Amsted Rail

Mechanical Association Railcar Technical Services

Loaded Car Hunting and Suspension Systems

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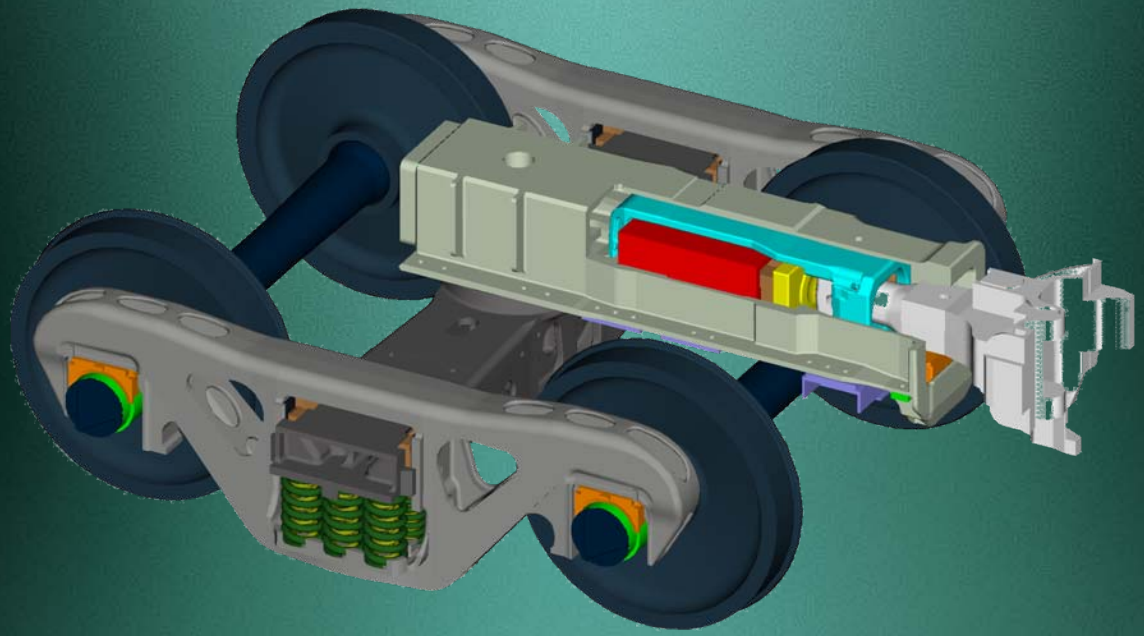
Loaded Car Hunting



Suspension, vehicle and track are a system

Demand for Productivity Increases

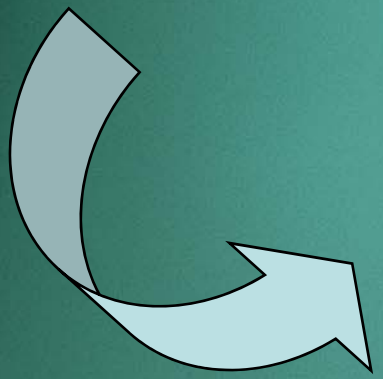
- Increased train velocity and improved asset utilization …
  - Longer trains
  - Heavier car loads
  - More lading per railcar / higher C.G, etc.

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

= More demanding operating environment

Many Moving Parts - Wear and Tear

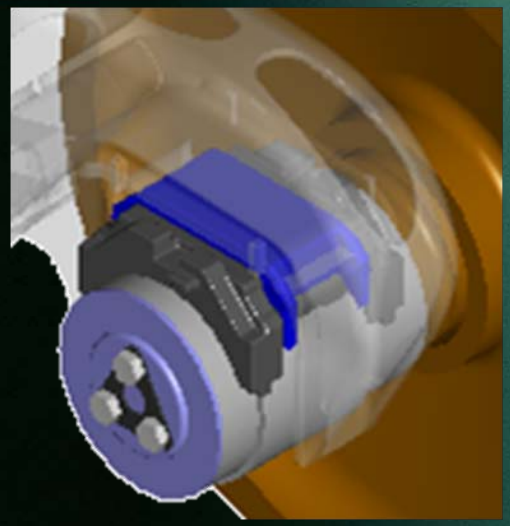
- System interaction impacts performance
  - Suspension and coupling systems
  - Freight car structure and body
  - Track systems and operations
- Desired component and system attributes
  - Quality / integrity / reliability
  - Reduced in-service failure and downtime
  - Long life / low maintenance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



