Towards a maintenance free rail

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- Extending rail life
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- Bainitic rails
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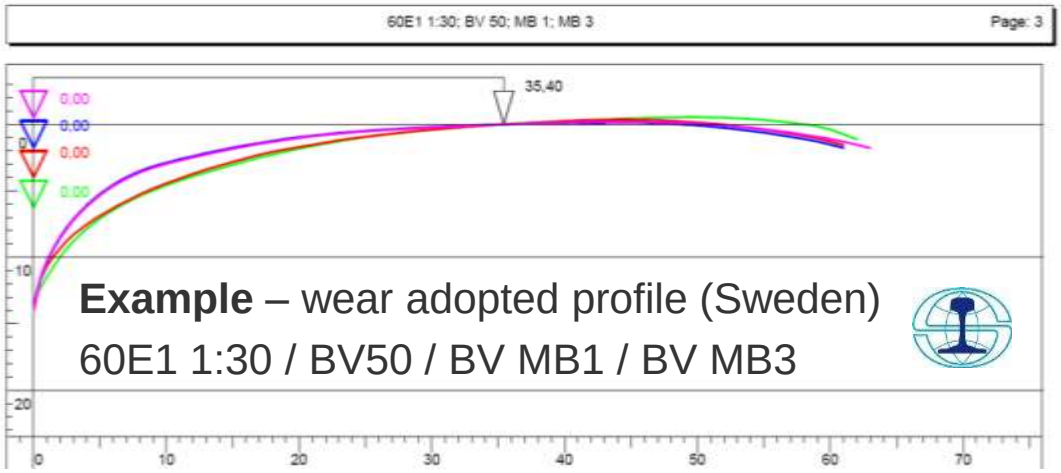
Reasons for rail maintenance

Speno 24 stone rail grinder near *Bruck an der Mur* / Austria

Maintenance: Rail wear

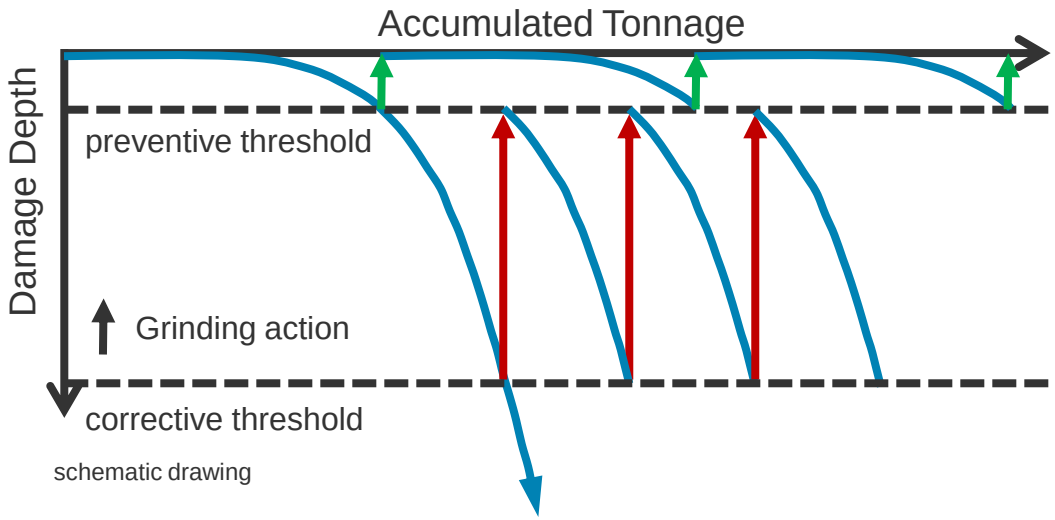
- Profile change caused by continuous metal removal from the rail surface due to wheel-rail contact.
- Maintenance for
  - profile restoration
  - production of profiles for specific purposes
- Extending the rail life



Source: Wolfgang Schoech, Speno International

Maintenance: Rolling Contact Fatigue

- Damage removal from the rail surface
- Preventive vs. corrective actions
- Extending the rail life



