# EFFECTS OF WHEEL/RAIL CONTACT PATTERNS and VEHICLE PARAMETERS on LOADED CAR HUNTING

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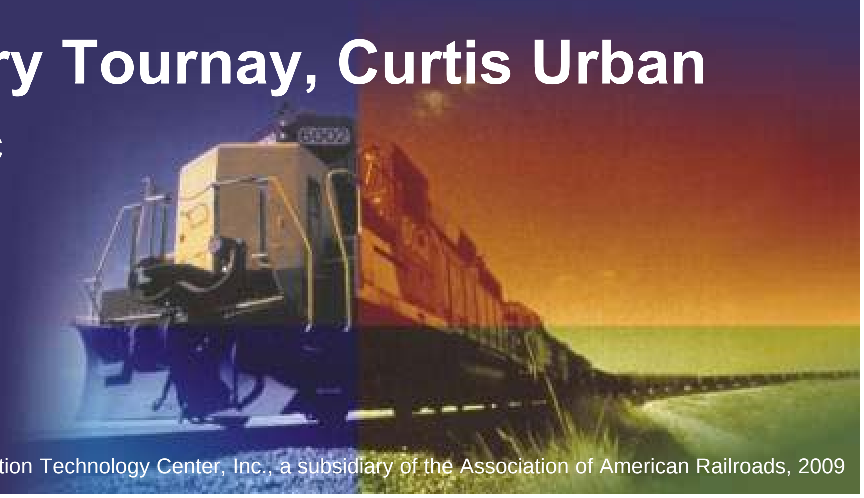
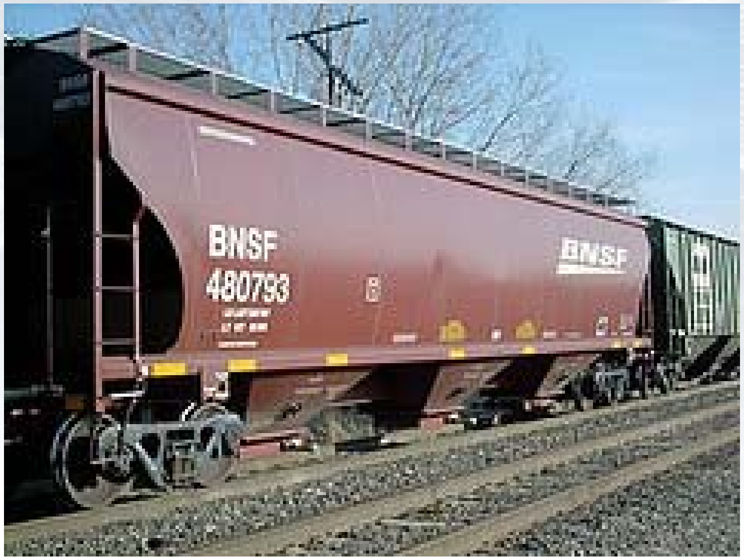
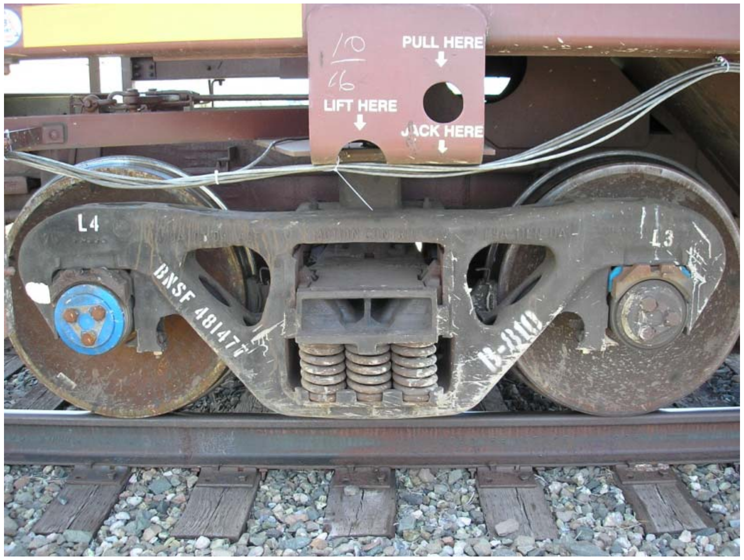


# *Background*

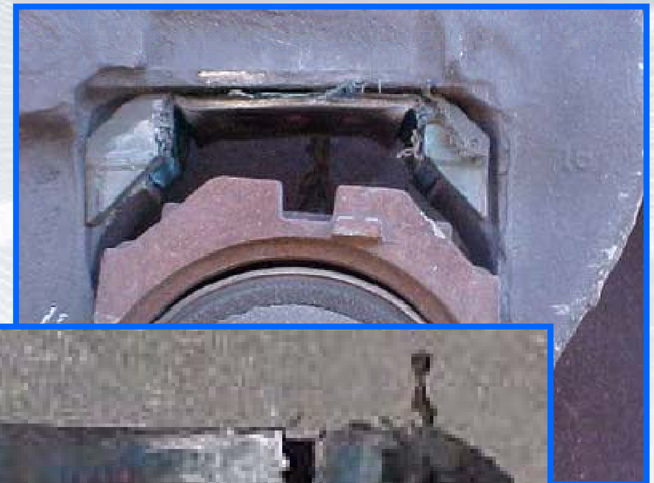
- **In 2006, failures of primary suspension adapter pads were reported on a particular type of grain car:**
  - Loaded high capacity (286k lbs) grain hoppers
  - Truck hunting: *loaded hunting is unusual*
  - M-976 trucks with improved tracking
  - Routes with specific rail wear patterns and tighter gage



# *Primary Suspension Adapter Pads*

- **Polymer pads improve axle steering, reduce W/R forces and rolling resistance**
- **Loaded Hunting motions appeared to cause failures:**
  - **Primary suspension pads**
    - If a pad does fail, it is typically only 1 out of 8 in a car
  - **Constant contact side bearings (CCSB)**



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# *Initial Lateral Stability (Hunting)Tests*

