The Magic Wear Rate

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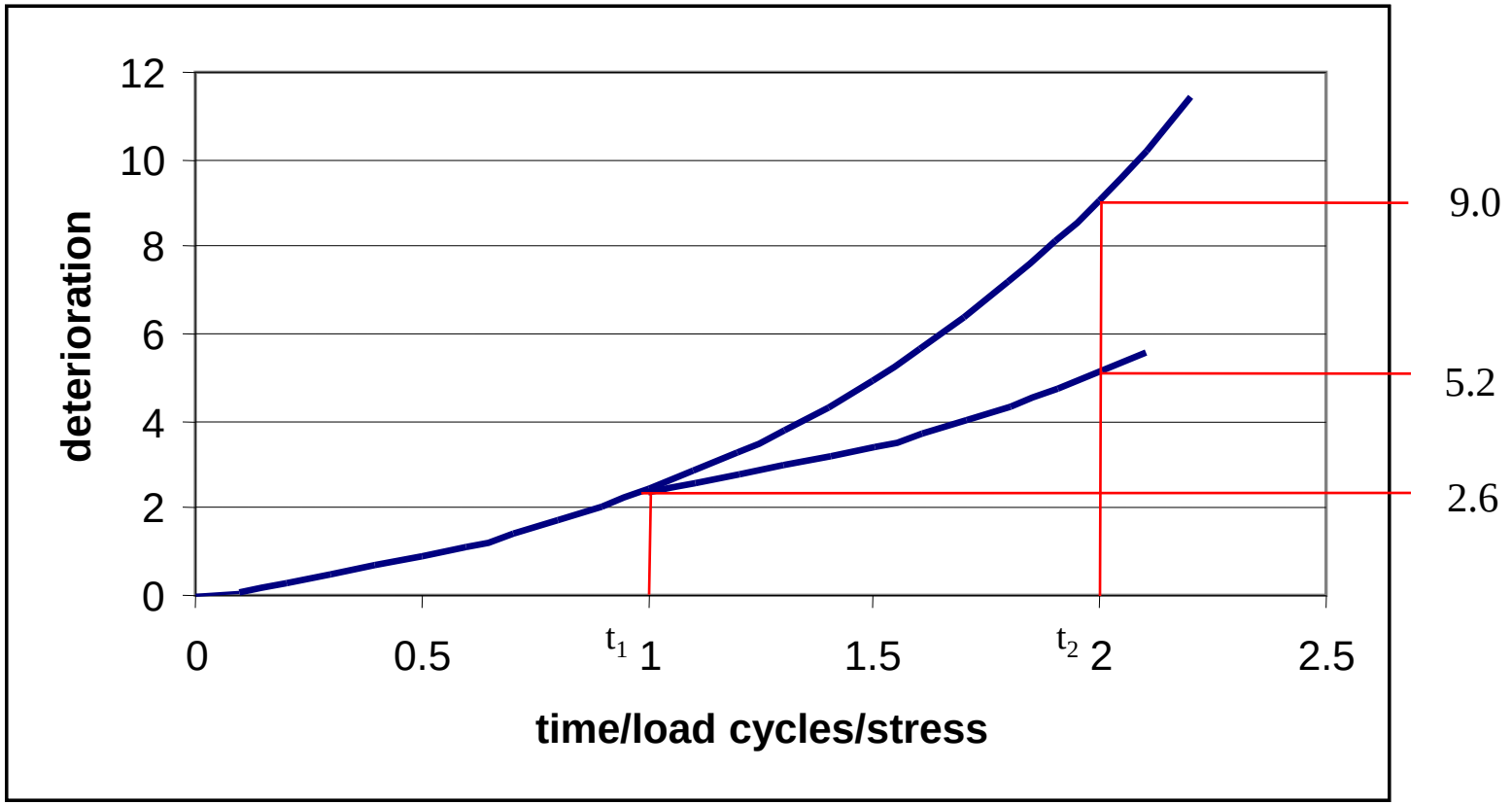
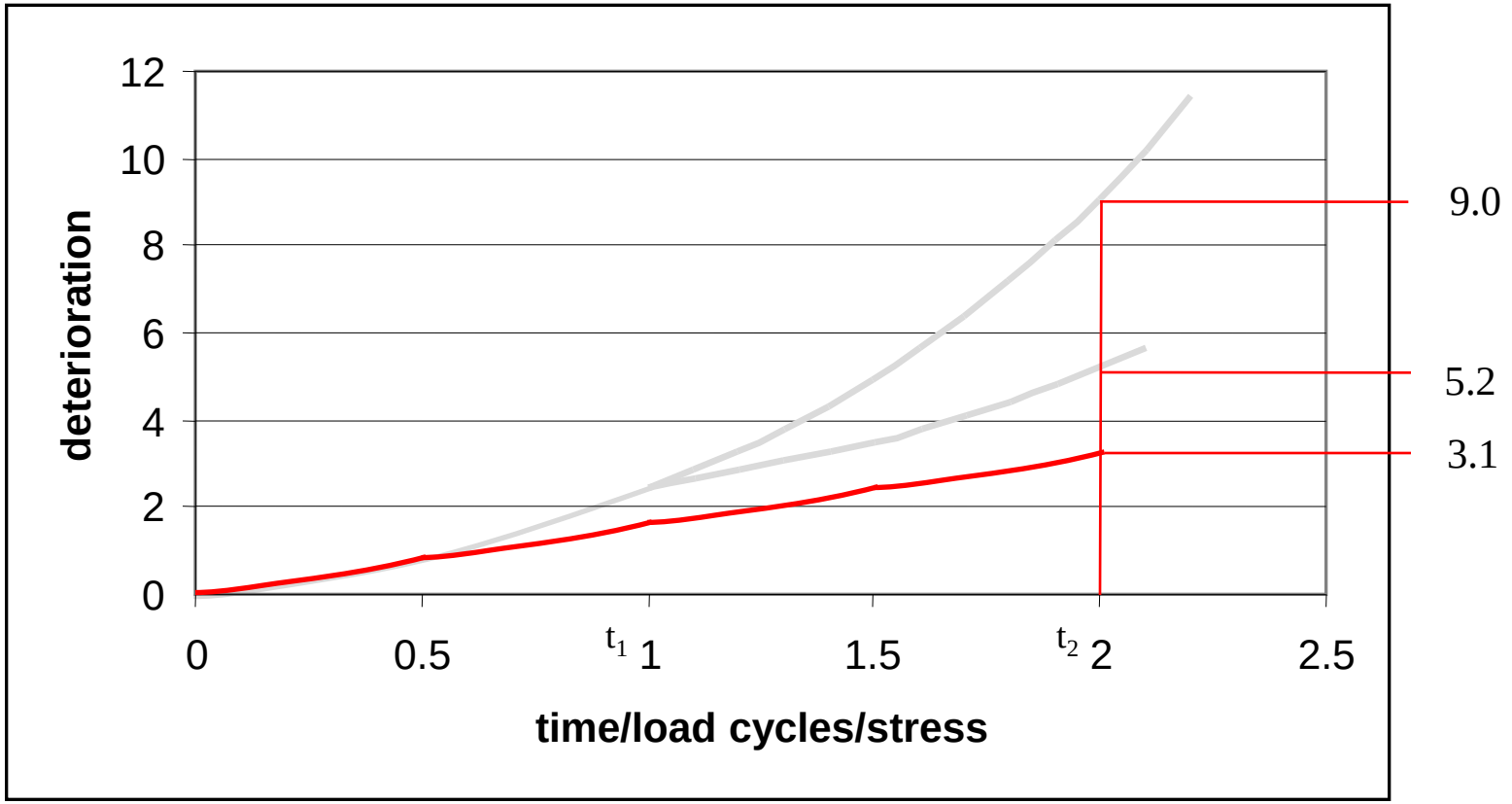
Principal Engineer

