Friction Management and Rail Wear CPs Western Corridor: 2008 - 2016

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Overview

- Background on Rail Wear Review at CP
- Objective/Method to Validate Benefit
- Rail Wear Analysis
- Data Sources/Procedure
- Wear
- Grinding
- Conclusions

Background on Rail Wear and Friction Management at CP

- NRC "100% Effective Lubrication" Project: **2000-2001**
  - Demonstrated Fuel Savings and Near-Elimination of GF Wear via GF Lubrication.
  - Revealed Increase in TOR Wear Due to Increased AoA with Extensive GF Lubrication.
- Northern Ontario Friction Management: **2003-present**
  - Outsourcing of Friction Management Oversight to Portec Rail Directing CP Internal Forces.
- NRC "100% Effective Friction Management" Project: **2004-2005**
  - Demonstrated Reductions in Lateral Forces (24%-40%) and Rail Wear (~50%) with Incorporation of KELTRACK Trackside Freight TOR Friction Control.

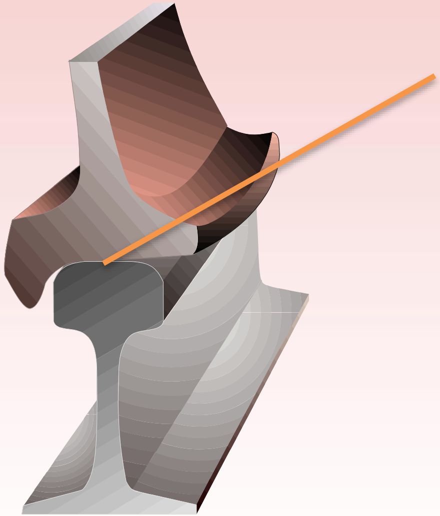
Background on Rail Wear and Friction Management at CP

- Validation of Rail Wear Reduction and Fuel Savings: **2007**
  - TFM Business Case Escalated for Approval at CP (Fuel and Rail Wear).
- Total Friction Management Deployment: West Corridor
  - 2008 – Present (GF + TOR + Dedicated Resources + Monitoring)
  - TFM Implementation on CP West Corridor
    - 139 GF/255 TOR: Initial Design
    - 139 GF/212 TOR: Following Re-spacing in 2015

Decision to Validate Rail Wear Benefit from Friction Management

- Validation of Benefit Required: Context of Current Operation
  - Dynamic Train Design and Train Speed
  - Curve Specific Replacement Rates
  - Deployment of 18-Inch Tie Plate
- Validation Objective:
  - Friction Management Effect on Rail Wear
  - Review Empirical Evidence from Available Sources of Information

Decision to Validate Rail Wear Benefit from Friction Management



TOR Impacts – Many Variables

- Lateral Forces and Rail Wear
- Rail Cant
- RCF Development
- Fuel Efficiency
- Derailment Potential (L/V, Rail Rollover)
- Noise
- Corrugations
- Hunting Traction / Adhesion

Method of Validation

- Test Results of Original Justification Without Use of Specialized Tools/Analysis
  - L/V and Fuel Consumption
- Use Existing Engineering Practices
- Use Existing Engineering Data and Tools Sets

