Chasing the Magic Wear Rate

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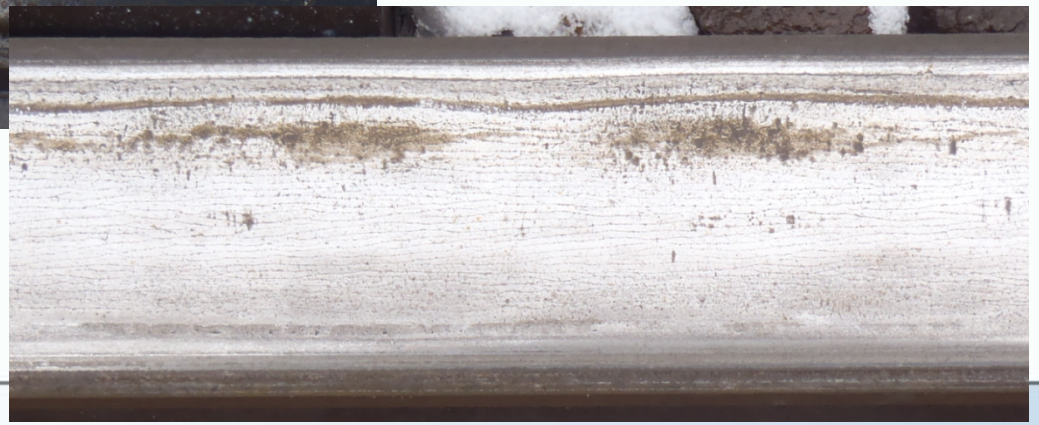
Outline

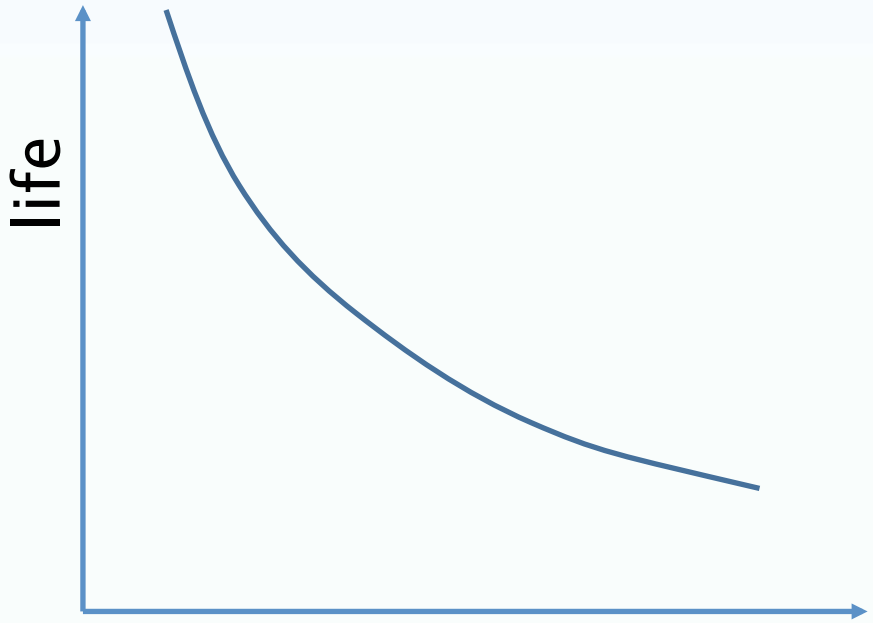
- Magic Wear Rate
  - Description
  - Definition
- Chasing
- Conclusions

Consequences of insufficient "wear"

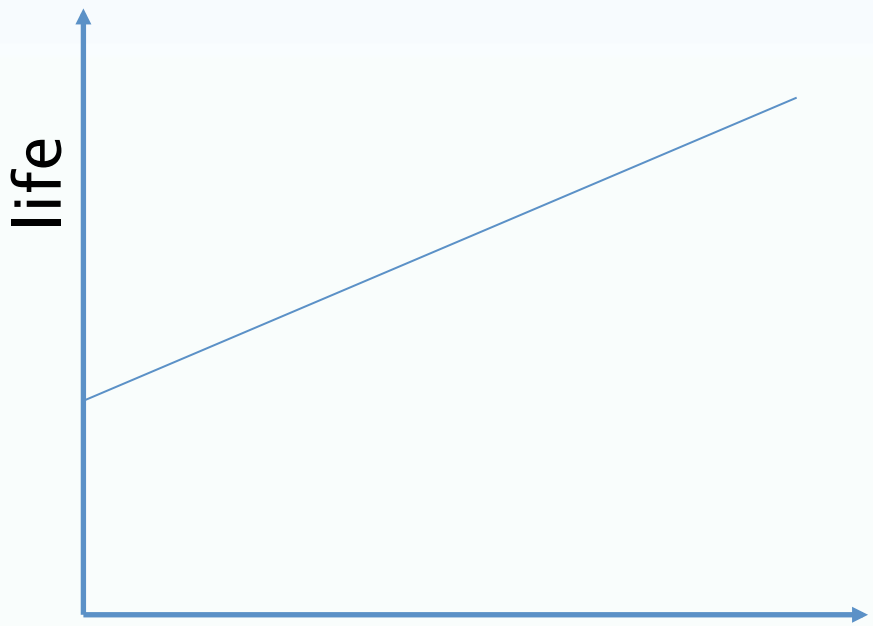


Description

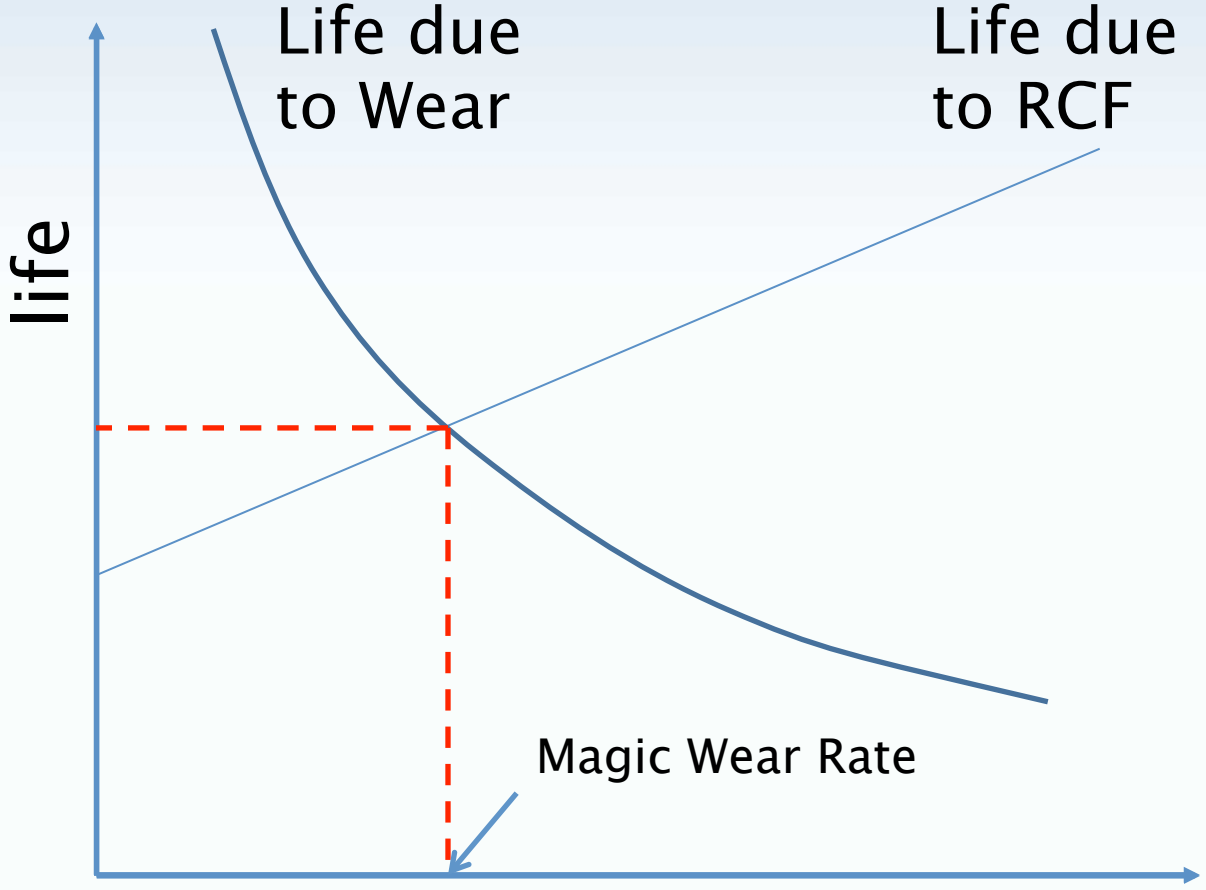
Life due to Wear



Life due to RCF



Description



Definition

Magic Wear Rate *is the* ***rate of wear*** *at which any rolling contact fatigue* ***cracks*** *that are in* ***initial stages*** *of development* ***are removed*** *either by natural or combination of natural and artificial wear*.

Magic ⇔optimal

- surface fatigue is safely controlled → eliminated
- component life is long, predictable and well managed

Wear Rate

- Natural Wear
  - TOR: Abrasion, delamination, oxidation
  - GF: adhesive, gouging wear
- Artificial Wear
  - rail grinding, milli
  - wheel retruing
  - abrasive brakeshoe

Wheels and Rails

- Wheels
  - 250,000 km
  - 70M revolutions
  - 5–12 mm from tread
  - 6 to 14 Mcycles / mm
- Rails
  - 50 MGT
  - 2.5 M wheel passes
  - 0.1–0.6 mm grinding
  - 4 to 25 Mcycles / mm

How do we chase the MWR?