- **50 mph Tests performed at TTC**

# *Initial Lateral Stability (Hunting)Tests*

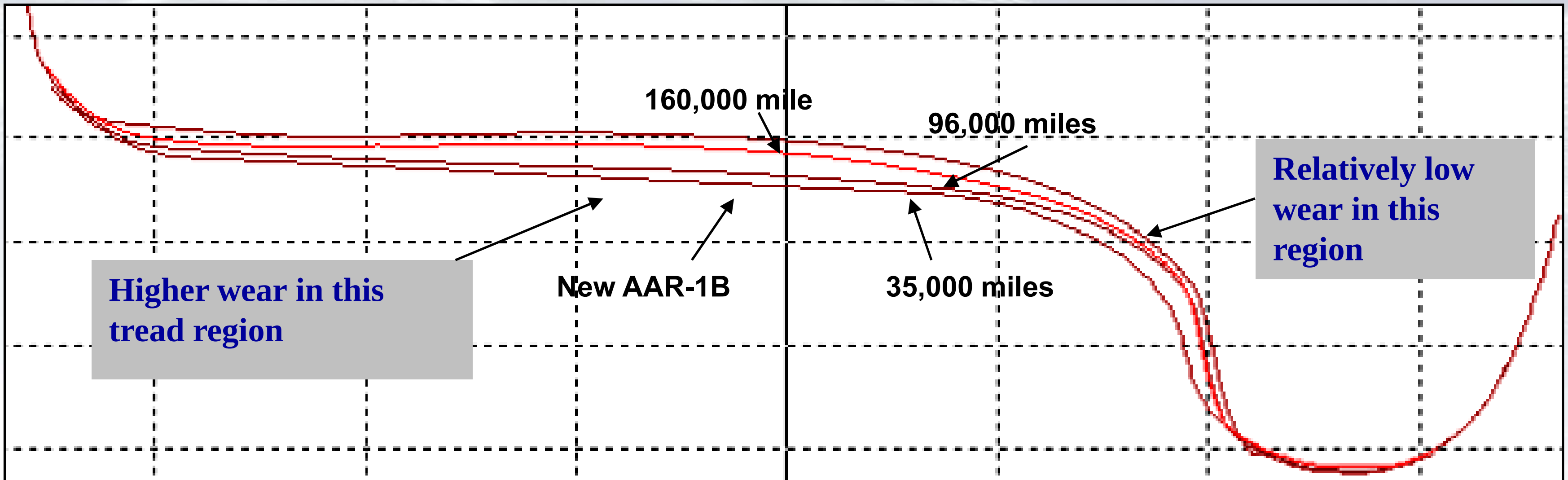
- **Tests performed at TTC**

| Wheel Profile and Conicity | Empty ~ Standard Pads | Loaded Hunting Threshold Speed | | | |
|---|---|---|---|---|---|
| | | Summer Standard Pads | Winter Standard Pads | Stiffer Pads | Standard Steel Adapters |
| Worn $\lambda>0.6$ | 65 mph | 47.5 mph | 55.5 mph | 65 mph | 70 mph |
| KR $\lambda>0.2$ | 80 mph | 65 mph | | 75 mph | 80 mph |
| AAR1B $\lambda>0.05$ | >80 mph | 75 mph | | 80 mph | 80 mph |

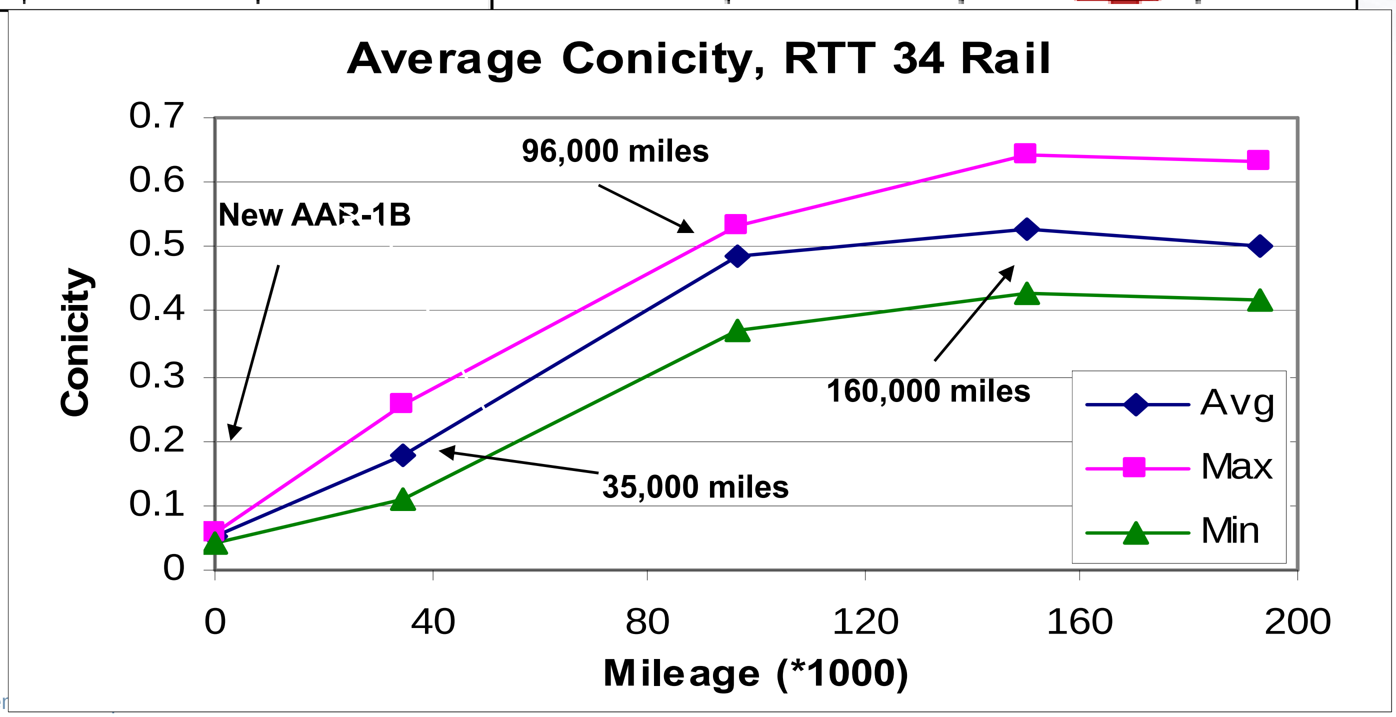
# *Initial Hunting Test Conclusions*

- Loaded car hunting a function of
  - Car body mass and inertial properties
  - High W/R Conicity
    - Worn wheels
    - Worn rail profile in straight track
  - Adapter pad stiffness
- Loaded car hunting also a function of:
  - Center plate friction
    - Steel center plates reduced hunting
  - Side bearing friction restraint

