Rail Maintenance

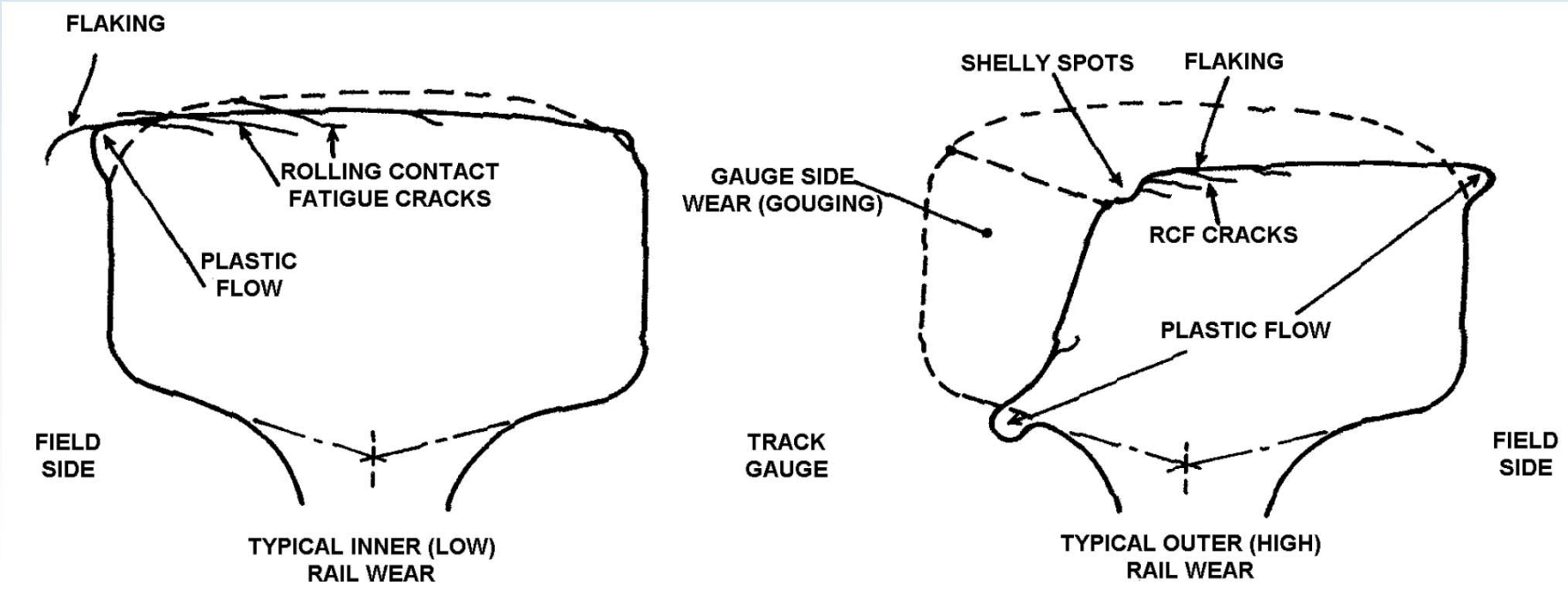
by

Gordon Bachinsky

Why we do Rail Maintenance

- Safety
- Economy
- Avoid Impacts of
  - Unscheduled Repairs
  - Squeal and corrugation noise
  - Ride quality

If Mother Nature is your Track Maintenance Engineer



Pro-Actively Manage Rail Maintenance to

- Reduce rail wear section loss
- Control gauge face wear
- Control rolling contact fatigue (RCF)
- Reduce formation of defects and fractures

Subjects Today

- **Internal Defects (UT)**
- **Surface Conditions (RCF)**
- **Maintenance Techniques**

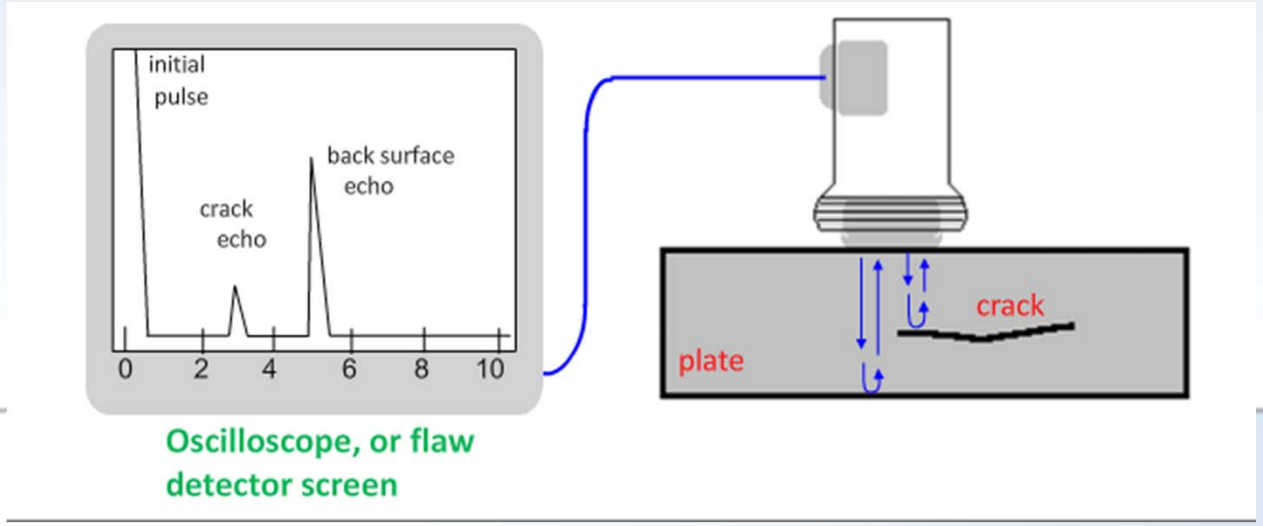
Broken Rail from Transverse Defects

Defect Detection

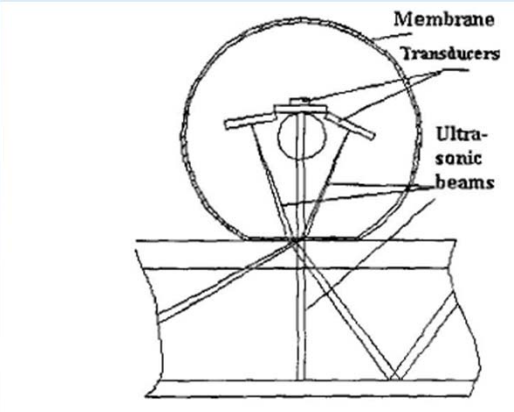
- Ultrasonic probes: reflections from cracks
- Mature technology
- A defect found by ultrasound must be cut out: safety mandate (FRA compliance)
- There are limits

