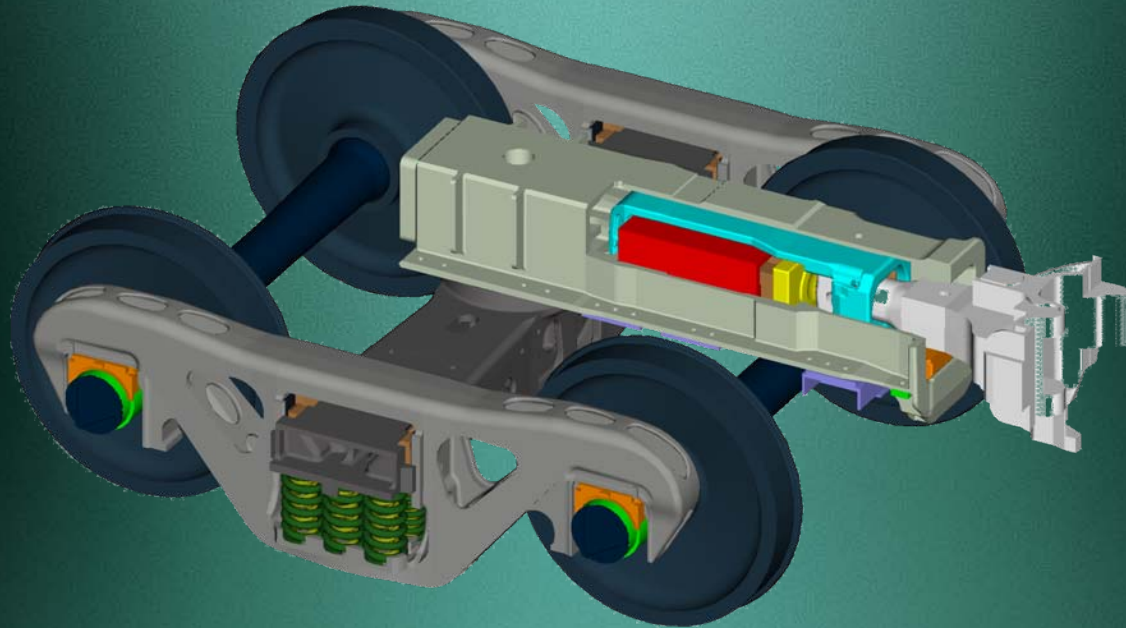


Mechanical Association Railcar Technical Services
Loaded Car Hunting and Suspension Systems

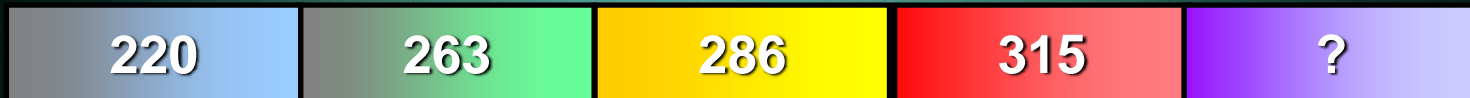
18 September 2009

Jay P. Monaco
Vice President Engineering
Amsted Rail Company, Inc.



Suspension, vehicle and track are a system

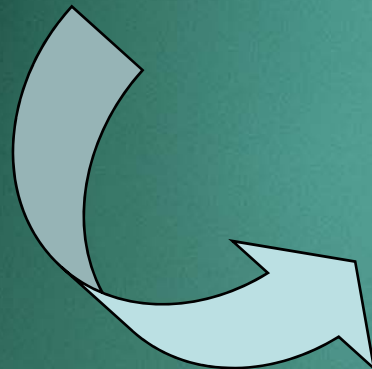
- Increased train velocity and improved asset utilization ...
 - Longer trains
 - Heavier car loads
 - More lading per railcar / higher C.G, etc.



- Increased railcar sensitivity to ...
 - Load balance and vehicle stability
 - Speed and track conditions
 - Car construction

= More demanding operating environment

- System interaction impacts performance
 - Suspension and coupling systems
 - Freight car structure and body
 - Track systems and operations
- Desired component and system attributes
 - Quality / integrity / reliability
 - Reduced in-service failure and downtime
 - Long life / low maintenance / reduced wear



- *Safety / security / service reliability*
- *System capacity and efficiency*
- *Asset utilization*
- *Train velocity*
- *Productivity*

