Profile Design for Sound Transit

Rob Caldwell, P. Eng
Senior Engineer

National Research Council Canada
Surface Transportation

Investigations – 2010 & 2011

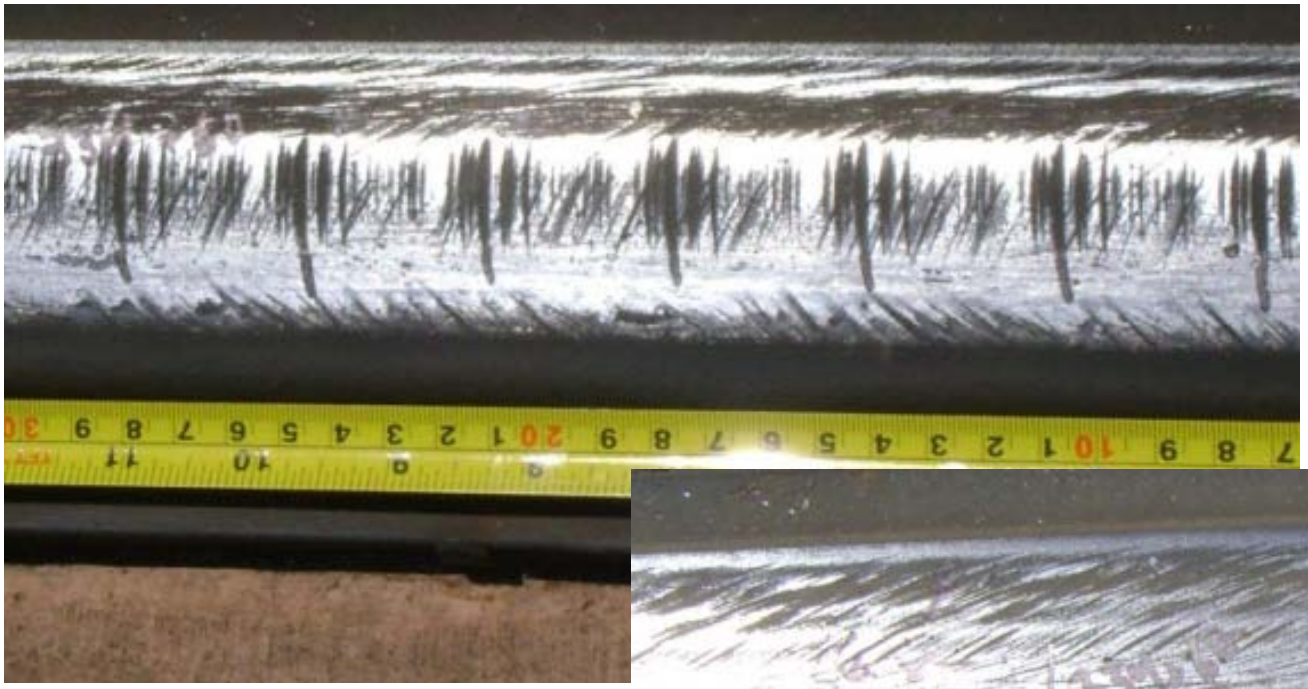
Activities included

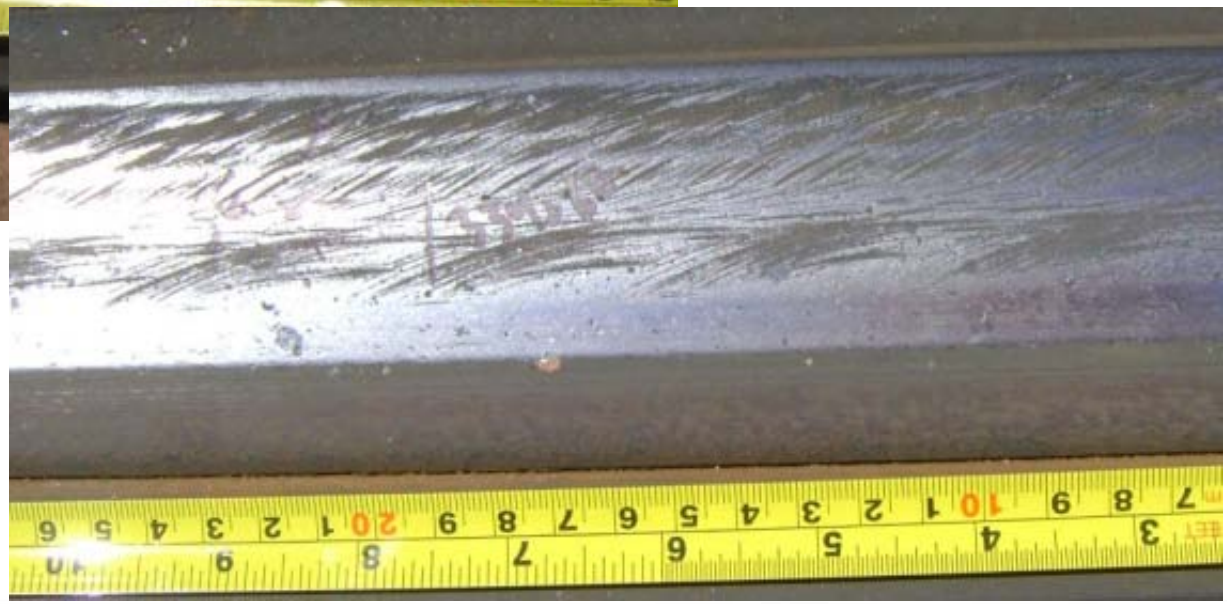
1. Listen for and measure noise
2. Hypothesis of root cause of noise, collect field evidence to validate
3. Perform wheel/rail interaction analysis
4. Review rail lubrication
5. Develop profiles to reduce wheel/rail noise and wear

Sources of Wheel/Rail Noise

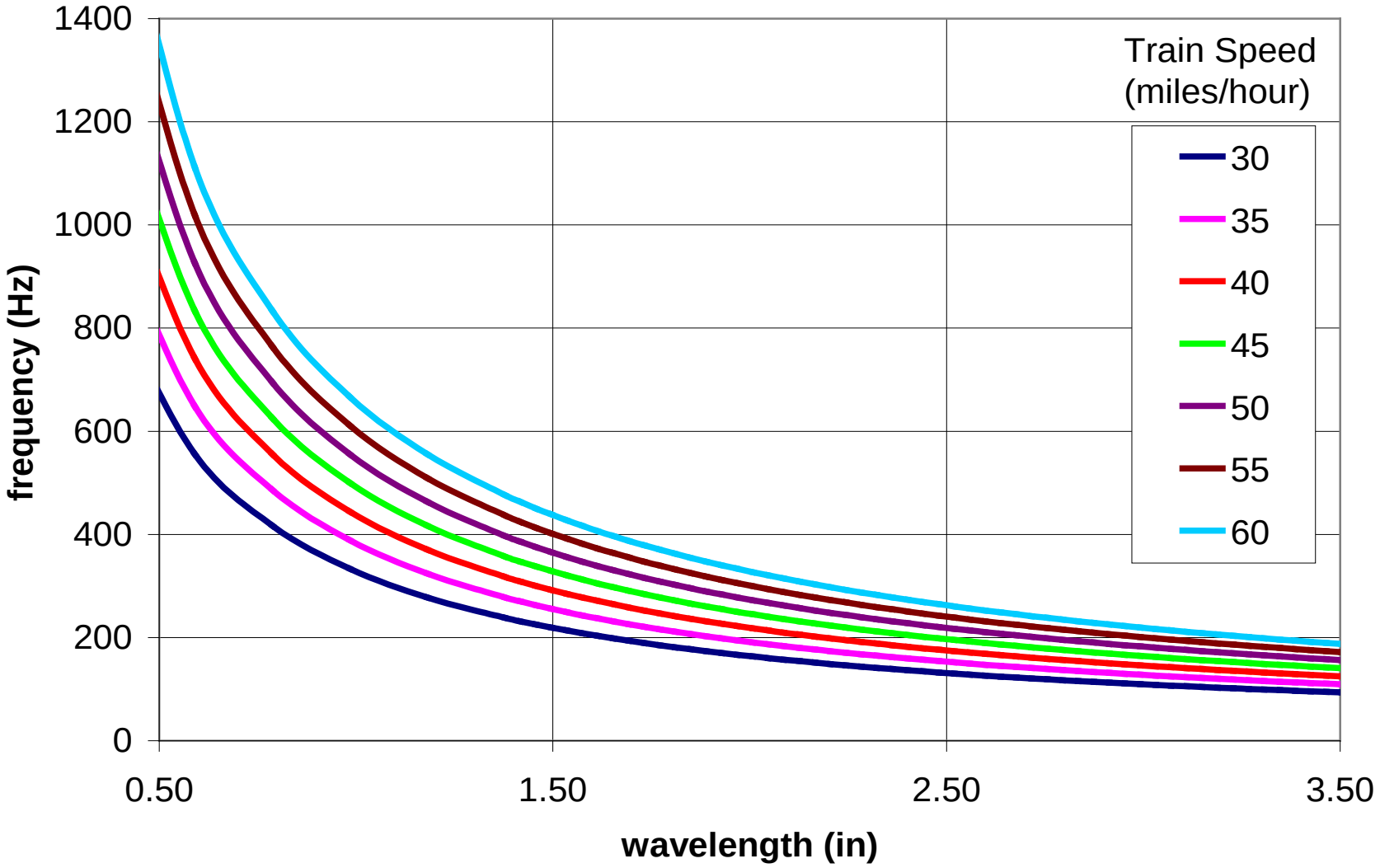
	Rolling Noise	Flanging	Wheel Squeal	Roaring
Description	Broadband	Screeching	Tonal/pure resonance noise	Howling
Root cause	Rail and/or wheel roughness	Dry contact of wheel flange and rail gage-face	Excitation of a wheel resonance, usually out of plane	Periodic wheel and/or rail roughness (usually corrugation)
Treatment	Smoother finished wheel surface Smoother rail surface	Improve steering Lubricate the rail gage face	Treat exciter, e.g. lateral stick-slip through profiles and/or friction management	Remove corrugation through grinding, reduce corrugation development through profiles, friction mgmt, rail grinding

