Friction Management: Uncovering a Cornerstone of Vehicle/Track Interaction.

Don Eadie

Don Eadie Consulting /
Advanced Rail Management

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Overview

1. Introduction
2. Pre-1994: Gauge face / wheel flange
3. Wayside gauge face lubrication development
4. TOR friction impacts – emerging understanding
5. TOR-FM development – turning points
6. The future and what's needed

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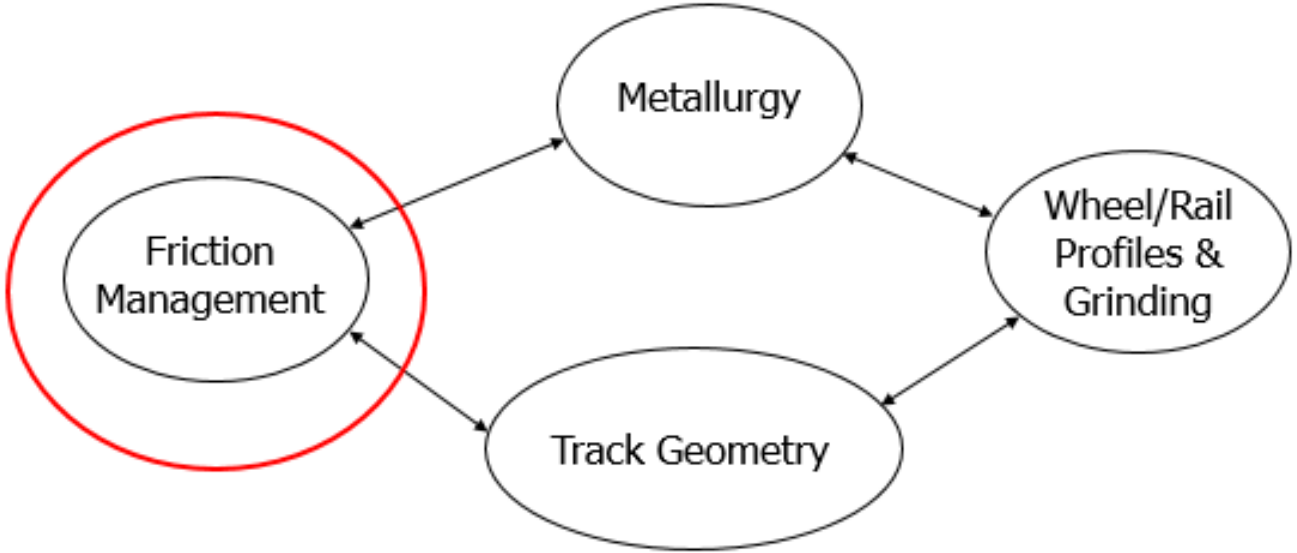
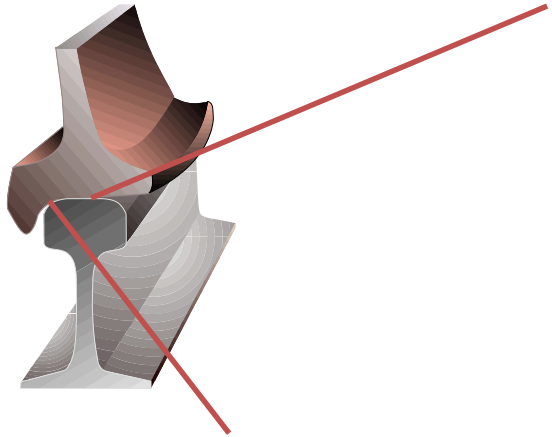
Friction Management is a key component in controlling the wheel / rail interface



Friction Impacts at the Wheel/Rail Interface



Top of Rail (TOR) Friction Impacts:

- Lateral Forces
- Rail / Wheel Wear (TOR, Tread, gauge face, flange)
- Rolling Contact Fatigue Development
- Fuel Efficiency
- Squeal Noise
- Flange Noise (indirect)
- Corrugations
- Hunting
- Derailment Potential (L/V, rail rollover)
- Traction / Adhesion

Gage Face (GF) Friction Impacts:

- Rail / Wheel Wear (Gage Face, Flange)
- Rolling Contact Fatigue Development
- Fuel Efficiency
- Flange Noise
- Derailment Potential (Wheel Climb)

Key people interviewed

- Joe Kalousek
- Kevin Conn
- Tom Brueske
- Michael Roney
- Rich Reiff
- Bruce Wise
- Vinny Dyavanpalli
- Norm Hooper
- Kelvin Chiddick
- Gary Wolf

- CNRC
- Norfolk Southern
- BNSF
- Canadian Pacific
- TTCI
- Portec Rail, Whitmores
- Tranergy, Loram
- BC Rail
- Kelsan Technologies, Whitmores
- Wolf Railway Consulting

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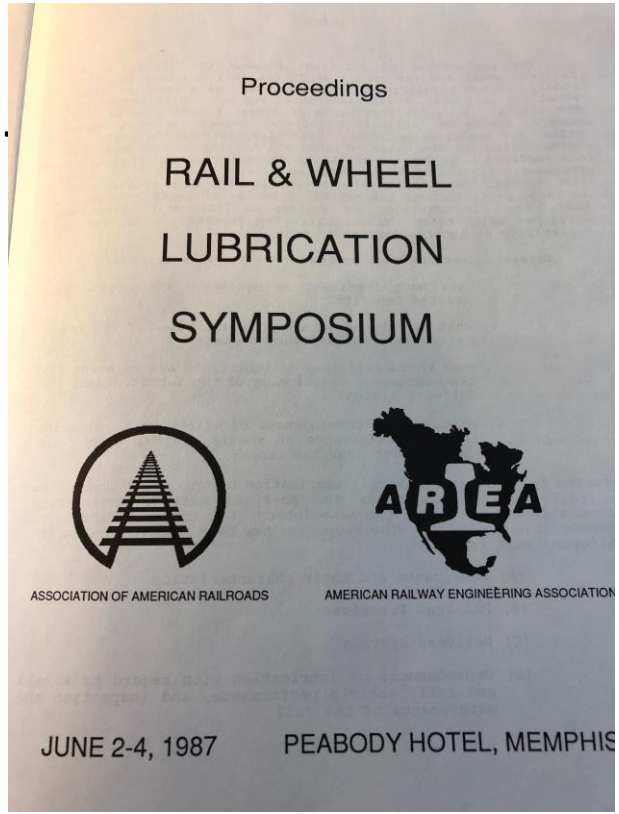
Early history

- Wayside gauge face lubrication
  - Mechanical equipment
  - Poor control
  - Wear of equipment
  - Local lubricant selection
  - Rail wear driven
- 1980s – increasing importance of fuel conservation
  - Emerging research on application equipment and lubricants

P&M Model C4L Mechanical Lubricator installed on British Rail in the UK, circa 1953