Truck System Performance

Amsted Rail

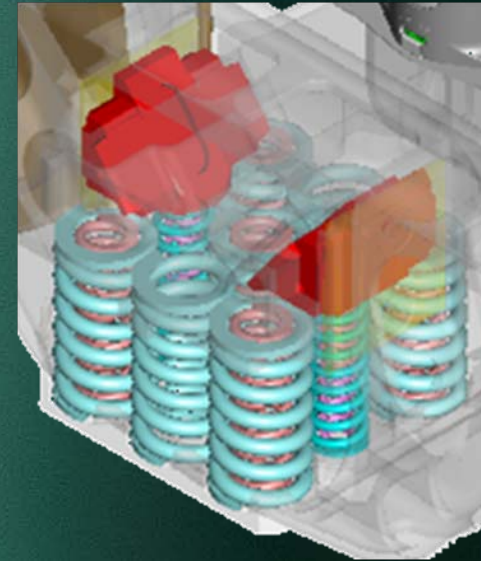
More demanding environment



Truck system performance



AAR Specification M-976



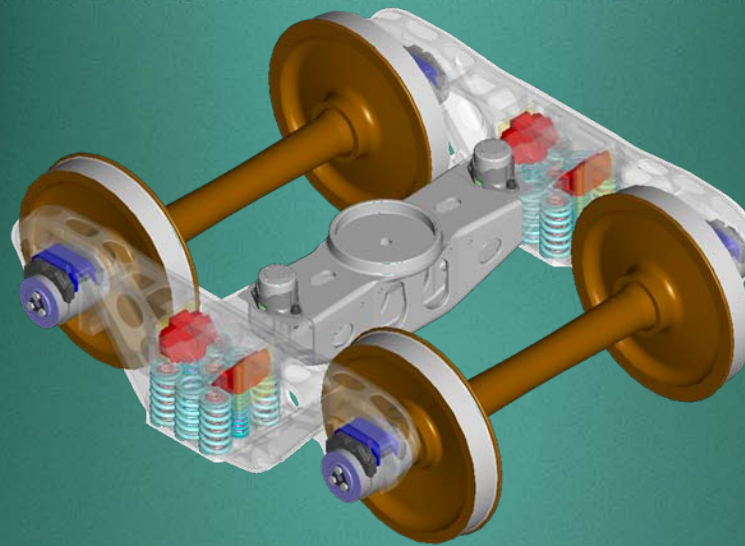
Suspension



Damping of vertical and lateral inputs; truck squaring



Reduced impact of loading conditions



Steering



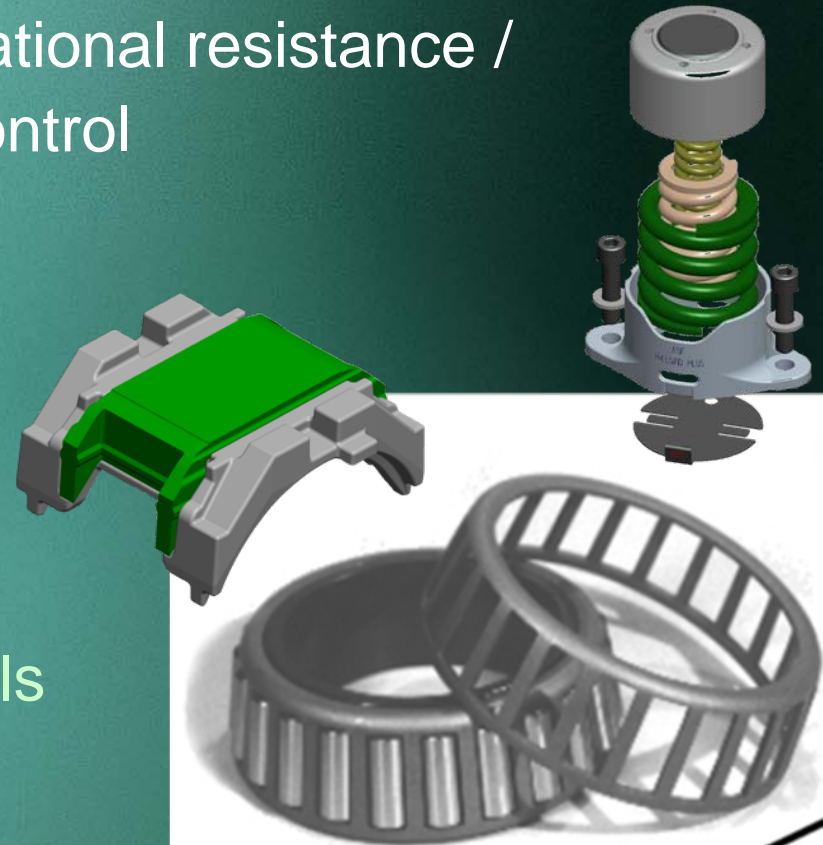
Curve negotiation with minimal effect on high speed stability



