Principles of Wheel-Rail Friction Management

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Contents

1. What is Friction Management?
2. Benefits of Friction Management.
3. Application of Rail Gauge Face and Flange lubrication.
4. Application of Top of Rail Friction Modifiers.
5. Application of Traction Enhancers
6. Standards
7. Properties of different Friction Management products.

What is Friction management?

Friction management using solid or fluid (oil, grease, etc) substances at the wheel-rail interface is a complex subject and includes:

- *lubrication of the wheel flange / rail gauge corner interface, commonly referred to as "flange or rail lubrication";*
- *lubrication of the back of flange/ check rail interface, commonly referred to as "check rail lubrication";*
- *altering the level of friction at the interface between the top of rail and the wheel tread, commonly referred to as "top of rail friction management";*
- *applying materials to the wheel rail contact to increase (improve/ enhance/ recover) adhesion.*

EN15427-1-1 (2022)

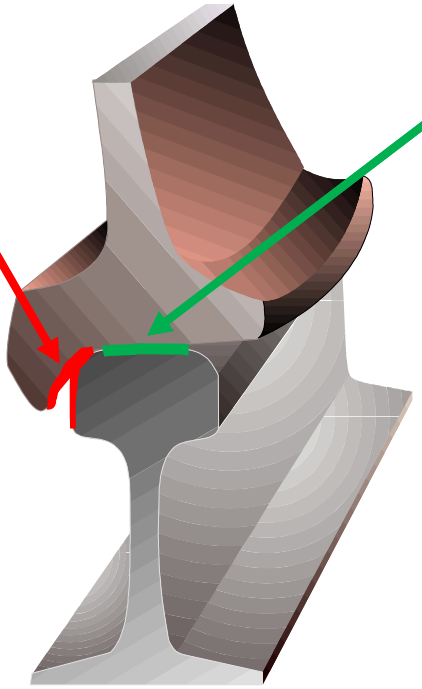
Benefits of lubrication and top of rail friction modifiers

Gauge Face / Wheel Flange

Benefits:

- Reduced Rail / Wheel Wear
- Improved Fuel Efficiency
- Lowers Derailment Potential
- Mitigates RCF Development
- Reduced Flange Noise

Target CoF: < 0. 15



Top-of-Rail / Wheel Tread

Benefits:

- Reduced Rail / Wheel Wear
- Improved Fuel Efficiency
- Reduced Lateral Forces
- Lowers Derailment Potential
- Mitigates RCF Development
- Reduces Hunting
- Mitigates Noise
- Mitigates Corrugations

Target CoF: ~0.35

CoF = Coefficient of Friction

Slide 4

JB0 missing corrugation from TOR benefits

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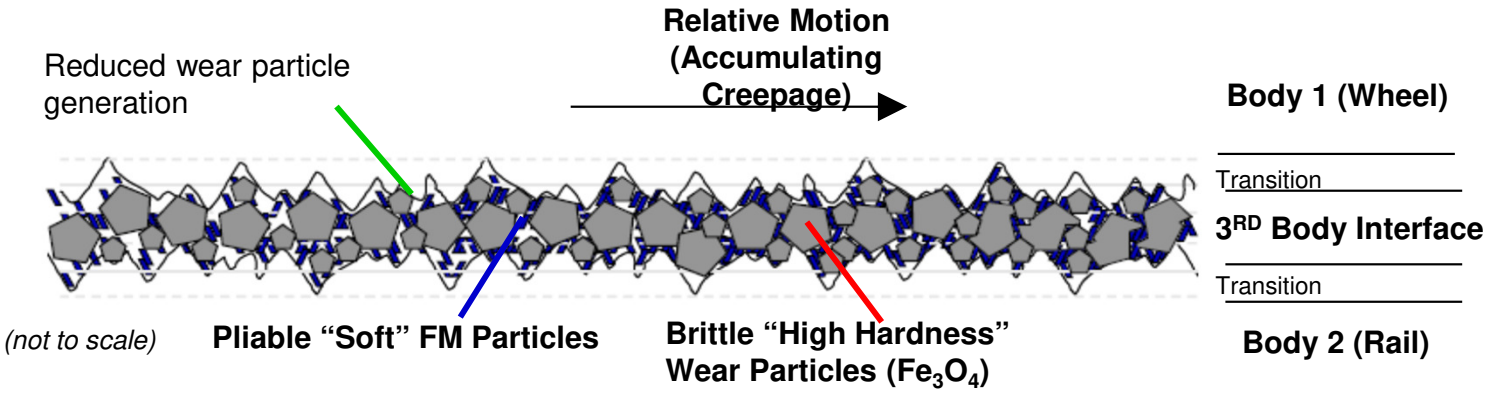
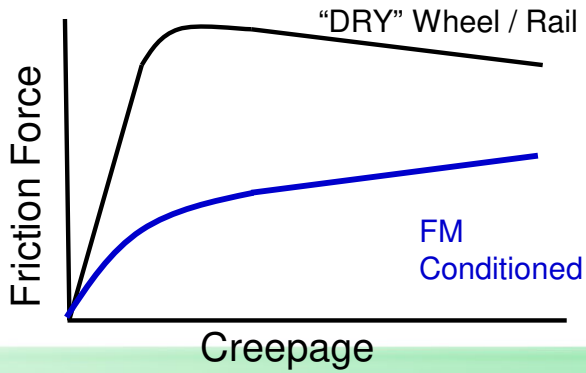
Top of Rail Fundamentals

"Treated" Wheel / Rail Interface



FM creates a *composite* deformation mechanism

Pliable FM particles provide an elastic shear displacement accommodation mechanism that negates/arrests brittle particle breaking and void collapse