# Grain Car Wheel Wear and Effects on Conicity



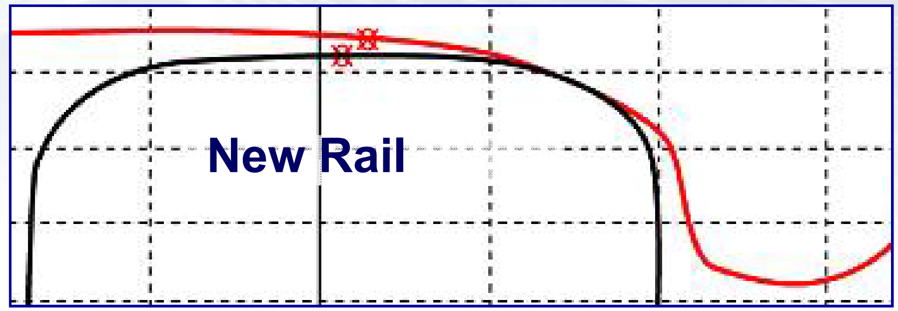

- Conicity (λ) on TTCI Hunting test zone

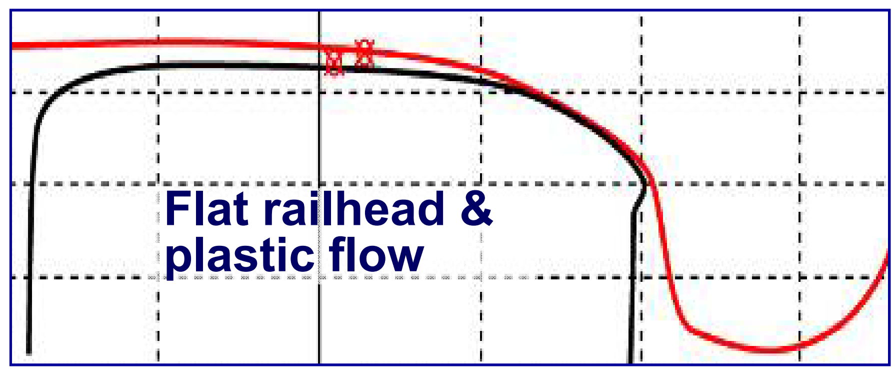


# *High Conicity W/R Contact Conditions*

- **Increased conicity on tangent track after ~ 160,000 km**
- **Tangent rail head profiles:**
  - **Certain new rail sections**
  - **Tight gauge**
  - **"Flattened" crowns**

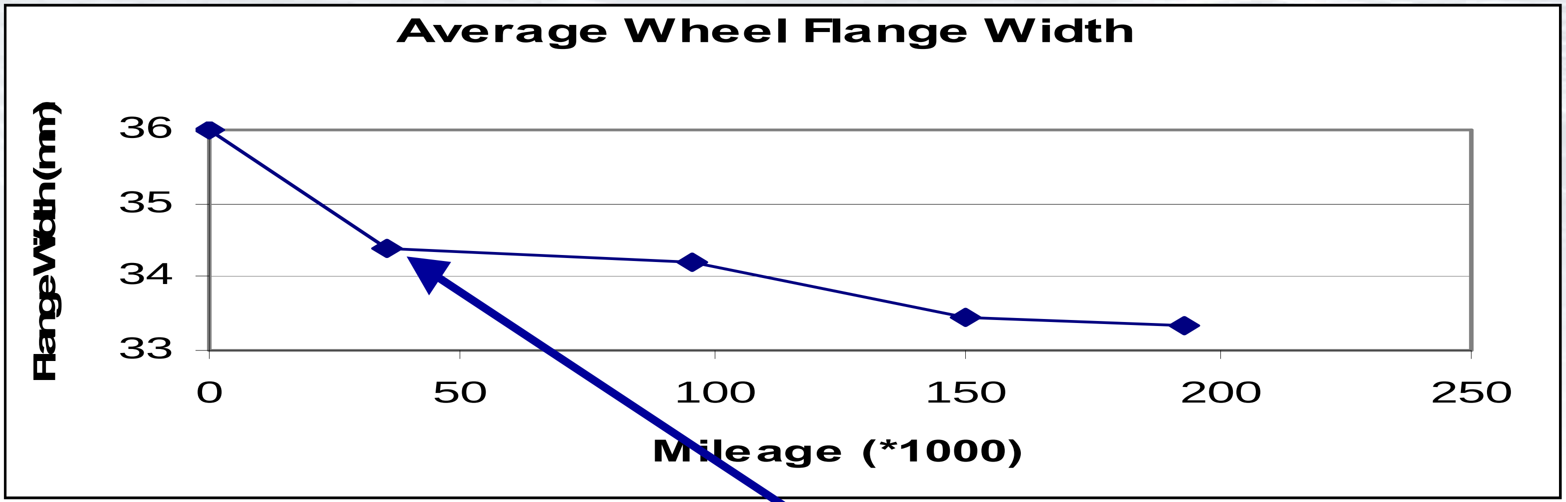
    **&**
  - **Flow to the gauge corner**