Method of Validation

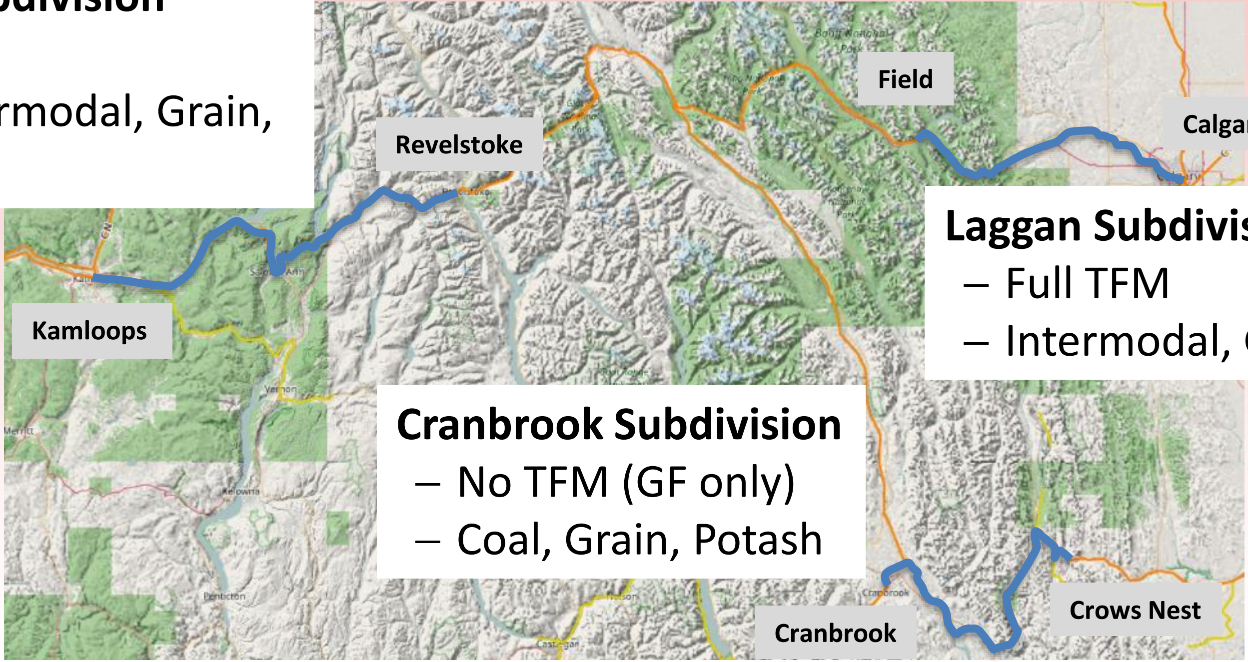
- Selected Geometry Car and Rail Grinder as the Most Consistent Data
- Target Curve Grinding Interval 25/30 MGT
- Existing Historical Record

Rail Wear Analysis

- Time Frame: 2014 - Mid 2016
- Selection of Subdivisions
  - With and Without TFM Implementation
- Three Curves per Subdivision
  - 4° Curve, 6° Curve and 9° Curve
  - No Other Disruptive Factors (Crossing, Differential Heavy Grades, etc.)

Data Sources: Analysed Subdivisions

Shuswap Subdivision
- Full TFM
- Coal, Intermodal, Grain, Potash



Laggan Subdivision
- Full TFM
- Intermodal, Grain, Potash

Cranbrook Subdivision
- No TFM (GF only)
- Coal, Grain, Potash

Data Sources: Applicator Uptime

- Applicator Uptime: Key Factor for Achieving Expected Benefits
- Average Uptime Around Examination Curves: **87%**

Data Sources: Traffic Conditions

- Average MGT in 2014 and 2015 Used for Calculations as Provided Wear Data Covered Period of 2014 -2016.

Subdivision	2013	2014	2015	Average (2014-2015)
Shuswap	98.7	101.8	103.7	**102.8** MGT/year
Laggan	56.0	59.1	62.2	**60.7** MGT/year
Cranbrook	27.1	29.4	29.3	**29.4** MGT/year

Data Sources: Track Geometry, Rail Wear, Grinding

- Track Geometry Data **Every Foot**
  - MP, L/R/Tangent, Deg. of Curvature, Wear (Gauge, Vertical)
- Wear Data **Every 15 Feet**
  - MP, Curve/Tangent Info, Gauge Wear, Vertical Wear
- Grinding Information, **One Value per Curve**
  - Metal Removal (Gauge, Vertical) and Grinding Passes