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

Operating environment is a complex system

Truck System Performance



More demanding environment

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Truck system performance

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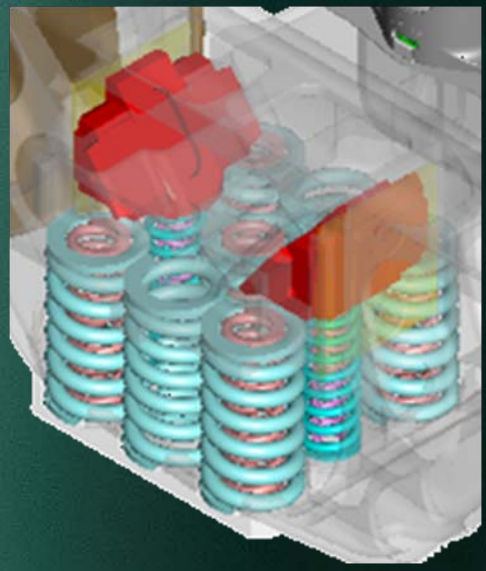
AAR Specification M-976



Steering

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Curve negotiation with minimal effect on high speed stability

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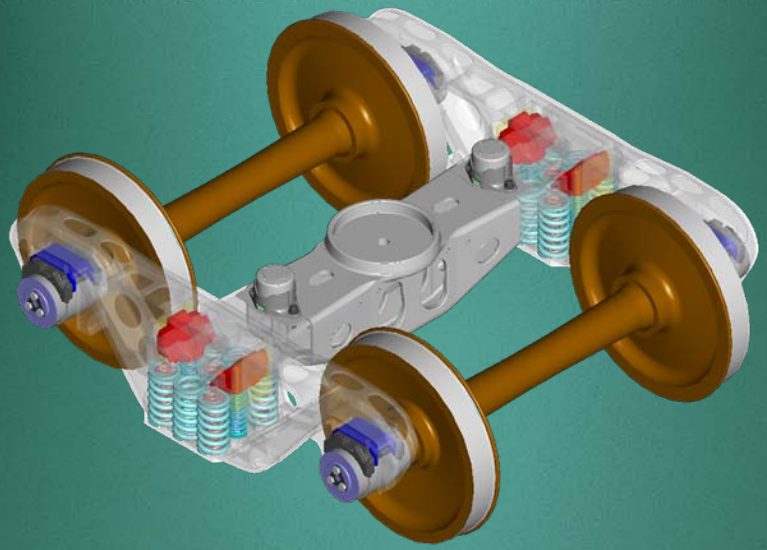
Reduced wheel and track wear



Suspension

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Damping of vertical and lateral inputs; truck squaring

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Reduced impact of loading conditions

M-976 Performance Requirements

- 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

Key Truck System Components

- 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

Passive Steering System

- 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

Reduces truck component loads and wear

Adapter Plus Bearing Adapter

- 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)