Preventive Maintenance



Preventive Maintenance

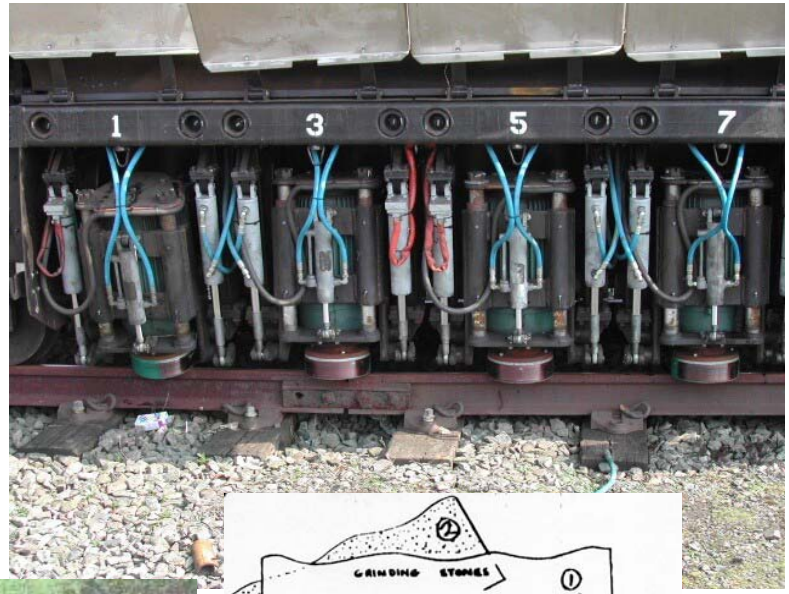


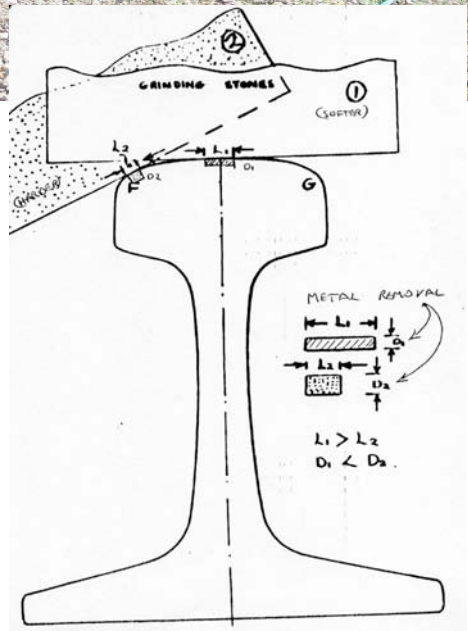
Magic Wear Rate

- no wear → contact fatigue dominates
- excessive wear → wasted life
- refers to the rate of wear (both natural and artificial) required to optimally manage rolling contact fatigue.

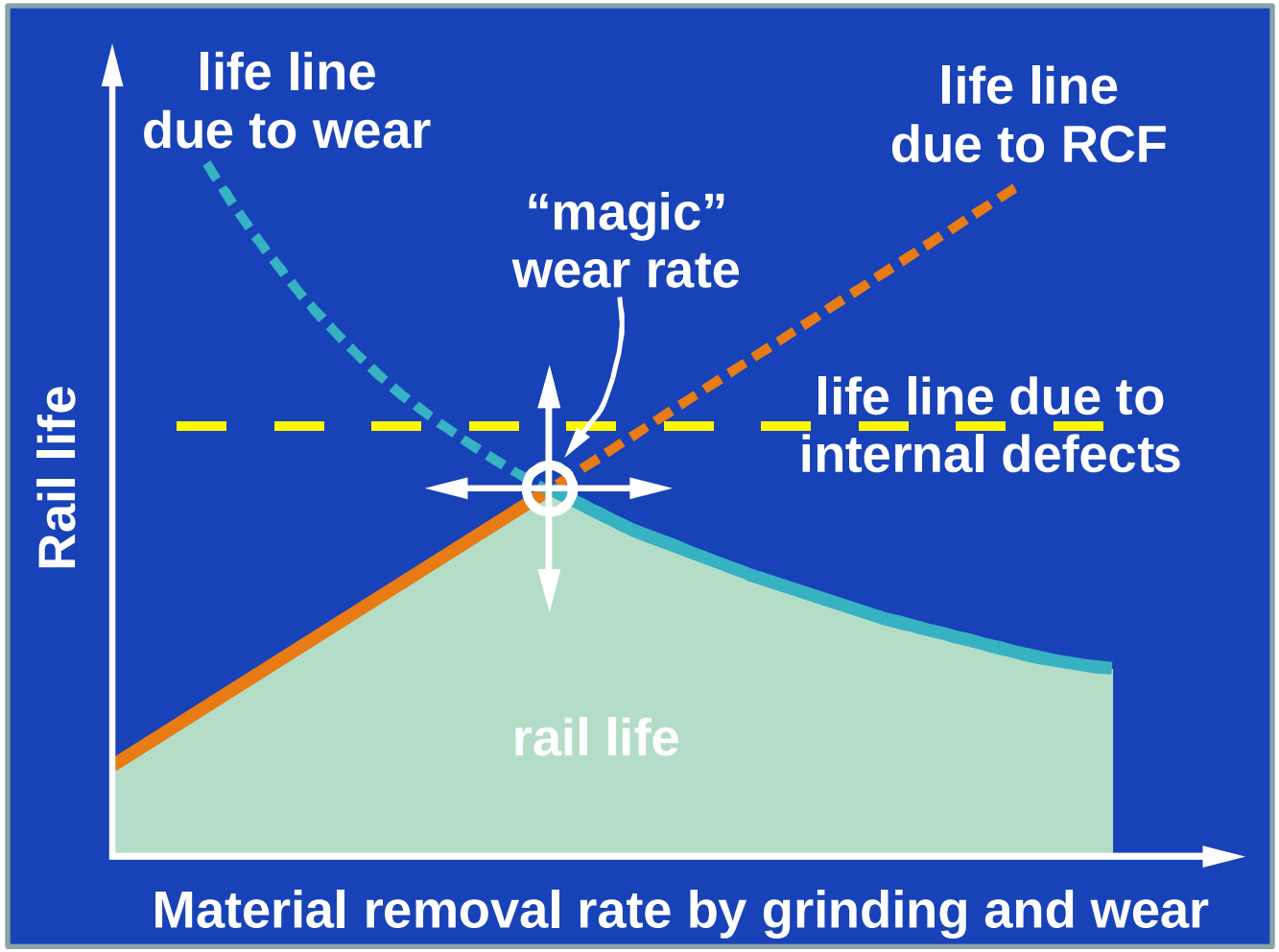
But what does optimal mean?

