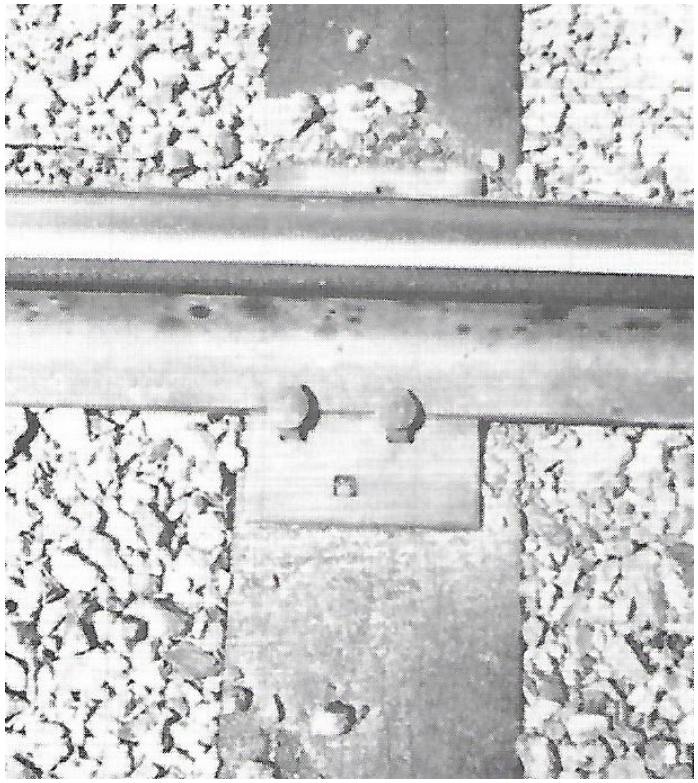
WEAR AND CONTACT FATIGUE MODEL FOR RAILWAY RAIL

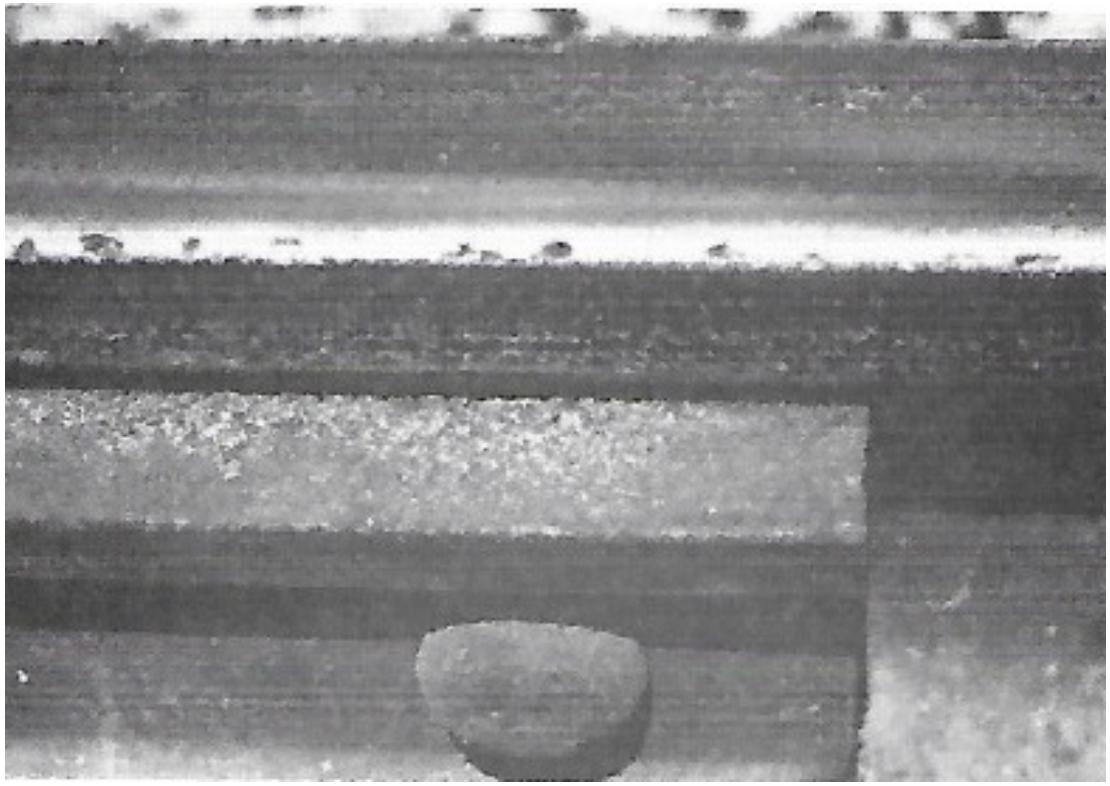
By JOSEPH KALOUSEK

Source: NRC technical report: J. Kalousek: Wear and contact fatigue model for railway rail, TR-WE-50, NRC NO. 27491, 1986/10