Rail Surface Roughness – Grinding

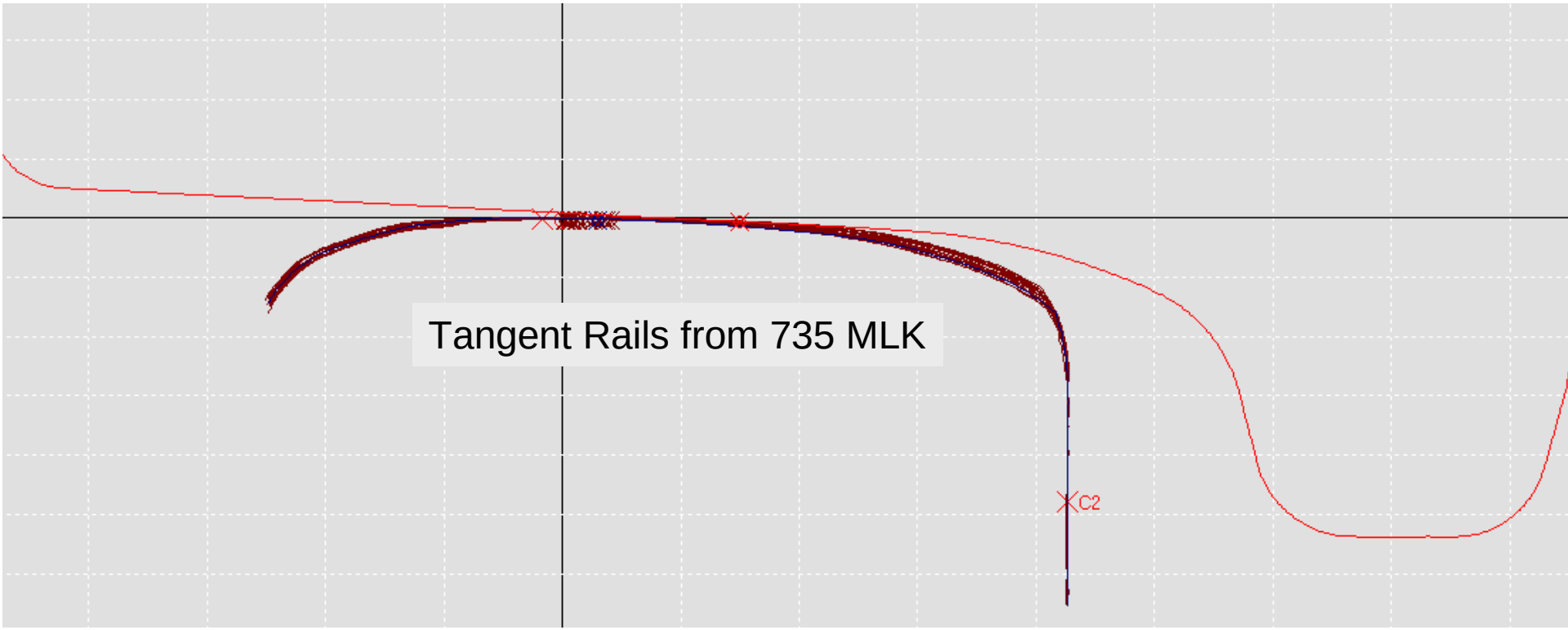




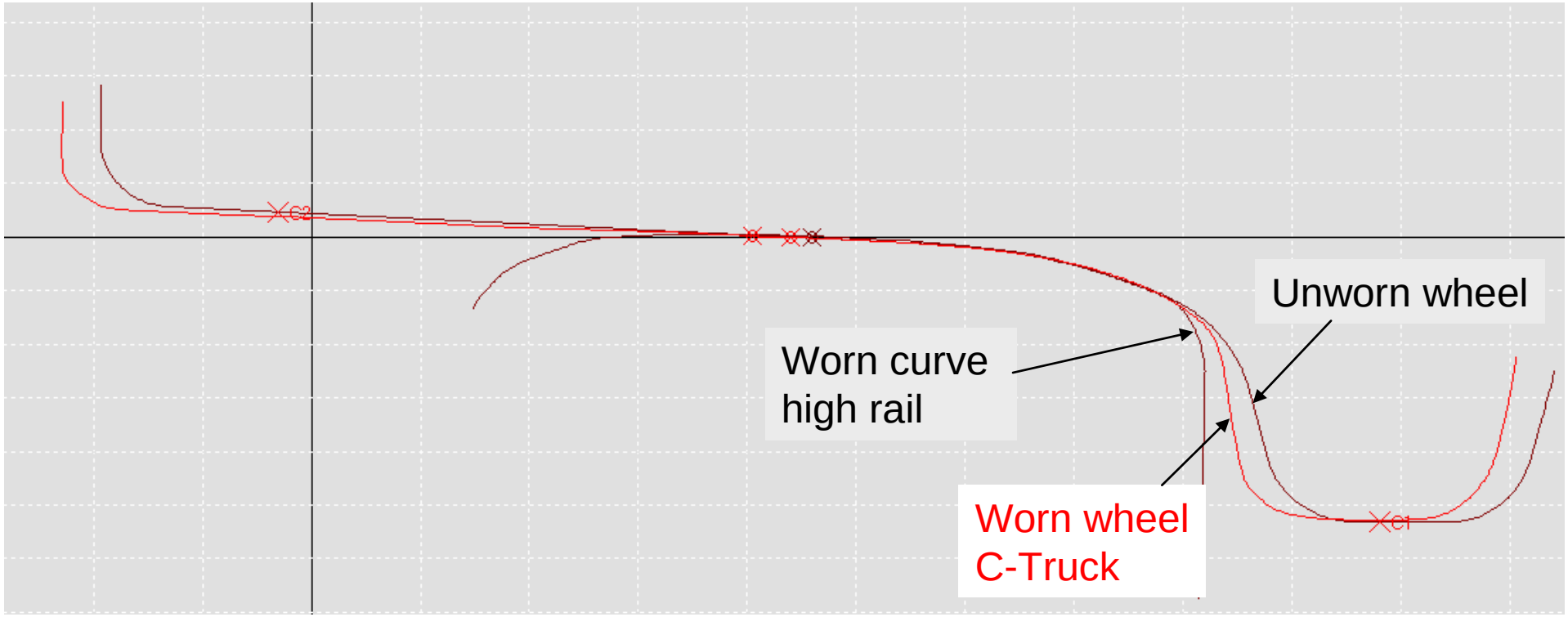
Corrugation and Noise Frequencies



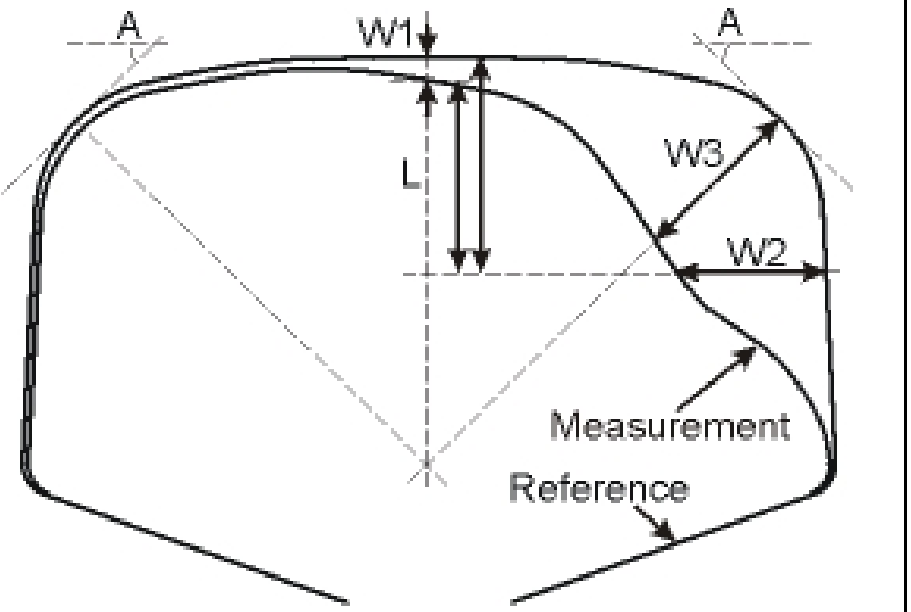
Rail Wear on Tangents

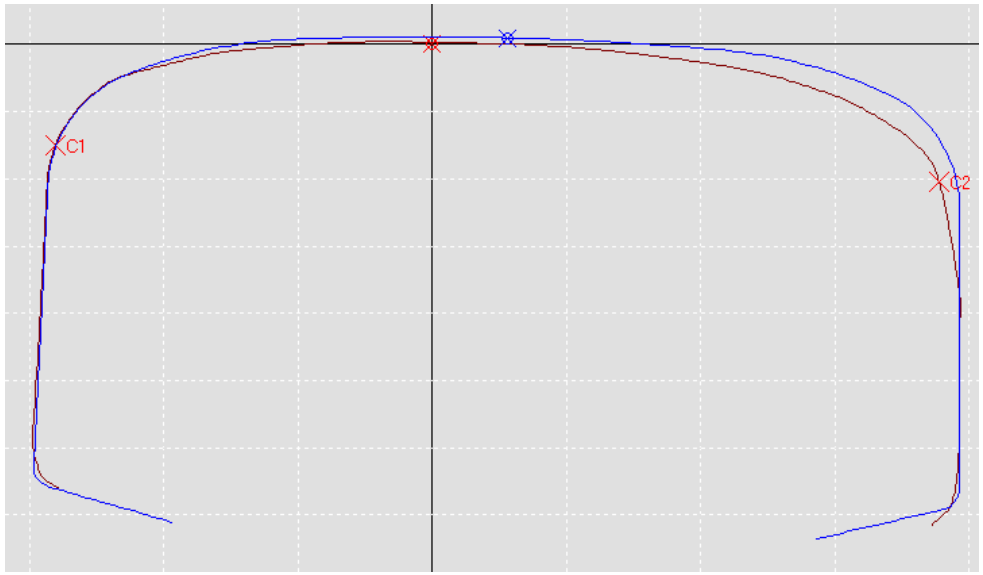


Rail Wear on High Rails

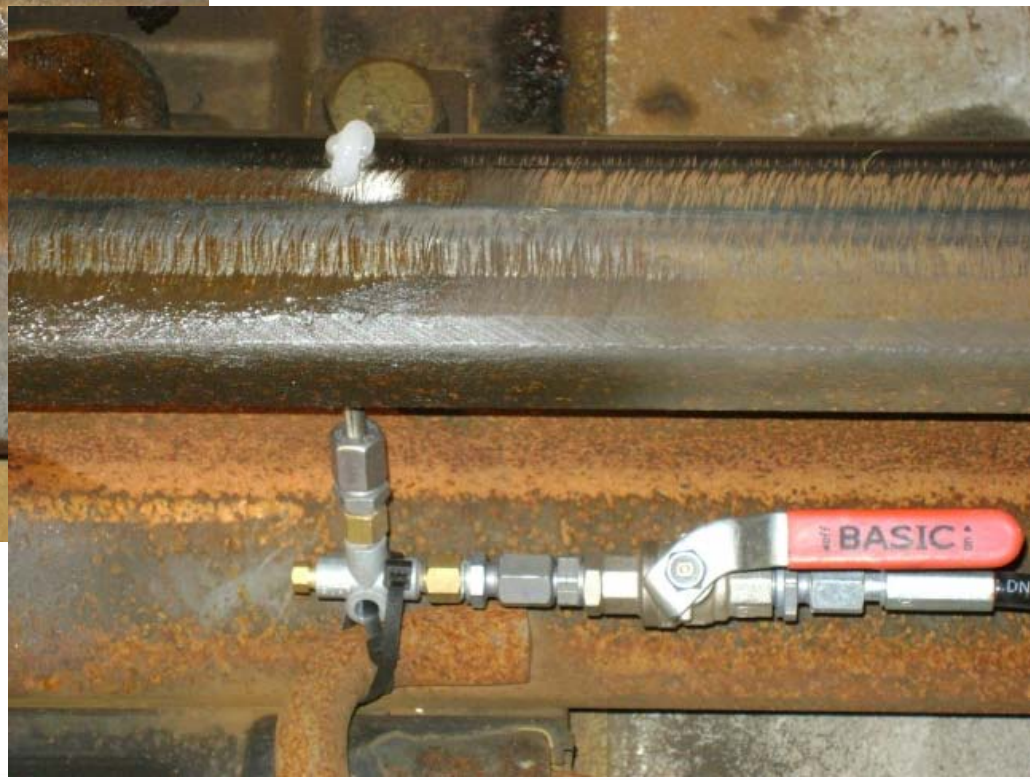


Rail Wear – Problem or Not ?