Rail grinding

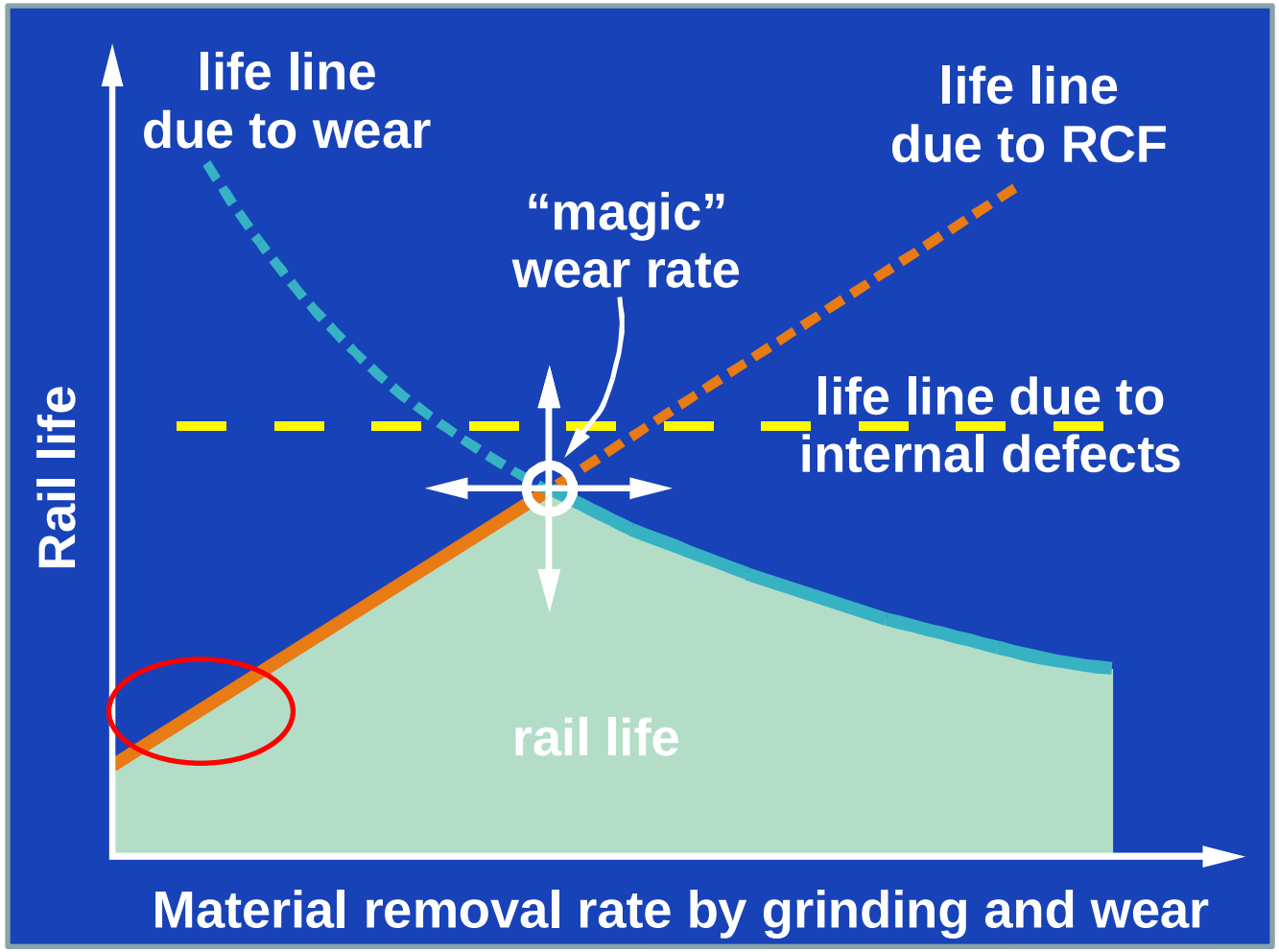




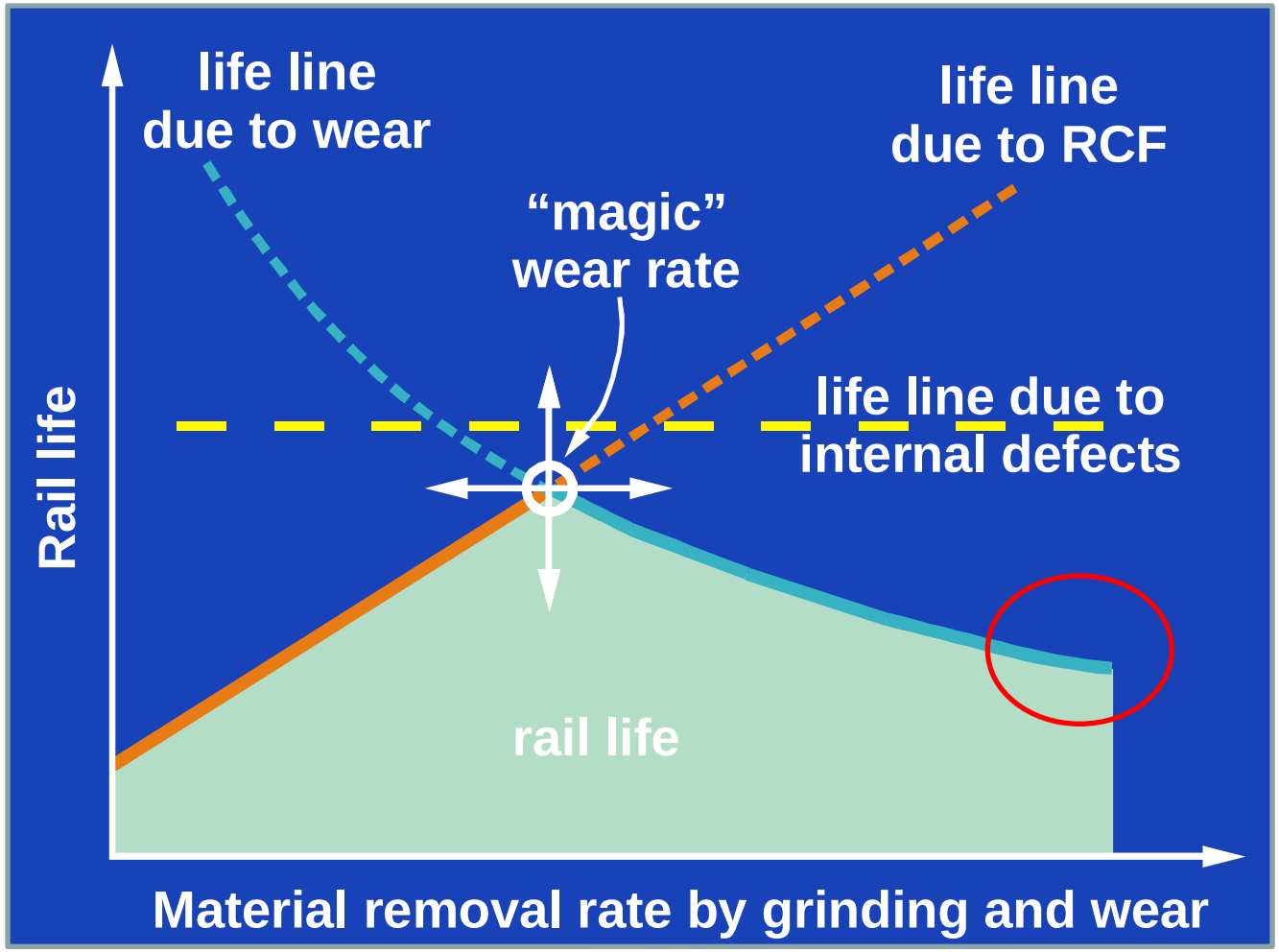
Graphic depiction of GCC, wear and rail life relationship