Reduced wheel and track wear

- **Tightened parameters** for heavier car loads
 - To be easier on track (and stay on track)
 - To reduce car inputs and component wear
- **Test regimes** (empty and loaded covered hoppers @ TTCI test track)
 - Hunting (loaded car hunting threshold being considered for M-976 re-write)
 - Steady state curving
 - Curve resistance
 - Spiral
 - Twist, roll
 - Pitch, bounce
 - Yaw, sway
 - Dynamic curving

- **Stability / hunting control**
 - Squaring; dimension control; friction wedges
 - **Center bowl liner** (loaded car) – rotational resistance / friction damping (too low = stability issues)
 - **Side bearings** (light car) – rotational resistance / friction damping; railcar roll control
- **Reduced rolling resistance**
(to reduce wheel tread wear and wheel flange wear)
 - Low torque **bearings**
 - **Passive steering components**
 - **Round / consistent tape wheels**



- Steering = axle movement to negotiate curves (axles move out of parallel)
- Elastomeric pad and special metal adapter enable steering (and absorb energy)
 - Pad deflects in shear with controlled stiffness (too stiff = harder on wheel; too soft = hunting / stability issues)
 - Stored pad energy restores axle on tangent track
 - Standard metal adapters can stick due to friction, causing wheel / flange scrubbing
- Curving vs. Stability...
 - Passive mechanical system is a compromise
 - Balance curving resistance and high speed stability

- Protects pedestal roof and thrust lugs from wear
- Controlled resistance, tight fit (+ clearance => hunting)
- Improves Radial Wheelset Alignment
 - Improve Curving
 - Passive Steering
- Evenly distributes bearing load
 - Increase life of roller bearing
 - Reduce Rolling Resistance
- Attenuates vertical impacts
- Nearly 1.5 million in service globally
 - Excellent track record
 - Improve wheel wear (Brazil)
 - Reduce noise (Australia)

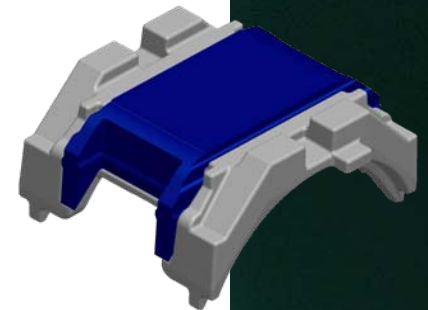
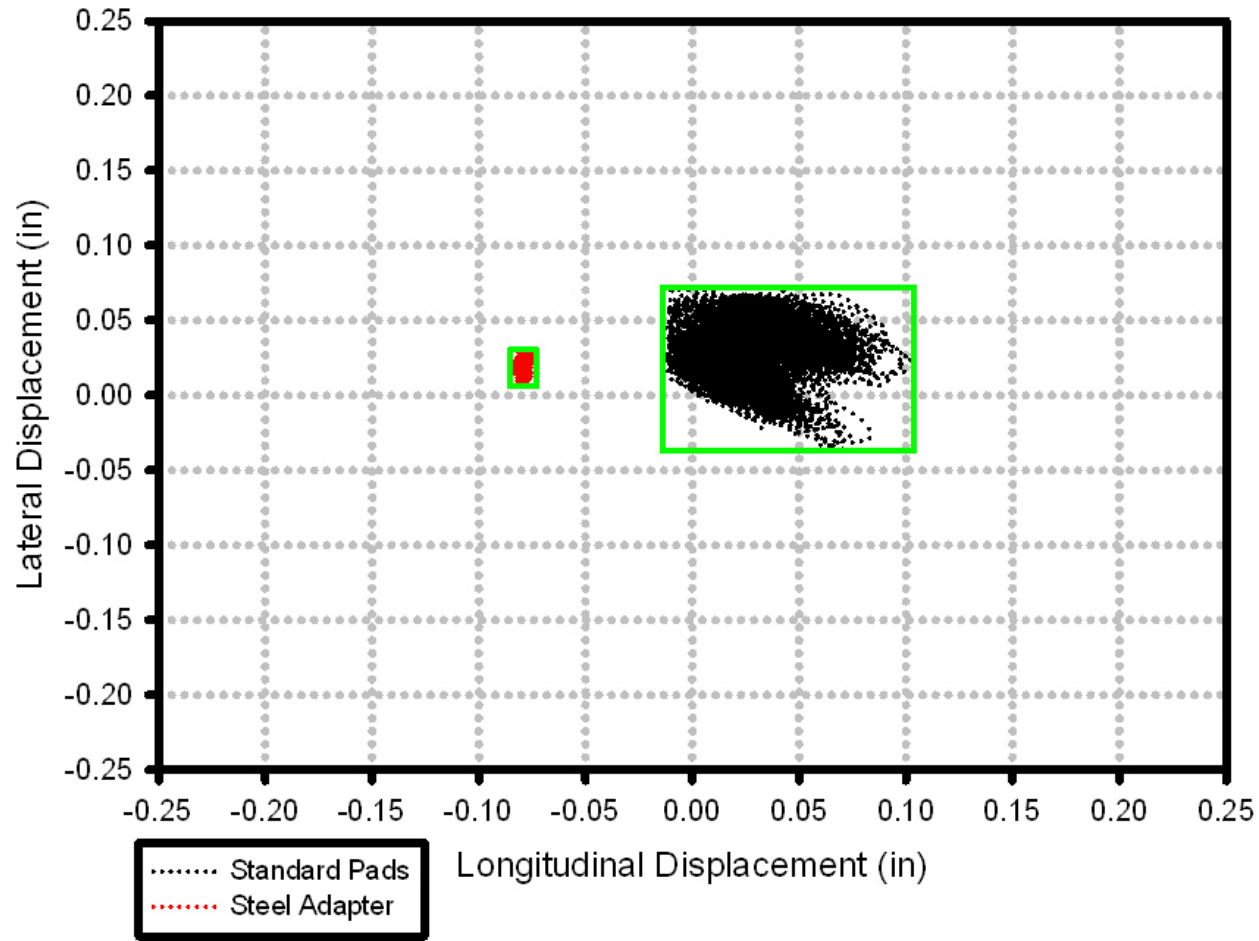