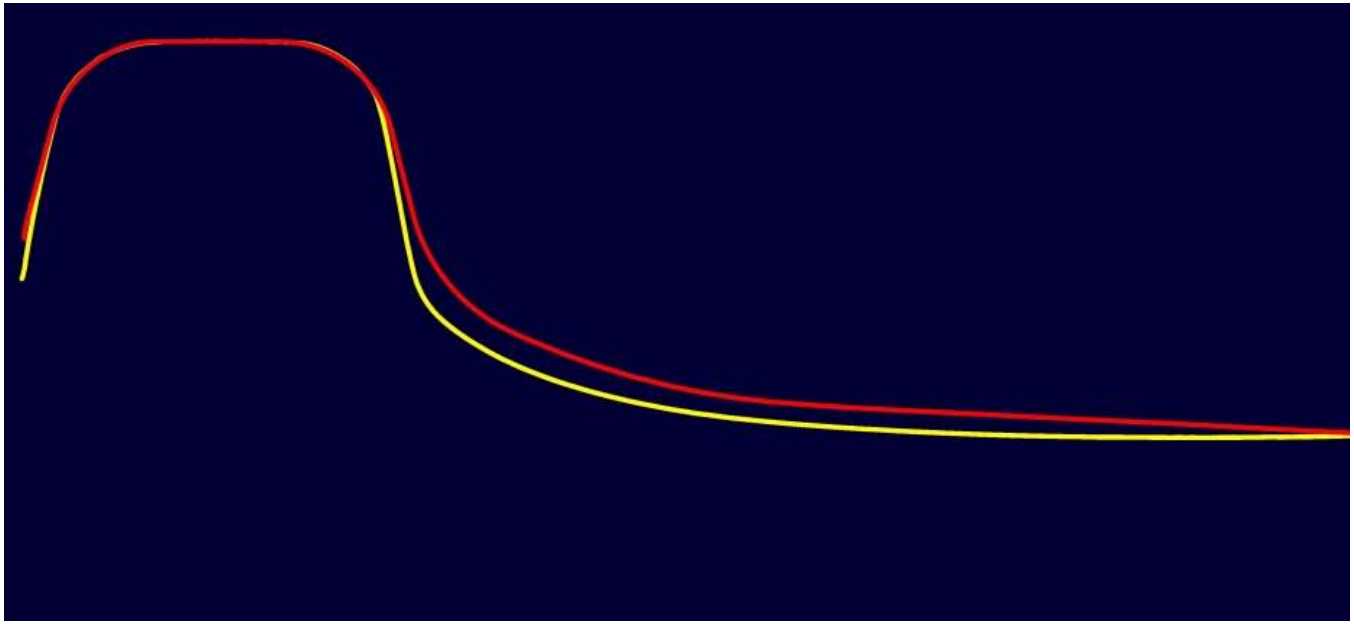




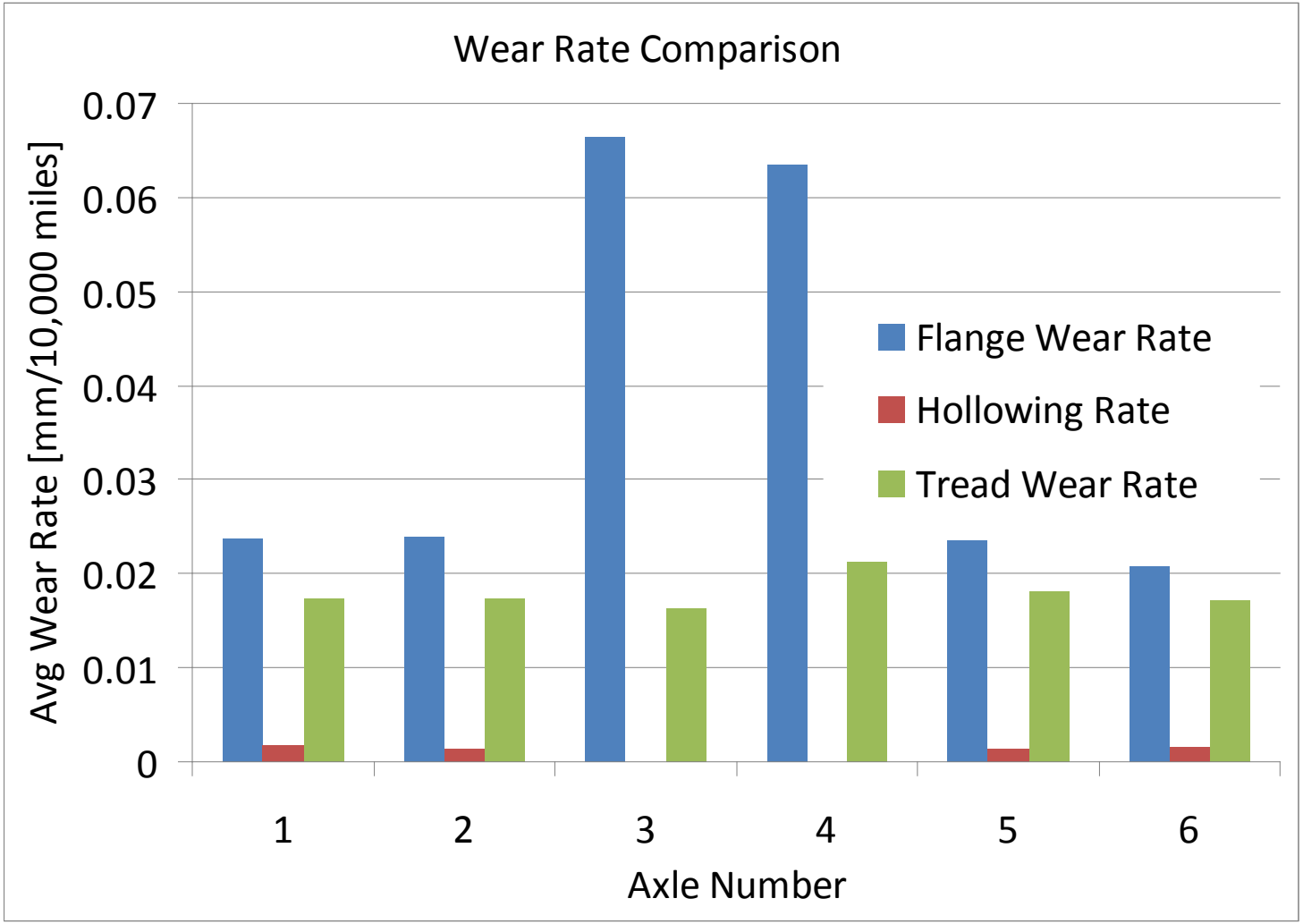
Rail Lubrication – Noise Control



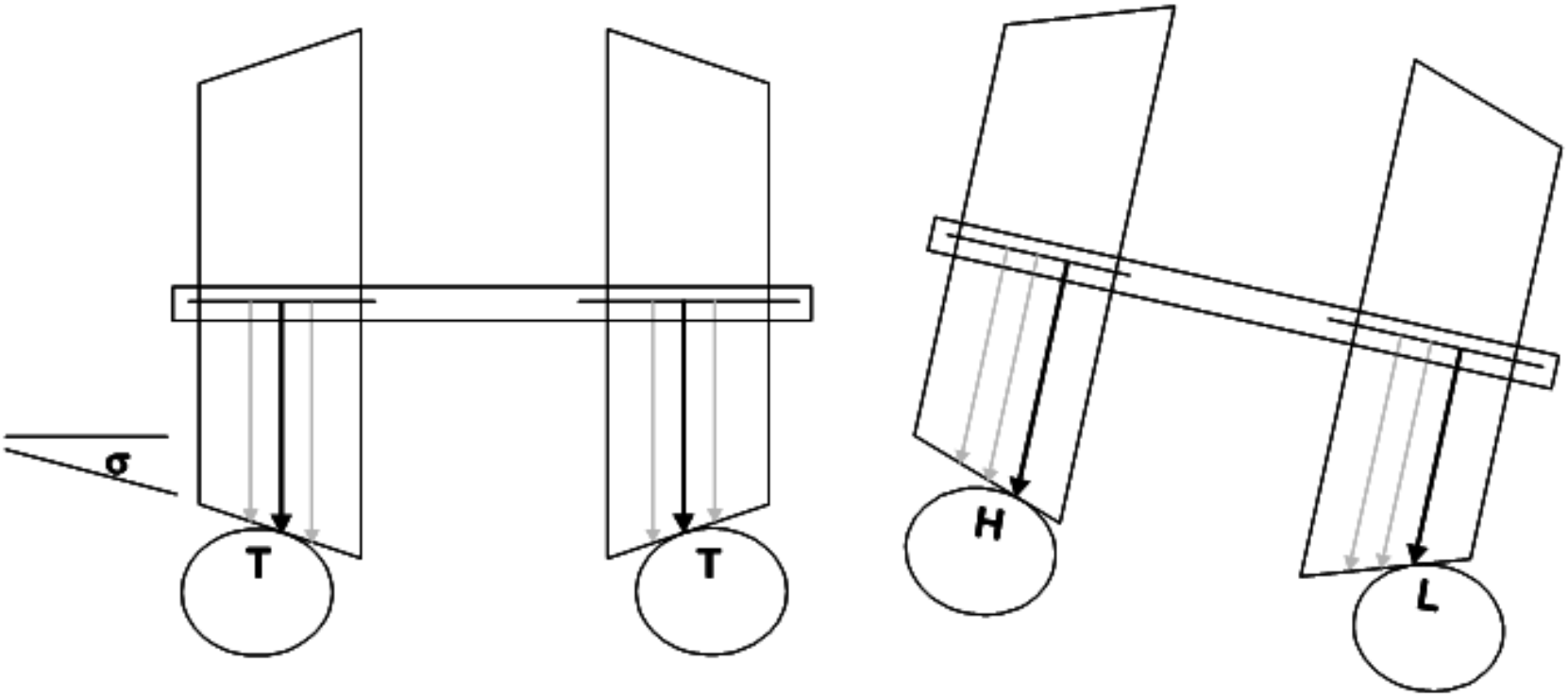
LRV Wheel Treads - Hollowing



LRV Wheel Wear Rates

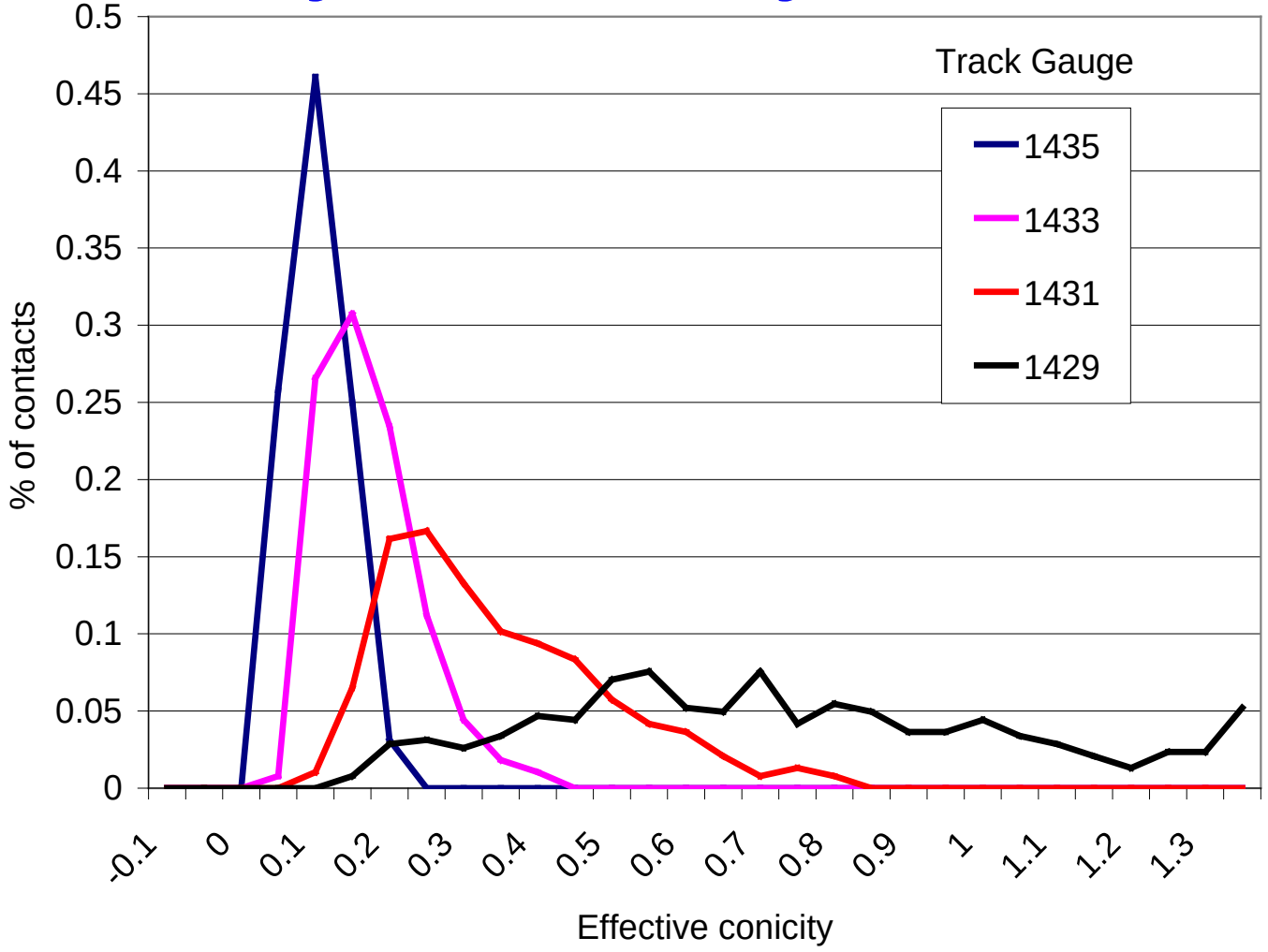


Wheelset Steering and IRWs



T: tangent H: high rail L: low rail

Ride Quality & Conicity



Summary of Observations

1. **Rolling noise from rail surface roughness, and perhaps from incipient corrugations**
2. **Corrugations developing in some areas where no lubrication was present (presumed high friction)**
3. **High rail wear rates are too great**
4. **High rails wearing to match the flange root of wheels**
5. **Lube strategy effective for reducing noise, but not effective in controlling wear.**

Summary of Observations (cont)

6. **Wheel surface condition was good, but:**
   - **End trucks developing hollow tread**
   - **Center trucks have rapid flange wear**
   - **No contact on large part of tread**