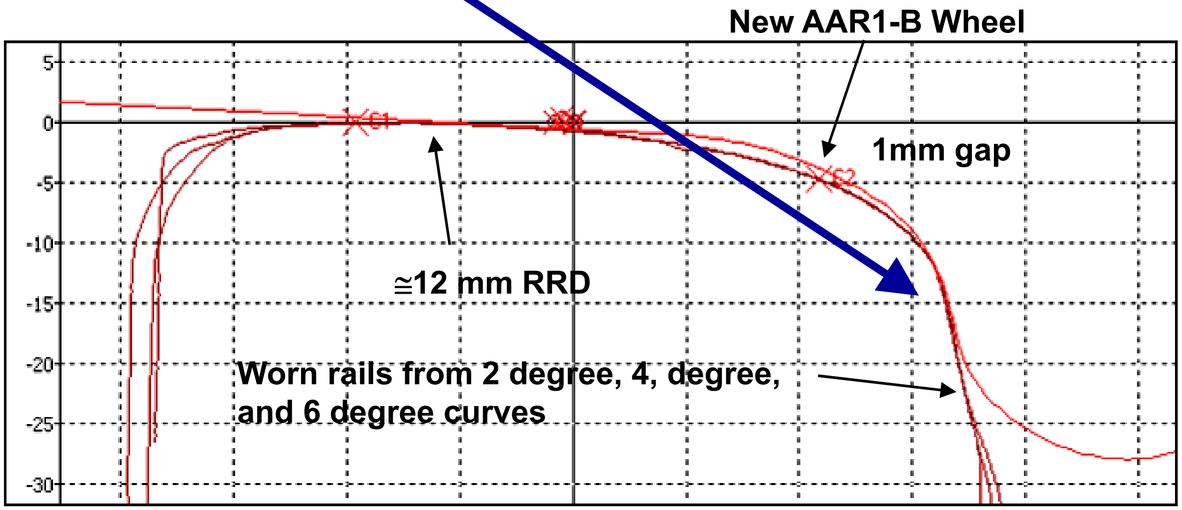



# *Wheel / Rail Profiles*

- **Accelerated initial flange wear**

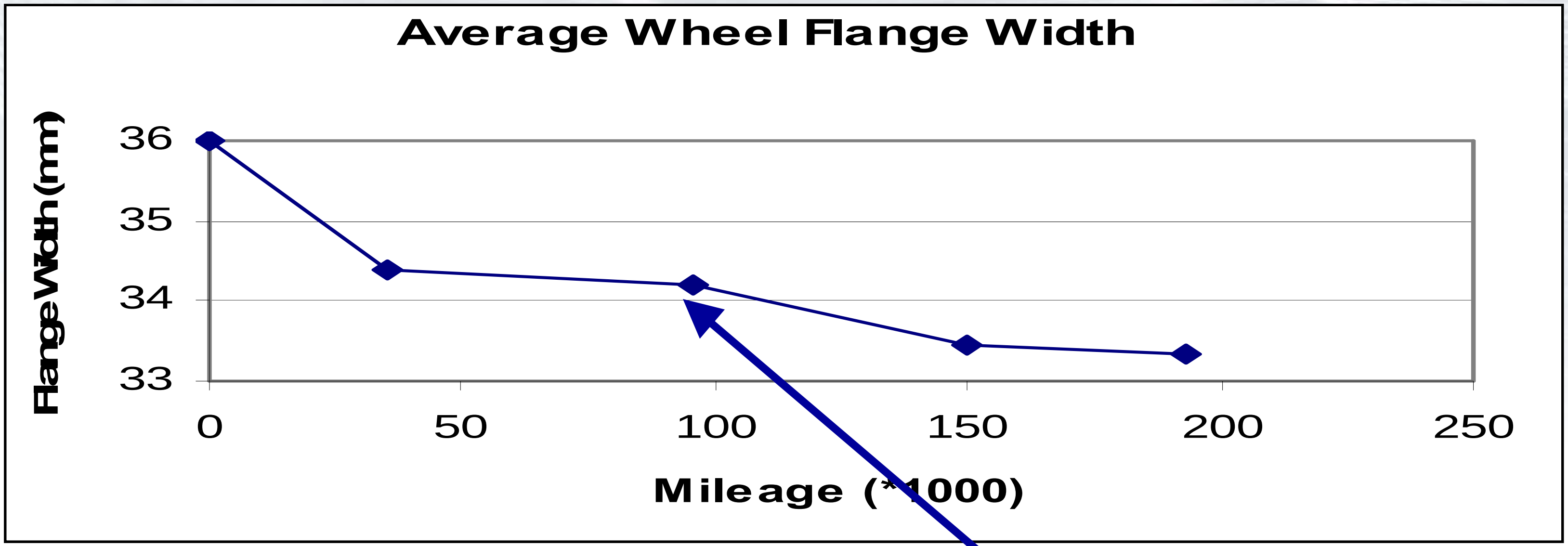



- **Associated with initial mismatch & 2-point contact between new wheel & worn high rail in curves**

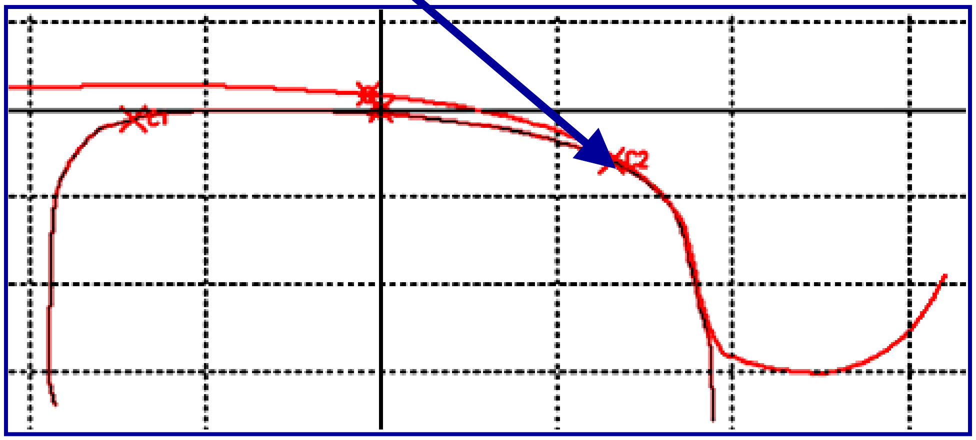


# *Wheel / Rail Profiles*

- Reduced flange wear after ~ 50,000 miles



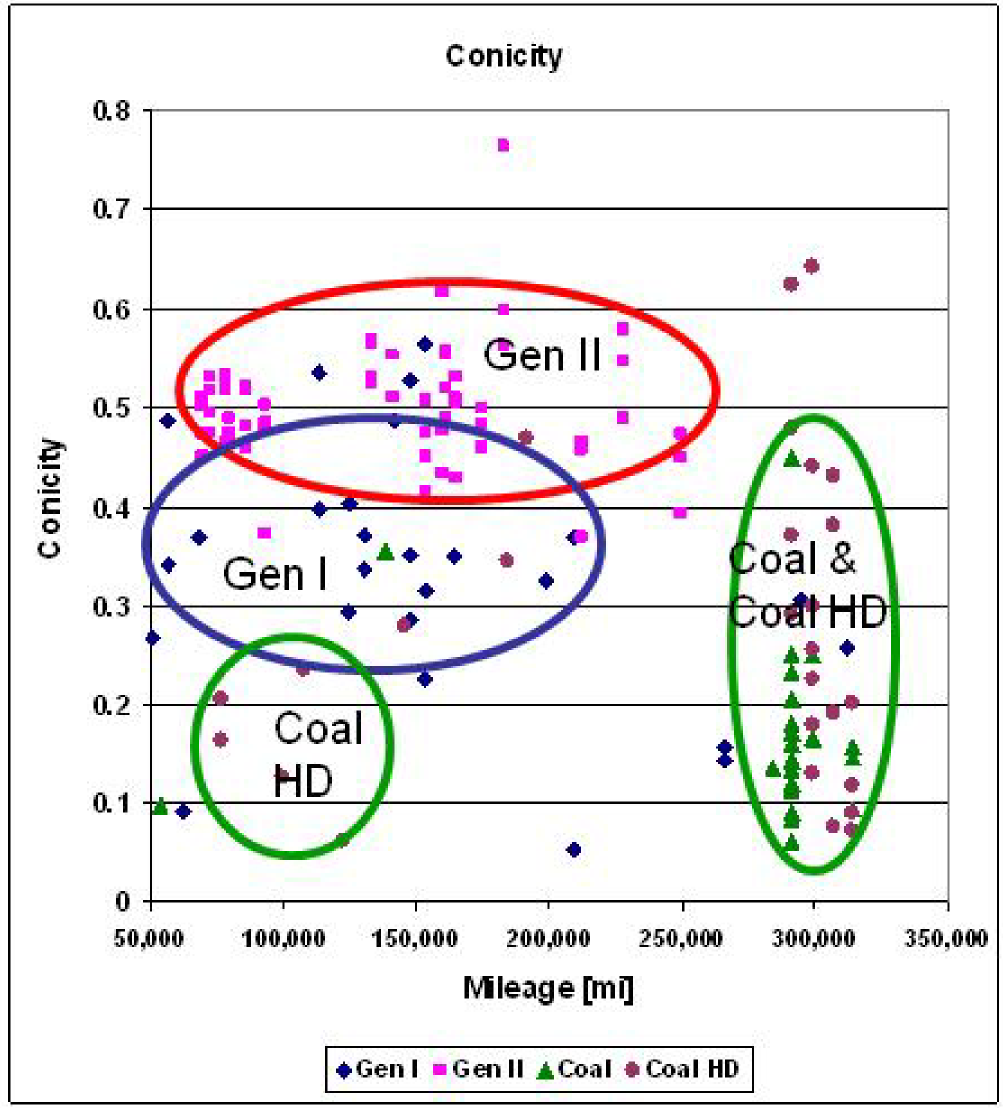

- Associated with single point contact & a large radius differential generated on the high rail in curves