1. Preventive rail grinding
2. Predictive Preventive Grinding

   based on analysis of past grinding history
3. System design

   brakeshoes

   improved rail steels

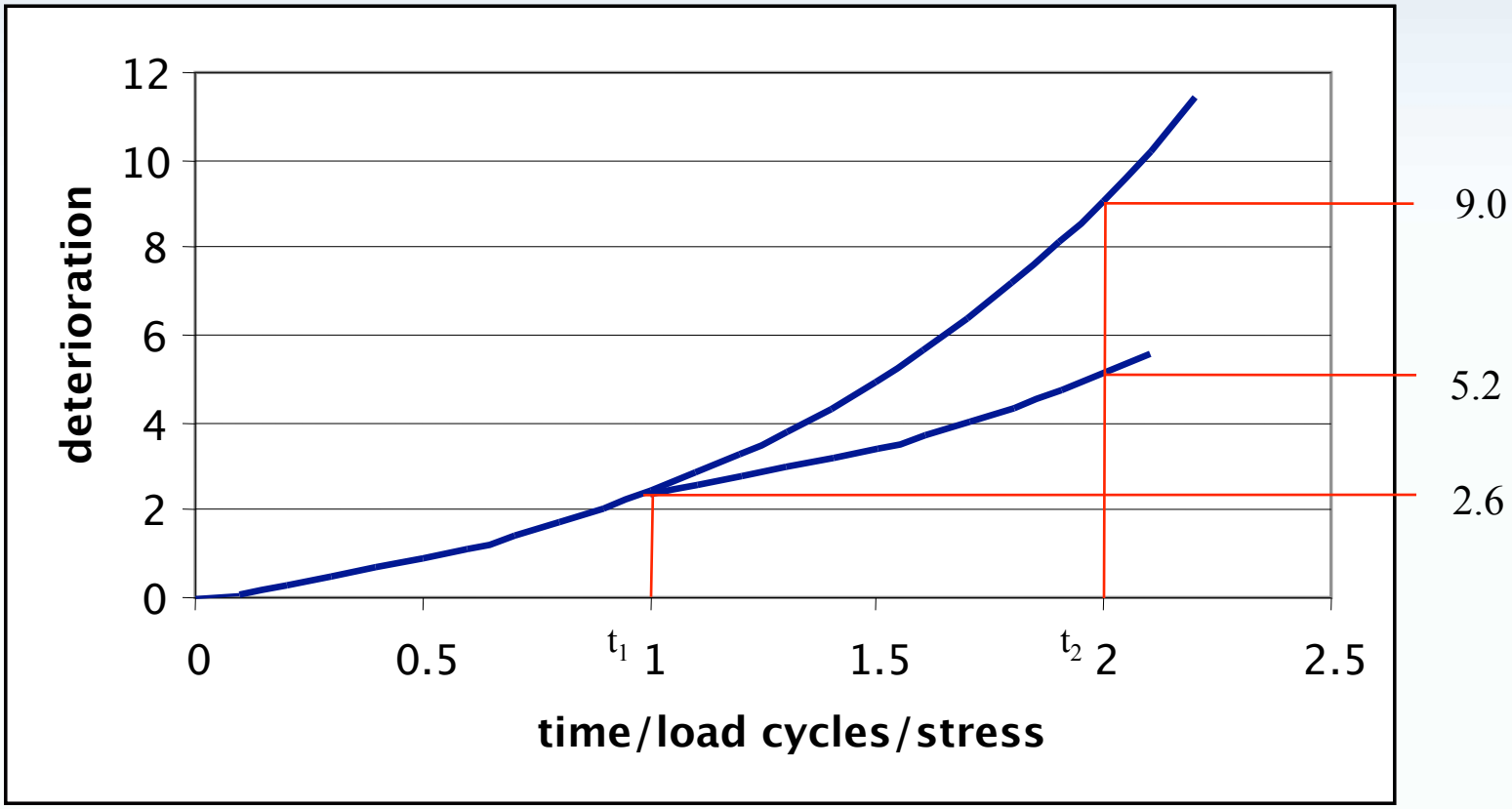
   friction management
4. Measurement of surface damage
5. Modelling