schematic drawing

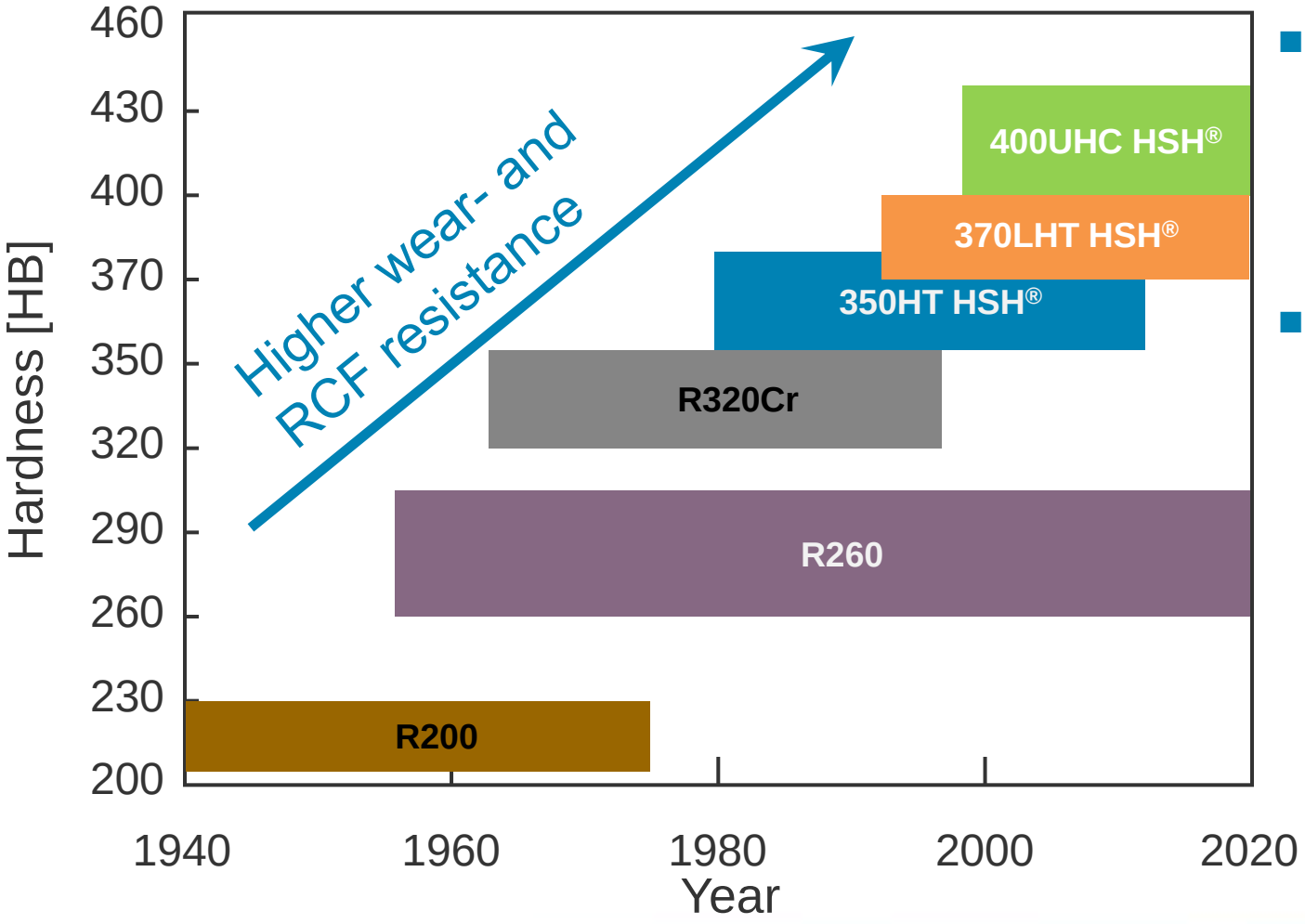
Source: P.T. Torstensson, Charmec

Extending rail life

Technical Development

Technical Development

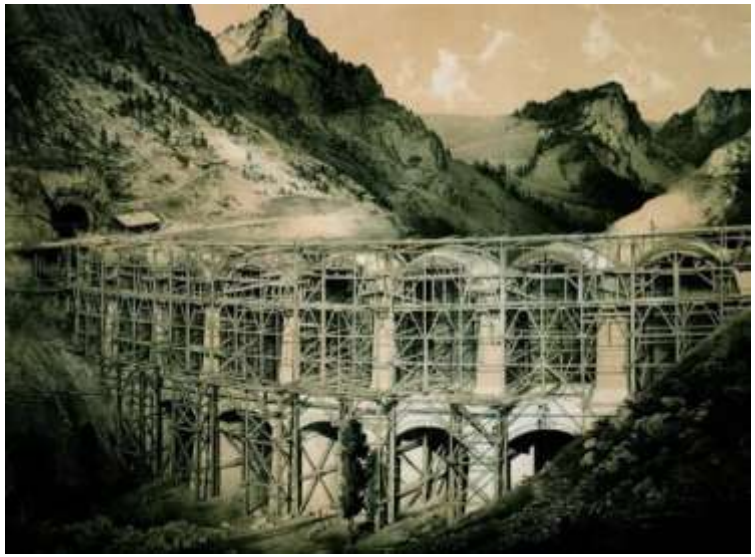
Rail grade development



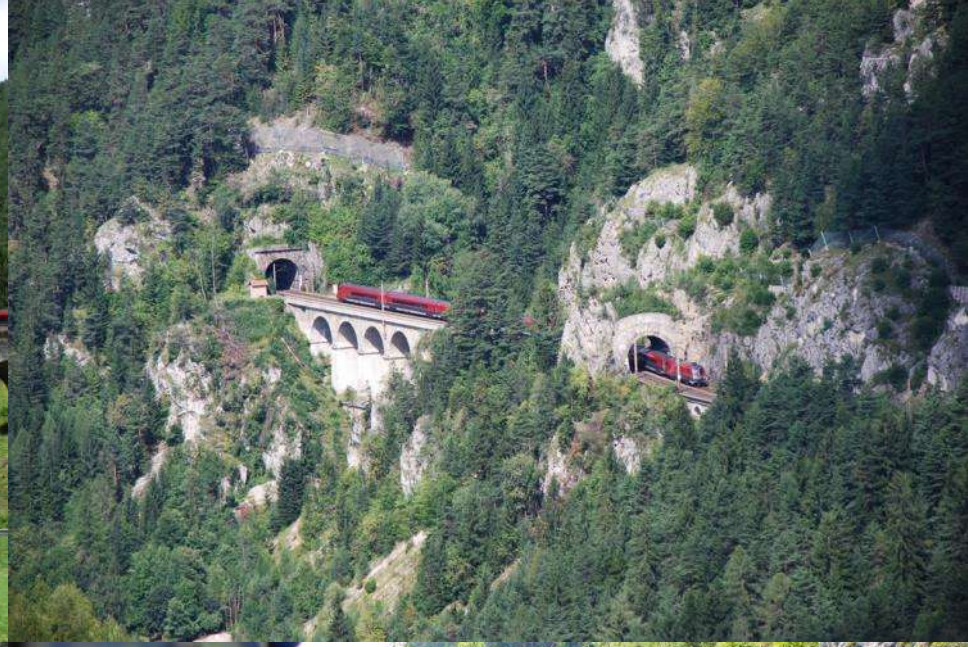
- Heat treated fine pearlitic premium and HE premium rail grades
- Highest wear and RCF resistance

Rail grade strategy: wear
The Semmering Track - Austria

- Part of Austria's Southern Main Line (corridor Vienna – Venice)
- Double track line - electrified
- 41 km (25.5 mi) mountain track over Semmering pass (1853)
- 16 railroad viaducts, 15 tunnels, 100 bridges
- Curve radius down to 185m (9.45°)
- Steepest gradient of 2.8%
- 60% of track with over 2% gradient
- UNESCO world cultural heritage

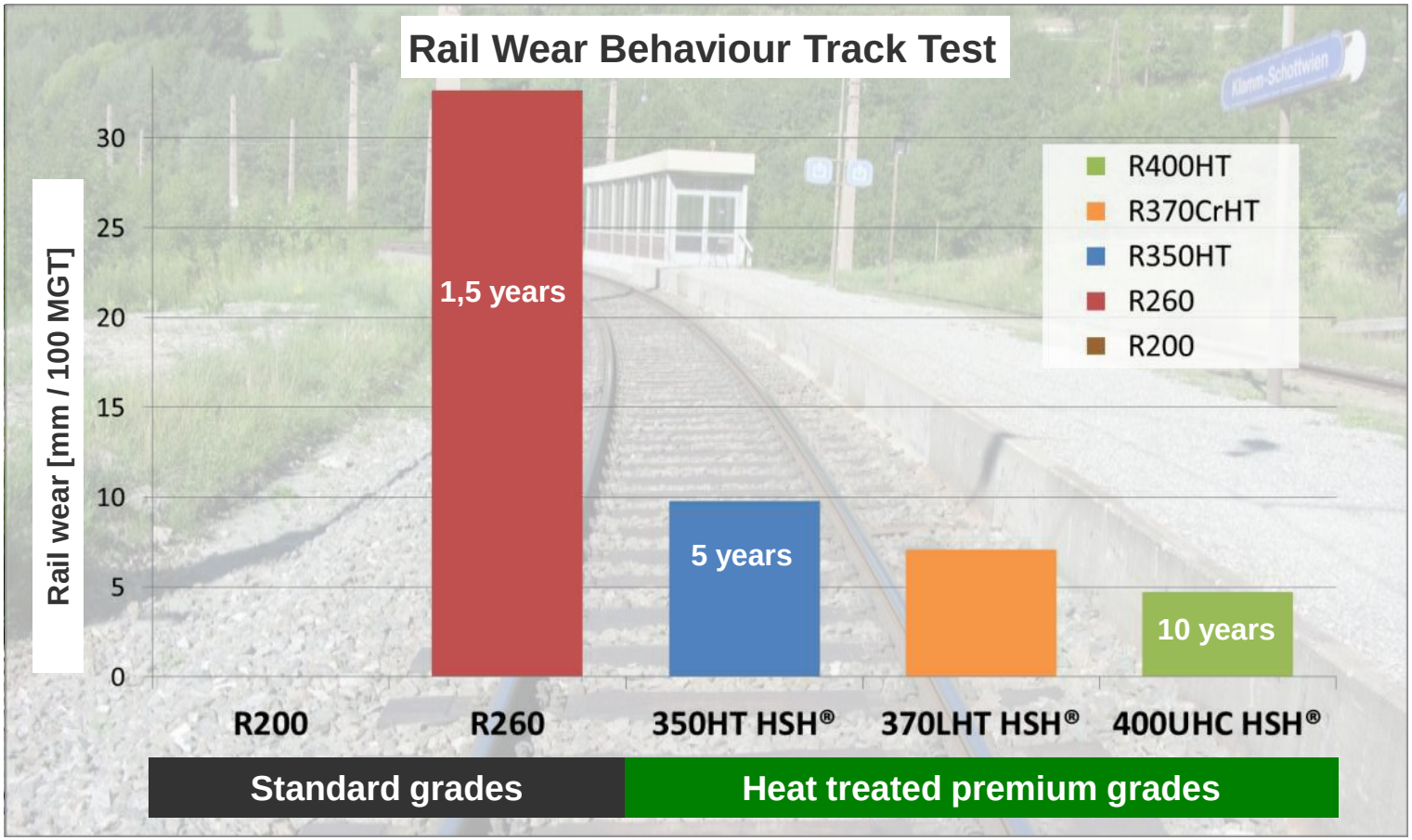


© Niederösterreichisches Landesmuseum
http://www.semmeringbahn.at/



Rail grade strategy: wear

Track test example (Semmering - Austria)



