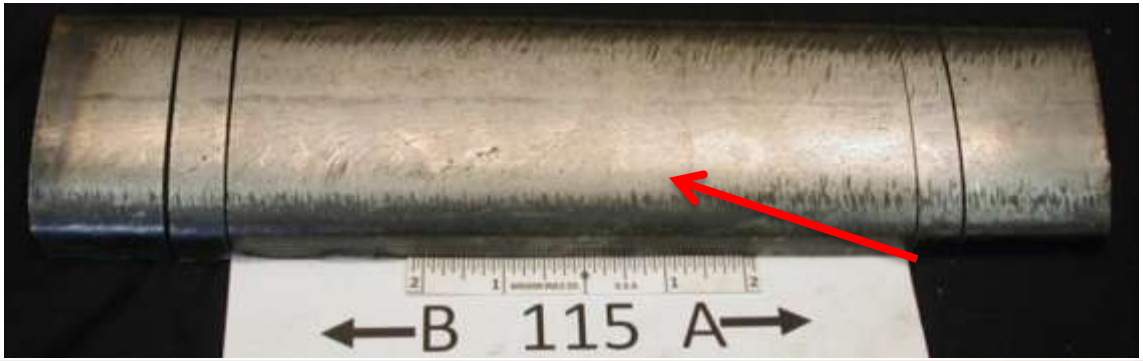


Rail sample sections nos. 36, 107 and 115

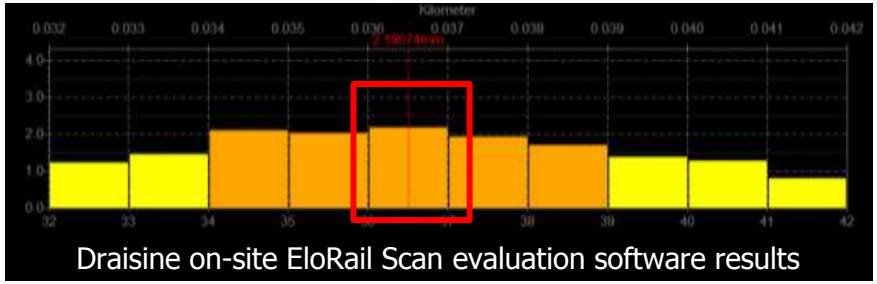






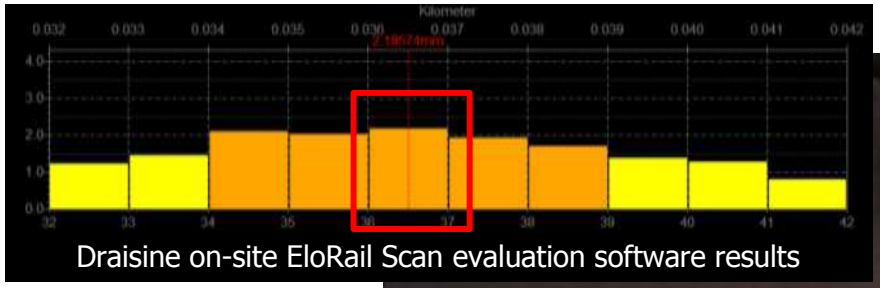


Section 36 = 2.1mm damage depth (Draisine)



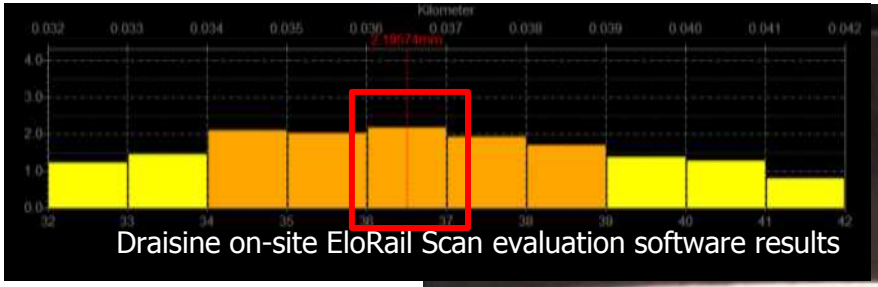
Draisine on-site EloRail Scan evaluation software results

Section 36 = 2.1mm damage depth (Draisine)



Draisine on-site EloRail Scan evaluation software results

Section 36 = 2.1mm damage depth (Draisine)
At 21°= 1.8mm damage depth (actual)