1987 Symposium



Proceedings

RAIL & WHEEL

LUBRICATION

SYMPOSIUM

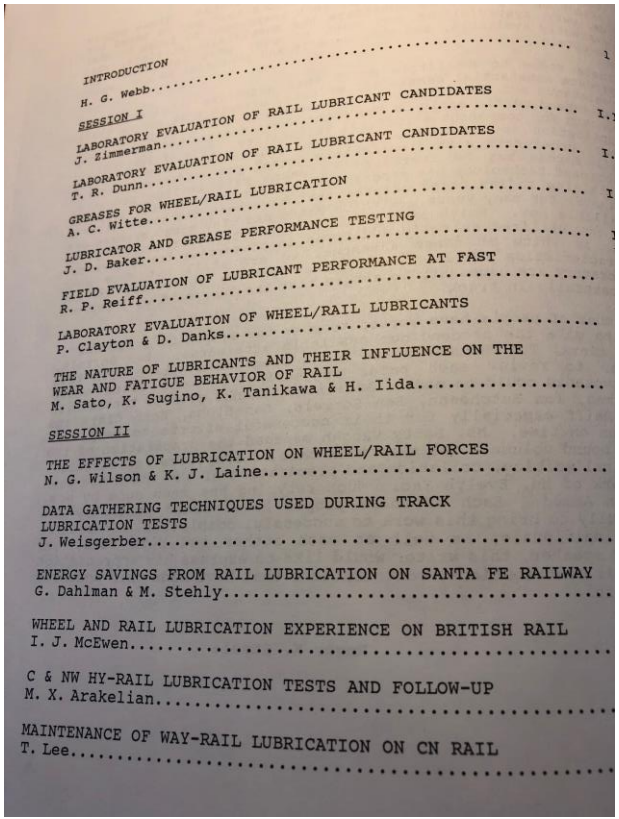
ASSOCIATION OF AMERICAN RAILROADS

AREA

AMERICAN RAILWAY ENGINEERING ASSOCIATION

JUNE 2-4, 1987

PEABODY HOTEL, MEMPHIS



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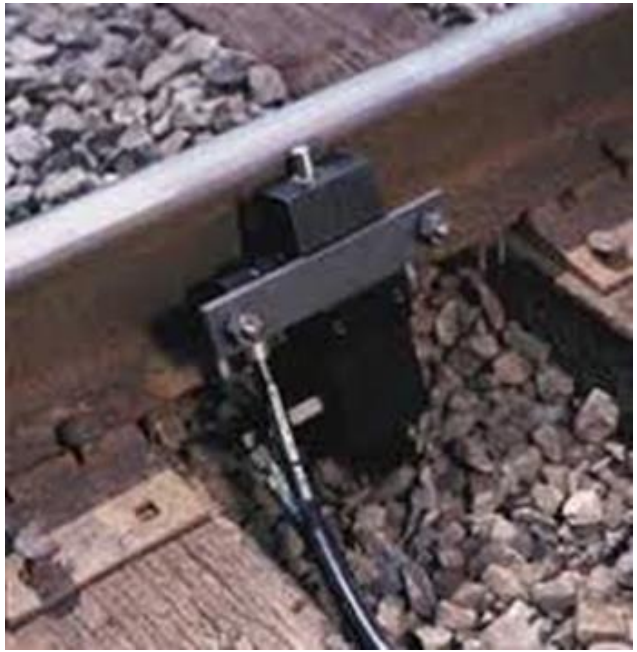
Typical hydraulic unit, early 1990s



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LEVEL OF ENFORCEMENT	WEAR/RATE IN/MGT	AVERAGE RELATIVE IMPROVEMENT OVER DRY
Dry Rail (No Lube)	0.005-0.007	1
Low	0.001	5
Medium	0.00029	17
High	0.000064	80

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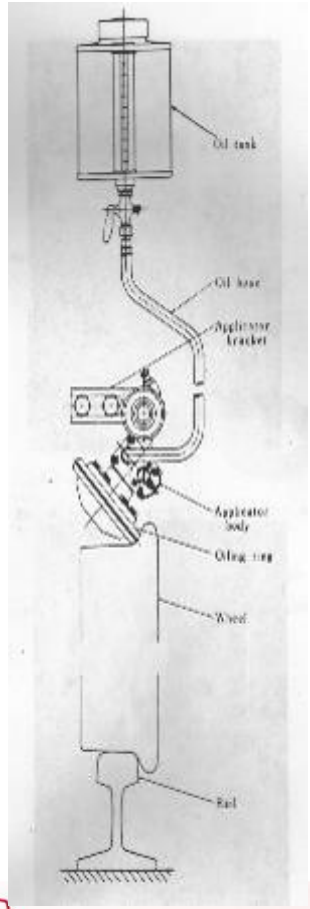
Locomotive wheel flange lubrication: 1980s and 90s



- Installed as OE equipment on thousands of road locomotives
- Eliminate need for wayside lubricators?
- Eventually “retired” due to reliability and maintenance chanllenges

Practical advancements in wayside GF lubrication: equipment

- 1994: change from piston pump to gear pump
- Purchase of Moore and Steele by Portec Rail
- Early electronic lubricators – 1990
- Development of applicator bars / pumping systems to reduce clogging
- Remote Performance Monitoring

Advancements in wayside GF lubrication: consumable and maintenance

- Centralized sourcing of lubricant
  - More recognition of value of higher performing greases
- Improved retentivity / carry down of premium greases
  - Increased spacing between application points
  - “$ per treated mile” rather than $ per lb.
- Wider temperature operating range
- Maintenance and uptime
  - Outsourced refilling and maintenance can lead to much higher uptime: 25% → 90%+
  - Remote monitoring of units for uptime determination

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TOP OF RAIL FRICTION MODIFICATION

