Principles of Wheel / Rail Friction Management

Jackie Butterfield, BEng, CEng, FIMMM
Lead Applications Engineer

Louisa Stanlake, PhD
Global Product Manager - Consumables

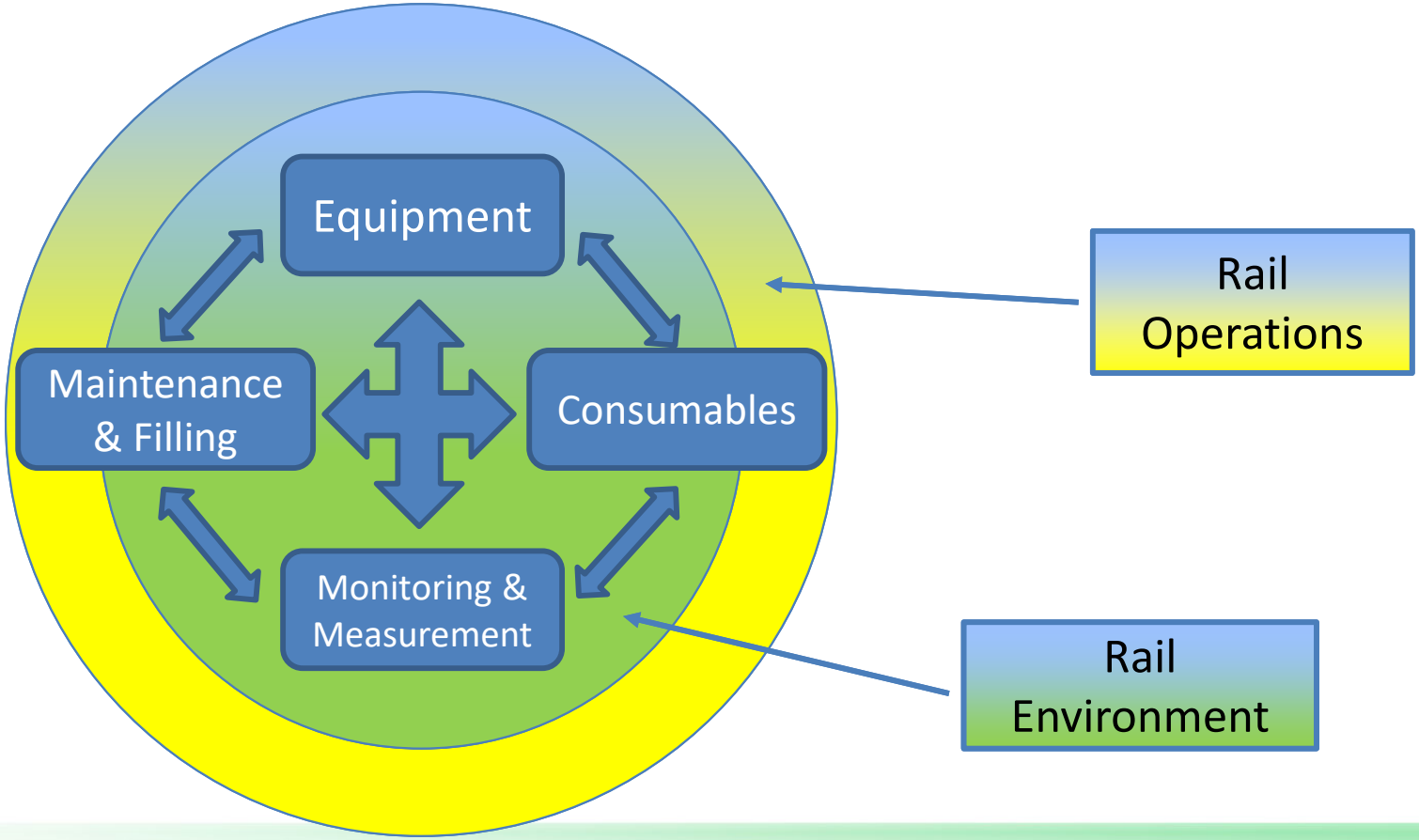
Outline

- What is Friction Management?
- Benefits of Friction Management
- Top-of-Rail / Wheel Tread Application and Validation
- Gauge Face / Wheel Flange Application and Validation
- Application of Traction Enhancers
- Summary

Wheel / Rail Interface Control

- Friction management is the intentional manipulation of the shear properties of the third body layer in the wheel / rail interface
- *Friction Management is a KEY component in controlling the wheel / rail interface*

The “Effective” Friction Management Programme



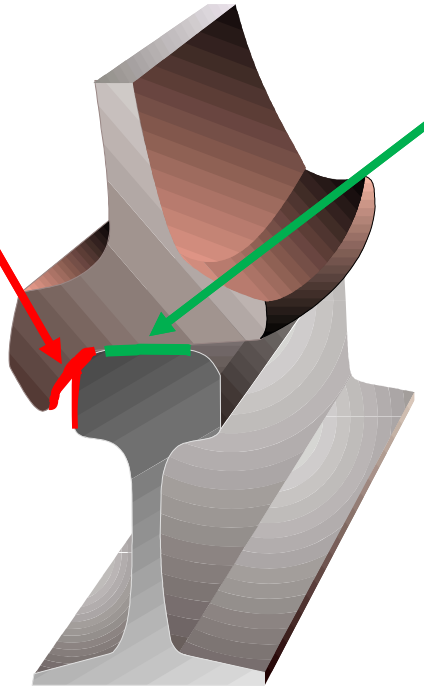
Benefits of Friction Management (FM)

Gauge Face / Wheel Flange

Benefits:

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

Target CoF: <0. 25



Top-of-Rail / Wheel Tread

Benefits:

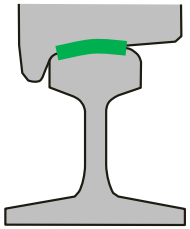
- Reduced Rail / Wheel Wear
- Improved Fuel Efficiency
- Reduced Lateral Forces
- Lowers Derailment Potential
- Mitigates RCF Development
- Reduces Hunting
- Mitigates Noise
- Mitigates Corrugations

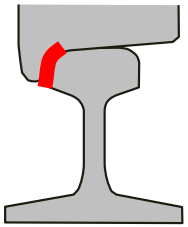
Target CoF: ~0.35

CoF = Coefficient of Friction

Segmentation of FM

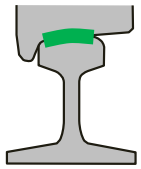
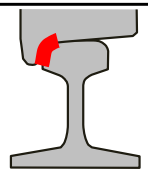
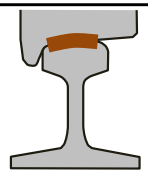
- **The Targeted Location**:
  - Top of Rail/Wheel Tread
  - Gauge Face/Wheel Flange



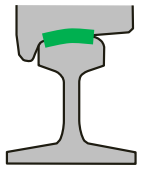


- **The Application**:
  - Trackside
  - On-Board

Friction Management

APPLICATION LOCATION		APPLICATION METHOD: Trackside 	APPLICATION METHOD: On-Board 
	 **Top of Rail / Wheel Tread Friction Modification**	- Water-based friction modifiers - Hybrids - Top-of-Rail (TOR) Oils (petroleum/non petroleum)	- TOR Friction Modifier Spray - On-Board Oil-Based 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

Friction Management

APPLICATION LOCATION		APPLICATION METHOD: Trackside 	APPLICATION METHOD: On-Board 
	 **Top of Rail / Wheel Tread Friction Modification**	- Water-based friction modifiers - Hybrids - Top-of-Rail (TOR) Oils (petroleum/non petroleum)	- TOR Friction Modifier Spray - On-Board Oil-Based 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