Definitions of Wear

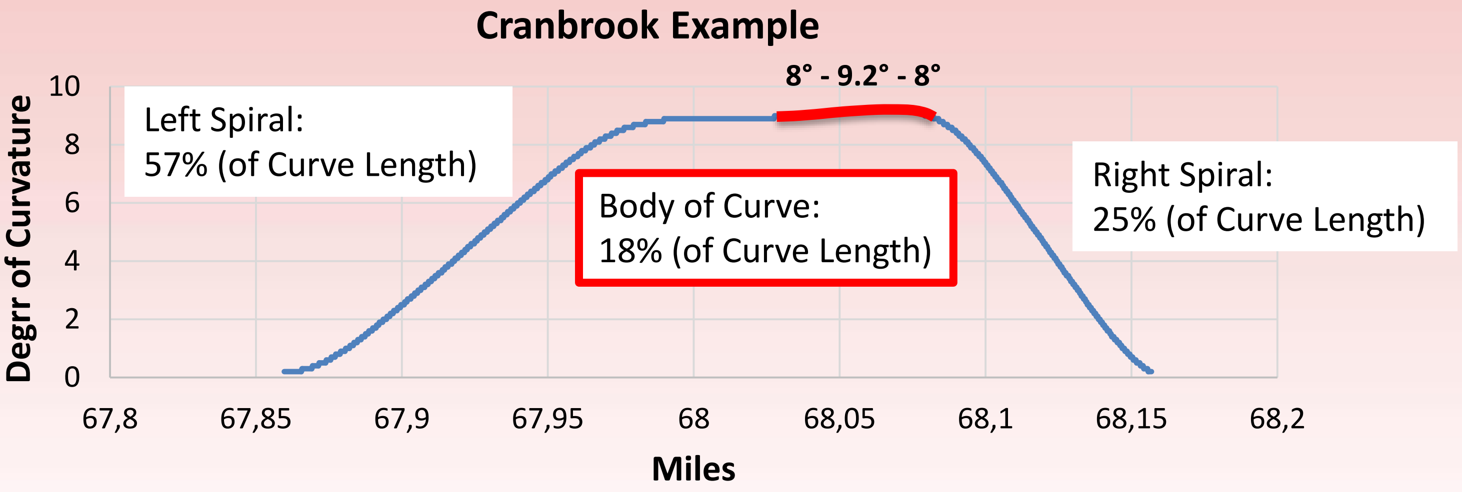
- **Natural Wear:** Wear of Rails Caused by the Railway Vehicles
- **Artificial / Grinding Wear:** Wear Caused by Rail Grinding Activities
- **Combined Wear:** Natural + Grinding Wear

Photo by voestalpine, WRI 2013

Data Analysis Procedure - Part I

- Select Curves for Analysis from Geometry Files
- Geometry Data:
  - Curve / Tangent Transition: Degree < 0.2°
  - Body of Curve: "Maximum Curvature - 0.2°" (Ensure Stable Wear Conditions)

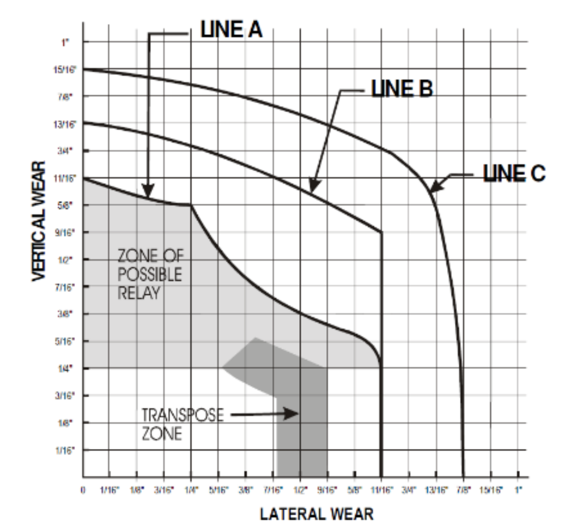
Data Analysis Example: Body of Curve



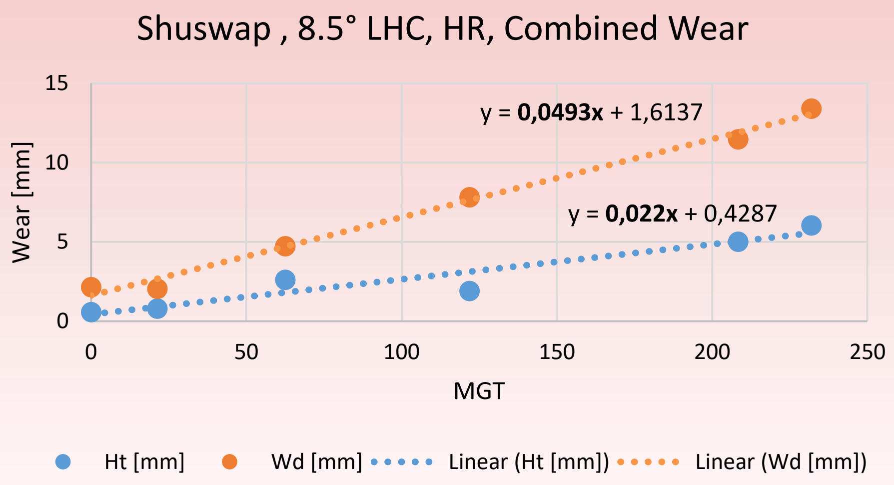
- Use the % "Spiral-Body-Spiral" Length from Geometry Data to Determine Body of Curve Location in Wear Data Files