   e.g. WLRM

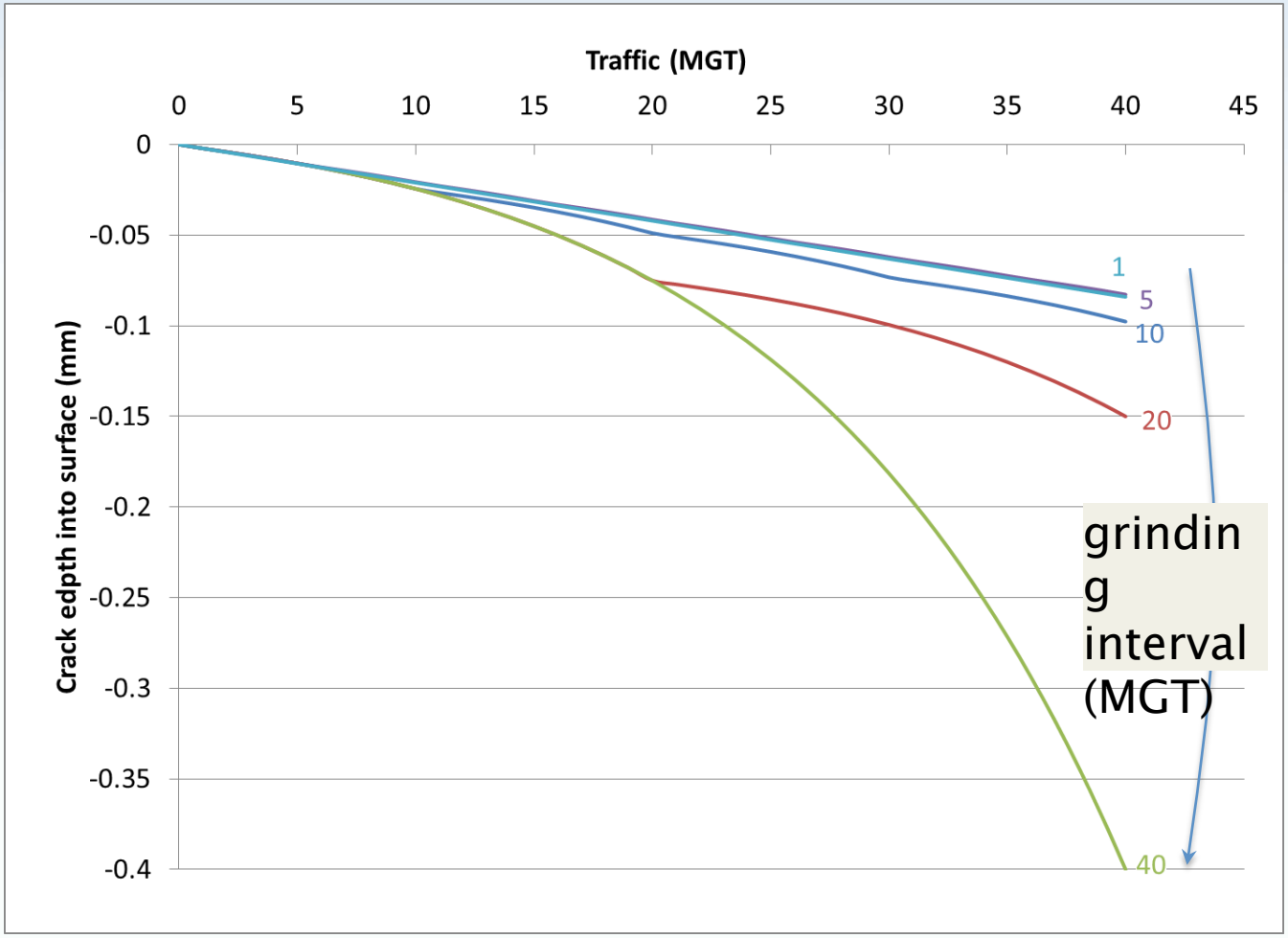
Chasing the Magic Wear Rate

PREVENTIVE RAIL GRINDING

Preventive Maintenance

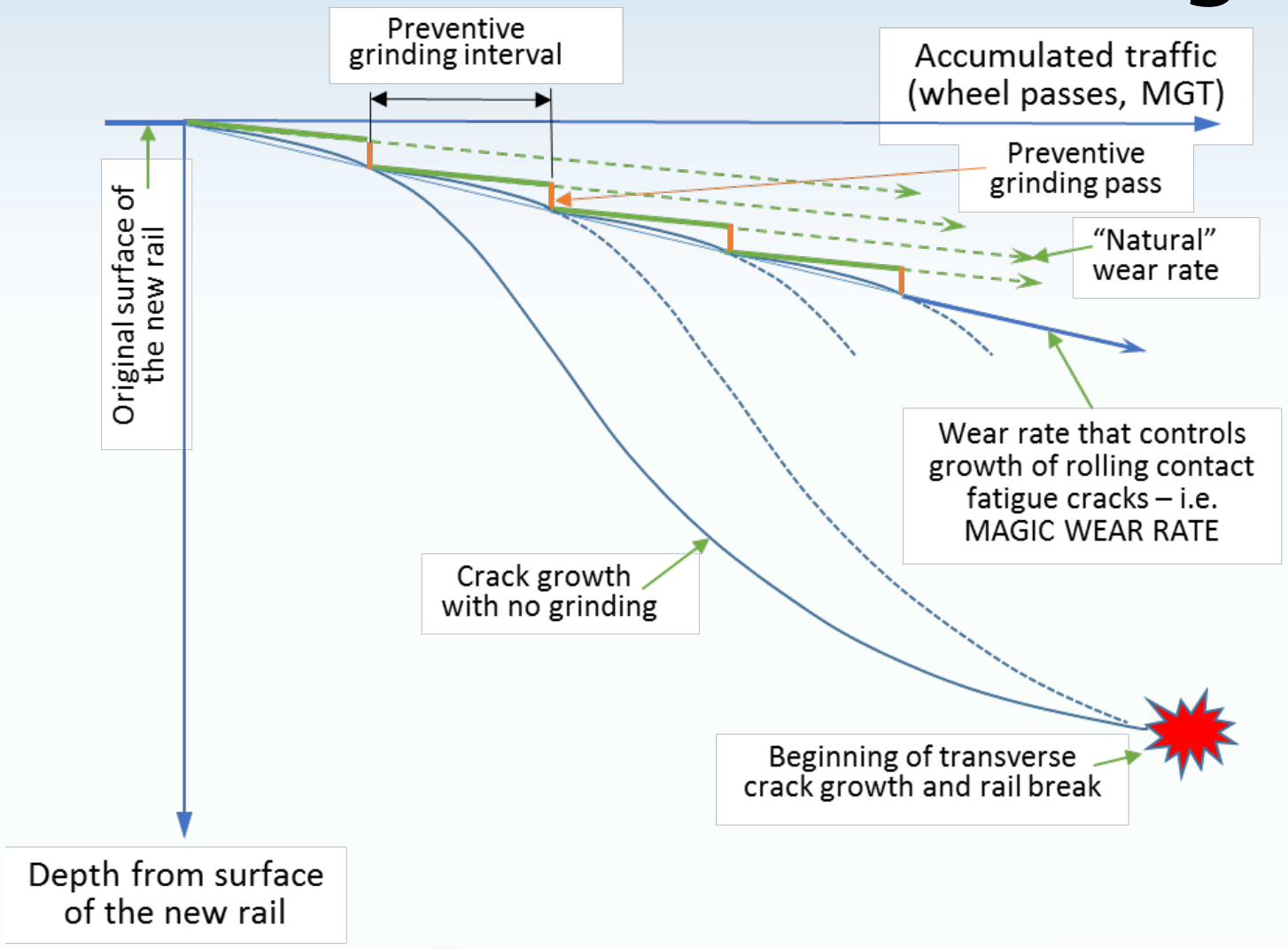


Crack Growth vs Periodic metal removal

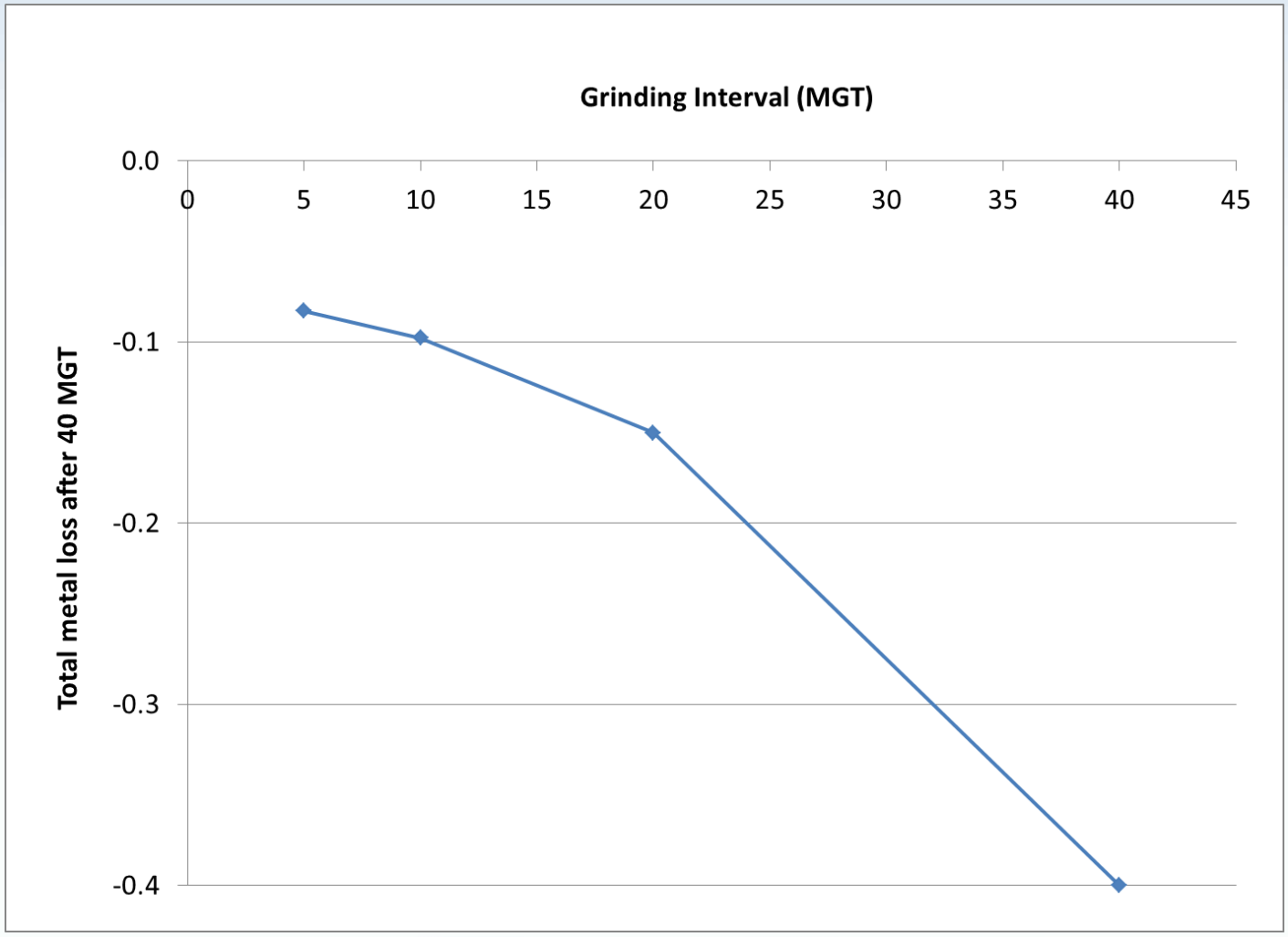


hypothetical exponential crack growth curves

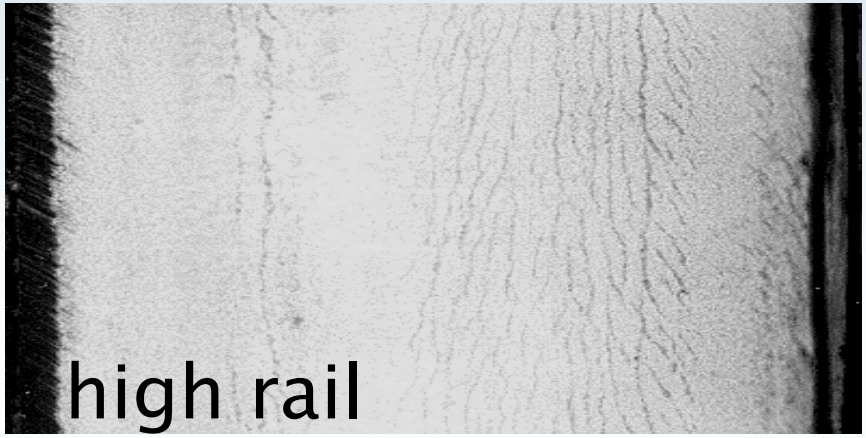
Preventive Rail Grinding

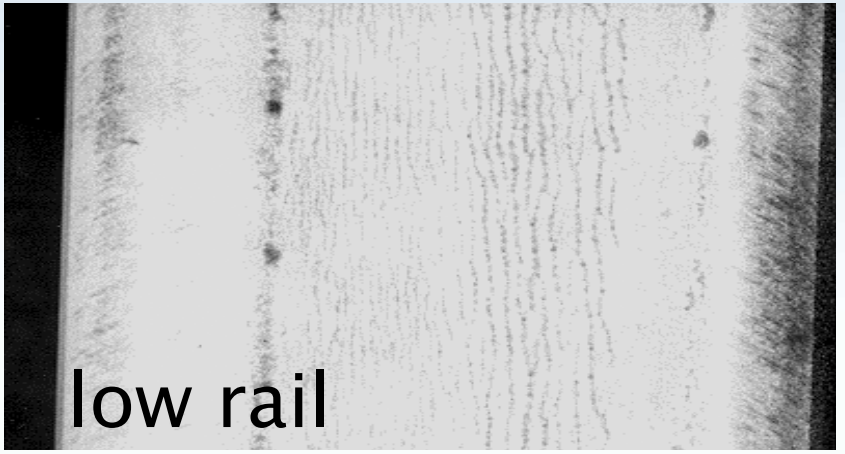


Preventive Maintenance

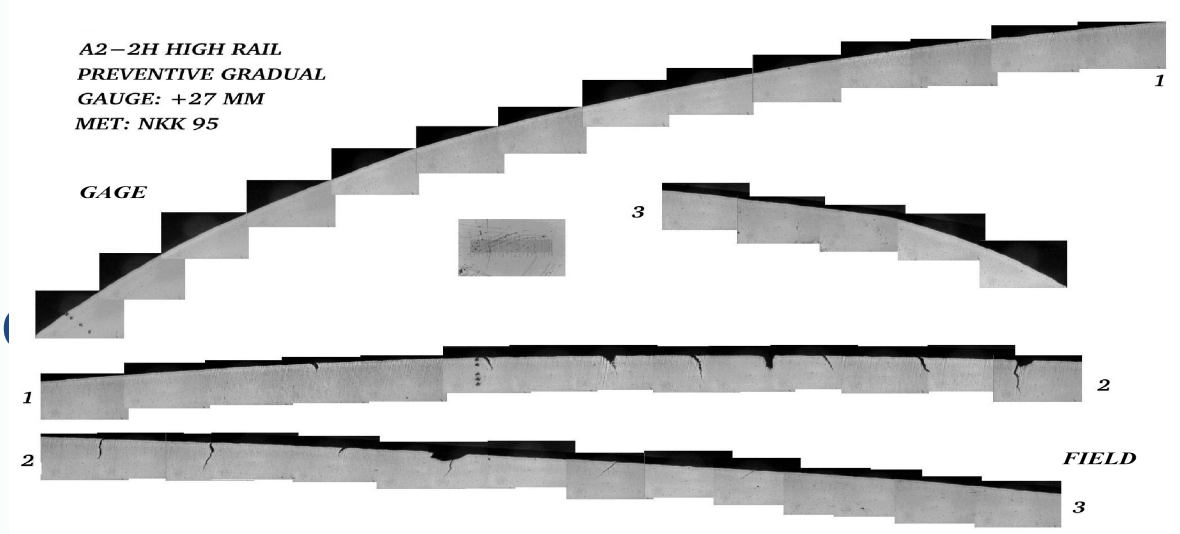


RCF at 15 MGT Cycles – BNSF

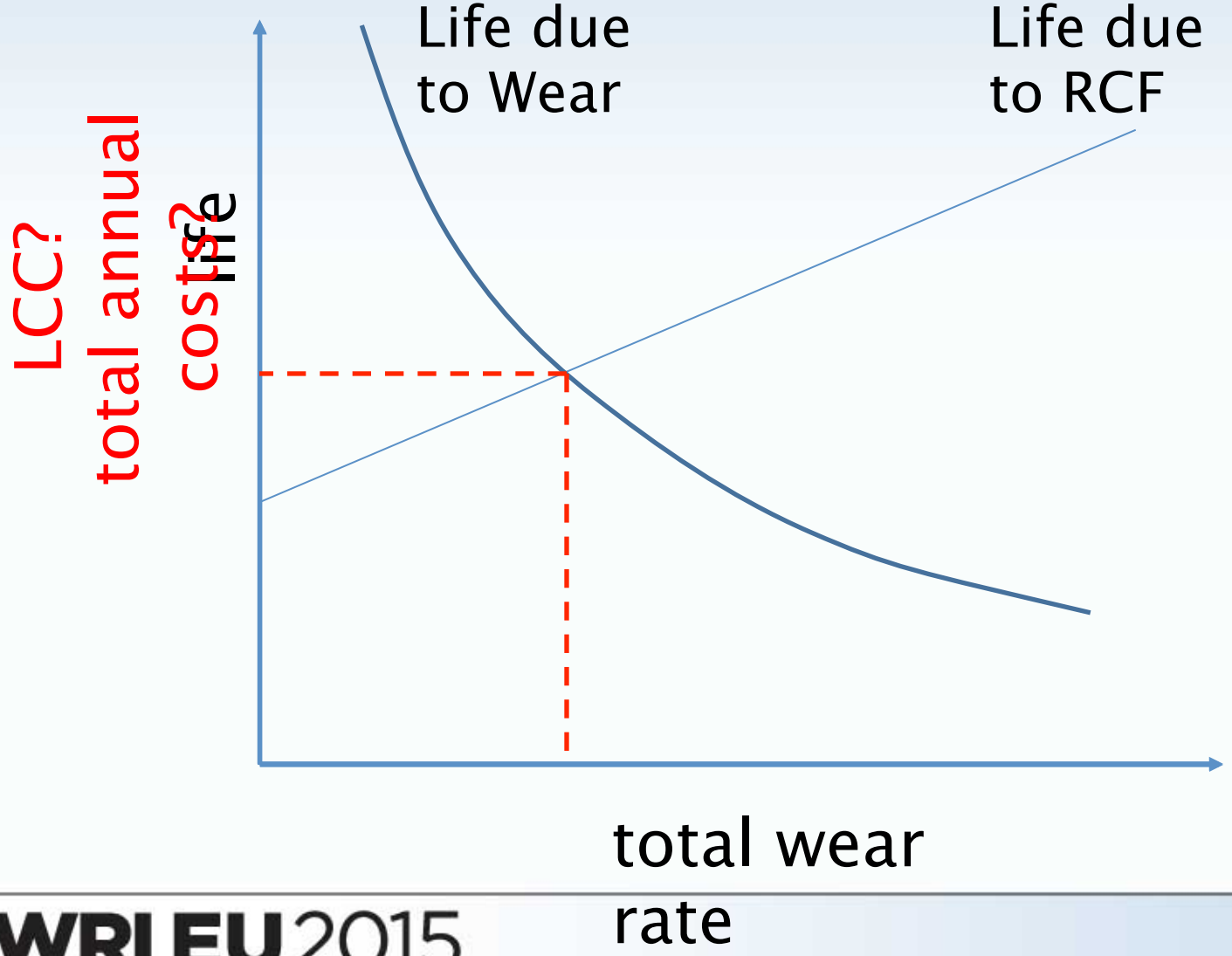




High Rail RCF at 15 M



Magic/optimal Wear Rate



The preventive grinding interval (cont'd)

- Based on crack initiation interval and early life growth rates