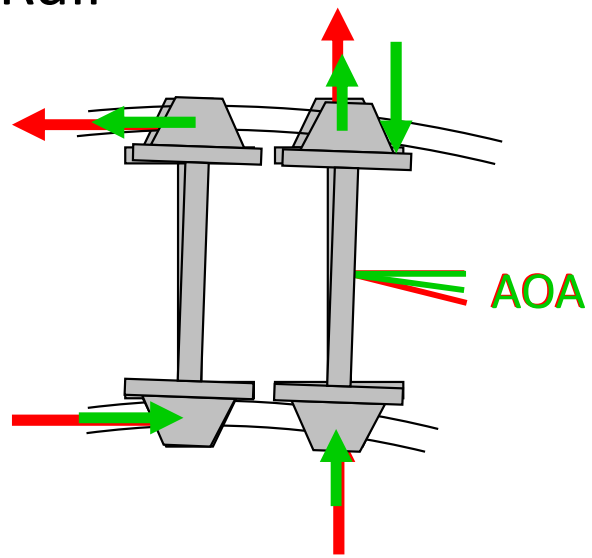
Top of Rail Fundamentals

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

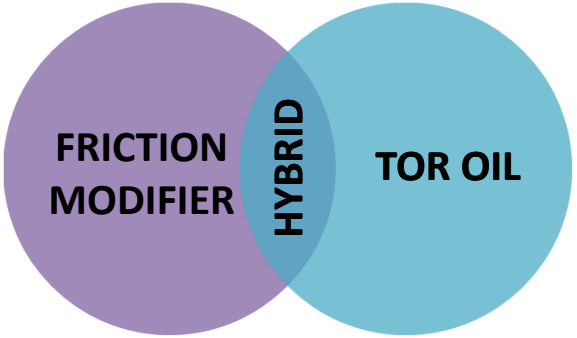
   Reduced lateral forces

   Reduced AoA

   Improved steering



Trackside TOR Materials



Friction Modifiers

Water-based with suspended solids

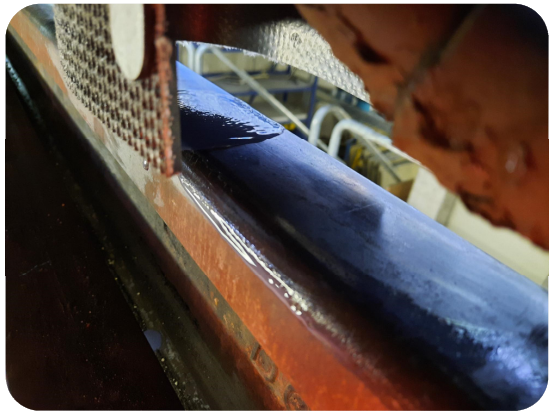
Hybrids

Oil and Water mixed formulations typically with suspended solids

TOR Oils

Oil-based products with no solids

On-Board TOR/Wheel Tread Materials



Friction Modifiers

Water-based with suspended solids sprayed direct to TOR

Oil-based materials

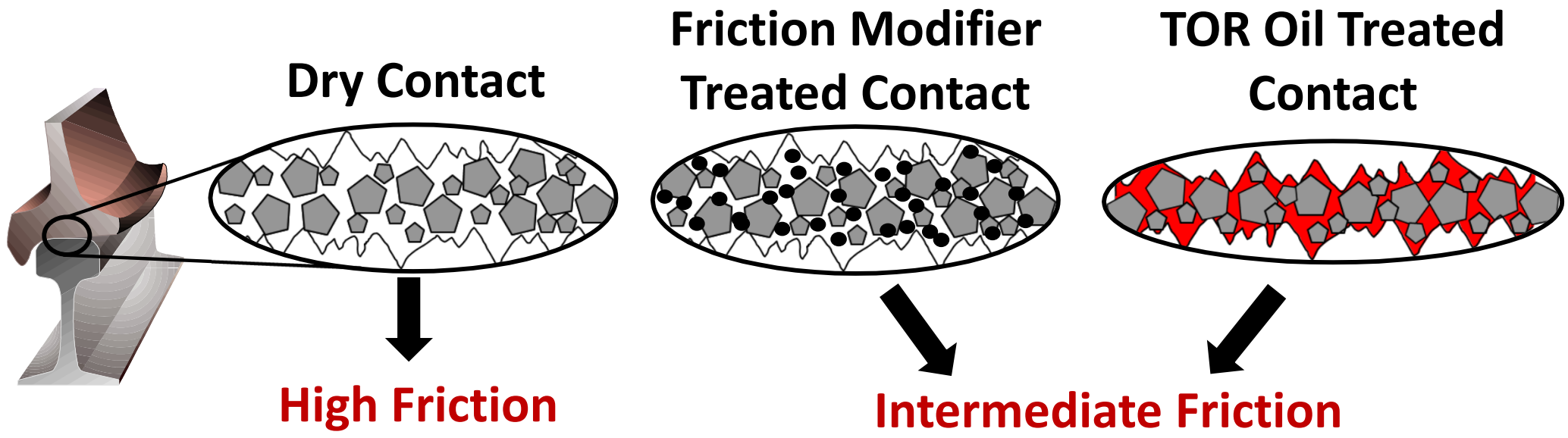
Oil or oil and water mixed formulations sprayed direct to the TOR or Wheel Tread

Solid Tread Sticks

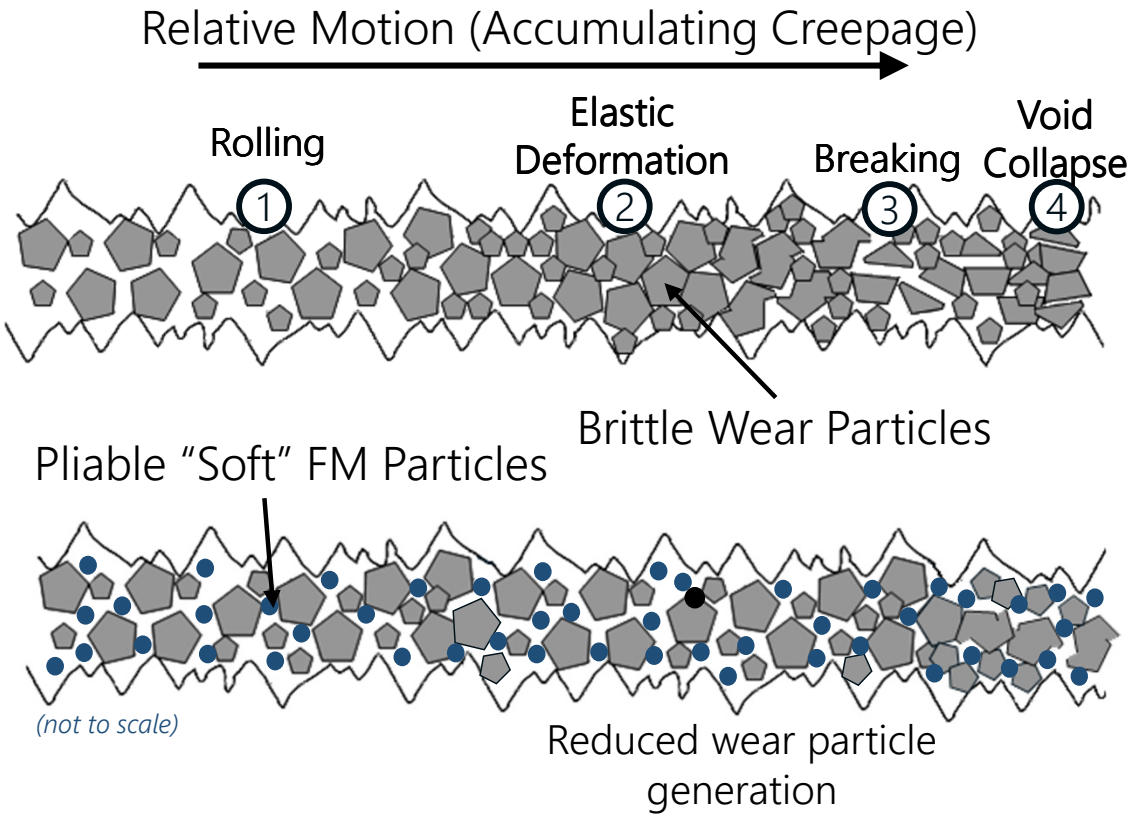
Friction modifier solids encapsulated in a polymer matrix applied direct to the wheel tread