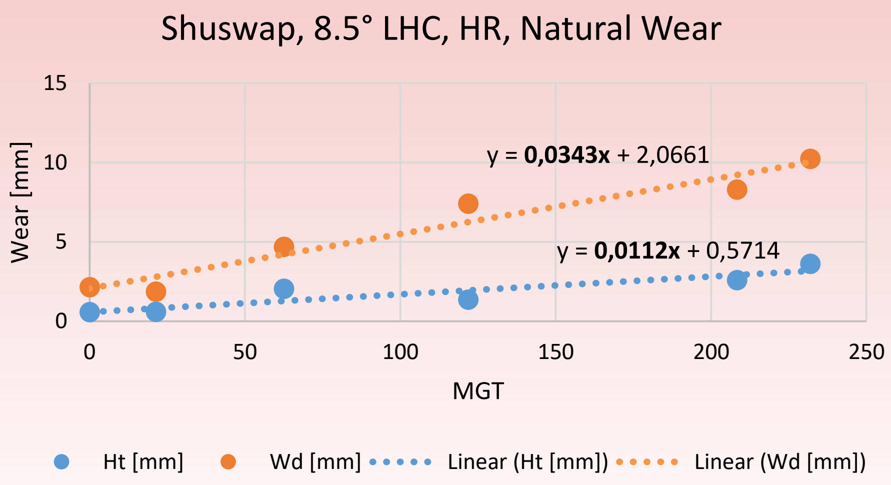
Data Analysis Procedure – Part II

- Calculate Average Vertical (Height) and Lateral / Gauge (Width) Wear for Body of Each Curve and Each Measurement
- Linear Regression of Wear Rate with MGT Information [mm/100 MGT]



Data Analysis Example: Wear Rates





Combined Wear Rates:
Vertical (Ht): 2.2mm / 100 MGT
Gauge (Wd): 4.9mm / 100 MGT

Natural Wear Rates:
Vertical (Ht): 1.1mm / 100 MGT
Gauge (Wd): 3.4mm / 100 MGT

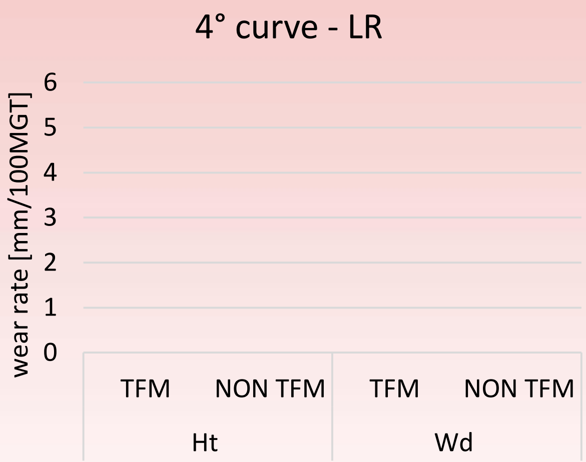
Data Analysis: Remarks

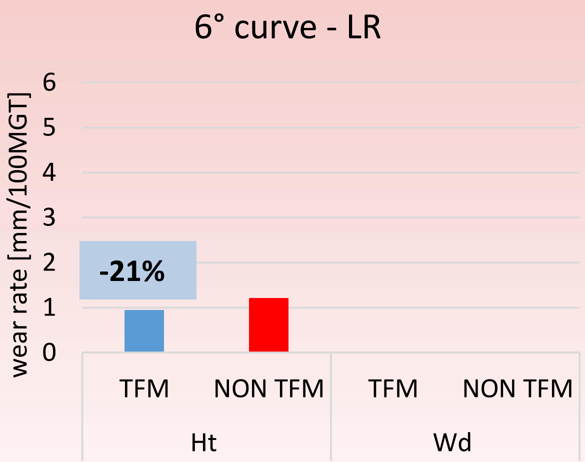
- Manual Correction for Rail Change-Outs
- Negative or "Zero" Wear Rates Were Removed from Analysis
- Rail Steel Grade:
  - 4°: Intermediate Grade (325 BHN)
  - 6° and 9°: Premium Grade (370 BHN)