7. **Ride quality issue on center trucks might be profile or equipment related**
8. **Ride quality on end trucks related to wheel hollowing**

What Can Profiles Do ?

1. **Rolling noise is a surface roughness issue, not result of improperly specified profiles**
2. **Corrugation development can sometimes be delayed through the implementation and maintenance of improved profiles**
3. **Better steering performance for end trucks could lessen combined wear rate of high rails**
4. **Lube could be improved to reduce wear, but this is not a profile solution**

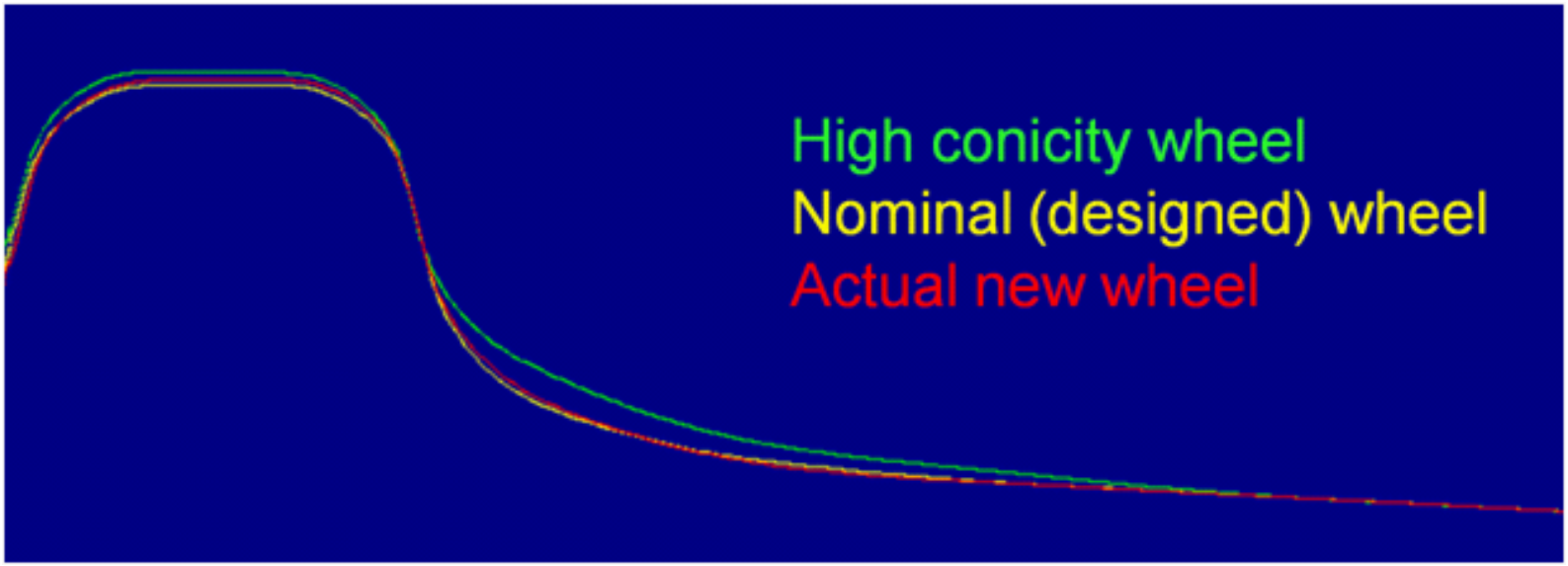
What Can Profiles Do ? (cont)

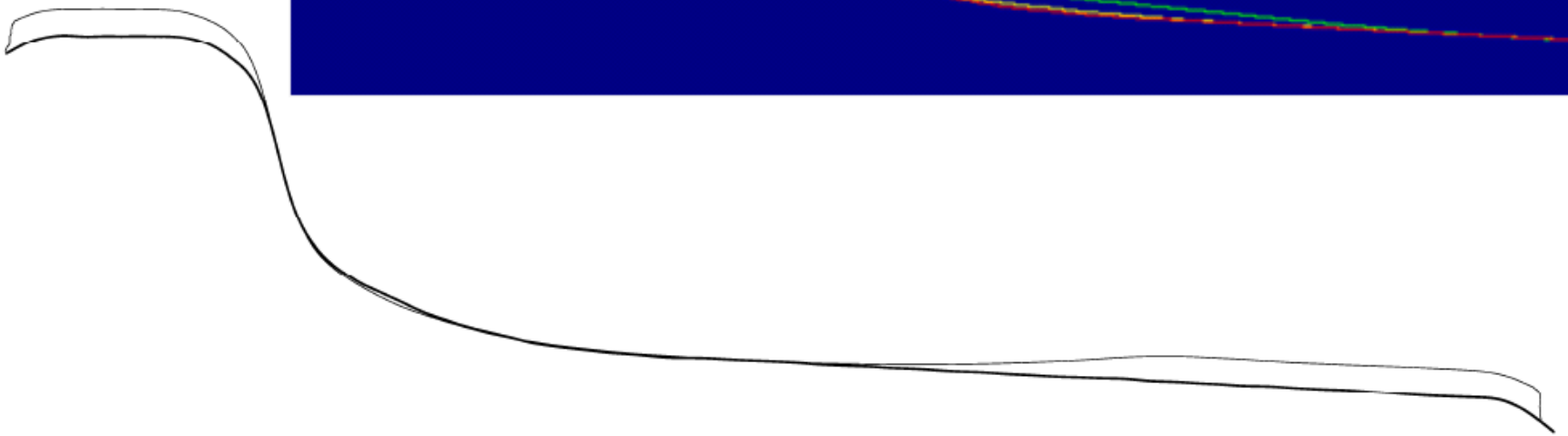
5. **Asymmetric rail profiling can address hollowing and flange wear on end trucks**

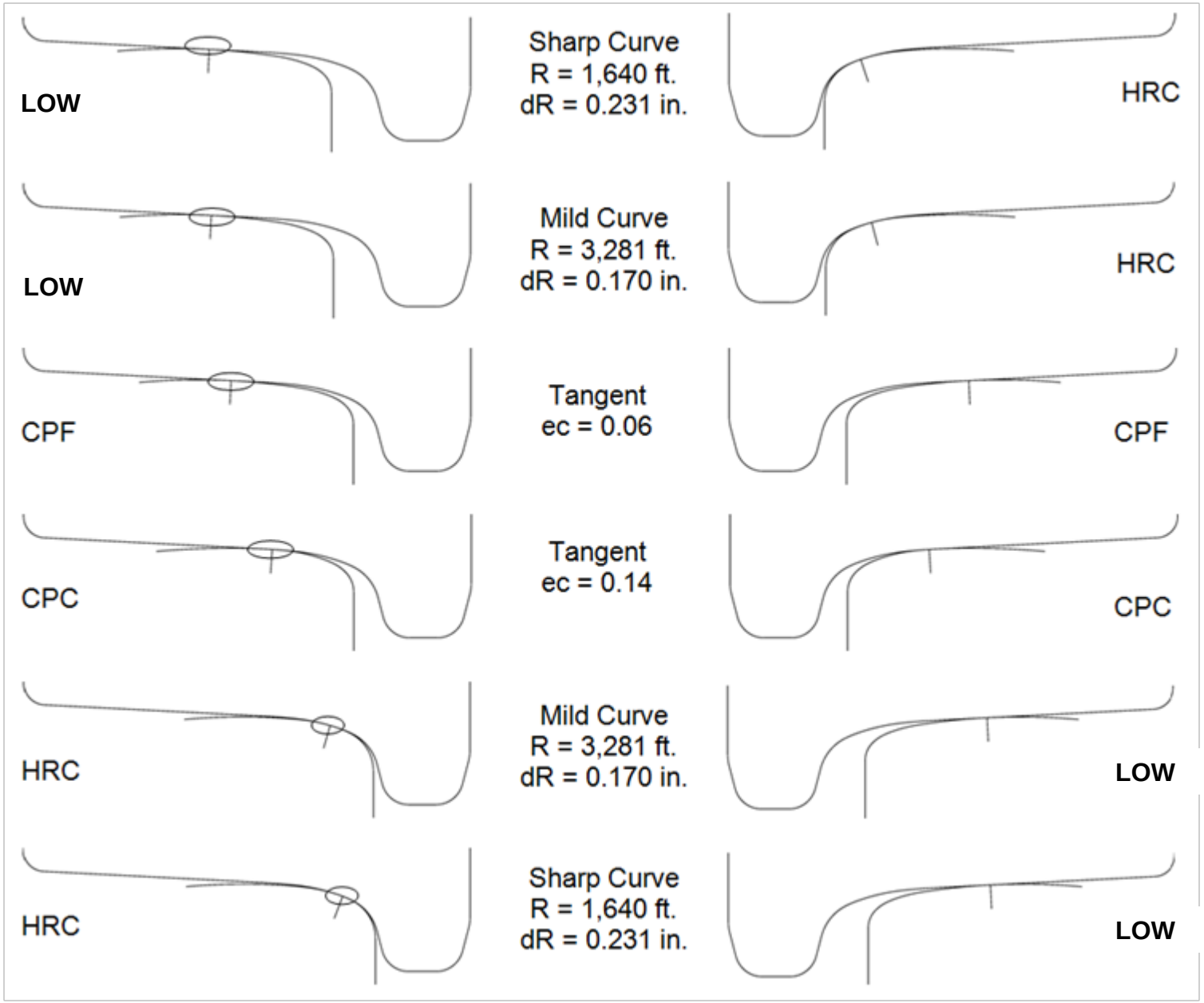
6. **Ride quality could be improved on end trucks through better profiles, perhaps not on IRWs**

Profile Design - Wheel

Do we need a new wheel profile ?

