Curve Noise and Friction Modifiers: A Case Study

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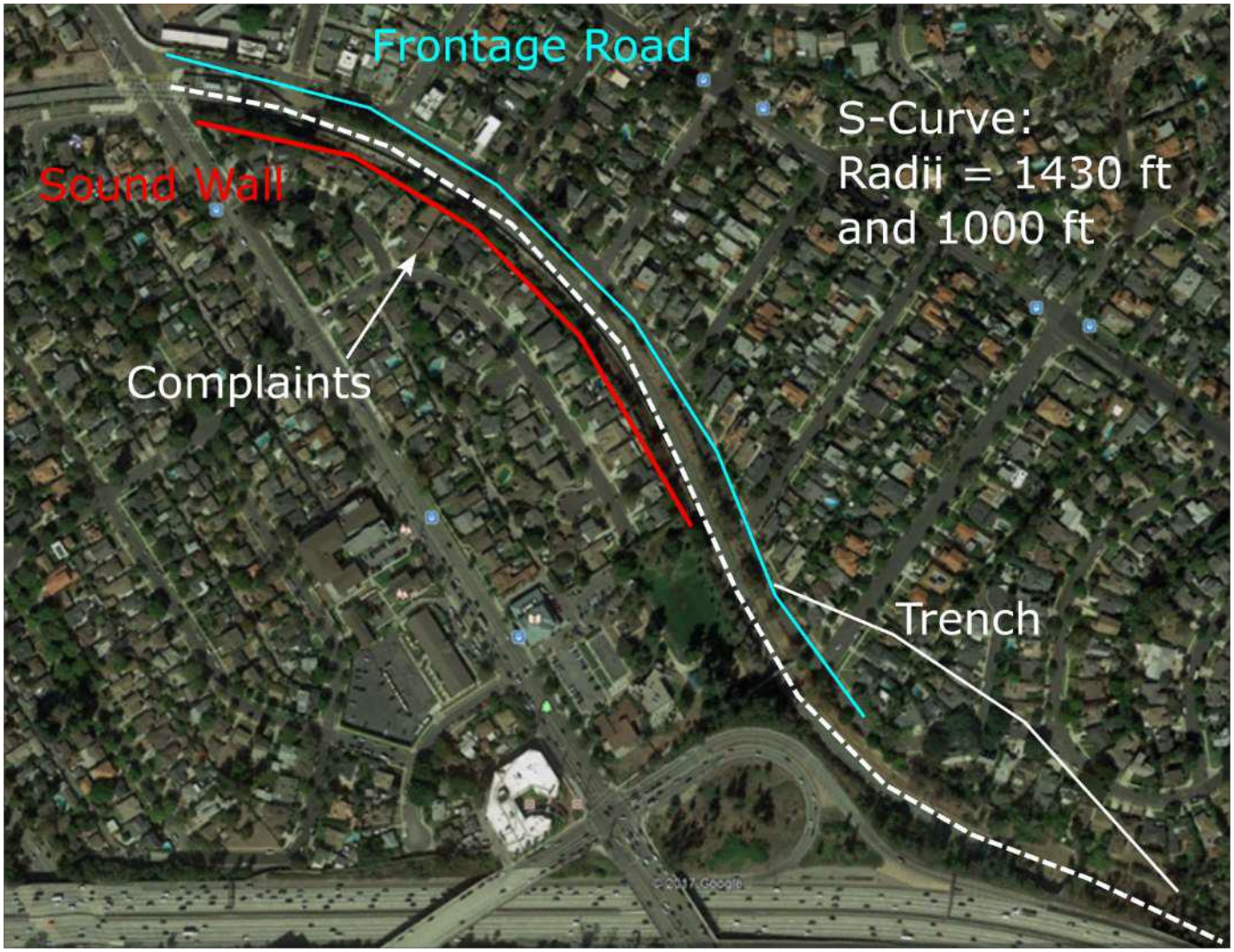
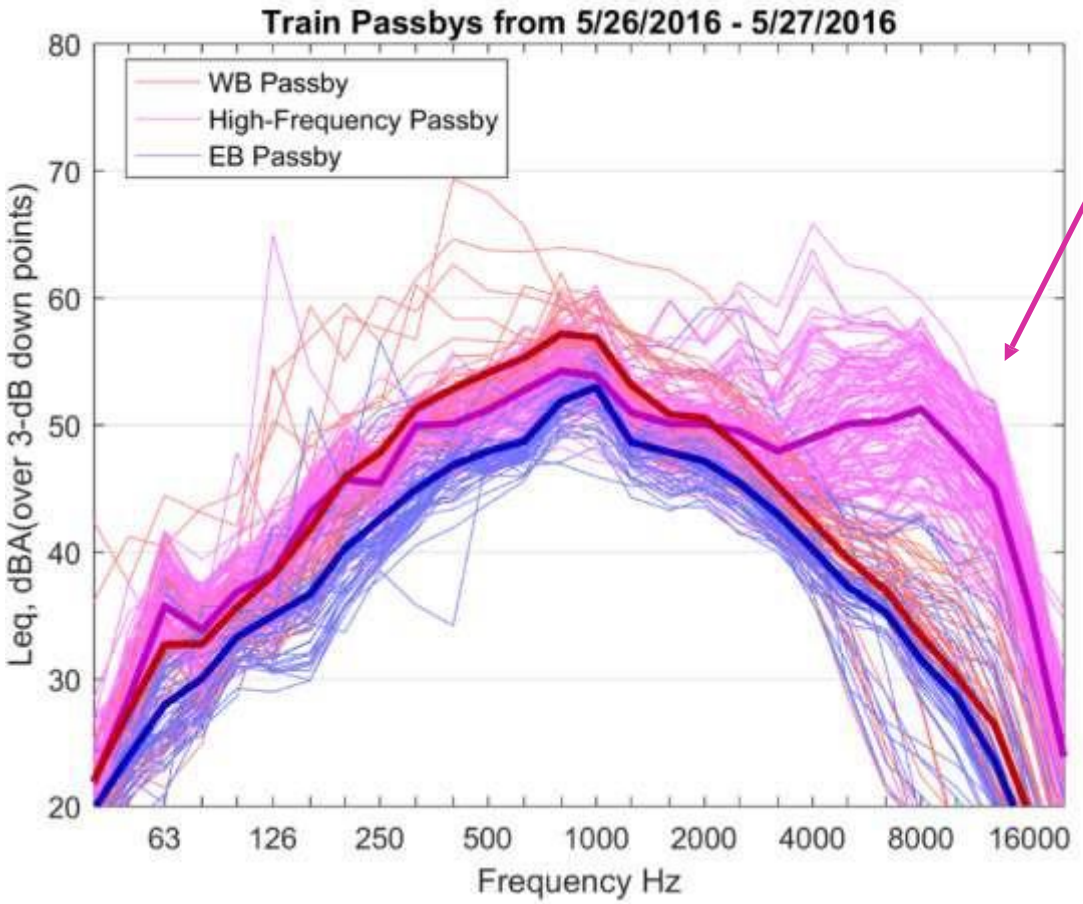
Case Study Overview