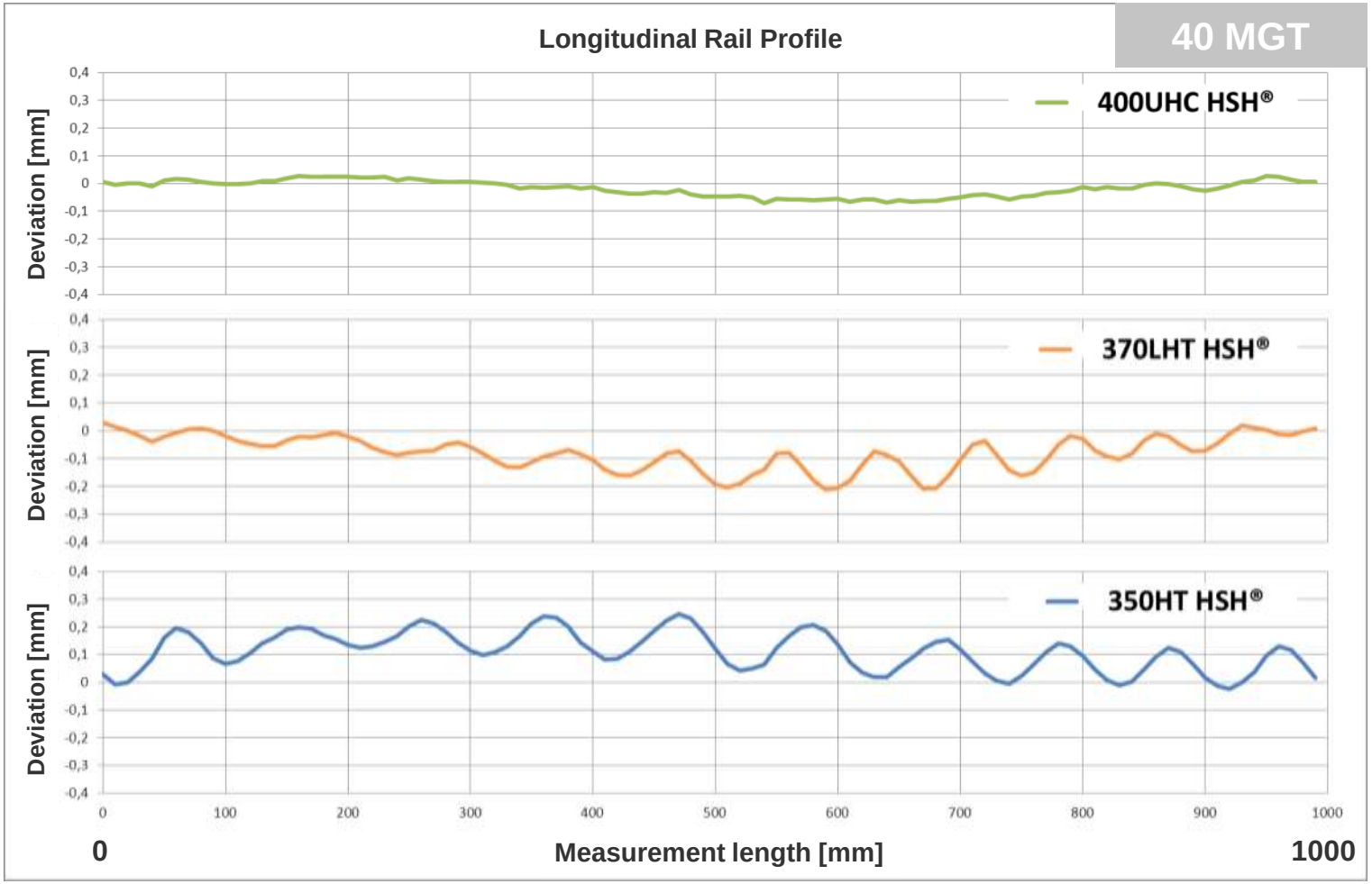
With increase in rail hardness less wear

Rail grade strategy: Corrugation
Track test example (Semmering - Austria)

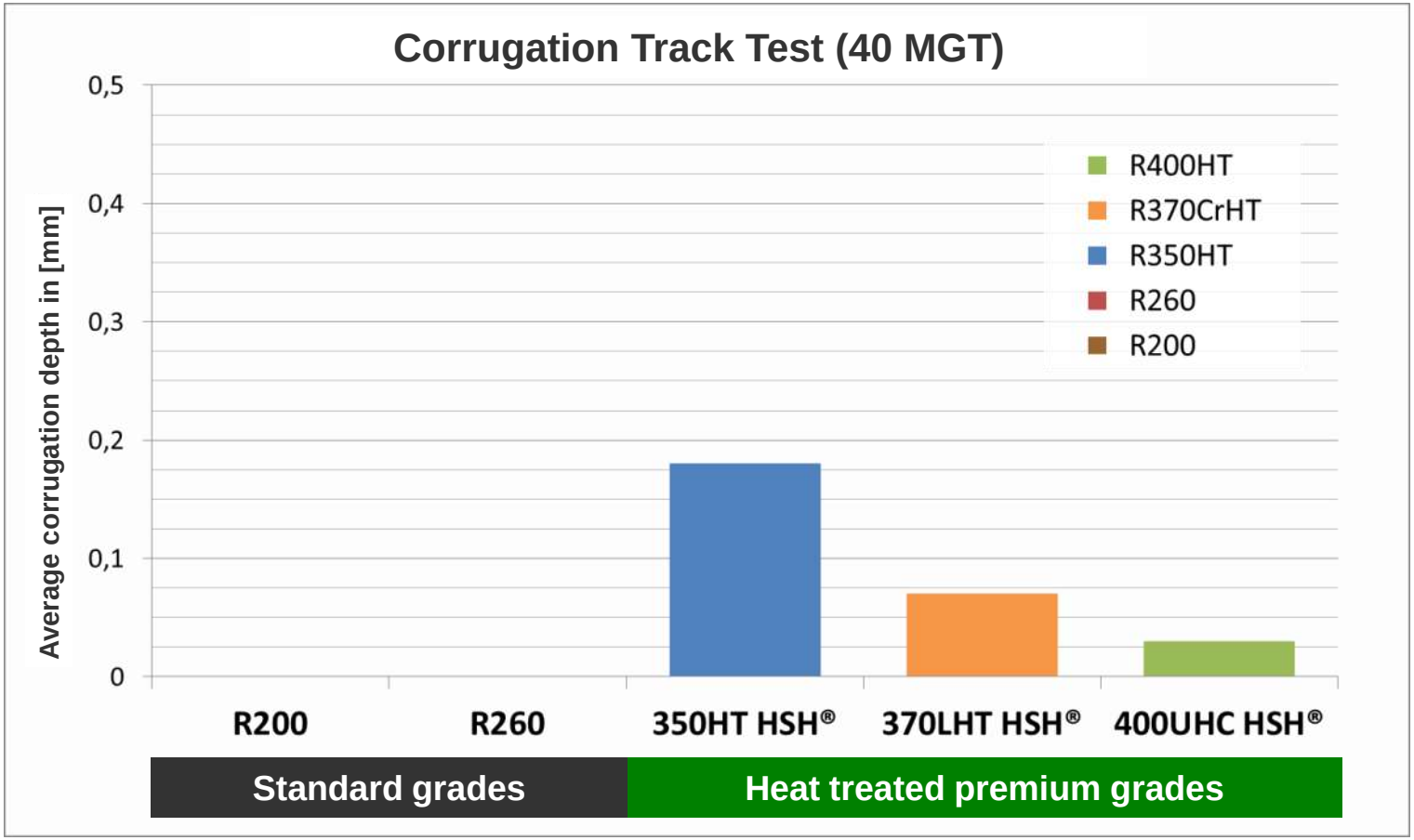
- With increasing rail hardness reduced formation of corrugation (mixed traffic, 40MGT)

Rail grade strategy: Corrugation

Track test example (Semmering - Austria)