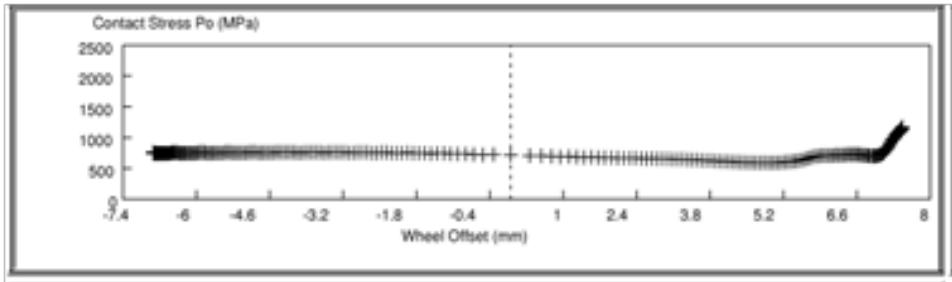


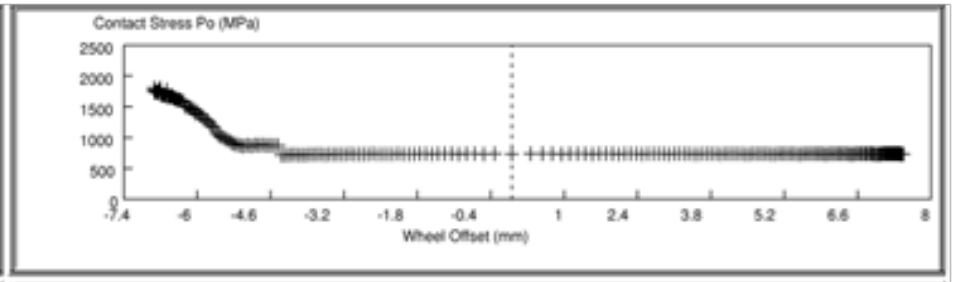


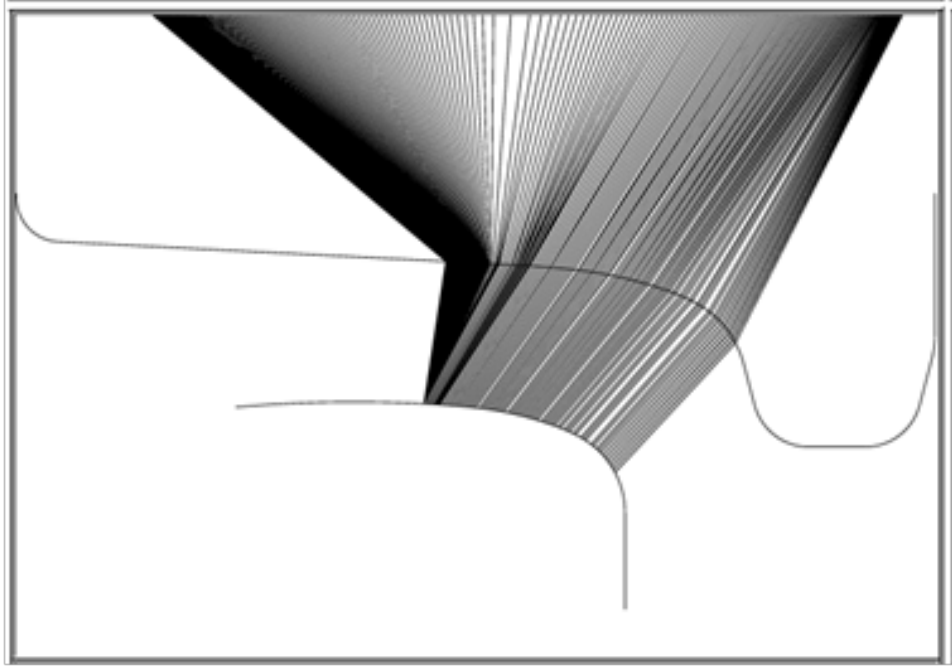

LOW
Sharp Curve
R = 1,640 ft.
dR = 0.231 in.
HRC
LOW
Mild Curve
R = 3,281 ft.
dR = 0.170 in.
HRC
CPF
Tangent
ec = 0.06
CPF
CPC
Tangent
ec = 0.14
CPC
HRC
Mild Curve
R = 3,281 ft.
dR = 0.170 in.
LOW
HRC
Sharp Curve
R = 1,640 ft.
dR = 0.231 in.
LOW