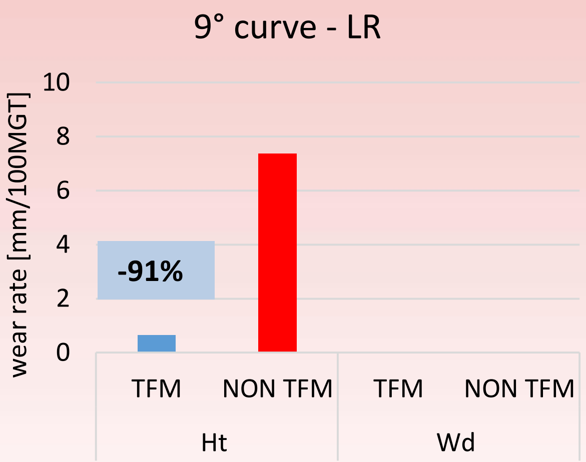
Unknown Factors

- Local Track Influence Between Measurements
- Impact of Different Levels of Data Accuracy in Provided Files
- Other Maintenance Activities that Might Influence Wear

Natural Wear – Low Rail

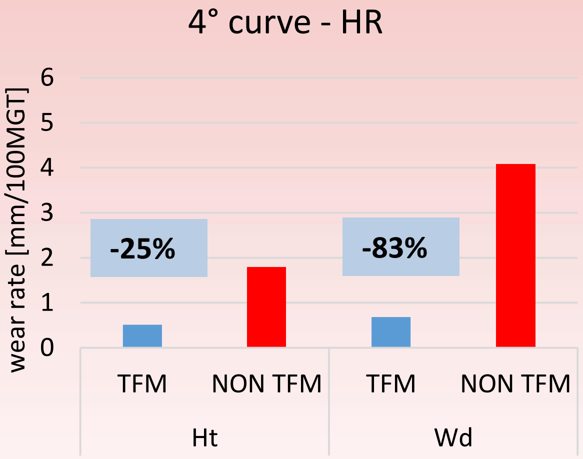


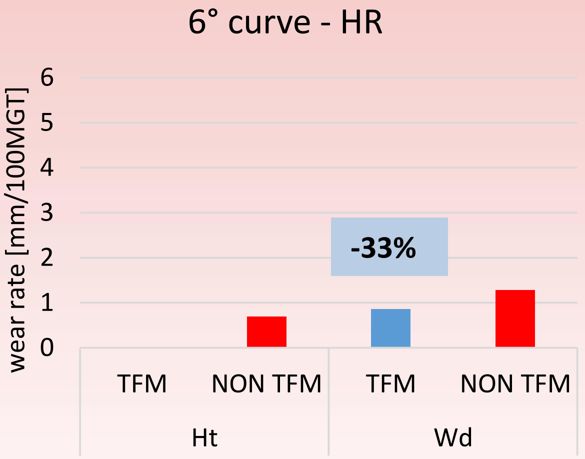


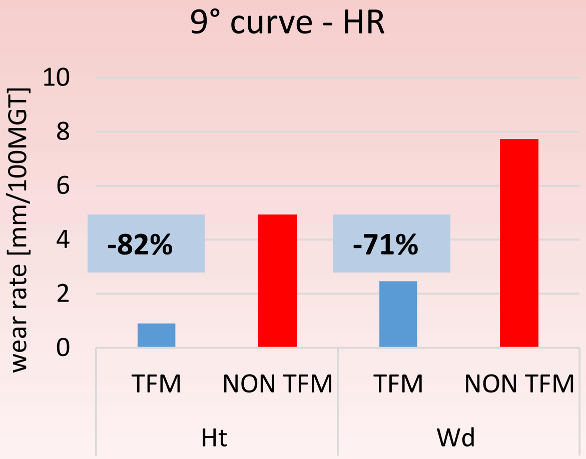


- LR: Only TOR (Top of Rail) Wear, no GF Wear
- Improvement TFM vs no TFM: Between 21% - 91%