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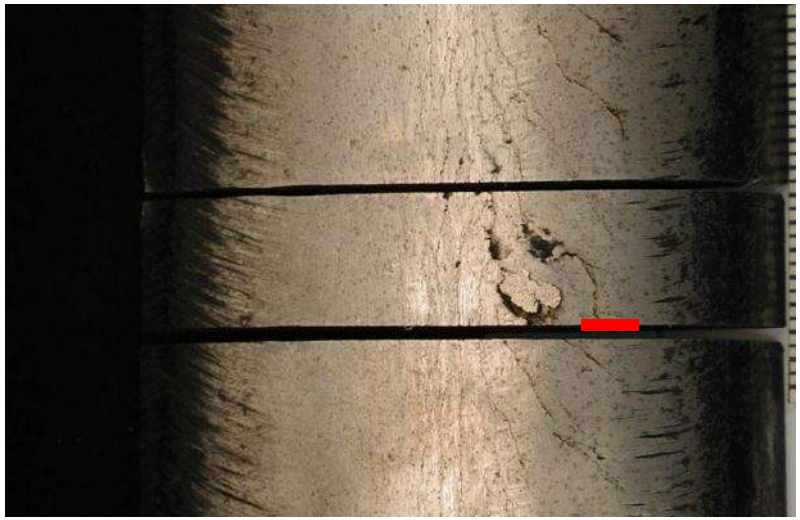
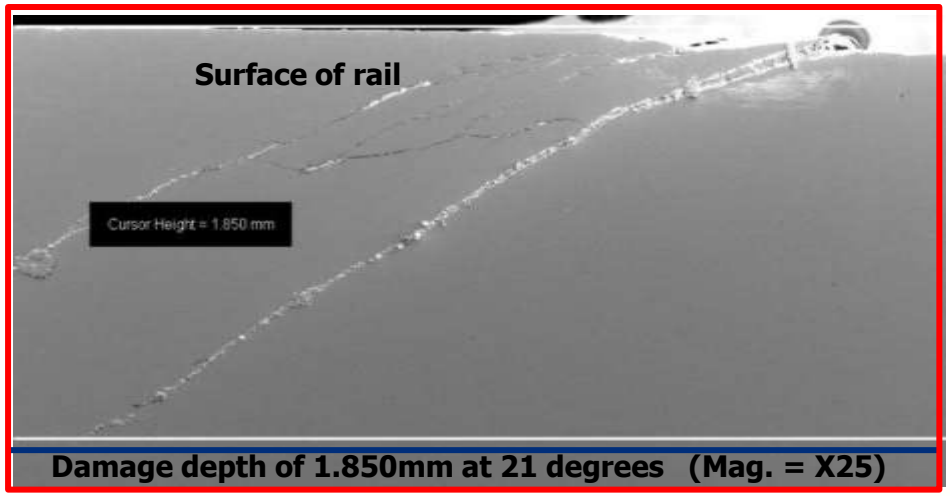
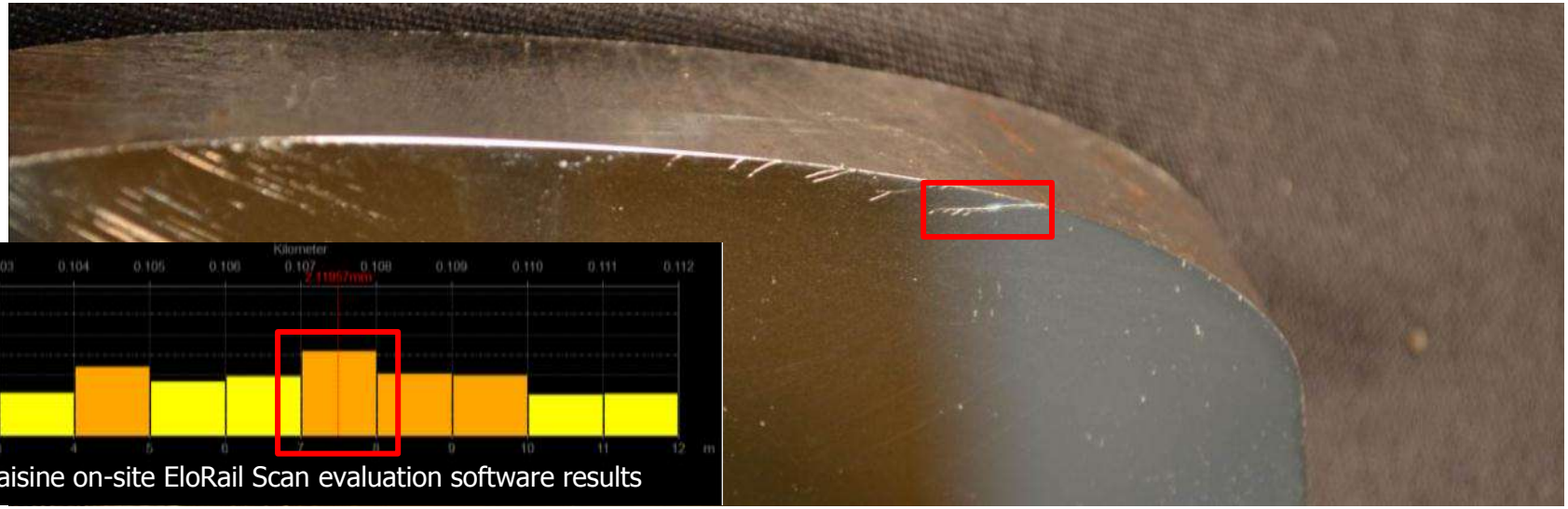