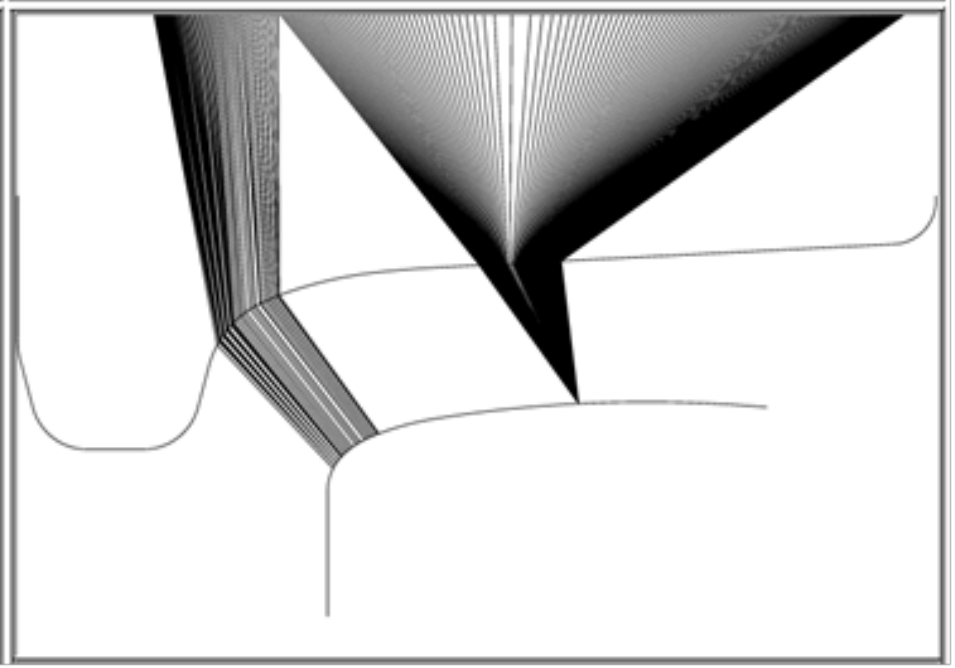
Profile Design – High & Low Rails

Contact stresses



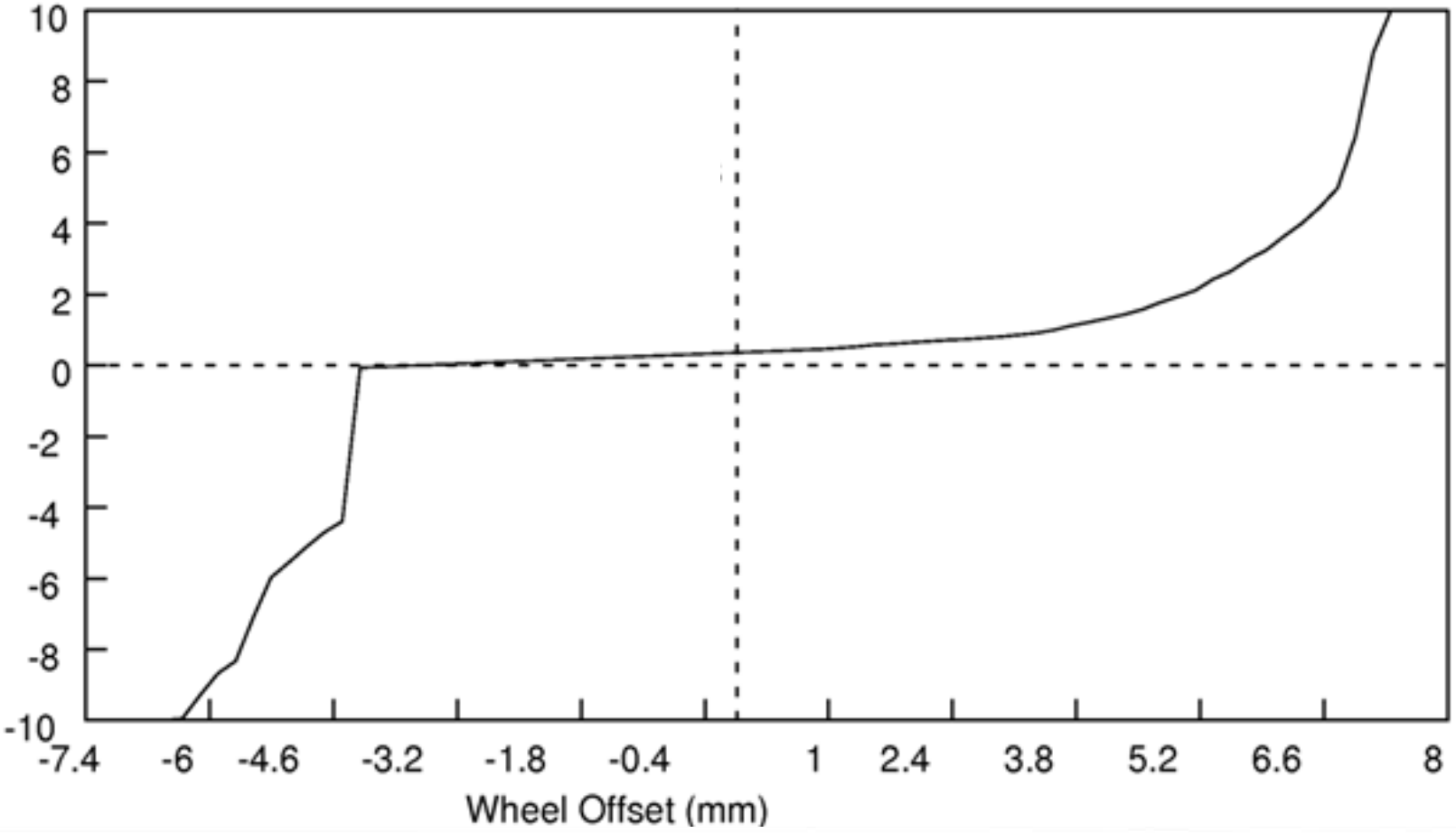






Profile Design – High & Low Rails

Rolling radius difference

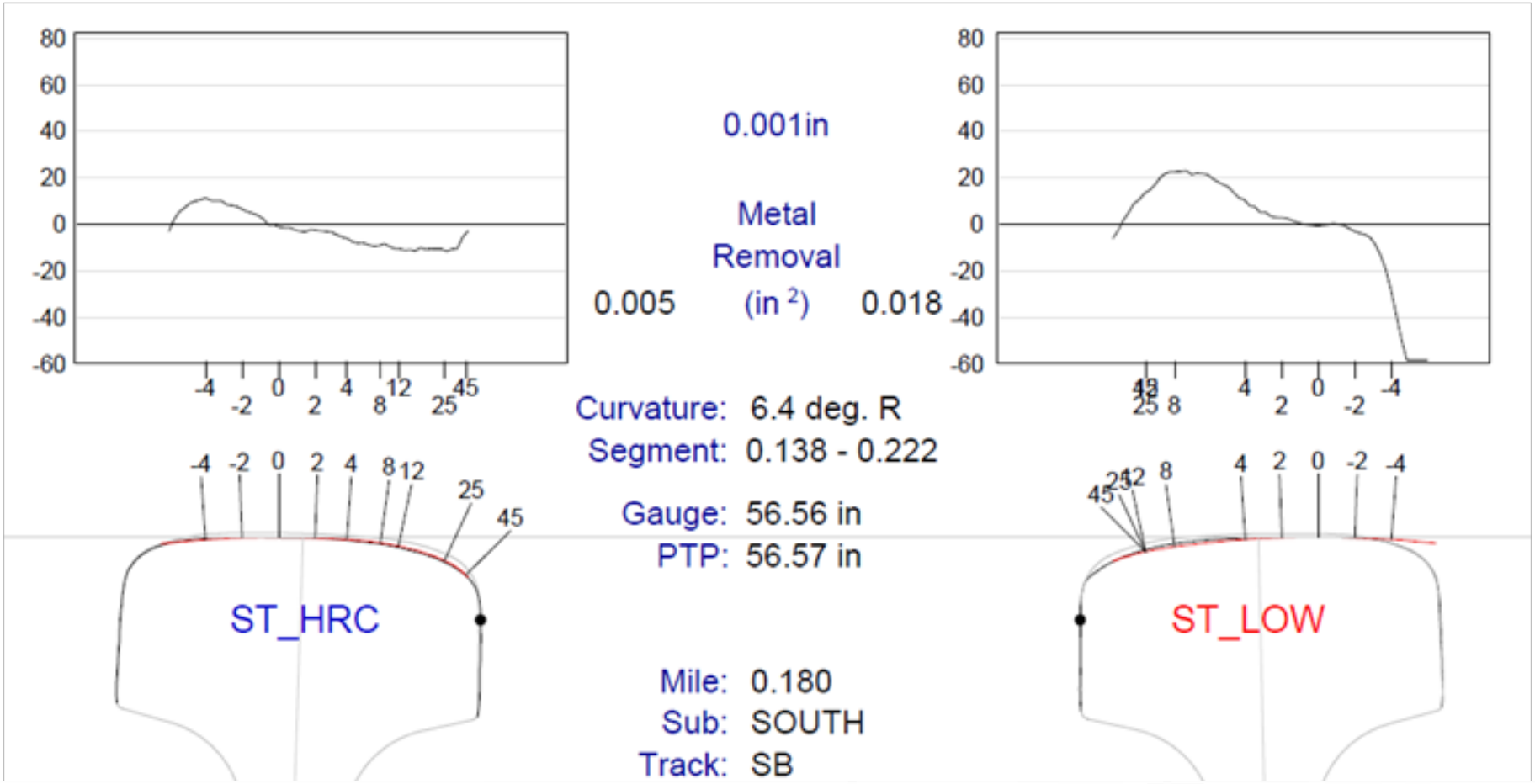


Profile Design – High & Low Rails

Simulation results – flange wear

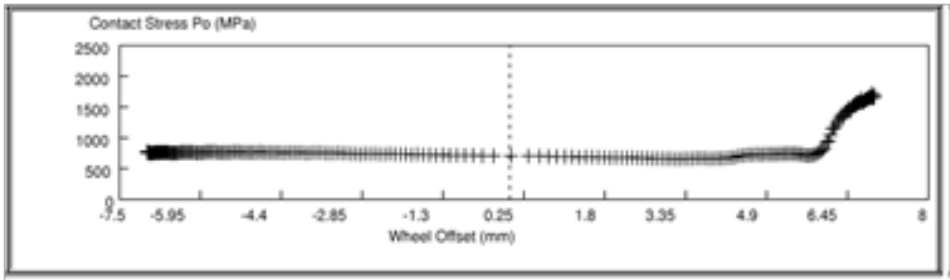
Profile Design – High & Low Rails

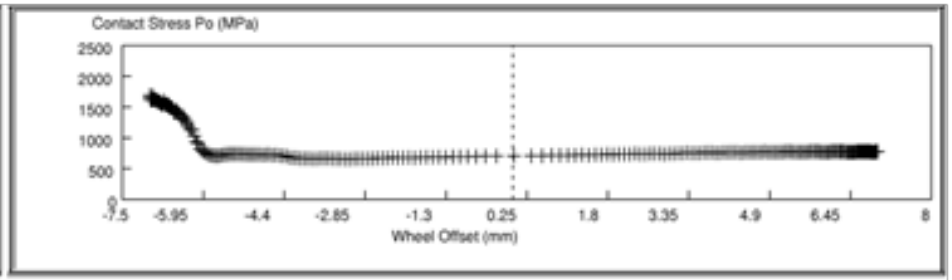
Metal removal requirements – open track

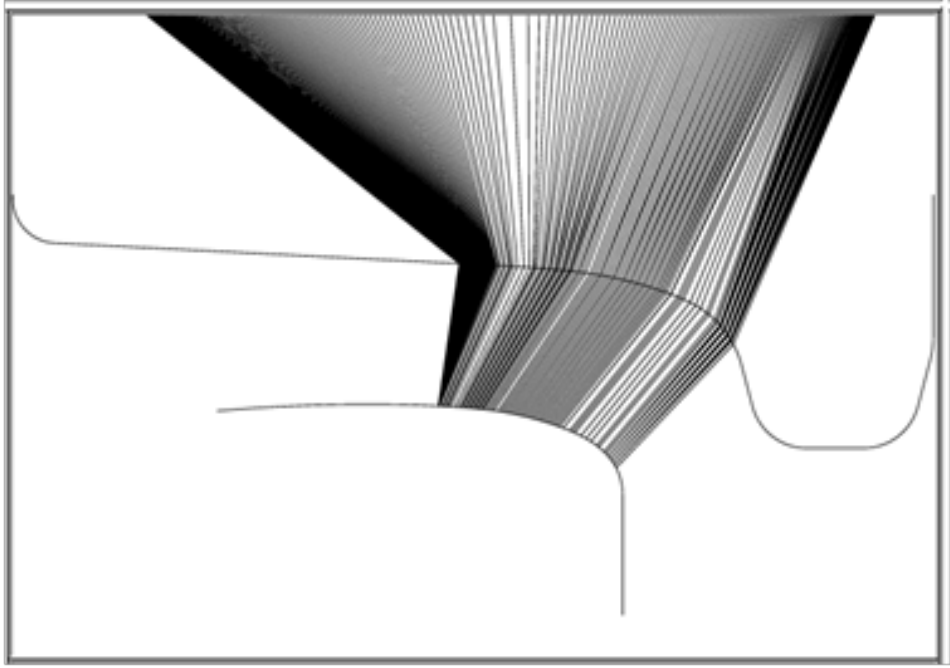


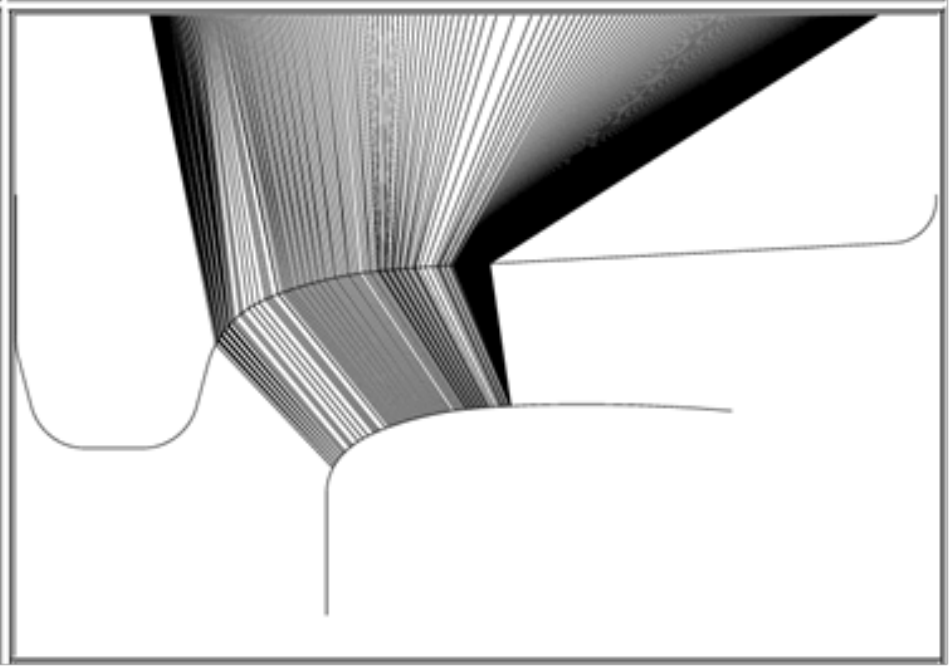