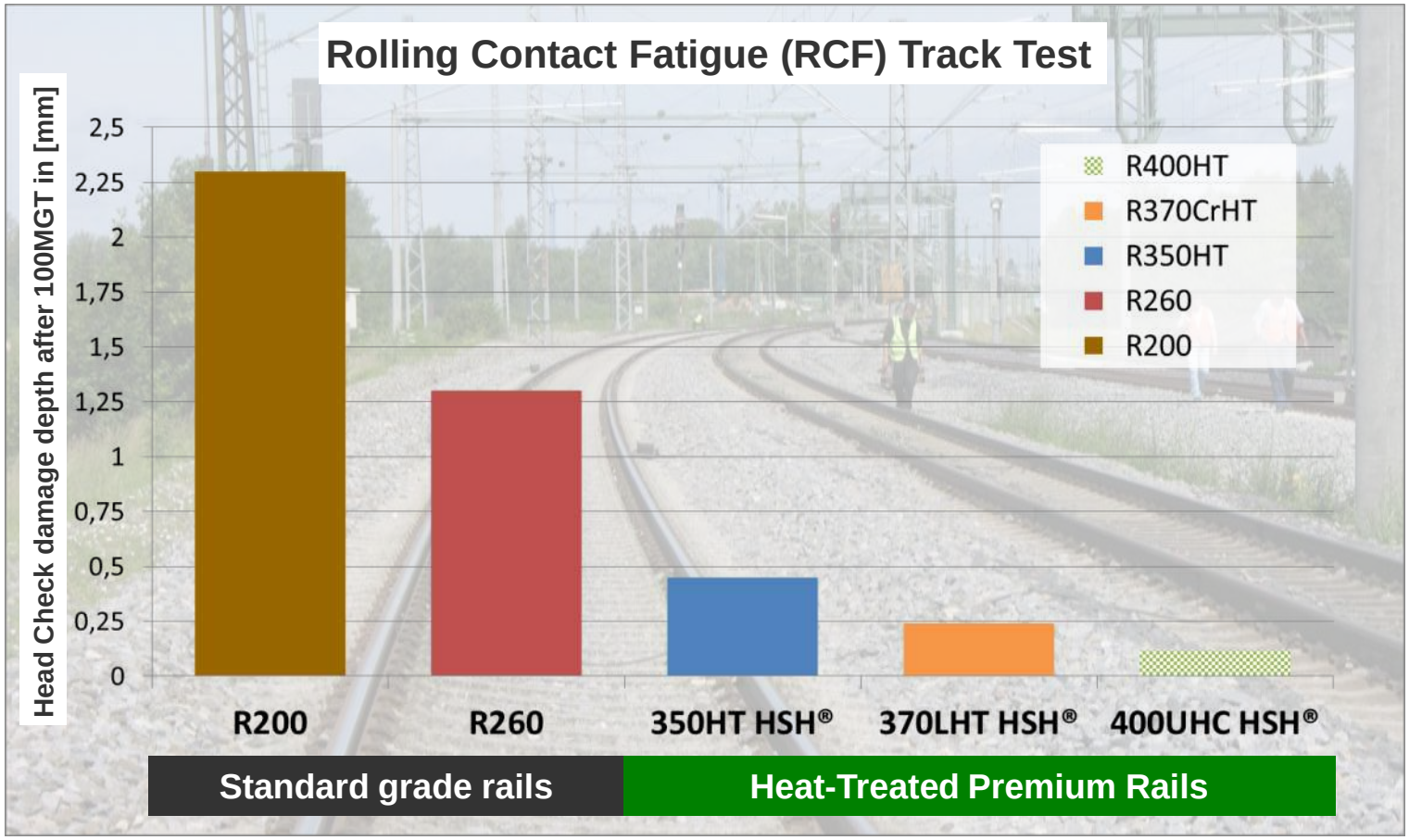


Rail grade strategy: Corrugation
Track test example (Semmering - Austria)



With increase in rail hardness less corrugation

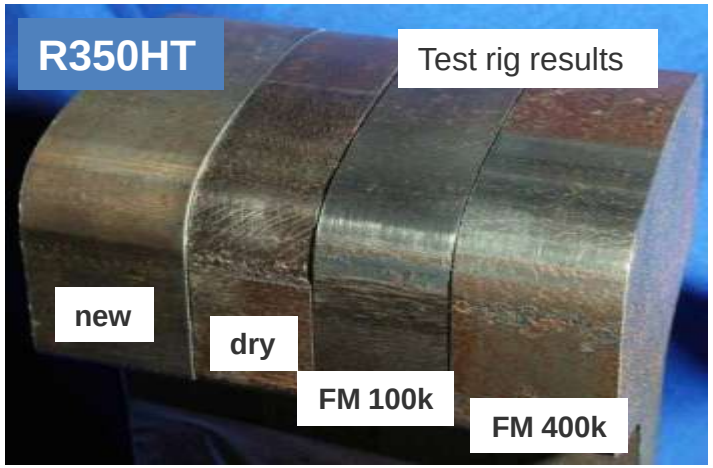
Rail grade strategy: RCF Tracktest example (Germany)



With increase in rail strength less RCF

Friction Management

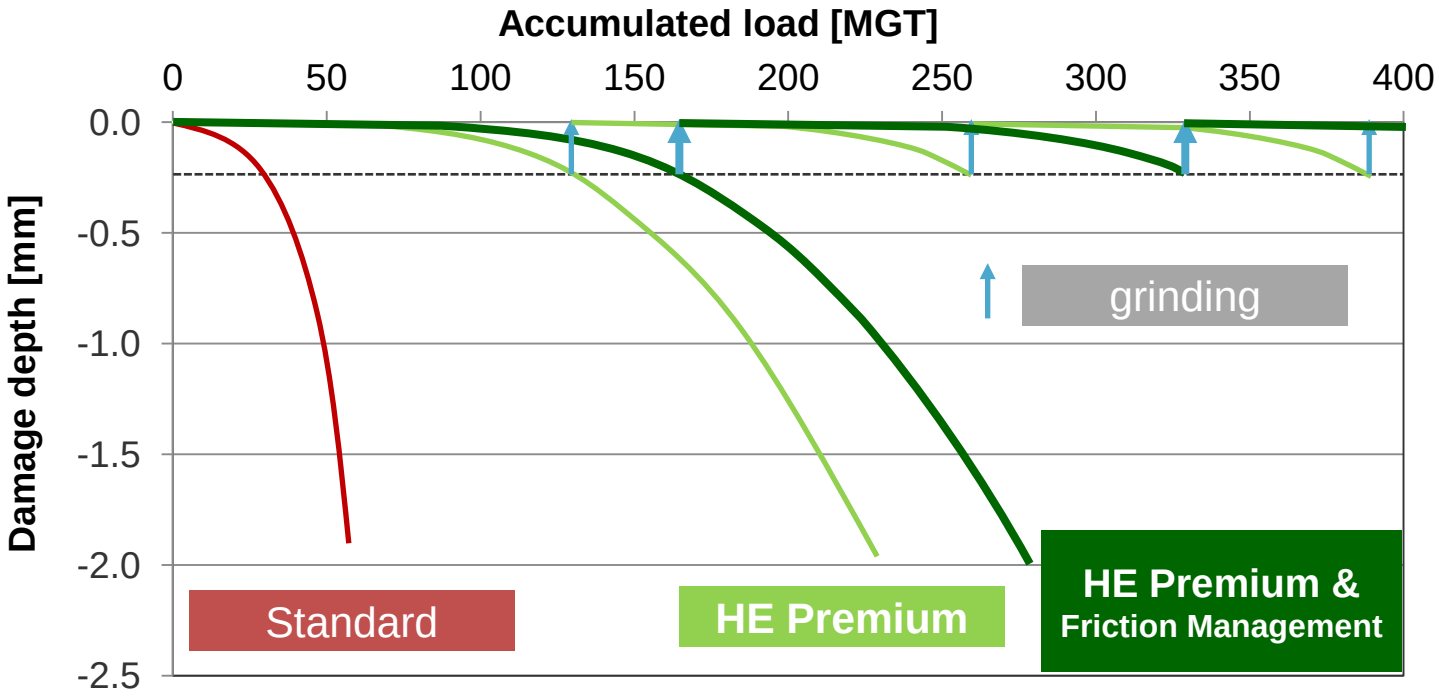
- Adjust friction to the right level
  - GF – as low as possible
  - TOR – approx. 0.35
- Reduction of tangential forces
- Tangential forces on rail surface:
  - Plastic deformation, wear, RCF
- Friction Management:
  - Extend time to initiate damage
- Further positive effects:
  - Fuel savings
  - Derailment safety
  - Damage prevention of track components



Source: LB Foster Friction Management

Combined approach for pearlitic grades

- Maximum possible rail life (positive influence on the whole track and vehicles / wheels)
- Highest reduction in LCC



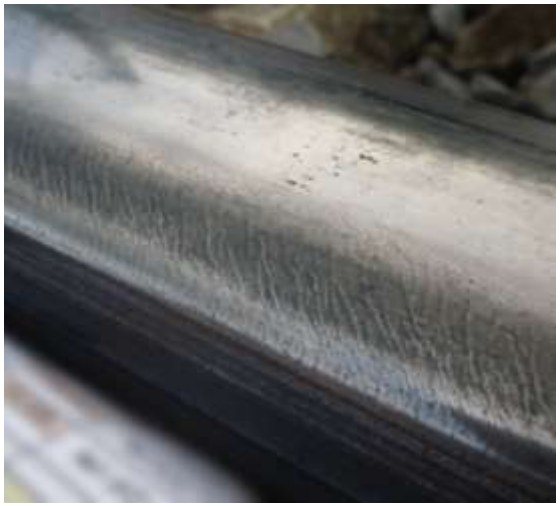
- Choose the best available rail grade
- Apply a preventive maintenance strategy
- Friction Management will further extend rail life and grinding cycles

State of the art solutions

- Wear :

  Narrow curves, Heavy Haul
  - **High strength HE premium rails**
  - Friction management
  - Profile restoration by grinding