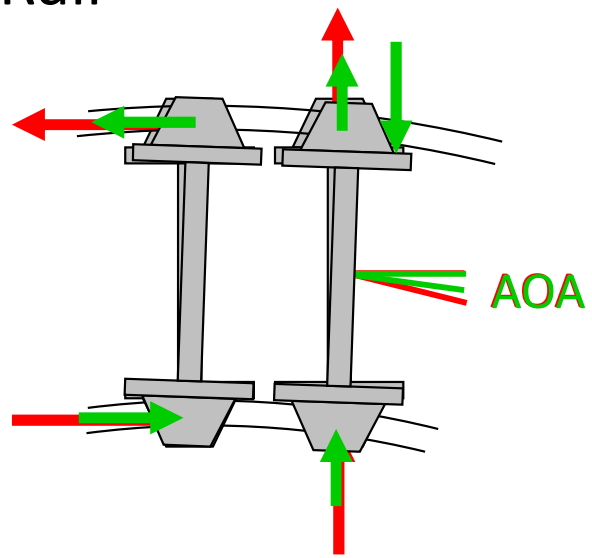
Top of Rail Fundamentals

1. High AoA Generated (Sharp Curves)
2. Top of Rail applied to High and Low Rail
3. Reduced creep forces

   Reduced lateral forces

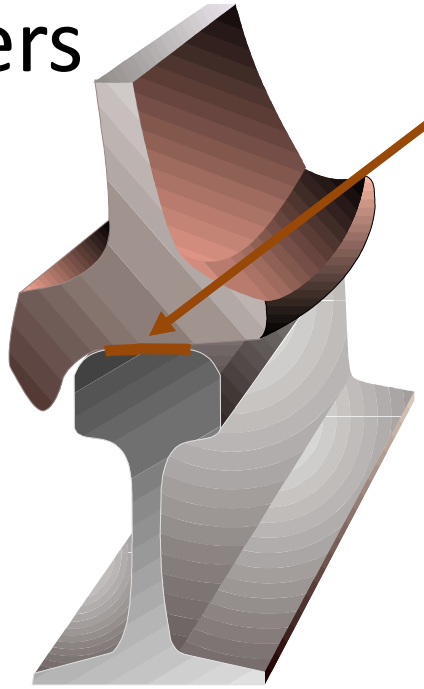
   Reduced AoA

   Improved steering



Benefits of traction enhancers

- Traction enhancers



Traction enhancers

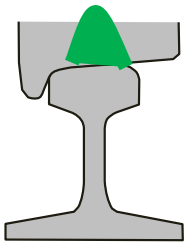
Benefits:

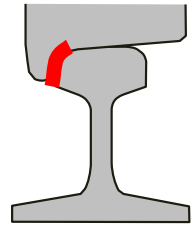
- Restored traction and braking performance in very low adhesion conditions eg leaf fall.

CoF restored

Segmentation of Friction Management

- **The Targeted Location**:
  - Top of Rail/Wheel Tread
  - Gauge Face/Wheel Flange

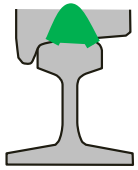
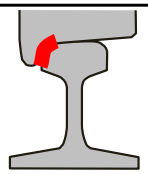
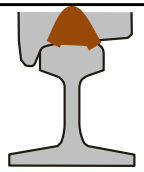




- **The Application**:
  - Trackside
  - On-Board

JBO

Friction Management

APPLICATION LOCATION		APPLICATION METHOD: Trackside	APPLICATION METHOD: On-Board
	 **Top of Rail / Wheel Tread Friction Modifiers**	- Water based friction modifiers - Hybrids - Top-of-Rail (TOR) Oils (petroleum/non petroleum)	- TOR Friction Modifier Spray - Solid Friction Modifier Wheel Tread Application
	 **Gauge Face / Wheel Flange Lubrication**	- Gauge Face (GF) Greases	- Solid Lubricants for Wheel Flange Application - On-Board Oil Spray
	 **Traction enhancers**	- Traction gels	- Sand - Traction gels - Innovative cleaning tech

Slide 9

JB0 rail/wheel diagrams just need tidying upas on the previous page
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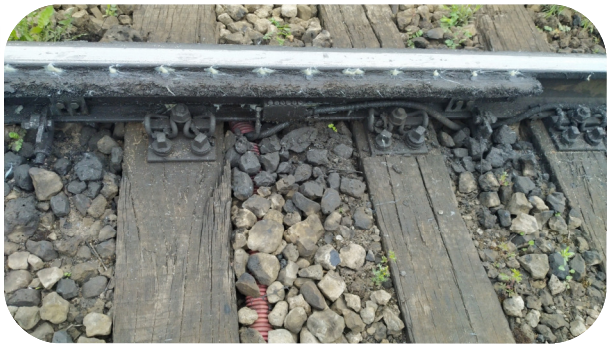
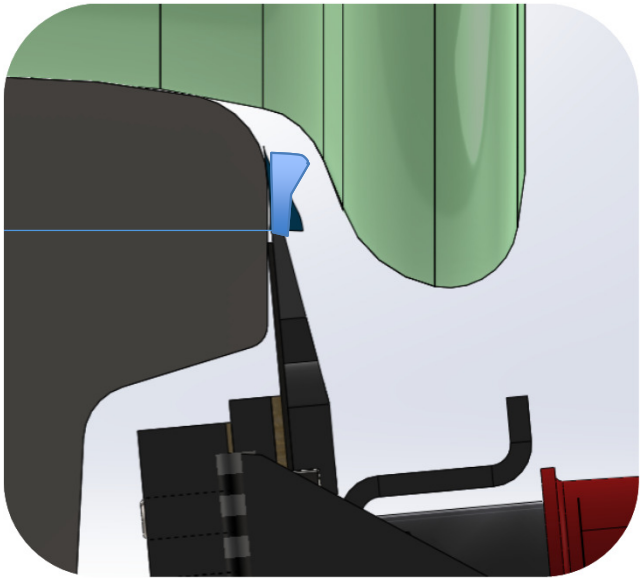
Application of gauge face and flange lubrication

