Benefits of Friction Management

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Agenda

- Why do we need to control Friction?
- Damage Mechanisms and Issues
- What is Friction Management?
- A solution-based approach
- Application Methods and Consumables
- Benefits of Friction Management

L.B. Foster

- We are a global business specialising in Rail Friction Management solutions for both freight and transit systems.
- We design, manufacture, supply, install and maintain solutions including:
  - Gauge Face Grease Lubrication Units and Consumables
  - Top of Rail Friction Modification Units and Consumables
  - Traction Gel Applicators and Consumables
  - On-board Top of Rail Spray Systems
  - On-board solid stick flange lubrication and tread friction modification systems
- We also provide:
  - Technical assessment of Friction Management needs
  - Field Installation Services and Training
  - Engineering Design and Support
  - Applications support, monitoring and analysis

Why do we need to control friction?

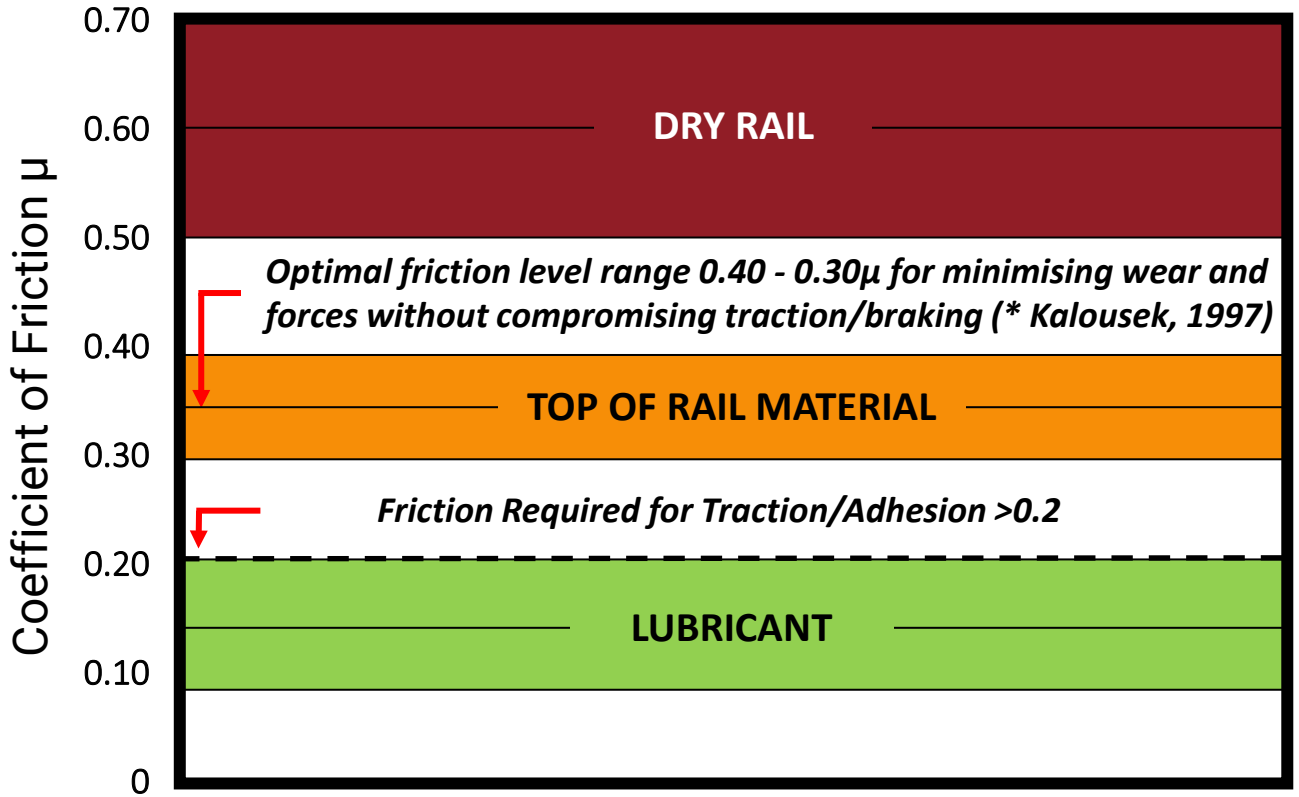
Friction is required for traction and braking

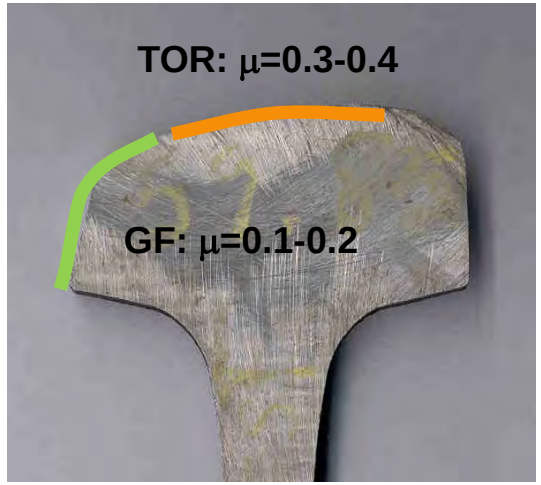
However, uncontrolled friction at the wheel/rail interface may lead to:

- Wheel and rail damage
- Excessive noise
- Safety issues
- Higher fuel / energy consumption
- Poor ride quality

Friction Management Definition:
The deliberate introduction of materials into the wheel - rail interface to influence the frictional behaviour.