- Changes with degree of curvature, super-elevation, metallurgy, and others
- Strives to match the magic wear rate
- Extends with optimal profile, improved track geometry, better steel and friction management
- Must include practical considerations for logistics and machine capabilities

Preventive grinding ≡ “on cycle” grinding

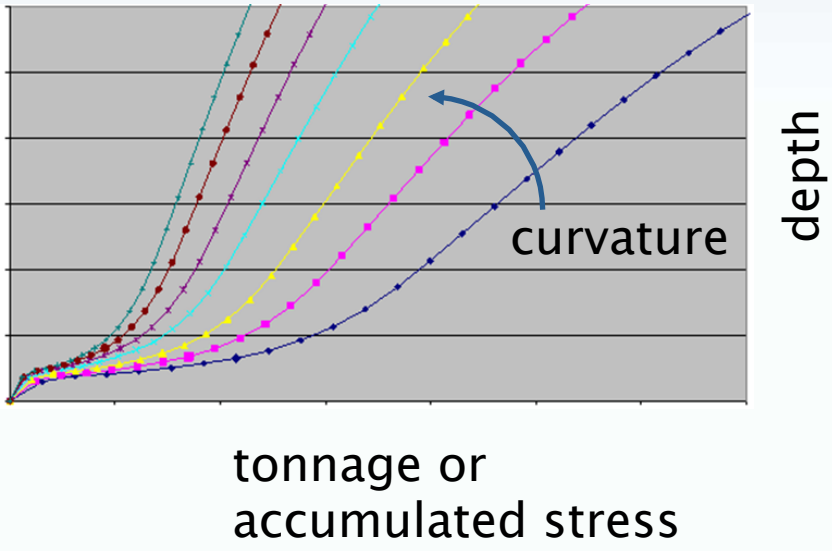
- First cycle
  - All severe and intermediate curves, half of mild curves, third of tangent track
- Second cycle
  - All severe and intermediate curves, second half of mild curves, second third of tangent track…
- Sixth cycle
  - Severe and intermediate curves = six grinds
  - Mild curves = three grinds
  - Tangent track = two grinds