Natural Wear - High Rail



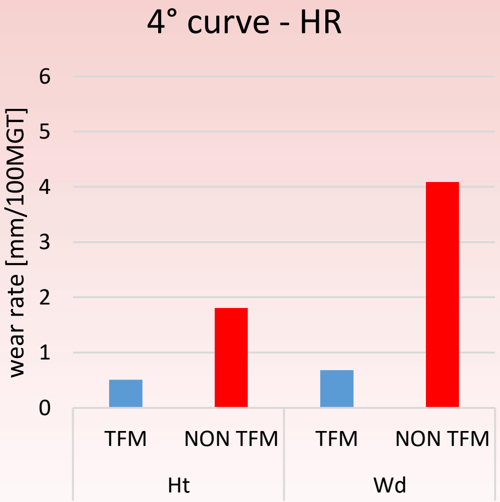


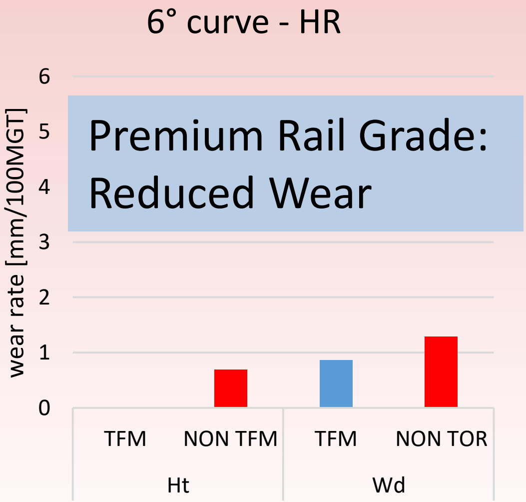


- High Rail: Wear on TOR and GF
- Improvement TFM vs no TFM: Between 25% - 83%

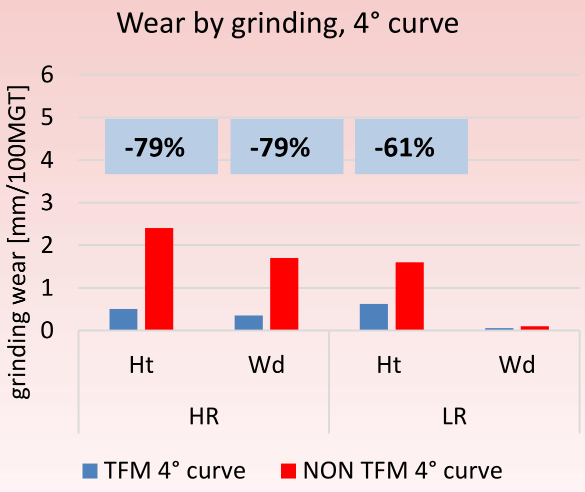
Rail Grade Influence

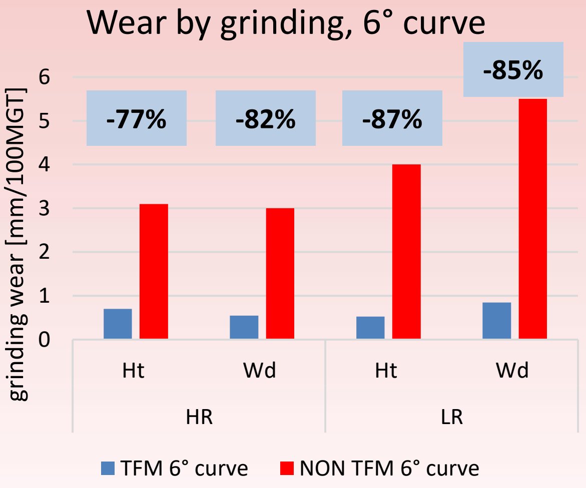
- Intermediate Grade (4° curve) vs. Premium Rail Grade(6° curve)
- Despite Sharper Curve Radius – Less Wear in 6° Curve.