- Trackside
  - How to apply product to gauge face/corner of the rail?
    - Applicator bars
    - Drilled rail
    - Squirting systems

Application of gauge face and flange lubrication

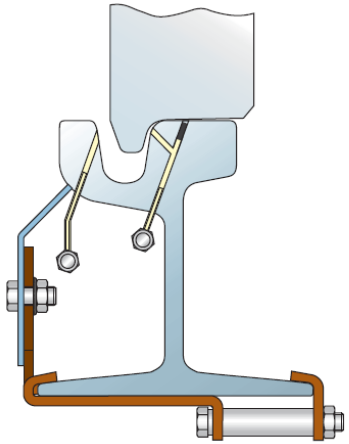
- Trackside – applicator bars





Application of gauge face and flange lubrication

- Trackside – drilled rail – typically only for embedded rail



Application of gauge face and flange lubrication

- Trackside – squirting systems



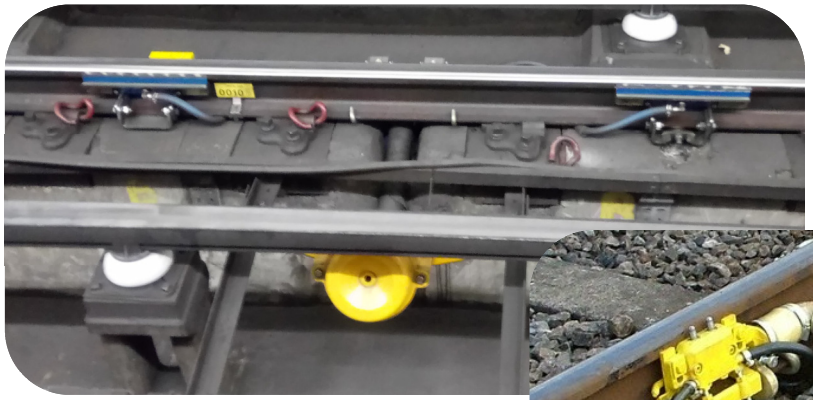
Application of gauge face and flange lubrication

- Trackside – Electric – solar or mains powered



Application of gauge face and flange lubrication

- Trackside – Hydraulic and Mechanical



Application of gauge face and flange lubrication

- Trackside

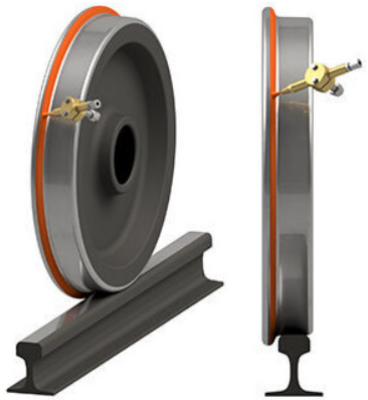
Single Point lubricators

Electro-pneumatic

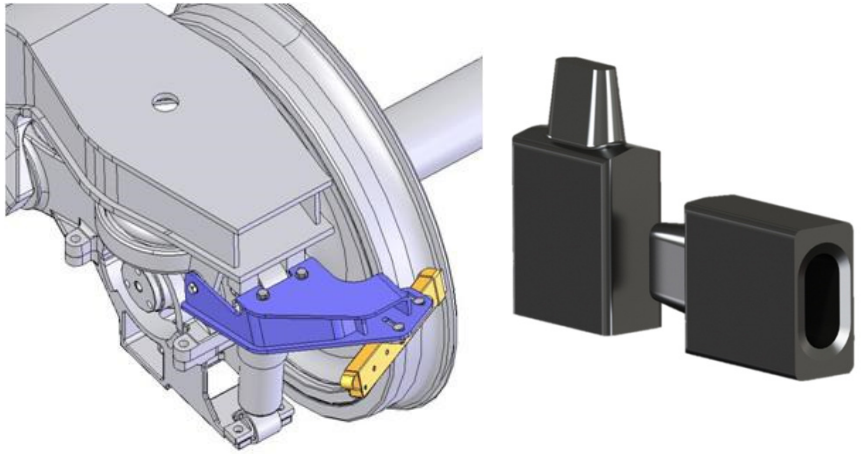
Application of gauge face and flange lubrication

- On-board

Oil spray system



Solid lubricating sticks



Application of Top of Rail Friction modifiers

- Trackside electric applicators

Applicator bars

Drilled rail

Application of Top of Rail Friction modifiers

- On-board

Spray systems

Tread sticks

Application of traction enhancers

- Trackside – application of traction gel

Application of traction enhancers

- On-board

Train sanders

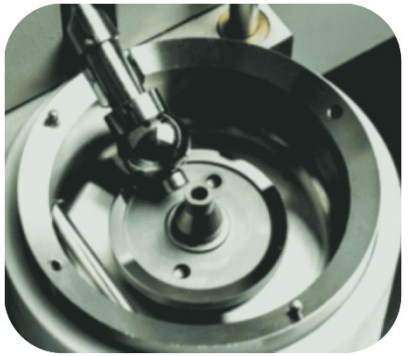
Traction gel application from specialist vehicles