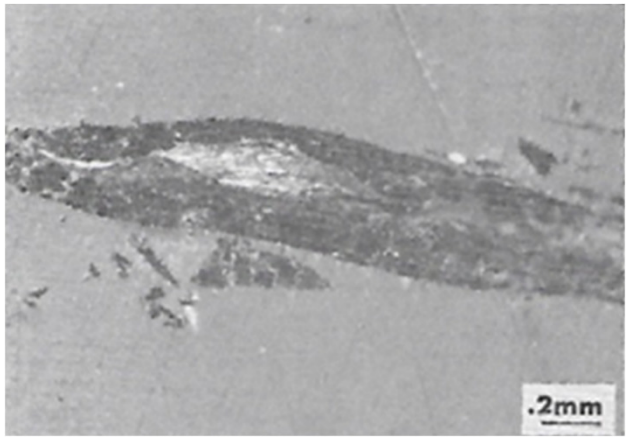
Observe, observe, seek serendipity

Severe adhesive gauge face wear





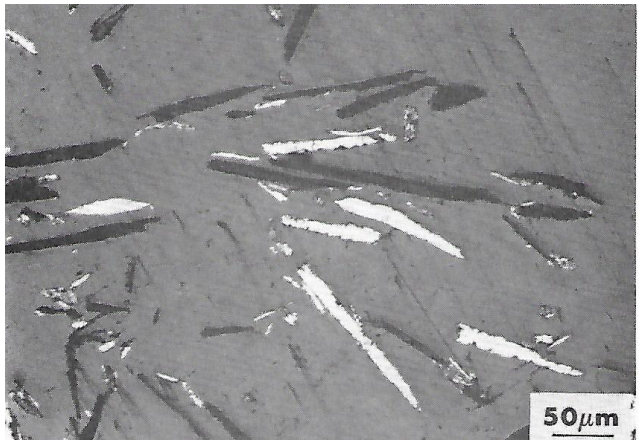
Wear particles



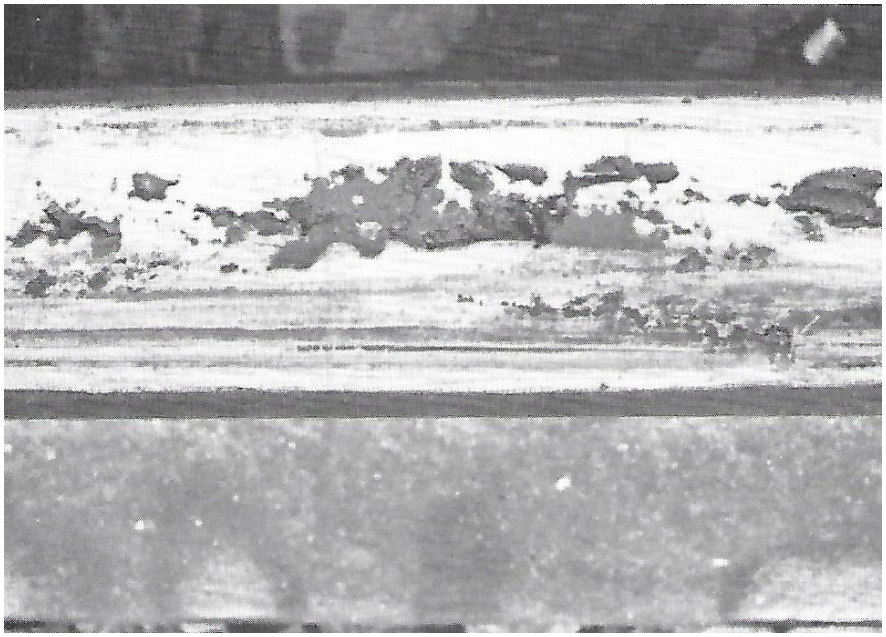
Severe
adhesive wear

Oxidative wear

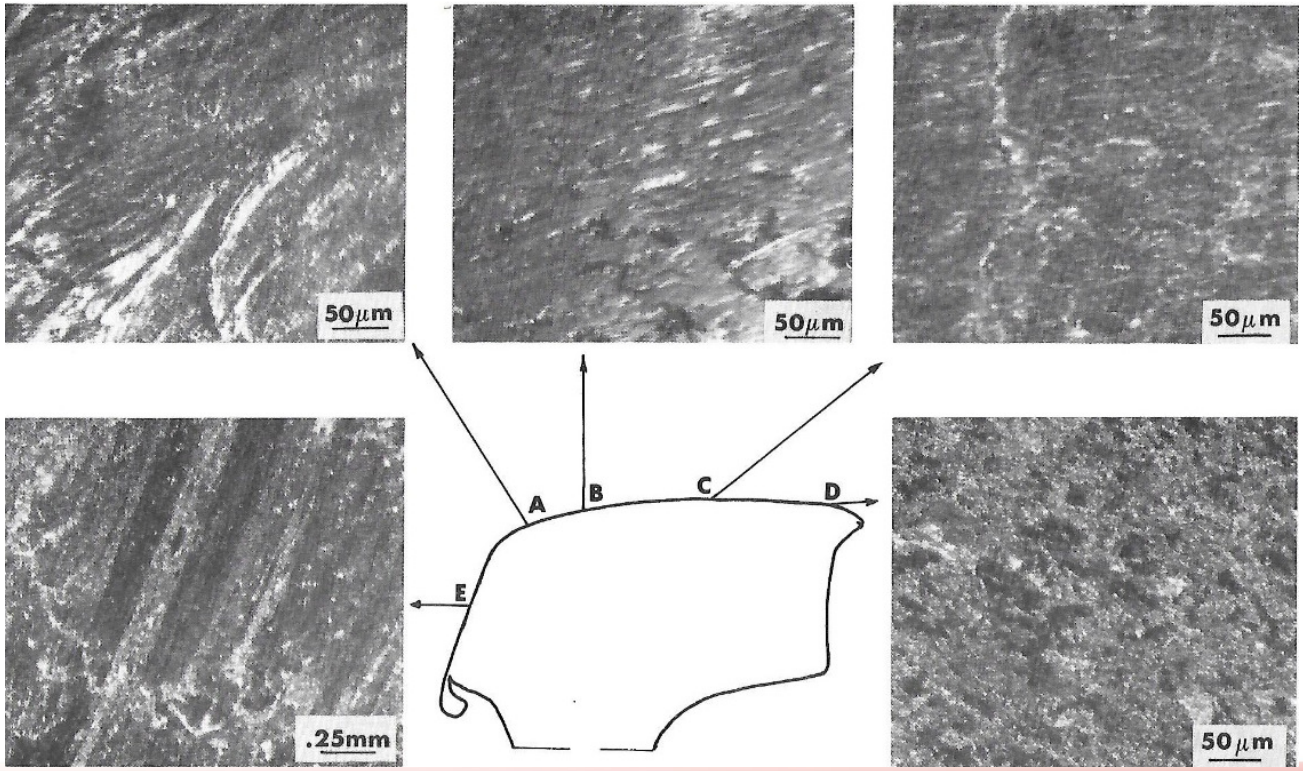
Delamination wear



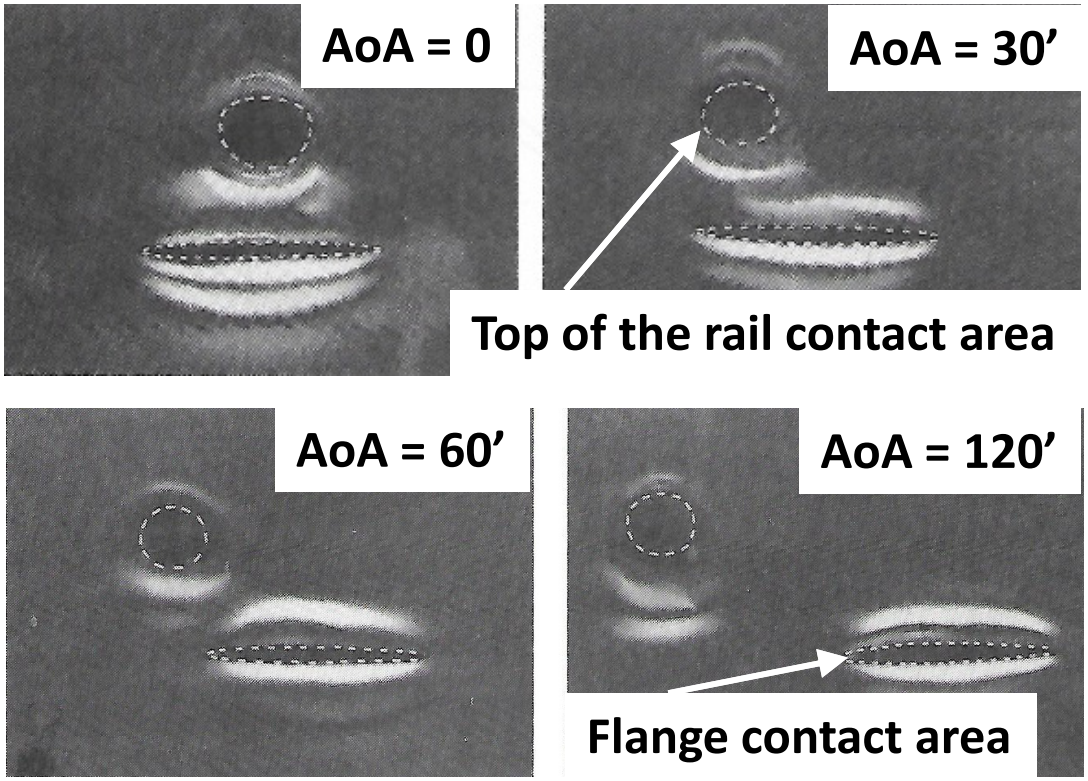
Severe forms of contact fatigue

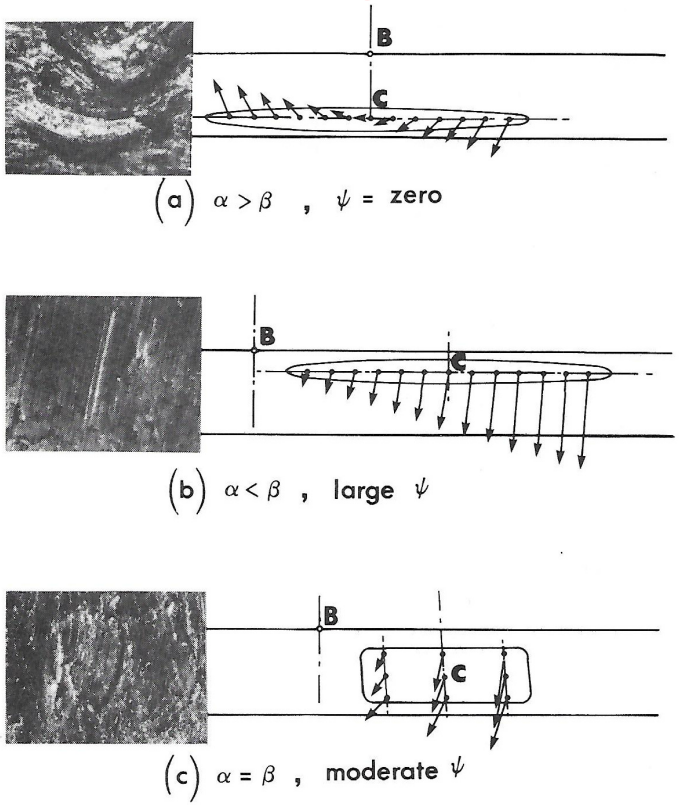