Ultrasonic Inspection (Pulse-Echo)

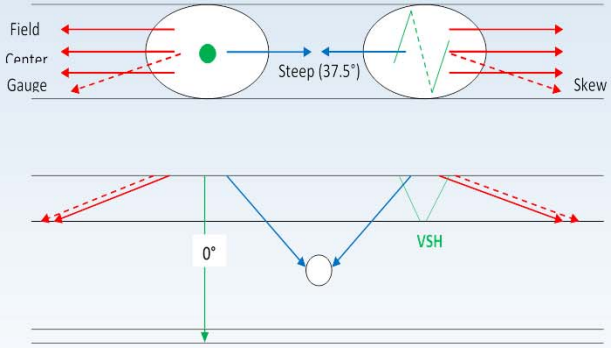
- High frequency sound waves are introduced into a material and they are reflected back from surface or flaw
- Reflected sound energy is displayed versus time, and inspector can visualize a cross section of the specimen showing the depth of features that reflect sound



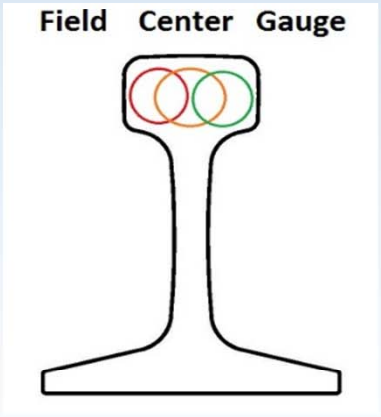
Current Equipment:
Multiple Ultrasonic Sensors to Increase Overall Rail Section Detection Capability



Typical wheel probe arrangement



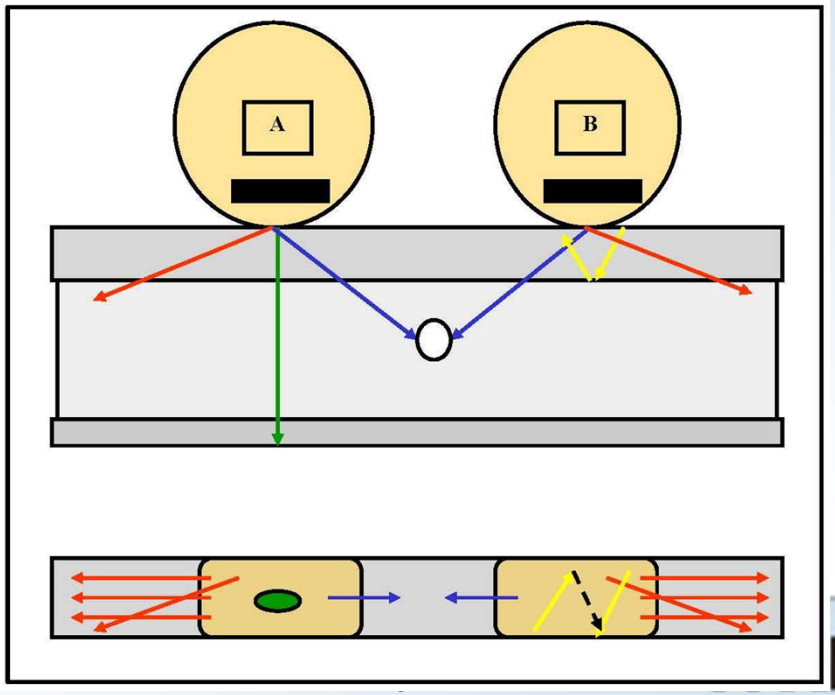
Probe angles for rail testing



70 degree inspection within the rail head

Testing Parameters (Herzog)

- Optimal testing speed is track dependent
- Current maximum speed is 29 mph (47 km/hr)
- Roller Search Unit (RSU)
  - (6) Straight 70°
  - (2) Skew 70°
  - (2) 37.5°
  - Pitch Catch Zero
  - VSH