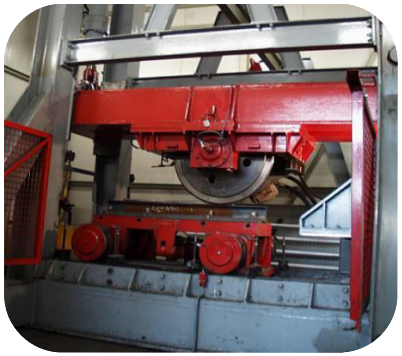
Lubricant properties

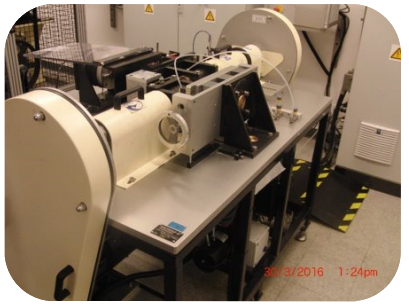
Property	Grease	On-board Flange oil	On-board Stick
Lubricity	■	■	■
Retentivity	■	■	■
Spray pattern		■	
Reaction time			■
Stick consumption rate			■
Stick hardness – mechanical strength			■
Thickness –strength for applicator bars (temperature range)	■		
Pumpability (at temperature range)	■	■	
Oil separation	■		
Pick-up and carry down	■		
Biodegradability/environmental impact	■	■	■

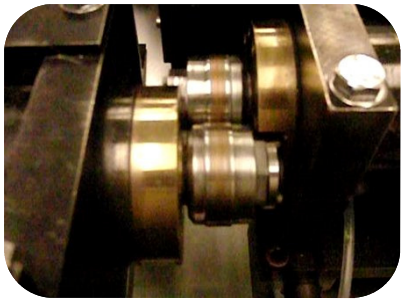
MTM, Twin disc testing and full scale testing

- Lubricity
- Retentivity
- Reaction time
- Stick consumption rates

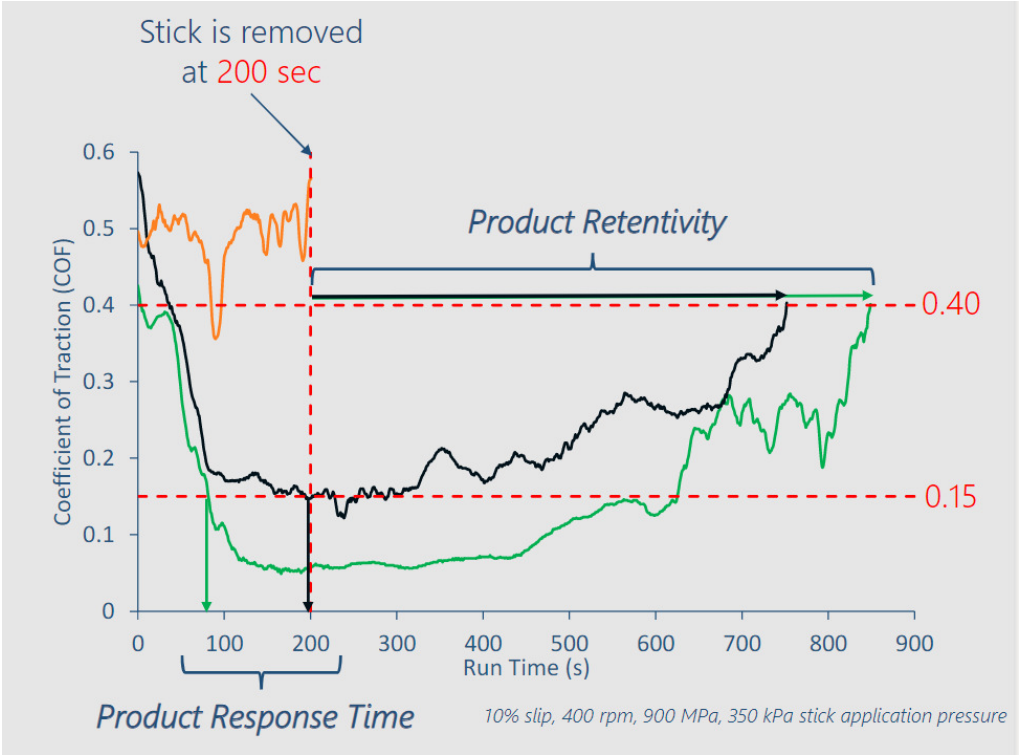


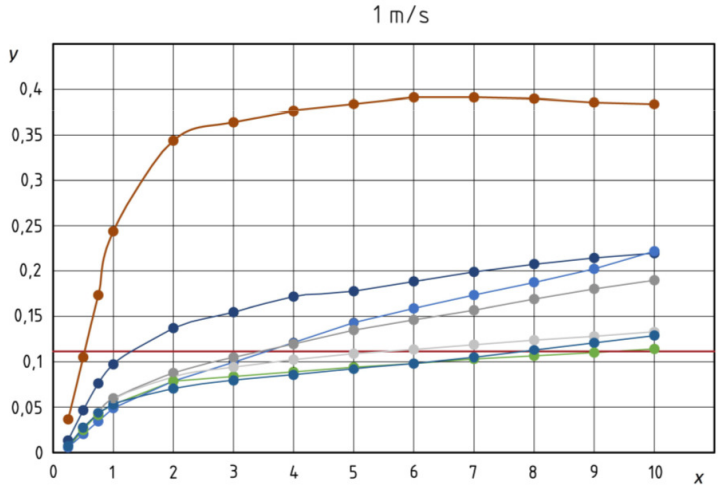






MTM and Twin disc testing





Key

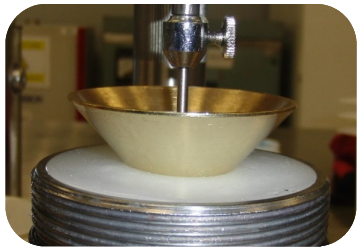
x Creep (%)