Profile Design – Tangent Rails

Contact stresses for CPC



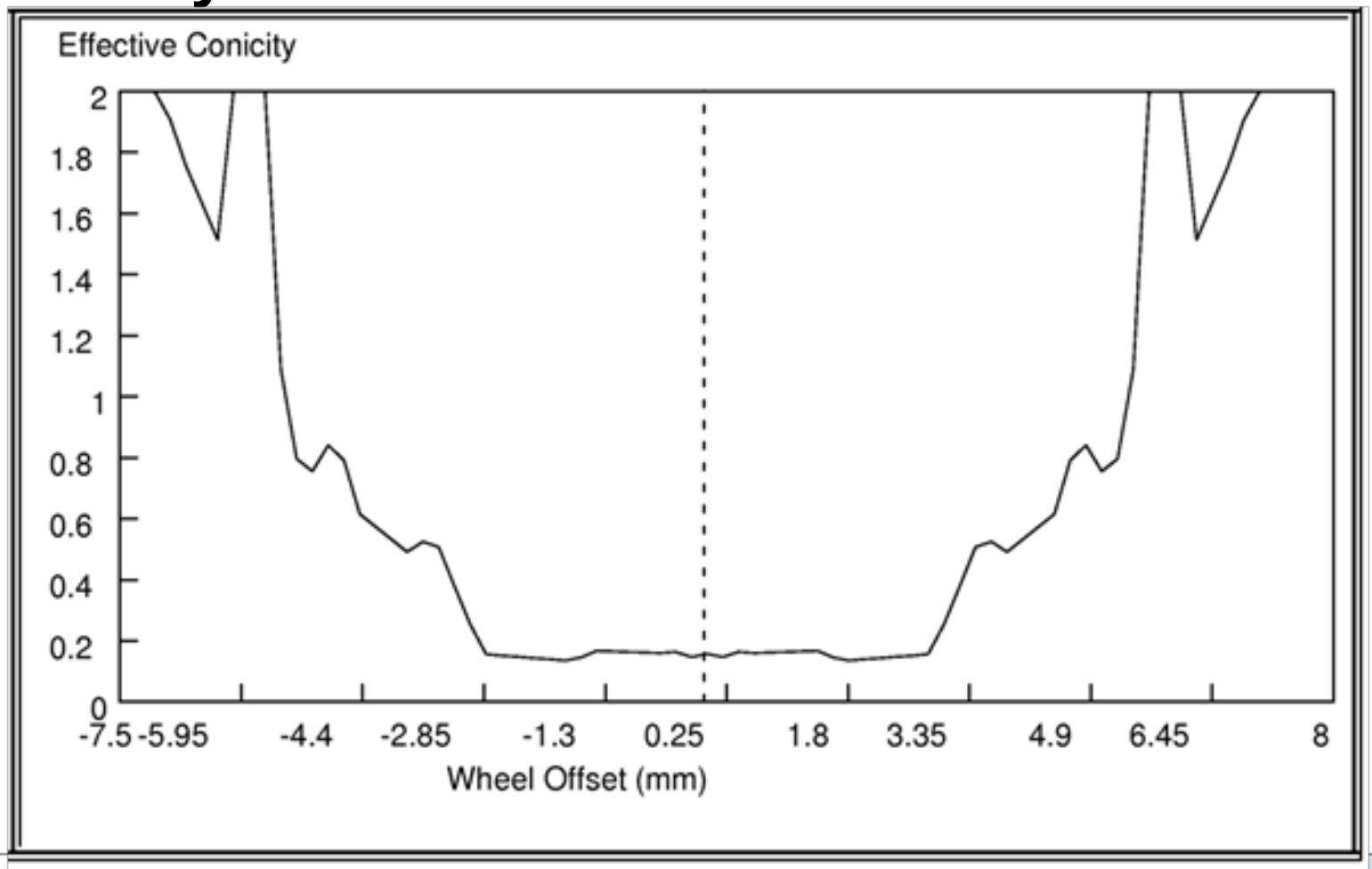






Profile Design – Tangent Rails

Conicity for CPC

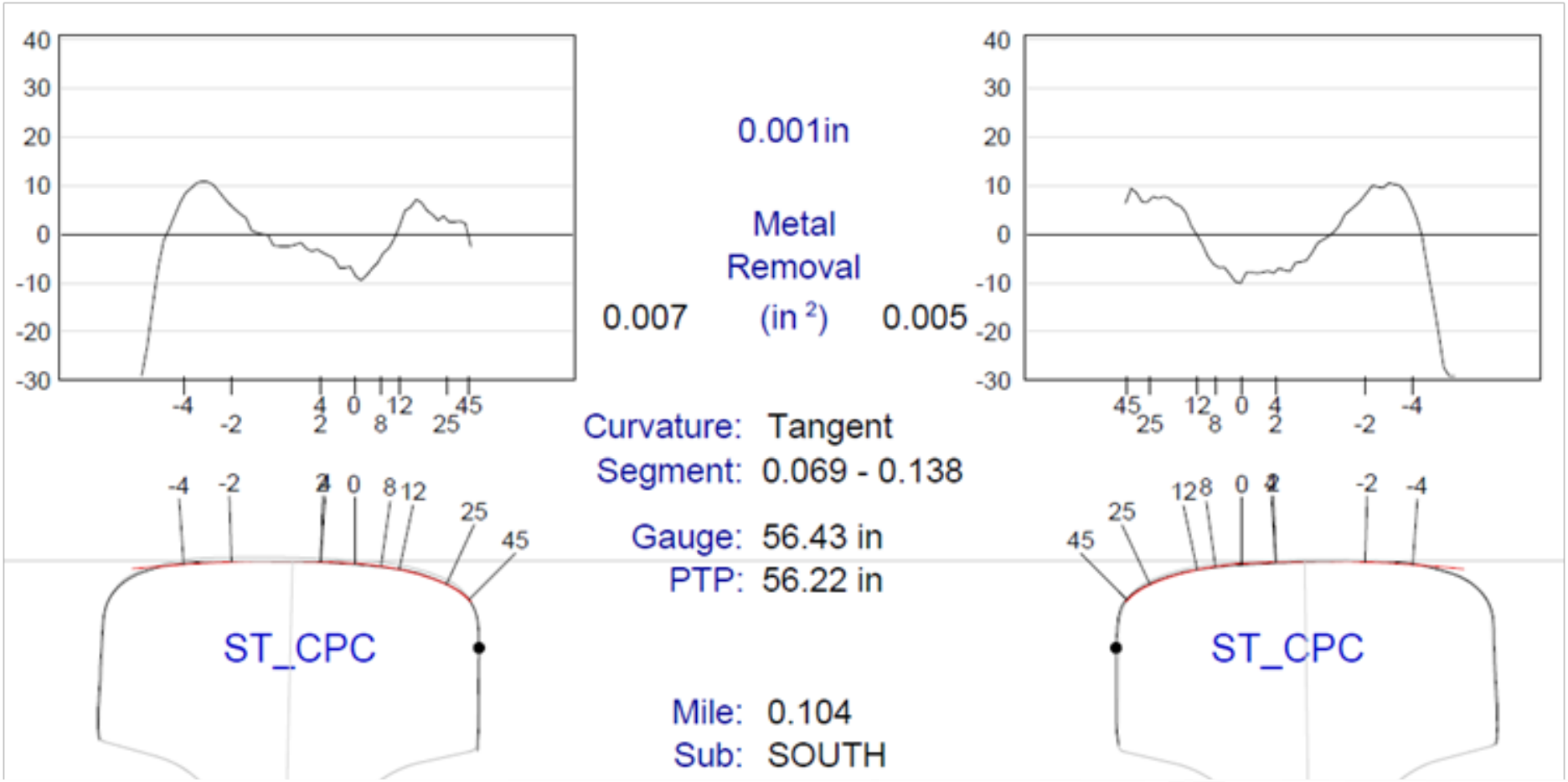


Profile Design – Tangent Rails

Simulation results – tread wear CPC & CPF

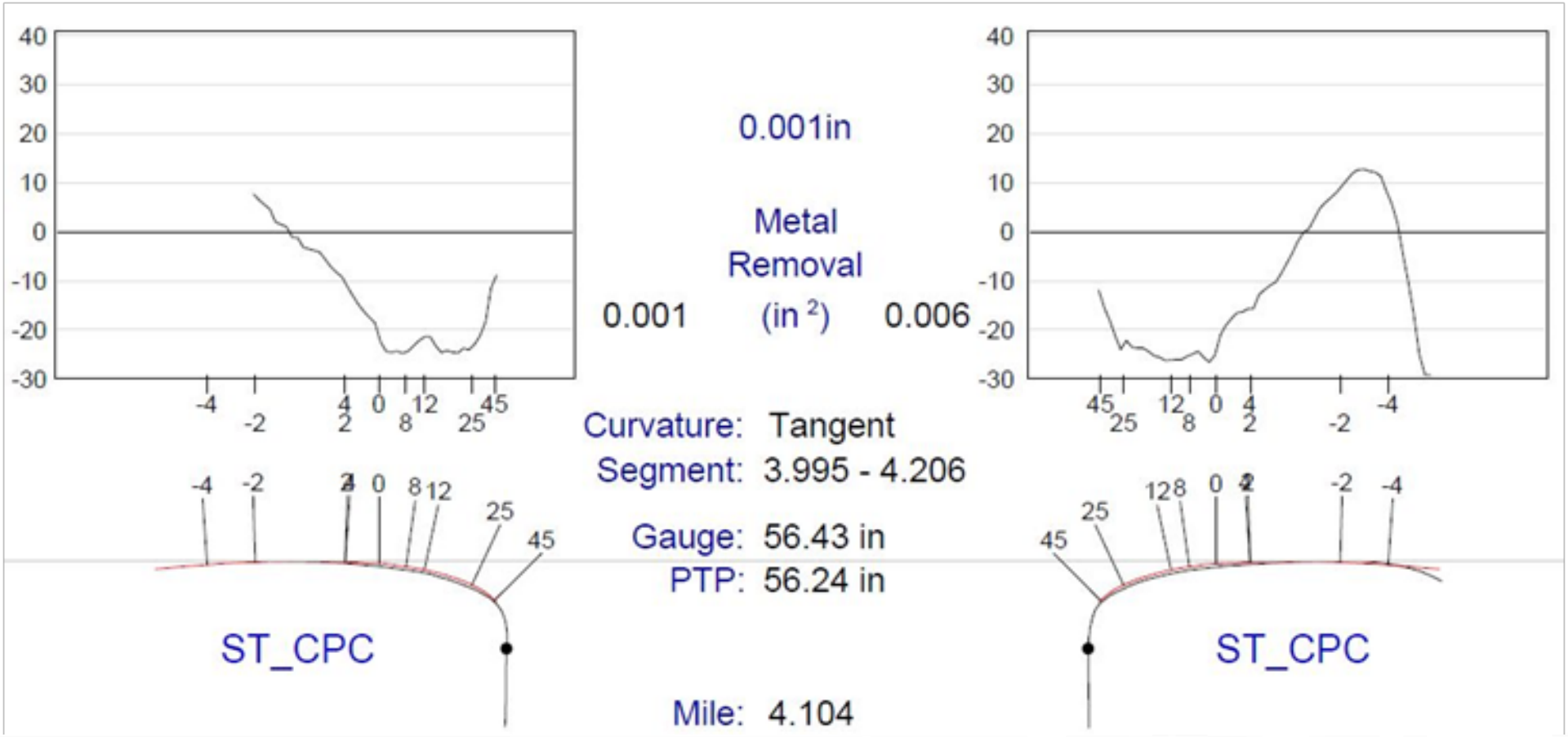
Profile Design – Tangent Rails

MR requirements for CPC – open track



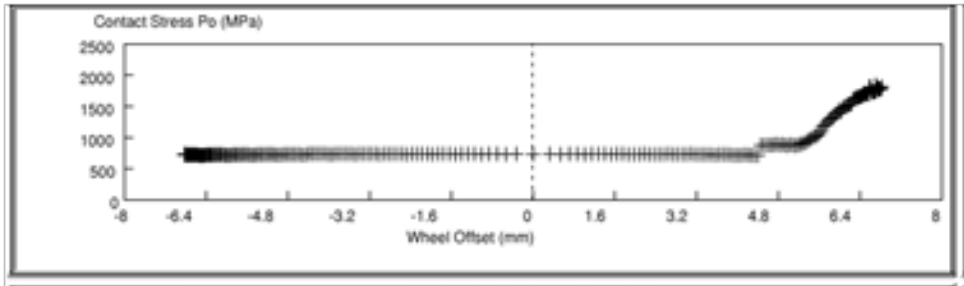
Profile Design – Tangent Rails

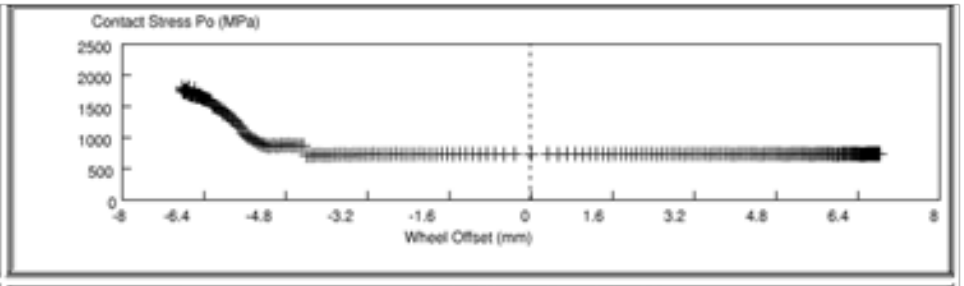
MR requirements for CPC – embedded rails

