Curve Noise and Friction Modifiers: A Case Study

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Case Study Overview

• Major US metro system receiving noise complaints on newly opened line.

• Noise measurements and investigation of wheel-rail contact conditions used to identify root cause of noise.

• Limited options to address noise because of grinding constraints and safe braking concerns with grease.

• Successfully implemented Top-of-Rail Friction Modifiers to control noise.
Site Description

- Frontage Road
- S-Curve: Radii = 1430 ft and 1000 ft
- Sound Wall
- Complaints
- Trench

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50% of trains are showing elevated high-frequency noise levels.

- Broadband high-frequency spectrum suggests noise is gauge face flanging (5-20 kHz), not top-of-rail squeal (1-5 kHz).

- Noise levels are below the FTA limits due to the sound wall.

- Residents complain about annoying train noise.
Two Common Causes of Wheel/Rail Noise

1. **Gauge Face (GF) Flanging**
   1. ‘Buzzing’ or ‘hissing’ sound.
   2. Broadband high frequency (5000 – 20,000 Hz)
   3. Caused by friction between the wheel flange and rail gauge face.

2. **Top-of-Rail (TOR) Squeal**
   1. High pitched, tonal squeal.
   2. Predominantly 1000 – 5000 Hz
   3. Caused by stick-slip oscillations due to creep forces and negative friction.
Addressing Gauge Face Flanging Noise

1. Reduce the Coefficient of Friction (COF) between the Flange and Gauge Face to 0.1 – 0.2

2. Reduce the COF between the Tread and Top-of-Rail to 0.3 – 0.4
   - Reducing TOR friction results in lower lateral forces, which improves vehicle steering. This reduces or eliminates flanging forces.
Install 4x Friction Modifier Units: June 2016

- Applicator placed at the entrance of each curve.

- Friction Modifiers used instead of lubrication because of concerns about braking and traction.
Noise Levels: Nov-Dec 2016

November 18

No evidence of flange noise over 24 hrs.

December 9

Some flange noise still exists.
Friction Modifier Adjustment

- LB Foster returns to investigate on-going noise complaints.
- Identifies two-point contact as the root cause of the noise.

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<th>High Rail</th>
<th>Low Rail</th>
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<td><img src="image1.png" alt="High Rail" /></td>
<td><img src="image2.png" alt="Low Rail" /></td>
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- 1/8” narrow gauge also identified.
- Optimizes placement of applicator bars.
- Reduces noise from 78.7 to 71.5 dBA Leq.
Additional Mitigation: Jan–Mar 2017

• Different spacers installed to try and correct for narrow gauge condition.

• Rail grinding completed to improve wheel-rail contact conditions.

• Changes to the track resulted in no changes to the noise level.

• ATS and LB Foster independently concluded that the flanging noise did not seem to be strongly related to:
  – Speed, Vehicle Type, Number of Cars, Weather

• Despite significant noise level reductions, complaints continue.
Noise Measurements: Mar 2017

- 45% of EB trains exhibit high-frequency noise events.
- 20% of WB trains exhibit high-frequency noise events.
- Explanation for period of low noise unclear.
Noise Measurements: Mar 2017

High-frequency noise events appear to be related to distance from the Friction Modifier applicator.
Recommendation from ATS

- Install additional Friction Modifier applicators spaced 500 feet apart to help the product carry through the curve
  - Lubrication not considered due to safety concerns.
  - Gauge face grinding not considered due to equipment constraints.
  - August 2017 – Additional Friction Modifier applicators installed.
  - September 2017 – Safe Braking Trial conducted and passed.
Noise Measurements: Jan 2018

- 5% of trains exhibit high-frequency noise events.
- Noise still not completely eliminated at locations furthest from the Friction Modifier applicators.
Conclusions

• Initial use of Friction Modifier applicators reduced overall noise levels by 7.2 dBA Leq

• Additional Friction Modifier applicators reduced high-frequency noise events by 75-90%

• Although optimized for addressing Top-of-Rail Squeal noise, Friction Modifiers can also be used to effectively address Gauge Face Flanging noise.

• This is especially true when there are safety concerns with using a lubricant, such as grease.
Future Work

• Customer has indicated:
  – Narrow gauge condition still exists.
  – Limited or no ability to address this.
  – Interested in eliminating high-frequency noise events.

• ATS available to do continued noise monitoring.

• LB Foster investigating solutions to improve the carry-down of the KELTRACK® Friction Modifier.
Thank You

Questions?
Addressing Root Cause of Wheel/Rail Noise

1. Top-of-Rail (TOR) Squeal – Use a Friction Modifier to:
   1. Reduce coefficient of friction (COF) on the TOR to 0.3 – 0.4
   2. Create positive friction conditions to eliminate stick-slip oscillations.


**AREMA Section 4.7**