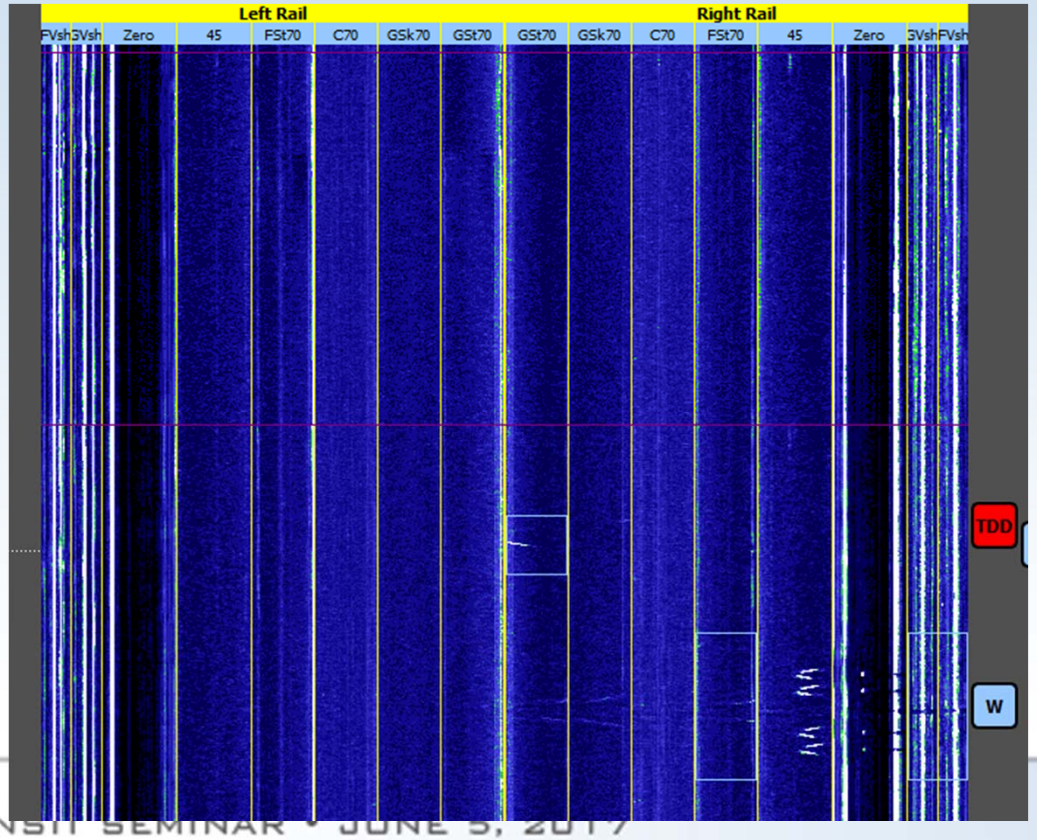
Defects and Fractures

- Small transverse defects (head of the rail)
  - Stress related
  - Defective welds
- Longitudinal defects
  - Web defects
  - Head defects
- Software driven operator alerts
  - Mandatory responses
  - Icons denote decision

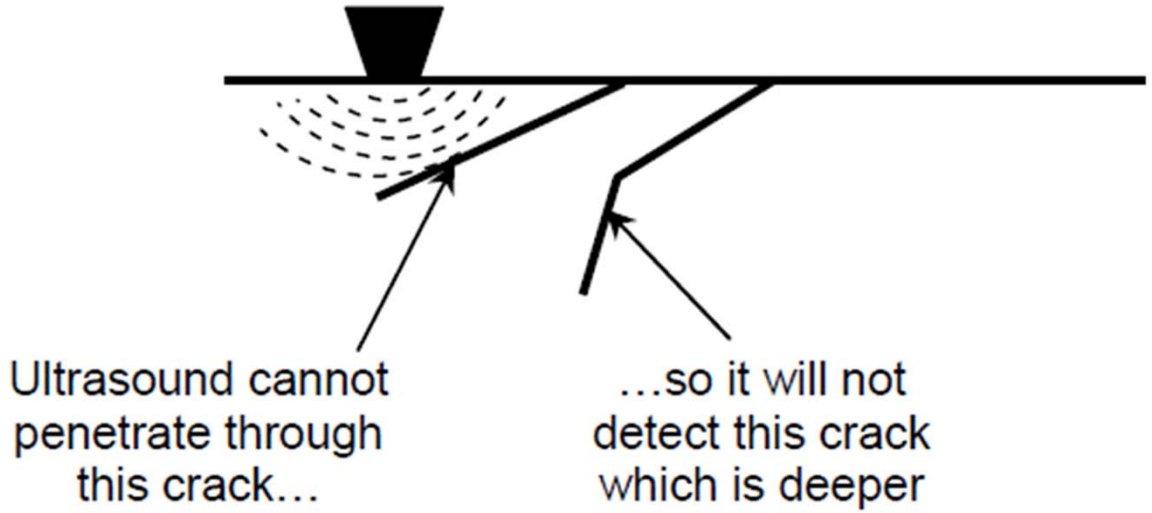
Challenges

- **Environmental factors**
  - **snow, wind, dirt and other surface contaminates**
  - **Testing temperatures as low as -30F***

Phased Array NDE for Railroads



Shadowing of Ultrasonic Sound by RCF Crack (Head Checks, Squats..)



Ultrasonic Flaw Detection Systems Detect Reflectors Not Defects

Rolling Contact Fatigue (RCF) Crack is One of the Reflectors

(UT cannot detect cracks below the RCF)

Subjects Today

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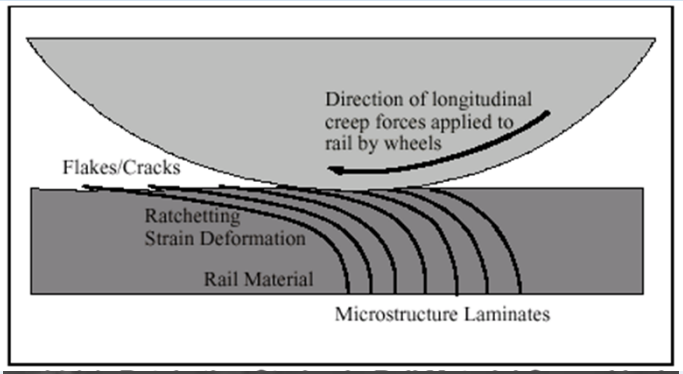
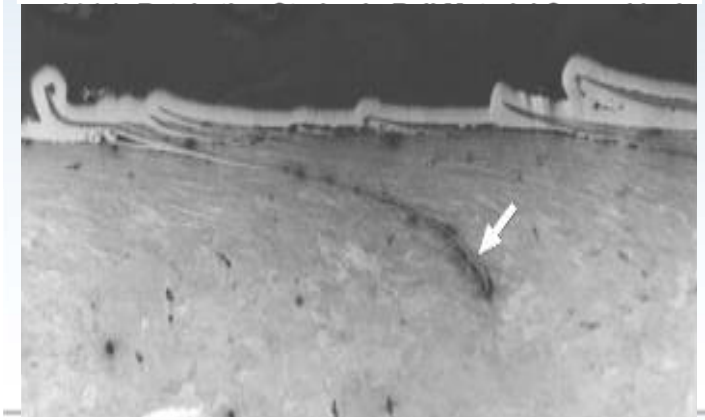
- **Surface Conditions (RCF)**
- Maintenance Techniques

