THE INDIANA RAIL ROAD

Entrepreneurial Railroading℠

HOW A REGIONAL PREPARED FOR HEAVY HAUL

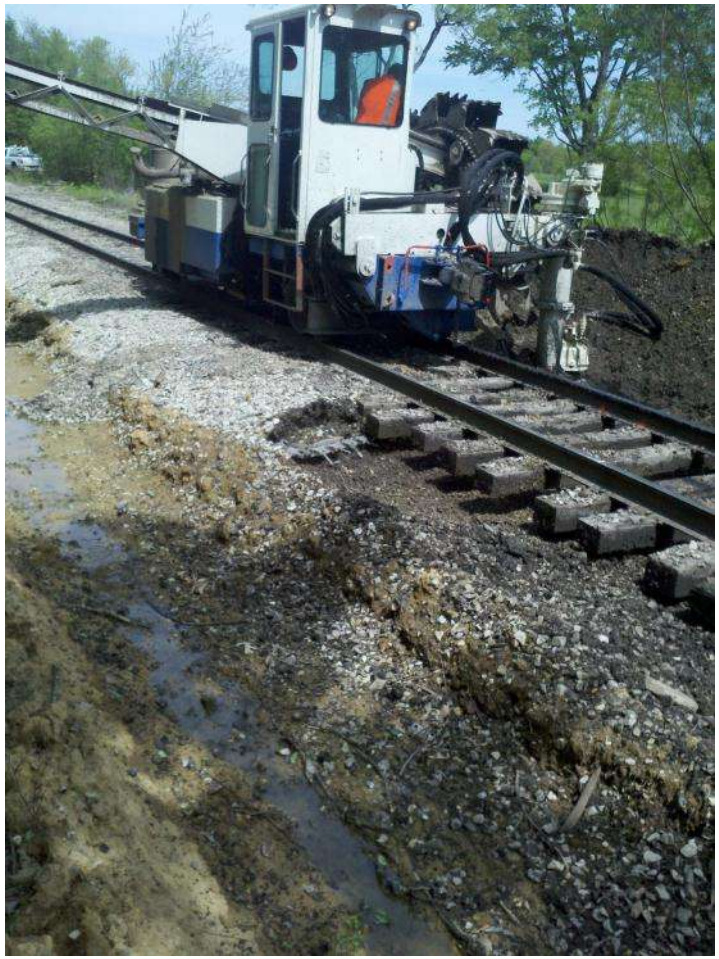
ORIGINAL CONDITIONS

ORIGINAL CONDITIONS

FOULED BALLAST

UNDERCUTTING

UNDERCUTTING



UNDERCUTTING

UNDERCUTTING

UNDERCUTTING

ORIGINAL BRIDGES

HOLLOW PILES

REJECT PILES/CAPS

BRIDGE BEFORE AND AFTER

BRIDGE REPLACEMENT

BRIDGE REPLACEMENT

BRIDGE RECONSTRUCTED

BRIDGE RECONSTRUCTED

CAPS UP REPLACEMENT

CAPS UP REPLACEMENT

STEEL PILE STRENGTHENING

STEEL PILE STRENGTHENING

COMPONENT REPLACEMENT

BRIDGE REMOVAL

BRIDGE REMOVAL

BRIDGE REMOVAL

UNSTABLE EMBANKMENTS

STABILIZED EMBANKMENT

ROLLING CONTACT FATIGUE BEFORE AND AFTER

ROLLING CONTACT FATIGUE BEFORE AND AFTER

ROLLING CONTACT FATIGUE BEFORE AND AFTER

ROLLING CONTACT FATIGUE

CORRECTIVE GRINDING

RE-ELEVATE CURVES

HEAVY HAUL

ULTIMATE HEAVY HAUL

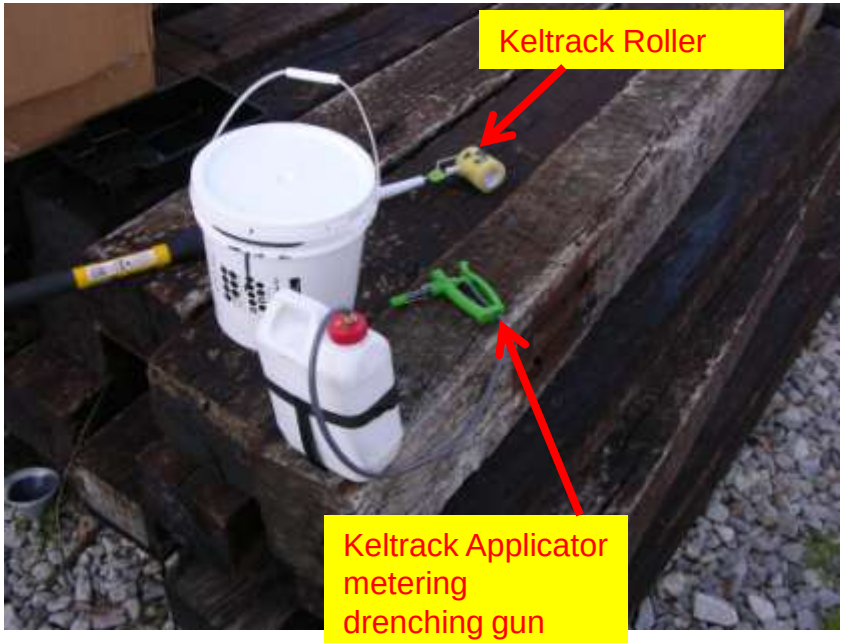
Technology Applications on INRD

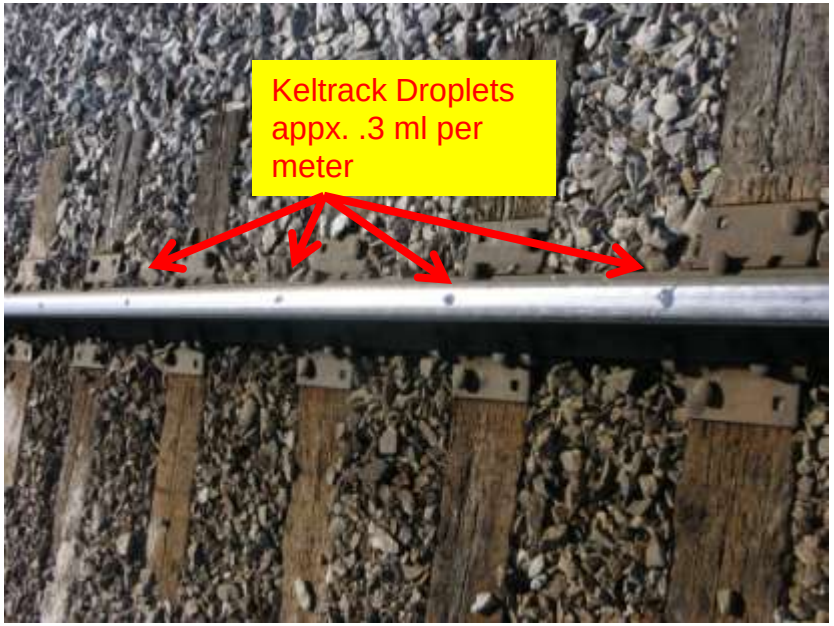