Chasing the Magic Wear Rate

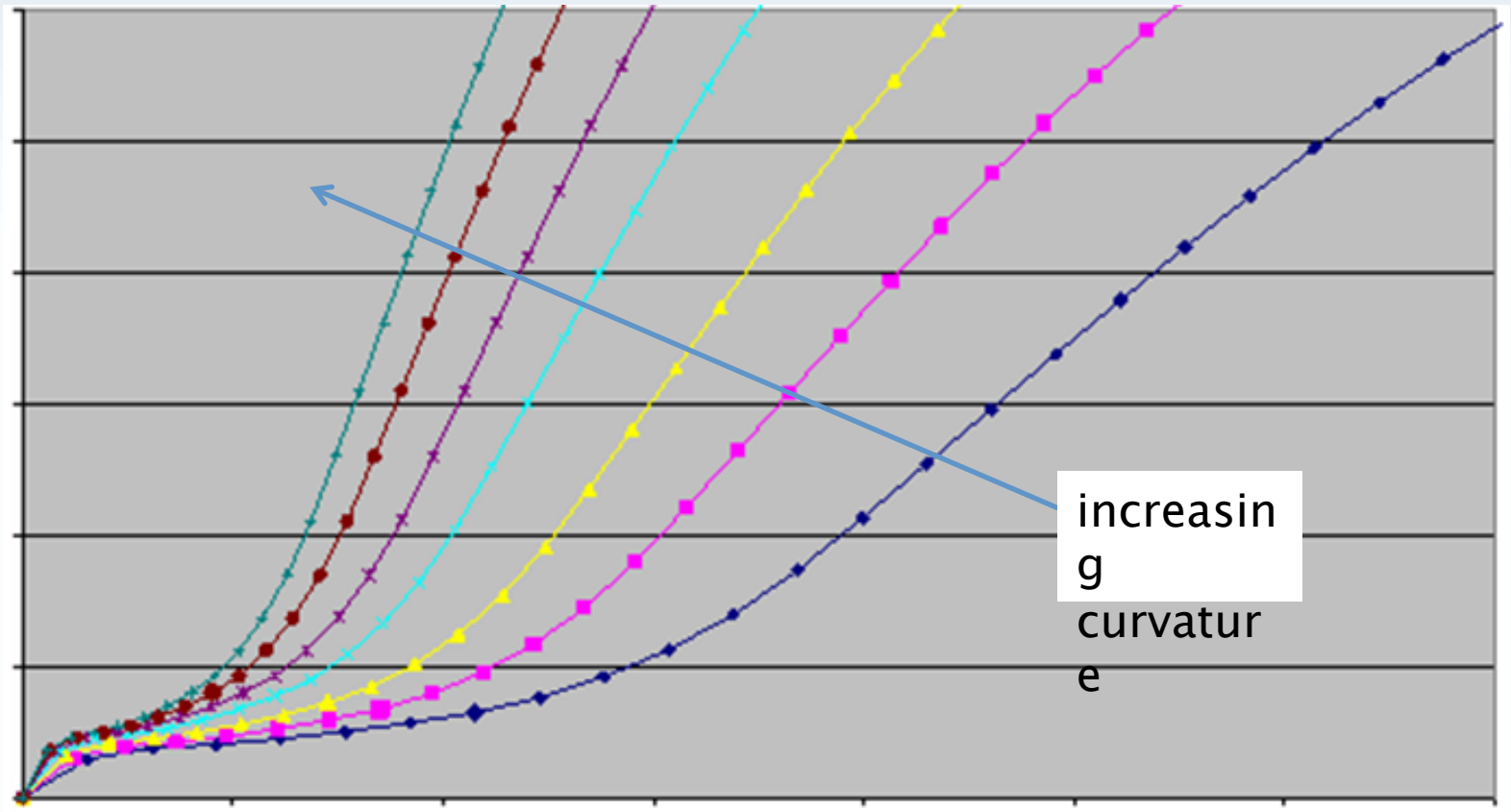
PREDICTIVE-PREVENTIVE RAIL GRINDING

A family of crack growth curves

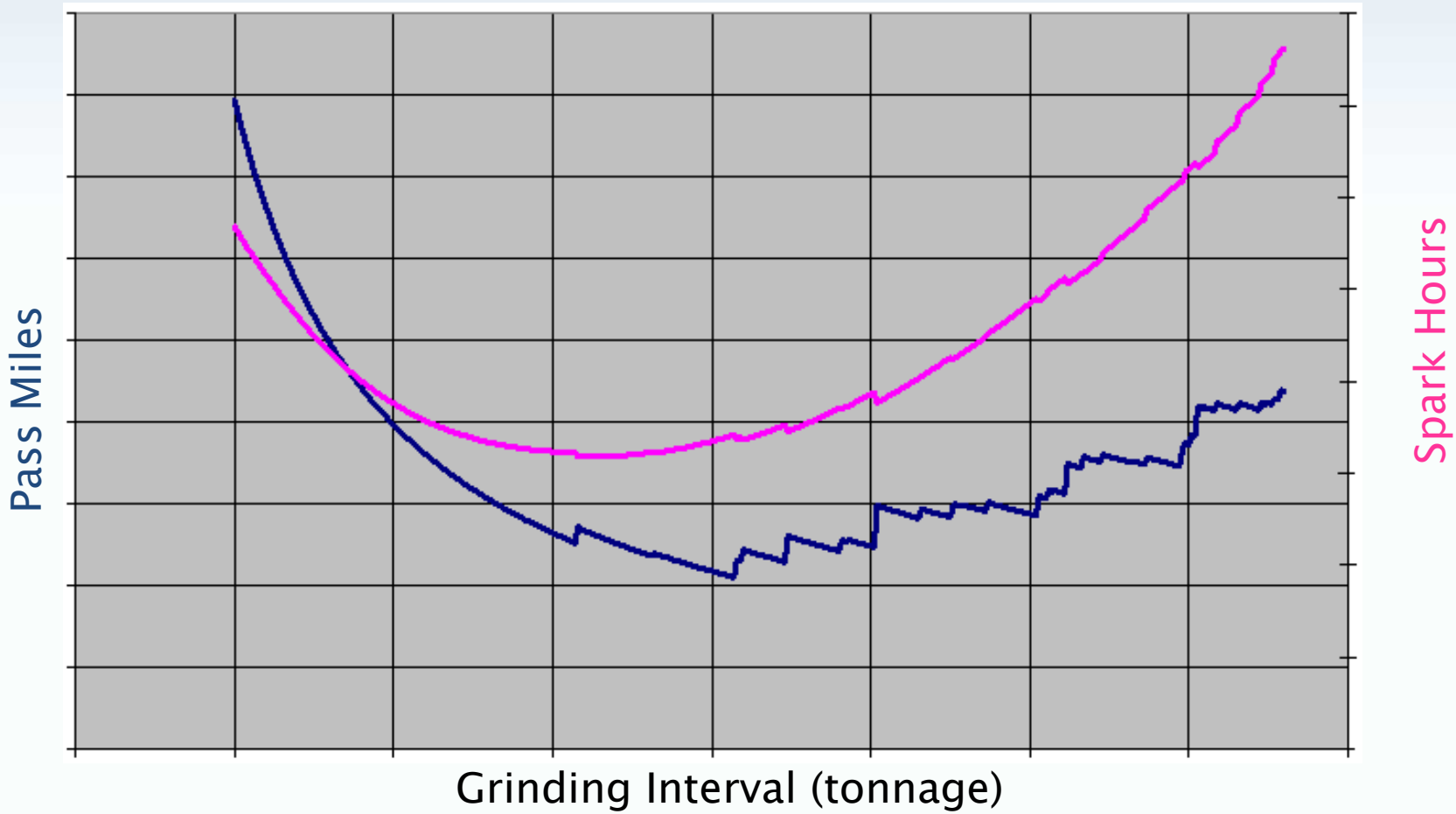
- probably for different
  - rail steels
  - territories
  - traffic types (e.g. passenger, transit, freight)
  - friction regimes



Predictive-Preventive Grinding



Optimization



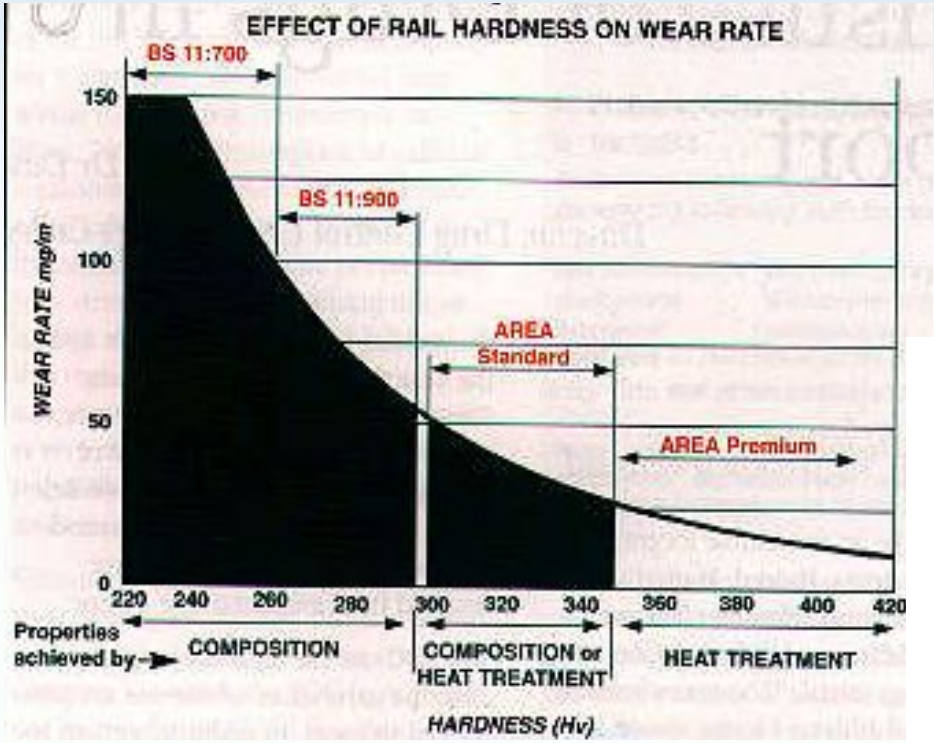
Chasing the Magic Wear Rate

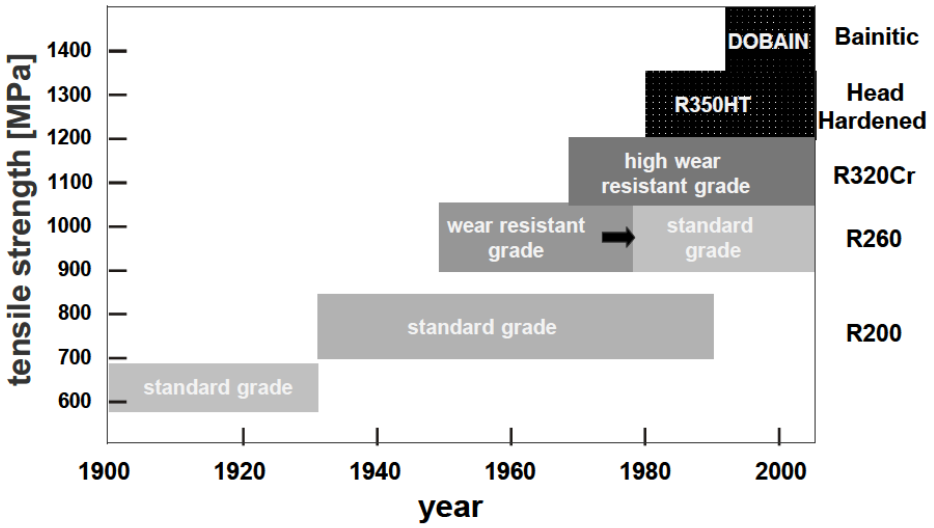
SYSTEM DESIGN

Chasing MWR: System Design

- Abrasive brakeshoes
  - NA Freight Railroad: “The railways have sufficient experience to know that the rates of wheel shelling are reduced through the use of the “scrubber” shoe “. i.e. composite brakeshoes with cast iron inserts.
- Softer Wheel Steels?
  - Sumitomo/NRC project