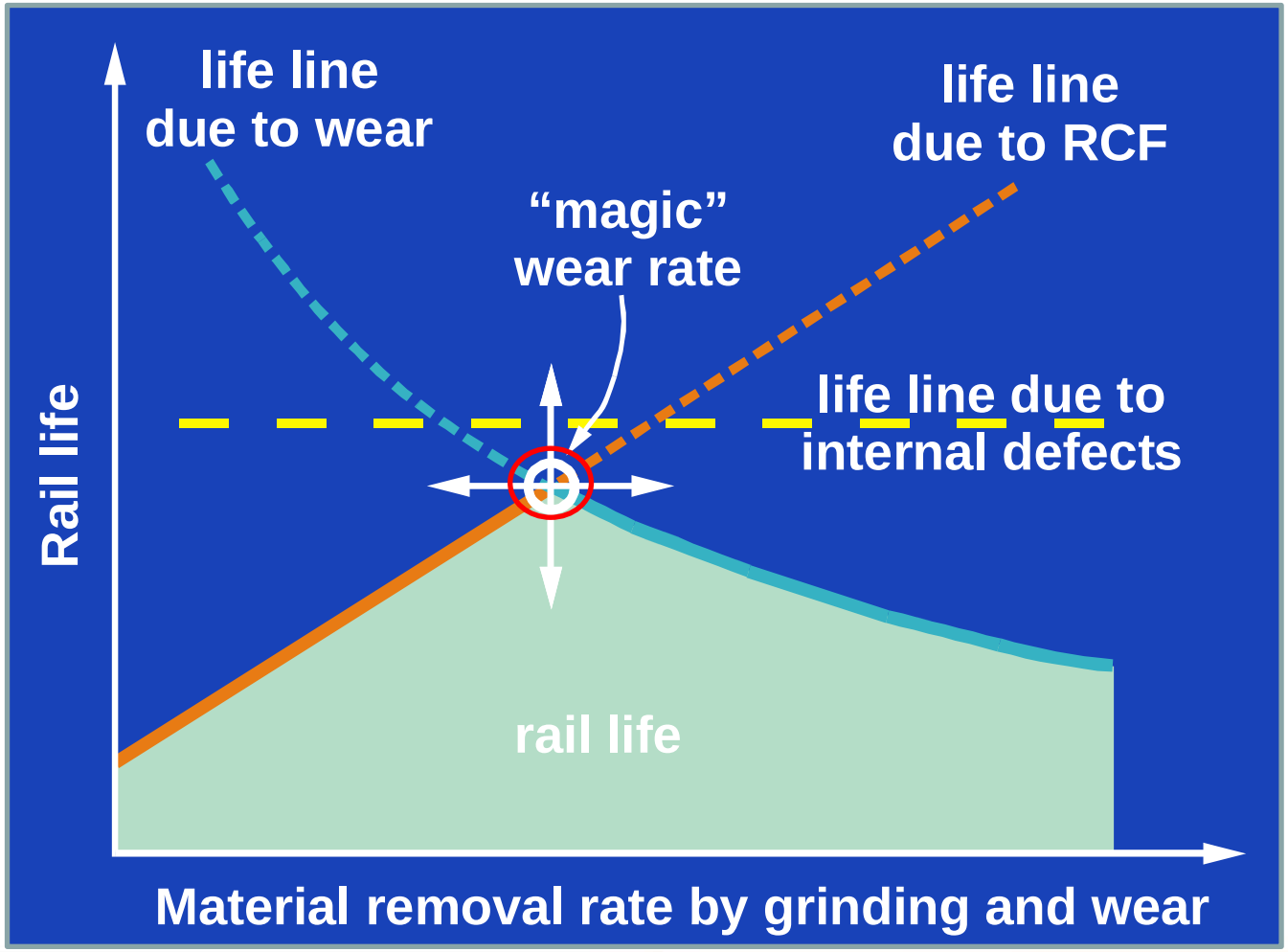
Graphic depiction of GCC, wear and rail life relationship (no grinding)



Graphic depiction of GCC, wear and rail life relationship (corrective grinding)