- VERSE rail neutral temperature testing
- Wheel-Rail Friction Management
- MRail Vertical track deflection Measurement

TUV-Rail Sciences
VERSE Testing
To determine Rail Neutral Temperature

Neutral Temperature Results

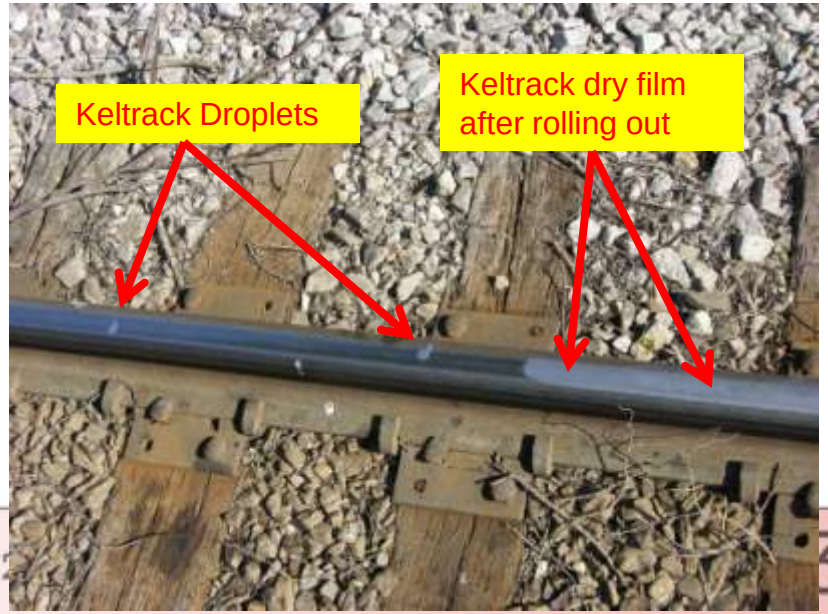
Indiana Rail Road VERSE Testing Results				
	Dec-11			
Milepost		East Rail	West Rail	
		Neutral Temp. °F		
~~152.2~~		80.6	64	
~~150.8~~		74.3	82.04	
~~137.6~~		81.68	77	
~~134.8~~		73.58	68.72	
~~135.55~~		89.6	82.76	Just south of 141 pound transition rail
~~132.3~~		79.34	79.34	
~~128.7~~		69.98	77.9	
~~127.4~~		82.76	82.58	
~~122.2~~		53.6	59.9	
~~113.4~~		59	50	
~~86.4~~		63.5	77.9	
84.5		Jointed Rail		
~~78.7~~		75.5	69.26	
~~75~~		<67.8	71.6	North of Tulip Trestle, South side was jointed rail for 2 miles
~~68.6~~		67.82	64.22	
~~63.5~~		81.5	86	At the whistle board
~~61.3~~		87.8	83.3	
~~48.7~~		67.46	59.36	Moved North, no room between crossing and jointed rail