→ **Solution**

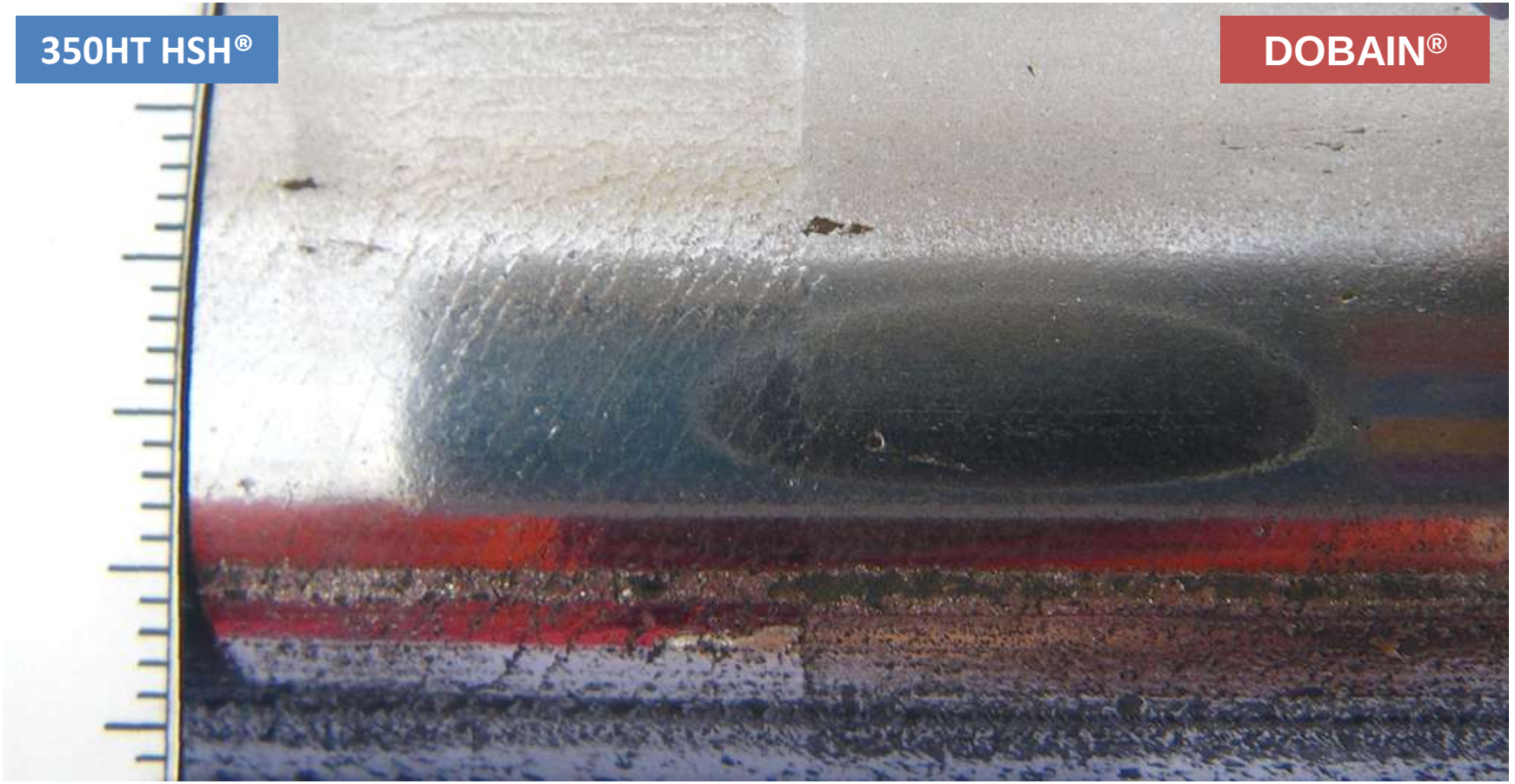


- RCF – delayed

  Shallow curves, medium to light loads
  - **High strength HE premium rails**
  - Preventive grinding strategy
  - Friction management

→**Best possible mitigation**

Bainitic Rails



Detail of flash but weld – left pearlitic with HC, right bainitic without damage

Towards a maintenance free rail

- Starting position:
  - High strength HE premium rails provide highest wear resistance and reduced, low crack growth
  - However these rails do develop cracks that need to be removed

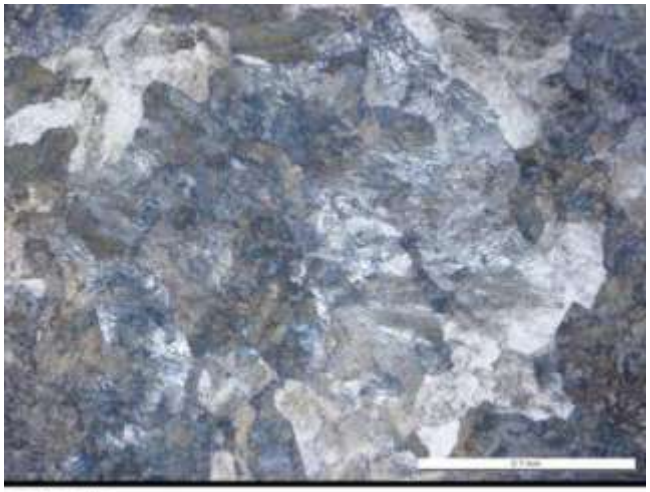
Development target
„RCF-maintenance free rail with lowest LCC“

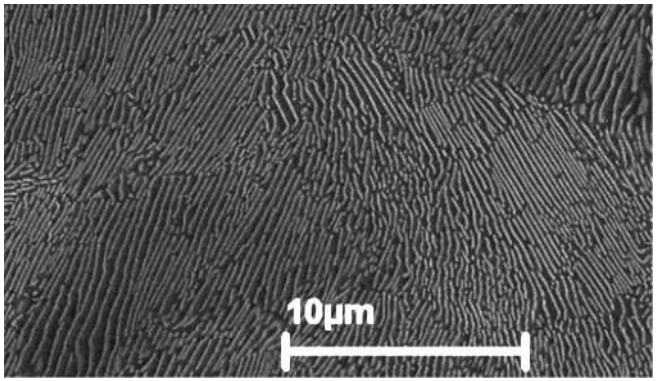
- Chosen Approach:
  - Bainitc rail steel

Due to the fact that
- Bainitic microstructure resistant to cracks / crack free
- Proven by Optikon Test in Germany

Pearlite

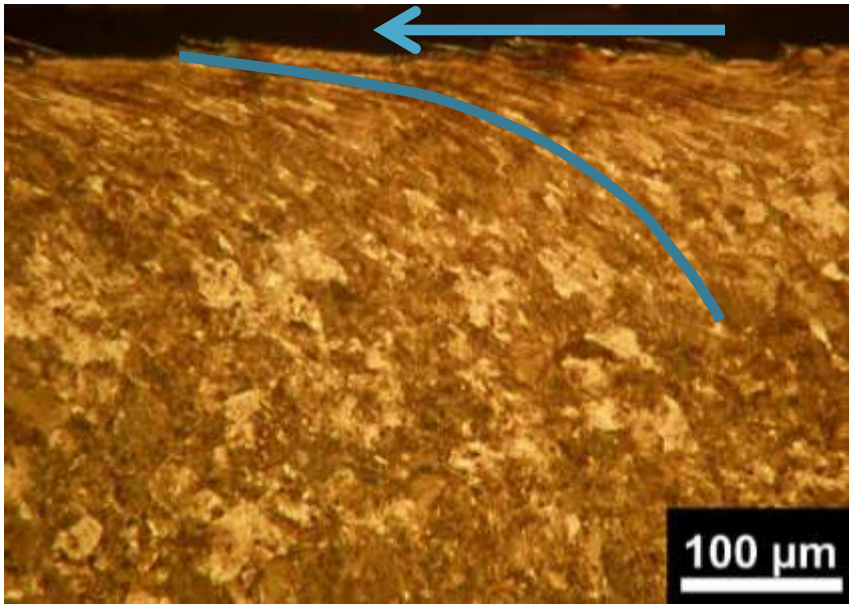
- Two phase material: Ferrite & Fe_3C
- Lamellar or layer structure
- Lamella spacing defines material properties
- Used for all kind of steels
- Used in rails for standard and premium grades