- 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



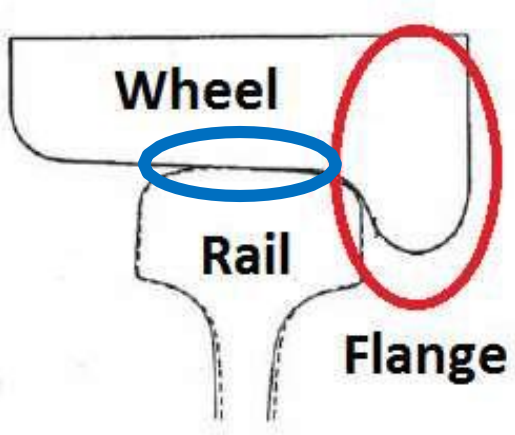
Noise Levels at System Opening: May 2016



- 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

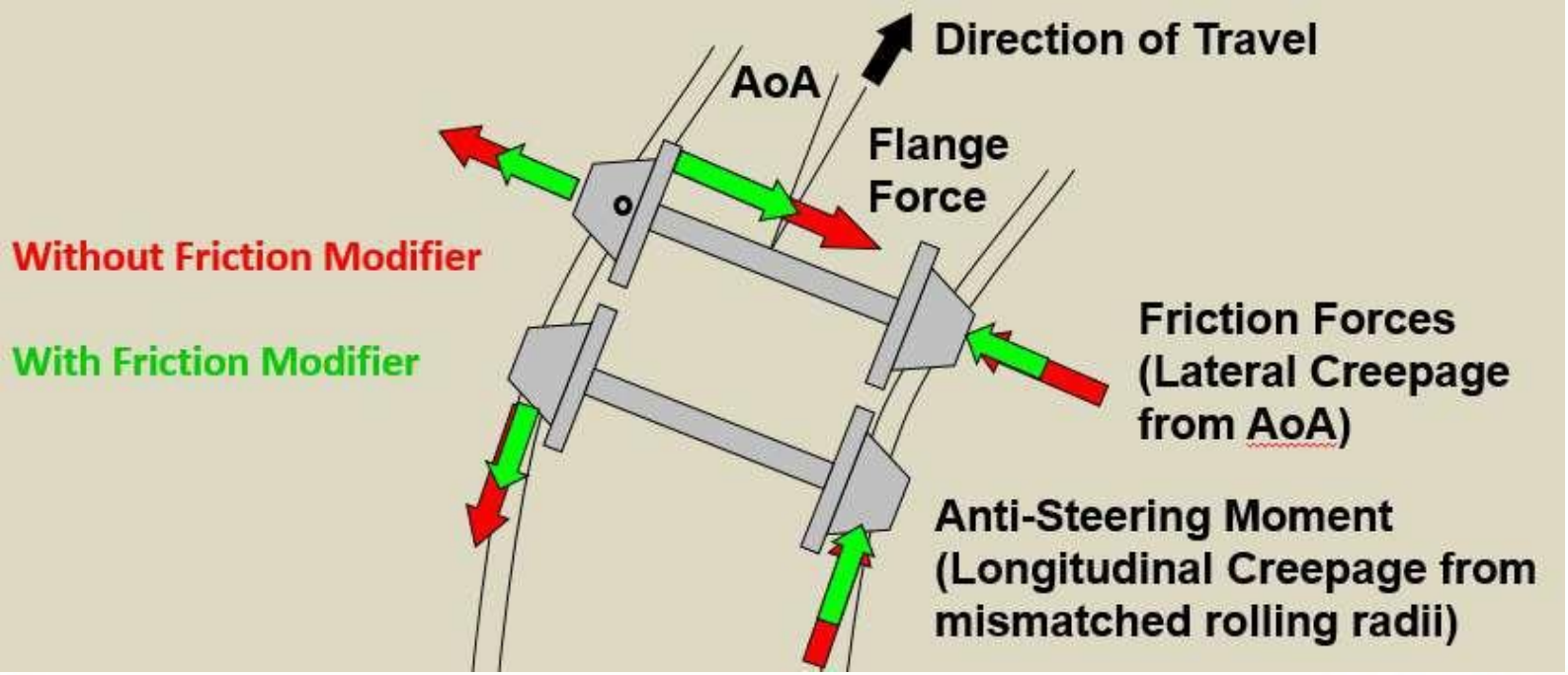
1. Gauge Face (GF) Flanging
    1. ‘Buzzing’ or ‘hissing’ sound.
    2. Broadband high frequency (5000 – 20,000 Hz)
    3. Caused by friction between the wheel flange and rail gauge face.