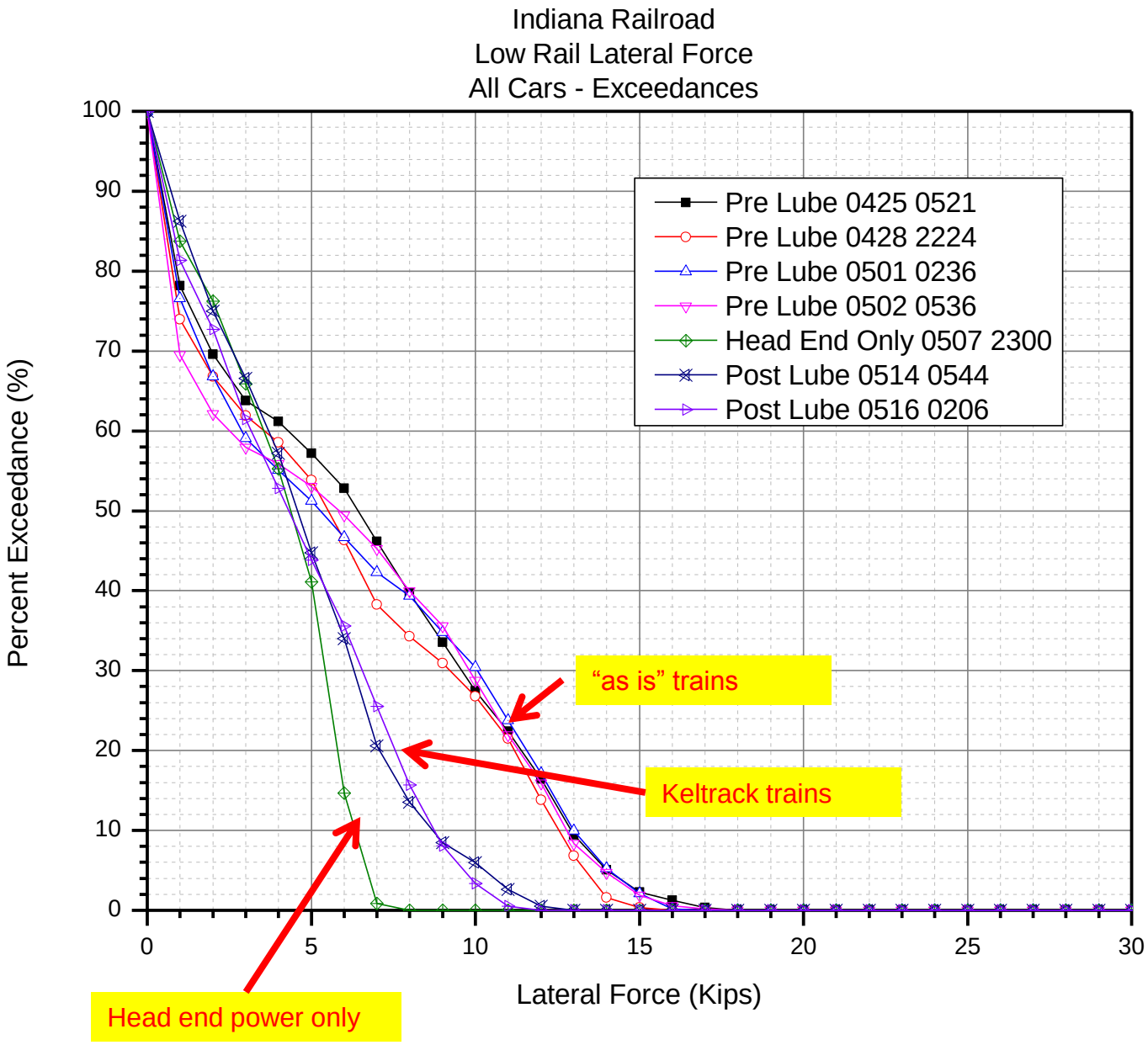


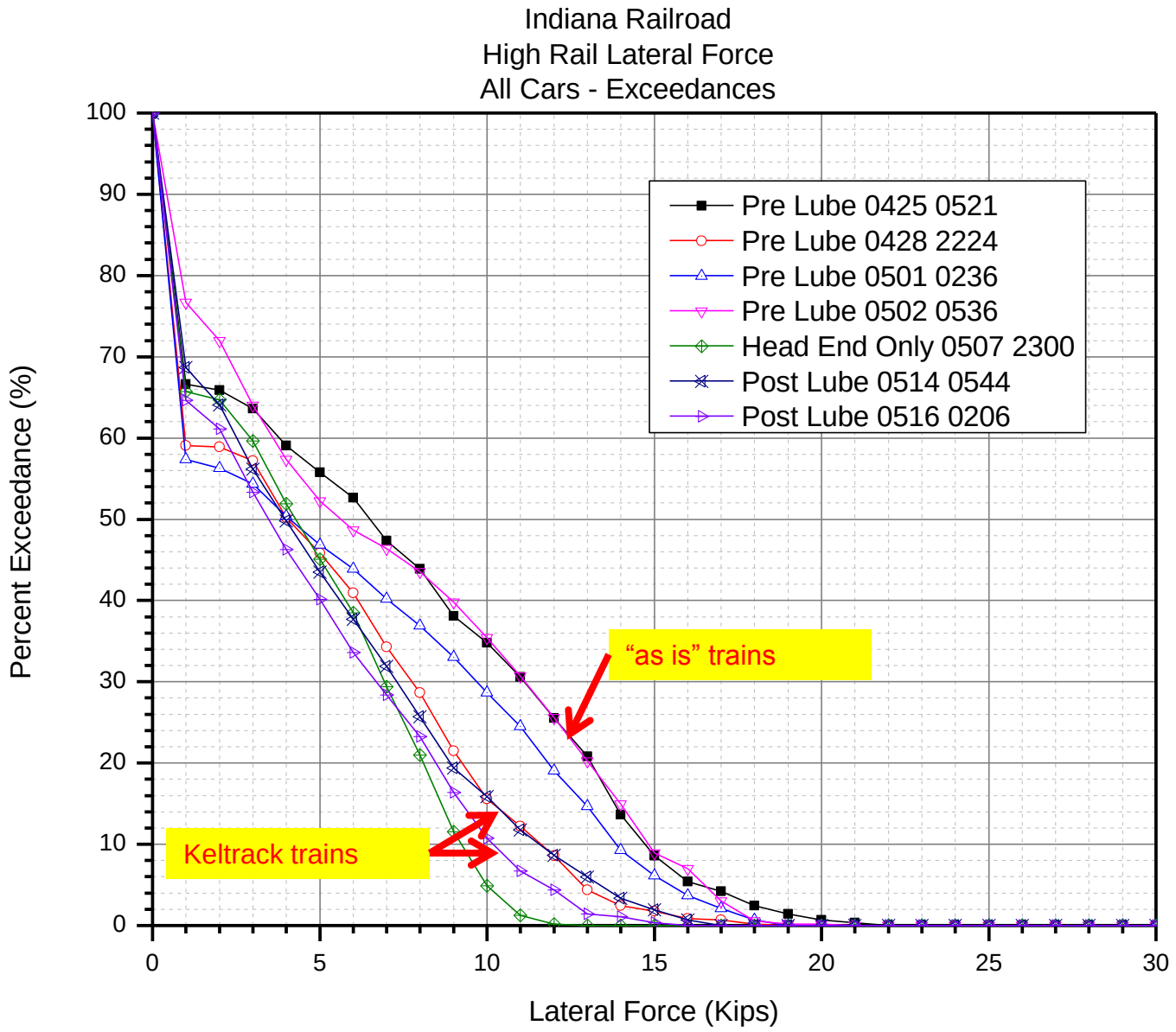


Friction Management to reduce RCF and Curve wear

Results of testing with Keltrack

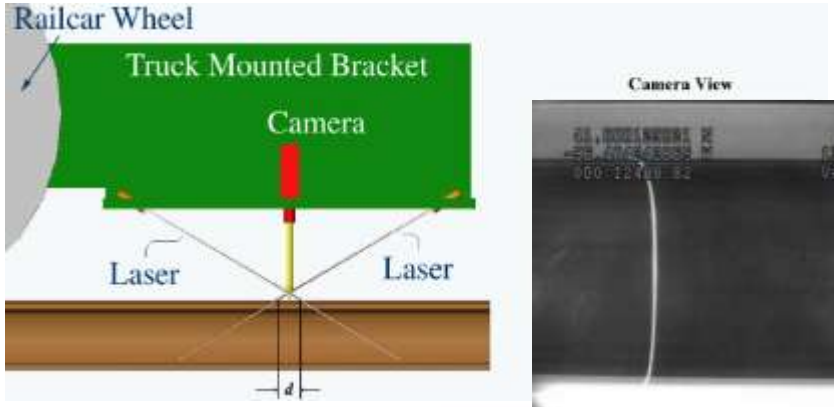



Indiana Railroad
Low Rail Lateral Force
All Cars - Exceedances
Percent Exceedance (%)
Lateral Force (Kips)
Pre Lube 0425 0521
Pre Lube 0428 2224
Pre Lube 0501 0236
Pre Lube 0502 0536
Head End Only 0507 2300
Post Lube 0514 0544
Post Lube 0516 0206
"as is" trains
Keltrack trains
Head end power only


Indiana Railroad
High Rail Lateral Force
All Cars - Exceedances
Percent Exceedance (%)
Lateral Force (Kips)
Pre Lube 0425 0521
Pre Lube 0428 2224
Pre Lube 0501 0236
Pre Lube 0502 0536
Head End Only 0507 2300
Post Lube 0514 0544
Post Lube 0516 0206
"as is" trains
Keltrack trains
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30