Rubbing marks and indentations on the surface of the rail

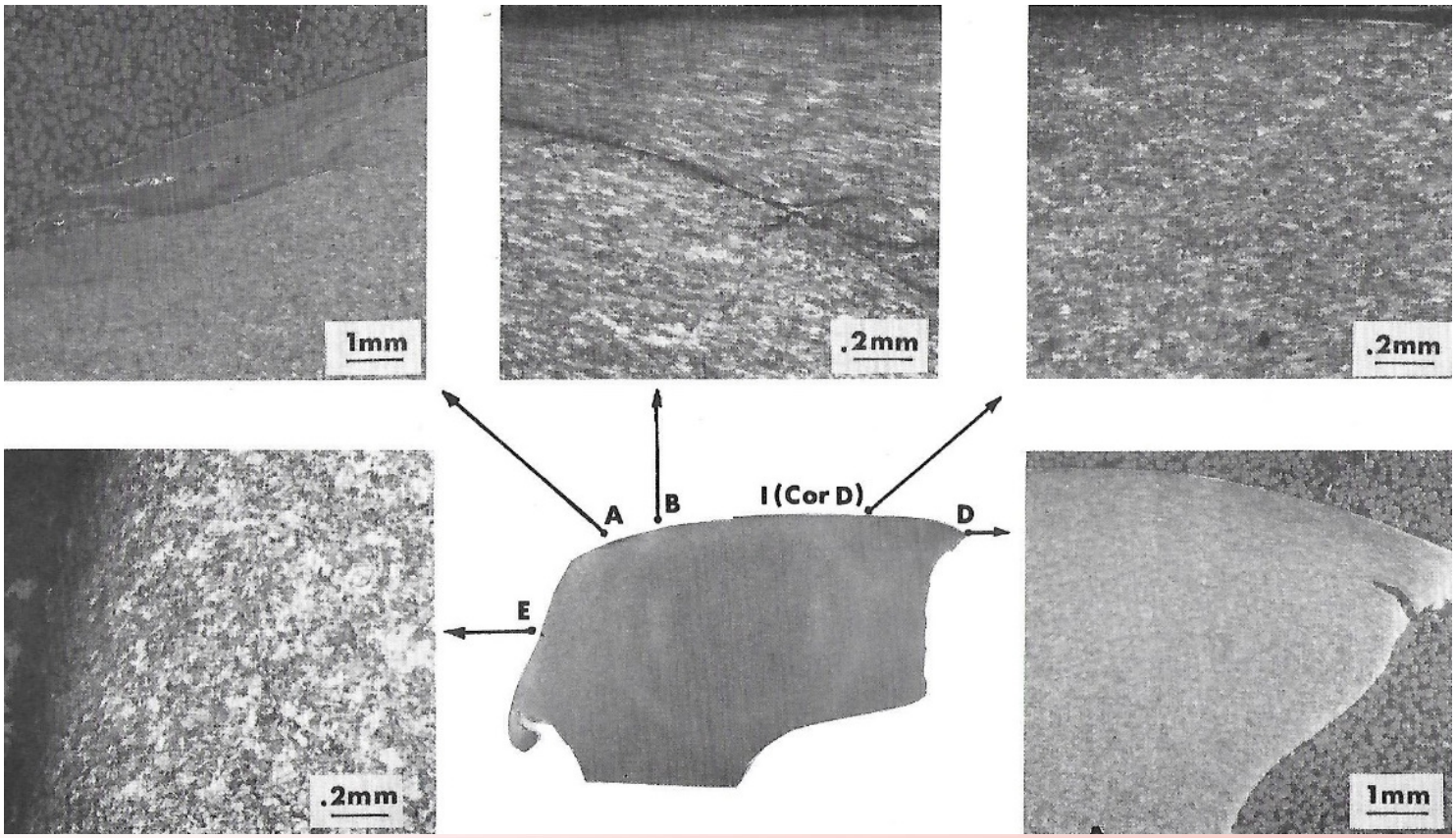


Gauge face rubbing marks originate from prolate cycloid trajectory of wheel flange asperities

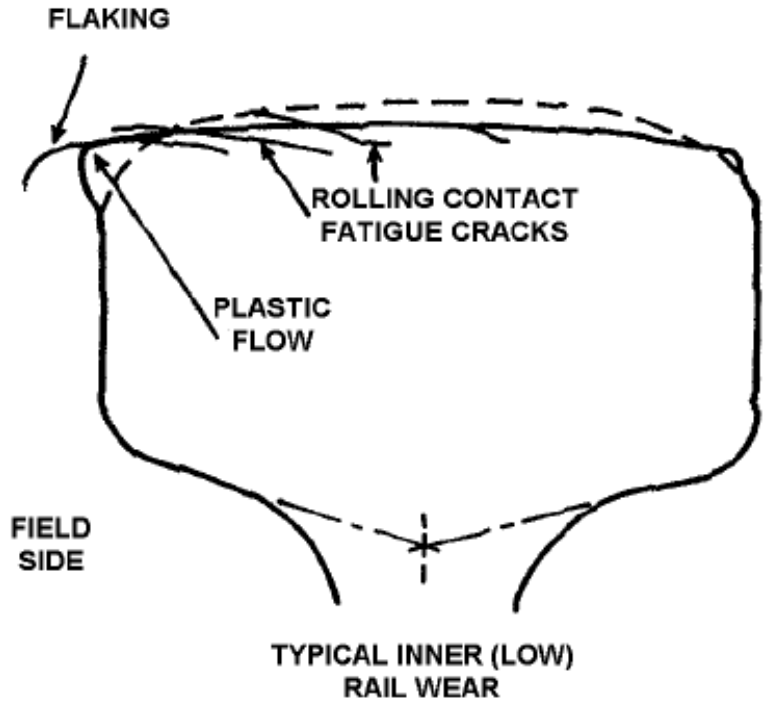


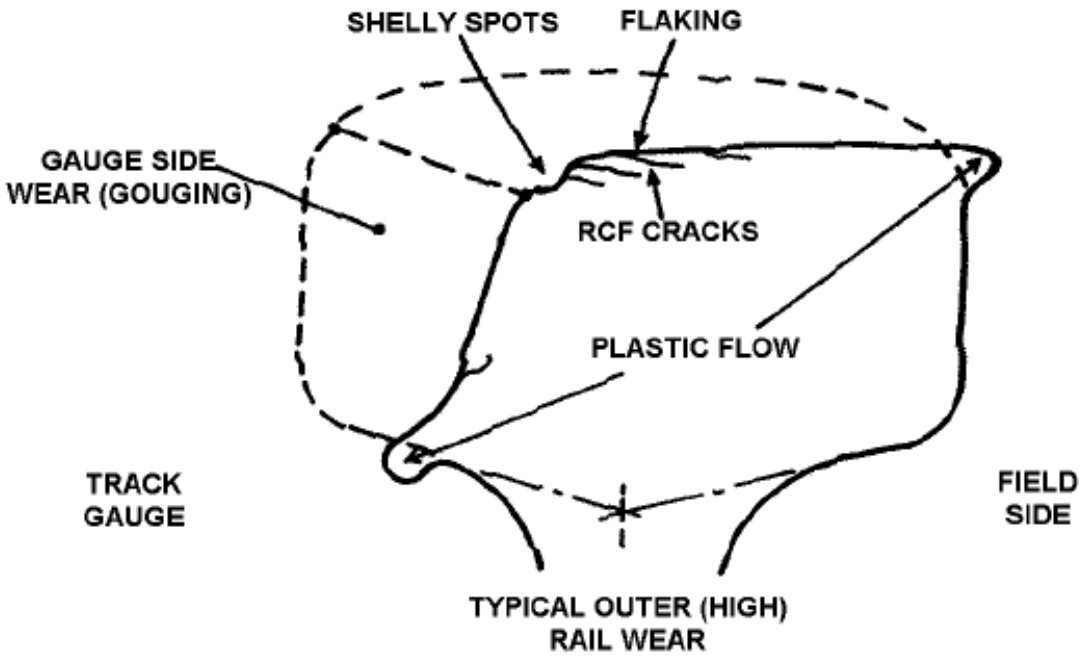


Subsurface plastic deformation, RCF cracks

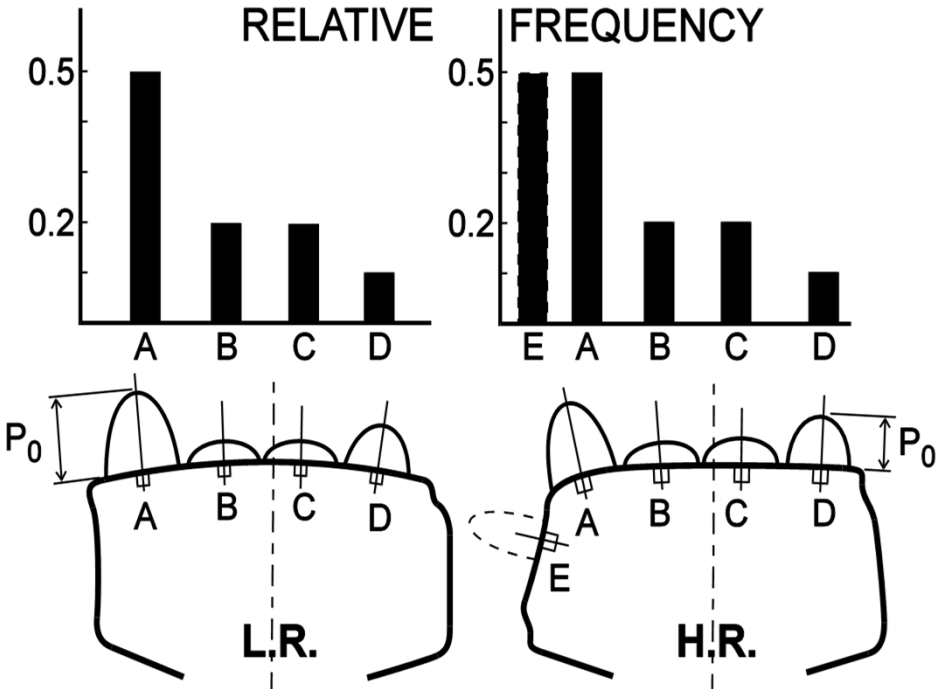


Wear and RCF damage of the H and L rails (one of my first illustrations ≈ 1975)