Friction Management – Optimal Friction Level





High Rail

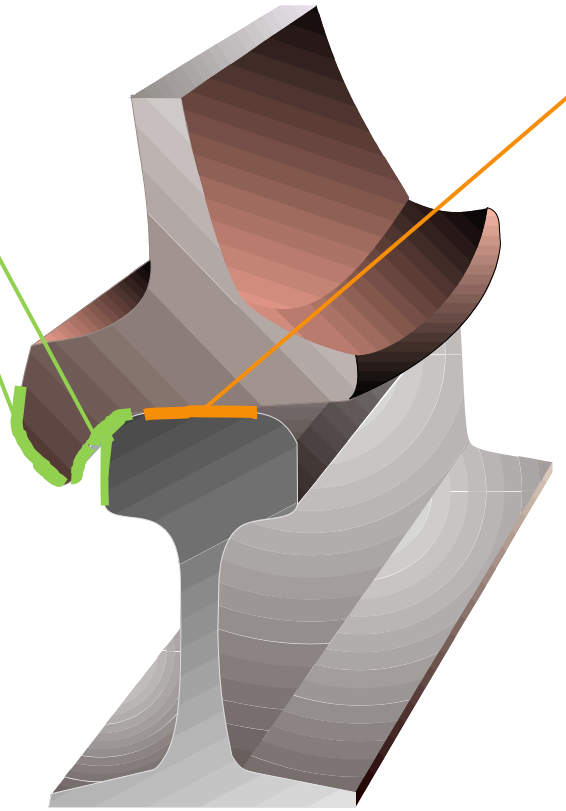
Effective Friction Management requires two different types of products.

Influence of Wheel/Rail Friction Targets

Gauge Face / Wheel Flange & Back of Flange Lubrication

Impacts:

- Rail / Wheel Wear (Gauge Face, Flange, Check Rail)
- RCF Development (gauge corner cracking)
- Flange Noise
- Derailment Potential (Wheel Climb)
- Fuel Efficiency



Top-of-Rail / Wheel Tread Friction Control

Impacts:

- Rail / Wheel Wear (TOR, Tread)
- RCF (head checks)
- Corrugations
- TOR Squeal Noise
- Lateral Forces
- Flange Noise (indirect)
- Fuel Efficiency
- Derailment Potential (L/V)
- Hunting
- Adhesion Recovery

The overarching goal for any FM program is to maximise benefits.

The Solutions Based Approach

The application strategy needs to be specific for the system requirements:

- Assessment
  - Where and what is the issue?
  - How severe / widespread?
  - Network details?
  - Options to apply consumable?
  - Budget?
  - Constraints / Regulations?
- Implementation
- Management (Maintenance & Filling)
- Performance Verification & Long Term Benefit Monitoring

Application Location		APPLICATION: Trackside 	APPLICATION: On-Board 
 **Top-of-Rail / Wheel Tread Friction Modifier**		- Water-based Friction Modifier - Top-of-Rail (TOR) Oil - Oil-based Hybrid	- Solid Stick Friction Modifier - Friction Modifier Spray - TOR Oil-Based Spray
 **Gauge Face / RR / Wheel Flange Lubrication**		*Gauge Face (GF) or Restraining Rail (RR)* - Rail Curve Grease	*Front or Back of Flange* - Solid Stick Lubricant - Oil Spray
 **Traction Enhancers**		- Traction Gel	- Sand - Traction Gel - Innovative Cleaning Tech

Using the optimal equipment and consumables at the right locations, maintained efficiently with validated results

Trackside Solutions

Application Units – Hydraulic Systems

Benefits:

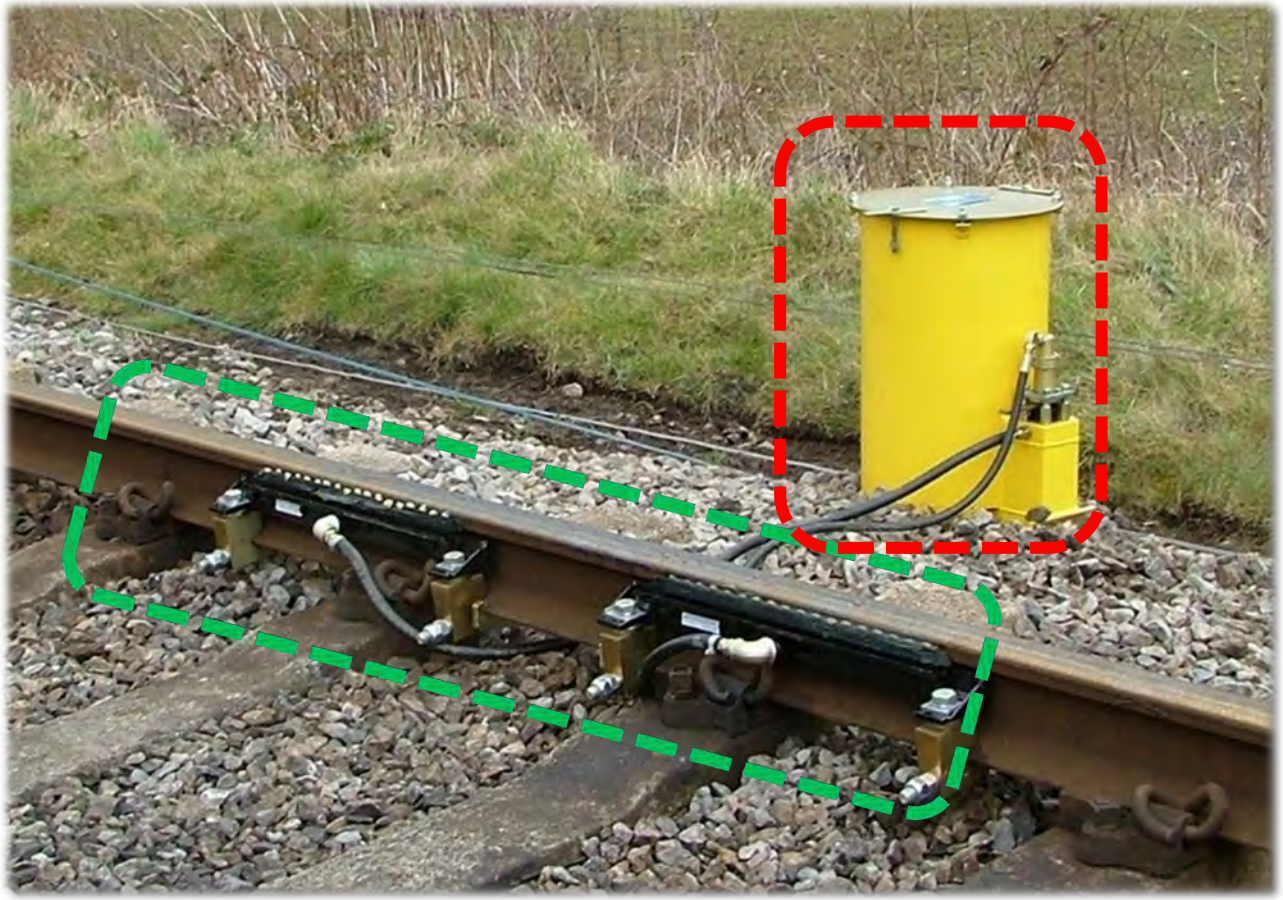
- Simple and cost effective
- Multiple tank capacities available
- Outputs grease each time a wheel passes

Limitations:

- Limited output adjustment
- Limited product carry down (~800m)
- Only available for gauge faceand check rail lubrication
- No Remote Performance Monitoring (RPM)

Target Market:

- Networks with train speed up to 110 km/h (70 m/h)
- Low budget



Application Units – Electrical Systems

Benefits:

> Accurate control of output rates
> Extended carrydown (up to 8km)
> Remote Performance Monitoring (RPM) Optional
> Robust, durable and easy to maintain
> Various appliable products
  - Lubricants => Flange or Restraining rail
  - Top of Rail Material => Top of Rail
  - Traction Enhancer => Top of Rail to increase traction

Limitations:

> Higher cost compared to Hydraulics
> More space required

Target Market:

> All types of networks
> Customers that require a bespoke FM strategy
> For operators that look at total cost of ownership

Applicator Bars

Interface with Rail/Wheel:

- Key component of a trackside unit for material distribution and pick up

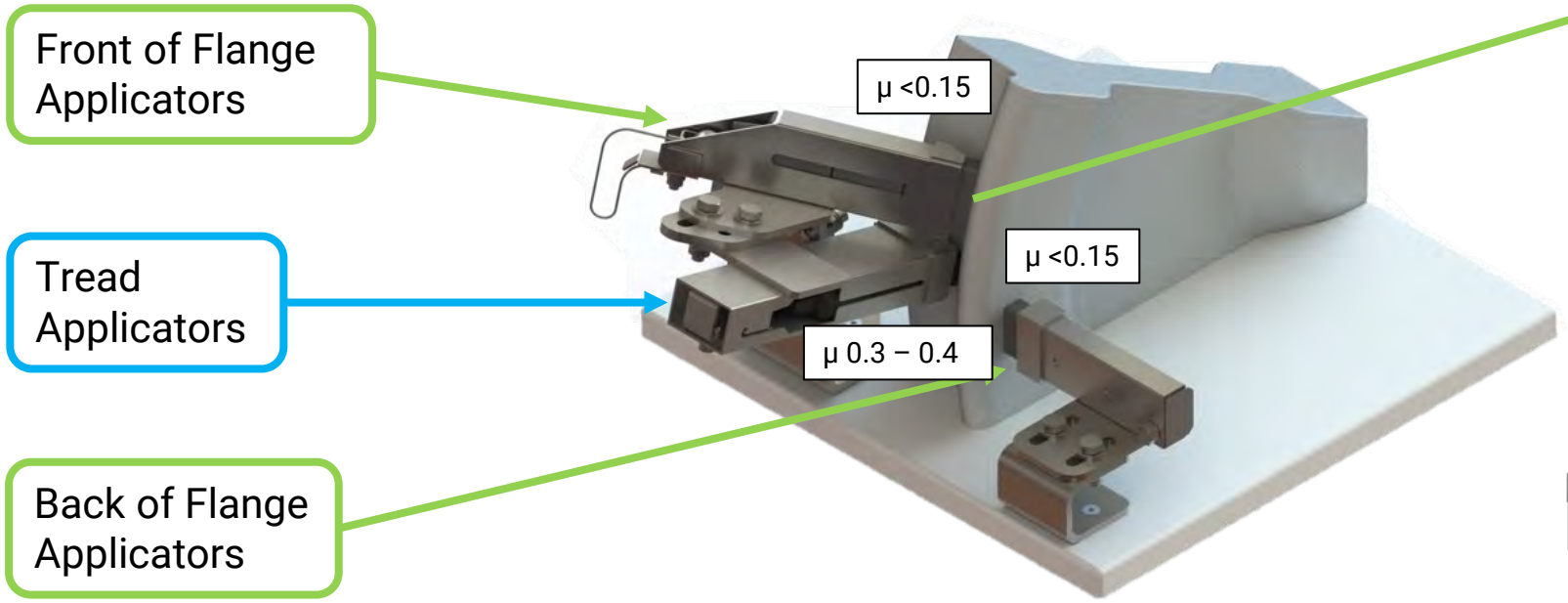
Key Features:

- Multiple ports (Gauge Face), single port (Top Of Rail/Traction Gel Applicator)
- Trough or guide for GF
- Application to running or restraining rails
- Easy to install/maintain
- Adjustable height to account for wear and rail / wheel profile

On-Board Solutions

On-Board Solid Stick Systems

- **Clean** – No liquid contaminants. Self-regulating layer prevents over application.
- **Precise** – Does not migrate outside the band of the wheel it is applied to.
- **Reliable** – Purely mechanical system. Simple, and easily maintainable.
- **Carry Down** – Film transfers onto rail and is picked up by consecutive wheels.