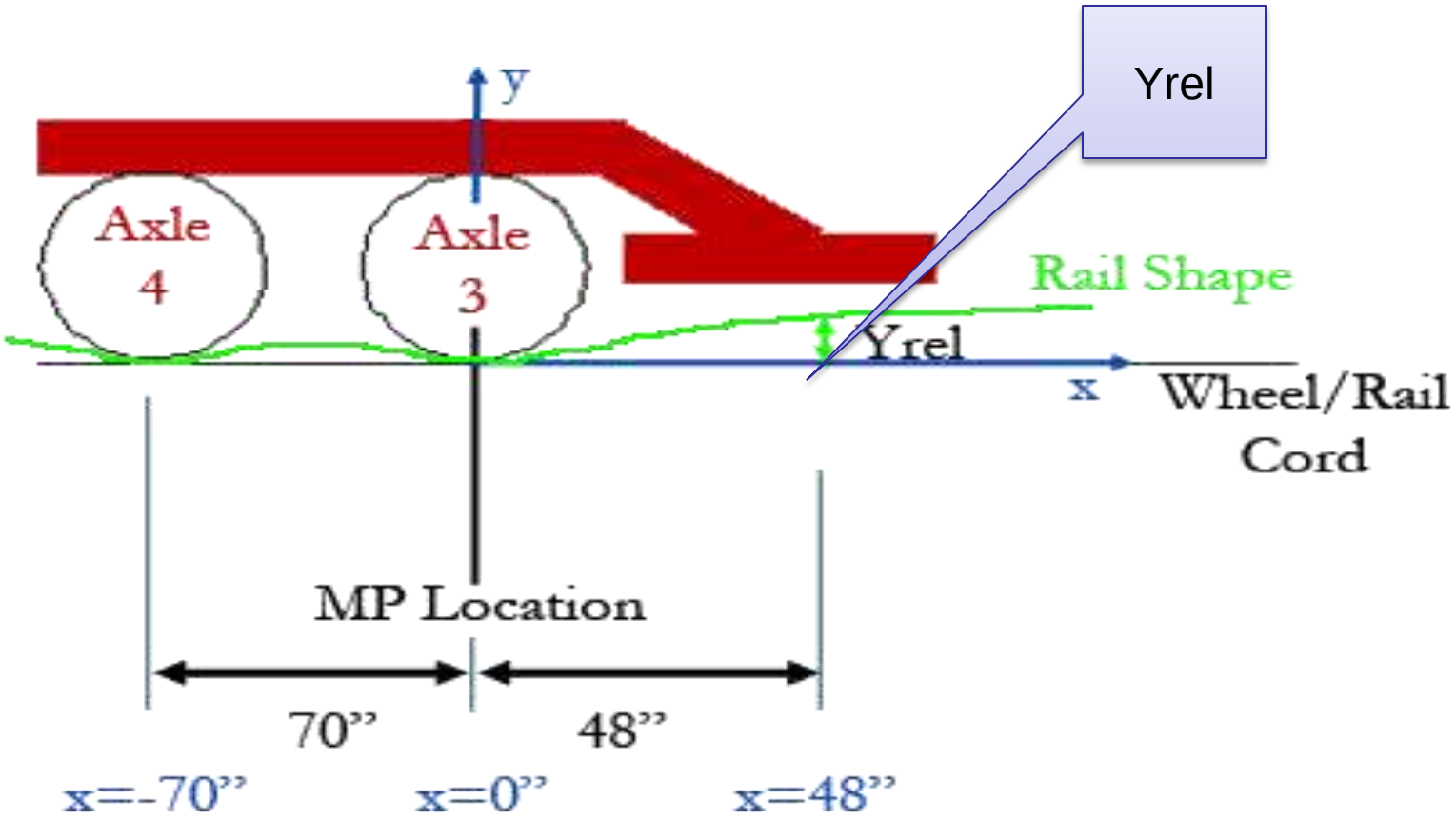
MRail MEASUREMENT SYSTEM

- The measurement system consists of a loaded hopper with a camera/laser sensor to detect the vertical deflection of the rail relative to the wheel/rail contact point.



Definition of Yrel

The system's measurement output is called "**Yrel**" which is the **relative vertical deflection** of the rail at 4 feet away from the axle as shown in the diagram below.