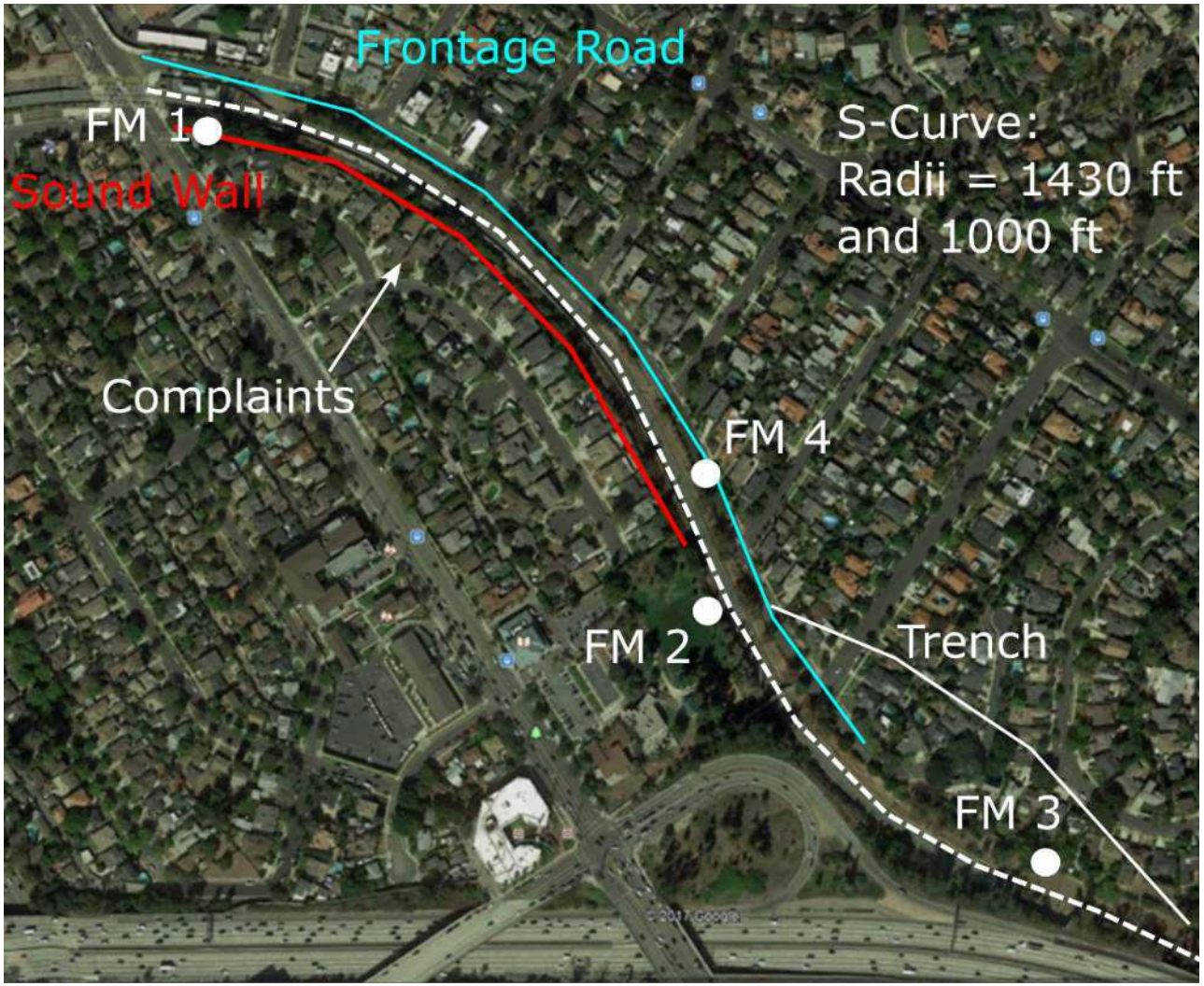
2. Top-of-Rail (TOR) Squeal
    1. High pitched, tonal squeal.
    2. Predominantly 1000 – 5000 Hz
    3. Caused by stick-slip oscillations due to creep forces and negative friction.

Addressing Gauge Face Flanging Noise

1. Reduce the Coefficient of Friction (COF) between the Flange and Gauge Face to 0.1 – 0.2[1]
2. Reduce the COF between the Tread and Top-of-Rail to 0.3 – 0.4[1]
   - Reducing TOR friction results in lower lateral forces, which improves vehicle steering. This reduces or eliminates flanging forces.



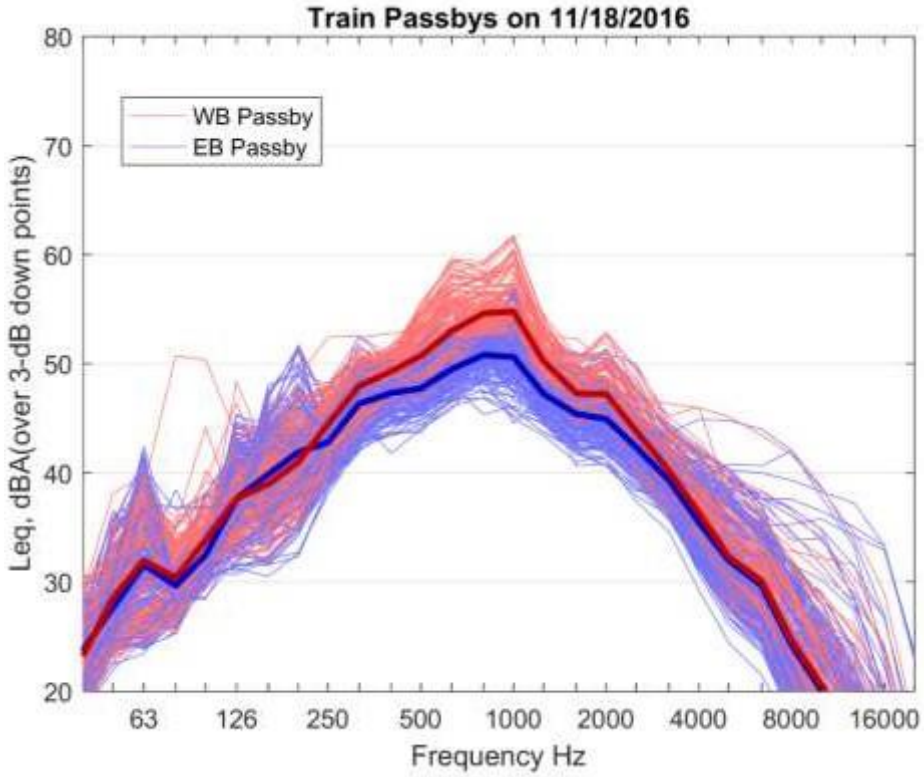
Install 4x Friction Modifier Units: June 2016