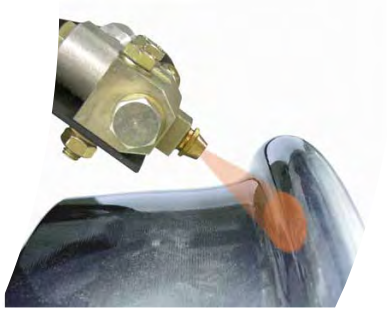


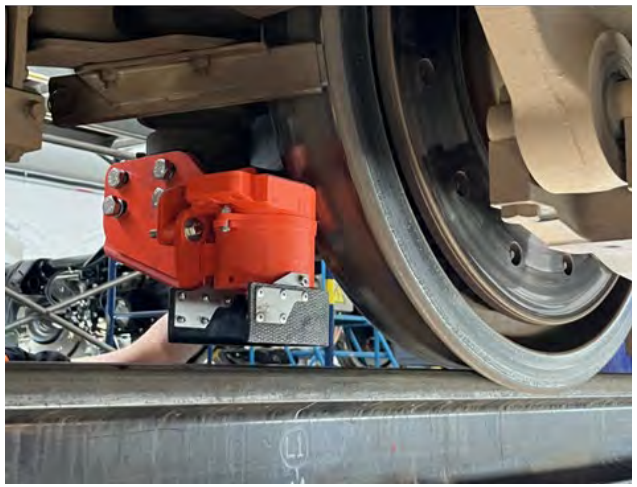
Applicator Cross Section

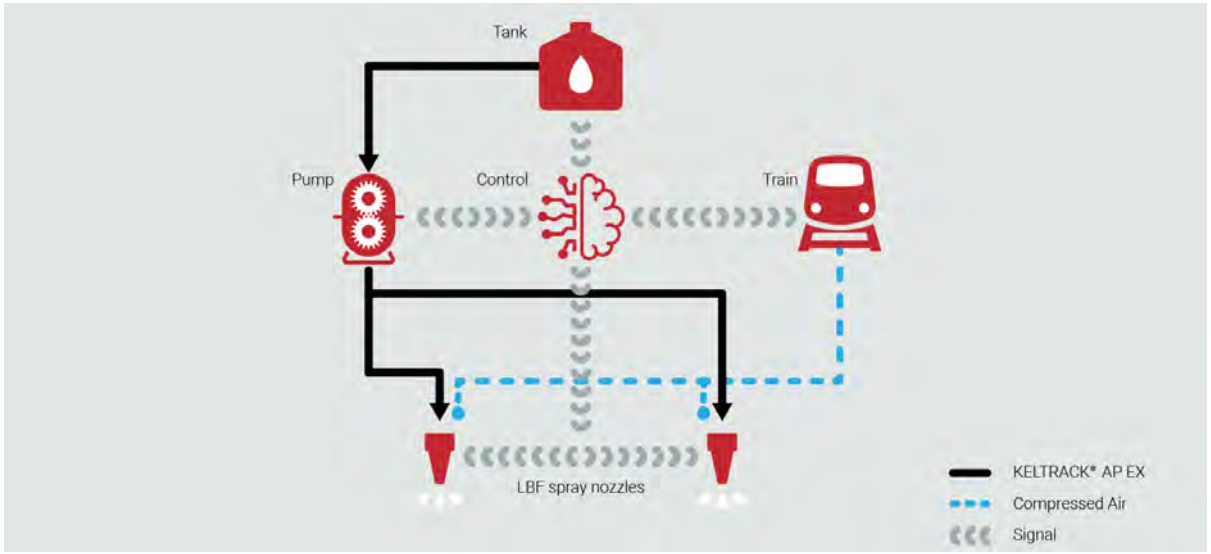
Solid Stick

Onboard Lubrication –Wheel Flange and Top of Rail Spray

- Wheel flange spray well established
- TOR spray provides the same benefits as TOR trackside eliminating the operational constraints associated with trackside systems
- KELTRACK® On-Board (KOB) SL is a vehicle mounted spray system for transit vehicles.
- KOB dispenses water-based drying Friction Modifier material directly to the top-of-rail.
- It is a smart system, applying product only where and when it is needed.
- Maintenance is done in the vehicle depot. No track access is required.







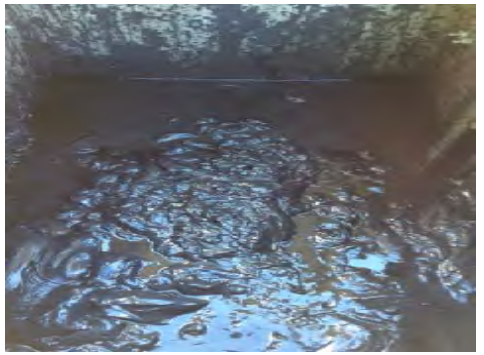
Consumables

Lubricant Consumables - Key Specifications

ALL	• Low coefficient of friction • Good film durability & wear protection • Effective product carry down and transfer • Low environmental & health impact • Good product stability & consistent properties
LIQUID	• Low bar clogging propensity • Good column strength • Optimized pumpability at operating temps • Optimized oil separation • Good adhesion to rail & water wash-off resistance
SOLID	• Good mechanical strength & thermal stability • Optimized consumption rate • Interlocking (continuous) design

TOR Consumable - Key Specifications

ALL	• Intermediate friction • Positive friction • Safe operation • Good film durability & carry down • Low environmental & health impact • Good product stability & consistent properties
LIQUID	• Effective pumpability & pick-up at operating temperatures • Water wash-off resistance
SOLID	• Good mechanical strength & thermal stability • Optimized consumption rate • Interlocking (continuous) design



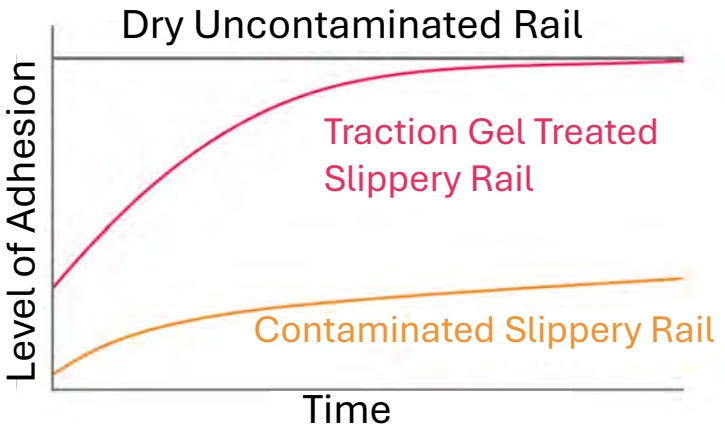
Trackside Traction Enhancer Gel

Key Specifications

- Effective traction enhancement
- Effectively breaks down leaf film
- Good film durability & carry down
- Effective pumpability & pick-up at operating temperature
- Product stability
- Low environmental & health impact

Benefits

- Reduced operational & safety issues
- Enhanced braking and traction
- Fewer station overruns
- Reduced risk of Signals Passed at Danger (SPAD)
- Fewer train delays and improved on-time reliability
- Fewer wheel flats
- Reduced consumption of train-based traction enhancement solutions (e.g. sand)



Benefits of Friction Management

What are the Tangible Benefits?