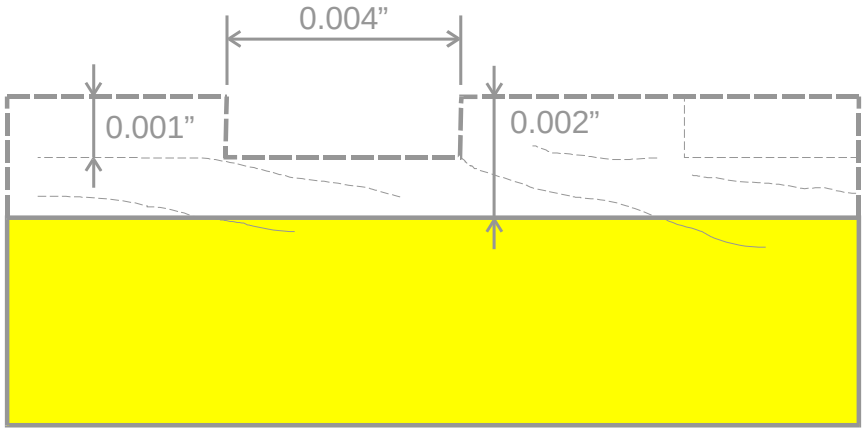


The Magic Wear Rate balances wear with fatigue

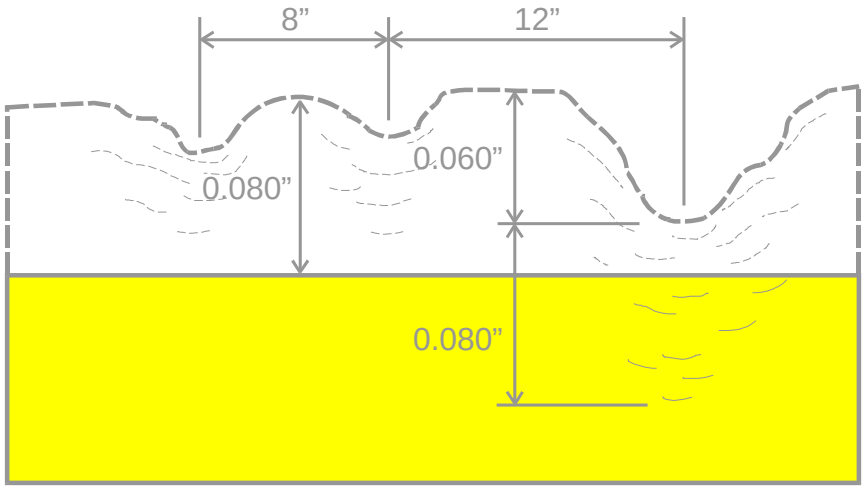


Preventive vs. Corrective

Preventive



Corrective



Before grinding After grinding

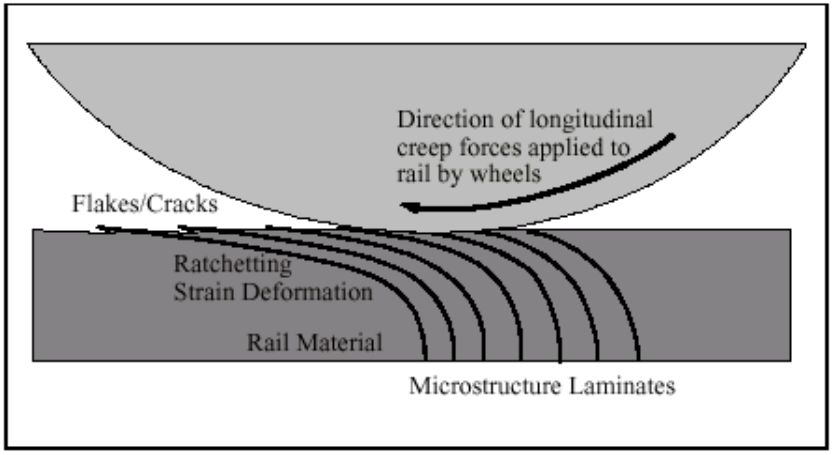
- frequent, high speed, single pass
- surface cracking mostly removed
- profile regularly maintained
- always good/safe surface condition

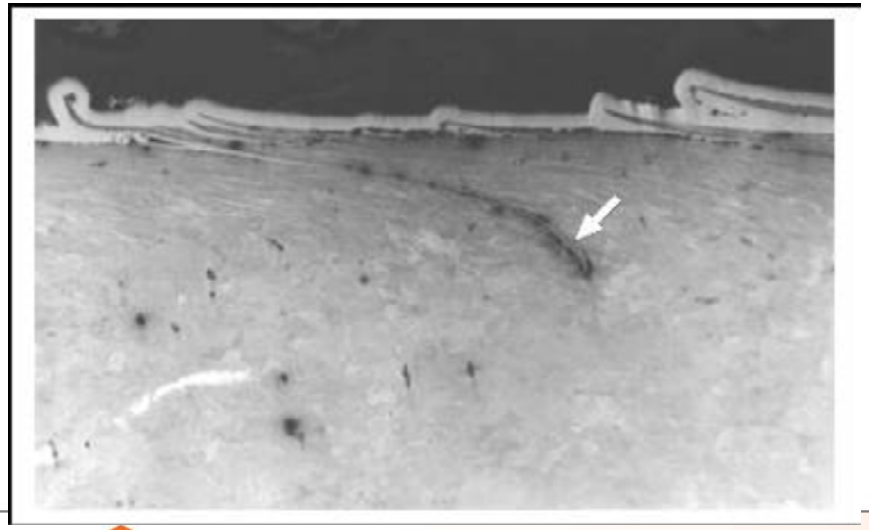
- infrequent, slow, multi-pass
- cracks rarely removed
- profiles deteriorate btw cycles
- surface cracking impedes NDT

Magic wear rate?

- Controls RCF - safely, efficiently
- The minimal value required “to do the job”
  - synergistic with other approaches (profiles, friction management, best superelevation, track geometry)
- practically achievable
  - can’t have the rail grinder in all places at all different times.
- accounts for local and seasonal variations
  - curvature, tonnage, speeds, metallurgy, risk

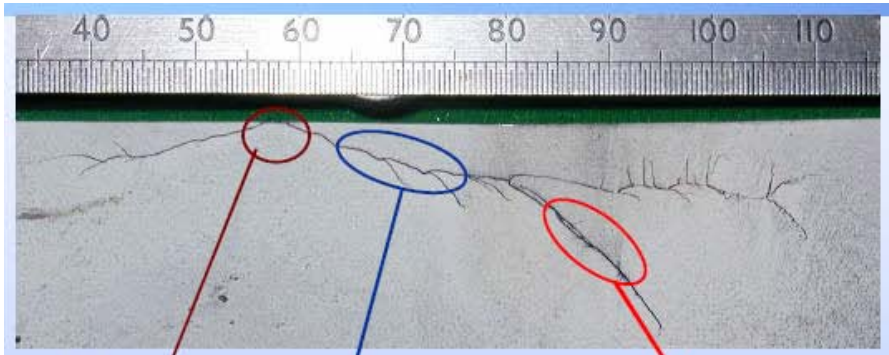
Crack Initiation

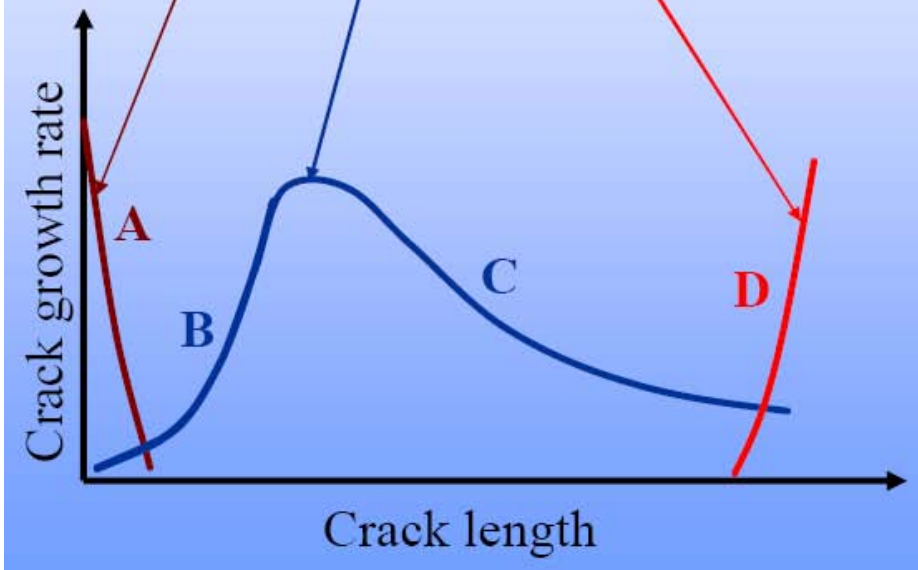




- 33 MGT = 1 million wheels passes on heavy haul track
- A certain fraction of wheels plastically deform the rail in the direction of applied tractions.
- Each loading cycle “ratchets” the surface layer until the ductility of the steel is exhausted
- Eventually a crack initiates