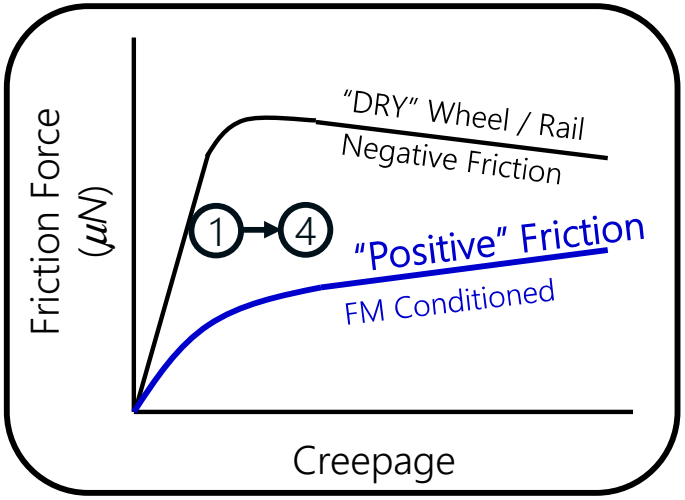
How do TOR / Wheel Tread Products Work?

- Friction Modifiers provide pliable “soft” particles into the wheel-rail interface to counteract the brittle “hard” iron oxide particles
- Oils lubricate the surfaces of the wheel and rail



Friction Modifier Treated WRI





Friction Modifier creates a *composite* deformation mechanism

Pliable FM particles negates/arrests brittle particle breaking and void collapse

TOR / Wheel Tread Product Properties

ALL

- Intermediate friction
- Positive friction characteristics
- Good film durability or retentivity
- Low environmental and health impact

LIQUID

- Effective pumpability, spray quality and pick-up at all temperatures
- Water wash-off resistance
- Product stability

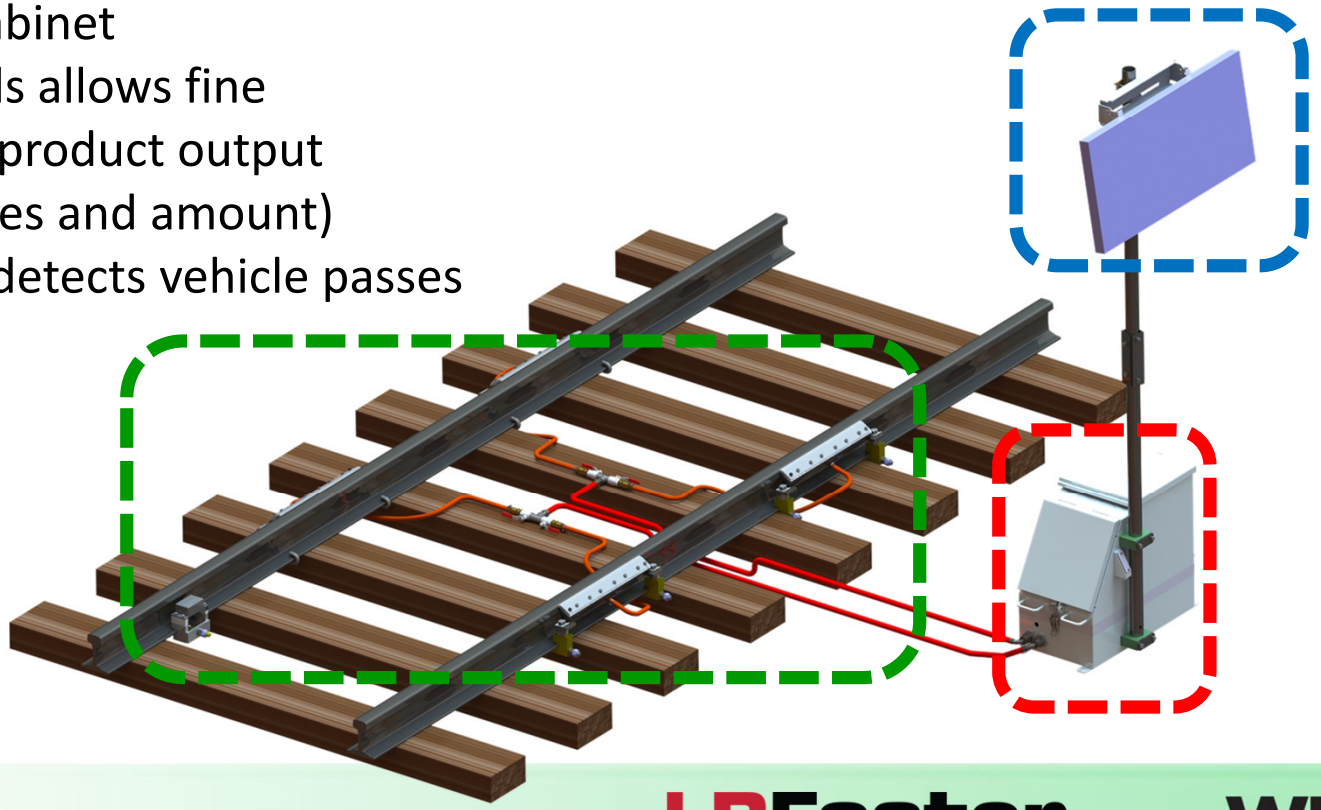
SOLID

- Good mechanical strength and thermal stability
- Optimized consumption rate

Application of Top of Rail Friction Modifiers

Key Features

- Clean hands cabinet
- Electric controls allows fine adjustment of product output (number of axles and amount)
- Wheel sensor detects vehicle passes