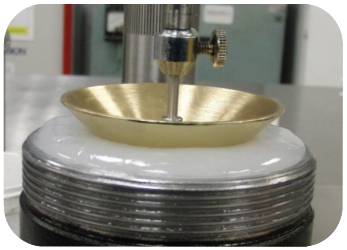
y Coefficient of Traction

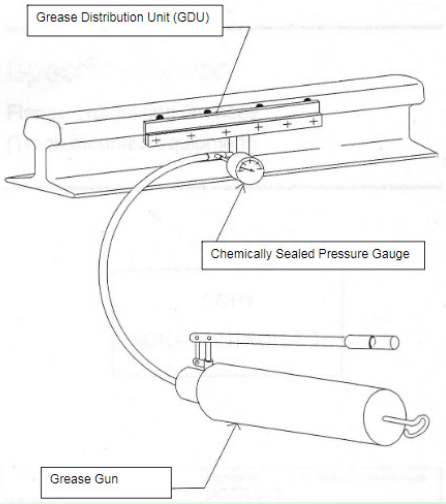
Top of Rail Materials

Grease hardness/Stiffness

- Penetration test
- Hand pump and bar test







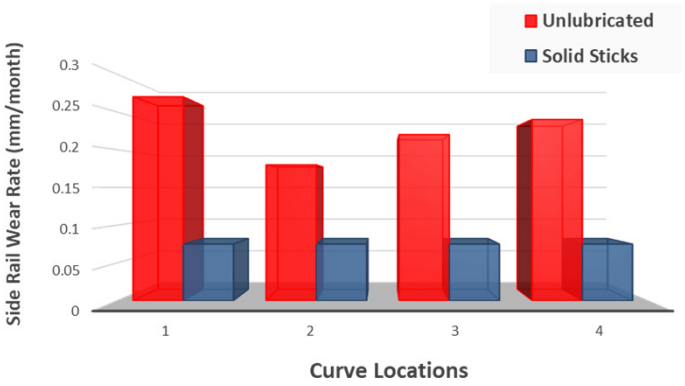
On-track testing

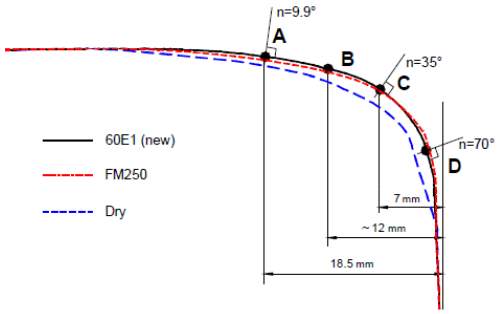
- Lubricity - tribometer
- Pick up and carry down

