Switch Life Improvement Through Application of a Water-Based, Drying Friction Modifier

Richard Stock, Barnaby Temple

L.B. Foster Rail Technologies
Outline

• Definitions
• Trial at NetworkRail/UK
• The impact of FM on steering
• Business Case
• From Europe to North America
Function of a switch/turnout

- Mechanical installation enabling railway trains to be guided from one track to another
- Safety critical element of track – movable parts, machined parts (reduced cross-sections), welded parts, lubricated parts...
Switch maintenance

- Specialized and smaller grinders
- Repair welding
- Hand grinding
- Labour, time and cost intensive
  - Track closures – no trains running
Water based friction modifier

- Intermediate Coefficient of Friction
- Positive friction characteristics
- Solid, dry FM particles
Test site: Nuneaton Cemetery Junction / NR
Nuneaton Cemetery Junction

- Mixed traffic (specific passenger train type and loaded freight trains)
- Annual tonnage approx. 9MGT, line speed 40mph
- Between 2004 and 2012 the curve closure rail portion of the switch had to be replaced every 15-18 months
- NR switch geometry / R260 grade
Conventional protection

• Switch is well lubricated
Nature of the damage

• High flange contact forces, vertical and horizontal crack development
• Unzipping of rail material 2m (6ft) away from switch tip
Initial maintenance cycle

- Weld repair of switch point every 3-5 months
- Replacement of ½ switch: 15-18 months
Background: Steering of a train

• Barnt Green
  – Curve squeal and rail head corrugations, significant complaints
  – Initially water spray implemented causing drainage issue
  – Installation of FM application system in 2007
  – Observation of impact on truck steering behaviour in 2011 after manual application of FM
Could this work at a switch?

• **Experience:**
  – Flange contact is a consequence of a high angle of attack (AOA)
  – AOA (and lateral forces), wear and RCF reduced by using FM on main line curves

• **Proposal**
  – Manual application of FM to explore impact on Nuneaton switch
  – Subsequent application from trackside system if successful

Ref Coleman, Kassa & Smith, 2012
Consumable consideration

• NR chose a specific water based, drying FM (KELTRACK®)

  – Proven to extend rail life and grinding intervals, improve steering of vehicles

  – Dry FM particles at the switch point – no risk of causing additional maintenance activities on a safety critical track component
Manual application

• Test track in Europe
At the normal point of switch damage

Continuous, hard contact

Spray paint in orange colour

untreated
At the normal point of switch damage

Intermittent, light contact

Both rails FM treated
At the normal point of switch damage

- untreated
- Both rails FM treated
At the switch tip

untreated

No contact
At the switch tip

Extended no contact

Both rails FM treated
At the switch tip

- untreated
- Both rails FM treated
How does it work

• The challenge to explain...
  – Measurements – would have been good
• Simulation could answer some questions and enable analysis of other sites
• Simplified explanation
Revenue testing – wear reduction

• Class 1 trial managed by TTCI
• Optimised track conditions and GF lubrication for both zones, comparable curvature
• TOR FM zone with reduced wear for both high and low rail

Revenue testing – RCF reduction

- Heavy Haul environment
- Control zone (no TOR FM) vs. TOR-FM zone under comparable conditions
- Reduced formation of RCF

Revenue testing – grinding interval extension

- Western “Megasite” managed by TTCI
- Drying FM: extended grinding interval and rail life

Lateral loads: wheel climb

• Low speed derailment criterion
  – L/V threshold
  – Friction on low rail TOR

• Friction Modifier:
  – Reduce COF on TOR
  – Reduce Lateral Forces and L/V
Steering of truck in sharp curve

Anti-Steering moment (longitudinal creepage from mismatched rolling radii)

AOA

Curve radius R

AOA tends to increase with degree of curvature

Friction forces (lateral creepage from AoA)

Flange force(s)

Track spreading forces

Direction of travel

All forces shown acting on the wheelset
Friction Modifier impact (simplified)

• Creep forces in equilibrium at lesser AOA
• Reduced creep forces – reduced lateral forces
• Improved steering
• Reduced response of truck to a track disturbance
Trial timeline

- Dec 2011 – site visit/photos, manual application trial
- Nov 2012 – new switch blade fitted to WN572A
- Feb 2013 – trackside FM system installed and activated
- Feb 2014 – Site visited – no damage visible, no repairs required to date. Further regular inspections found no defects
- April 2015 – unit ran empty (not refilled in time)
- May 2015 – first weld repair (following ~1 month without FM)
Timeline view

**Initial condition:**

- Weld repair
- Weld repair

3-4 months

**Friction Modifier condition:**

- 26 months with FM protection
- 1 month without FM (tank ran empty)
- Weld repair
- Weld repair

**Calculated potential improvement factor for switch life: 7.5**
Resulting benefits

• 6 weld repairs and half switch replacement being saved
• Increase in replacement interval, similar ratio to repair
• Less inspection (with confidence, the regime can be reduced)
• Fewer man-hours on track (safety)
• Reduced risk of delay and constraint of operation

Photo from www.railtechnologymagazine.com
Cost-Benefit-Analysis

• $C_{\text{BL}}$: Costs for baseline case “as is”
  – switch installation, repair welding and site visits

• $C_{\text{FM}}$: Costs for the case with FM
  – switch installation, repair welding, consumables, refills and site visits
Cost-Benefit-Analysis

- $C_{\text{CAP}}$: Capital costs for FM implementation
- Payback (P): $C_{\text{CAP}} / (C_{\text{BL}} - C_{\text{FM}})$
- Not included are costs due to train delays
Payback calculation

- Keeping all conditions and costs constant
- Only varying the improvement factor for the given case
- Improvement factor ≥ 4 to achieve payback within a year.

For the given case:

**Improvement factor: 7.5**

**Payback: 9 months**
Further implementation

• NR switch with premium rail grade
  – Superior lifetime over standard grade switch
  – No deposit welding allowed
  – Baseline lifetime: 2 months
  – Extended Lifetime with FM: 8 months
  – Improvement factor: 4

• Interest and trials at European IMs
From Europe to North America

- Yes, there are switches in North America, different switch design
- Typical damage to switch rails/points – chipping, cracks, wear
- Damage related to: hollow worn wheels, AOA, lateral forces
- Wide implementation of Friction Management

All photos by Gary Wolf
North American implementation approaches – Wayside and Onboard

• Single site vs. whole system
  – Protect one switch for all trains
  – Protect all switches for one train
  – Vehicle / track ownership

• Benefits of existing implementation
  – High curvature areas with few switches
Conclusions

- Benefits of water based, drying FM translate well from conventional application to switches
  - Reduce AOA and creep forces, improve steering through switches
  - Damage mitigation and increase in maintenance intervals
  - Extended life of switch blade and increased track availability
- Easy hand application test of FM to immediately show effects of improved steering
- Switch life extension of 4 to 7.5 times shown in two trials
Thank you for your attention!