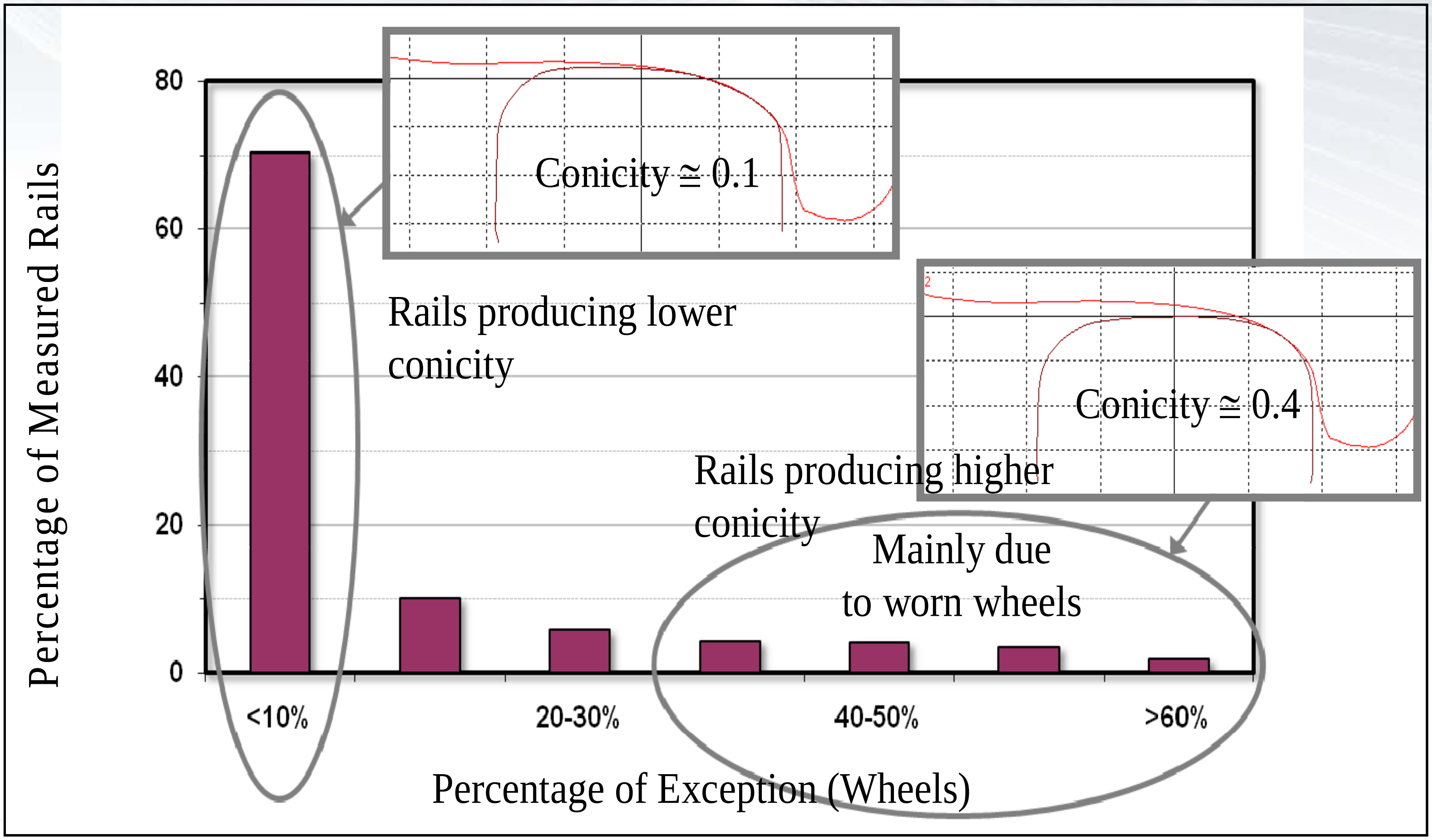
# *W/R Conicity as a Function of Mileage, Car and Truck Arrangement*

- **Car/Truck types**
  - Gen I: Grain car with steel adapters
  - Gen II: Grain car with polymer adapters
  - Coal: Coal car with steel adaptors
  - Coal HD: Coal car with polymer adapters
- **Root causes for differences are still unknown but suspected to be a function of:**
  - Curving ability
  - Vehicle stability



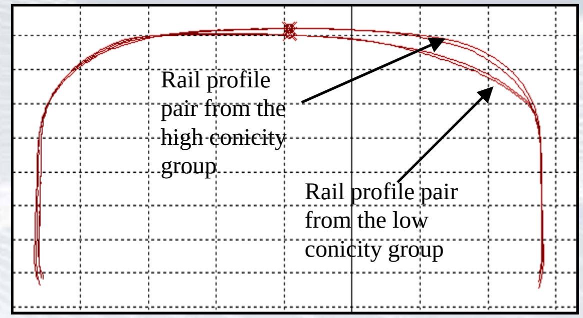
# *W/R Conicity as a Function of Rail Profiles for a Particular Grain Car Route*

- Analysis of conicity for 108 axles on 25,000 measured rail profiles from 19 miles of tangent track

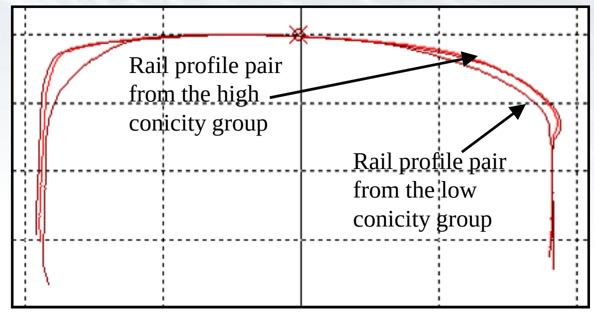


# *Tangent Track W/R Conicity Summary*

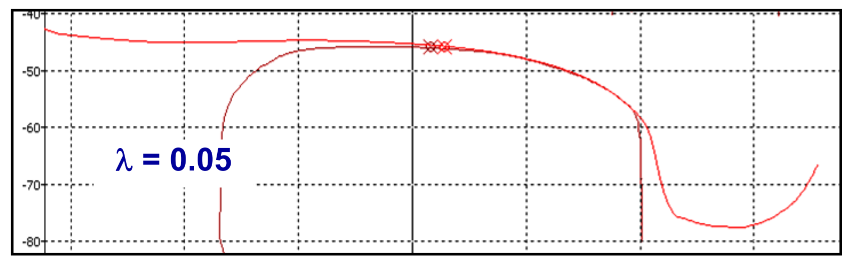
- **New AAR-1b wheels produce low conicity on all rail profiles**



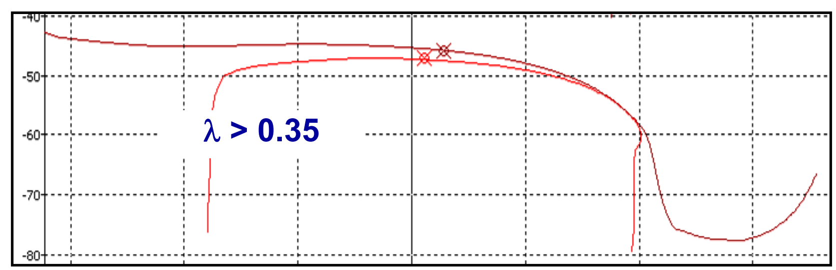

- **Rails with a low rail shoulder produce lower conicities, high shoulder gives high conicity**