Application of Top of Rail Friction Modifiers

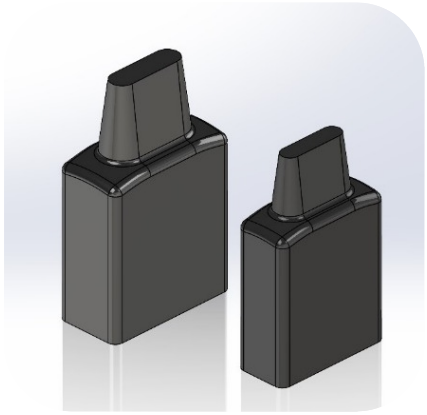
- Trackside electric applicators

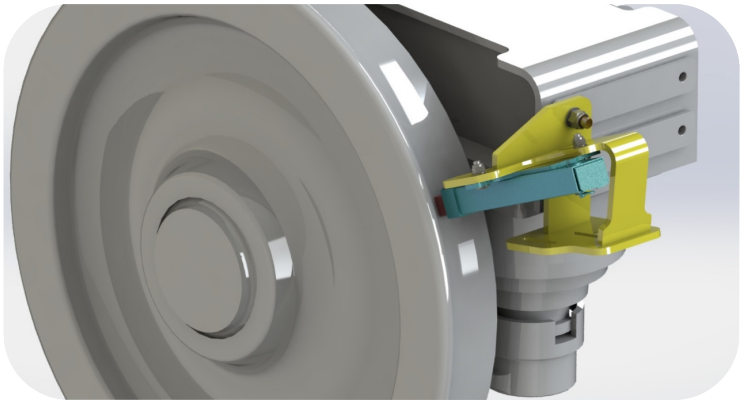
Applicator bars

Drilled rail

Solid Tread Stick Application

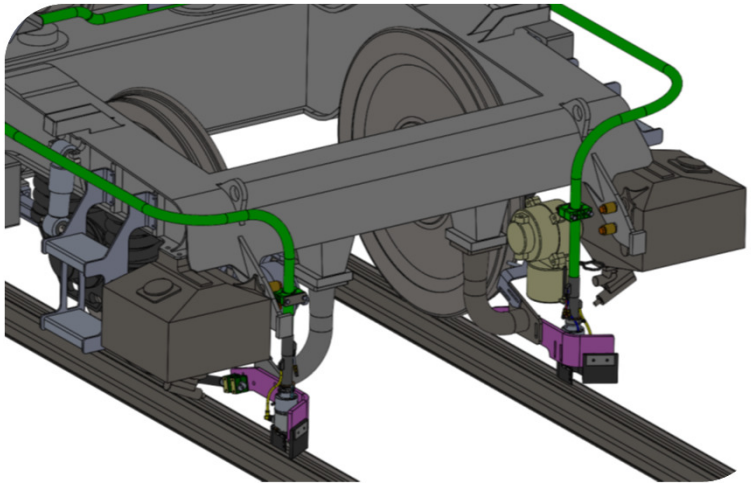
- Continuous application to wheel tread

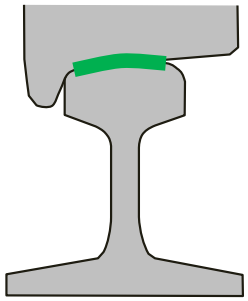




OnBoard TOR Application

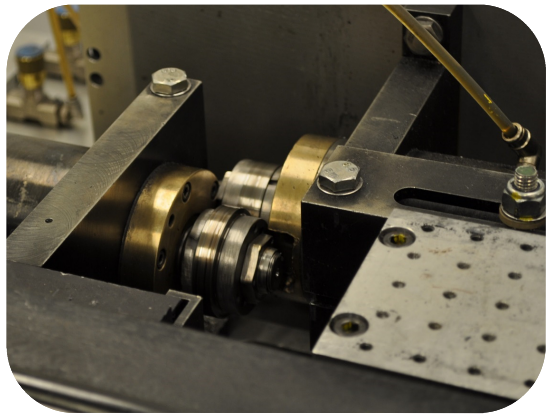
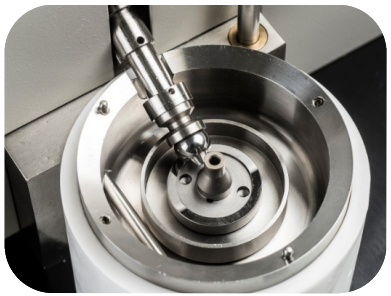
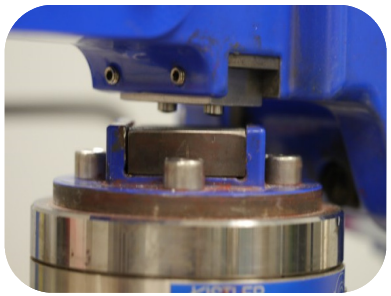
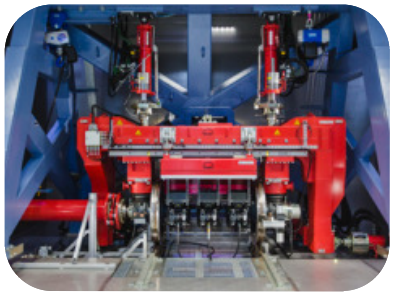
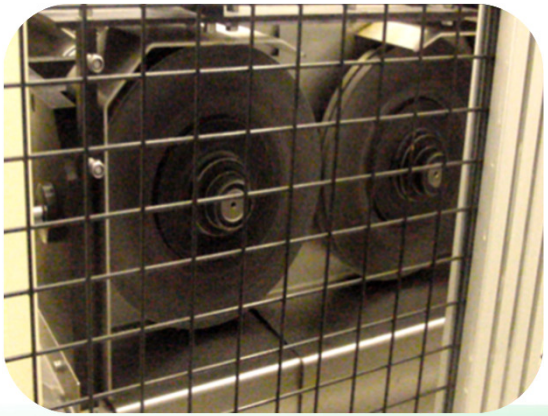
- Direct application to TOR with liquid spray





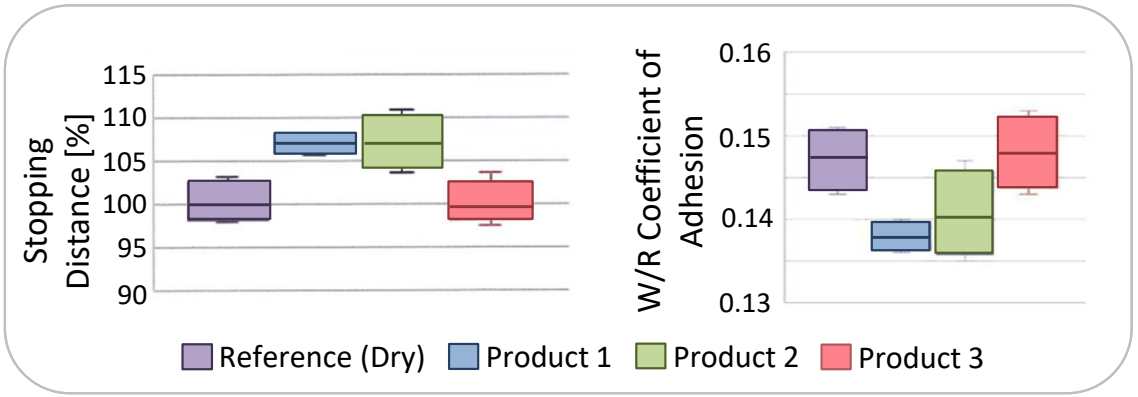
TOR / WHEEL TREAD FRICTION MANAGEMENT VALIDATION

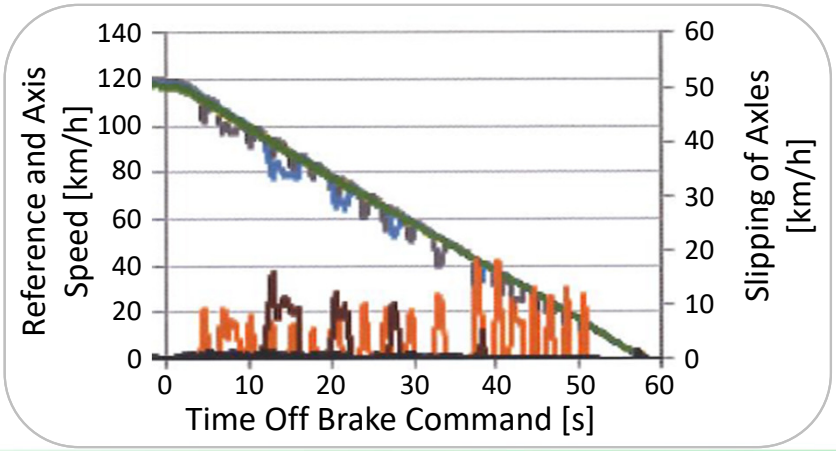
Laboratory Performance Testing


Braking and Traction Tests

- Emergency and revenue service braking
- Different starting speeds
- Stopping distances are measured
- Wheel-slide protection monitoring
- Friction levels of TOR
- Adhesion levels