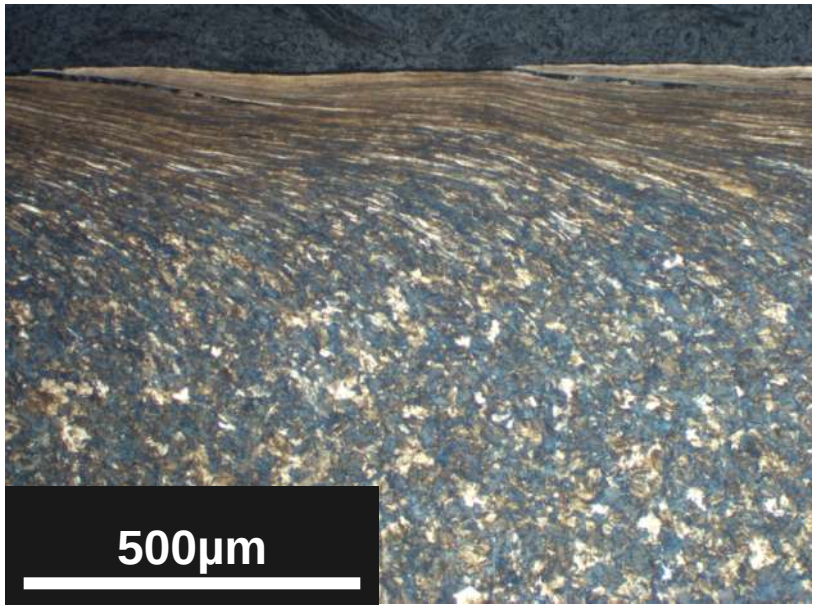

Perlit 260HB



Damage of pearlitic rail grades

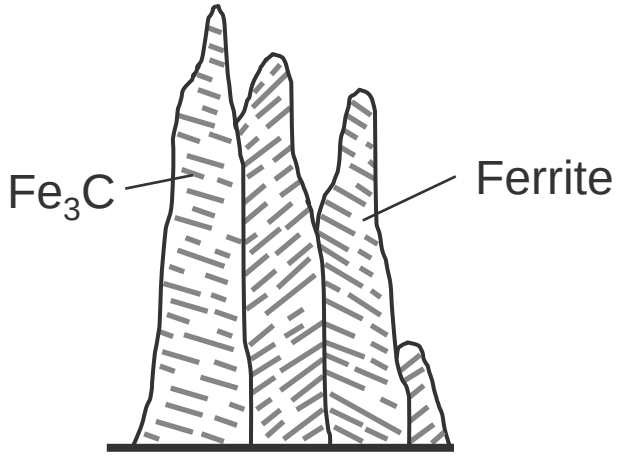
- Pearlitic material structure: layer structure of cementite and ferrite
- Plastic deformation:
  - lamella alignment
  - given crack path for initiated cracks

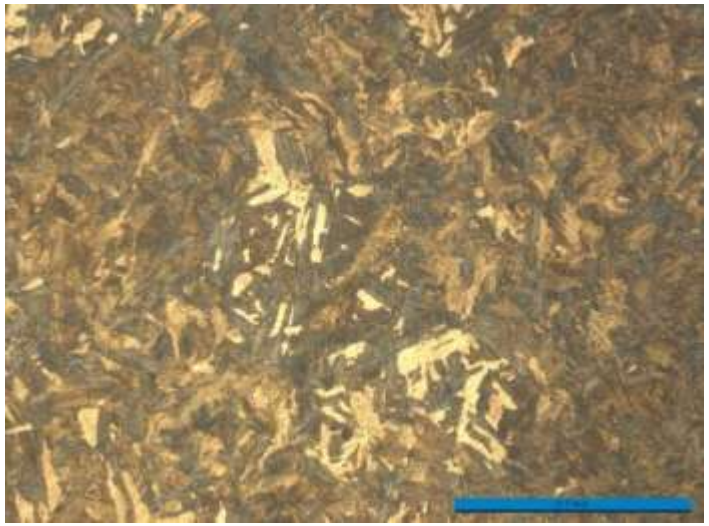




Bainite

- Two phase material: Ferrite & Fe_3C
- High toughness and hardness
- Produced by accelerated cooling or alloying
- Intermediate structure, randomized structure of ferrite and carbide
- Upper, lower or carbide free Bainite





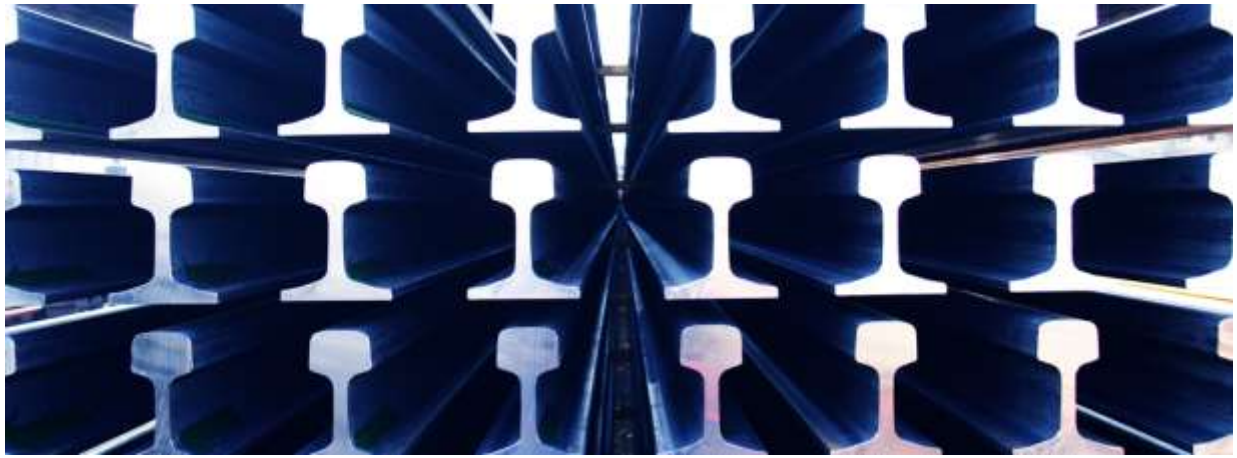
Development objective

- Provide a solution for the massive Head Check problem – no crack formation at GC and on running surface – no need for maintenance to remove damage
- Sufficient high wear resistance for rail life cycles of 30 years+ in medium to wide curves
- Adequate weldability and similar material characteristics as pearlitic grades (thermal expansion, conductivity)
- Economic production route for 400ft (120m) un-welded rails
- Mass-produced rail with a clear economic benefit, just-in-time available

Bainitic rail grades – different approaches

- Heat Treatment
  - Economic process
  - Welding with minor adjustments
  - Adequate wear resistance
  - Thermal expansion and electric conductivity equal to pearlite

- Alloying
  - High costs
  - Complicated welding
  - Low wear resistance
  - Low electric conductivity
  - Increased thermal expansion



DOBAIN®

DOBAIN® - Properties

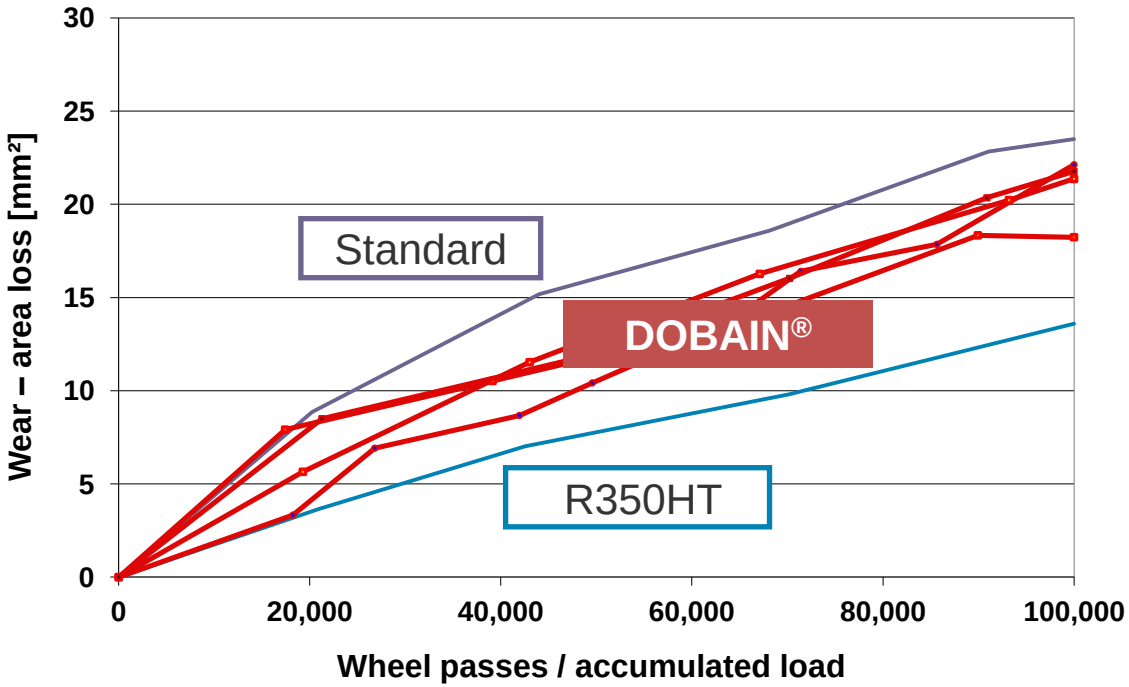
- Multi-Phase (MP) Bainitic Microstructure
- Low alloy content
- Mechanical properties
  - 340 – 410 HB
  - ultimate tensile strength ~ 1150-1400 Mpa
  - Mechanical properties adjustable by heat treatment
- Physical properties fulfil standards or better than actual standards
- Welding
  - AT-Welding in optimisation
  - FB and FB mobile available
- Reproducible & automated manufacturing process