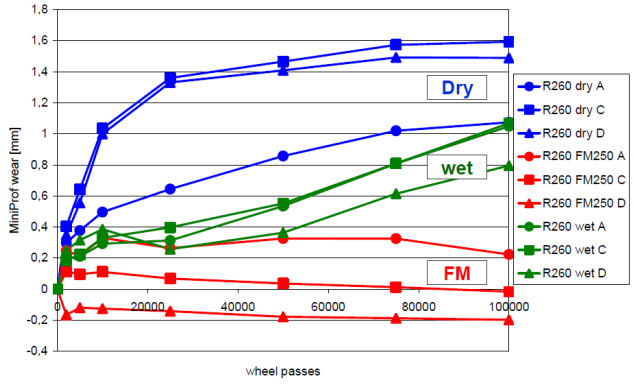
On-track/On-vehicle testing

- Wear measurements









A = TOR C = Gauge Corner D = Gauge Face

On-track/On-vehicle testing

- Consumable consumption rates

Solid stick mechanical strength and thermal stability

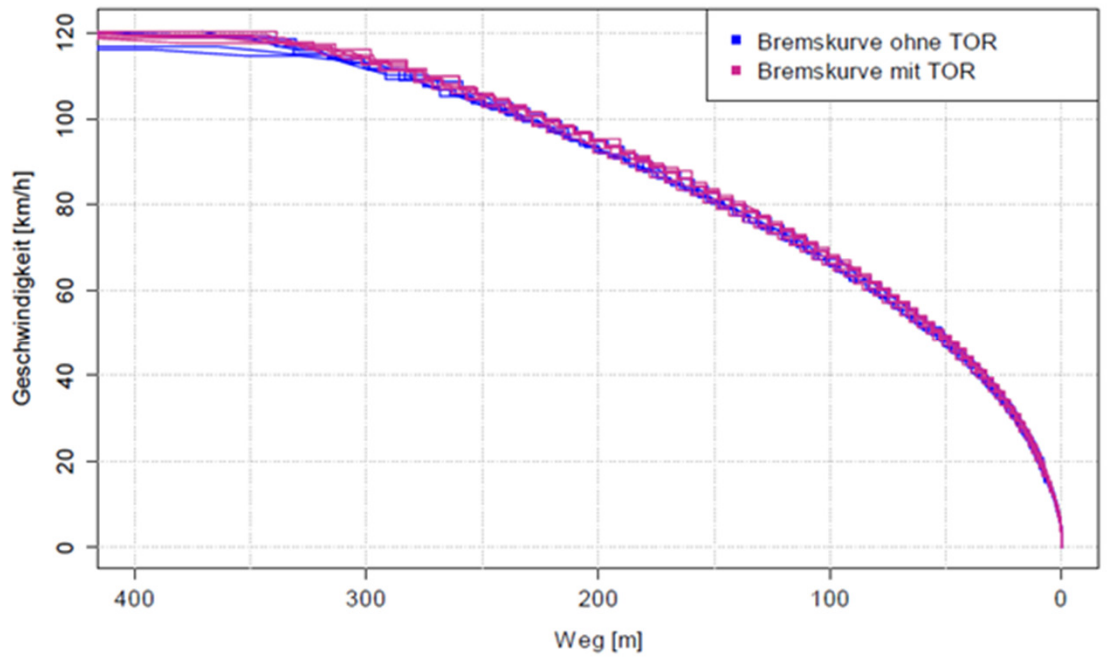





Top of Rail properties

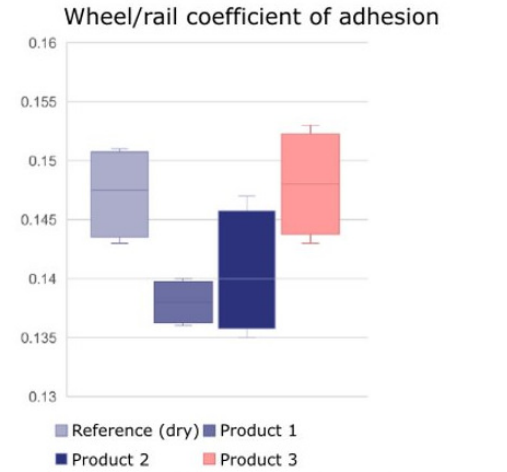
Property	Liquid Top of Rail - trackside	Liquid Top of Rail - onboard	On-board Stick
Intermediate friction	■	■	■
Positive friction characteristics	■	■	■
Retentivity	■	■	■
Braking and traction performance	■	■	■
Pumpability	■	■	
Spray pattern		■	
Stick mechanical strength			■
Stick consumption			■
Pick-up and carrydown	■		
Product stability/separation	■	■	
Environmental impact	■	■	■

Braking and traction trials



Braking and traction trials

		Product 1	Product 2	Product 3
Percentage extension of the stopping distances (initila speed 115km/h (E-brake) or 120km/h)				
Block brake	R	Unchanged	Unchanged	Unchanged
Disc brake	R	+7%	+7%	Unchanged
	R+Mg*	+11%	Unchanged	Unchanged
Electro-dynamic brake	E	+34%	+39%	+4%
Percentage extension of the acceleration time (target speed 120km/h)				
Trailer load: 87t		~ +24%	~ +18%	Unchanged
Trailer load: 111t		~ +54%	~ +48%	Unchanged

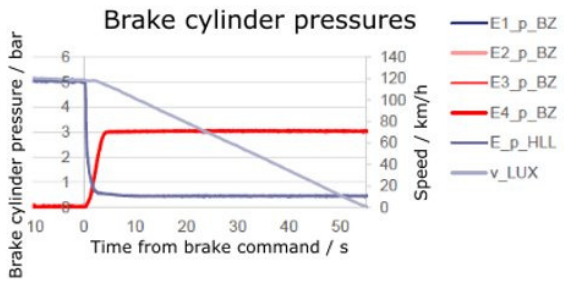


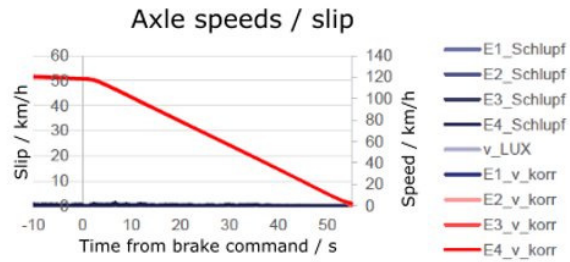
Ref. Zbinden, Franziska, Dipl.-Ing. Zoller, Roman / Leibundgut, Daniel, Schönholzer, Urs, Dr. sc. techn., SBB, Schienenkopfkonditionierung, Internationale Schienenfahrzeugtagung Dresden, 2020

Braking and traction trials

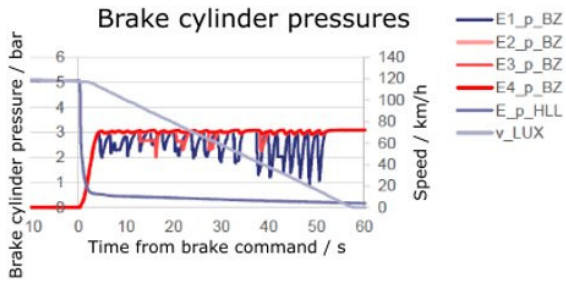
Results vehicle control
Example of a disc brake, brake position R