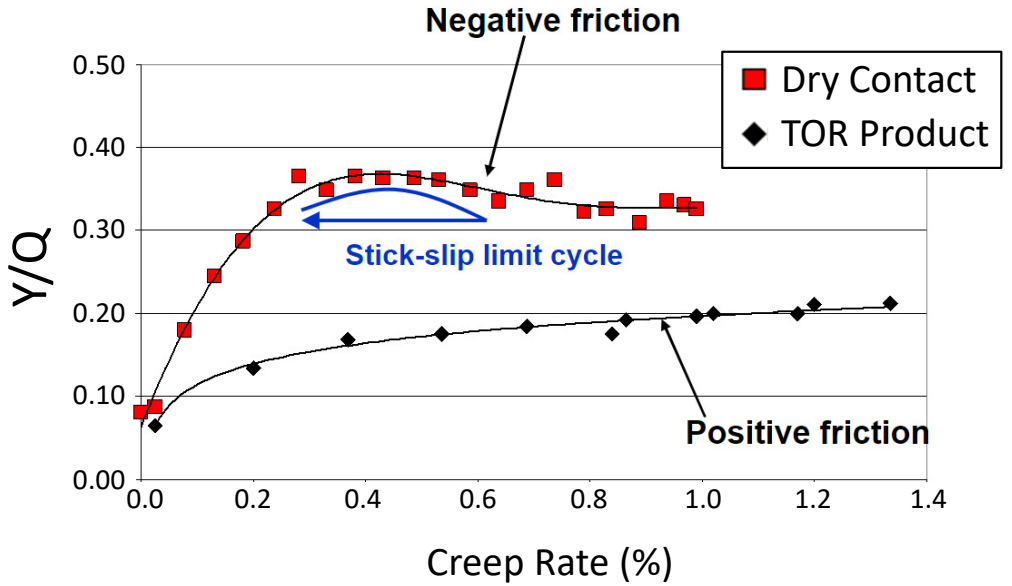


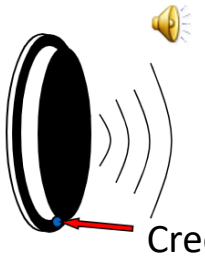


Reference: SBB, Rad Schiene Conference, Dresden, Feb 2020

Top of Rail Squeal

- Negative friction results in stick slip
- Measurement on track





Creepage / Friction Force

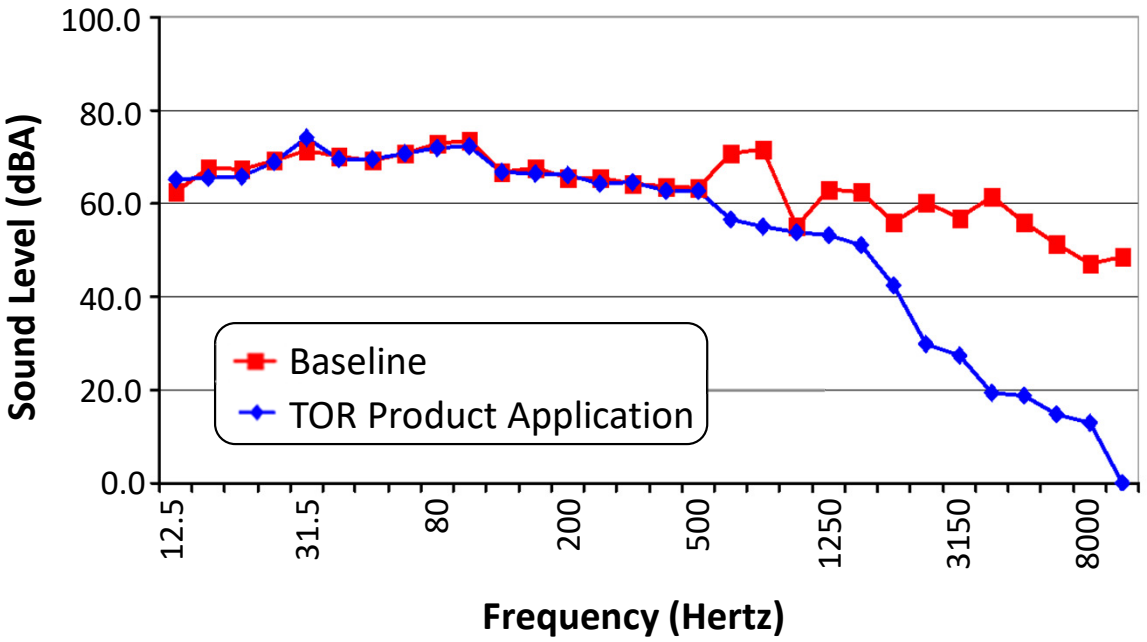
Noise

Baseline – No TOR FM application

AFTER TOR FM application - manual

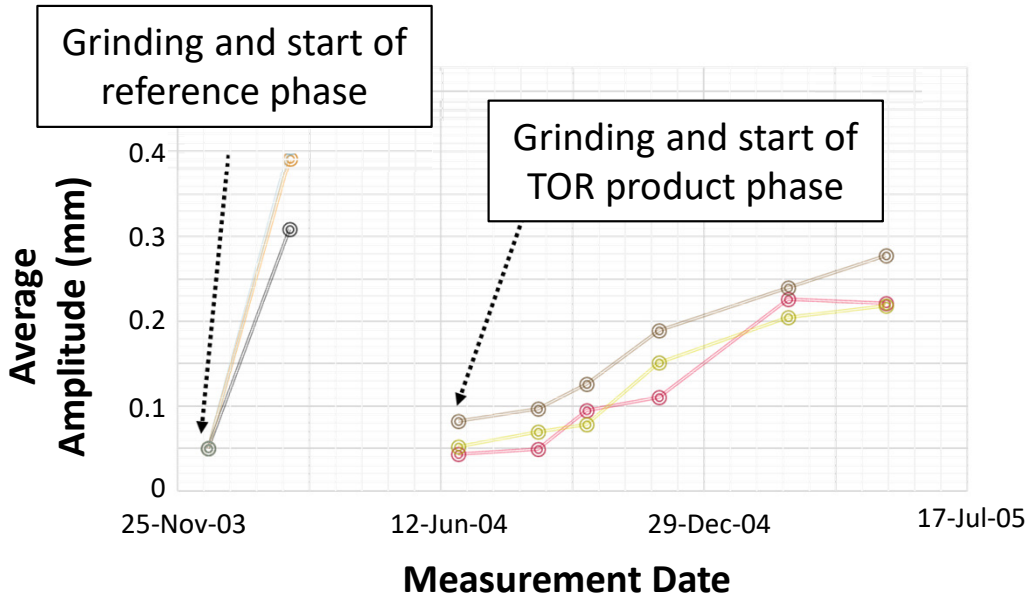
Noise Measurements

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



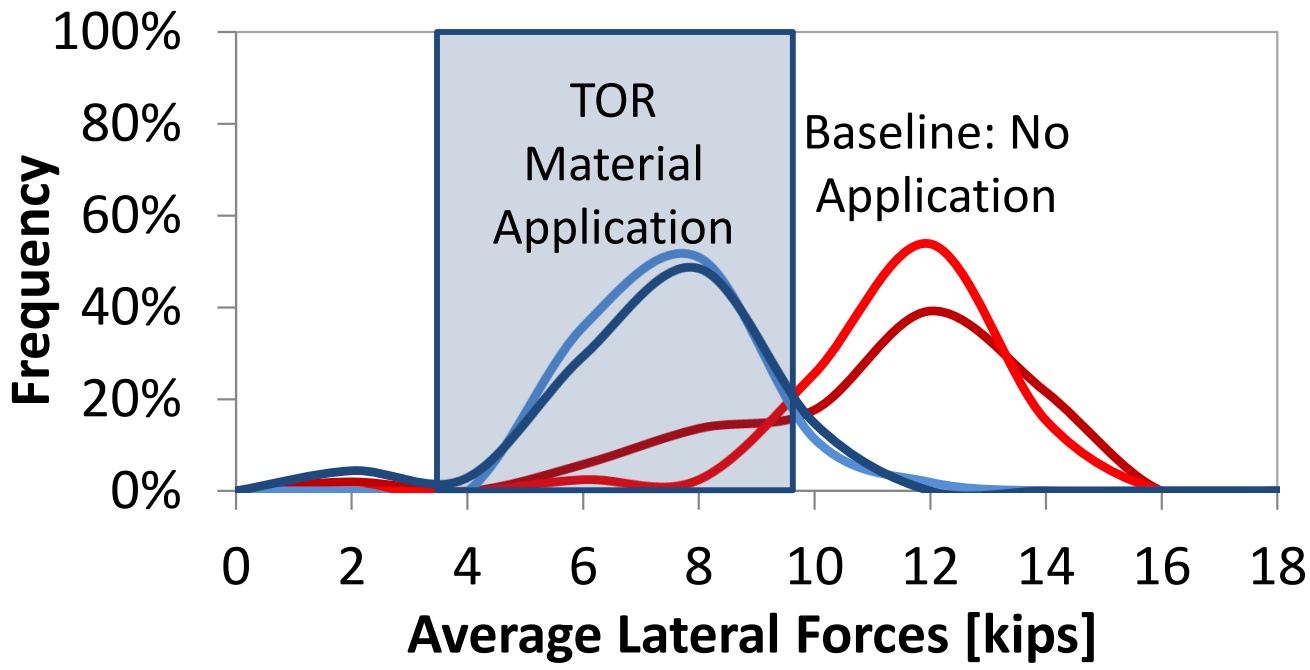
On-Track/Vehicle Testing

- CAT – Corrugation Analysis Trolley



Lateral Force Measurement

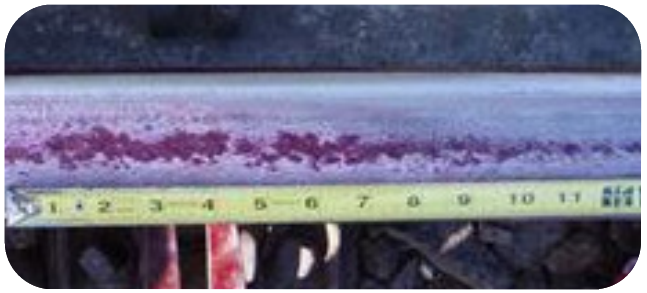
- Force measurement site can be used to determine effectiveness of TOR material at reducing lateral forces



RCF Measurements

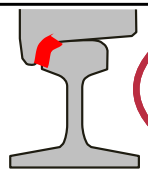
- Rolling Contact Fatigue (RCF) can be visually assessed
- Images after 8 months using dye penetrant, 135 MGT in a 4º, 430 m curve

No TOR Product Application



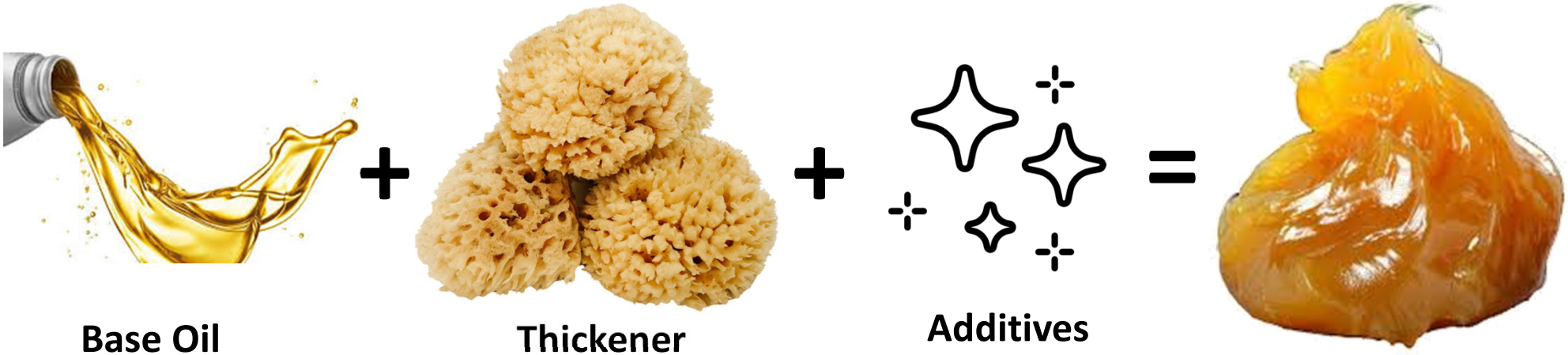
With TOR Friction Modifier Application

Friction Management