- Applicator placed at the entrance of each curve.
- Friction Modifiers used instead of lubrication because of concerns about braking and traction.

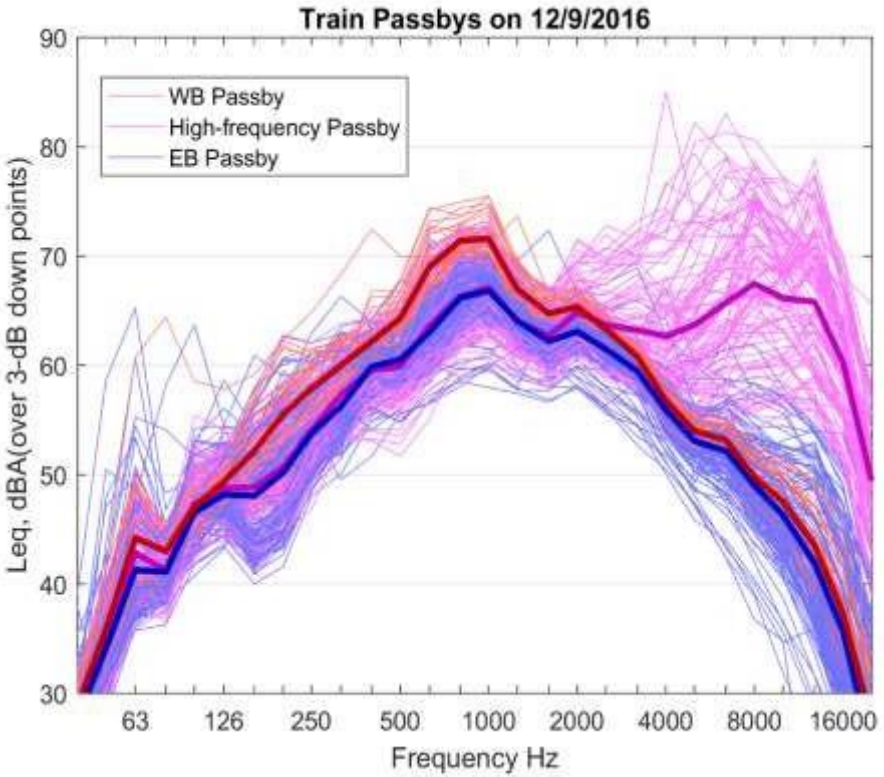
Noise Levels: Nov-Dec 2016

November 18



No evidence of flange noise over 24 hrs.

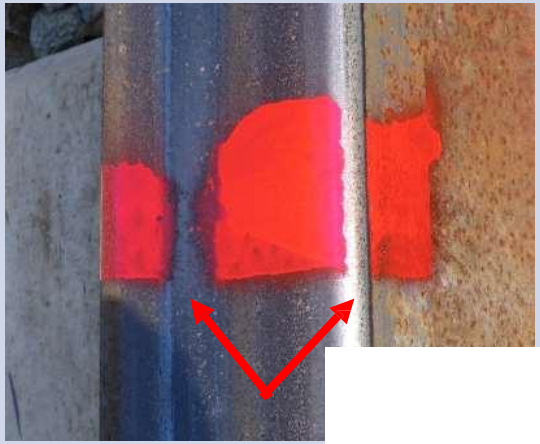
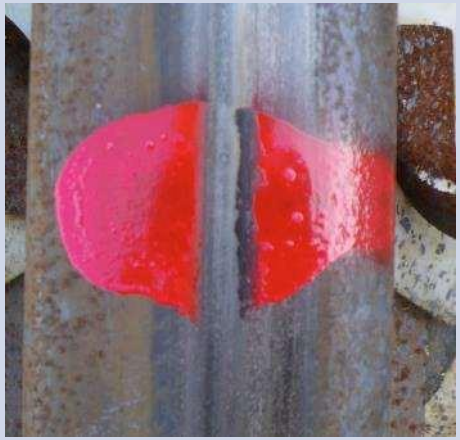
December 9



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.