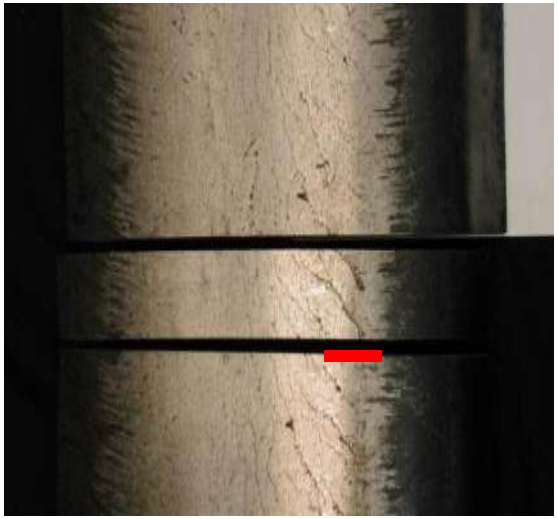


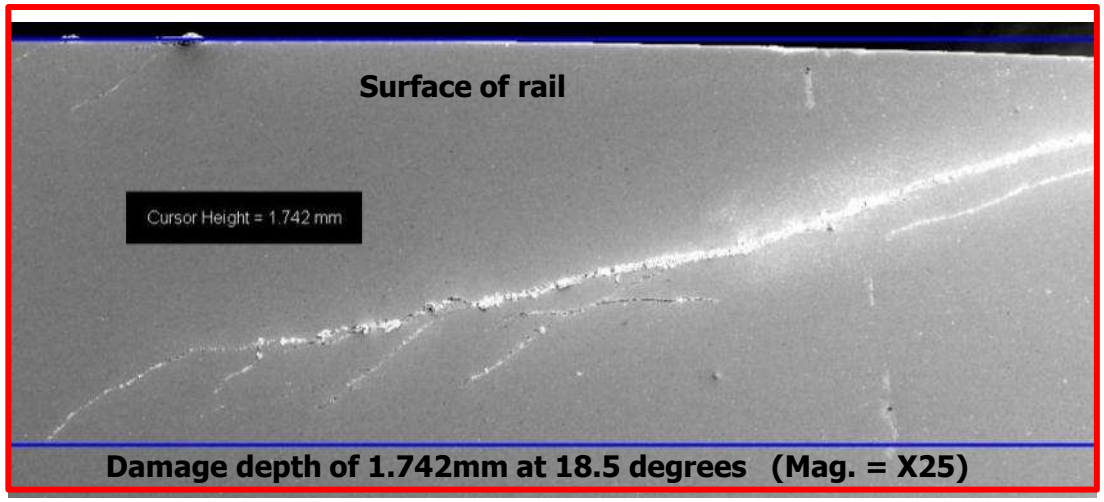
Damage depth of 1.850mm at 21 degrees (Mag. = X25)

Section 107 = 2.1mm damage depth (Draisine)
At 18°= 1.7mm damage depth (actual)



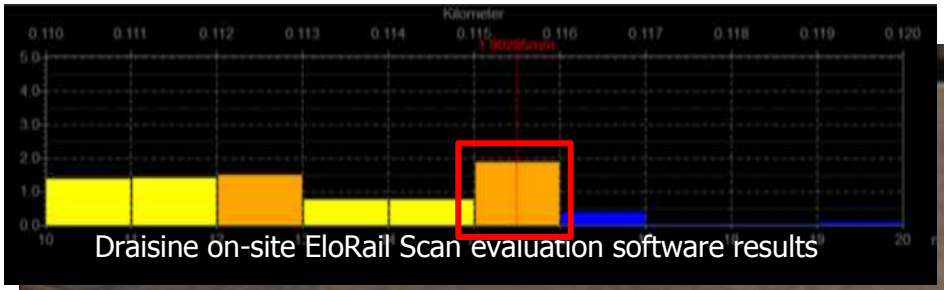
Draisine on-site EloRail Scan evaluation software results