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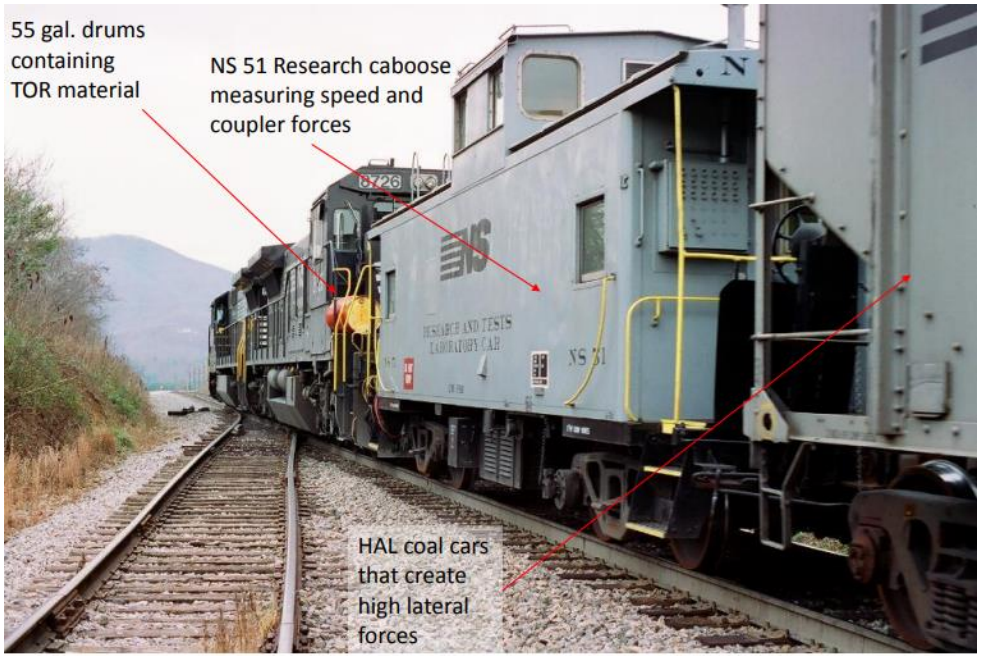
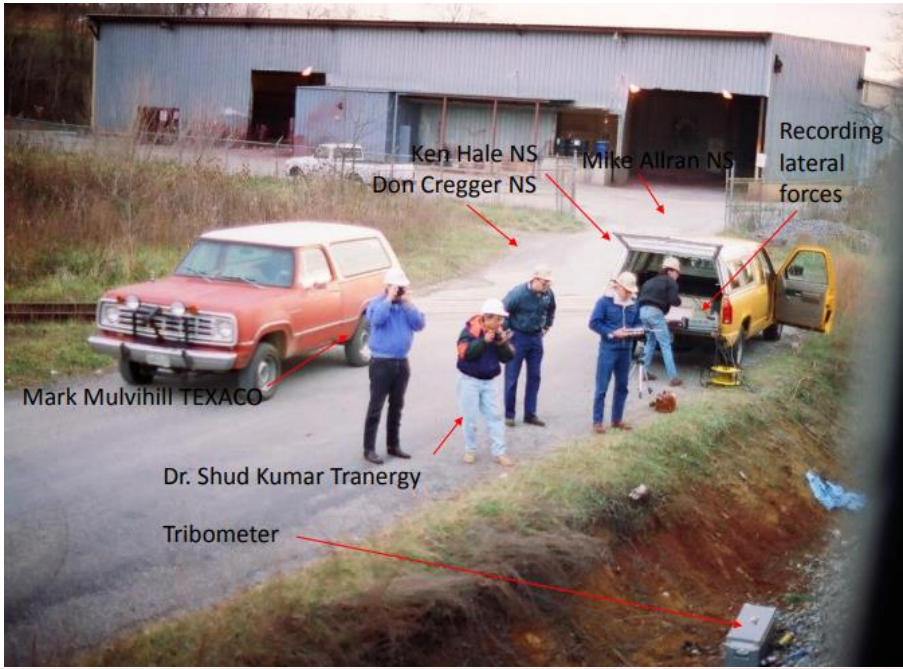
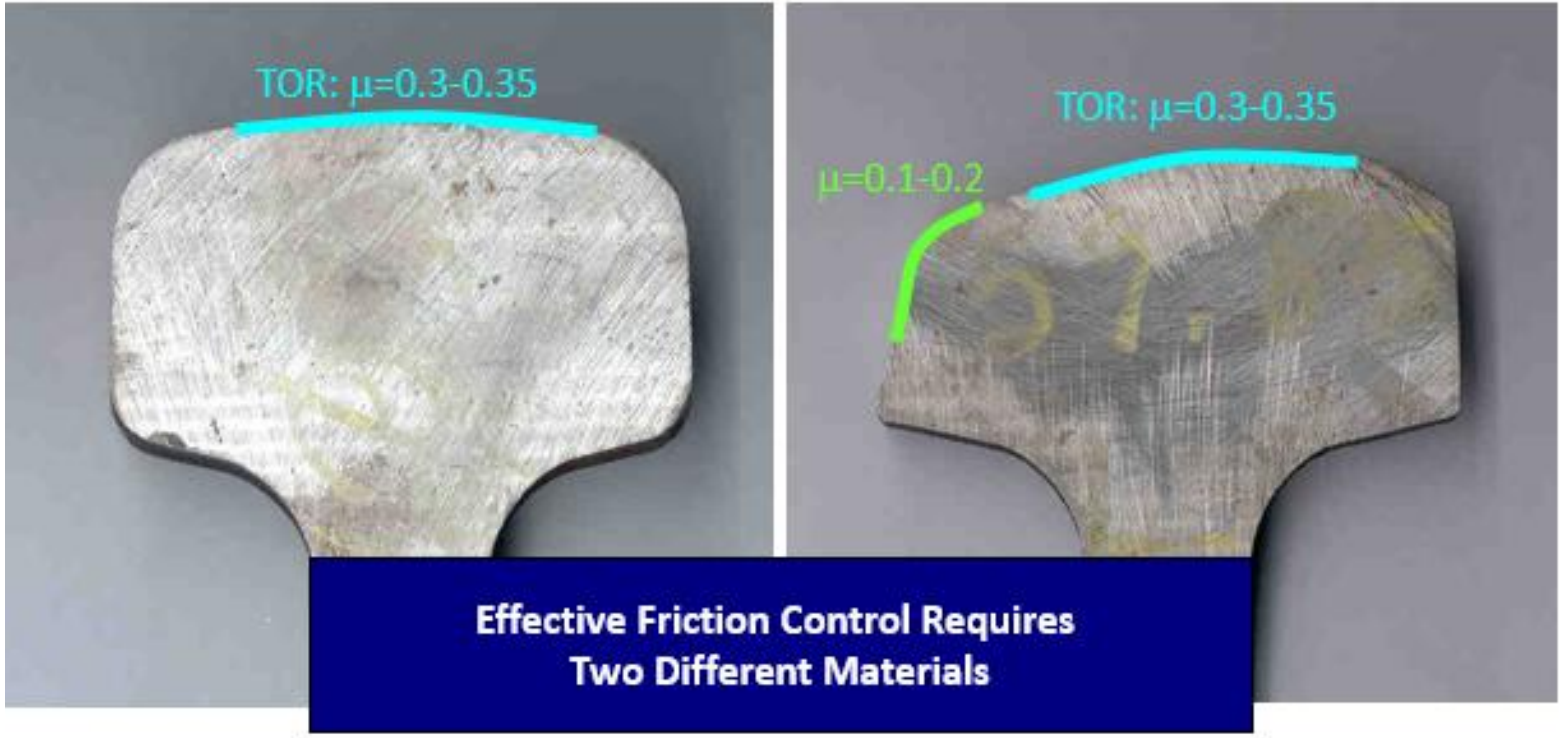
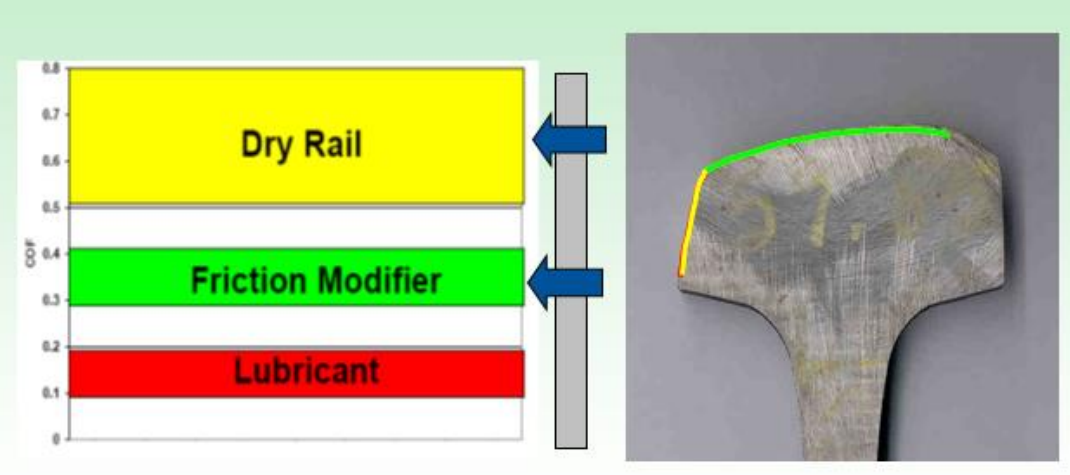
Locomotive TOR lubricant testing at Norfolk Southern, 1993