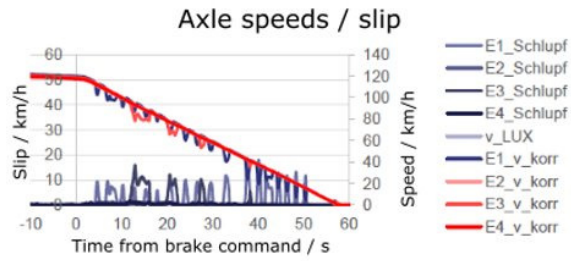
→ Reference measurement





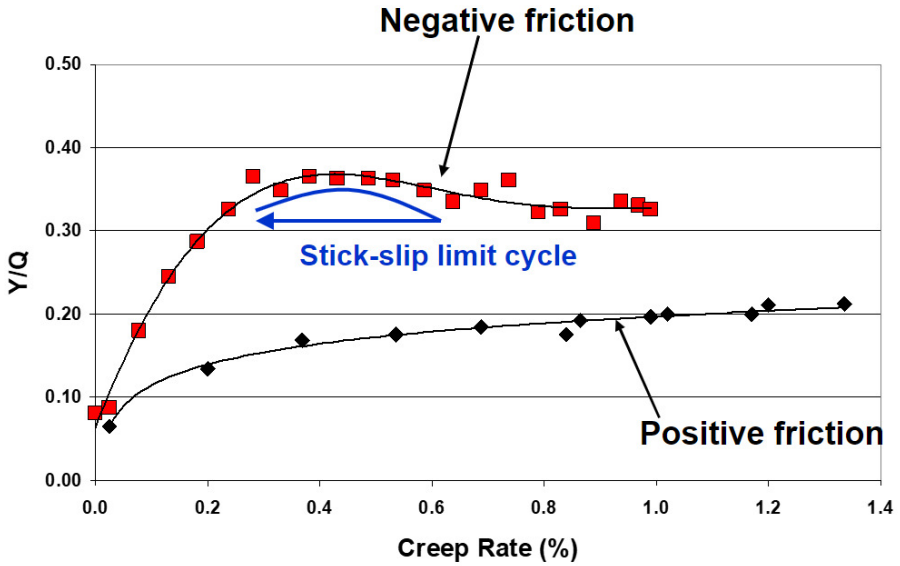
→ Conditioned: Product 1 or 2





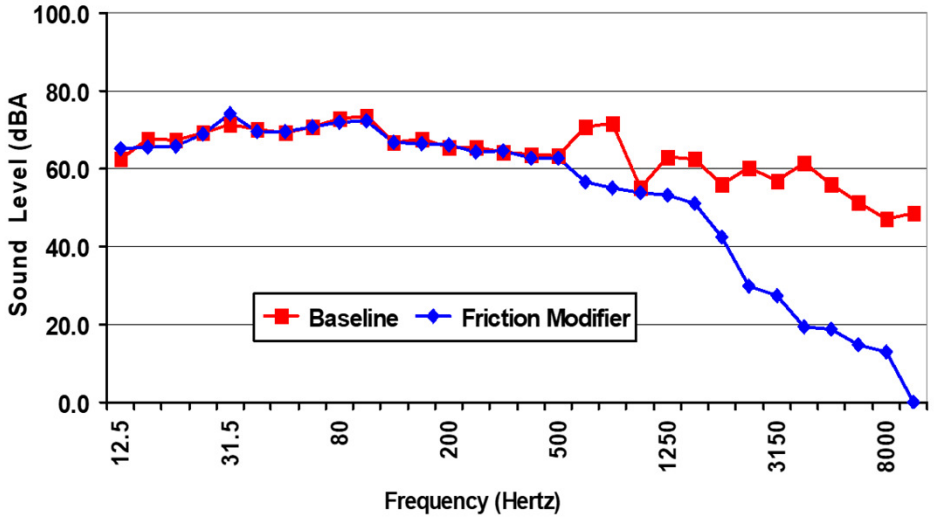
Top of Rail Squeal

- Positive friction characteristics
- Measurement on track



Noise

Noise Type	Frequency range [Hz]
Rolling	30 – 2500
Rumble (including corrugations)	200 – 1000
Flat spots	50 – 250 (speed dependant)
Ground Borne Vibrations	30 – 200
Top of rail squeal	1000 – 5000
Flanging noise	5000 – 10000