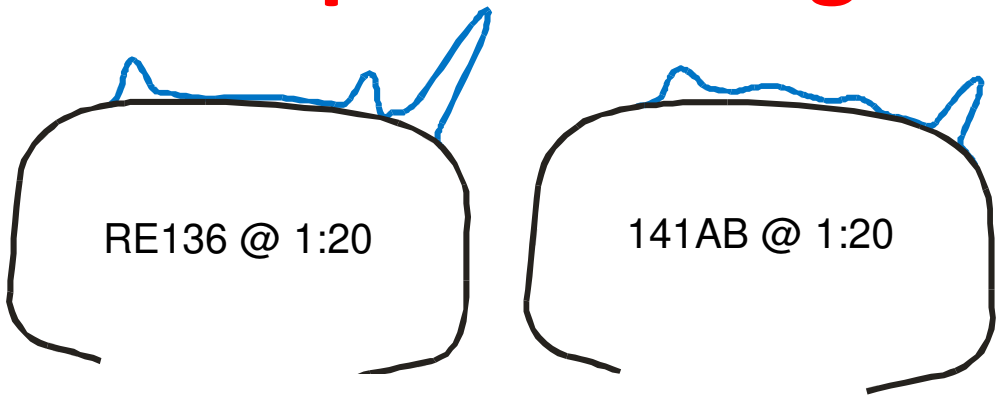


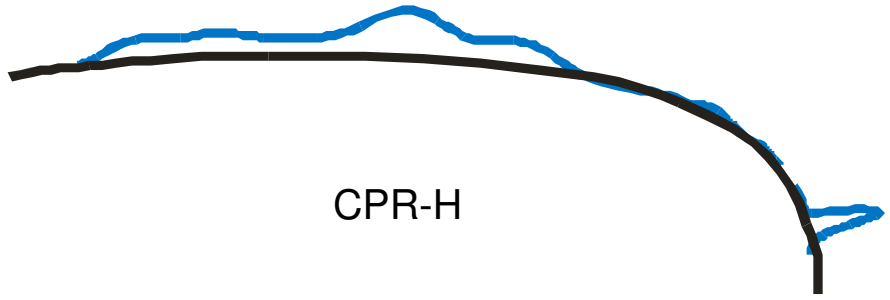


Pummelling - essential in profile design

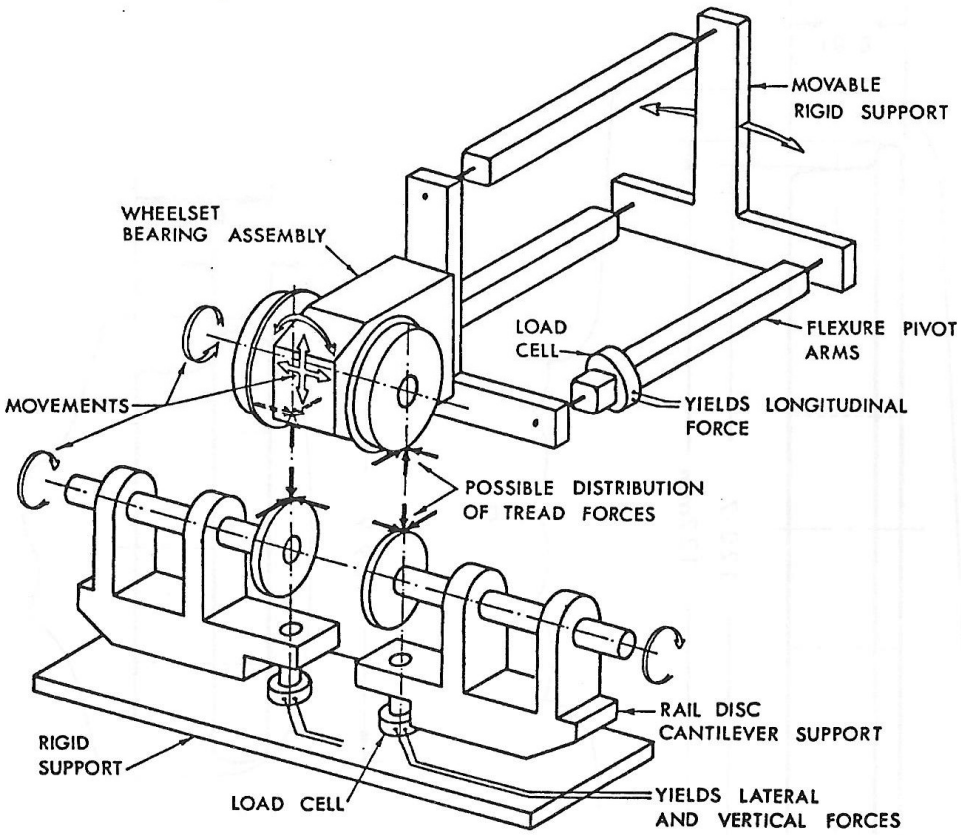


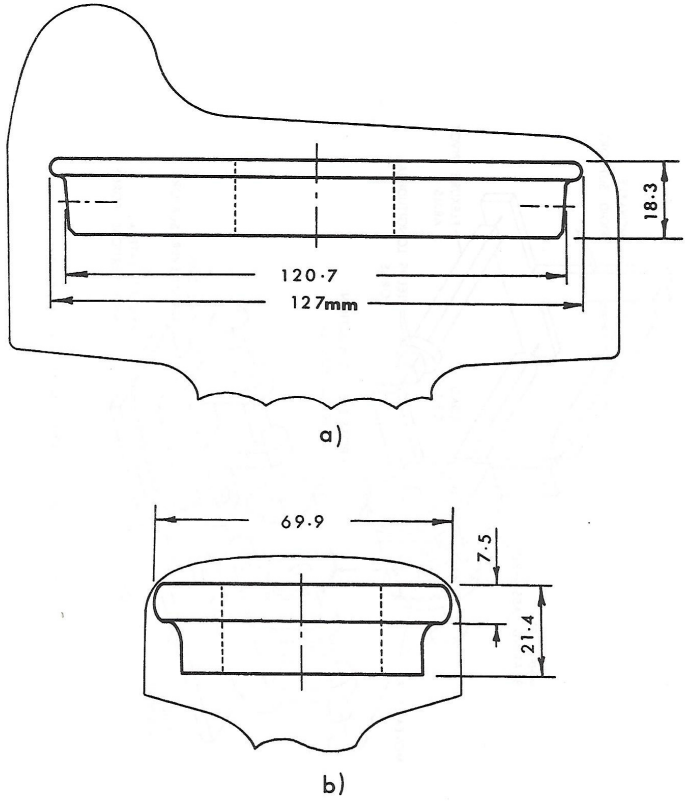
Relative frequency of contact for high and low rails in 8º curve