- ~ 6,000 5,161 c.f. grain hopper cars built 2004 - 2006
Grain export service to ports in Mexico
No indication of pad degradation for 1 ½ - 2 years
Center bowl liner low friction lowered hunting threshold
Side bearing elements lost preload, reducing capacity to dampen hunting oscillations
- Several inputs simultaneously caused severe hunting
 - Combination of speed / track condition / loading condition can cause pad degradation as an isolated event
 - 10 percent of cars experienced problem
 - One pad affected; other seven were okay

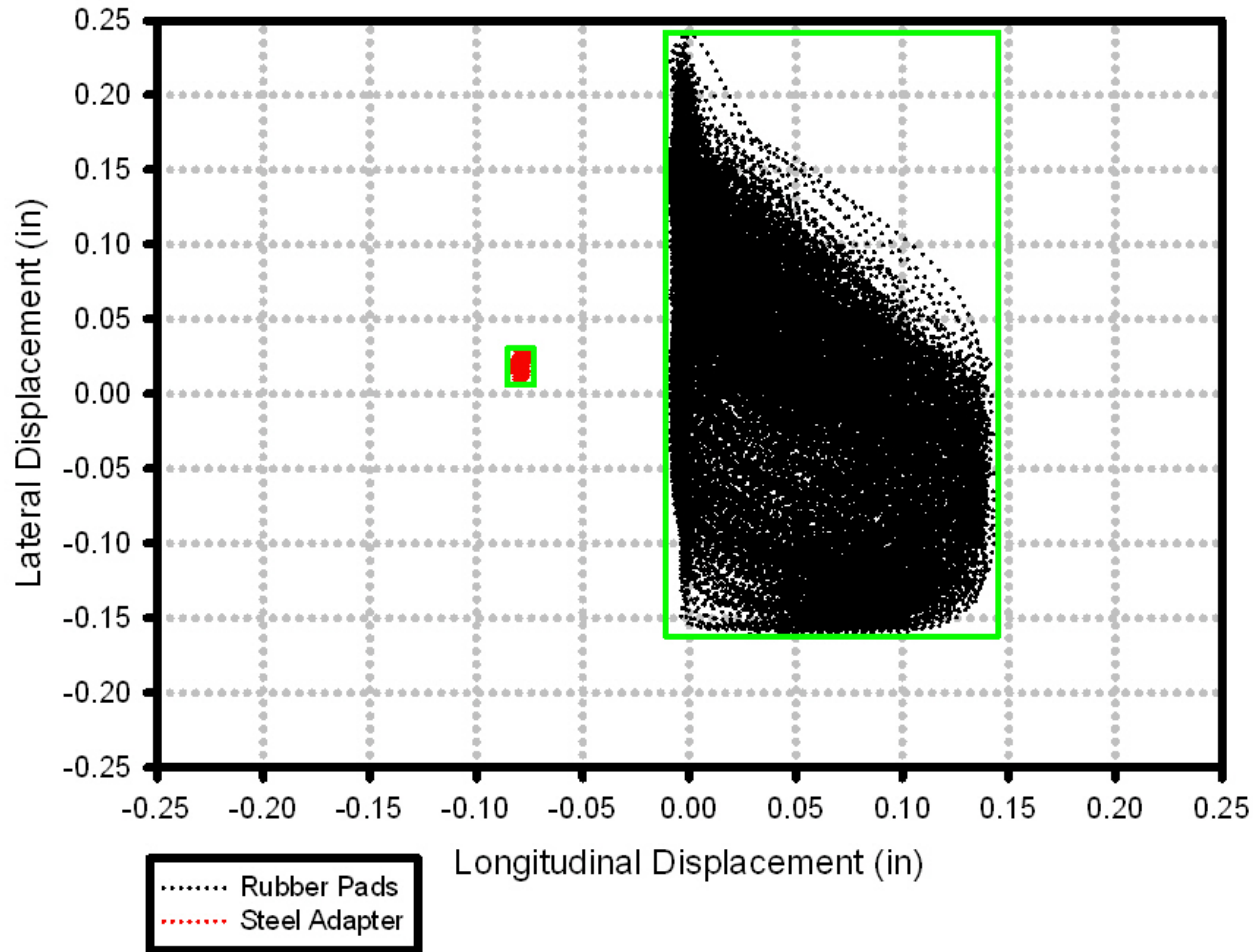
- **Field testing in revenue service**
 - Instrumented car in Granite City, IL
 - Started in November 2006
 - Loaded hunting evident during instrumented trips, 50 – 60 mph speed
 - New wheelsets – hunting eliminated; worn wheel profiles impact hunting modes
 - Imbalanced loading affects stability
- **Laboratory testing of pads**
 - Existing and new compounds / configurations
 - Using field test data, replicated pad degradation
 - Hysteretic heat generation at higher frequencies during severe hunting causes breakdown from inside out

- Attenuate the inputs that are resulting in loaded car hunting
 - Track profile; track grinding practices
 - Track gauge; track maintenance
 - Worn wheel profile / maintenance
 - Control imbalanced loading
 - Overall vehicle stability; torsional stiffness
 - Suspension specific to vehicle and service type
- Modify equipment to mitigate the effect of the inputs
 - Suspension equipment modifications
 - Additional equipment – dampers, springs...
 - Car body modifications
 - Modified wheel profile