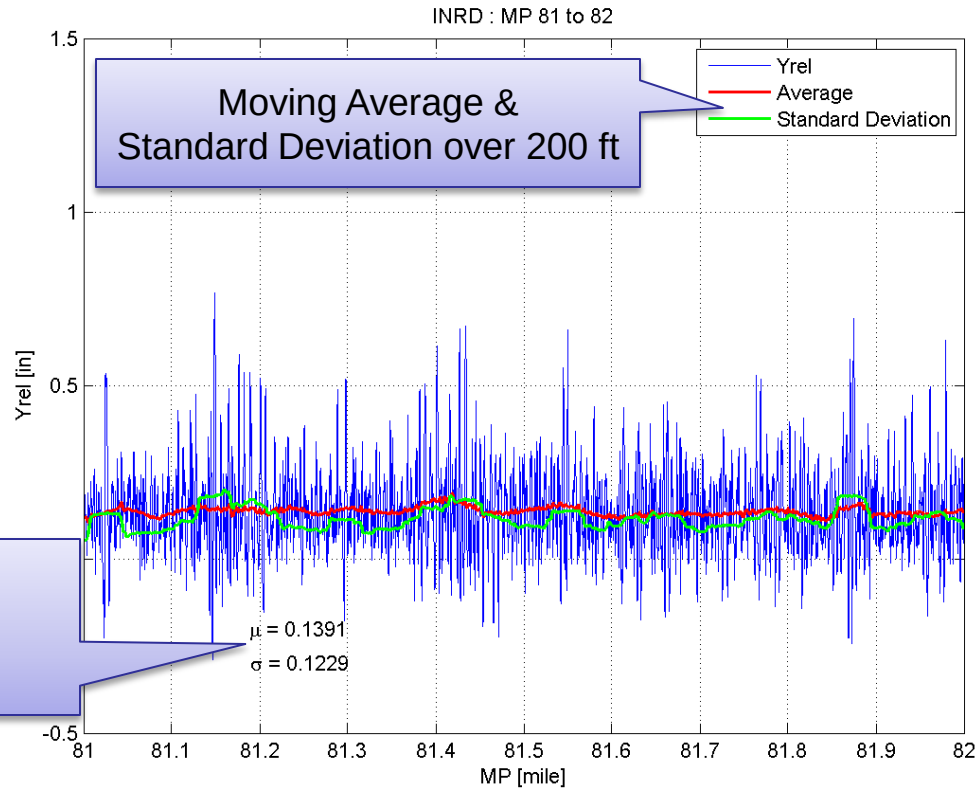


Interpretation of the data

- The plot below shows one mile of deflection data (Yrel) along with the moving average and standard deviation of a moving window of 200 ft.
- The average of Yrel is an indicator of track stiffness over longer distance. Lower average means stiffer track. The average of Yrel can be affected by many factors including ties, ballast, subgrade, rail size, etc. Jointed rail usually has higher averages than CWR due to the larger deflection at each joint. The averages also change over seasons with lower averages in winters and higher averages in springs. The averages will also drift in curves due to the load shift between the wheels during curving.
- The standard deviation of Yrel is an indicator of the variation of track vertical stiffness. A low standard deviation indicates a section of smooth track.