The Problem

- ~ 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

System Testing

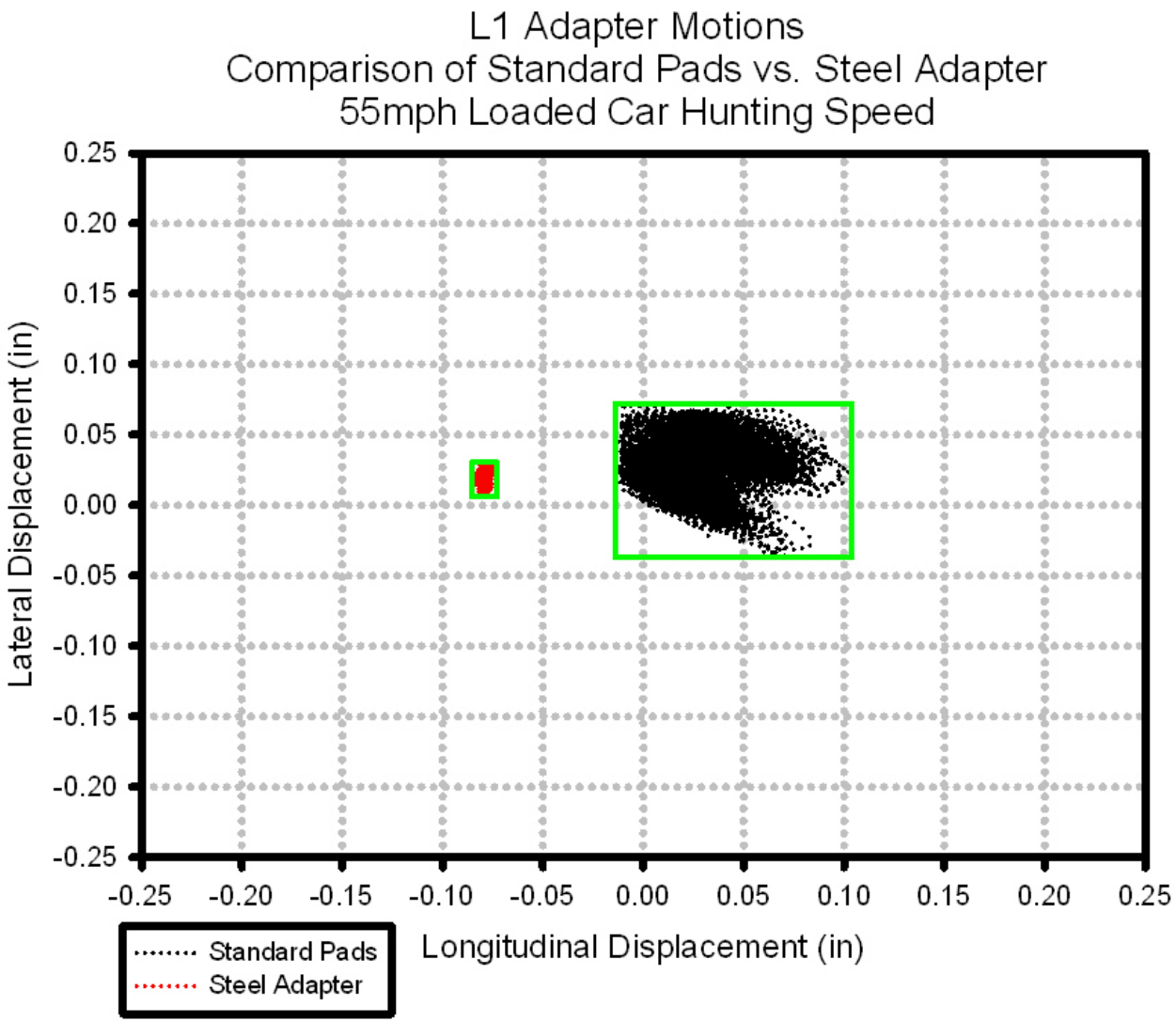
- Field testing in revenue service
  - Instrumented car in Granite City, IL
  - Started in November 2006
  - Loaded hunting evident during instrumented trips, 50 – 60 mph speed
  - New wheelsets – hunting eliminated; worn wheel profiles impact hunting modes
  - Imbalanced loading affects stability
- 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