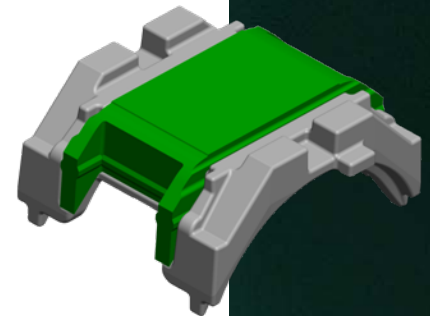
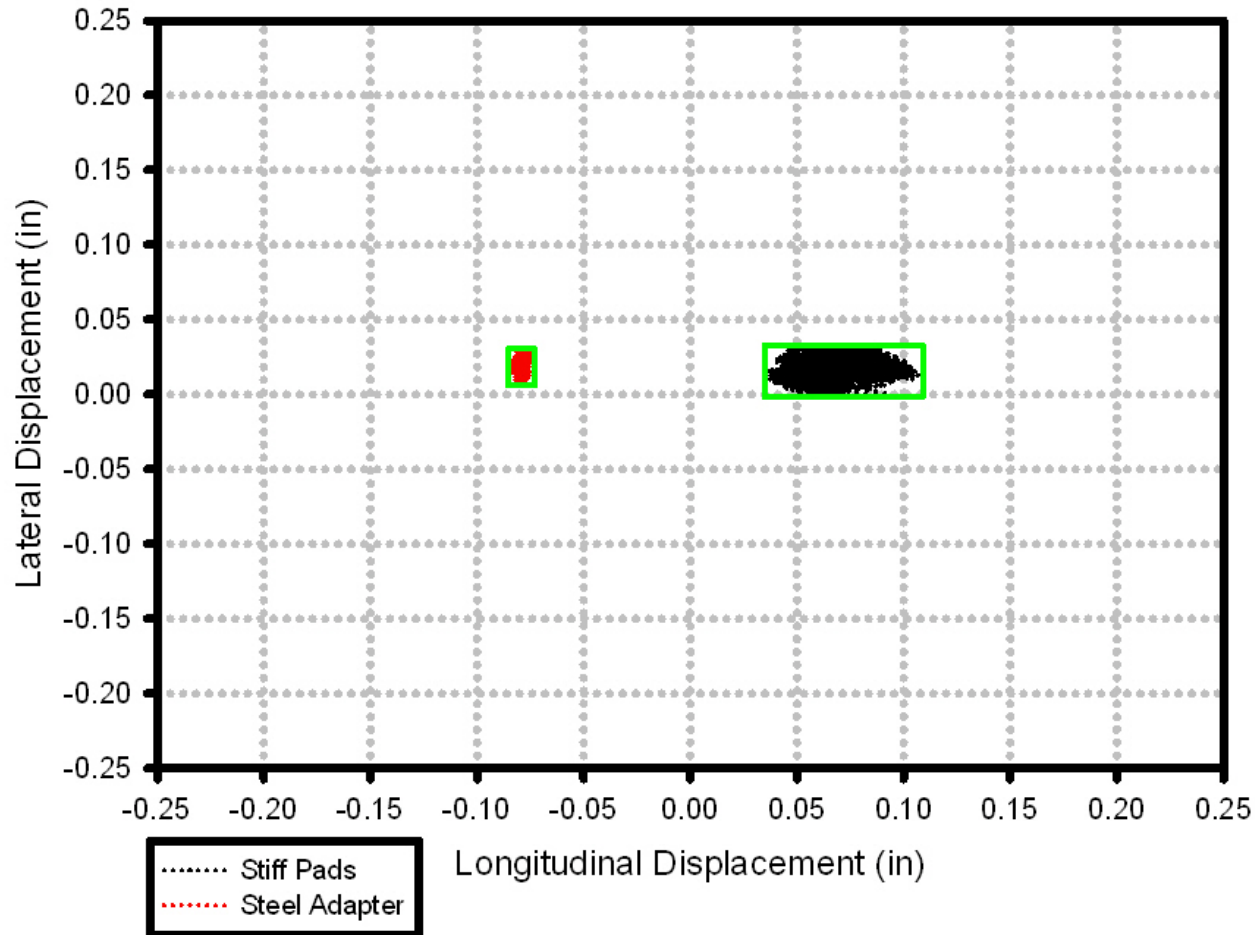
L1 Adapter Motions Comparison of Standard Pads vs. Steel Adapter 55mph Loaded Car Hunting Speed