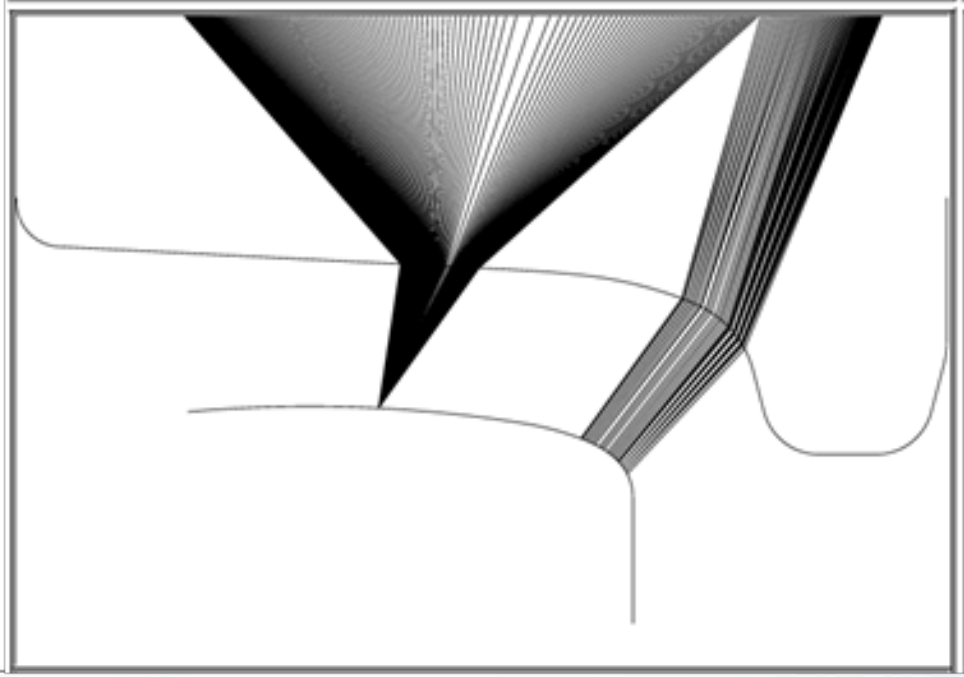


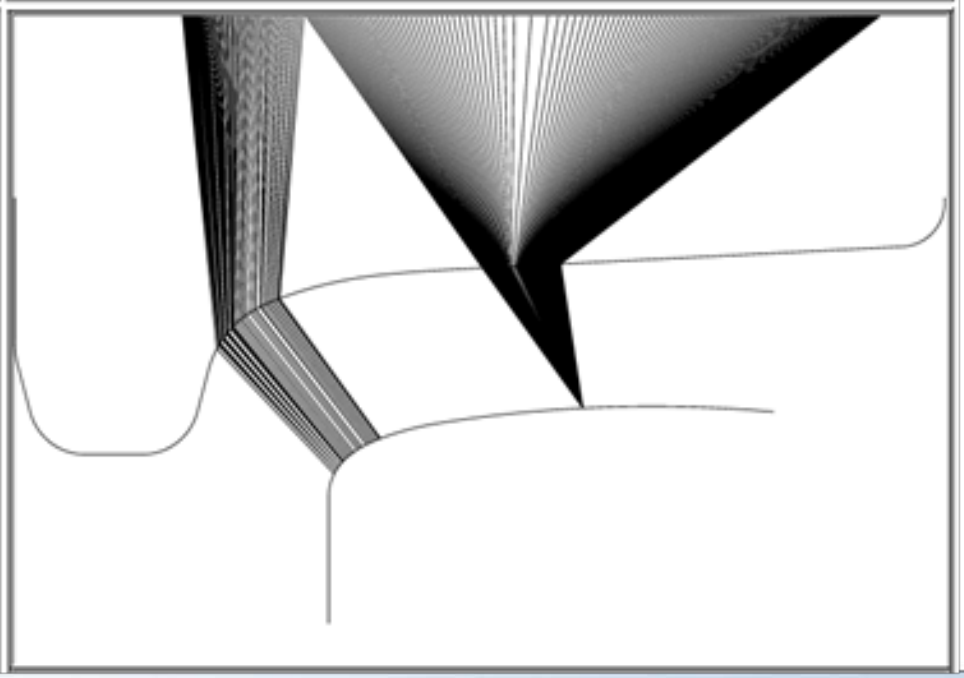
Profile Design – Tangent Rails

Contact stresses for CPF



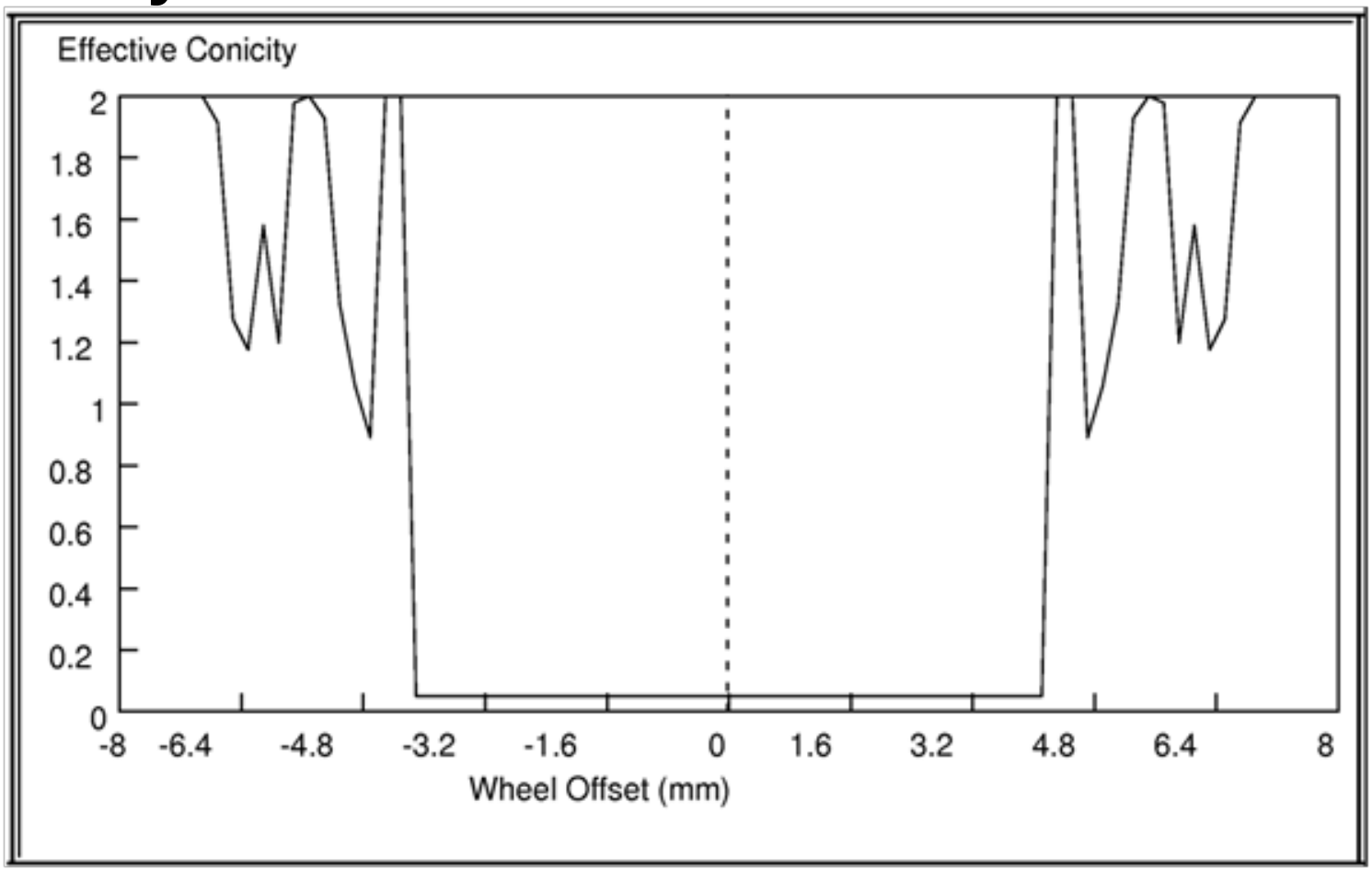






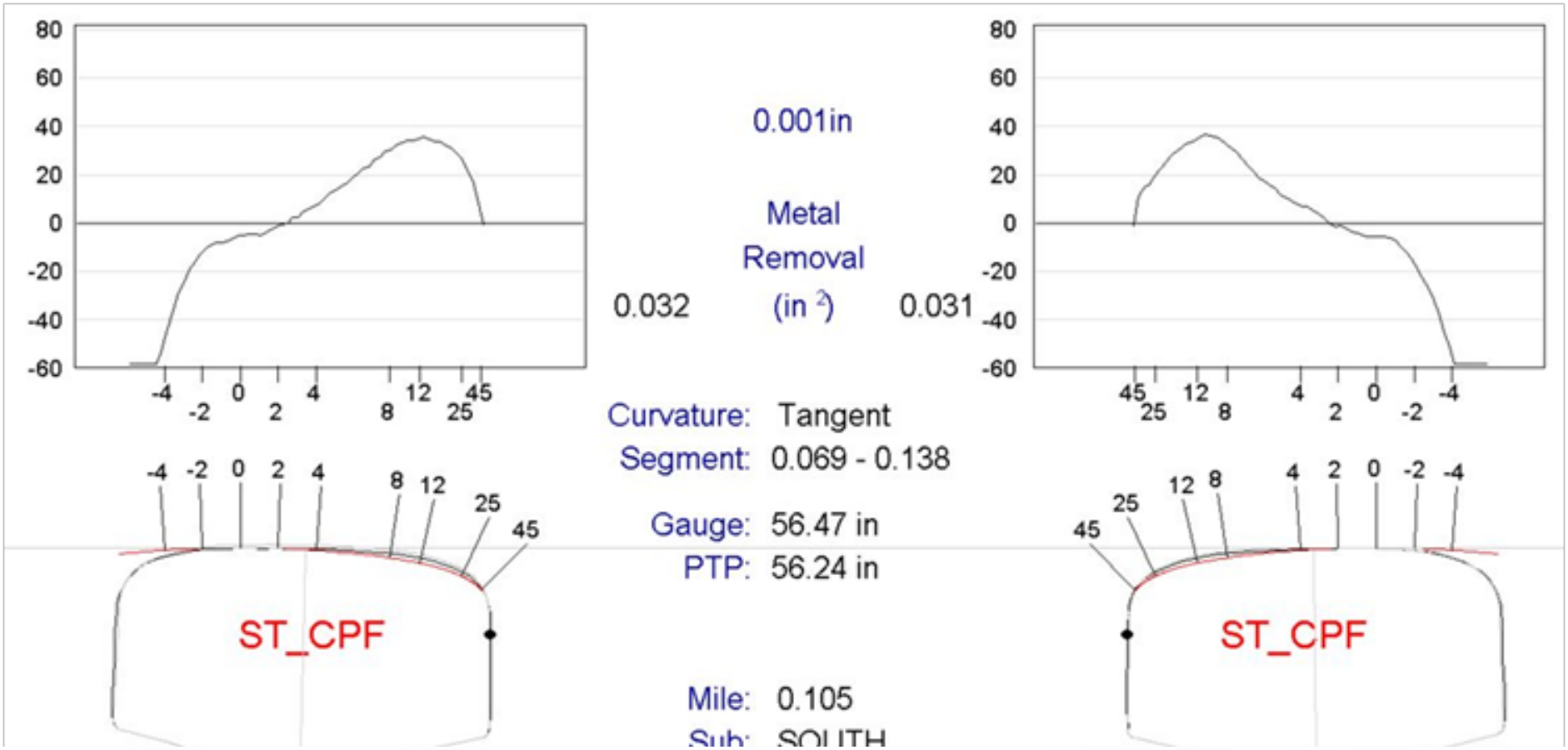
Profile Design – Tangent Rails

Conicity for CPF



Profile Design – Tangent Rails

MR requirements for CPF – open track



Profile Design – Tangent Rails

MR requirements for CPF – embedded track