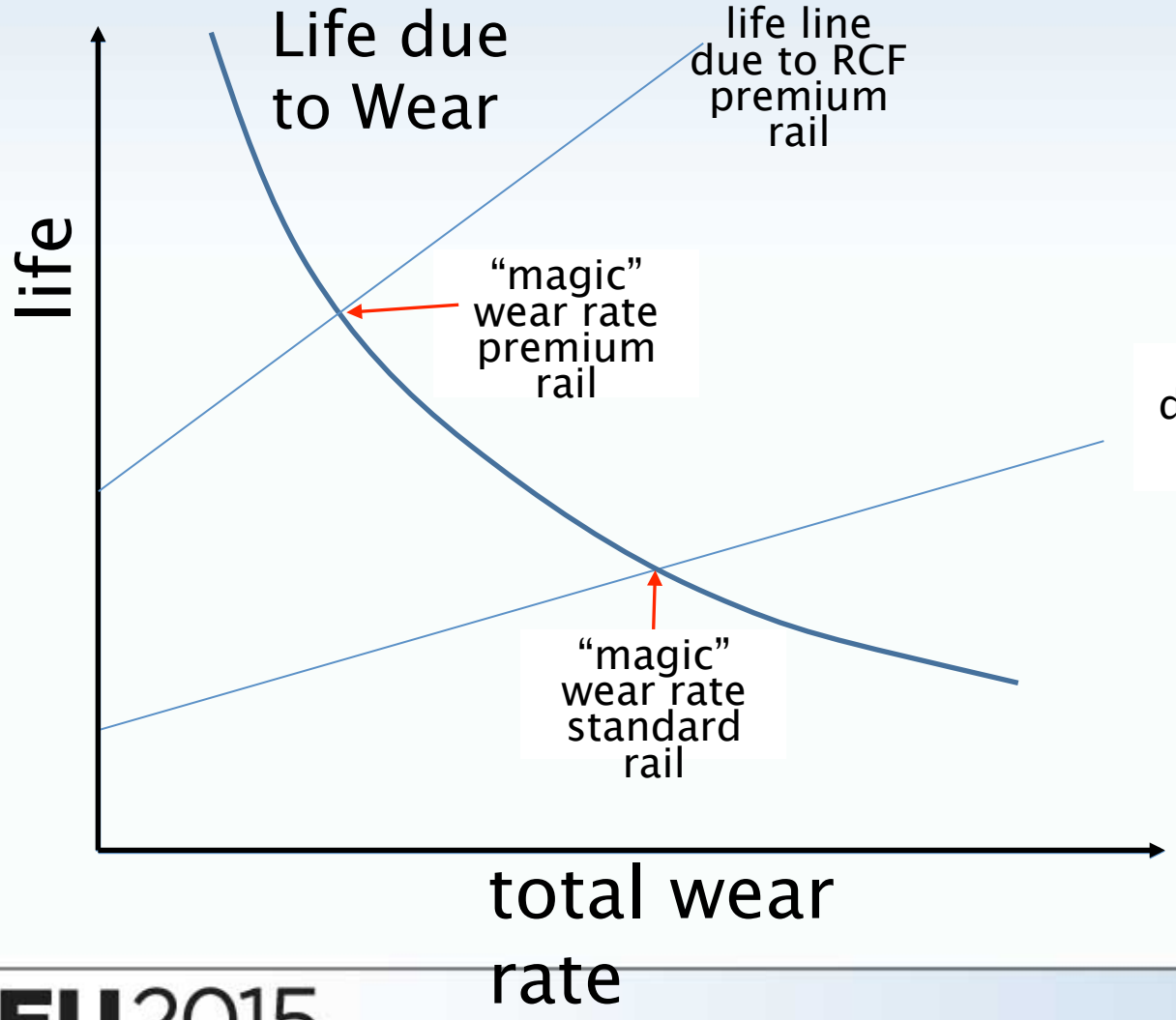
Premium Metallurgy





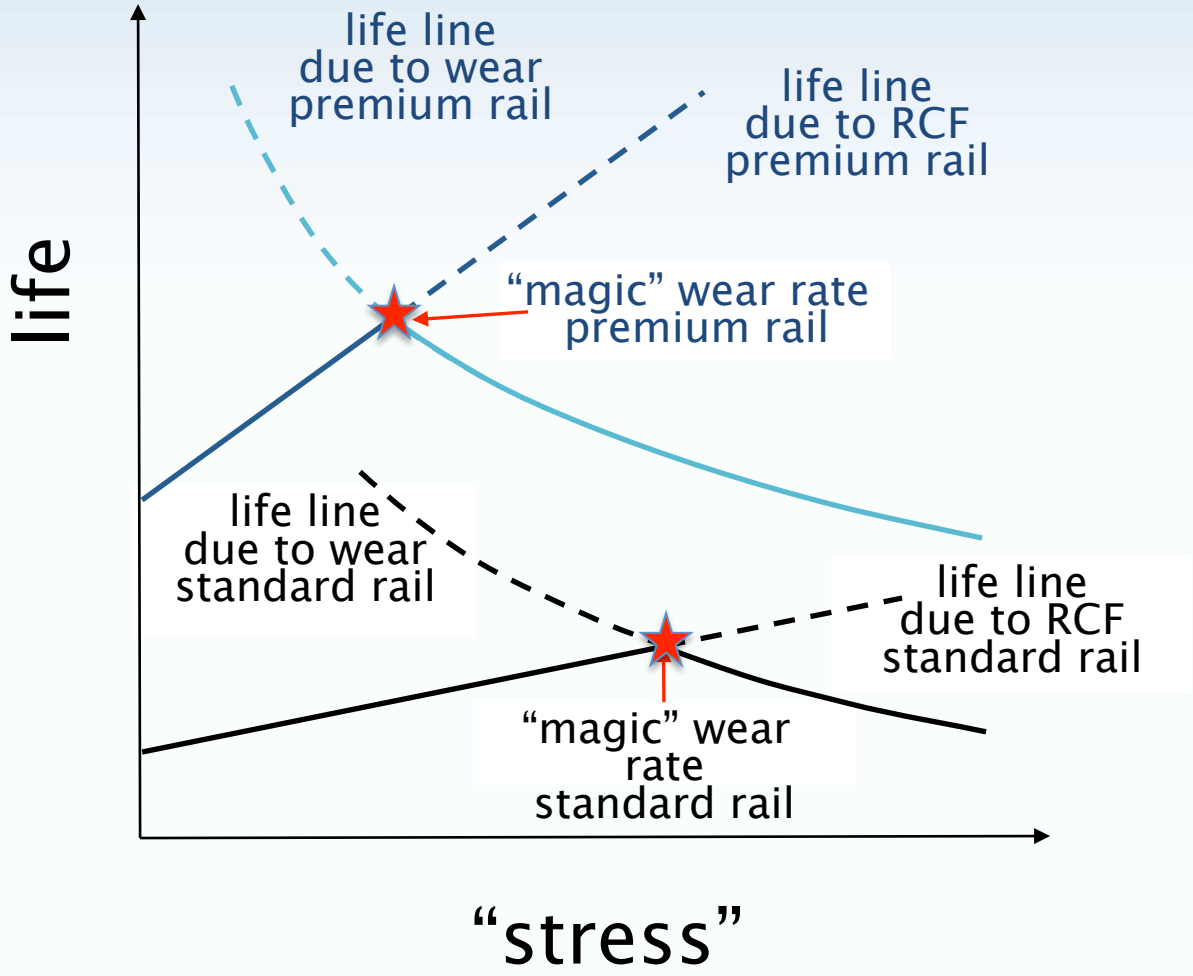
Girsch and Heyder: Advanced pearlitic and bainitic high strength rail steels promise to improve RCF resistance

The Effect of Metallurgy?



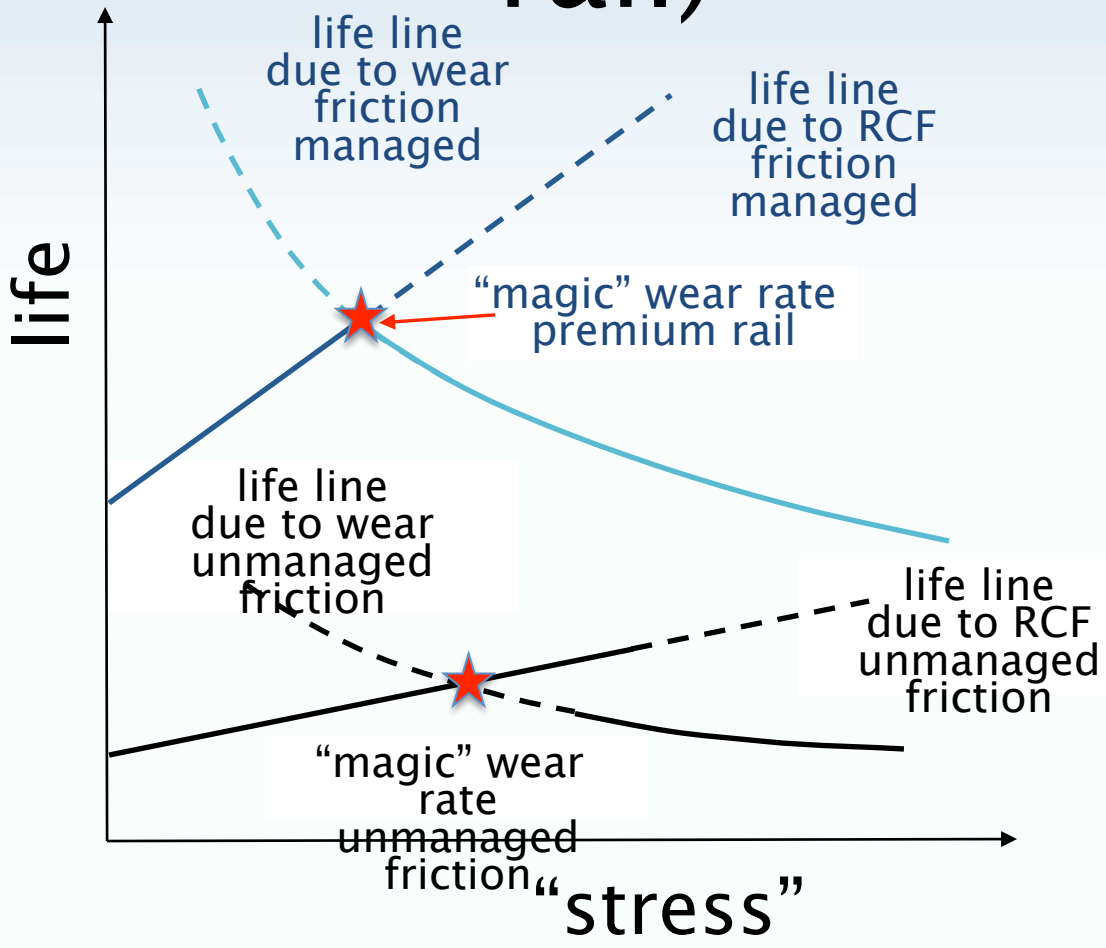
Note: Schematic only

The Effect of Metallurgy



Note:
Schemati
c only

The Effect of TOR FM (low rail)



Note: Schematic only

Caveats

- M. Burstow (Iron and Steelmaking 2013): "…the results from one of these trial sites, on a tight radius curve, where it was found that the risk of RCF actually increased with the use of premium grade rail".