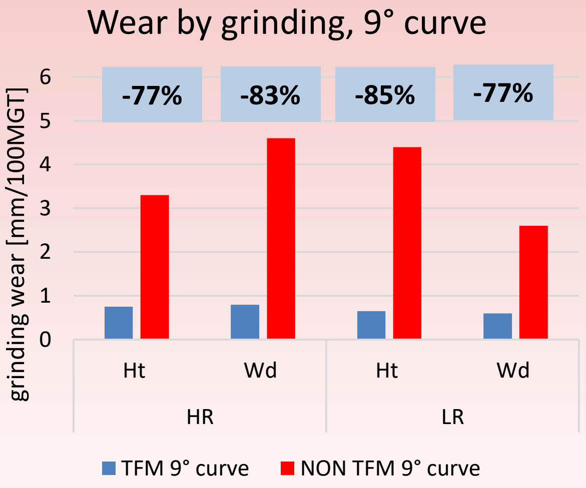




Metal removal by grinding

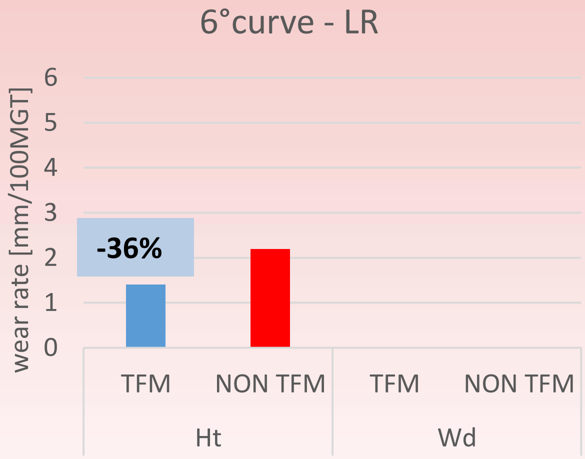


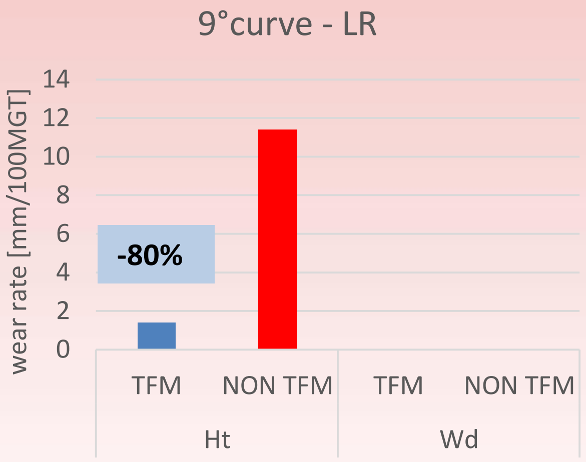




- Considerably Less Metal Removal by Grinding Required for TFM Curves Compared to Untreated Curves