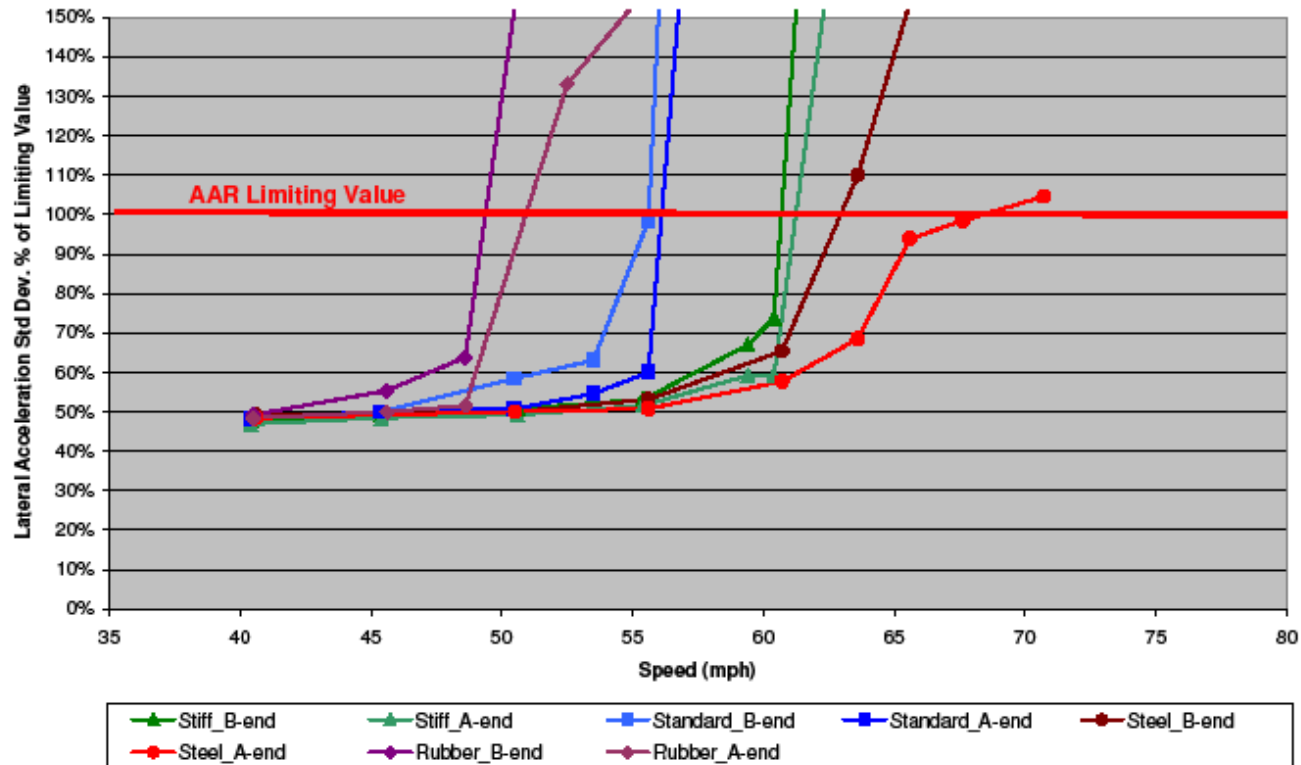
L1 Adapter Motions Comparison of Rubber Pads vs. Steel Adapter 55mph Loaded Car Hunting Speed