- *Improve Asset Reliability (fewer failures, fewer interventions)*
- *Extend Asset Life (lower lifecycle cost for track infrastructure & rollingstock)*
- *Reduce Emissions (noise, vibration, fuel/energy)*
- *Enhance Safety (lower risk of derailment & defects, better ride quality)*

Immediate Benefits	Longer Term Benefits
Reduce Wear (~25-60%)	Reduce Grinding Intervals (~50%)
Reduce Noise (~5-10dBA)	Reduce Defects (~50%)
Enhance Safety (Derailment Risk)	Reduce Fastener Damage (~20-80%)
Improve Fuel Economy (~3-5%)	Improve Ride Quality (Vehicle Steering)
Payback / Return on Investment (< 1 year)	

Savings will be different for every system

Case Study 1: Rail Wear Reduction

Trackside Application of KELTRACK Friction Modifier to Top of Rail

> **Port Authority Transit (Pittsburgh)**

Rolling Stock:

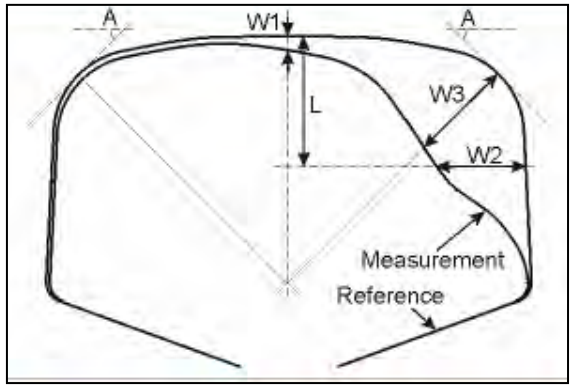
Siemens Transportation System SD400 double-ended articulated six axle LRV

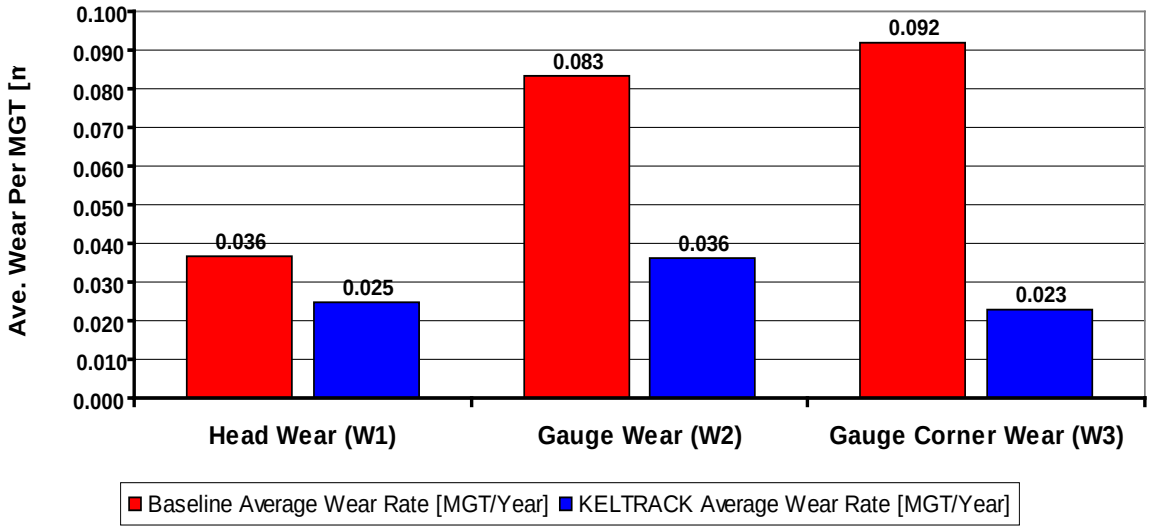
Annual tonnage is ~11.6 MGT

Test Site:

Curve: 91 m radius, 122 m length

Gradient: 2-3% downhill



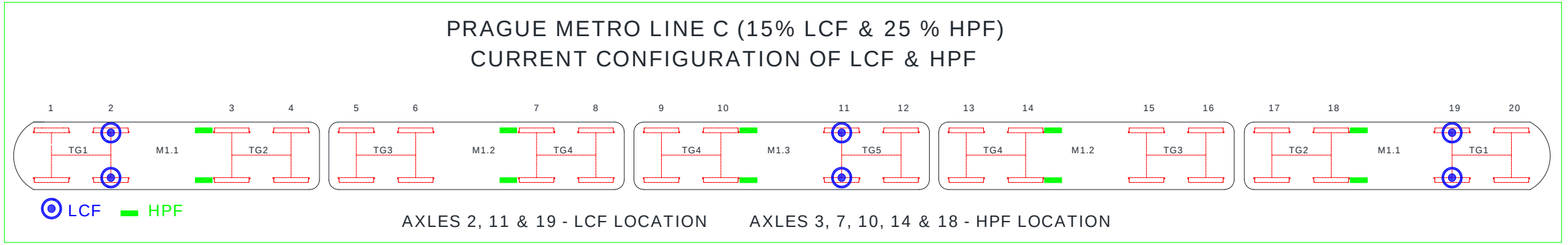


Case Study 2: On- Board Wheel Flange & Tread Wear Reduction

Prague Metro

- KELSAN LCF sticks fitted on all three lines (A, B & C):
- Line B in 1996, and
- Lines A & C in 1997
- The wheel life increased from 150,000 km to 800,000 km
- KELSAN HPF introduced onto Line C in 2001

- Current wheel life 1.5 M km by reducing tread wear
- Additional benefits: 3% - 4% reduction in electricity costs
- Reduction in corrugation growth
- Vehicle hunting reduced