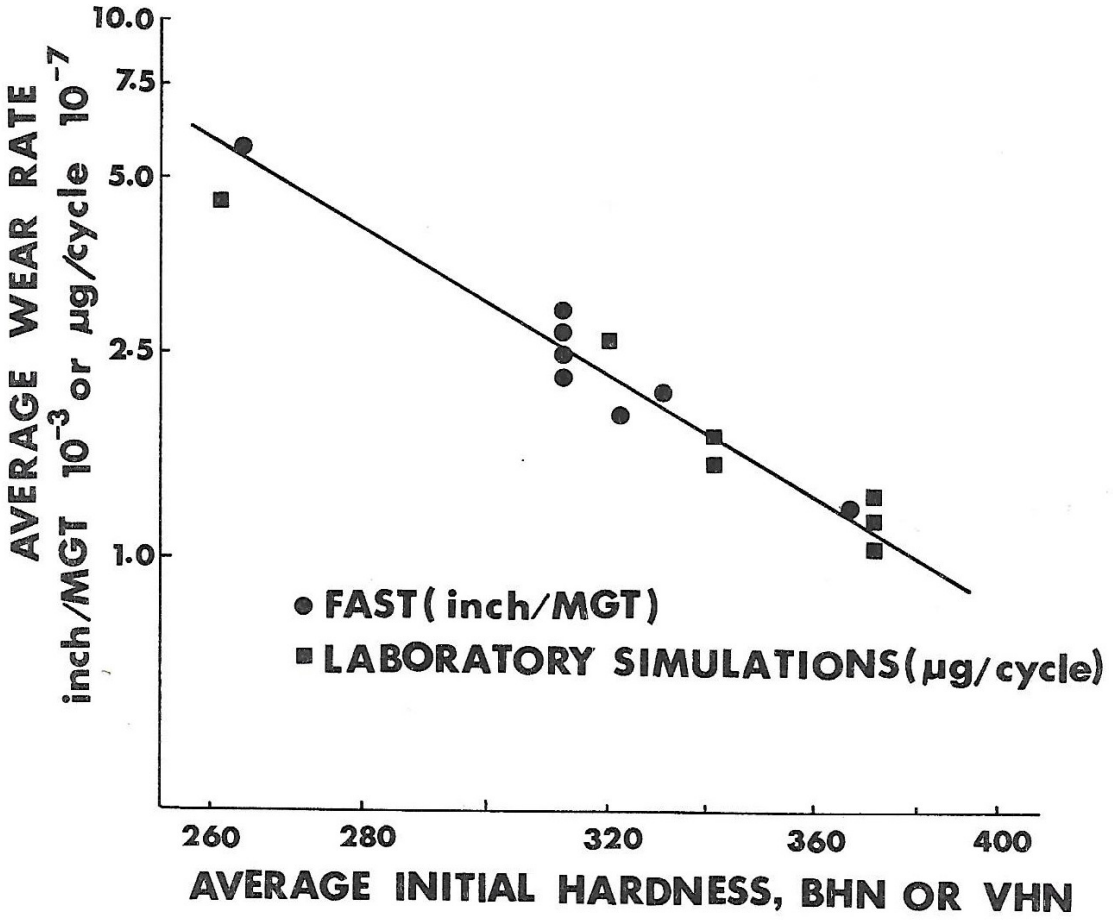


Schematic of wheelset on pair of rails 1/10 scale wear test apparatus





Correlation of dry gauge face wear at FAST and rail/wheel wear apparatus

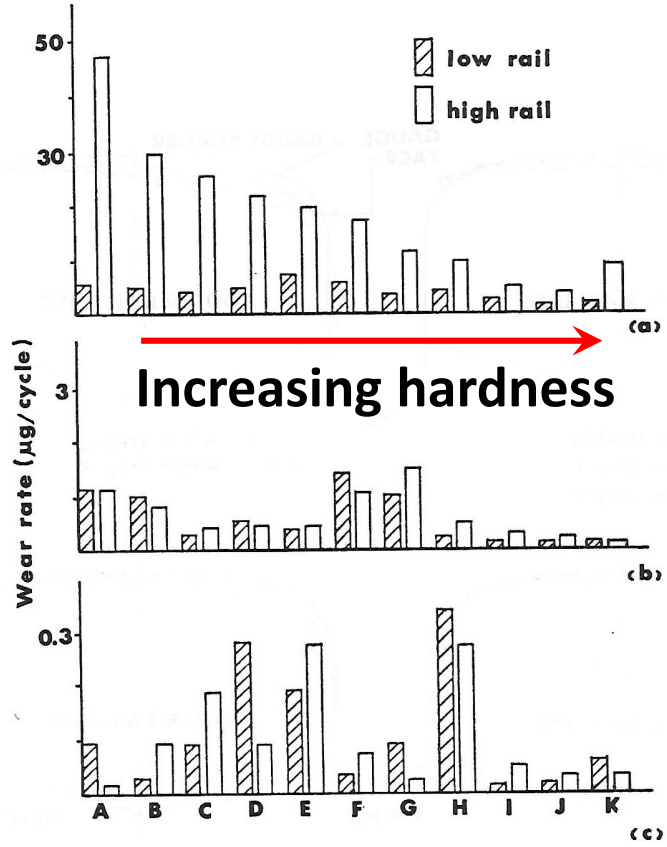


Wear rates of several rail steels

No lubrication - Dry

Grease + 20% sand

Grease lubrication



Difference in scales; about 1 : 160

Wear rate converted to surface recess of steel[4] in sharp (8°) curve

GD – gauge face, dry (no lub.)