APPLICATION LOCATION		APPLICATION METHOD: Trackside 	APPLICATION METHOD: On-Board 
	Top of Rail / Wheel Tread Friction Modification	- Water-based friction modifiers - Hybrids - Top-of-Rail (TOR) Oils (petroleum/non petroleum)	- TOR Friction Modifier Spray - On-Board Oil-Based 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

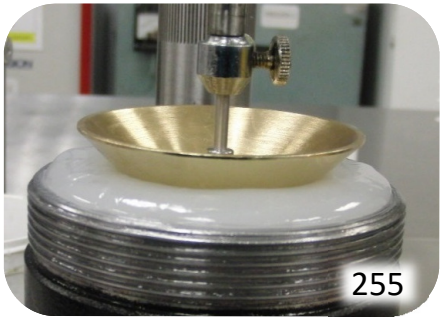
What is a Grease?

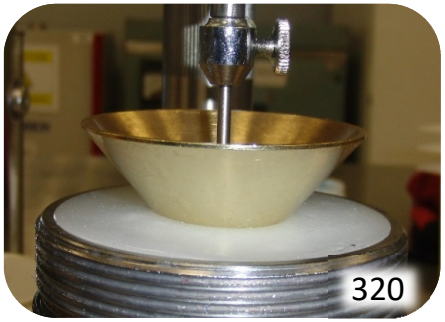
- Basically it's a "Solid" oil
- Thickener matrix acts as a sponge to absorb the oil
- 60-90% oil, 5-15% thickener and 0-5% additives



Grease Consistency

- The ***greater*** the penetration, the ***softer*** the grease





Season	Penetration	NLGI Grade	Analogy
Summer	265-295	2	Peanut Butter
Winter	310-340	1	Tomato Paste
All-season	295-330	1 to 1.5	-

GF Grease Product Properties

- Low coefficient of friction
- Good film durability and wear protection
- Effective product carry down and transfer
- Low bar clogging propensity
- Good column strength
- Optimized pumpability at all temperatures
- Optimized oil separation
- Good adhesion to the rail and water wash-off resistance
- Low environmental impact