Crack growth





A: Crack initiation and early propagation by ratchetting

B: As length increases, the crack propagation rate increases

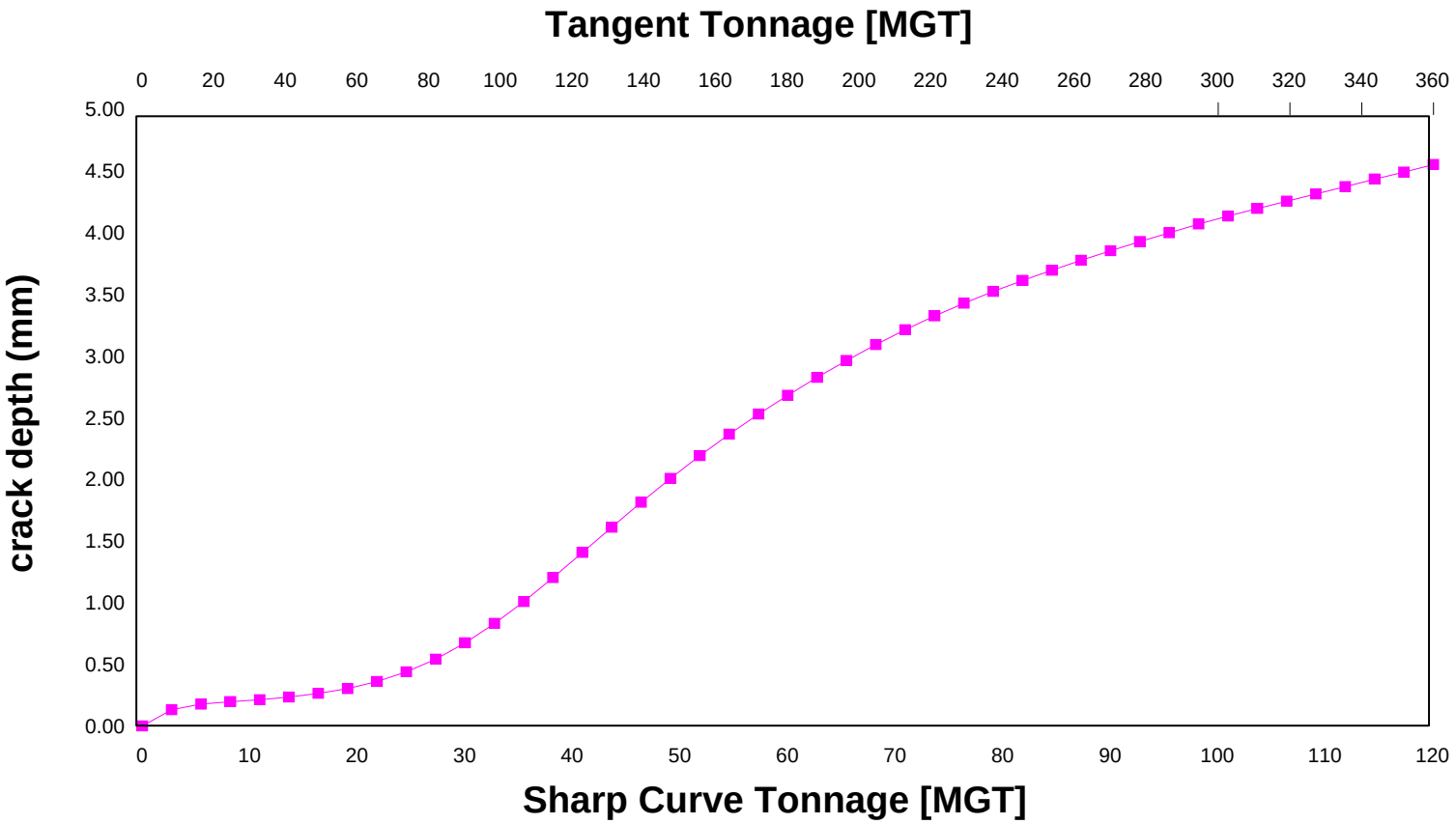
C: However, long(ish) cracks move away from the contact stress field, and the rate of crack propagation drops

D: Finally the crack is driven by bending

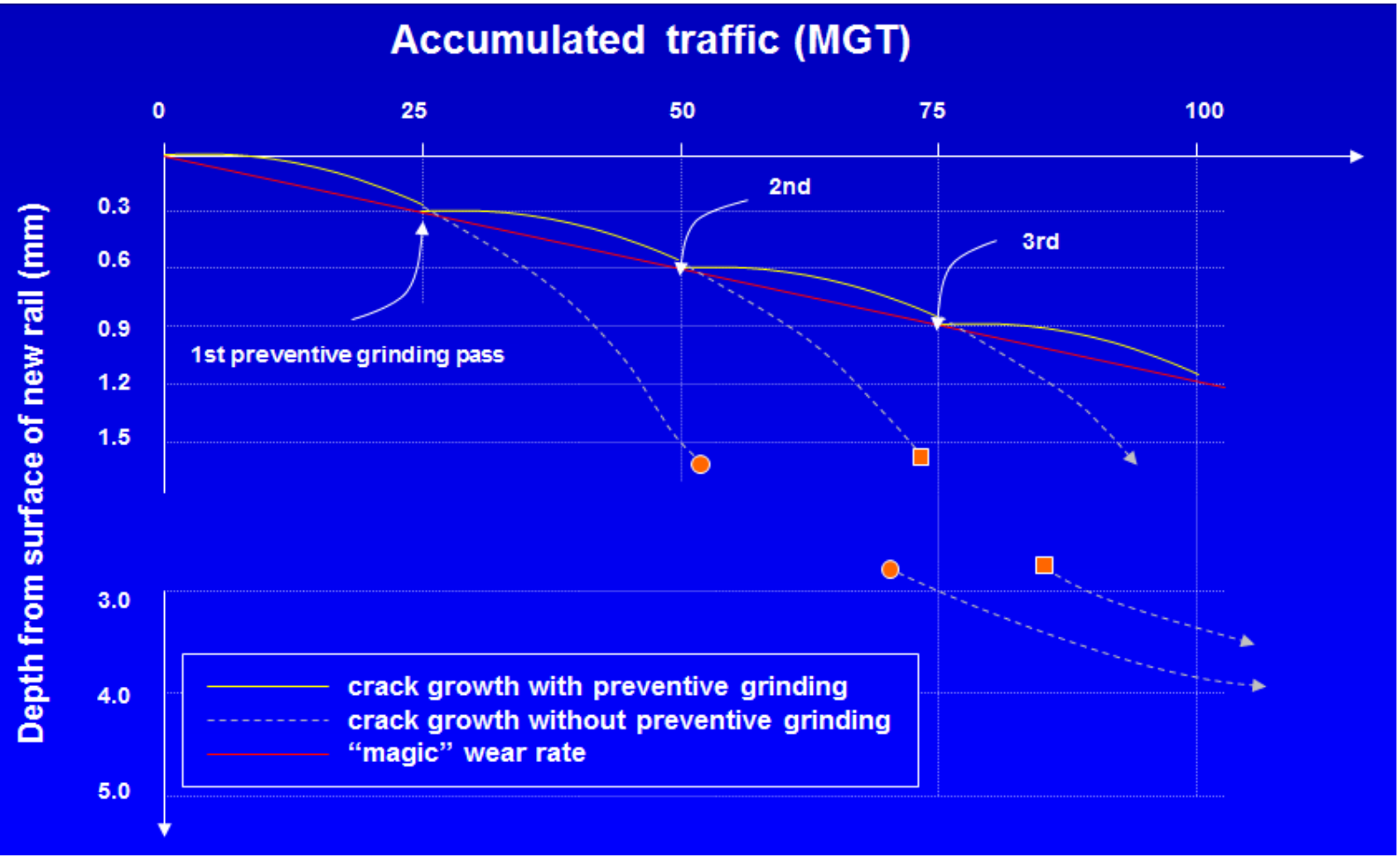
Note that these curves shift with operating conditions.