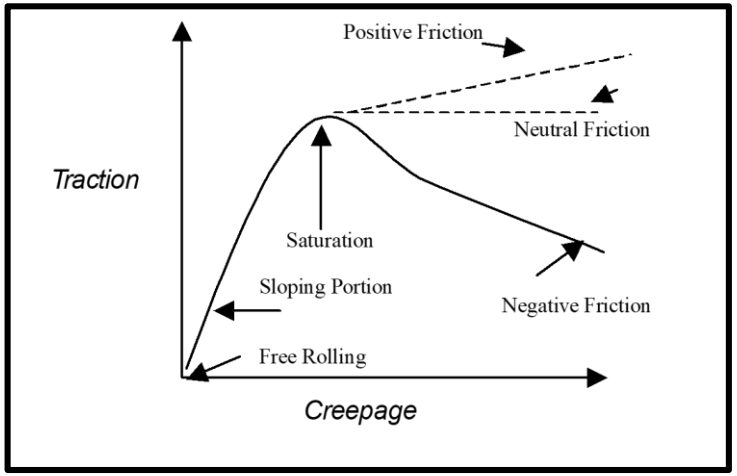





TOR: μ=0.3-0.35
TOR: μ=0.3-0.35
μ=0.1-0.2
Effective Friction Control Requires
Two Different Materials
Low Rail
High Rail

TOR Friction Modifier Characteristics

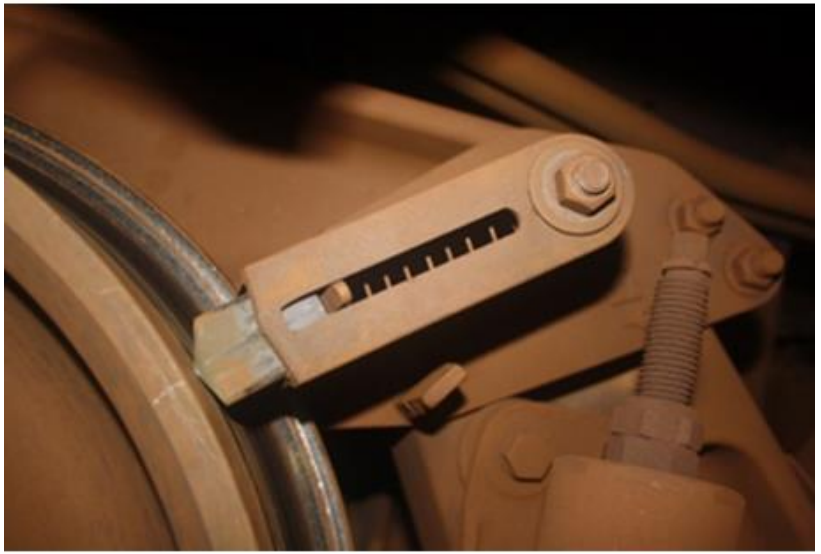




TOR-FM started on transit systems for noise and corrugation control

Vancouver Skytrain:

- Development of tread mounted solid sticks , first commercial TOR application, 1988-1990



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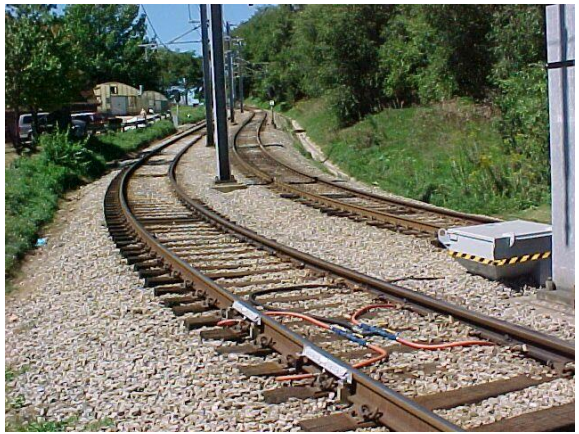
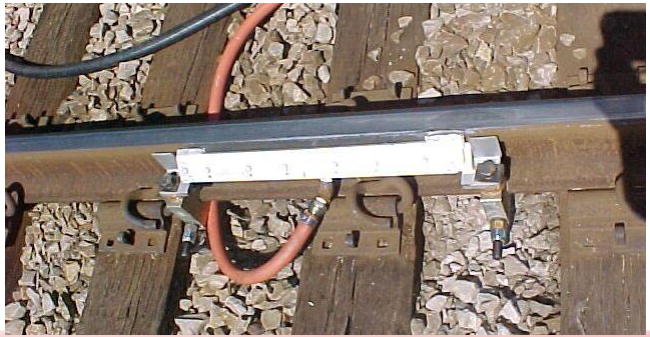
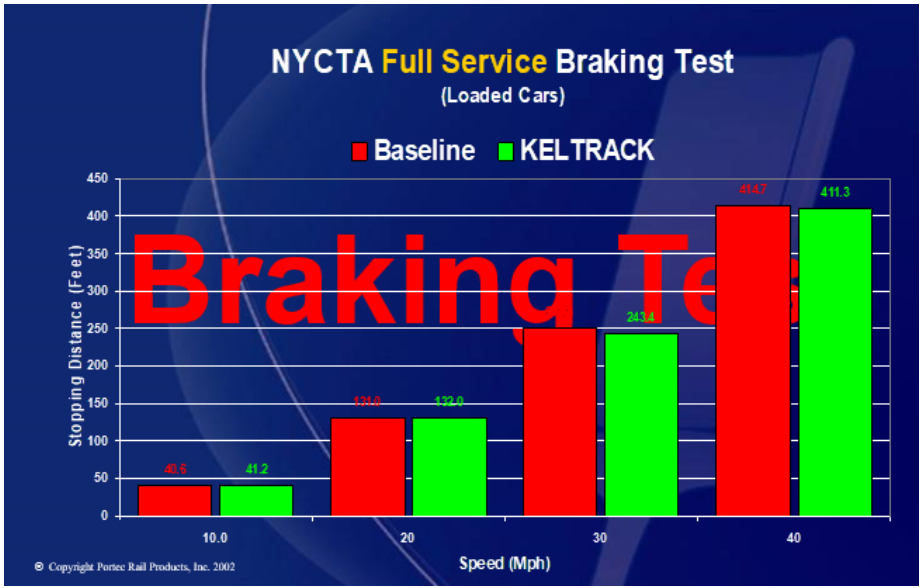
Port Authority of Allegheny County (Pittsburgh): First revenue service wayside TOR-FM, 1999 / 2000



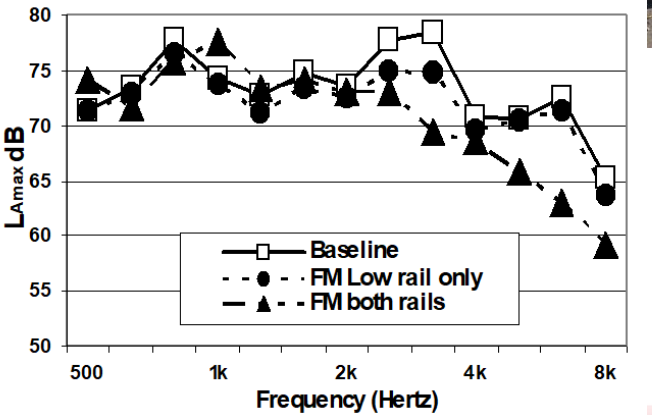


NYCT: Comprehensive safety evaluation of water based TOR-FM prior to implementation, 2002



- Braking test:
  - Multiple speeds
  - Full service and emergency
  - Loaded and empty cars
- Signalling evaluation