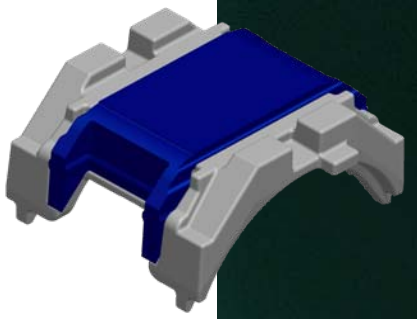
Approaches to LCH problem

- 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

Motion Control ® Testing at TTCI





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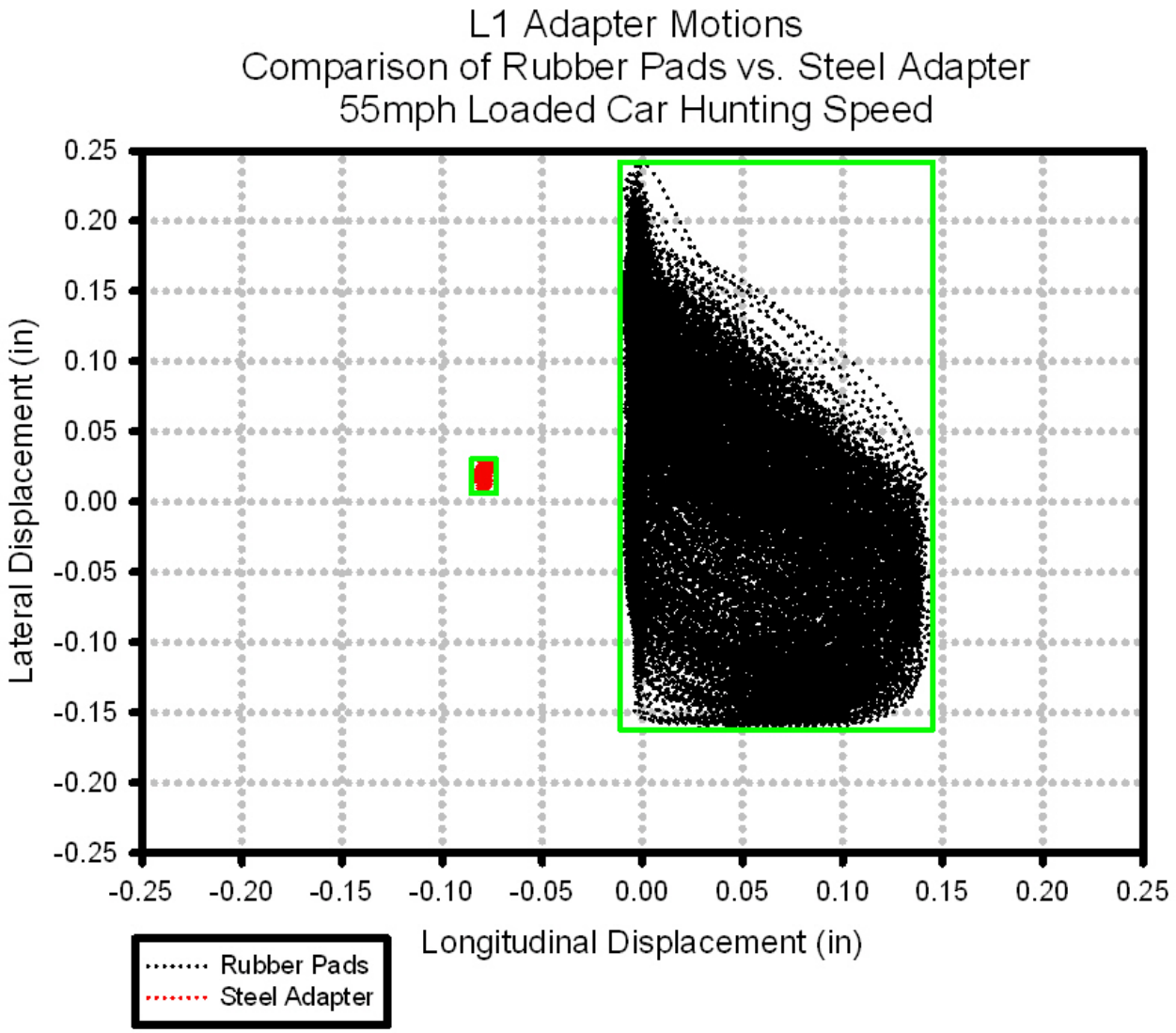