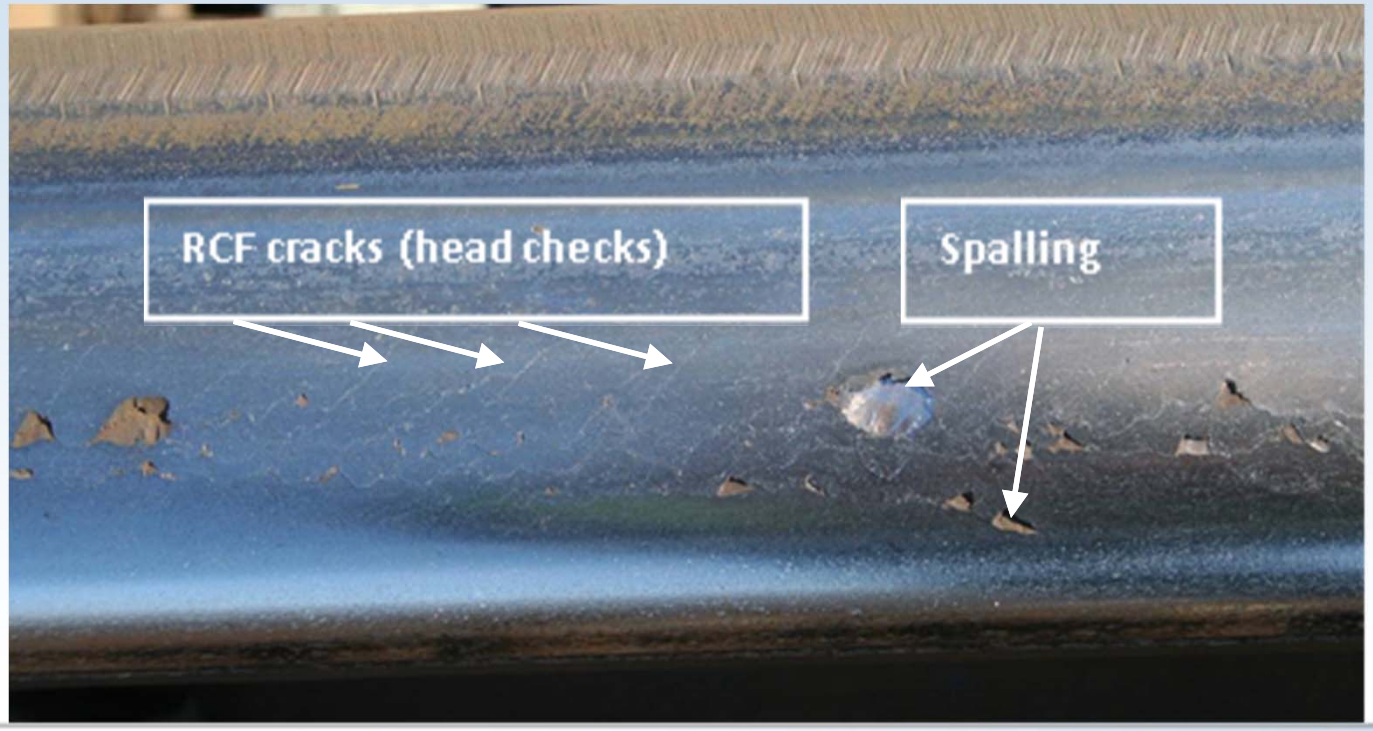
How do RCF Cracks Form



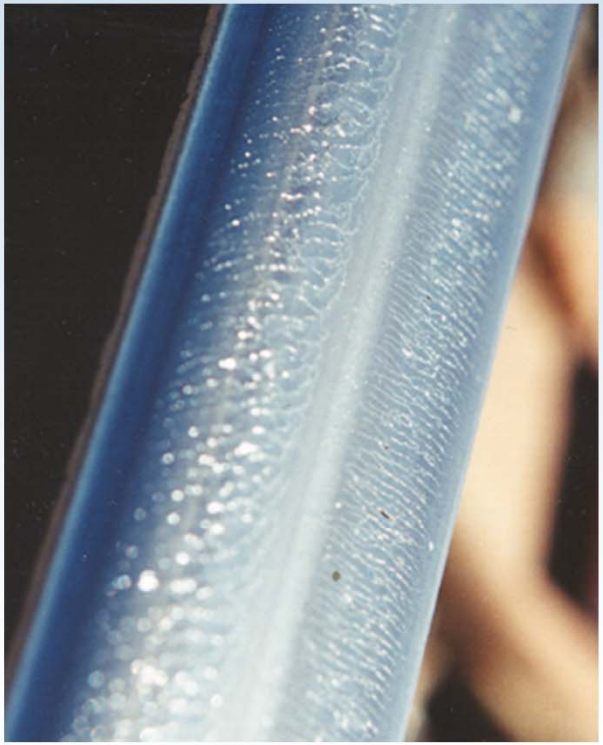


- **33 MGT = 1 million wheels passes on heavy haul track**
- **A certain fraction of wheels plastically deform the rail in the direction of applied tractions (due to ΔR and AoA).**
- **Each loading cycle "ratchets" the surface layer until the ductility of the steel is exhausted**
- **Eventually a crack is generated (usually within 1 to 5 MGT)**