TOR-FM in Japan: TMTB in 2000



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WAYSIDE TOR-FM: HEAVY HAUL

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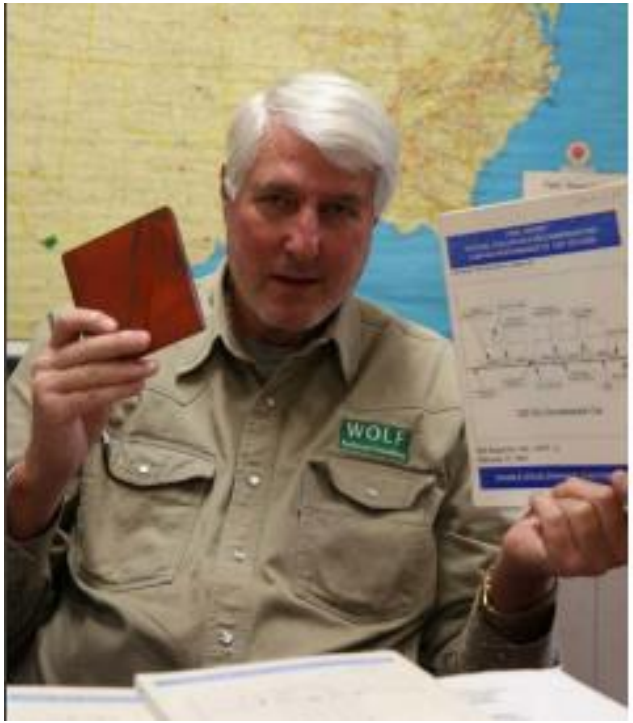
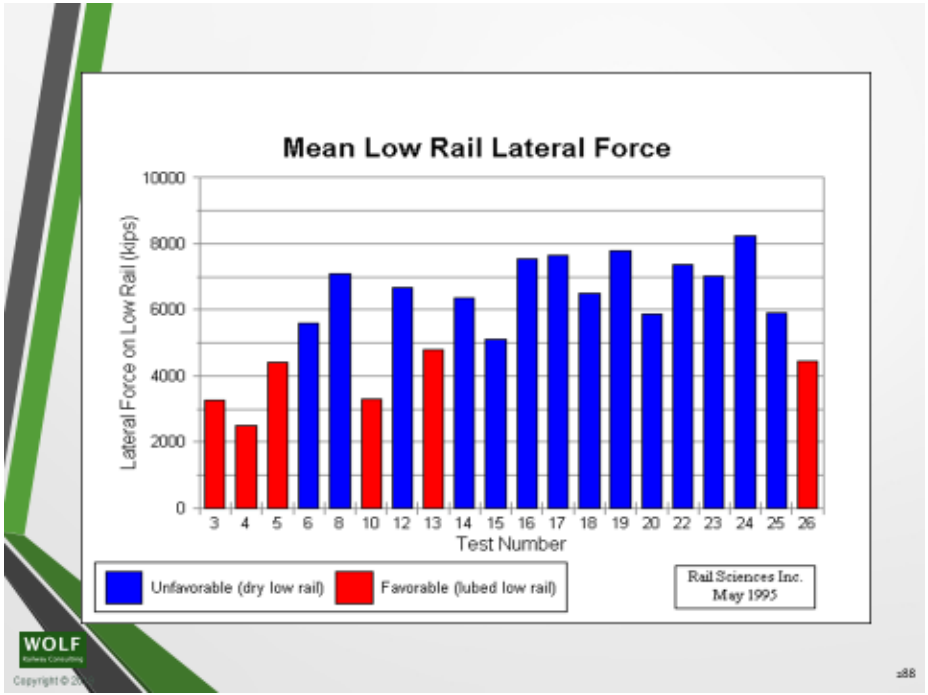
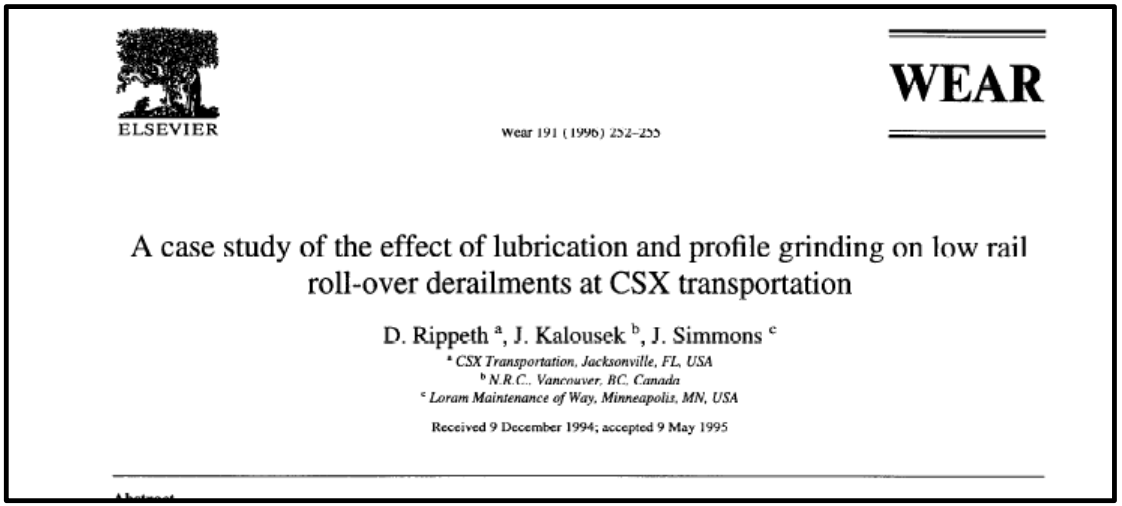
Double stack project: Impact of top of low rail friction on lateral forces





TOR friction impacts: Applying grease to top of low rail to reduce rollover derailments



ELSEVIER

Wear 191 (1996) 252–255

WEAR

A case study of the effect of lubrication and profile grinding on low rail roll-over derailments at CSX transportation

D. Rippeth [a], J. Kalousek [b], J. Simmons [c]

[a] CSX Transportation, Jacksonville, FL, USA

[b] N.R.C., Vancouver, BC, Canada

[c] Loram Maintenance of Way, Minneapolis, MN, USA

Received 9 December 1994; accepted 9 May 1995

- Hirail grease application to top of low rail
- Reduction in derailments but no lateral force data
- Application difficult to control (train stall potential)

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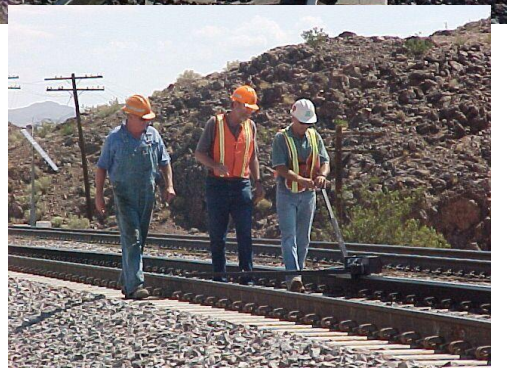
BNSF: First wayside TOR-FM tests on heavy haul: August 2001, Siberia and Ludlow, California



30-50% reduction in leading axle lateral forces

BNSF

- Multiple site testing of lateral force reduction
- Carry down of FM materials
- Gauge face equipment improvements: reduced bar clogging etc.
- Key fuel testing led to major TOR-FM expansion starting in 2011
    - Careful design and accurate control of testing