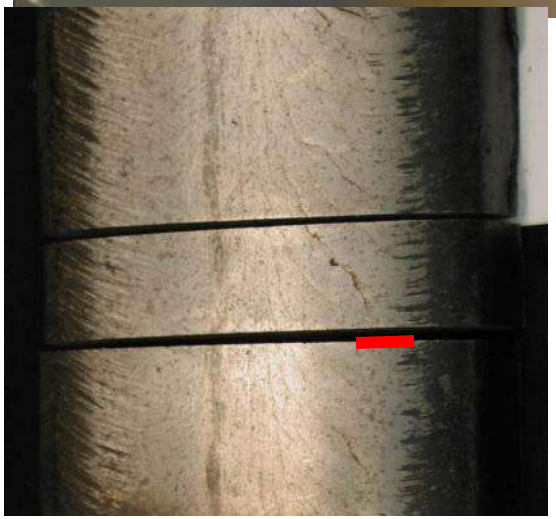


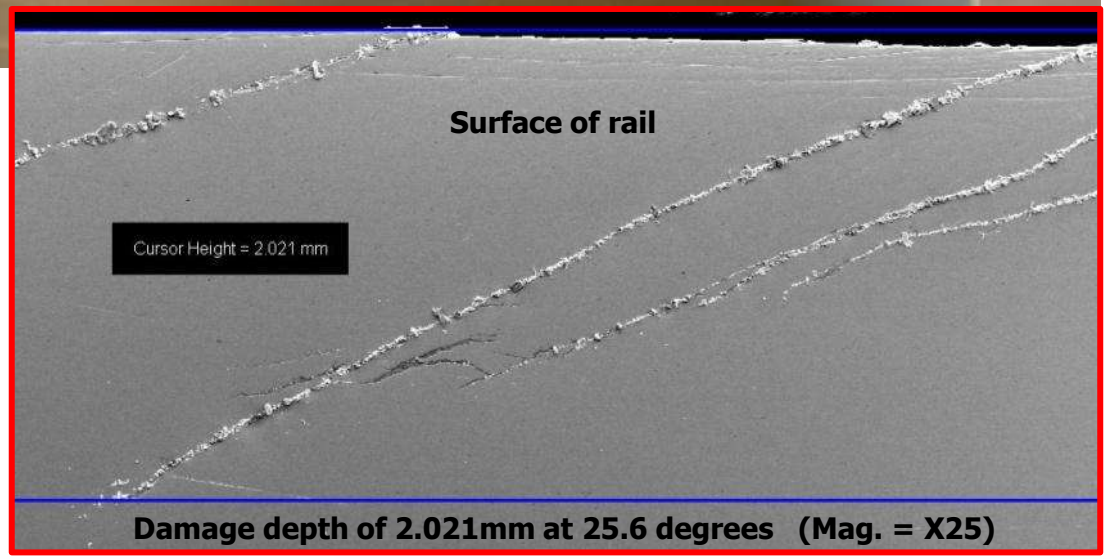
Damage depth of 1.742mm at 18.5 degrees (Mag. = X25)

Section 115 Steelton = 1.9mm damage depth (Draisine)
At 25°= 2.0mm damage depth (actual)



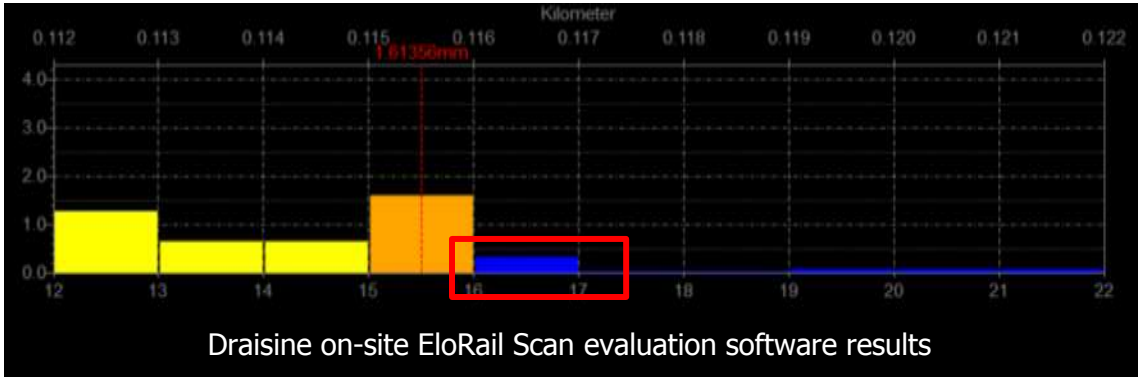
Draisine on-site EloRail Scan evaluation software results