Chasing the Magic Wear Rate

DAMAGE MEASUREMENT

Measurement/Monitoring of RCF – walking sticks

MRX

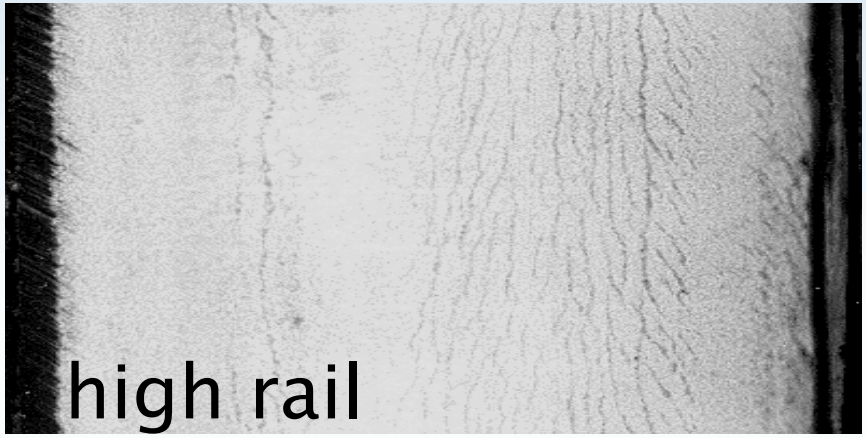
Sperry

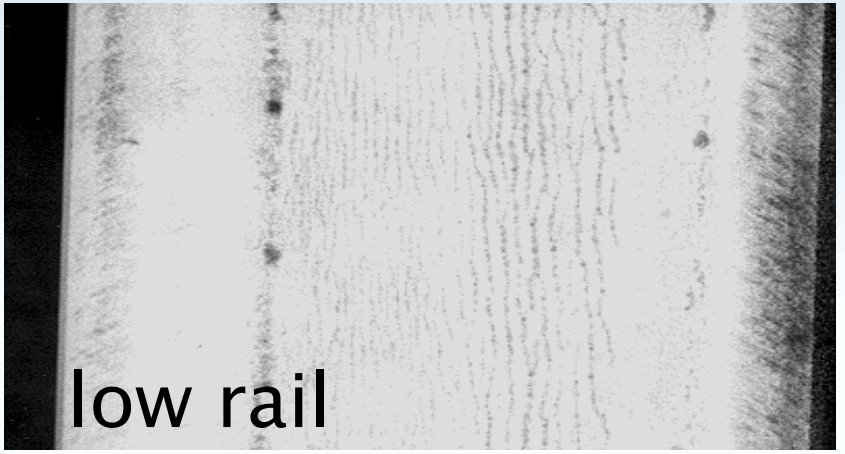
Rohmann

Measurement/Monitoring of RCF

up to 40 mph

RCF at 15 MGT Cycles – BNSF





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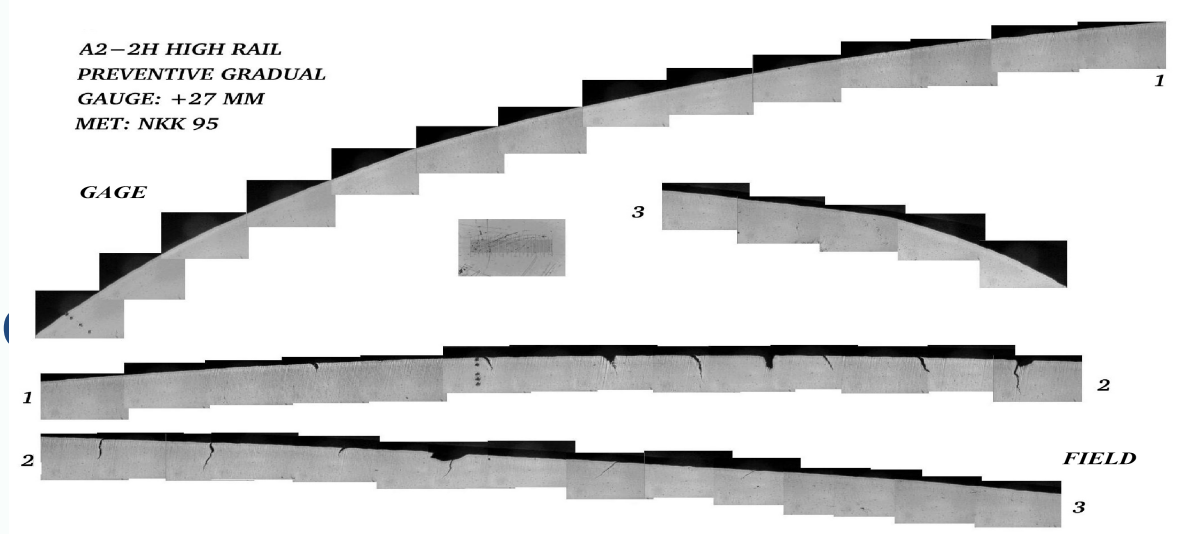

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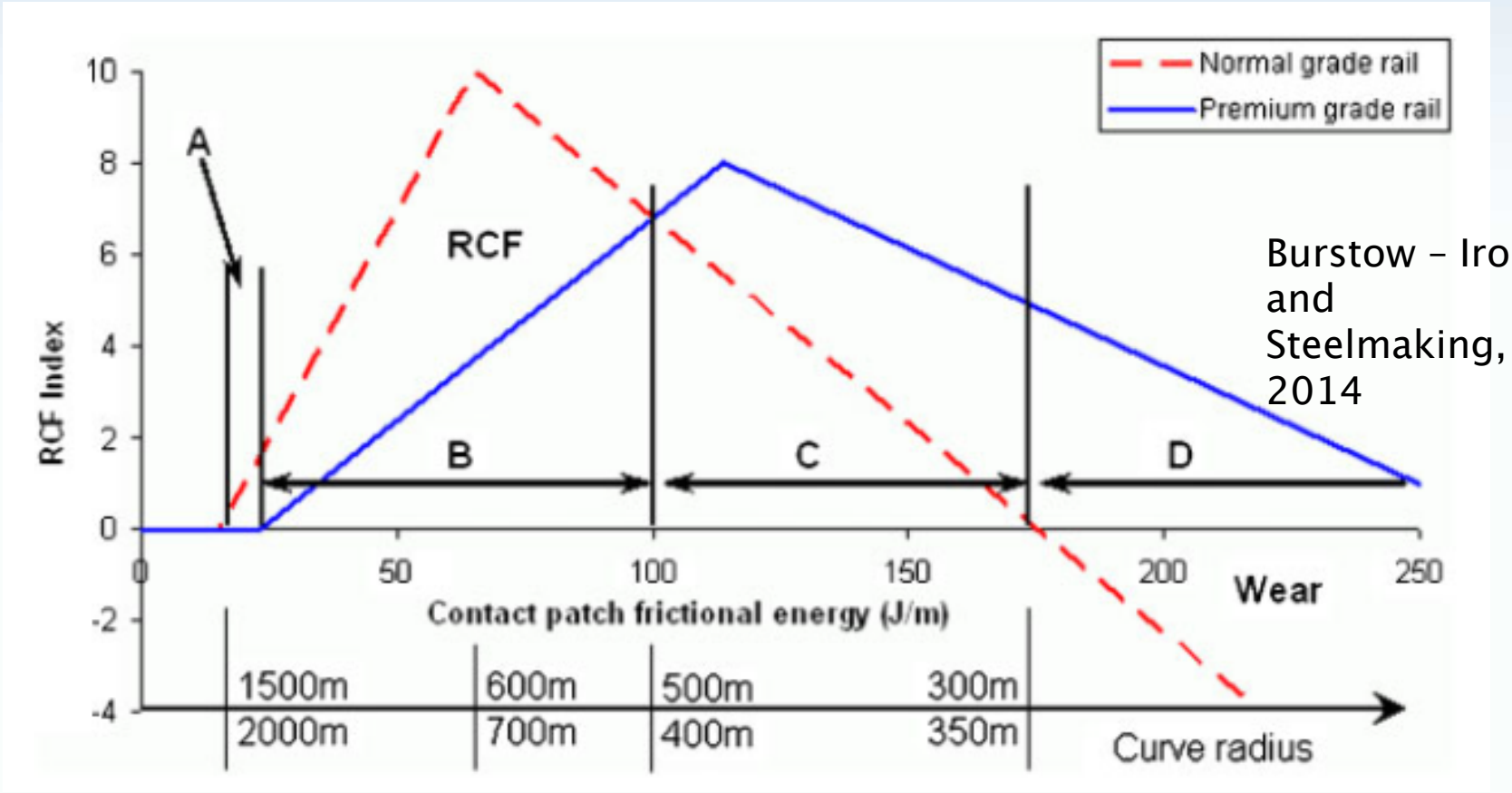
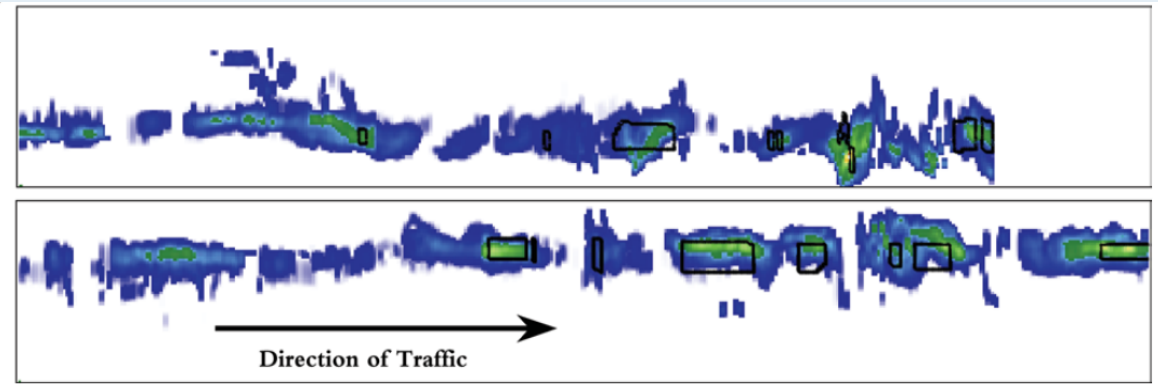
CRACK/DAMAGE MODELLING