Application of gauge face and flange lubrication

- Trackside – Electric – solar or mains powered

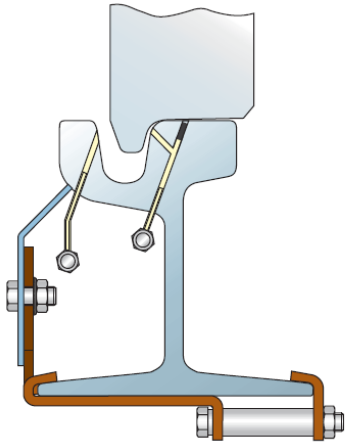


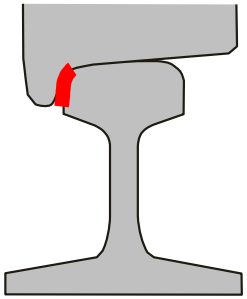
Application of GF Products

- Trackside application to gauge face and gauge corner
  - Applicator bars
  - Drilled rail
  - Squirting systems

Trackside GF Application

- Trackside – drilled rail – typically only for embedded rail





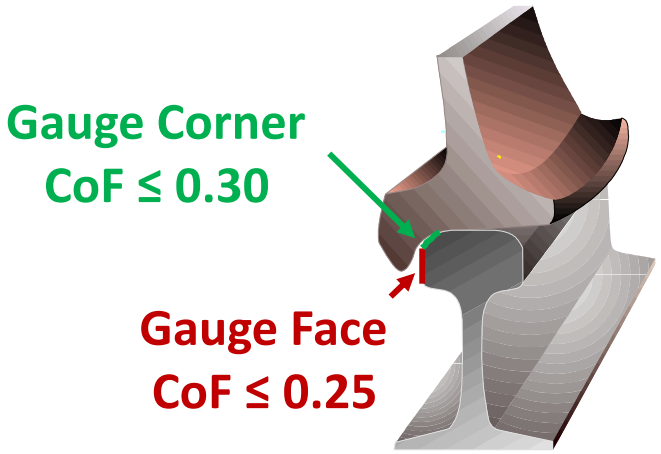
GAUGE FACE (GF) FRICTION MANAGEMENT TRACKSIDE VALIDATION

On-Track Testing

- Lubricity – push tribometer
- Pick up and carry down

How Do We Evaluate a Grease?

- Push tribometer measurements

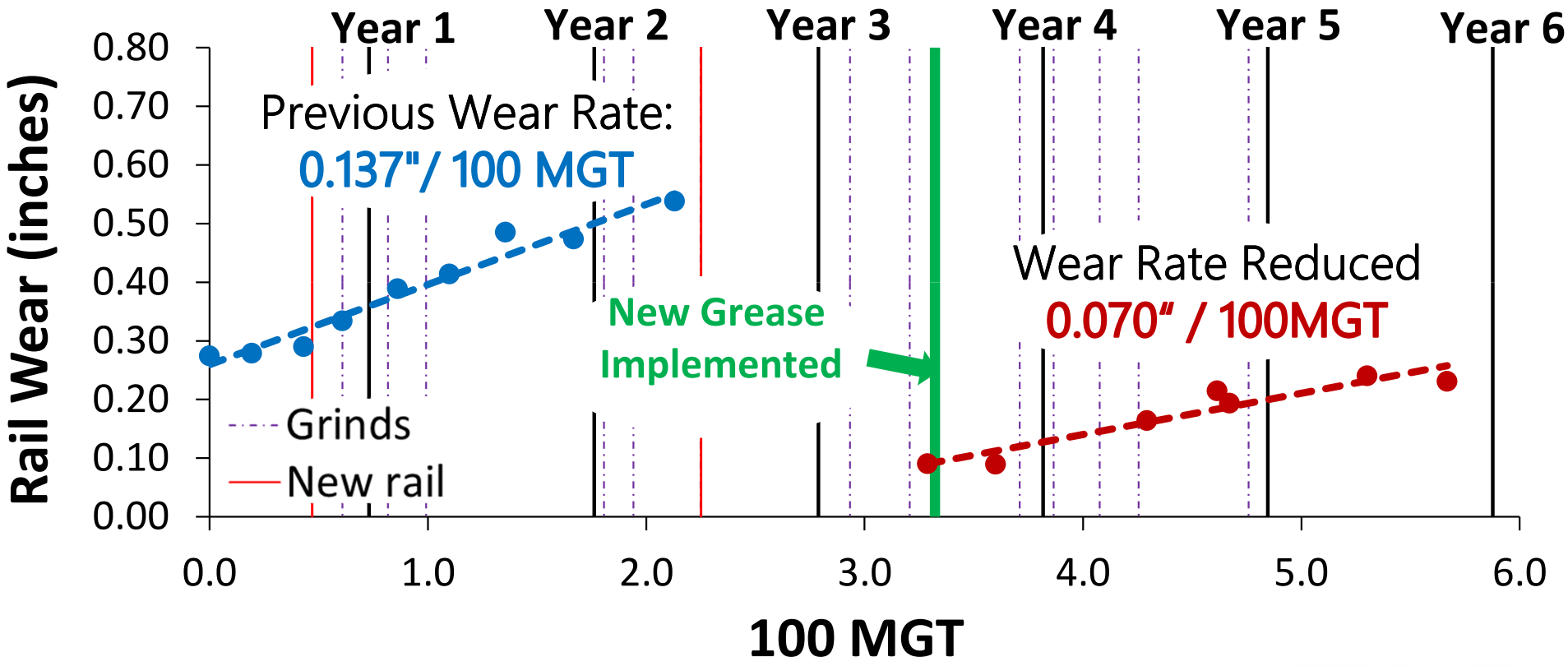


- Visual Assessment

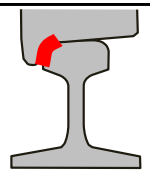
Good Grease Coverage

Grease Coverage

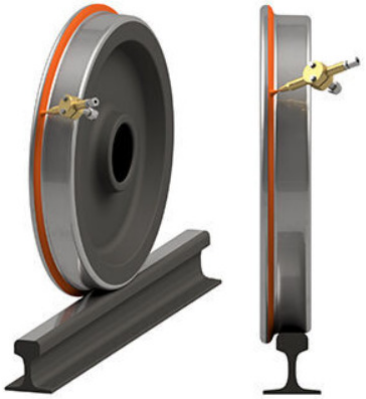
Field Trial – 7.6° Curve



Friction Management

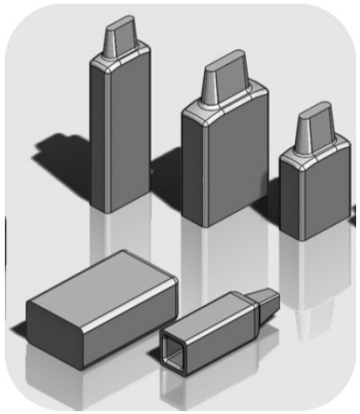
APPLICATION LOCATION		APPLICATION METHOD: Trackside 	APPLICATION METHOD: On-Board 
	Top of Rail / Wheel Tread Friction Modification	- Water-based friction modifiers - Hybrids - Top-of-Rail (TOR) Oils (petroleum/non petroleum)	- TOR Friction Modifier Spray - On-Board Oil-Based Spray - Solid Friction Modifier 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