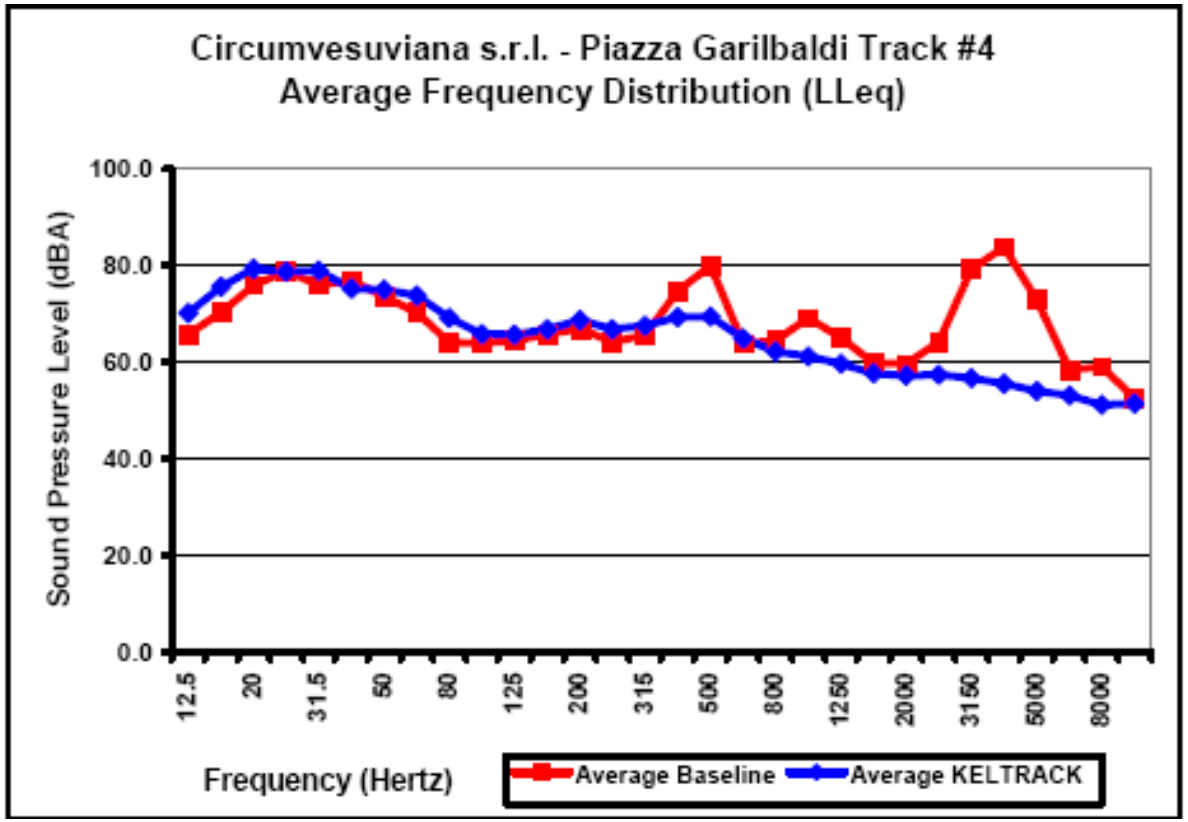
Case Study 3: Noise

Top of Rail noise mitigation with KELTRACK

Light rail/Trams: distinct TOR squeal peaks, less flanging component

Site details: Circumvesuviana

- Track # 4 towards Terminale
- 90m radius / 70m length
- Level gradient / UNI 50 rail
- Onboard WF lubrication

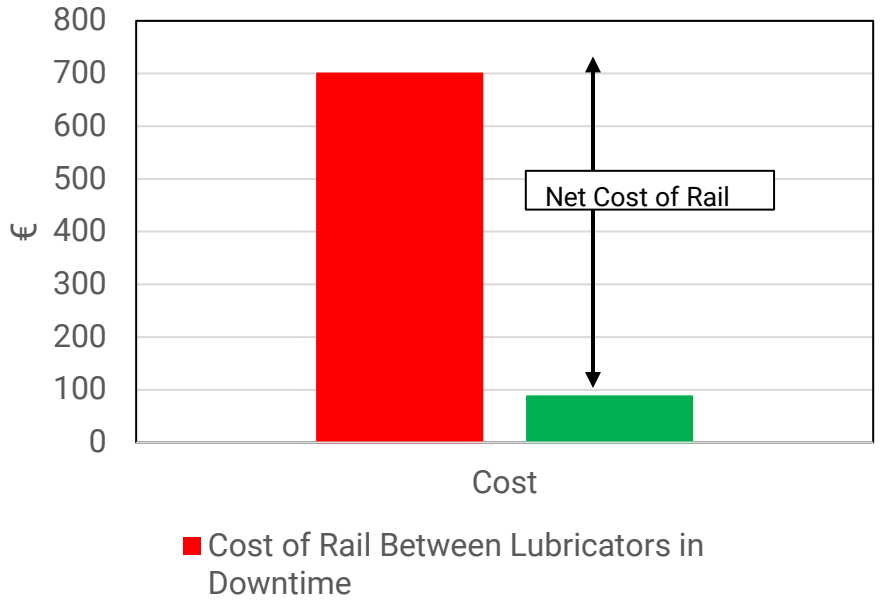


Case Study 4: Cost of Friction Management Downtime

Estimated cost of Gauge Face (GF) Lubricator unit downtime on one single Heavy Haul subdivision of CN