- **Conformal contact tends to produce low conicity**

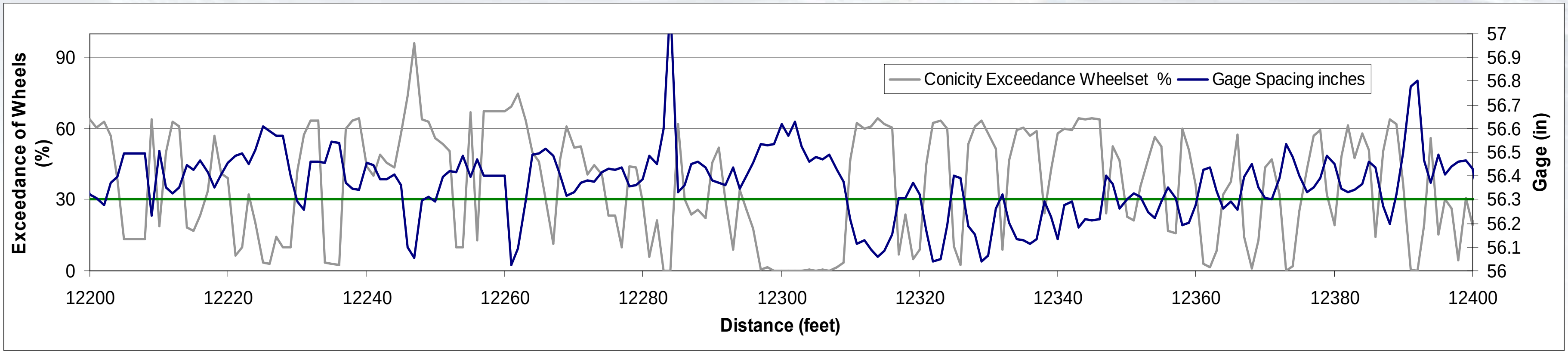



- **Flattened rails, gauge flow and narrow gauge produce high conicities**



# *Tangent Track W/R Conicity Summary (cont.)*

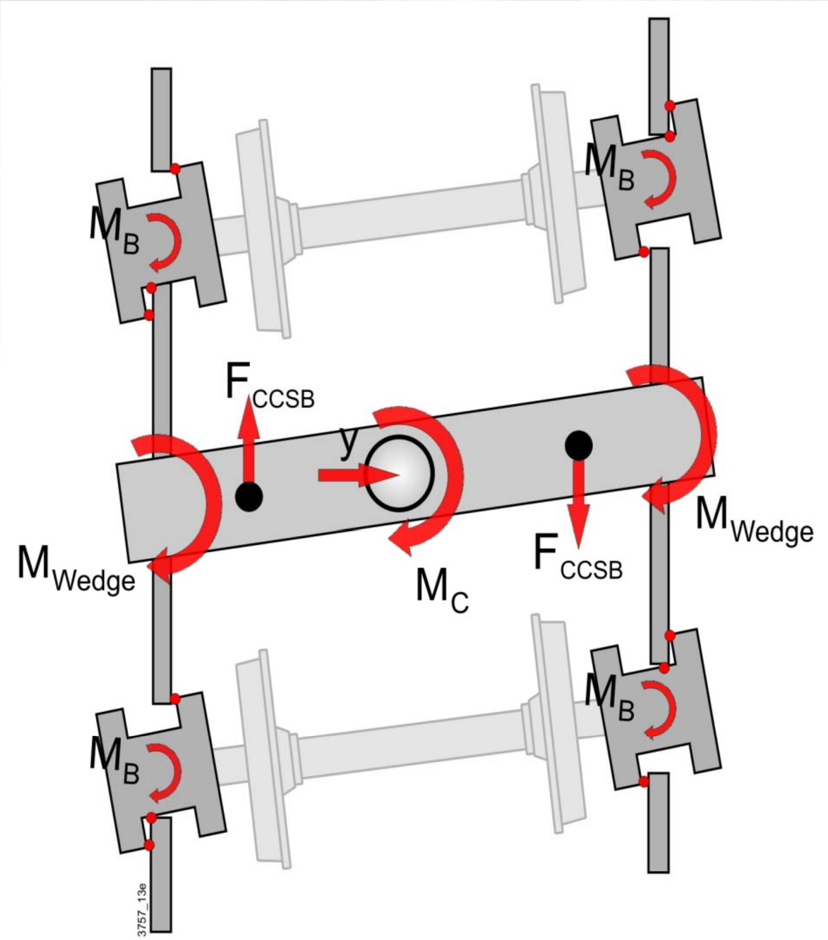
- **Tight gauge is highly correlated to high conicity in tangent track**



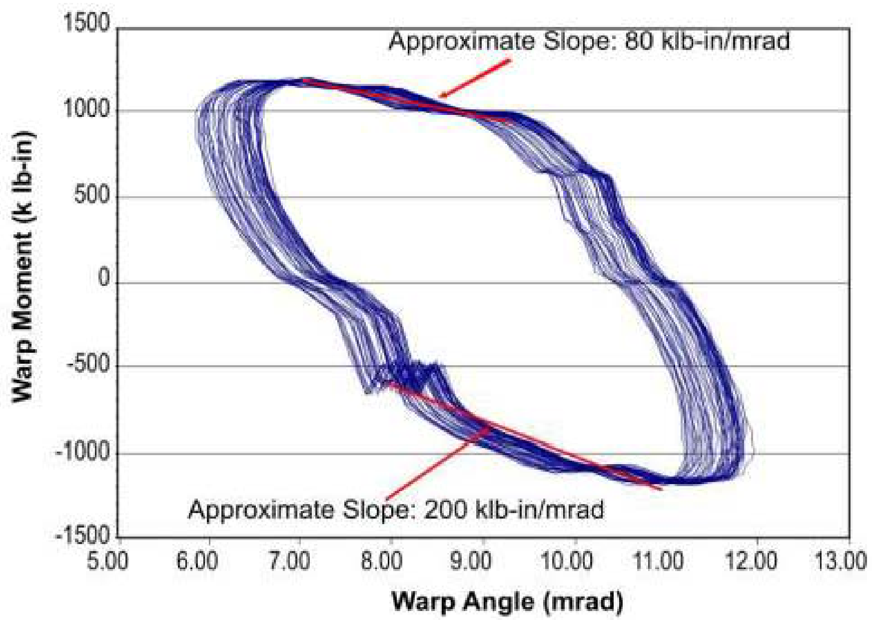

- **High conicity was found on only 10% of track**
- **Rail grinding to relieve reduce flattened rails, relieve the gauge corner and remove metal flow in the gauge corner could reduce conicity**
- **A more conformal new wheel profile could change the rapid initial wear pattern of new wheels**

# *Truck Hunting and Warp Dynamics*

- **Loaded hunting tests revealed:**
  - Predominantly in-phase motion (warp) of the wheelsets & truck bolster
  - Little longitudinal deflection of the adapter pads
  - Dependence on moments due to the adapters / adapter pads & truck rotation on stability