Full scale rail – wheel test rigs

- Realistic loading and contact conditions
- Test results within day(s)
- Reproducible results
- Automated documentation of relevant test data

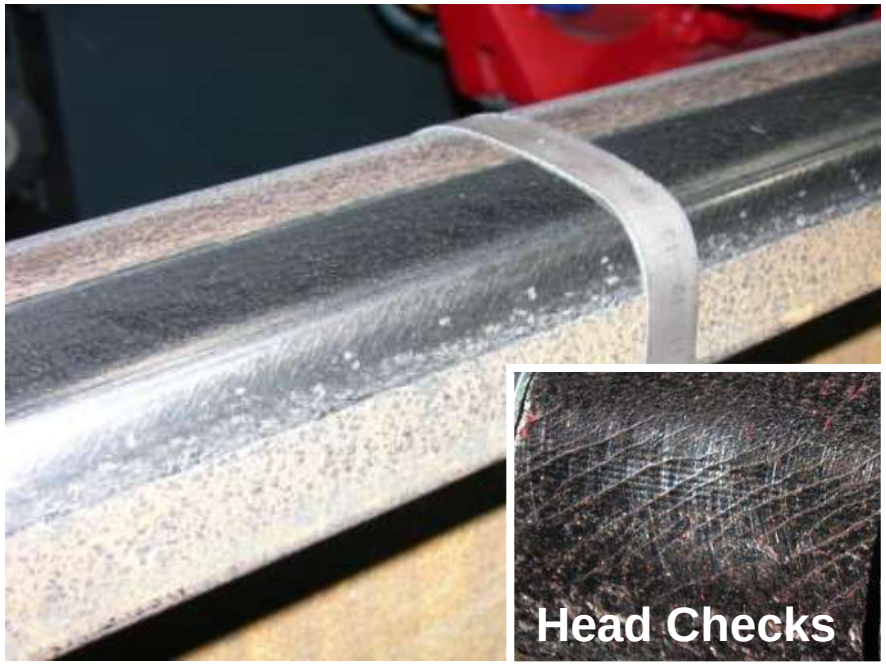
Rail-wheel test rig tests: wear

- DOBAIN® MP380: Wear resistance better than standard grade



Rail wheel test rig - RCF

- No formation of cracks for DOBAIN® MP380 after 500,000 wheel passes



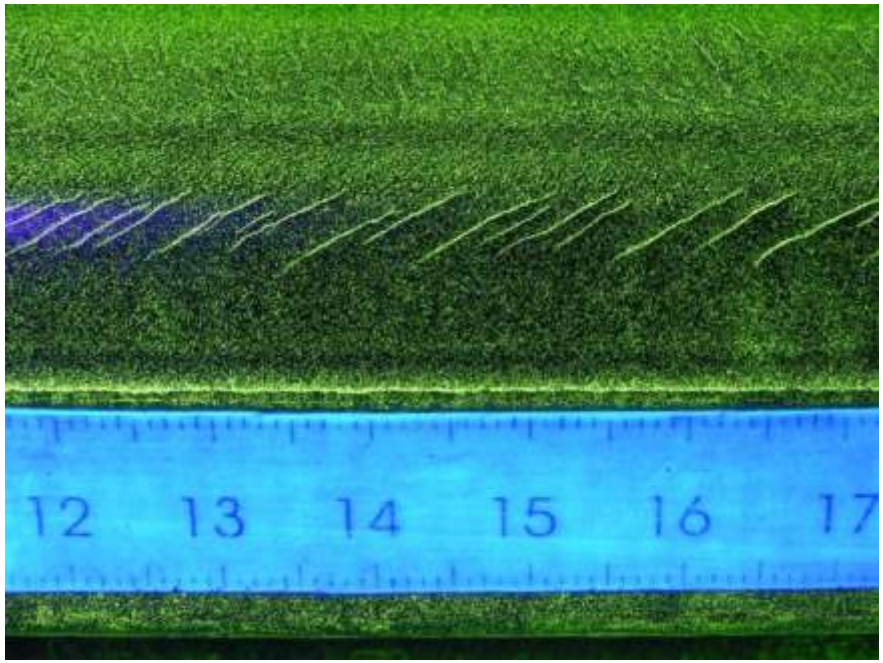
R350HT after 30.000 wheel passes

DOBAIN® after 500,000 wheel passes*

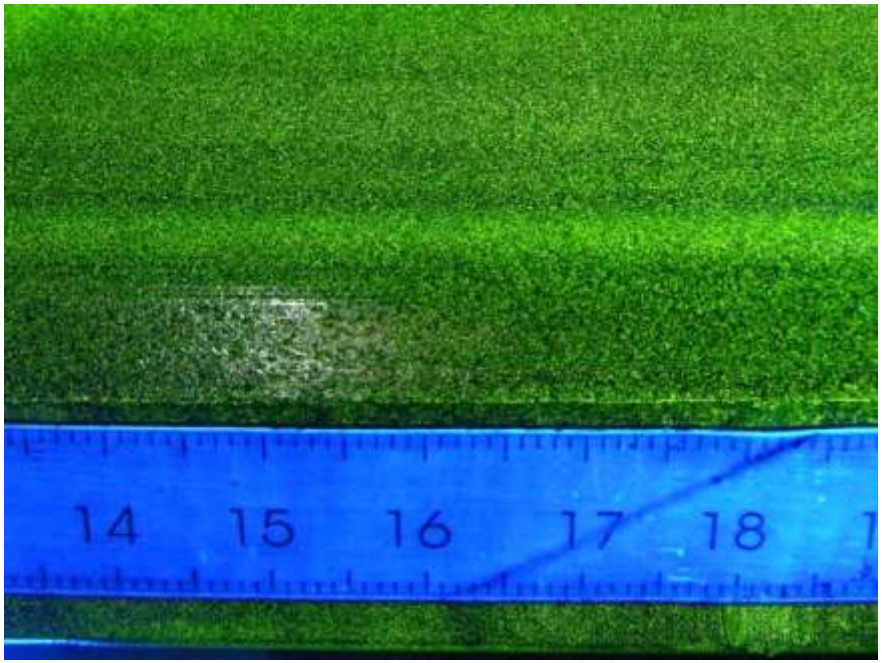
*Standard test: 100.000 wheel passes, 20t vertical and 4t lateral load. Head Checks on all pearlitic rail grades