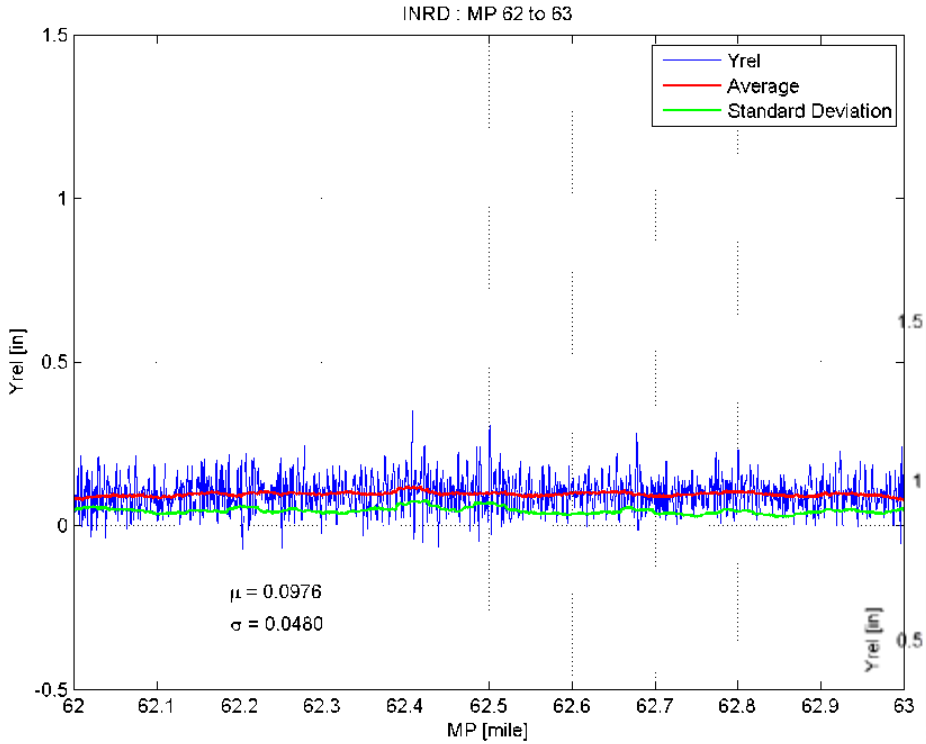
$$\mu = \sum_{i=1}^{n} \frac{d_i}{n}$$

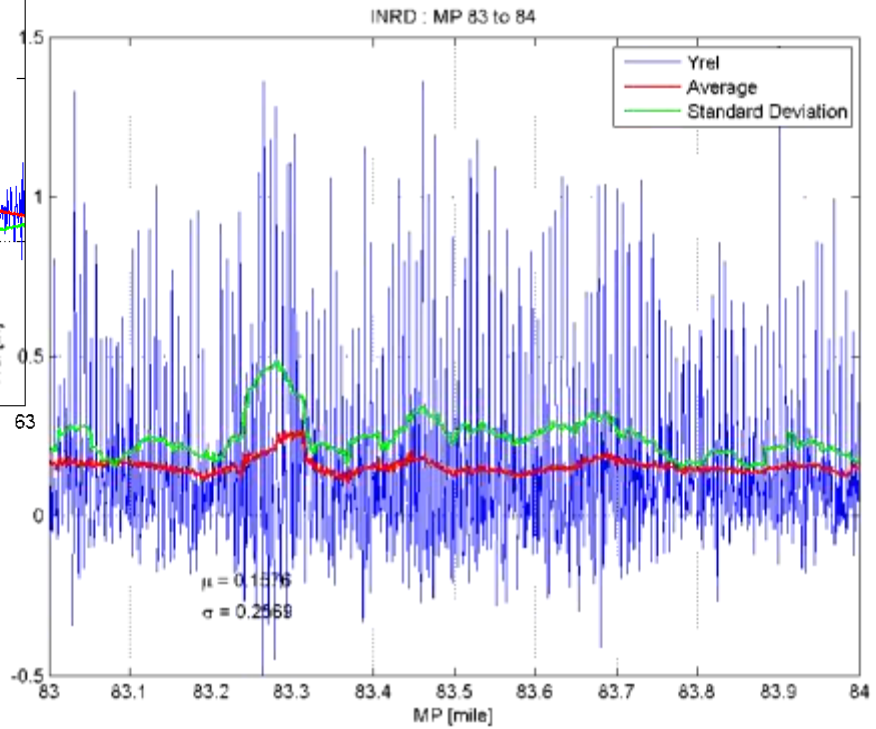
$$\sigma = \frac{\sum_{i=1}^{n} d_i - \mu}{(n-1)}$$