High Rail	Low Rail
	

80 dB

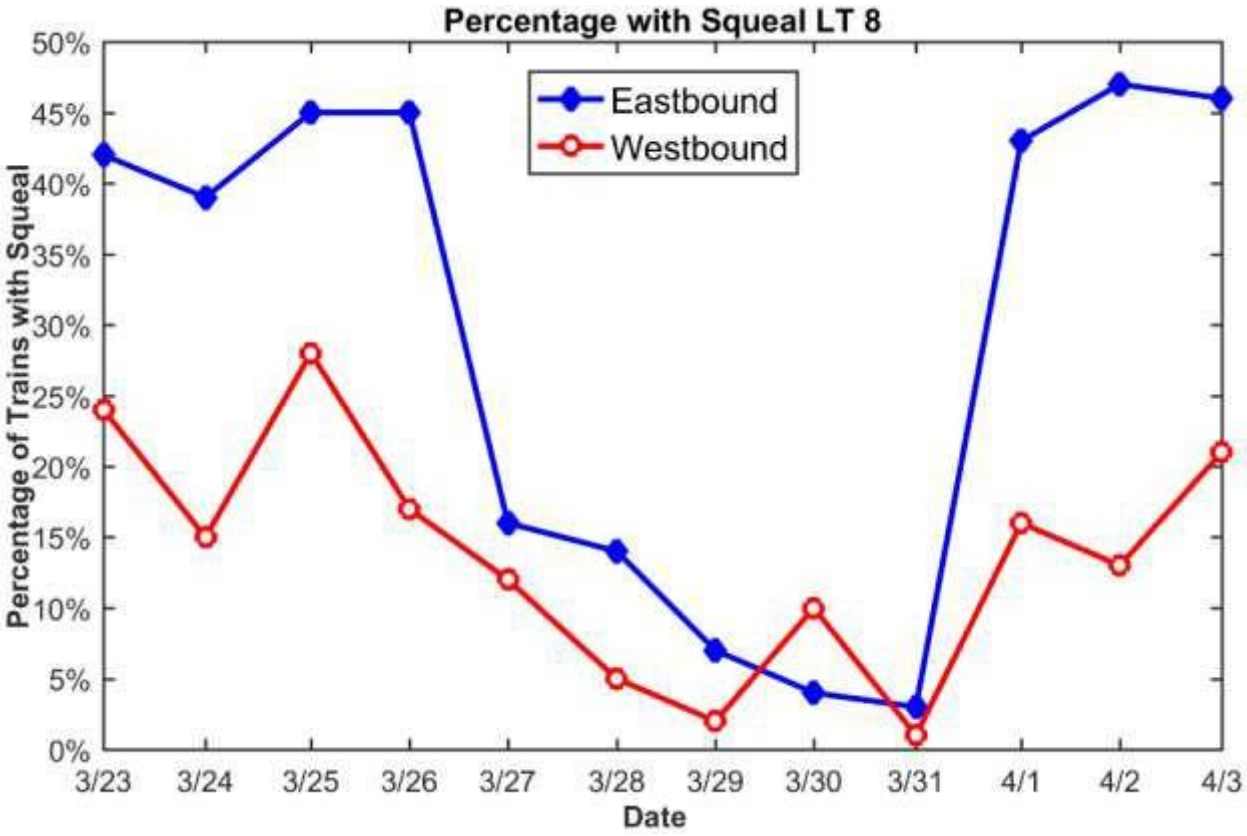
70 dB

- 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.