Rail-wheel test rig - RCF

- MPI after 200,000 wheel passes with different set-up



R260 after 100,000 test cycles
Head Checks at the gauge corner

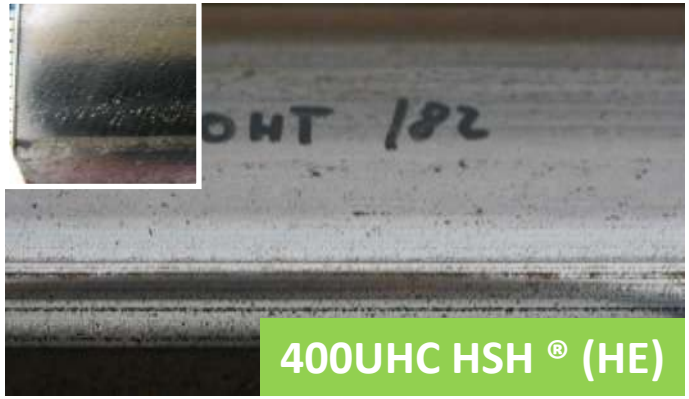


DOBAIN® after 200,000 test cycles
Completely Head Check free

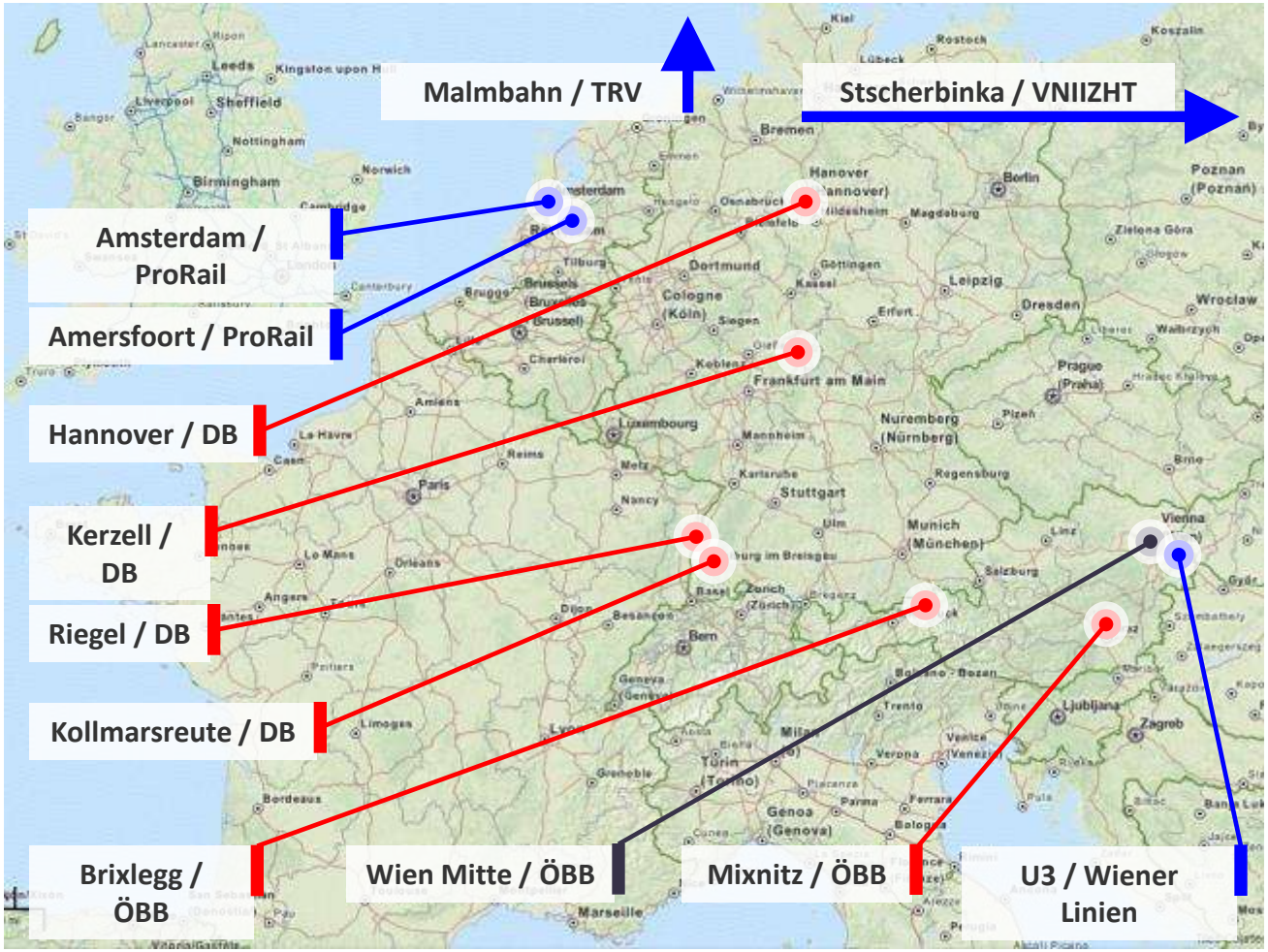
Track test results

- Track test in Germany
- R = 600m (~3°)
- All pearlitic grades show HC after 15 MGT

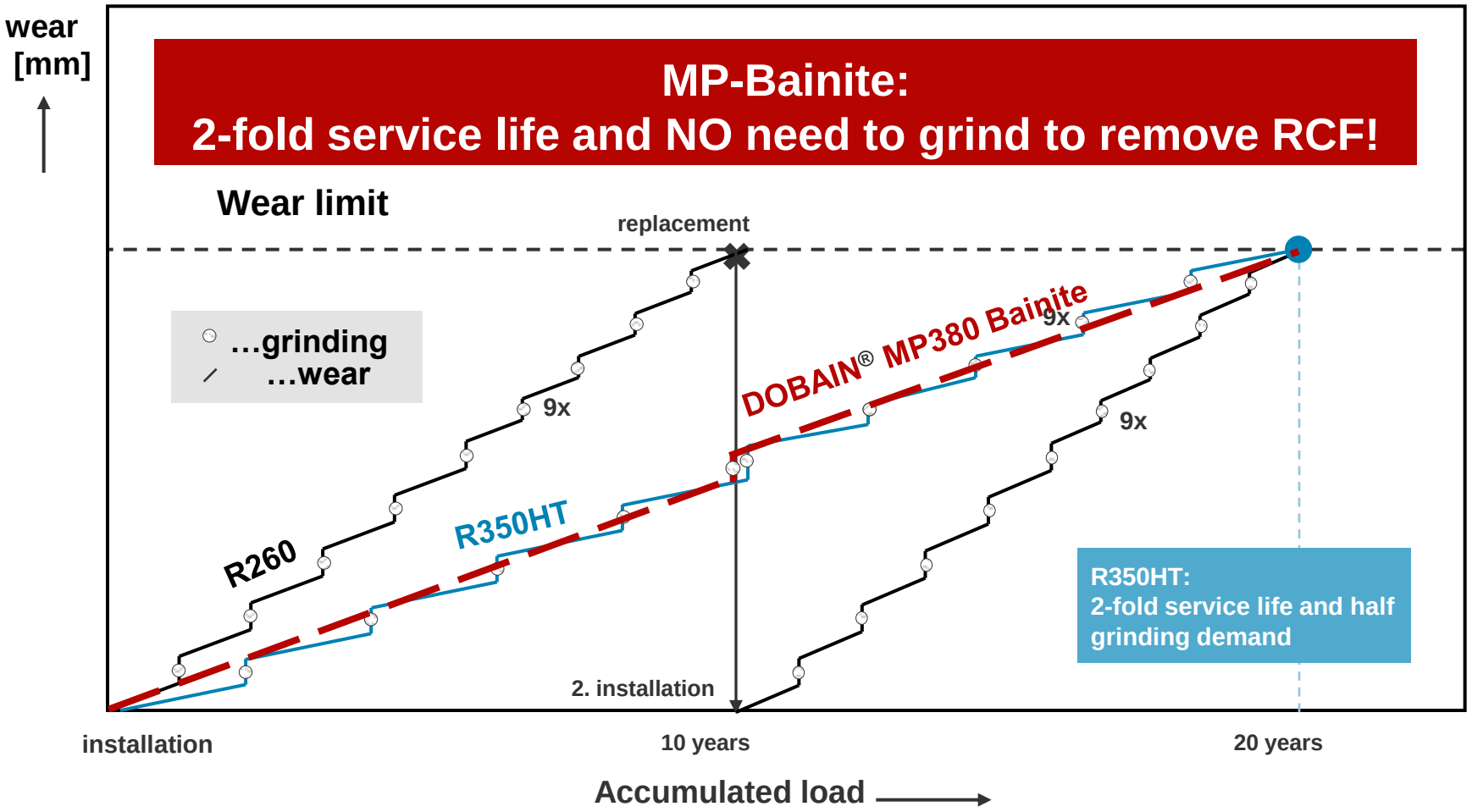
- NO HC on DOBAIN® after 15 MGT



DOBAIN® track tests in various conditions



Comparing the life cycle



Summary Wear

Solution to the wear problem (Heavy Haul, sharp curves)

- Best available premium rail grade
  - hypereutectoid
  - heat treated
  - fine pearlitic
- combined with
  - Friction Management
  - Preventive grinding strategy

Maximum customer benefit by longest possible rail life

Summary RCF

Future solution to RCF Problem

- Moderate Heavy Haul / mixed traffic / commuter traffic
- Wide curves (R > 500m) – RCF predominant form of damage

- Bainitic rail **DOBAIN® MP380**
  - No development of RCF
  - Wear resistance – service life time > 30 years
  - Drastically reduced maintenance effort
  - Maintenance only for profile restoration
  - Friction Management – positive contribution

Towards a maintenance free rail with highest cost efficiency

Thank you for your attention

voestalpine

ONE STEP AHEAD.