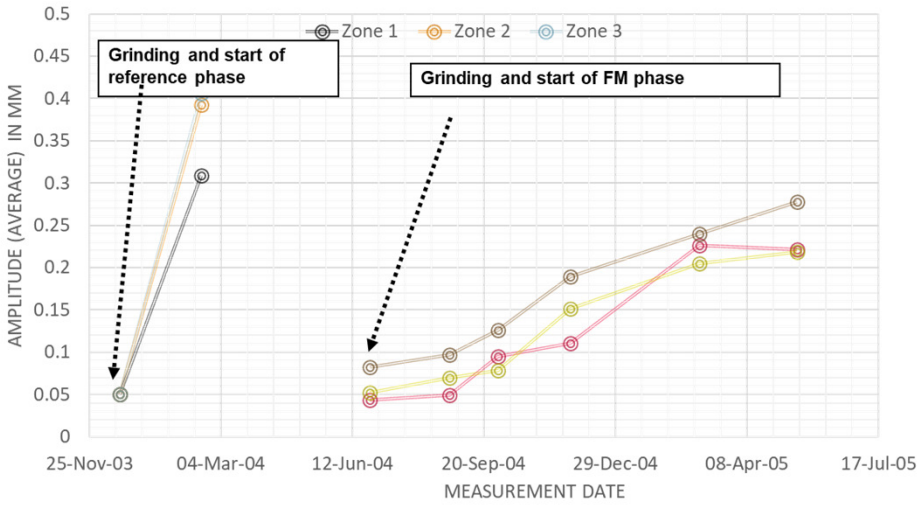
Noise

Baseline – No TOR FM application

AFTER TOR FM application - manual

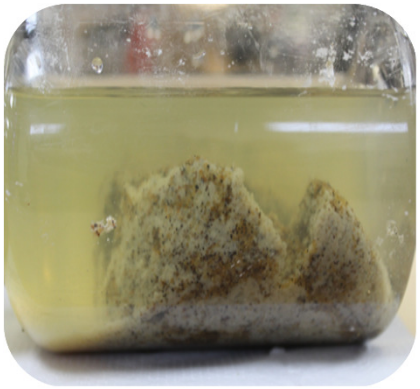
On-track/vehicle testing

- CAT – Corrugation analysis trolley

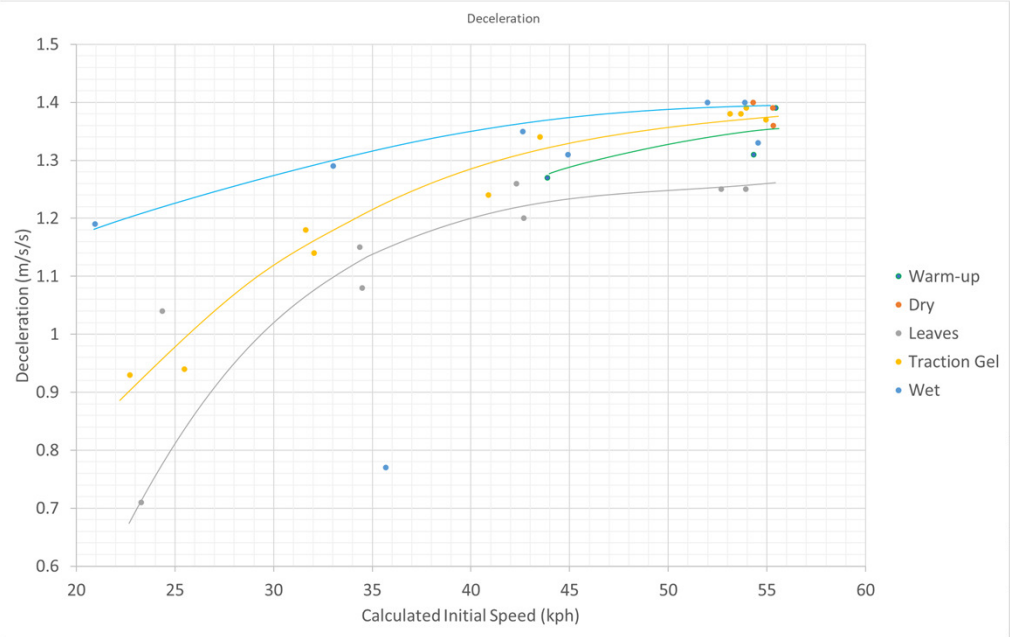


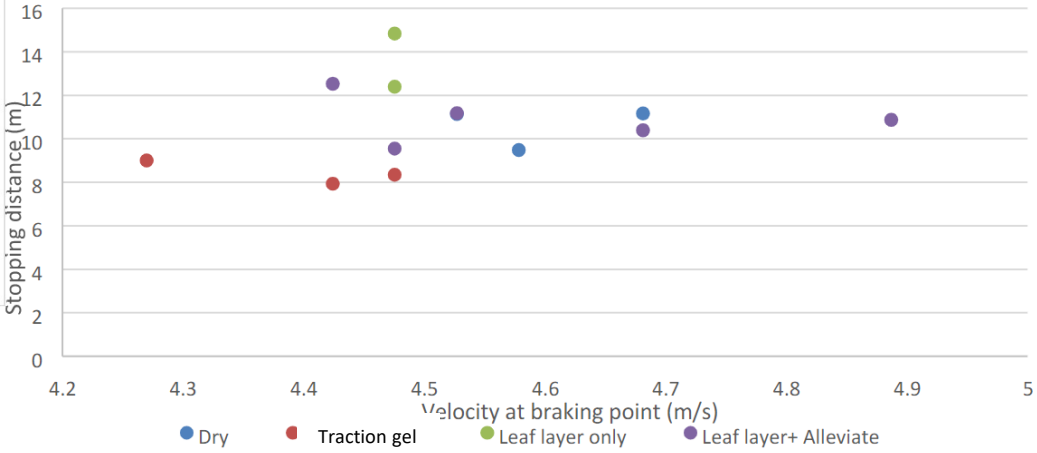
Traction Enhancer properties

- General
  - Traction enhancing properties – friction measurement
- Traction gels
  - Product stability
  - Pumpability
- Traction particles
  - Particle flowability
  - Particle size, shape and structure



Traction enhancer braking trial





Standards related to friction management

CEN European Standards

- EN15427-1-1:2022— Part 1-1: Equipment and Application – Flange lubrication
- TS15427-1-2:2021 — Part 1-2: Equipment and Application – Top of Rail materials
- TS15427-1-3:2021 — Part 1-3: Equipment and Application – Adhesion materials
- EN15427-2-1:2020— Part 2-1: Properties and Characteristics – Flange lubricants (supersedes EN16028)
- TS15427-2-2:2021— Part 2-2: Properties and Characteristics – Top of Rail materials
- TS15427-2-3:2021— Part 2-3: Properties and Characteristics – Adhesion materials
- prTR15427-3 – Part 3: Technical report

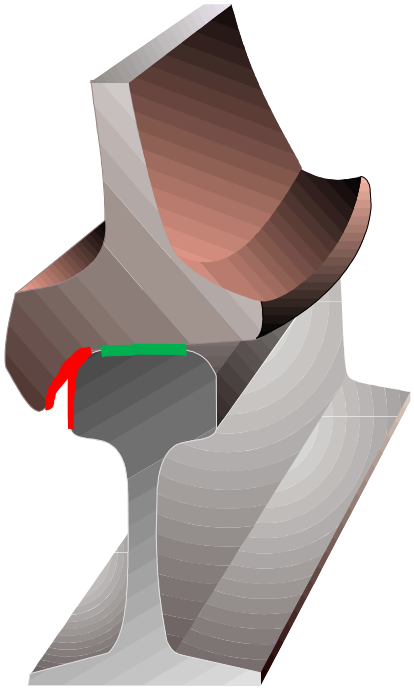
Standards related to friction management

National standards/railway undertakings standards eg:

- Network Rail – NR/L3/TRK/3530 Track Lubricants, NR/L3/TRK/003/TEF3219
- Swiss Standard - R RTE 49410 Spurkranzschmierung Eisenbahnfahrzeuge Normalspur
- Australian Standard – RISSB AS 7641:2017 - Rail Gauge Corner Lubrication Management – for friction levels and measurement
- Metro Trains Melbourne - L1-CHE-STD-033 - ENGINEERING STANDARDRAIL LUBRICATION STANDARD
- Transport for New South Wales - T HR TR 00111 S Rail Lubrication

Summary

- Friction management – reduce damage to wheel/rail, reduce fuel consumption and noise
- Wide range of products with different properties and application methods
- Laboratory measurements and track testing can help select optimal solution
- Range of standards available to guide selection



Questions