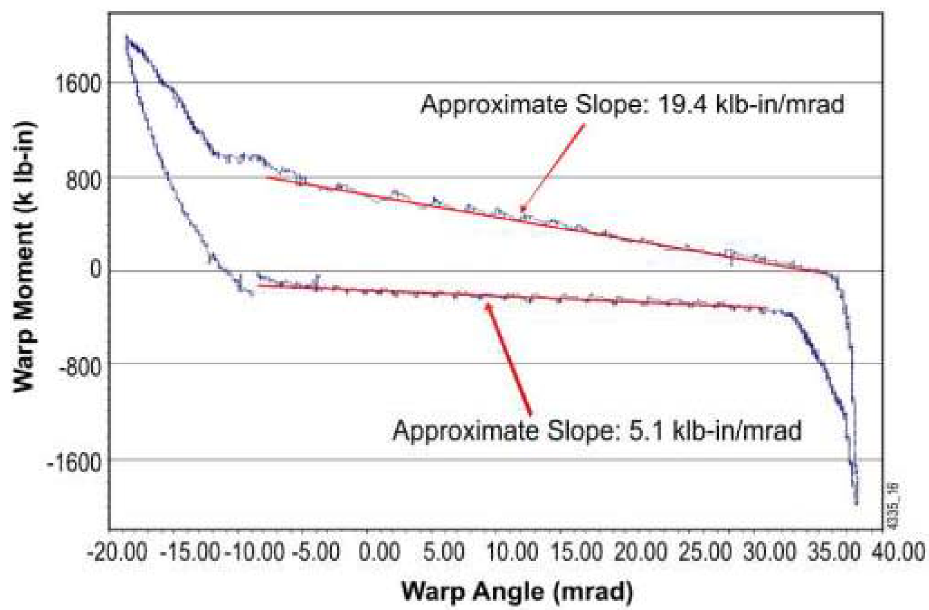


# *Truck Warp Test Results*




**Avg. stiffness = 140 klb-in/mrad**

**High warp restraint similar to previous tests of the same truck type when friction wedges have little motion**




**Avg. stiffness = 12.5 klb-inmrad**

**Warp stiffness reduced by factor of about 11 due to friction saturation with large wedge motions from combined body vertical/lateral motions**

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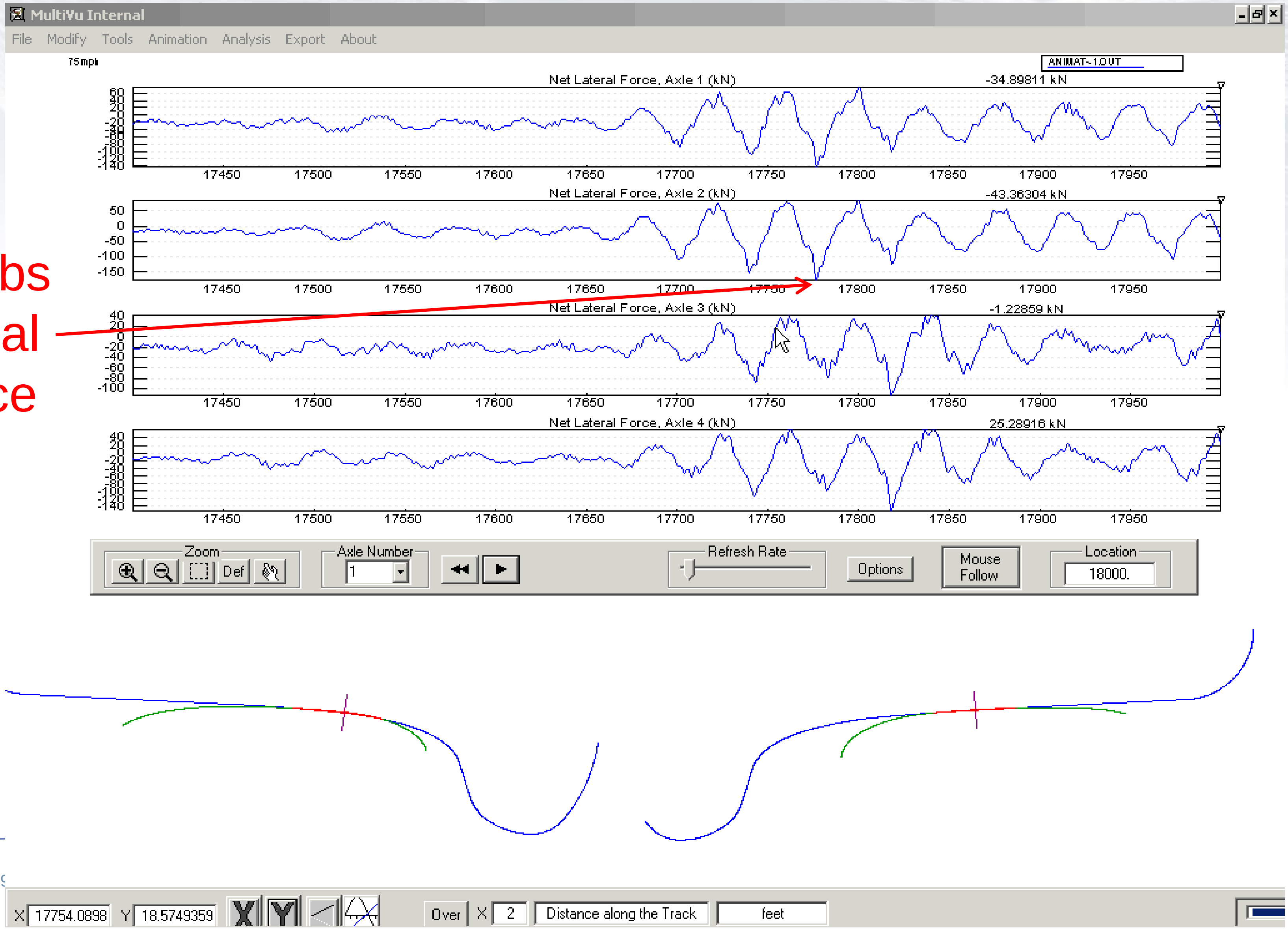
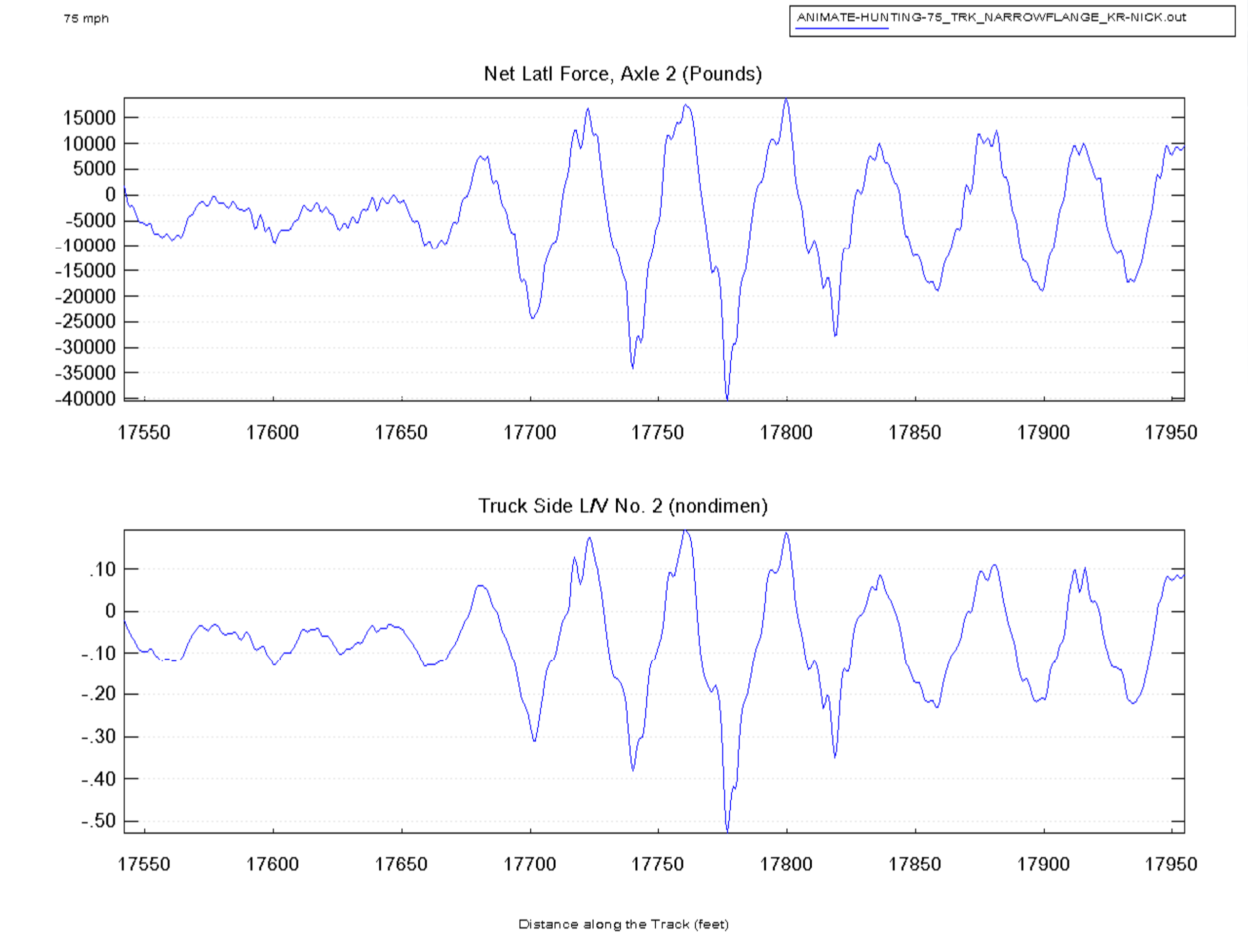
# *NUCARS® simulations to evaluate W/R forces and effects of Carbody and Suspension Parameters*