Combined Wear – Low Rail

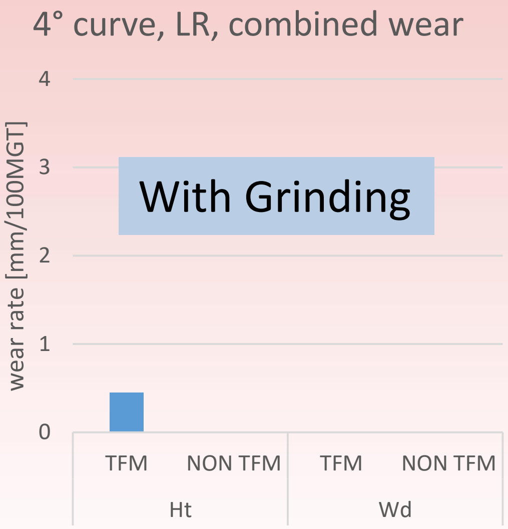


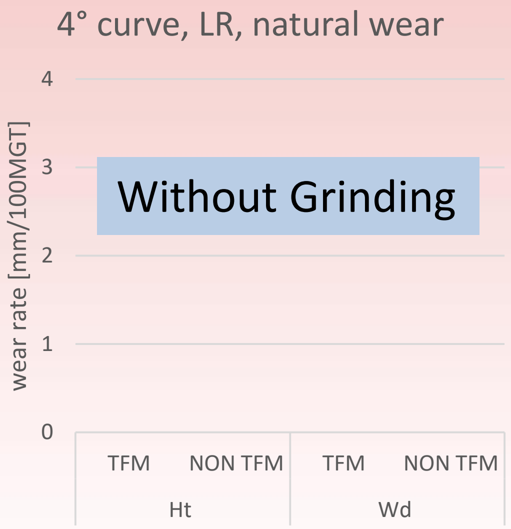


- Similar Trends as Natural Wear Analysis
- Improvement: TFM vs no TFM: 36-80%

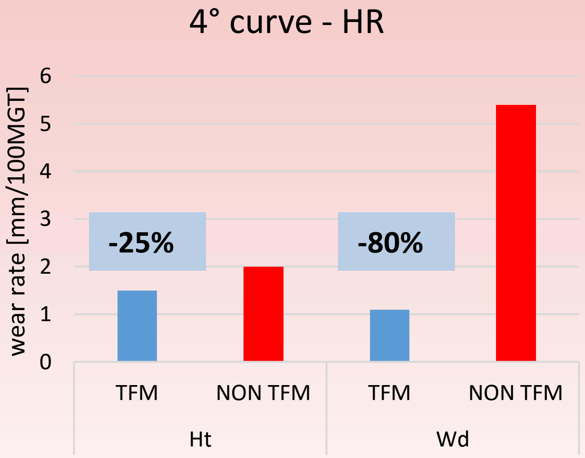
Impact of Grinding

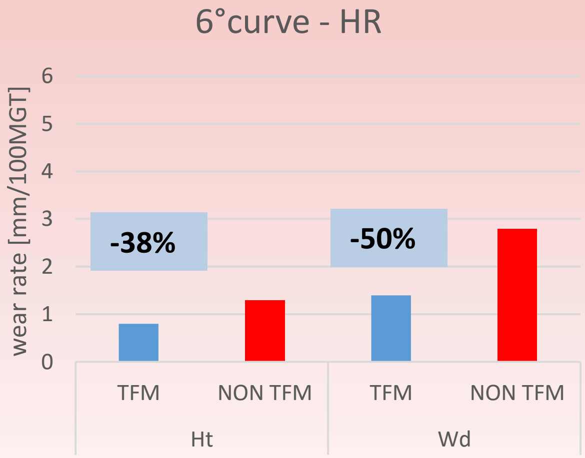
- Specific Grinding Actions can Disguise Rail Wear Behaviour
- Grinding Data: One (Corrective) Grinding Cycle (Laggan) with Higher Metal Removal

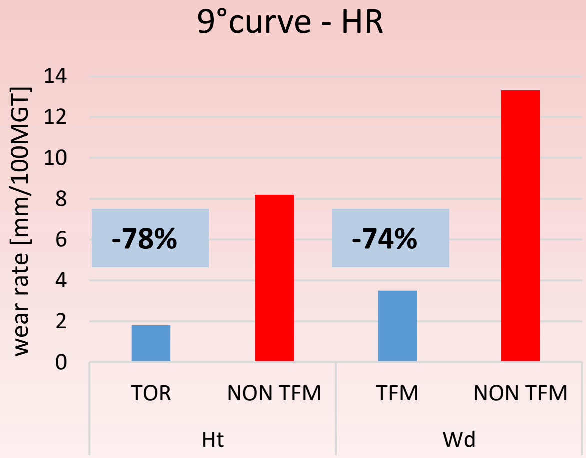




Combined Wear – High Rail







- Similar Trends as Natural Wear Analysis
- Improvement TFM vs no TFM: 25-80%

Considerations

- MGTs in Examination Period Differ Between Subs
- Traffic Type Different Between Subs
- Influence of Unknown Factors?
- Empirical Results Represent "Rough" Trends

Conclusions

- The Mapping of Railway Asset Life is Possible with Existing Railway Measurement Tools/Programs
- Total Friction Management (TFM) Curves Show Less GF and TOR Wear Compared to non-TFM Curves
  - Statement is Valid With and Without Wear Correction for Grinding Activities
- TFM Curves Require Less Metal Removal by Grinding Compared to non-TFM Curves
  - This Can be Attributed to Both, Reduced Wear and Reduced RCF Development Due to TFM

Thank You for Your Attention