Norfolk Southern

- NS first Class 1 to roll out wayside TOR-FM on a large scale
- Key early contributions by Don Cregger: (WRI 2000)
- Initially driven by lateral force reduction

Understanding FM pickup and carrydown at NS

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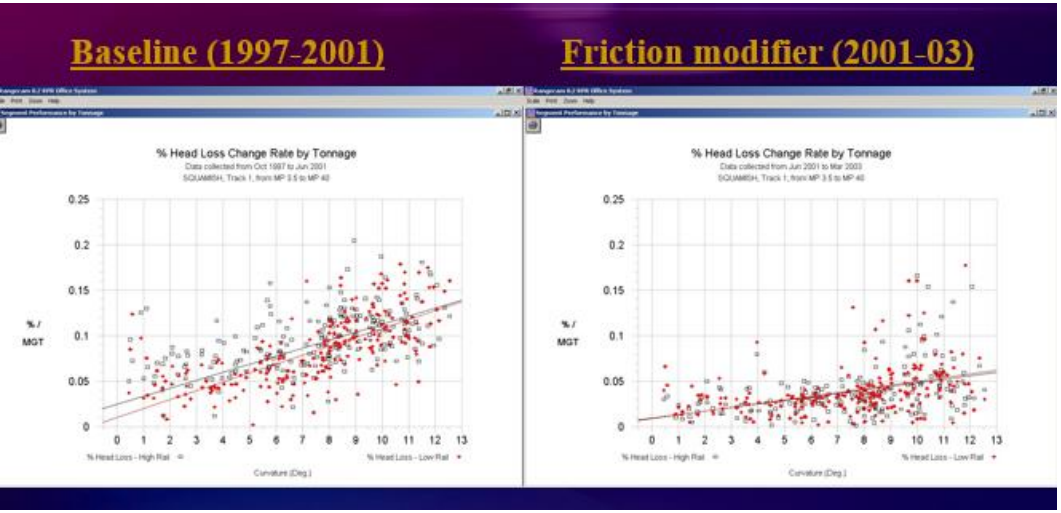
BC Rail

- Started with Hirail grease application to reduce lateral forces and derailments
- Converted to water based FM (wayside and Hirail)

BC Rail: 2003 IHHA paper reported rail wear and lateral force reduction



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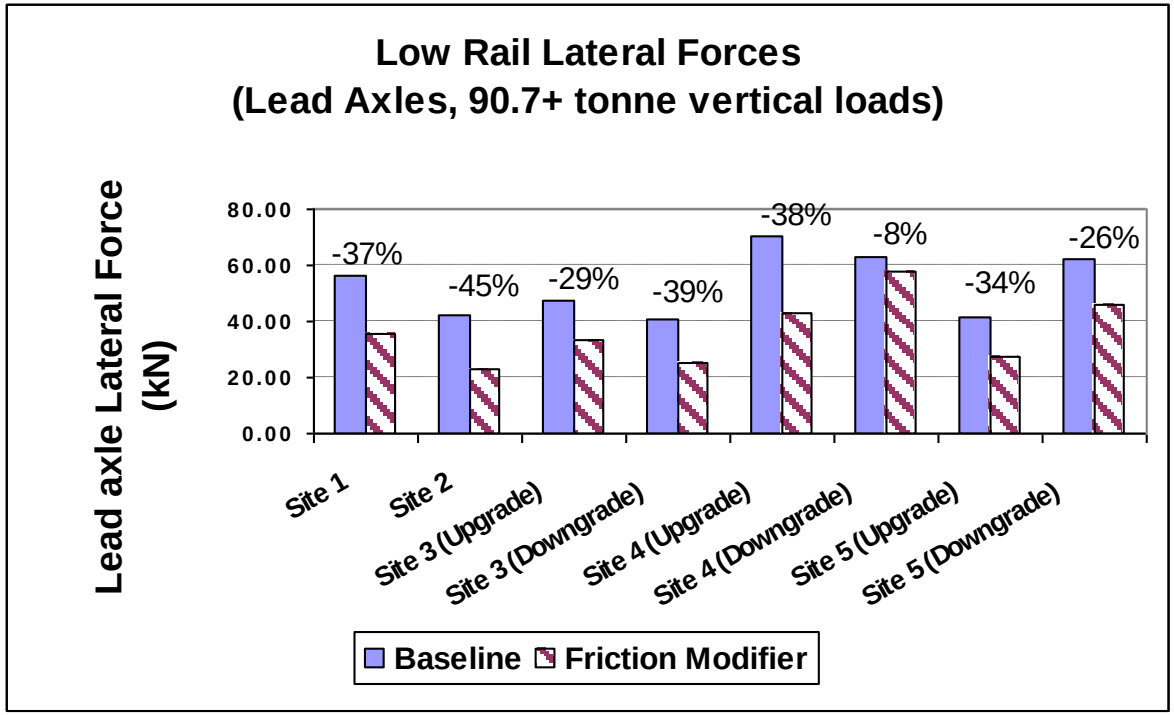
2006: Lateral force reduction Summary*



**Eadie, Reiff et al, World Congress of Railway Research*

RAIL WEAR REDUCTION

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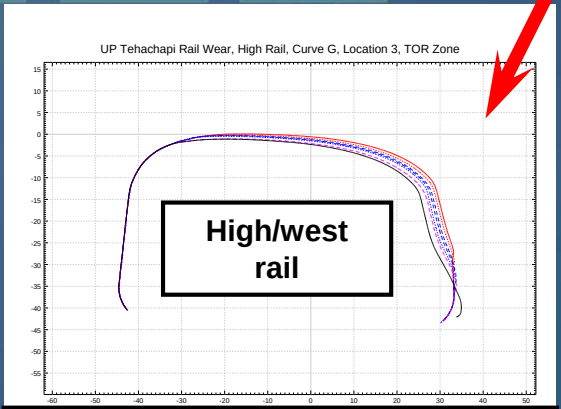
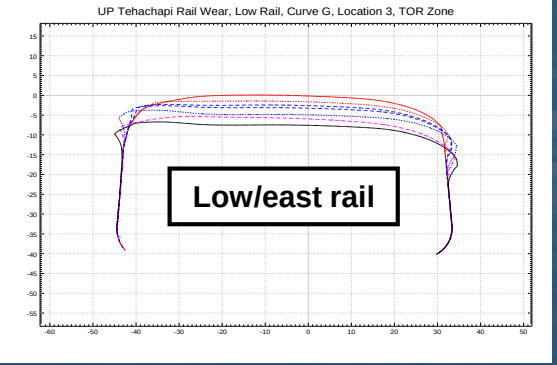
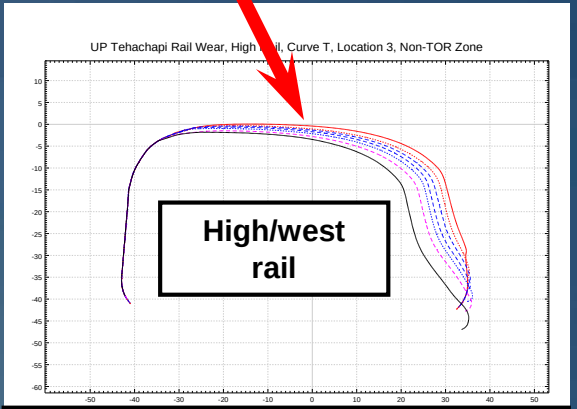
Profile Changes after 184 MGT (2+ Years)
Same traffic: TOR left, Non-TOR right