Kapoor et al (UK)

Crack growth rate (depth vs MGT)



Preventive Rail Grinding

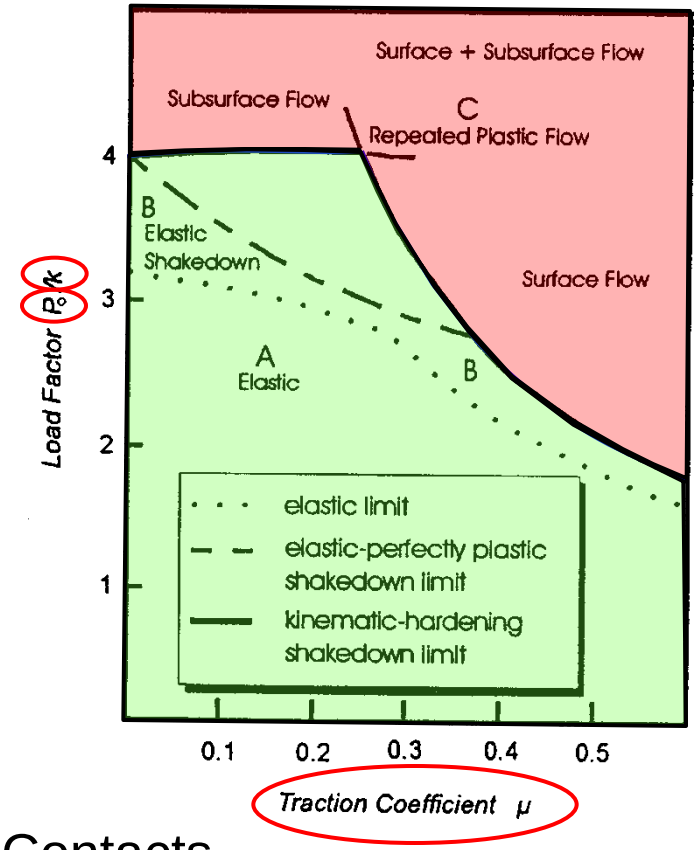


1.2mm/100mgt
0.75"→1.6BGT

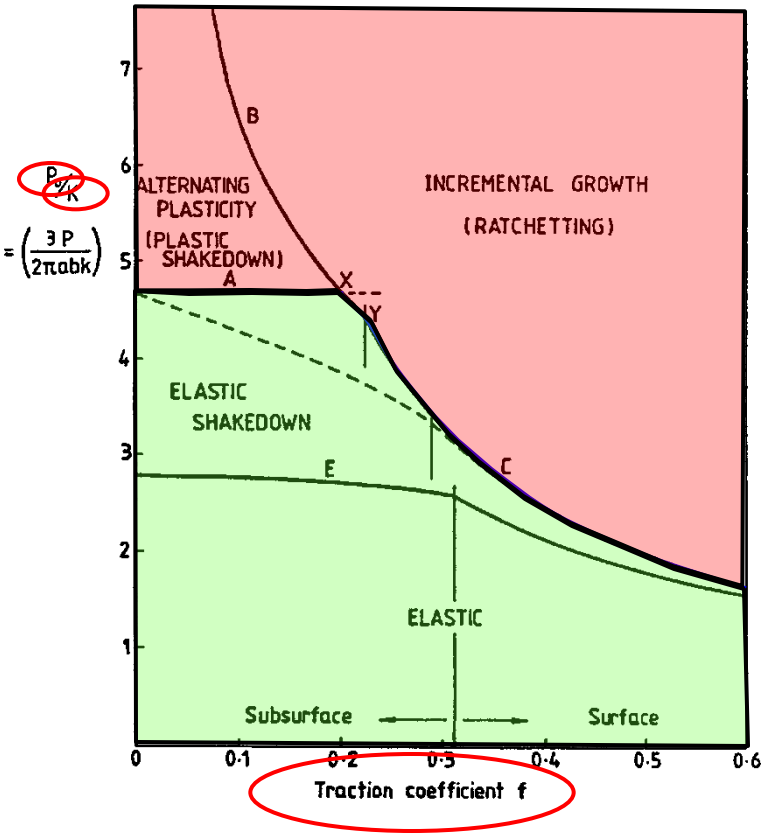
Local conditions

- Curvatures
  - tangent, mild, sharp
- Metallurgy
  - new, old, intermediate, premium
- Super-elevation
  - e.g. mixed freight/passenger
- Friction Management
- Logistics