Rolling Contact Fatigue (RCF) cracks

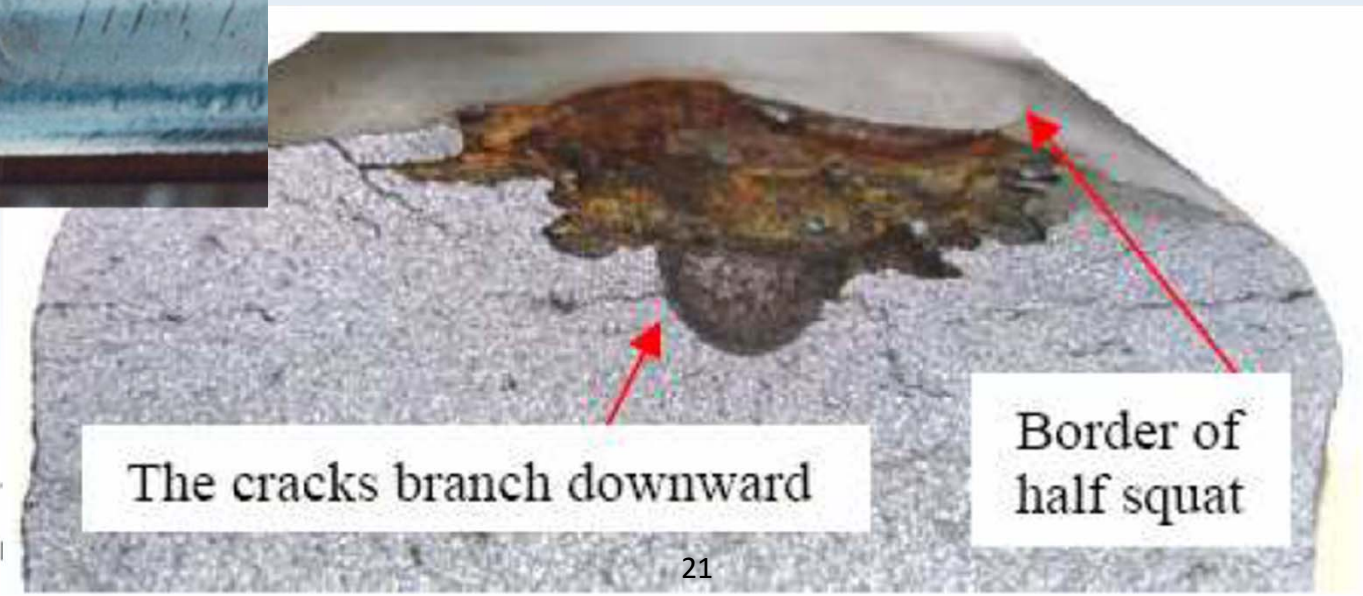


RCF Cracks on Heavy Haul Rails

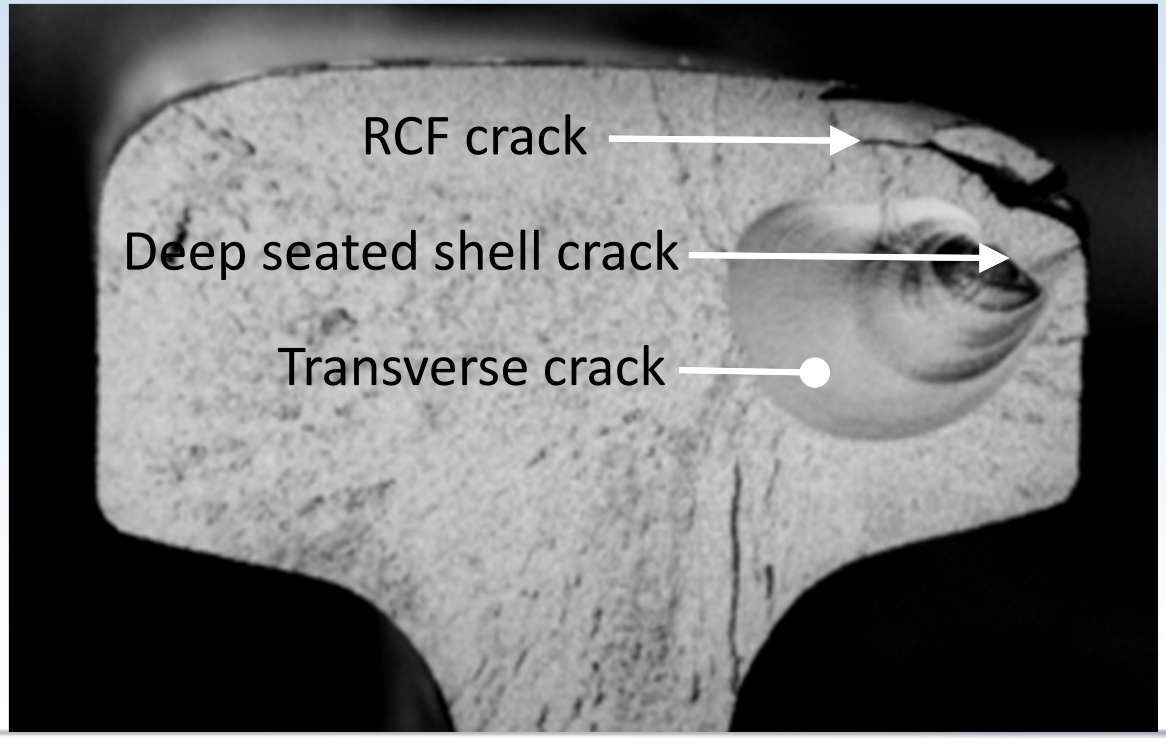



RCF Cracks on Mass Transit

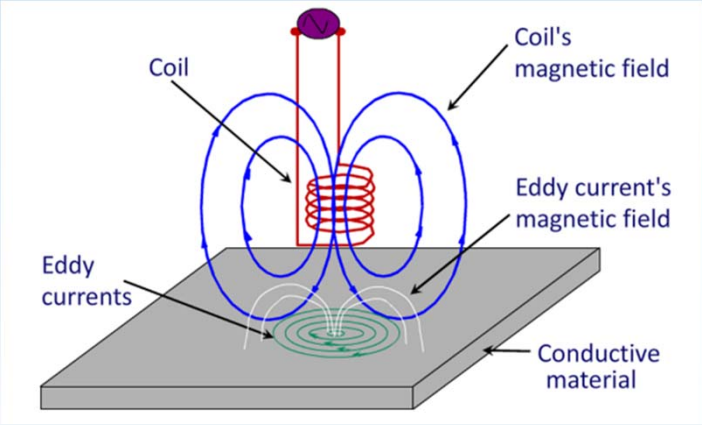
Squat – RCF Defect



RCF and Deep Seated Shell Cracks Shield Transverse Cracks from UT Waves



The Basis for Eddy Current Inspection

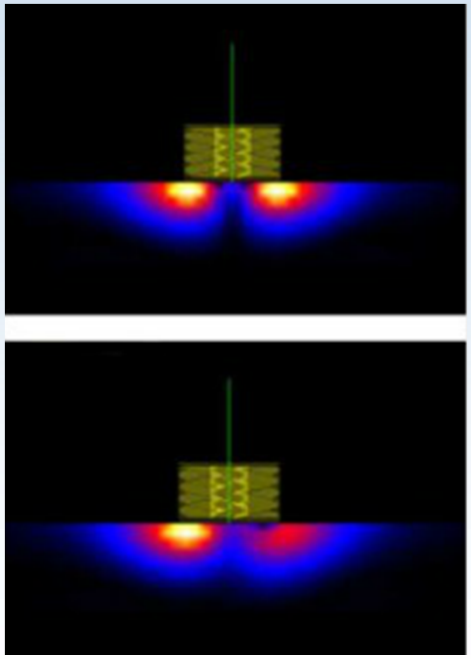


- The test probe is a coil of wire through which alternating current is passed.
- When the probe is close to a conductive material, the probe changing magnetic field generates current flow in the material.
- The eddy currents produce their own magnetic fields that interact with the primary magnetic field of the coil.
- By measuring changes in the resistance and inductive reactance of the coil, information can be gathered about the test material