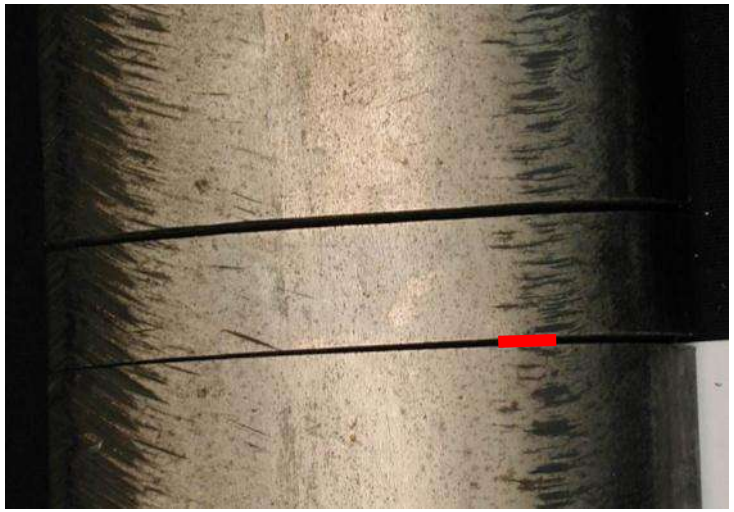
Damage depth of 2.021mm at 25.6 degrees (Mag. = X25)

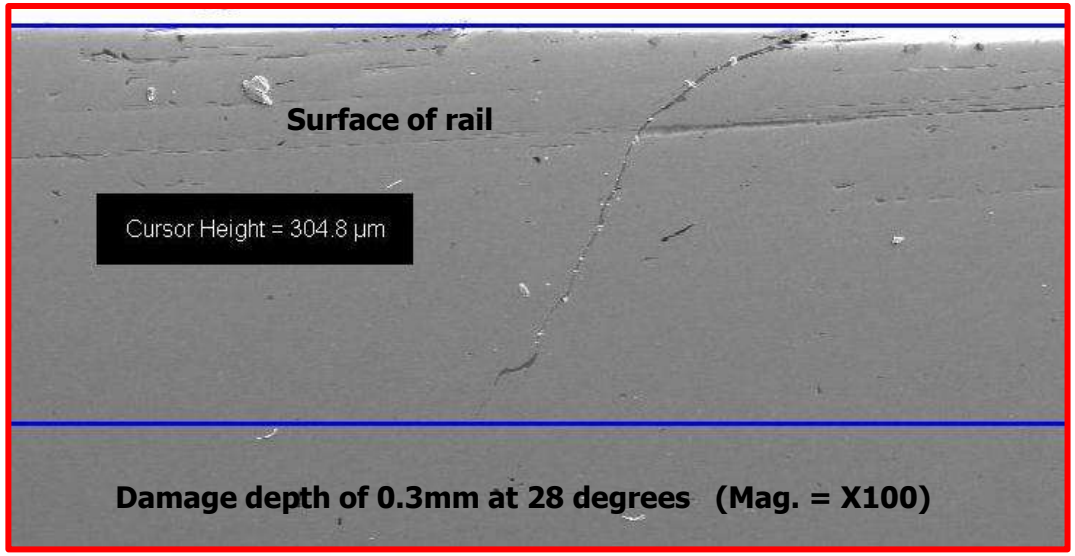
Section 115 Nippon = 0.4mm damage depth (Draisine)
At 28°= 0.3mm damage depth (actual)