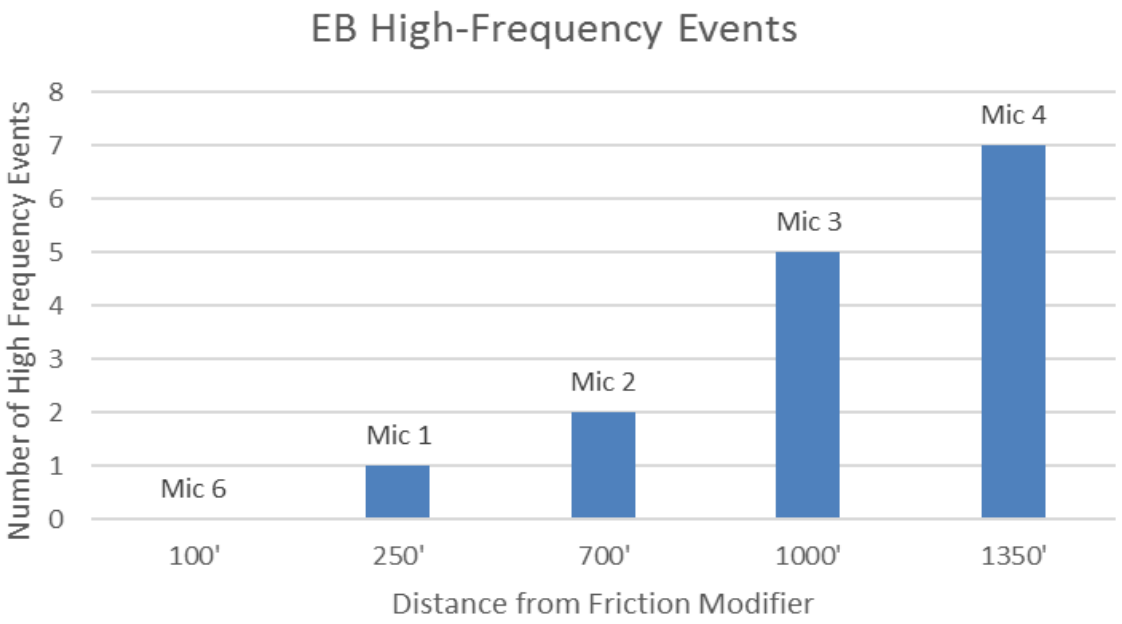
Noise Measurements: Mar 2017



- 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

Existing EB FM Applicator

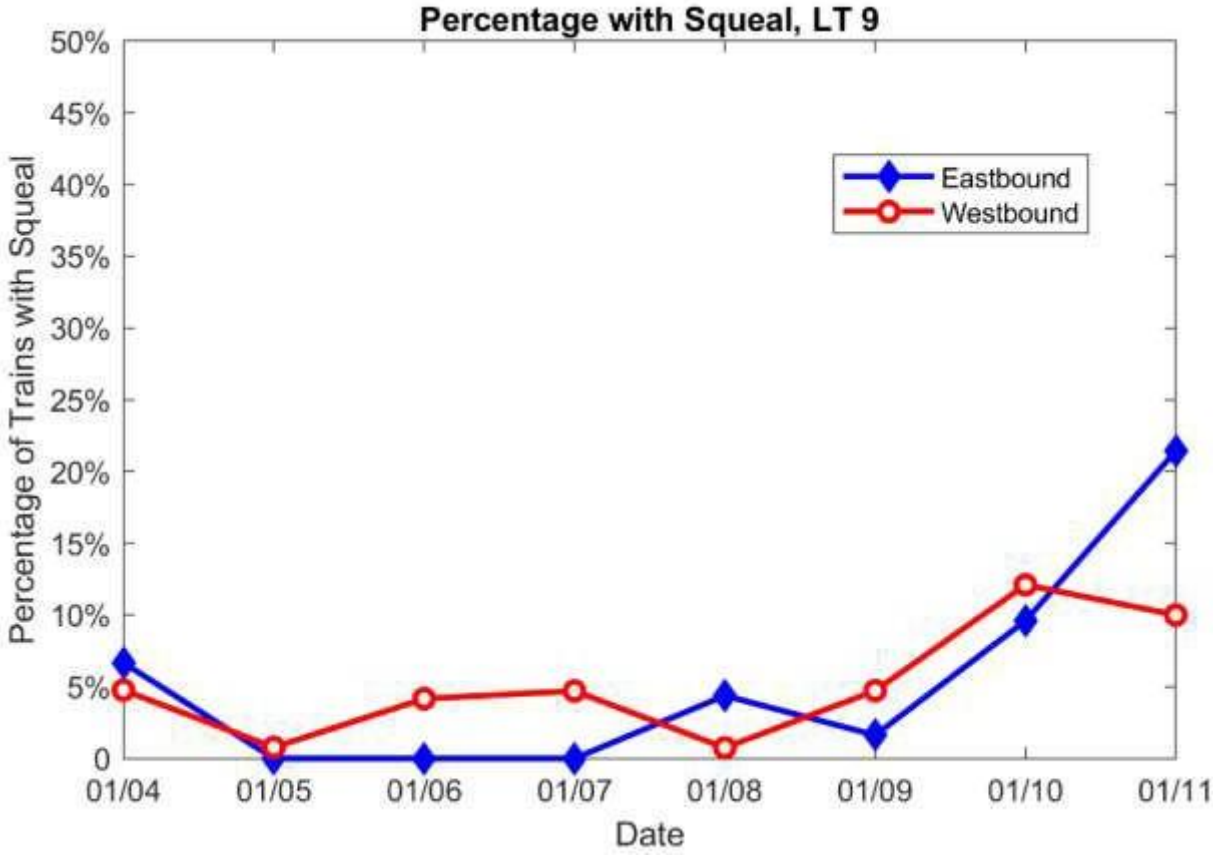


High-frequency noise events appear to be related to <u>distance</u> from the Friction Modifier applicator.

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.

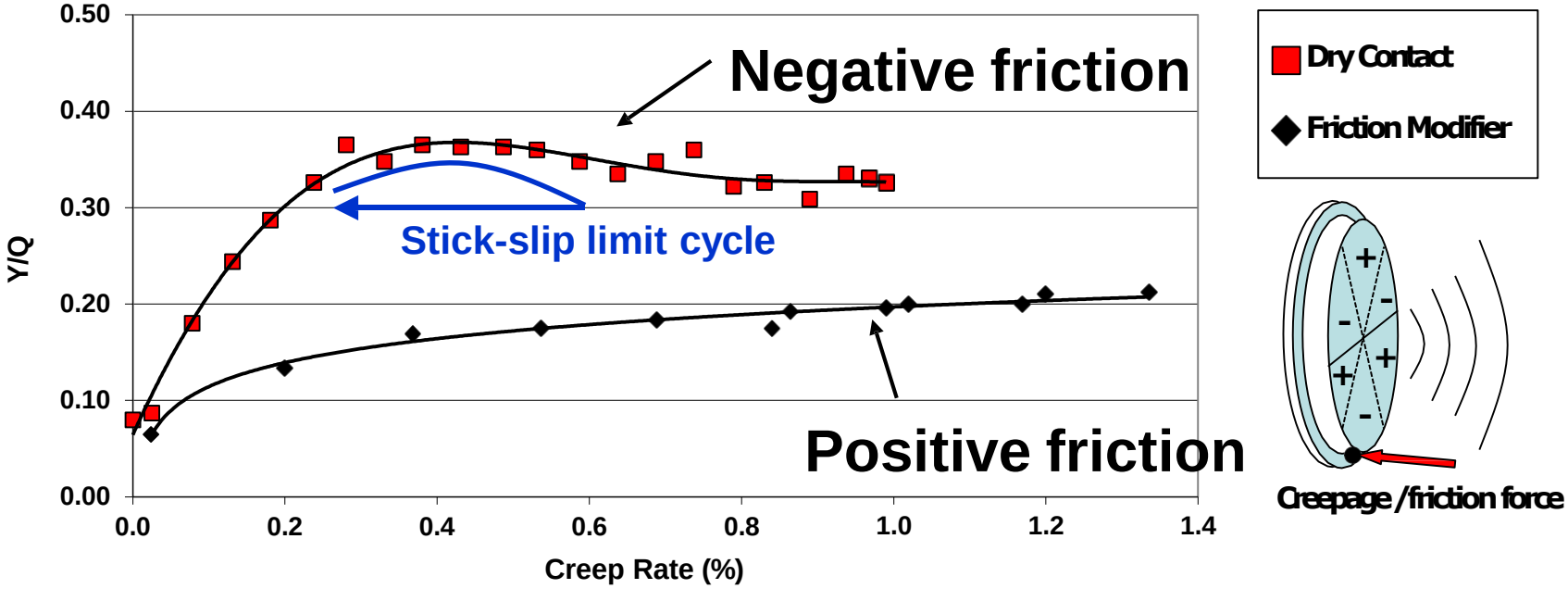
ATSConsulting
acoustics, transportation + strategy

LBFoster®
Rail Technologies

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[1]
2. Create positive friction conditions to eliminate stick-slip oscillations.



* Replotted from: "Matsumoto a, Sato Y, Ono H, Wang Y, Yamamoto Y, Tanimoto M & Oka Y, Creep force characteristics between rail and wheel on scaled model, *Wear,* Vol 253, Issues 1-2, July 2002, pp 199-203

[1]AREMA Section 4.7