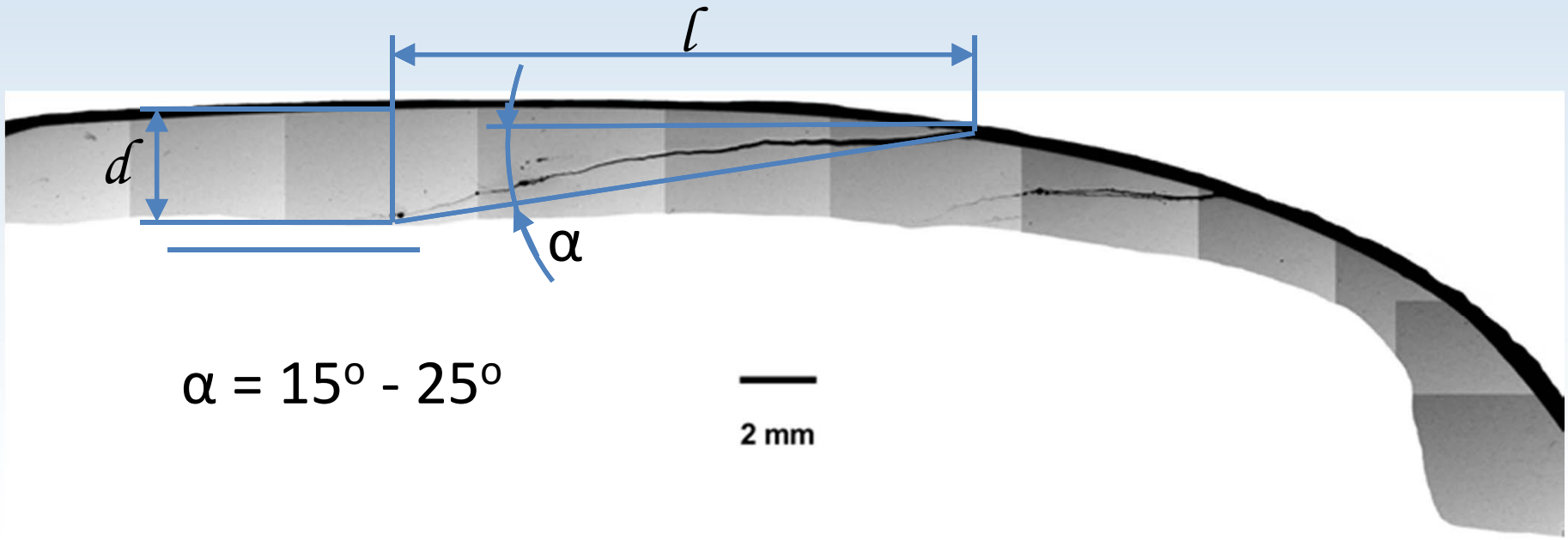
Eddy Current Detect Surface Breaking Cracks

Surface crack detection by sliding probes is used in many industries including railroads, commercial aircraft…

But new to rail industry !!!!!