Draisine on-site EloRail Scan evaluation software results

Cracks are not discernible on rail head

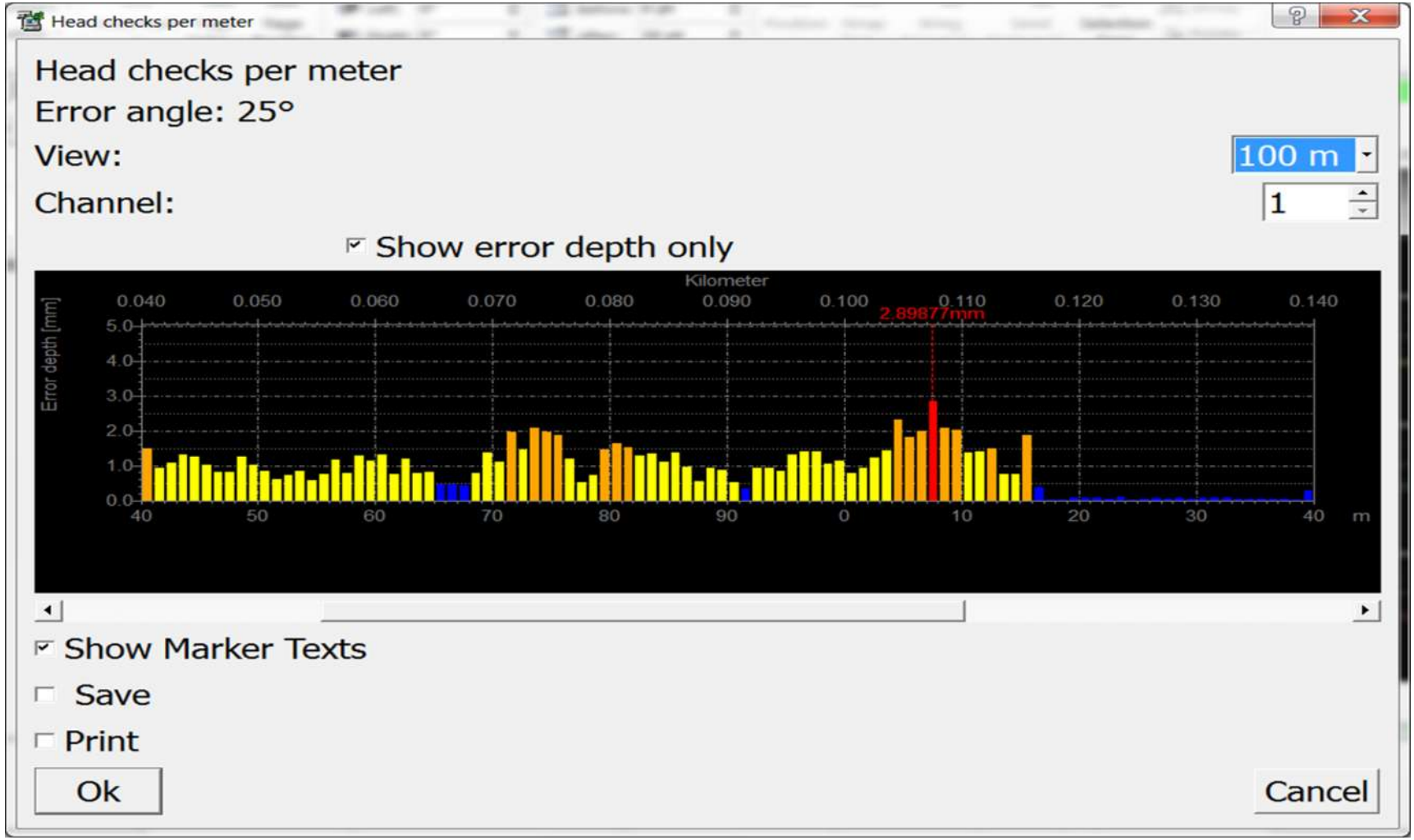




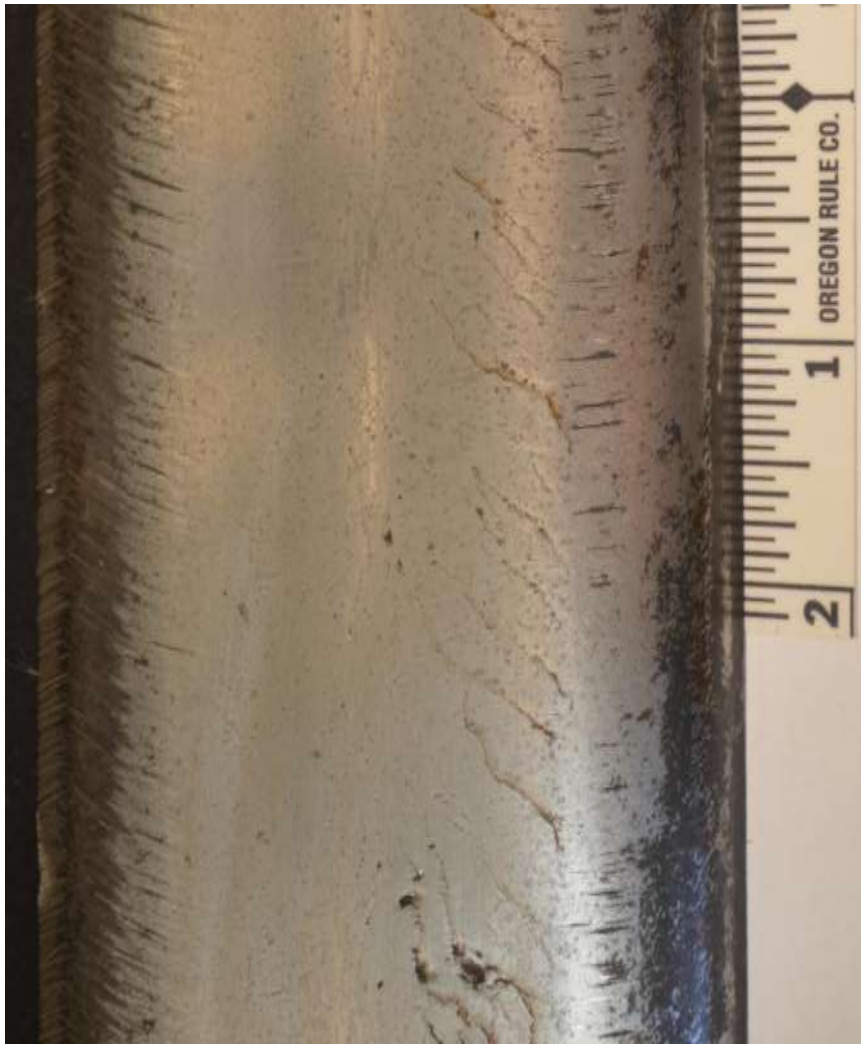
Damage depth of 0.3mm at 28 degrees (Mag. = X100)