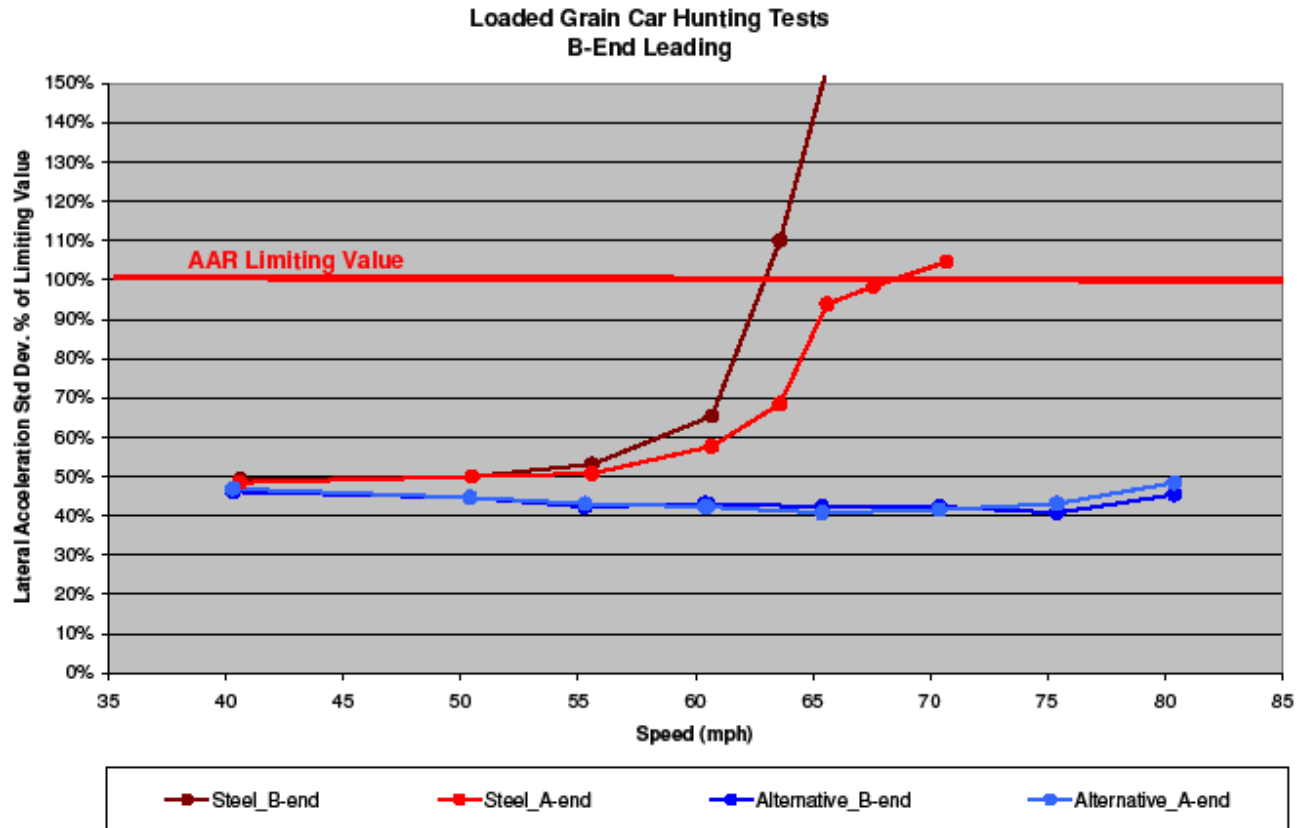


L1 Adapter Motions Comparison of Stiff Pads vs. Steel Adapter 55mph Loaded Car Hunting Speed



Loaded Grain Car Hunting Tests B-End Leading



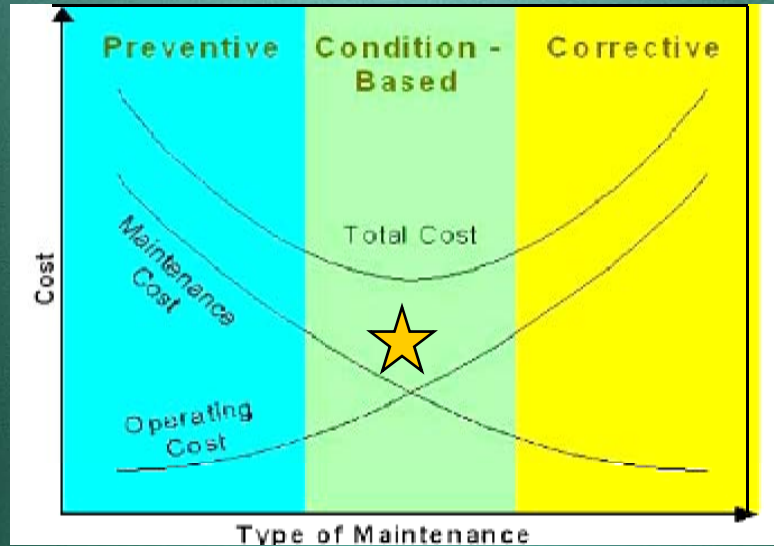


- Softer pad material = higher deflections
- Stiffer pad material = lower deflections
 - Less movement per pound of force
 - Less energy input - reduced hysteretic heating
 - Increase in hunting threshold
- Metal adapters in same car series and service showed uneven wheel / flange wear; M-976 trucks showed more even wear
- Solution = Stiffer pads with higher friction center bowl liners surviving in actual service; maintaining benefits of curving and even wear
- Alternatives exist to mitigate hunting and associated wheel tread scrubbing

- Heavier loads and longer trains = increased wear and tear
- Inspection is required to determine necessary repairs, and/or...
 - Wayside detector, TPD or WILD setouts
 - Scheduled (Preventive) maintenance
 - Reactive (Corrective) maintenance
 - Alternatives?
- Maintenance budgets are tight, but asset utilization and uptime are critical

Preventive Maintenance

- **Scheduled** maintenance based on life statistics of similar equipment
- **High** maintenance costs - **unnecessary** maintenance
- **Low** operating costs – limited downtime scheduled



Corrective Maintenance

- **Reactive** maintenance - run equipment to **failure**; **no** scheduled maintenance
- **Low** maintenance costs – performed only **after** failure
- **High** operating costs – downtime and damage

Condition Based Maintenance

- * Maintenance only **when required**
- * Availability of the equipment is guaranteed
- * Extends useful life of equipment

- * Unnecessary maintenance is avoided
- * **Overall cost** is reduced

but...

- * Condition monitoring **adds cost**

- Preventive maintenance may prevent some failures, but premature failures still occur
- **Corrective maintenance** promises lower costs, but cost of reaction to failures is high
- Benefits of **CBM** strategy ★
 - Lower operating costs
 - Extend useful life of equipment
 - Increase productivity and maximize asset uptime
 - Increase network velocity and reduce congestion
- Execute **CBM** strategy
 - Consider operating environment
 - Measure and analyze parameters real-time
 - Relay message to effect maintenance or repair (pre-emptively – *before* a failure occurs)

- A Condition Based Maintenance strategy should enable improved asset utilization and lower maintenance costs
- Knowledge of maintenance issues and volume will accelerate with CBM
- We can expect a better life cycle cost with CBM than is realized with current practices
- Diagnostic / prognostic technologies are progressing rapidly and becoming feasible and cost-effective