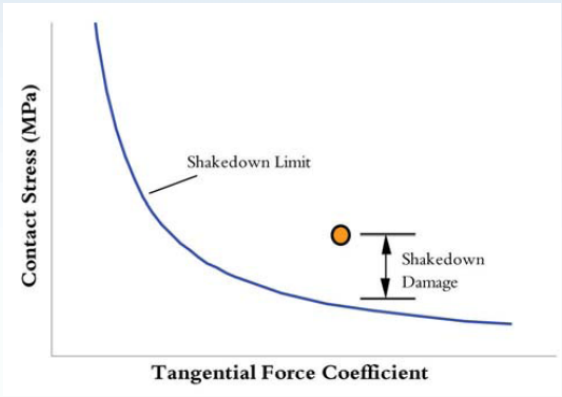
Modeling: Crack Growth vs Wear

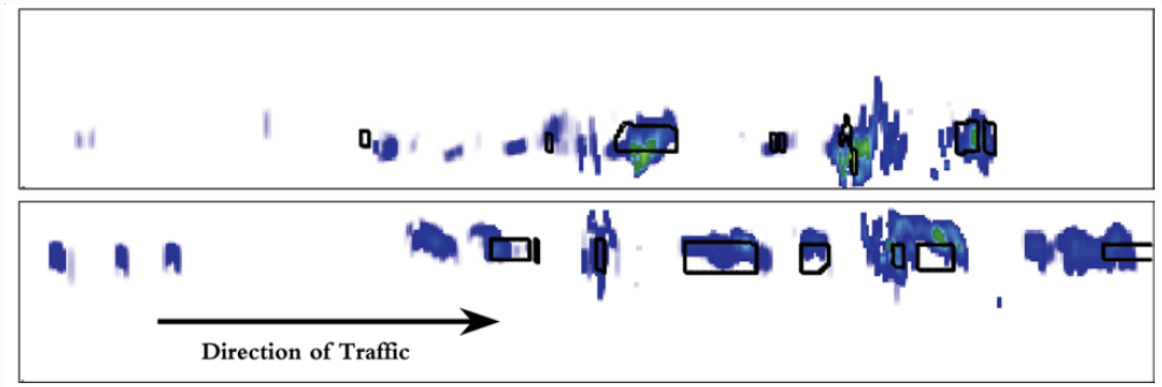


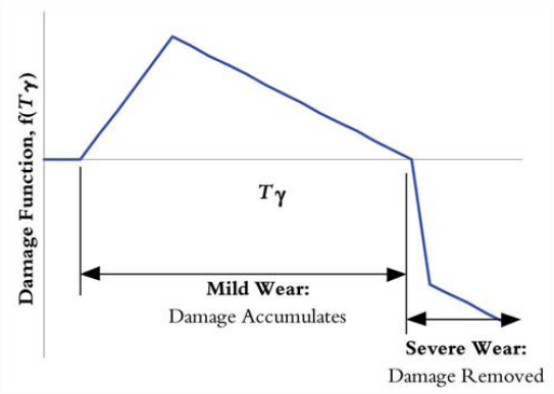
Burstow – Iron and Steelmaking, 2014

Crack initiation model









from: M.C. Burstow: Current developments in the whole life rail model to predict RCF in rails, WCRR 2003

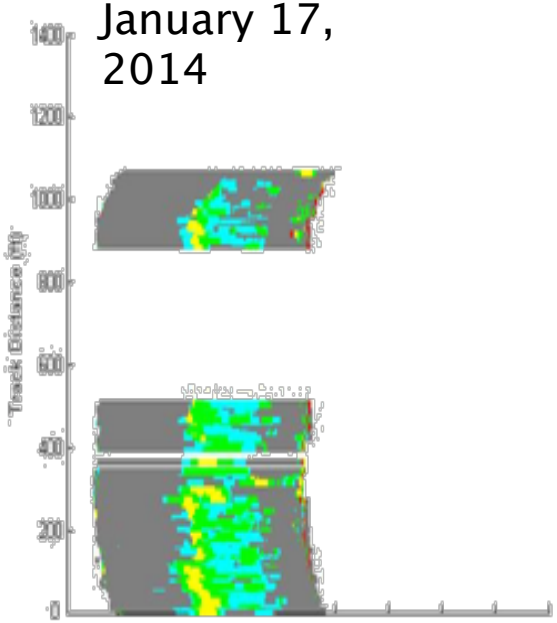
RCF index (380 Bhn)

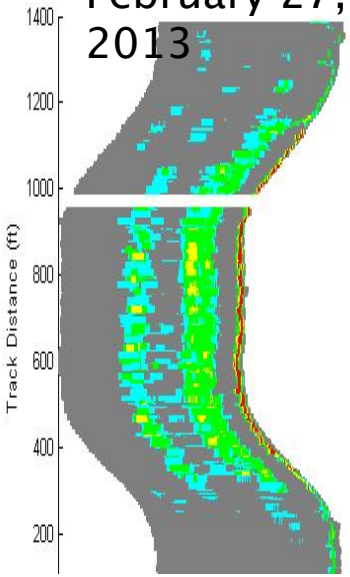
MP 7.66, 3.1˚ January 17, 2014

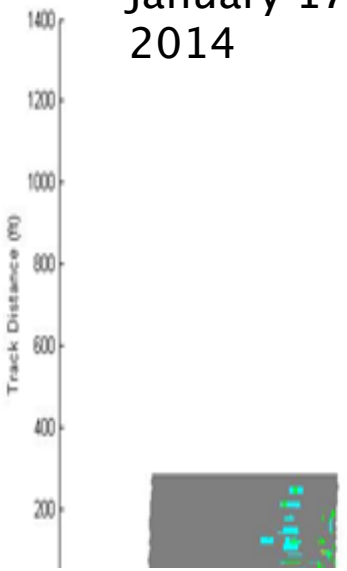
MP 10.63, 3.8˚ February 27, 2013

MP 16.19, 1˚ January 17, 2014

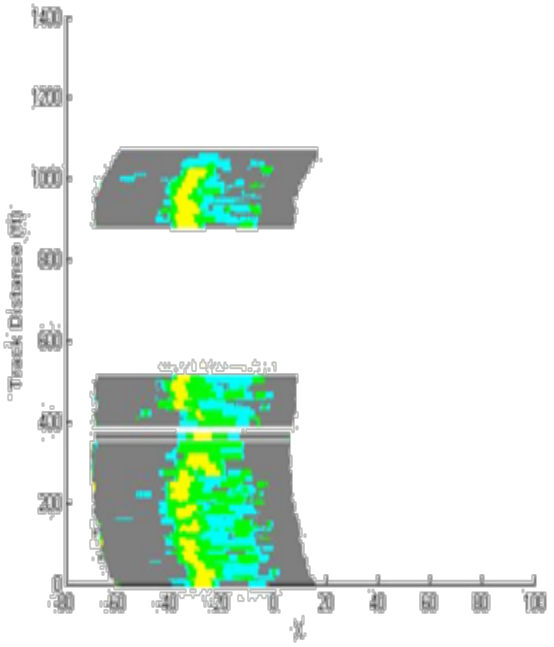
High Rail

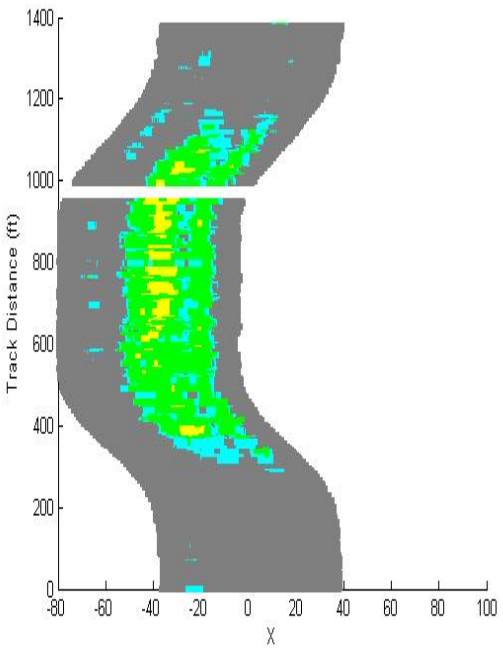


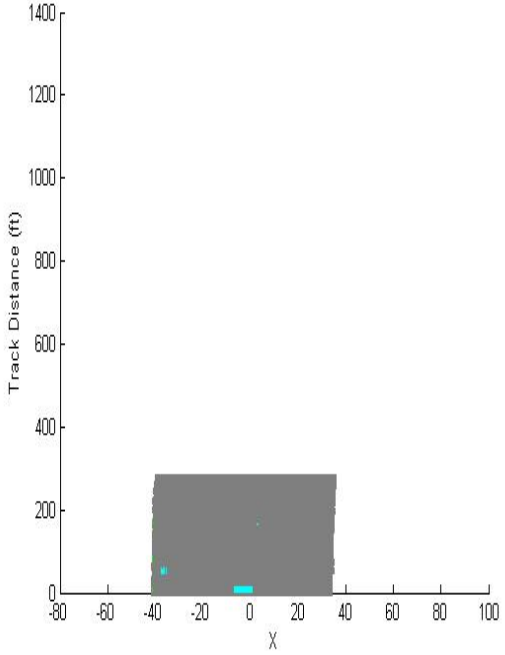




Low Rail







Chasing the Magic Wear Rate

- railroad/system specific wear and crack growth rates
  - depend on steels, friction, operating conditions, natural wear rates
  - rail grinding, wheel retruing
  - optimal implementation strategies (preventive, predictive)
- Key: crack growth rates
  - field measurement
  - validated crack growth and wear models

safety efficiency economy

ICRI Workshop on Rolling Contact Fatigue
Measurement, Modeling, Management

- Vancouver, Canada
- August 3-5, 2016 (Tuesday – Thursday)
- Plenary Session only: 30-40 presentations
- 50-70 participants
- Program:
  - Summarizing best practices
  - Understanding current limitations
  - Identifying needs
  - Railroad problem statements

Thank you!

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