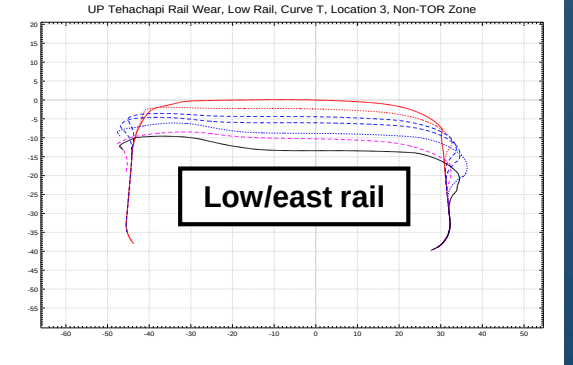


TOR Curve 'G' - MP 350.8 (10^0 02'CL)





Control Curve 'T' - MP 337.8 (10^0 03'CL)



Understanding and integrating fuel savings from TOR-FM into business case was a key turning point for several Class 1s

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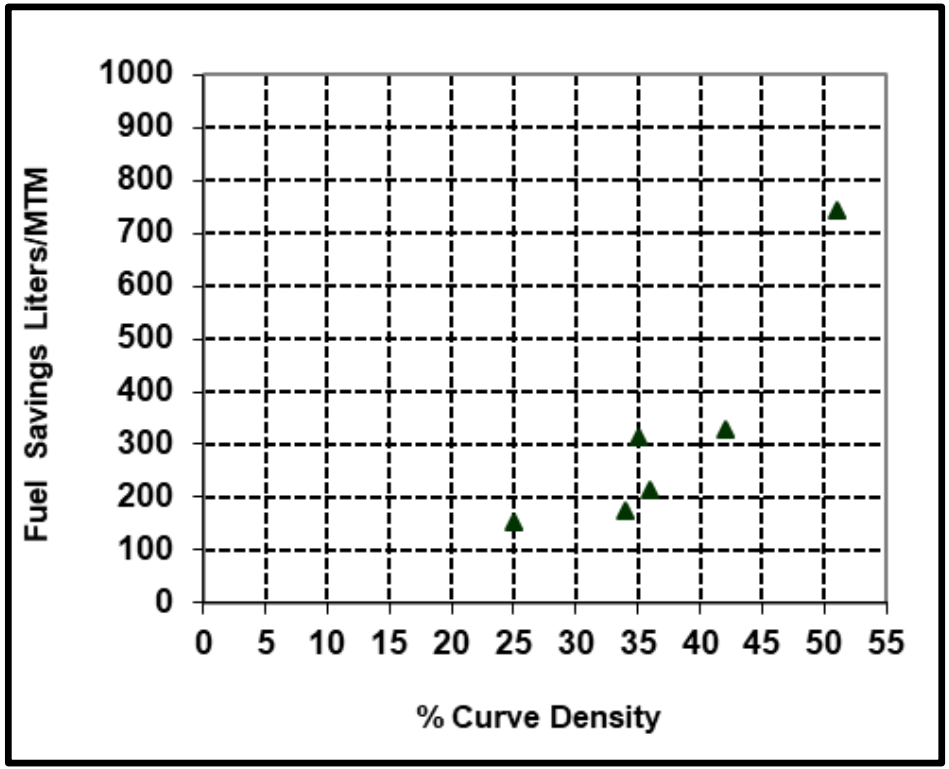
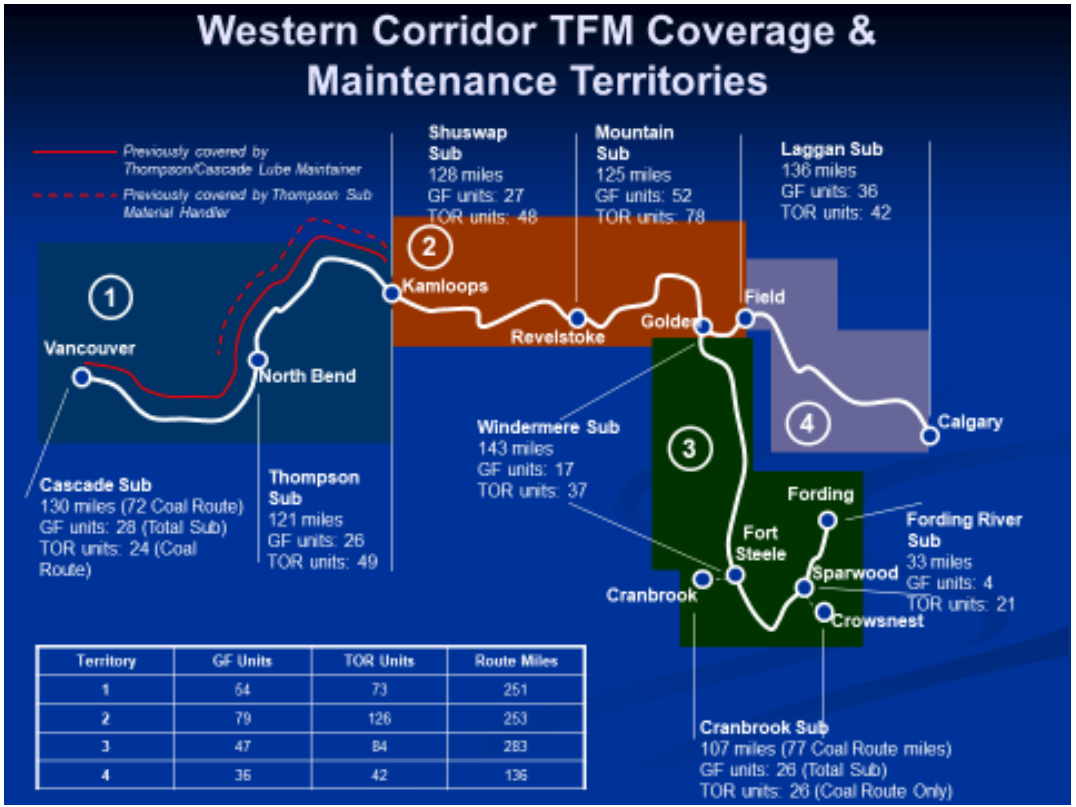
Fuel savings from TOR-FM: BC Rail



Canadian Pacific Railway



Territory	GF Units	TOR Units	Route Miles
1	54	73	251
2	79	126	253
3	47	84	283
4	36	42	136