GL – gauge face, lubricated

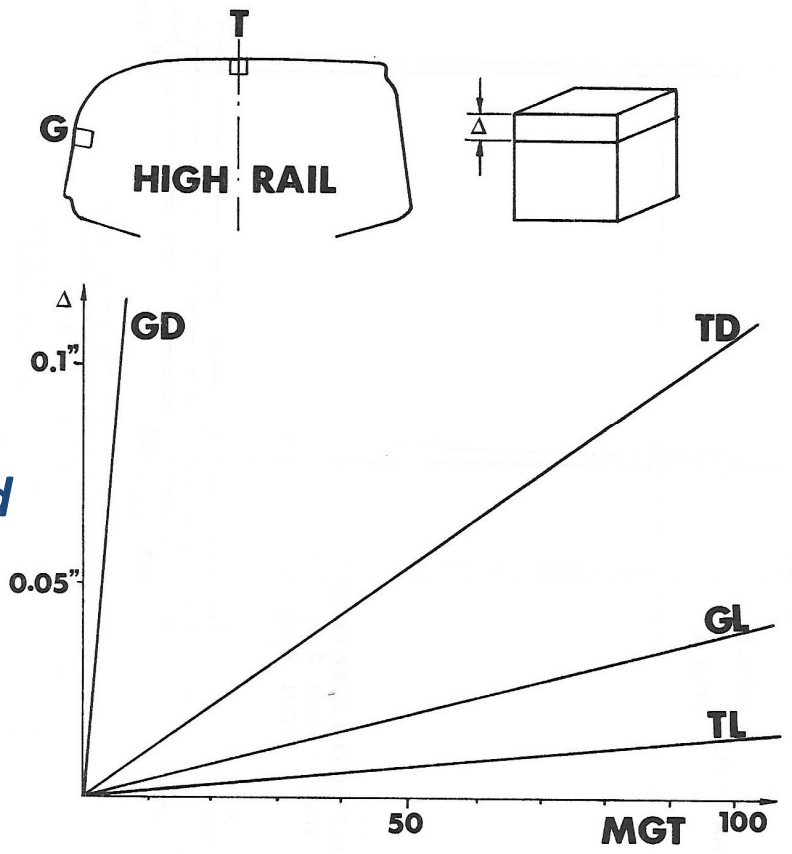
D to L wear ratio = 100 : 1

Lubrication is with grease + 20% sand

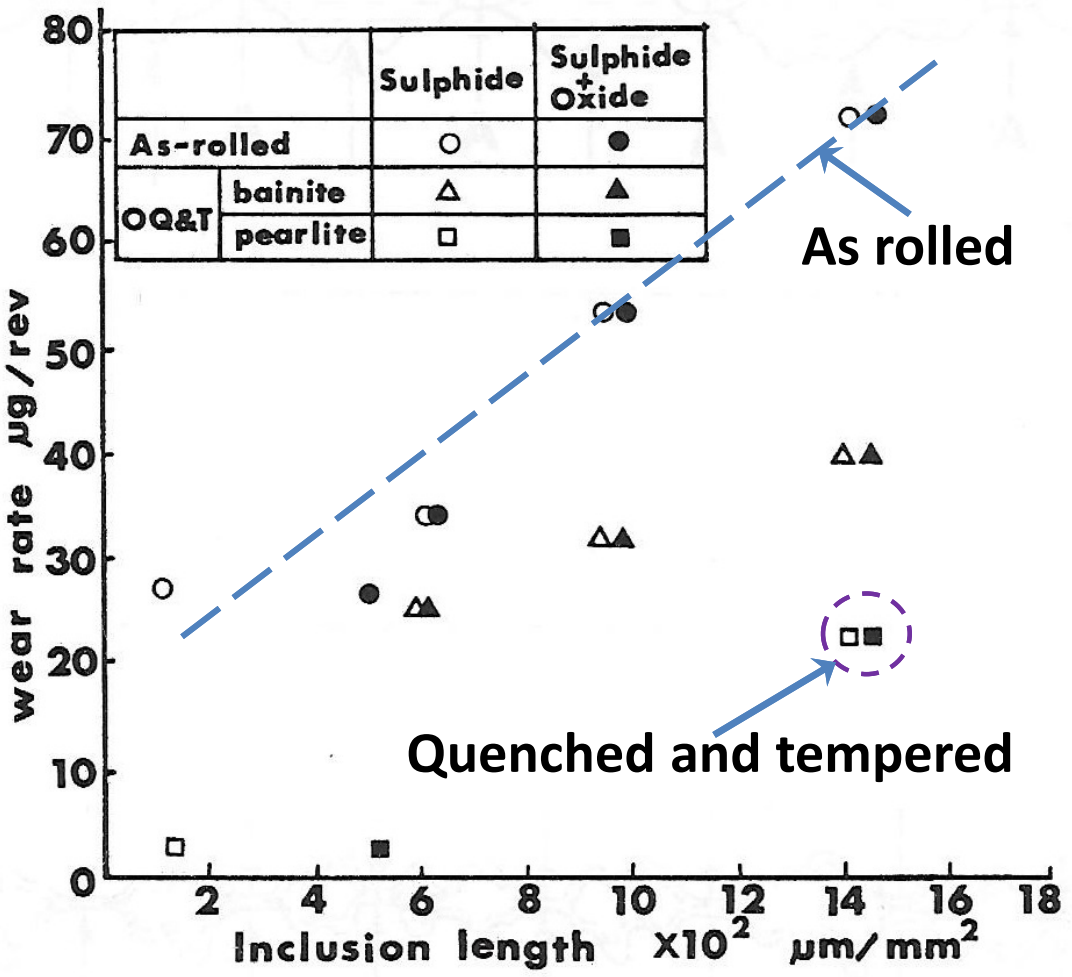
TD top of the rail, dry

TL top of the rail, lubricated

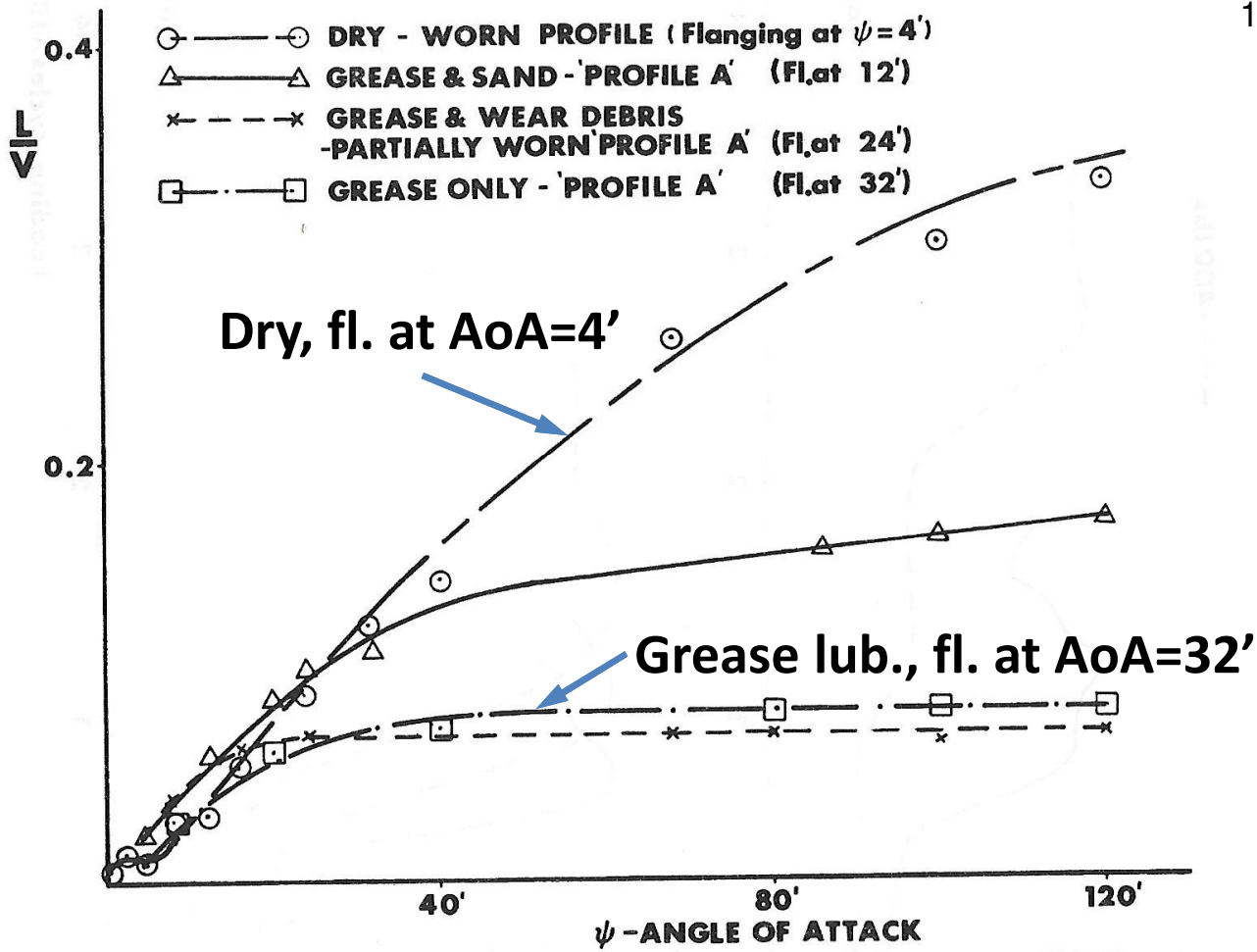
D to L wear ratio = 5 : 1



Effect of Sulphur inclusion density on dry adhesive wear at gauge face



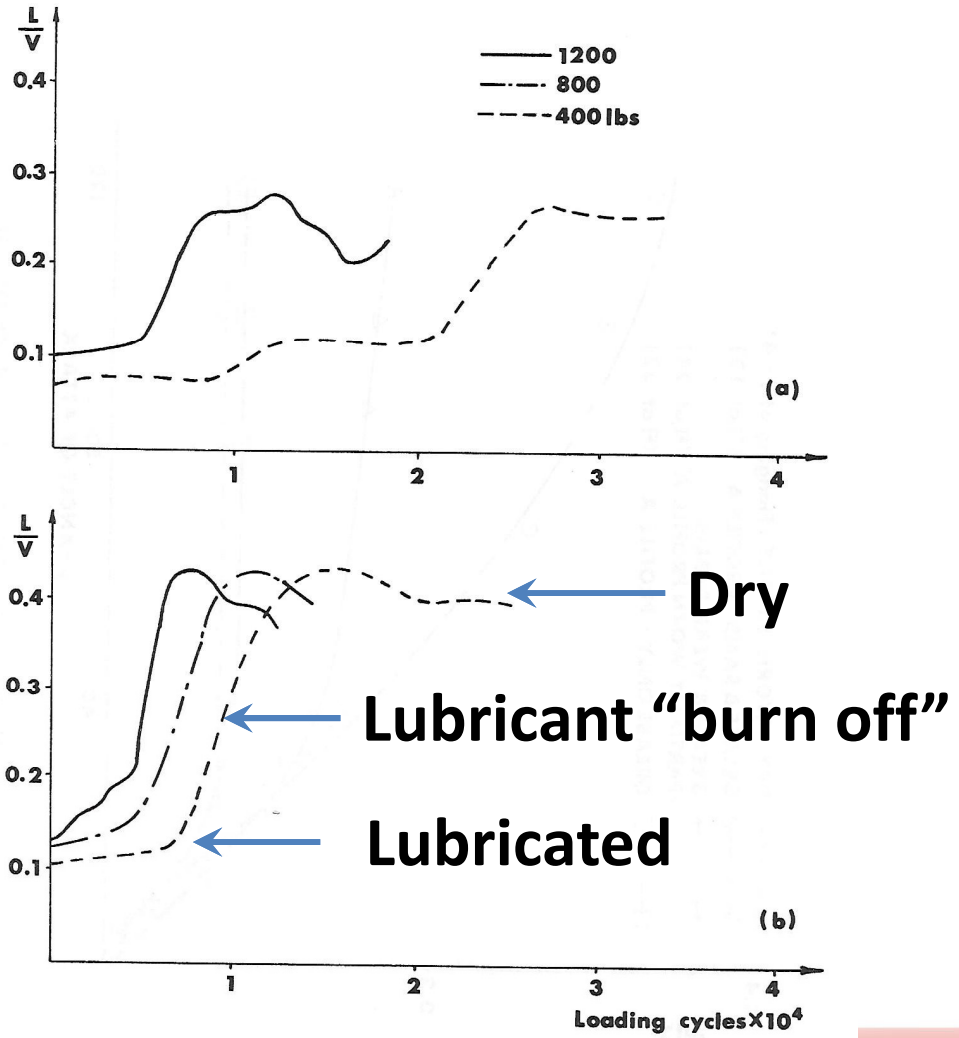
Effect of top of the rail lubrication on L/V of low rail disc



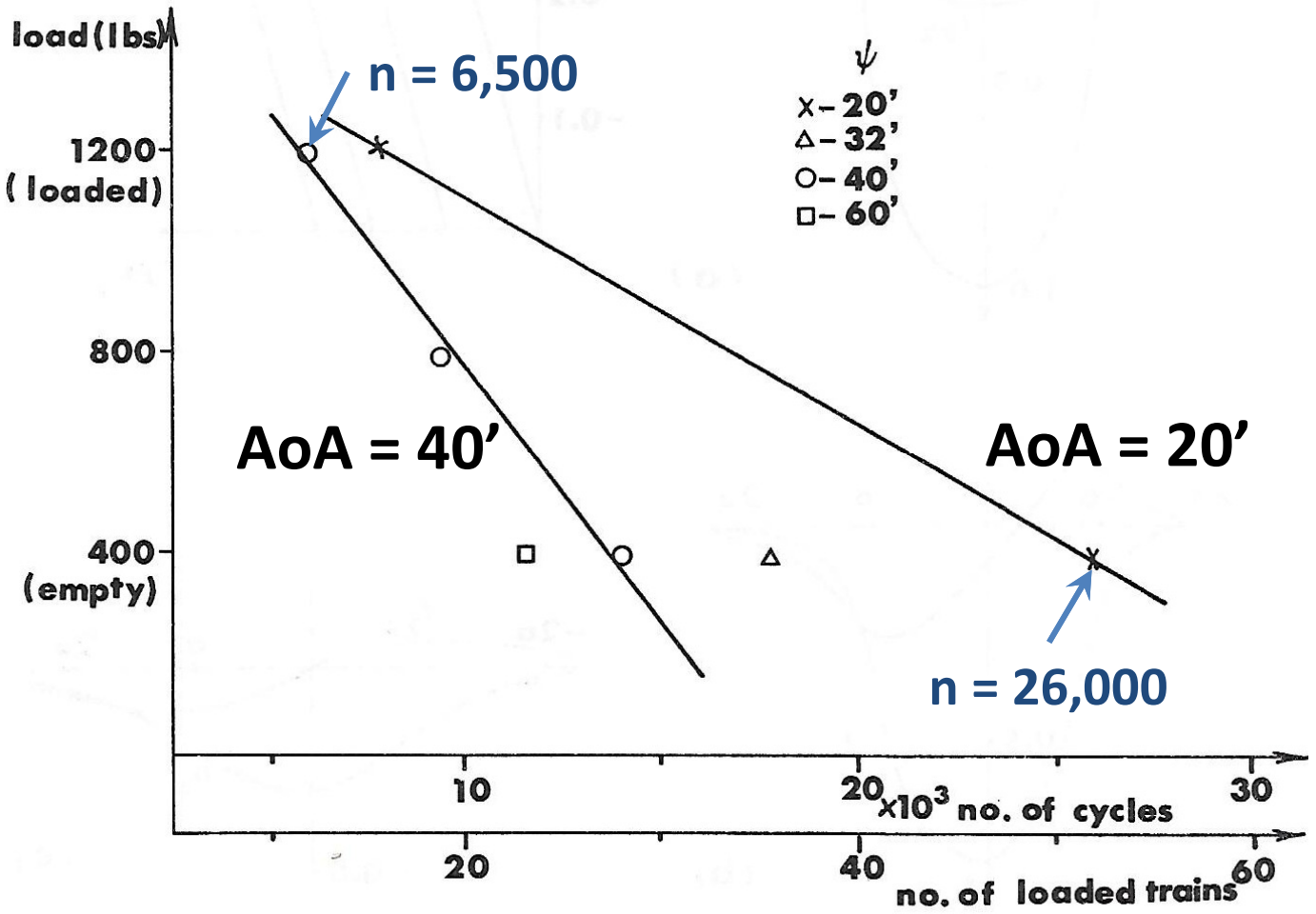
AoA = 20’