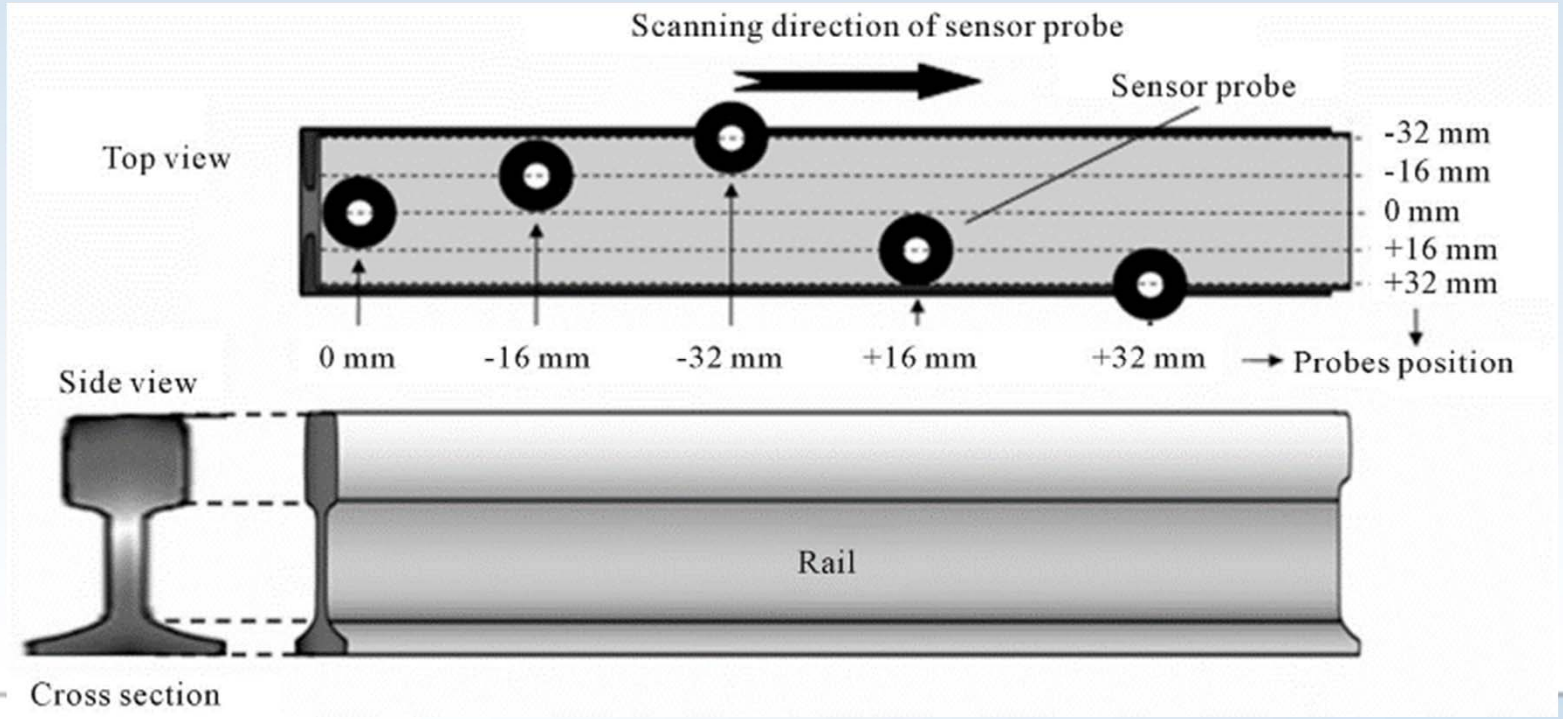


Depth of a Crack is Estimated from Crack Inclination



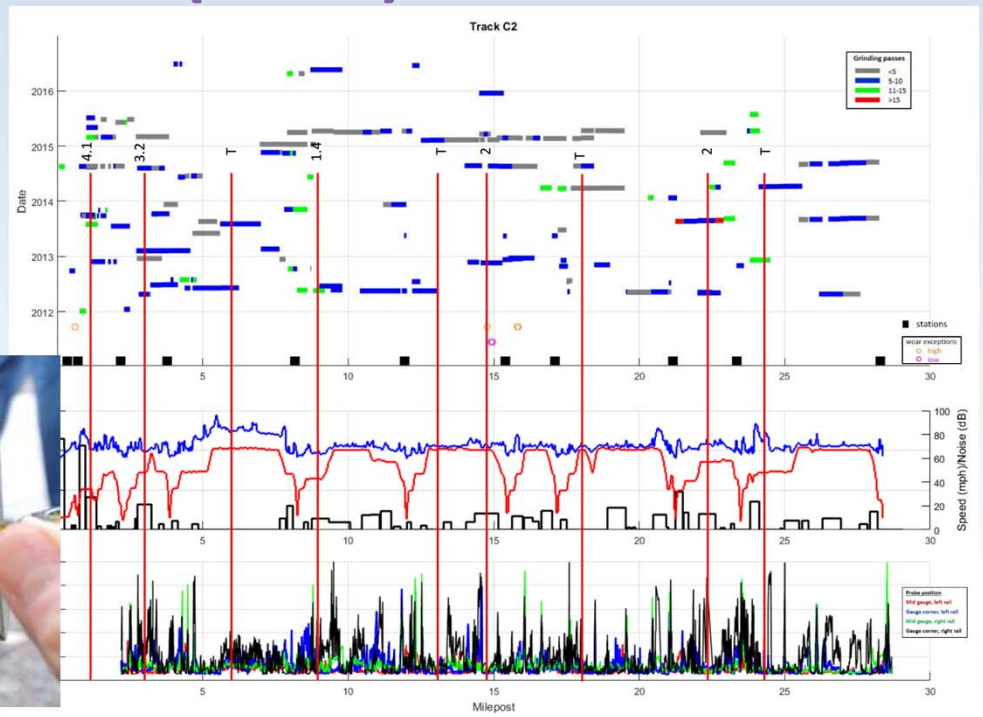
$\alpha = 15^{o} - 25^{o}$

Multiple Eddy Current (ED) Probes are Needed to Cover the Rail Crown

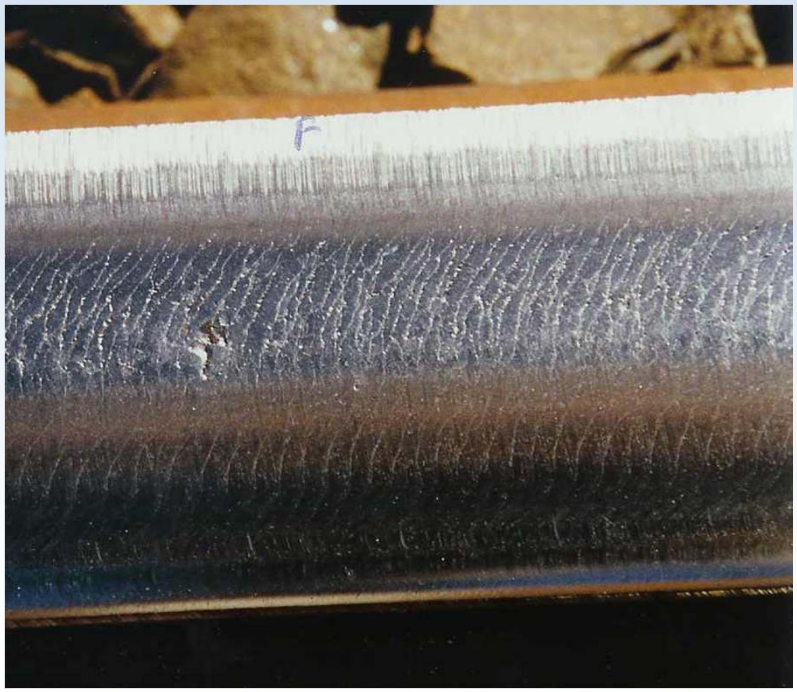


ED Probe Array Used by DB

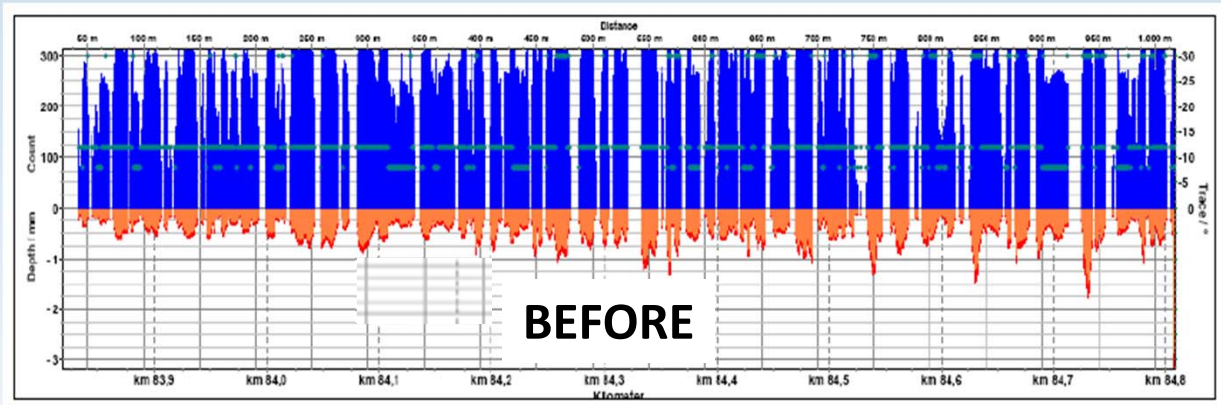
ED Inspection Vehicle Probe Array and Data Plot (ARM)