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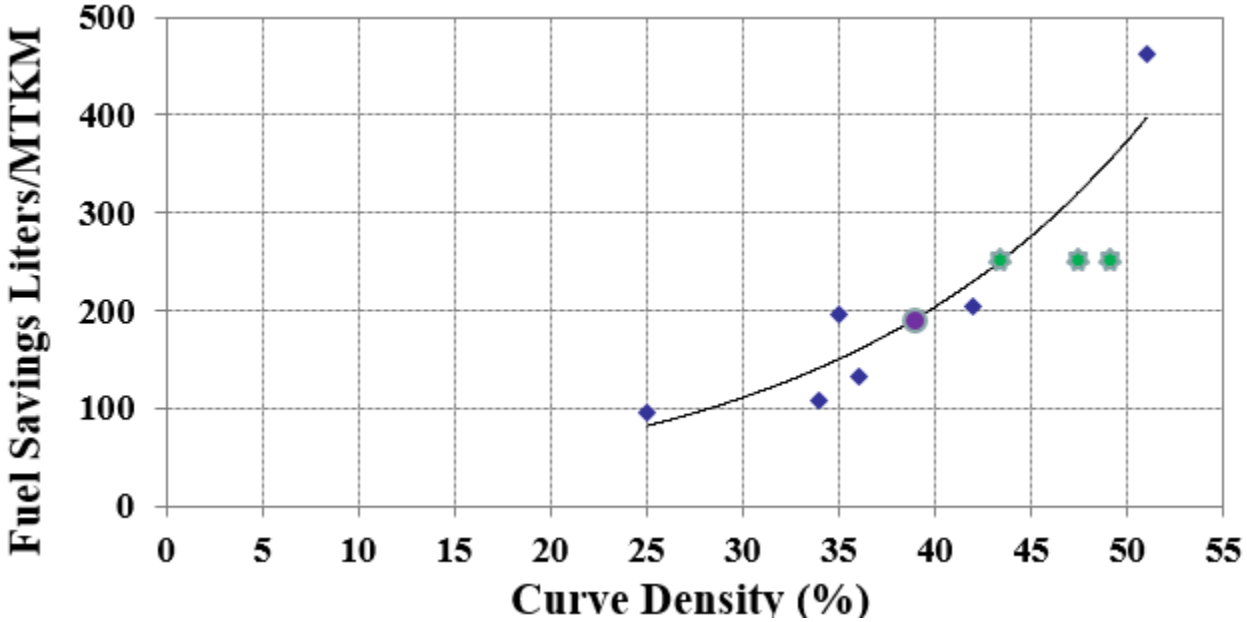
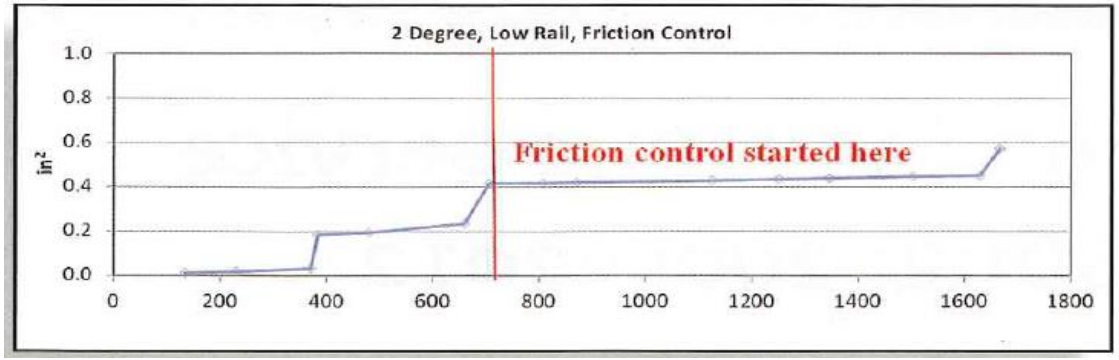
Fuel savings: three freight railways



Low rail in sharp curve A) TOR-FM, B) Control (GF only)

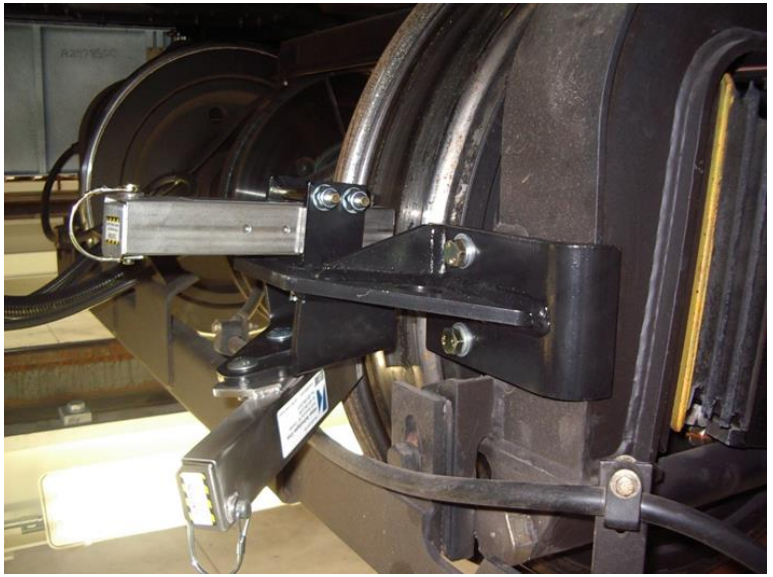


Mitigate initiation and growth of RCF

2. ***Friction Management***

- Reduce traction forces and prevent ratcheting

Train mounted solid sticks: Locomotives and transits



Where the industry is today

- North American heavy haul
  - A range of different TOR-FM materials are now available: innovation and competition has driven down cost per treated mile.
  - Most sharper curves on high tonnage lines have wayside TOR-FM and GF
  - Unit uptime and maintenance have improved - many opportunities for improvement

- Transits:
  - After pioneering TOR-FM, most North American transits have not yet taken advantage of opportunites for noise, wear and corrugation mitigation
  - Suppliers have to some degree ignored transit systems in product innovation and development

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Some keys to FM development

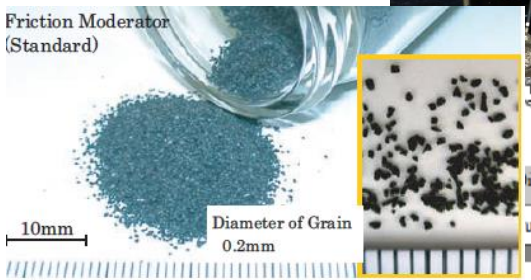
- Innovation by suppliers and railways
- Collaboration: railways, suppliers and TTCI
- Proper science based evaluations:
  - Detailed careful trial planning, execution and analysis
- Senior level understanding of all FM impacts (track, fuel, rolling stock etc)
- Supplier innovation to develop new materials
- Better unit uptime and maintenance
- More overall awareness of w/r issues and FM impacts

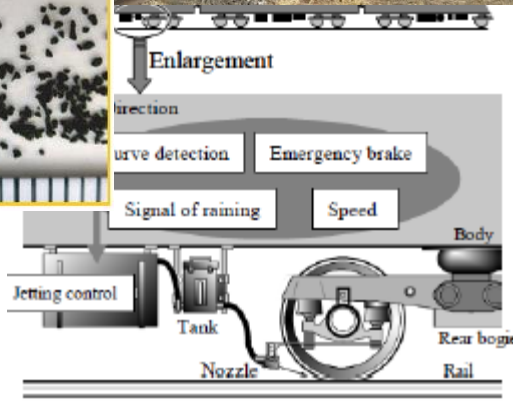
Future directions and opportunities

- Continued improvements in wayside unit uptime on Class 1s
  - Outsourced refilling and unit maintenance
  - Improved unit reliability and monitoring?
- Further improvements in lubricants and TOR-FM materials for carry and lower cost per treated mile
- High level integrated understanding of business case for FM within all Class 1s
- Better understanding of relationship between FM and grinding for RCF / defect control.
- Need for supplier innovation and railway awareness in transit systems
  - Customized delivery systems and FM materials
  - Better carry down

Future directions and opportunities

- Could train mounted FM return?
  - Potentially greater efficiency and lower costs
  - Need simpler and reliable equipment
- New adhesion enhancement technology?
- Integrate with novel solid TOR-FM materials?





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THANK YOU!

Acknowledgements:
- Interviewees
- Norfolk Southern, LB Foster and TTCI for pictures

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