Crack initiation and Shakedown

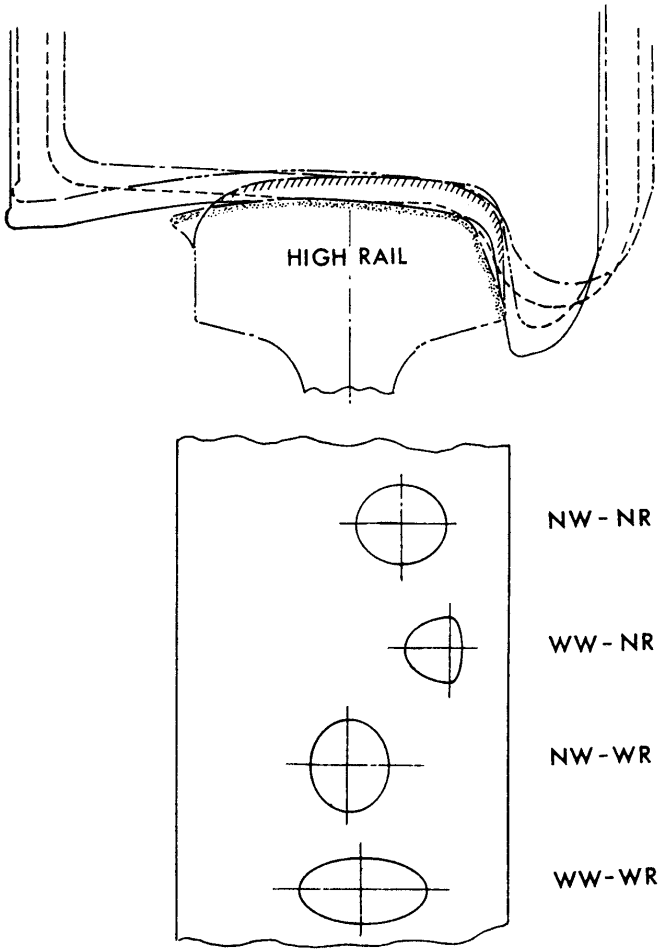


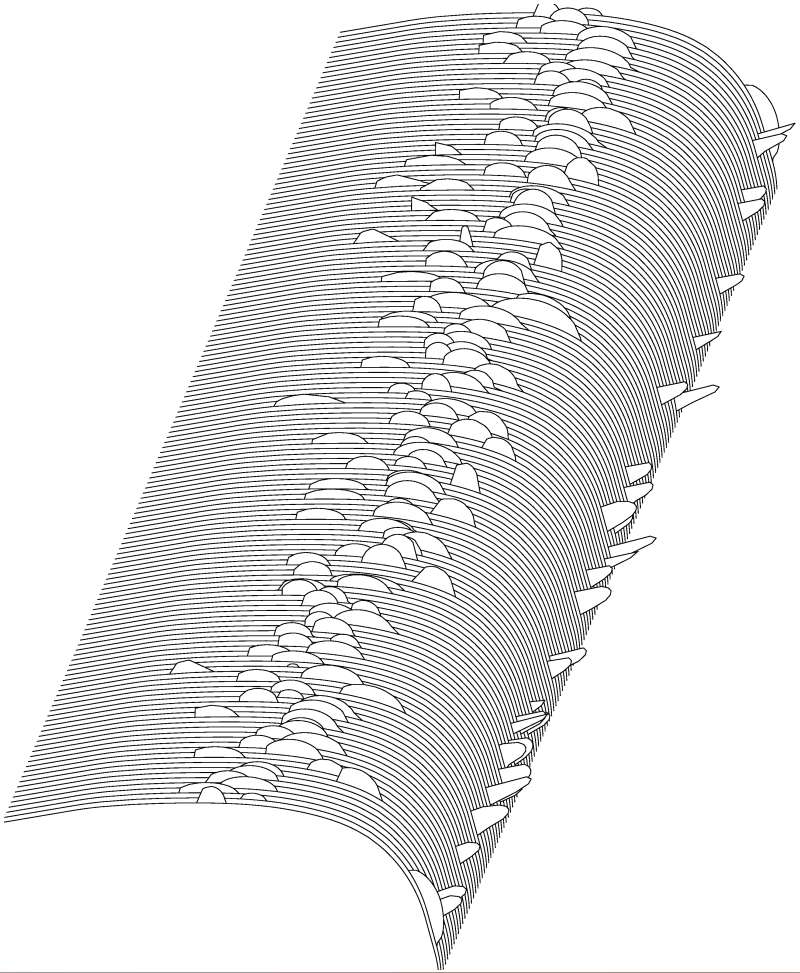
Line Contacts



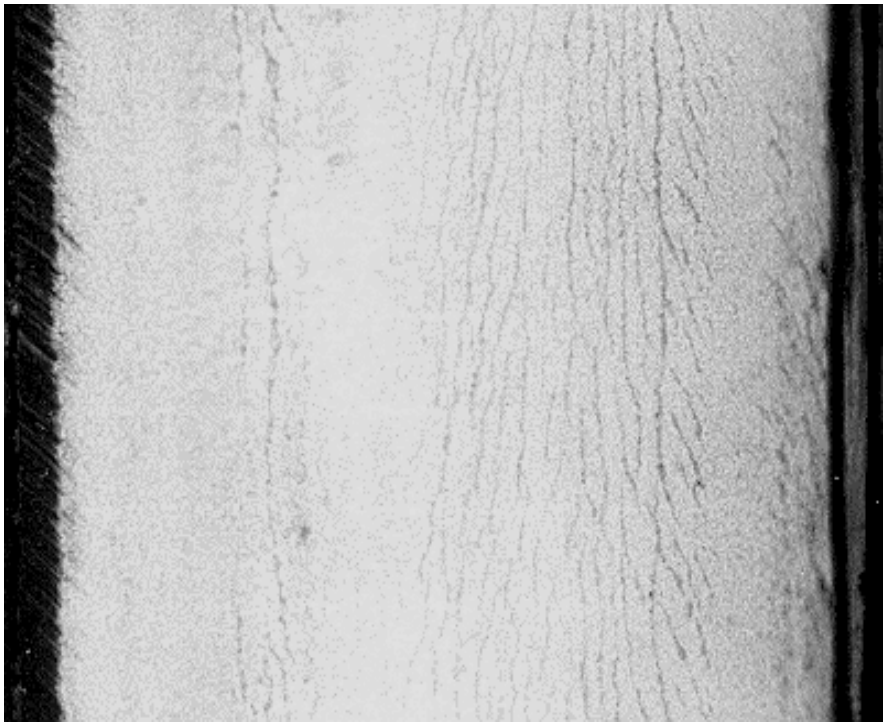
Point Contacts

Pummelling



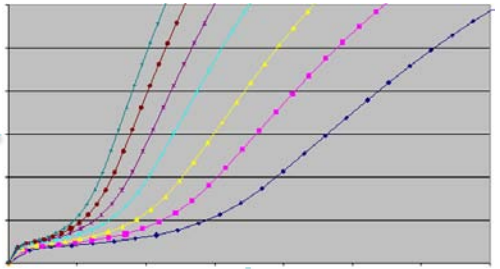


The Optimal Grinding Interval



Predictive Preventive

historical data
- past grinding effort
- defects
- costs



- curvature breakdown
- rail wear limits
- annual tonnage

optimized rail grinding cycle based on ROI analysis

grinder capabilities

The future?

- Condition based
  - crack detection, profile measurement
  - “mechatronic rail grinder”
- More frequent, higher speed
- incorporates metallurgy, defects, welds

The Magic Wear Rate

- Optimal metal removal to control RCF
  - Preventive
  - Synergistic with other methods
  - lowest cost, safest
- future:
  - improved measurement tools
  - better understanding of initiation and growth rates
  - improved implementation