Retentivity tests; how long does lubricant last

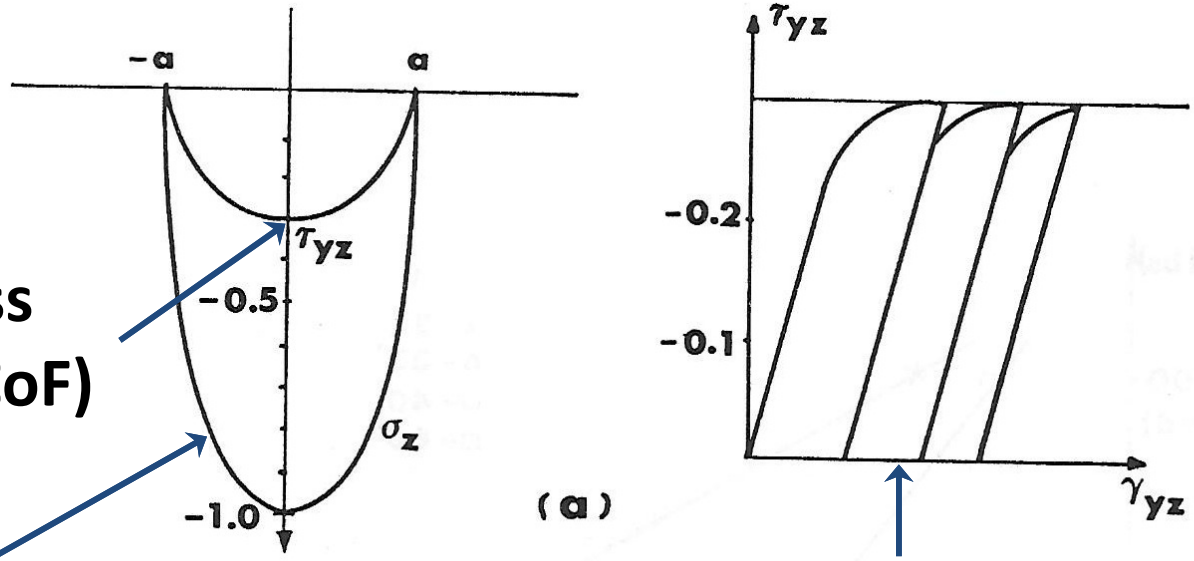
AoA = 40’



Lubrication breakdown as function of load and AoA



Generation of cracks by plastic instability within the surface layer



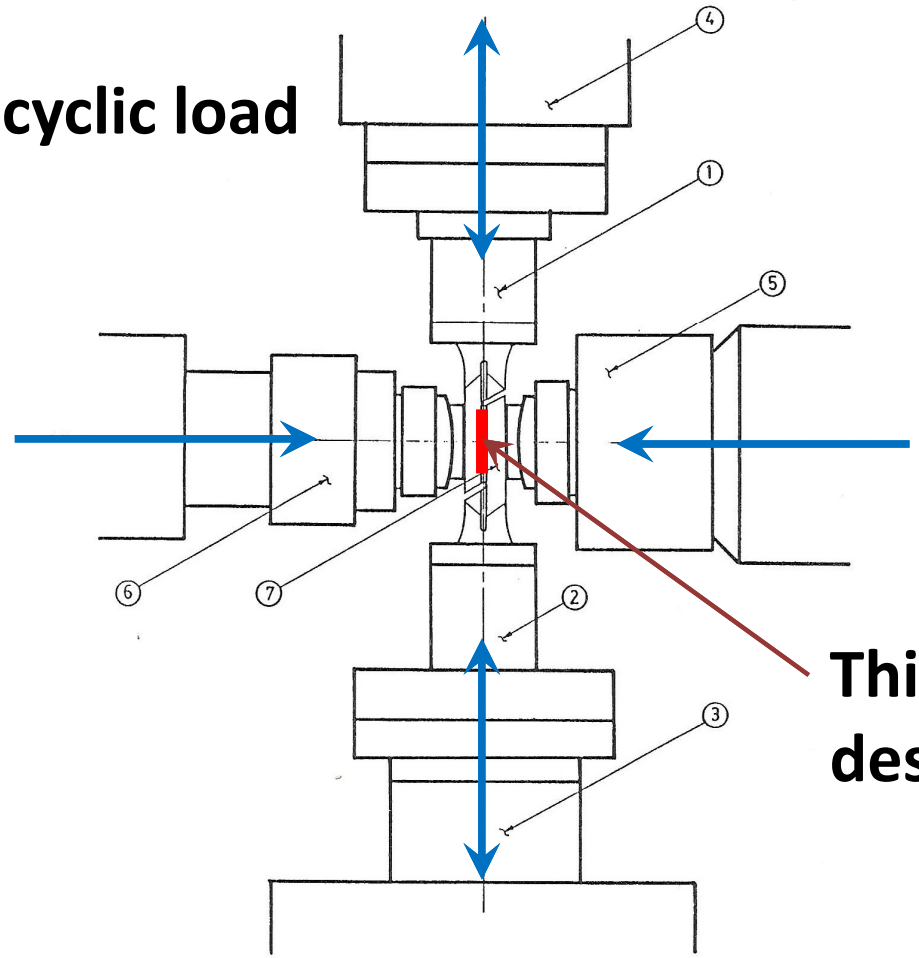
Shear stress (given by CoF)

Compressive stress

Ratchetting results in cumulative plastic flow, ductile fracture and formation of crack

Biaxial loading fatigue tester

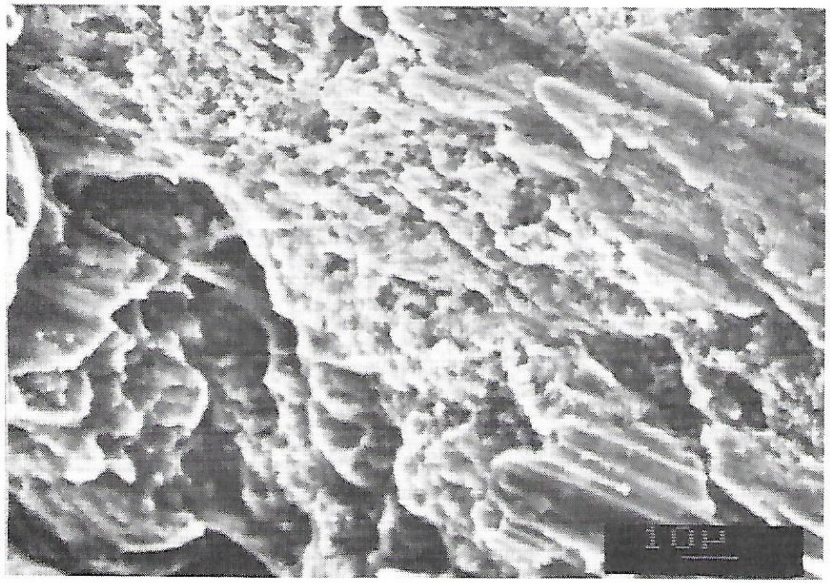
Shear cyclic load



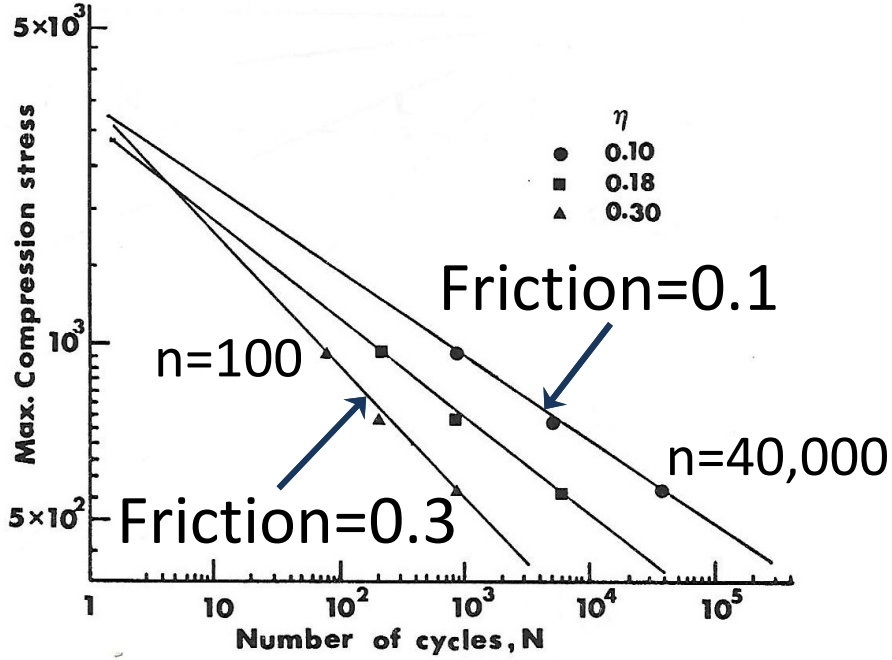
Compressive cyclic load

Thin test region of specially designed test specimen

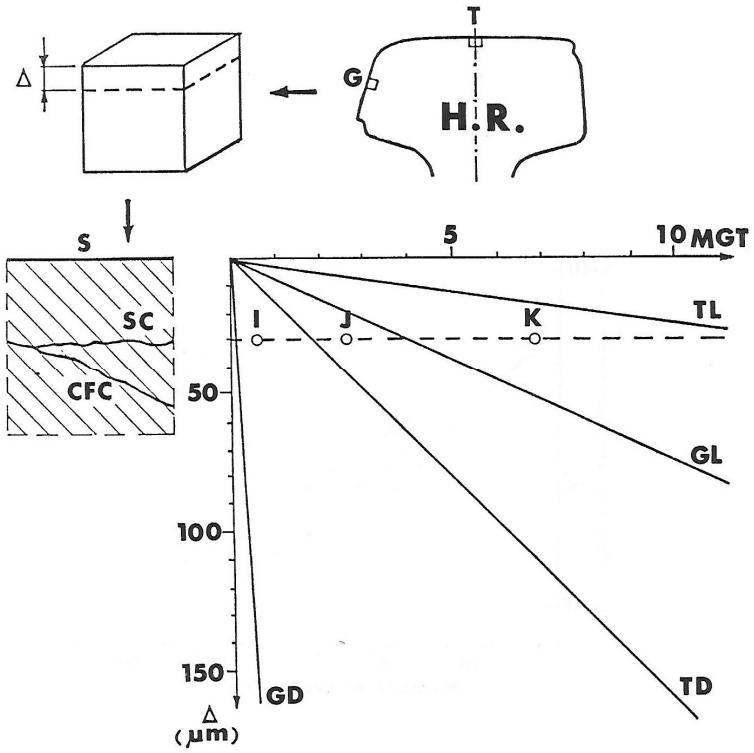
Number of cycles to crack initiation by plastic instability