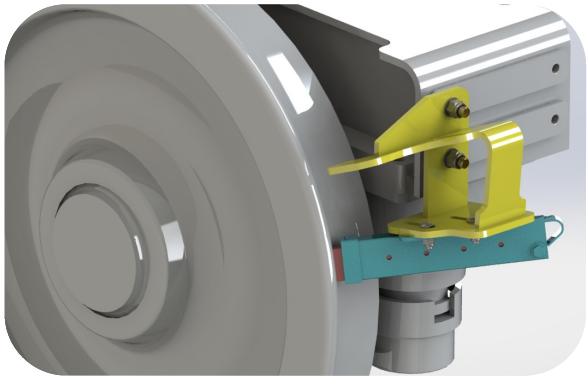
On-Board GF/Wheel Flange Materials



Oil Spray

Oil-based products with typically no solids continuously applied to wheel flange





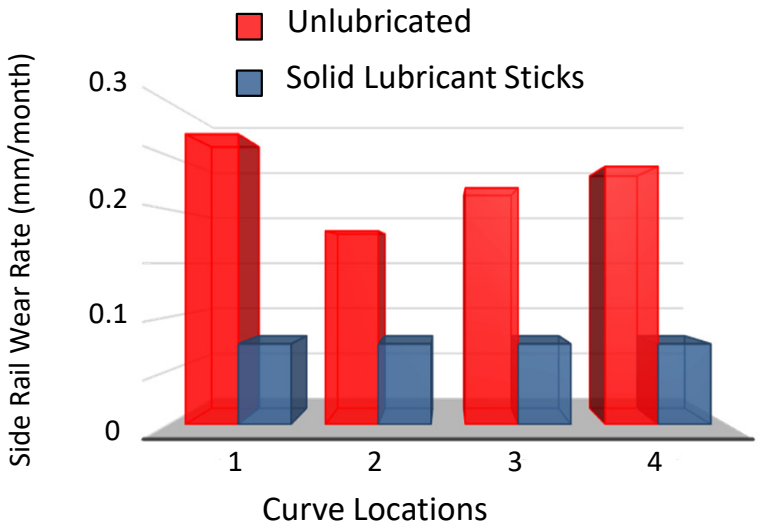
Solid Lubricant Sticks

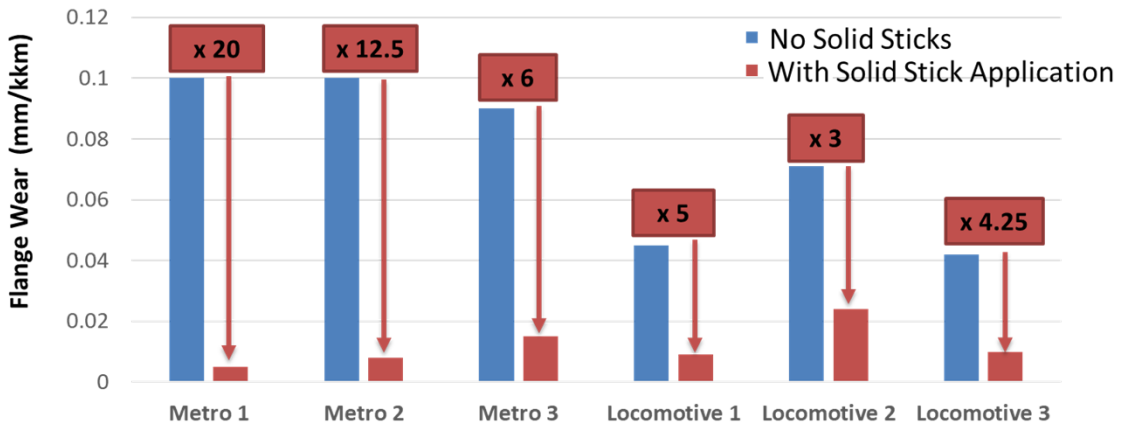
Solid lubricants encapsulated in a polymer continuously applied to wheel flange

On-Track/On-Vehicle Testing

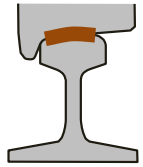
- Wear measurements



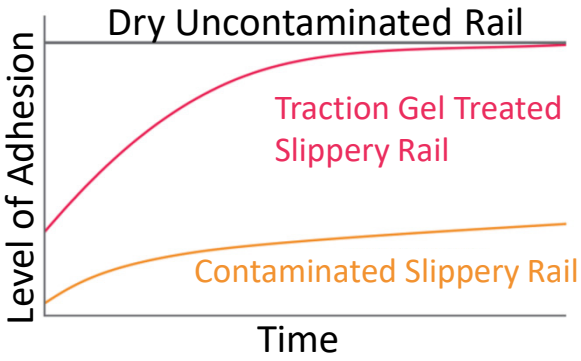


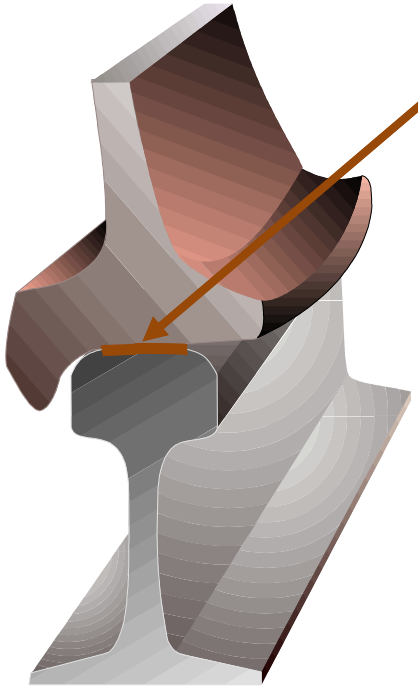


Friction Management

APPLICATION LOCATION		APPLICATION METHOD	
		Trackside 	On-Board 
	Top of Rail / Wheel Tread Friction Modification	- Water-based friction modifiers - Hybrids - Top-of-Rail (TOR) Oils (petroleum/non petroleum)	- TOR Friction Modifier Spray - On-Board Oil-Based 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

Benefits of Traction Enhancers





Traction Enhancers

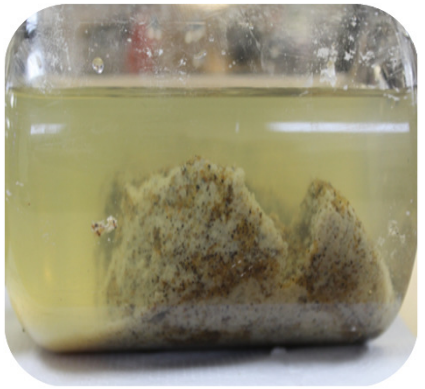
Benefits:

- Enhanced braking and traction capability
- Fewer operational safety related problems
- Reduced risk of signals passed at danger (SPAD)
- Fewer station overruns
- Less train delays and improved reliability
- Reduced risk of track circuit failures
- Fewer wheel flats
- Breaks leaf film during autumn season

CoF is restored

Traction Enhancer Properties

- General
  - Traction enhancing properties
- Traction gels
  - Product stability
  - Pumpability at all temperatures
- Traction particles
  - Particle size, shape and structure

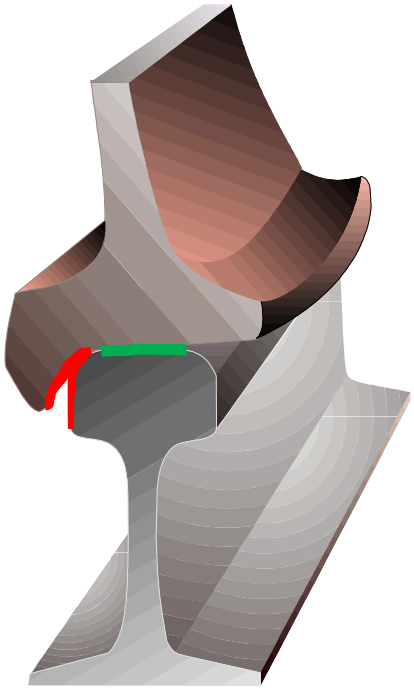


Application of Traction Enhancers

- Trackside – application of traction gel

Summary

- Effective Friction Management is one part of wheel / rail interface management
- Reduces wheel / rail wear and damage, reduces fuel consumption and noise
- Wide range of products with different properties and application methods
- Laboratory measurements and track testing can help select optimal solution



Thank you!