Steelton to Nippon raw data

Steelton to Nippon processed data

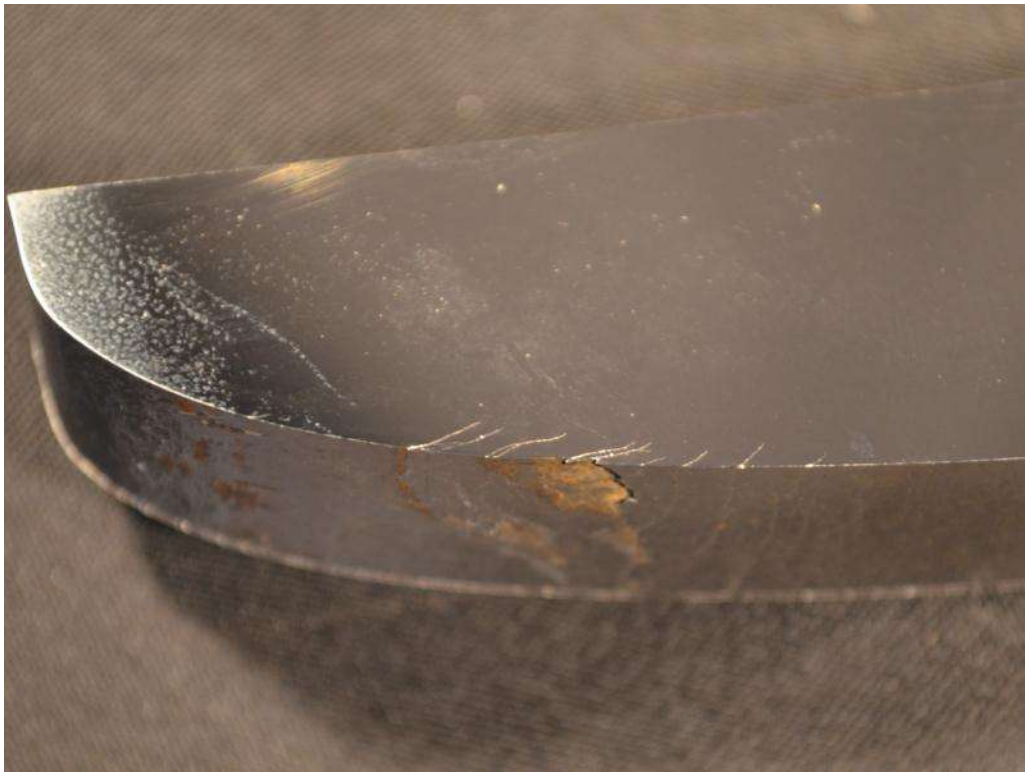


Crack orientation - high vs. low rails

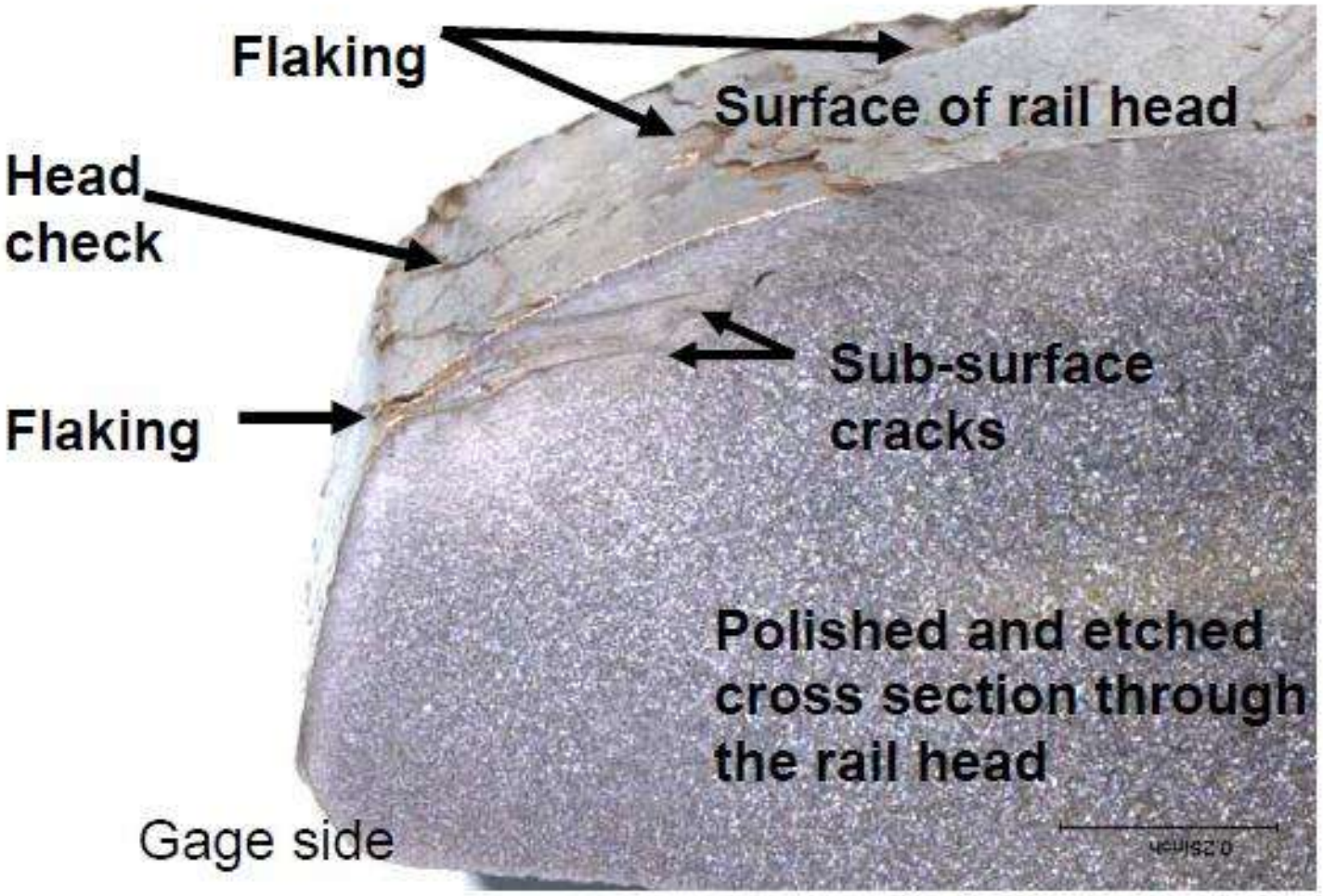


Getting the most out of this technology

- What is the crack growth rate?
- Is it worth removing cracks?
- Will crack removal extend rail life?



Questions?


Flaking
Surface of rail head
Head check
Sub-surface cracks
Flaking
Polished and etched cross section through the rail head
Gage side