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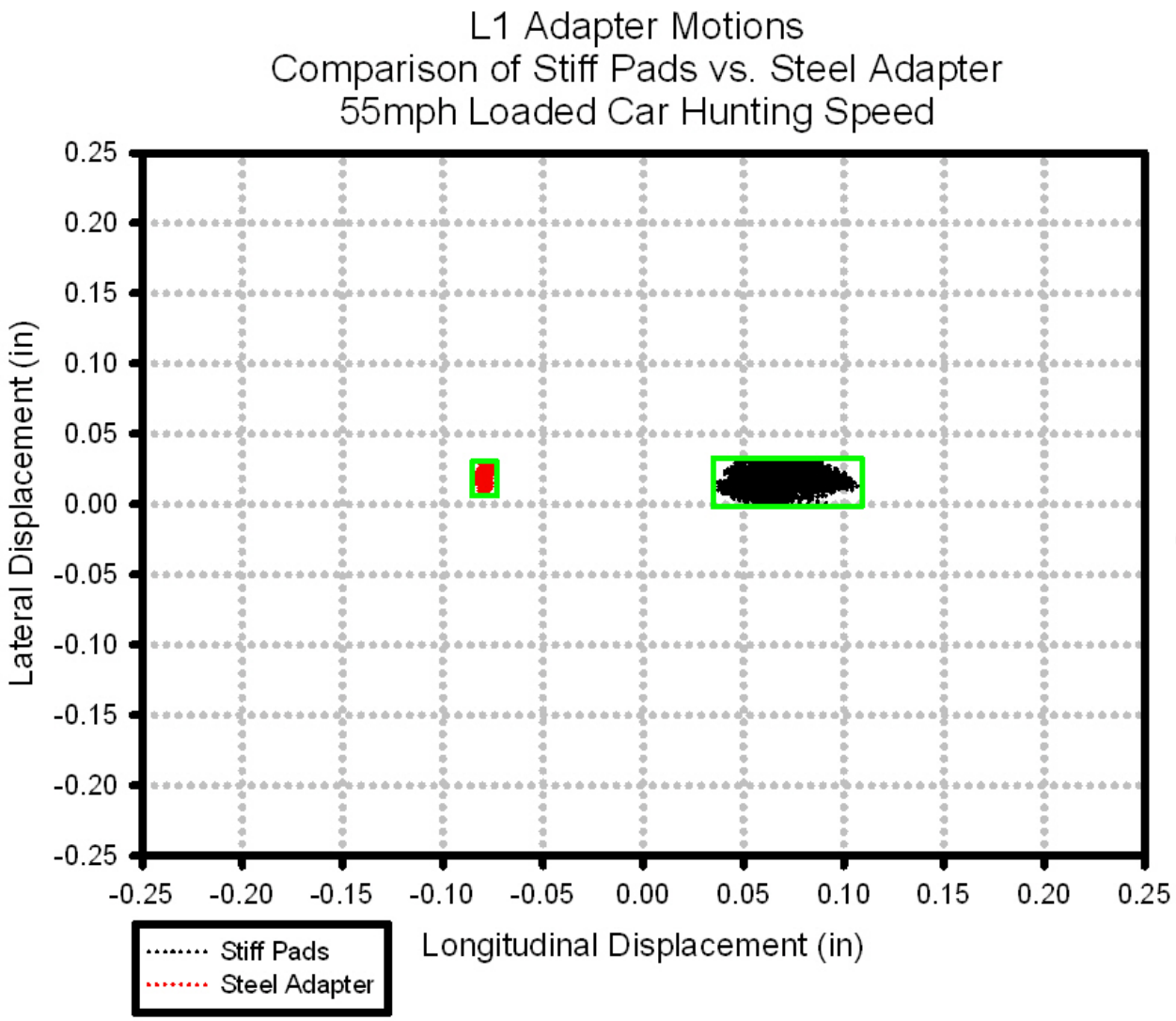