Based on:-

- Annual MGT of 104 on the Clearwater Subdivision of CN
- ~13,700 daily axle passes (based on RPM data)
- Average 1.189 miles between two Gauge Face units
- Average wear rates measured from 15 separate curves comparing no lubrication vs lubrication



Average incremental rail cost per curve mile per Day = 588.74 €
Cost of rail between two units = 1.189 * 588.74 € = 700.01 €
Cost of two operational GF units per day = 43.69 € * 2 = 87.38 €

Net cost of Rail between two Gauge Face units per day of downtime = 700.01 € - 87.38 € = 612.73 €

Proven Benefits: Rail Savings

GF / TOR	Rail Wear Reduction	Railway	Year	Reference
GF	41% - high rail TOR (vertical) 87% - high rail gauge face	CPKC	2001	AREMA 2001: Sroba. CPR 100% Effective Lubrication Initiative
GF + TOR	57% - low rail TOR (vertical) 50% - high rail TOR (vertical) 'Eliminated' – high rail gauge face	CPKC	2005	IHHA 2005: Sroba. CPR 100% Effective Friction Management Strategy
GF + TOR	57% - low rail TOR (vertical) 25% - high rail TOR (vertical) 61% - high rail GF and gage corner	UPRR	2005	TD-07-019: Reiff. Wayside-Based Top of Rail Friction Control: 95 MGT Update
GF + TOR	58% - low rail TOR	UPRR	2005	TD-05-018: Reiff. Implementation Demonstration of Wayside Based TOR Friction Control
GF + TOR	17 - 48% - low rail TOR (vertical) 21 - 53% - high rail TOR (vertical)	CN	2005	IHHA 2005: Eadie. Trackside TOR Friction Control at CN
GF + TOR	37 - 39% - low rail TOR (vertical) 16 - 32% - high rail TOR (vertical) 31% - average wear reduction	CPKC	2009	2009: Roney. Reducing the Stress State on CP's Western Corridor.
GF + TOR	23 - 60% reduction in natural wear rates (premium rail grade track results)	Voestalpine	2009	CM2009: Stock. Influencing rolling contact fatigue through top of rail friction modifier application - a full scale wheel-rail test rig study
GF + TOR	31% rail life extension on 2 deg curve	TTCI	2015	IHHA 2015: Baillargeon. Implementation of Rail Life Extension Methods in Heavy Haul Railways
GF + TOR	21 - 91% - low rail TOR (vertical) 25 - 83% - high rail TOR and GF	CPKC	2017	WRI2017: Stock. Friction management and rail wear CPs western corridor: 2008 - 2016
GF + TOR	25% - high rail GF 50% reduction in product application rates with premium synthetic grease	CPKC	2020	AREMA 2020: Furlong. Premium Synthetic Grease in a Heavy Haul Environment
GF + TOR	90% - high rail GF	CPKC	2025	WRI2025: Harrington. Effect of Total Friction Management on CPKC Thompson Subdivision Rail Wear

GF – Gauge Face
TOR – Top of Rail

Proven Benefits: Fuel Savings

GF / TOR	Fuel Savings	Railway	Year	Reference
GF	5.70%	CPKC	2001	AREMA 2001: Sroba. CPR 100% Effective Lubrication Initiative
GF + TOR	2.3 – 10.5% depending on curve density	BC Rail	2005	IHHA 2005: Cotter. TOR Friction Control: Reductions in Fuel and Greenhouse Gas Emissions
TOR	3 - 4% (fuel savings) 9.6% reduction (mechanical)	QCM	2005	IHHA 2005: Cotter. Freight Car Based Top of Rail FM System
TOR	4.9% all segments	UPRR	2008	TD-08-39: Reiff. Mobile-based Car Mounted TOR Friction Control Application Issues – Effectiveness and Deployment
GF + TOR	5 – 8% on average	CPKC	2009	IHHA 2009: Roney. TFM on CP
TOR	2.3 – 4.2%	NS	2010	ARM W/R 2010: Conn. For Sale – TOR/ATW FM
TOR	2.3 – 2.6%	UPRR	2016	Conference on Railway Tech: Elvidge. The Effect of Freight Train Mounted TOR-FM on Wheel Life Defects
TOR	5.3% (energy savings)	SHR	2016	2016: CARS. Study on the Application of Measures for Friction Control of Shuohuang Heavy Railway
TOR	4.4 – 6.9% (energy savings)	China Energy	2023	IHHA 2023: Lu. Development of TOR Locomotive Onboard Application System for China Energy

GF – Gauge Face
TOR – Top of Rail

Summary

- Uncontrolled friction can lead to damage, noise and safety issues
- Different areas of the rail and wheel require different friction levels and therefore different products
- A solutions-based approach should be used to optimise the friction management regime
  - Assessment
  - Implementation
  - Management (Maintenance & Filling)
  - Performance Verification
  - Long Term Benefit Monitoring
- Effective friction management can yield real benefits in terms of reduction in damage, noise and energy requirements

Thank you

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