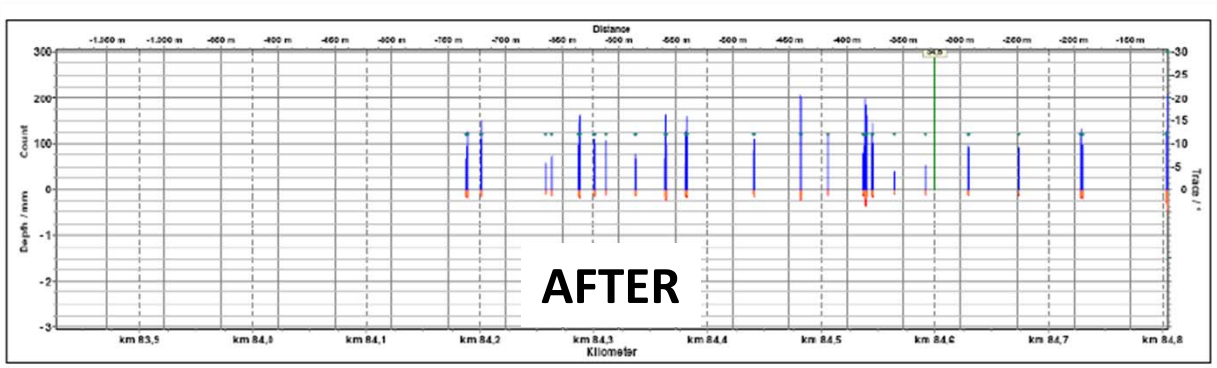


Eddy Current Data Indicate Location of RCF Cracks Across the Railhead



Eddy Current Signal Before and After Grinding





Blue:
RCF cracks/meter

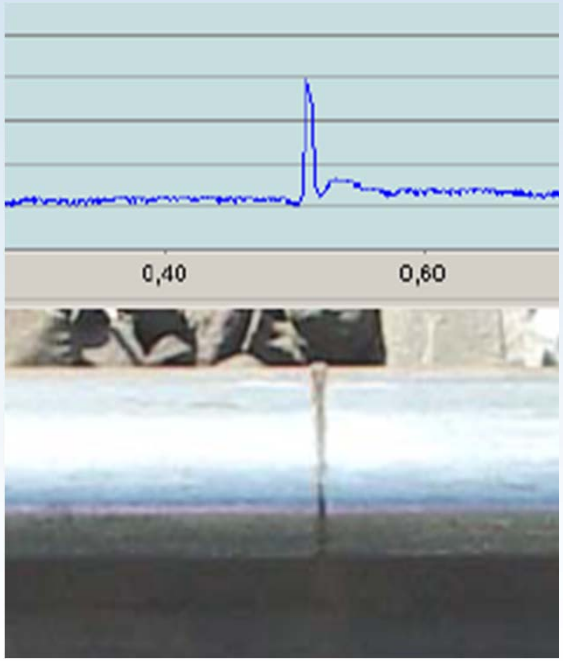
Orange:
depth of RCF cracks

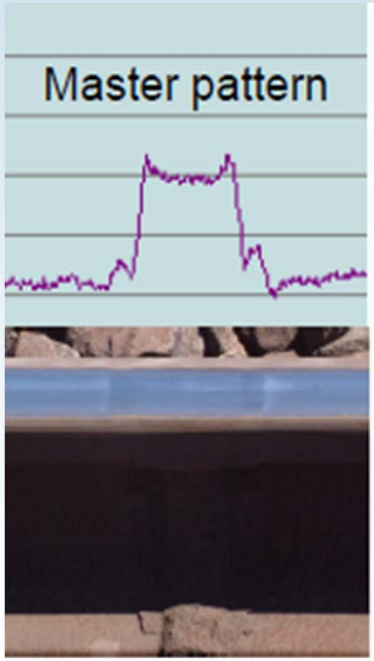
Turquoise:
sensor position
at deepest crack
across the rail head

Eddy Current Data aid the Selection of Grinding Patterns to Facilitate;

- Depth of crack removal
- Identification of high stress location across the ball of the rail
- Guides grinding effort
- Reduction of RCF crack formation

Other Eddy Current Signals; Rail Joints and Thermal Welds





Capability of Eddy Current Sensors in Detecting Various Surface Defects

Category	Detectabiity	Statement
Rolling Contact Fatigue	Very good	Quantity, location, period
Wheel burns	Very good	Location, extent
Indentures	Very good	Quantity, location, period
Grinding marks	Very good	Quantity, location, period
Rail joints	Very good	Location, kind
Squats	Good	Quantity, location
Short/long pitch corrugations	Good	Location, pitch
Welds	Good	Location, kind, lack of fusion

Eddy Current Supplements Ultrasonic Detection

- Initiation and formation of defects can have many causes ranging from surface RCF cracks to internal flaws and external damage of rail section
- Ultrasound echo is preferred detection technique to find defects in rail

Subjects Today

- Internal Defects (UTS)
- Surface Conditions (RCF)
- **Maintenance Techniques**

Example of Economic Choice: RCF Damaged Rail that was Never Ground = Waste of Money

NO WEAR !!!

RCF in the head obstructs UT detection

Rail Maintenance Strategies

- Using high hardness high cleanliness rail steels
- Gauge Face and Top of the rail friction management
- Grinding to recommended rail profiles (gauge corner relief, optimized high rail, low rail, and tangent track rail profiles)
- Grinding on preventive cycle (chase the Magic Wear Rate)

Make Your Grinding Count – Grind Preventively

- Preventive grinding is about cycles. At how many MGT's and at what speed (depth of cut) we should grind?
- Monitor RCF with Eddy Current probes to confirm if Magic Wear Rate is maintained and sustained
- Utilize Eddy Current data to decide about grinding interval, grinding speed, repeat passes (if any) and choice of rail grinding pattern

Eddy Current and Ultrasound Testing Synergy

- Untreated RCF cracks inhibit Ultrasound detection of defects
- Eddy Current monitoring enables economic management of RCF cracks
- Combining Ultrasound and Eddy Current testing improves safety and economy of rail operations

Moving Forward

- It's never too early to start preventive maintenance that includes Eddy Current monitoring
- Eddy Current monitoring greatly enhances planning of preventive grinding cycles and reliability of Ultrasonic detection technology

Questions ?