Average &
Standard Deviation
over the mile

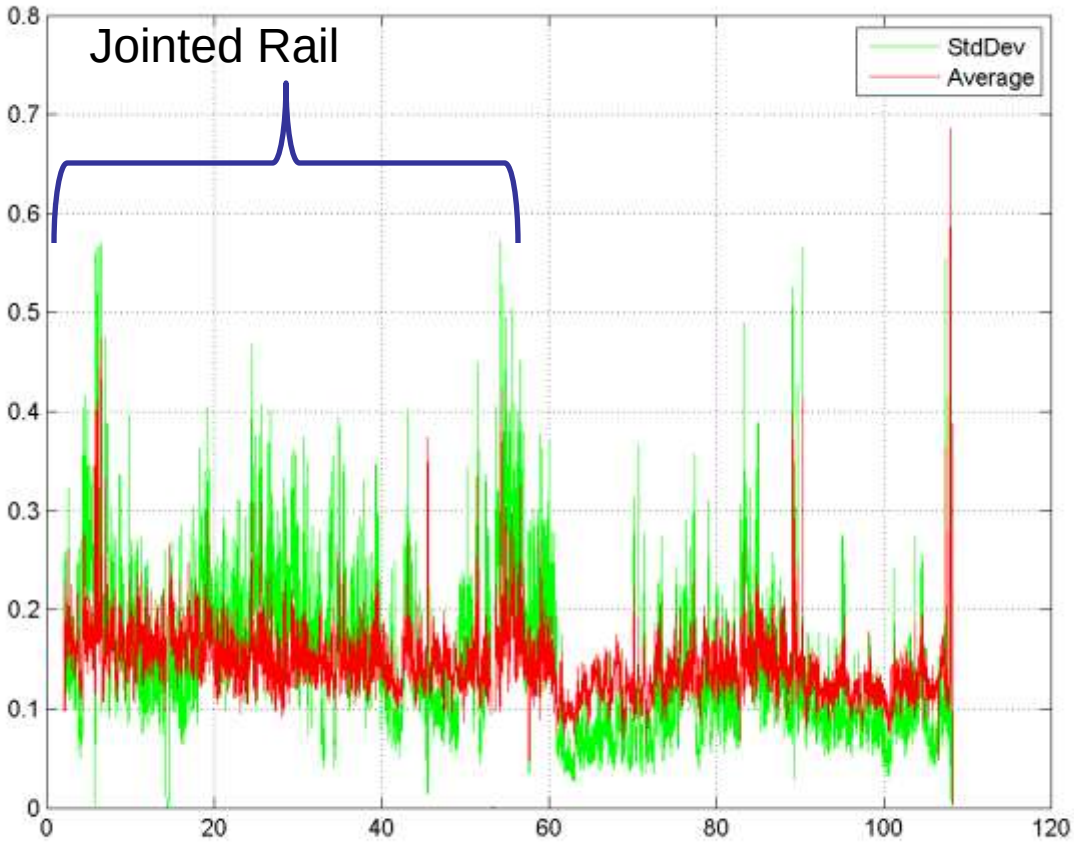
Vertical Deflection: Good vs. Bad





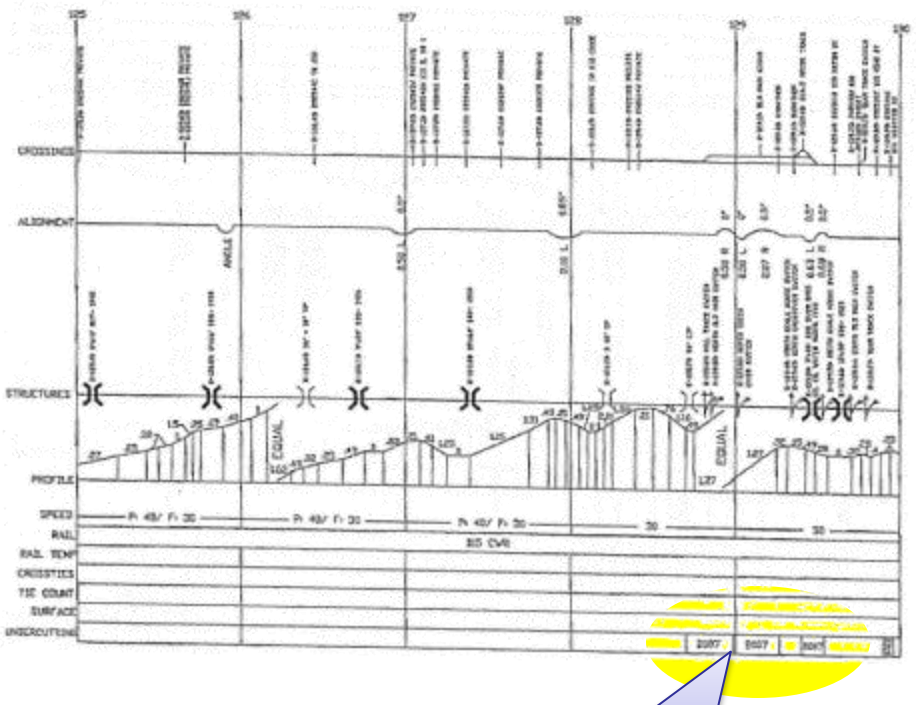
The Moving Average and Standard Deviation of Yrel between Indianapolis and Hiawatha

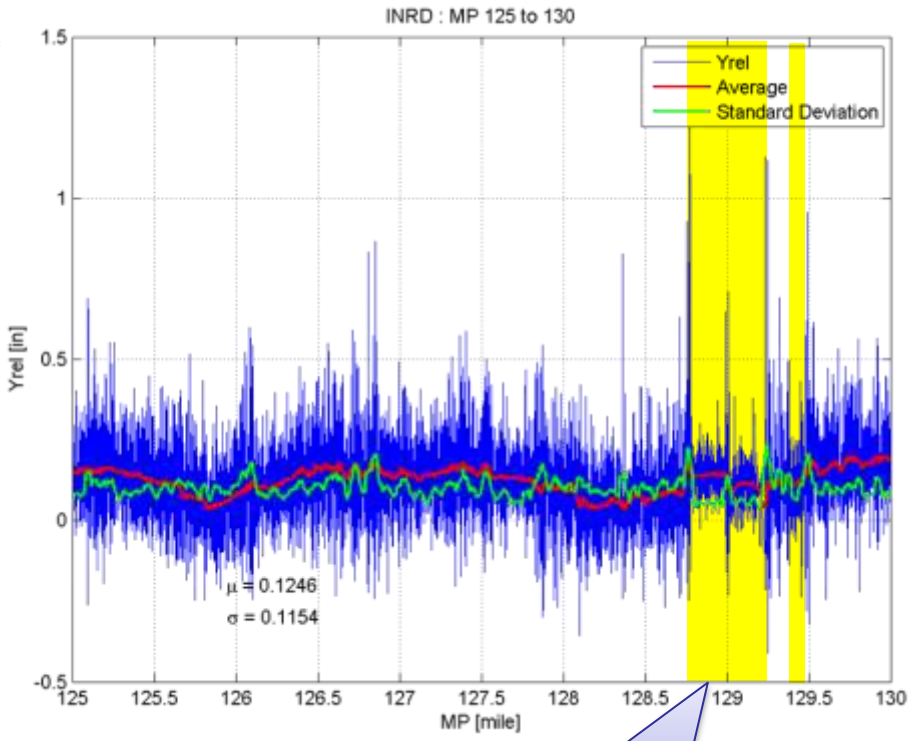
- The jointed rail has higher Yrel averages and standard deviations than CWR.
- Compared with the data from our past tests on Class I railroads, the Yrel averages on CWR and wood ties on INRD are in the same range (0.1”~ 0.15”) as on the Class I railroads. The standard deviations on INRD are slightly higher than the ones on Class I railroads at some sections. The standard deviation on Class I railroads are usually less than 0.08”.
- However, the INRD tests were conducted under near-freezing temperatures, the averages and standard deviations are expected to rise in a spring test.



Example: Undercutting

- The plot shows the effects of undercutting on track deflection.
- According to the track chart, the section between MP128.75 and 129.25 had been undercut in 2007. The result of this undercutting can still be seen clearly from the plot below. Even 5 years later, the sections had been through undercutting have less variations in vertical deflection. The standard deviations of Yrel over the undercut sections are lower than the surrounding tracks.
- This demonstrates that the MRail system can be used as a tool to evaluate the undercutting works.





MRail Data Used to Plan:

- Undercutting with emphasis on areas of large deflection (Avg. Yrel) and large Standard Deviation.
- Rail de-stressing. Weak vertical stiffness is indication of weak lateral stiffness.
- Joint tamping and bolt replacement.
- Tie and ballast replacement.
- Bridge and road crossing approaches