Ductile shear fracture of rail steel



Relationship between wear and surface crack initiation



Crack initiation points:

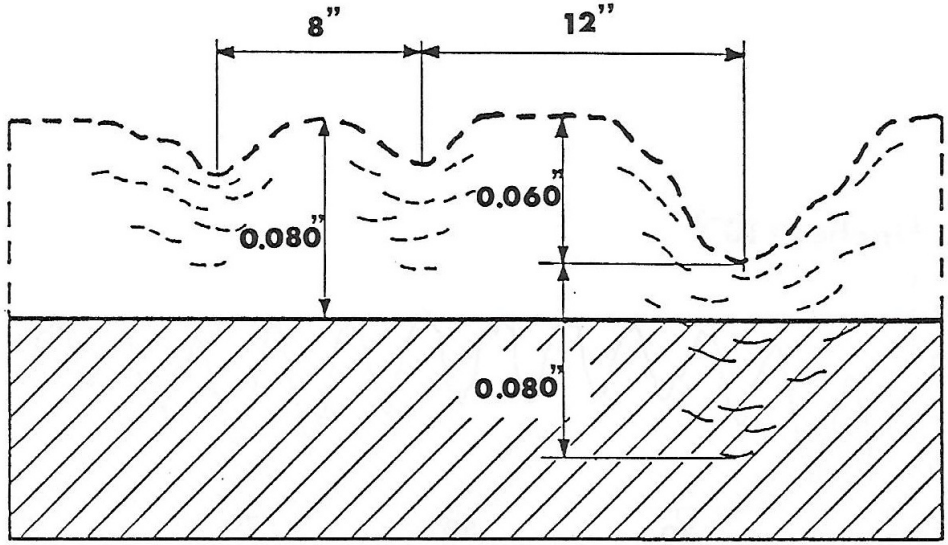
I – grease and sand lub at 0.18,
p_o = 2,500MPa

J – dry at CoF = 0.3,
p_o = 1150MPa

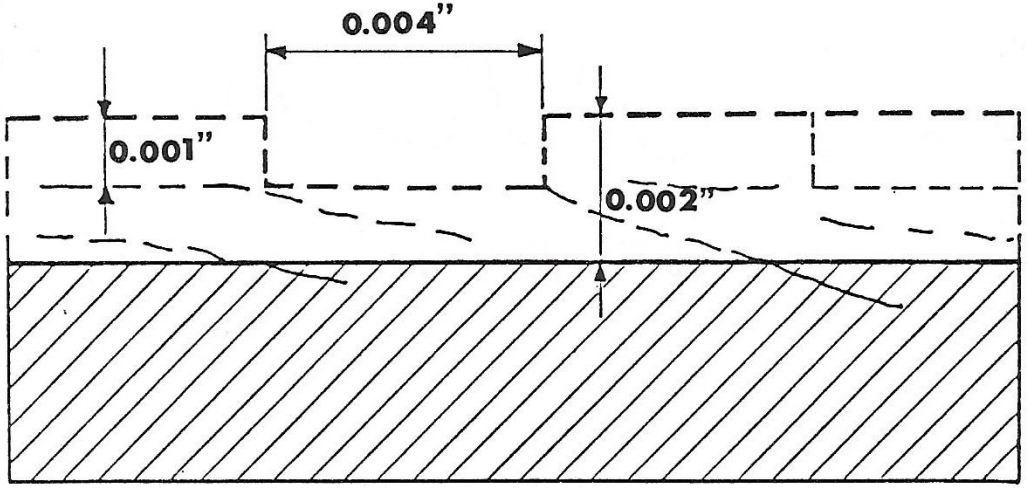
K – lubricated at CoF = 0.18,
p_o = 1150MPa

Joe Kalousek and Gordon Bachinsky are thinking how best to grind the rail

Cracks are removed by grinding of rail

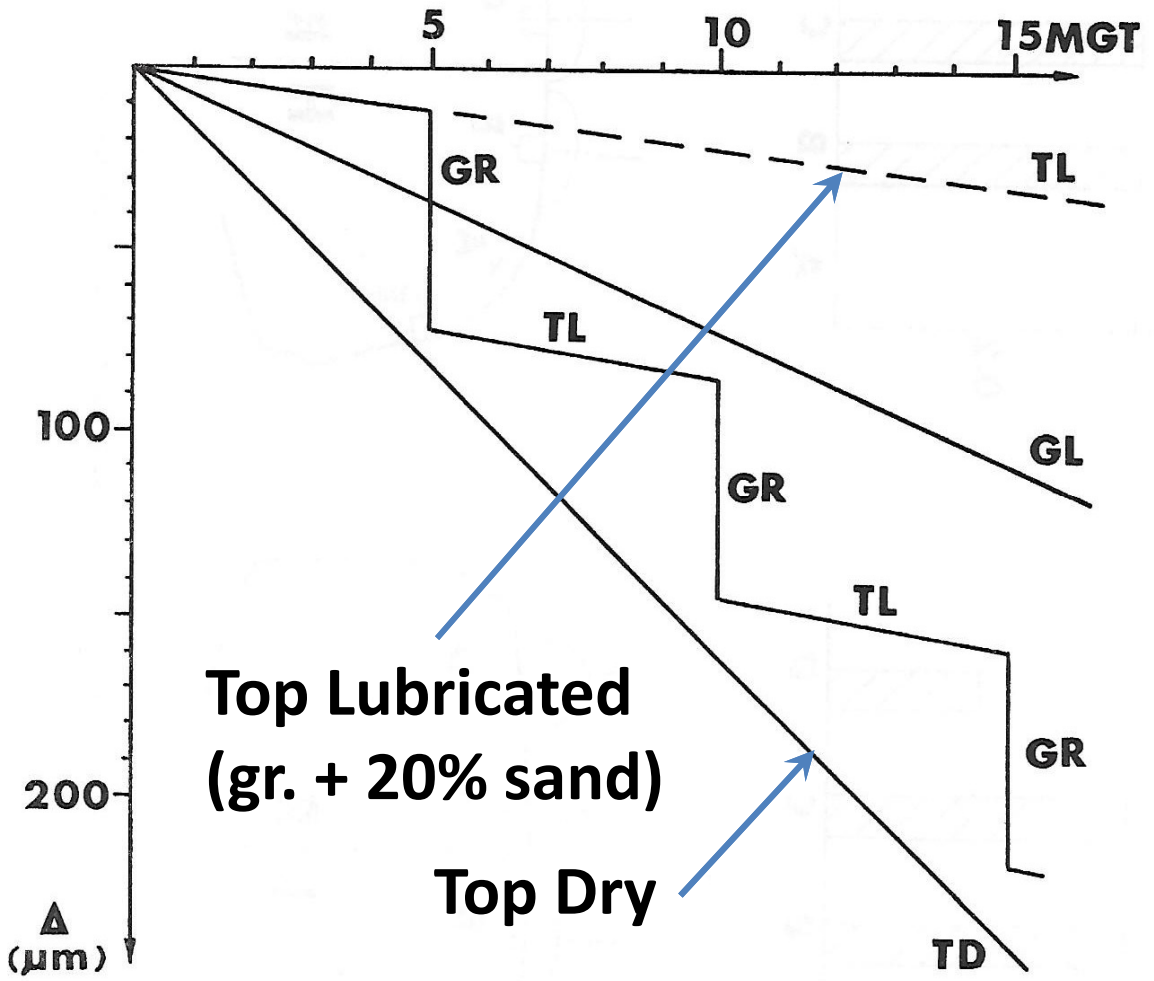


Corrective



Preventive

Preventive grinding in terms of surface recess at 8° curve



First rendition of preventive grinding method

“The grinding train passes over the territory each 5MGT and grinds all the sharp curves, half of the mild curves and a third of tangent track sections, so that all the mild curves and tangent track are ground once each 10 and 15MGT, respectively.”

Now referred to as 1:2:3 preventive grinding strategy

Historic conclusion from 1986

Preventive grinding

and thorough lubrication

with grease (GL) and grease and sand (TL)

that later evolved into friction modifiers

extends rail life!

Speakers at the first ARM seminar 1994

Joe Kalousek | Jude Igwemezie | Jim Hornaday | Gordon Bachinsky