40,000 lbs net lateral axle force



# *W/R Forces due to Loaded Hunting*

- **NUCARS® simulations of loaded grain car hunting show potential for very high W/R forces**
- **Large Net Axle L/V ratios could cause track panel shift**
- **Large truckside L/V could cause gauge widening and rail rollover**



# *Progression to Loaded Car Hunting*

- **Accelerated wheel wear occurs in curves as a result of a "mismatch" between the high rail profile & that on tangent track**
  - 2-point contact
  - High rail "conditions" the wheel of a car making flange contact to a conformal profile
- **"Conditioning" results in high conicity, especially on *__particular sections__* of tangent track**
  - New rail of particular section
  - "Flattened" rail with material flow to the gauge corner
  - Sections of track with tight gauge

# *Progression to Loaded Car Hunting (cont.)*

- **High conicity on tangent track**
  - On sections where higher speeds occur
  - High creep forces under load excite the wheelsets
    - to yaw/warp the truck frame
    - to yaw *within* the truck frame on soft adapter pads
- **Wheelset & truck yaw excite particular (longer) car bodies in a yaw-dominated mode (includes roll)**
- **Car body yaw and coupled roll motions saturate the truck wedge system, reducing the warp restraint**
- **Reduced warp restraint results in resonance between wheelset, truck & car body yaw above certain threshold speeds**

# *Progression to Loaded car Hunting (cont.)*

- **Truck warp restraint breaks-down almost completely**
- **Wheelset hollowing (& conicity) increases as a consequence of the hunting motion**
- **Loaded car hunting occurs:**
  - At progressively lower speeds
  - On increasingly longer sections of tangent track
- **Pad failure results together with degradation of constant contact side bearing elements**

# *Loaded Car Hunting: Conclusions*

- **Loaded car hunting is a system problem:**
  - Only certain car types – many cars with trucks do not hunt
  - Depends on truck center spacing, car body inertial characteristics (centers of gravity & moments of inertia associated with high capacity cars for low density bulk products)
  - Wheelset and truck constraints (adapter pad stiffnesses, loss of warp restraint due to friction wedge motion)
  - Track (rail profile mismatch, rail deformation, tight gauge)

# *Loaded Car Hunting: Conclusions (cont.)*

- **Many types of car with these trucks do not experience loaded car hunting:**
  - Need "tune" the car and truck suspension parameters to the specific car body characteristics:
    - Truck spacing, inertial parameters (CG height, yaw and roll moments of inertia)
    - Wheelset and truck constraints (adapter pad stiffnesses, truck warp restraint)
- **Loaded hunting may lead to very high W/R forces**
  - Possibility for increased risk of track damage and derailment (Oct 2009 tests will measure forces w/IWS)

# *Way Forward: Standards and Testing*

- **Primary Suspension Pad Durability Standards**
  - AAR MSRP, Volume H, Section 4.3.2
- **Develop M-976 and Chapter 11 Loaded Hunting Test/Analysis Requirements (2009)**
  - What wheel profile?
  - What car body and inertial parameters? (M-976)
  - What performance criteria?
- **Loaded Hunting Tests at TTCI (Oct/Nov 2009)**
  - Support development of loaded hunting tests
  - IWS to measure W/R forces while hunting

# *Way Forward: Wheel and Rail Profiles*

- **Rail grinding to relieve reduce flattened rails, relieve the gauge corner and remove metal flow in the gauge corner could reduce conicity**
- **A more conformal new wheel profile could change the rapid initial wear pattern of new wheels**
  - A new wheel profile design for freight cars is being evaluated at TTCI to replace the AAR-1b
  - Based on worn wheel shapes
  - More conformal to existing rail profiles in curves and straight track
  - Narrower flange for more gage clearance

# *Way Forward: Car and Truck Design*

- **Immediate:**
  - Replace adapters & pads with standard adapters
  - Consequent reduction in curving performance (increased wheel wear & wheel RCF)
- **Intermediate:**
  - Stiffer pads
  - Partial improvement in tracking performance (reduced wheel wear & wheel RCF)
- **Long term:**
  - Improved freight truck with reduced stiffness pads & increased warp restraint
  - Reduced wheel wear & eliminated RCF

# Thank you for your attention!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