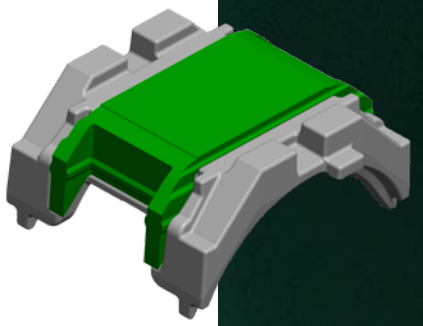

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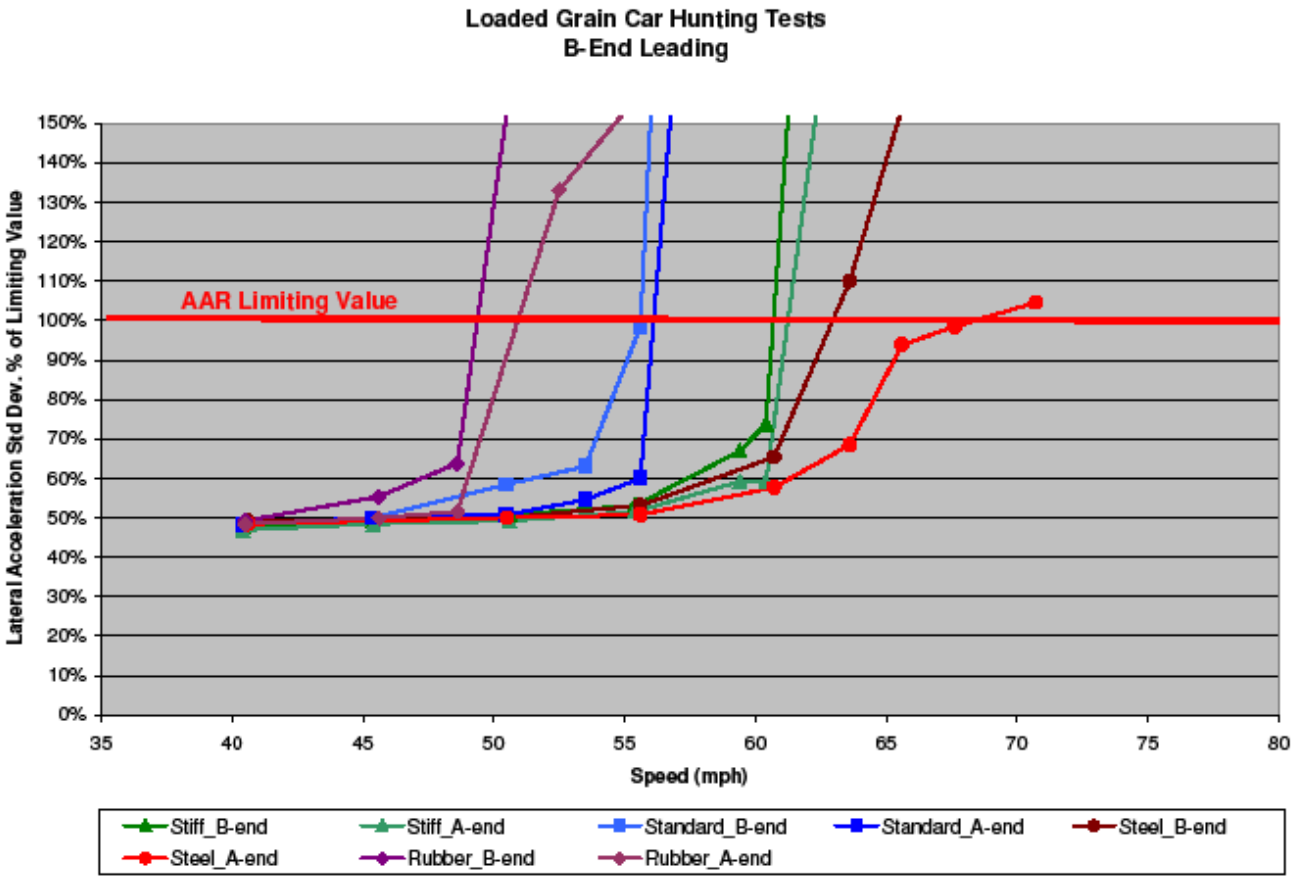

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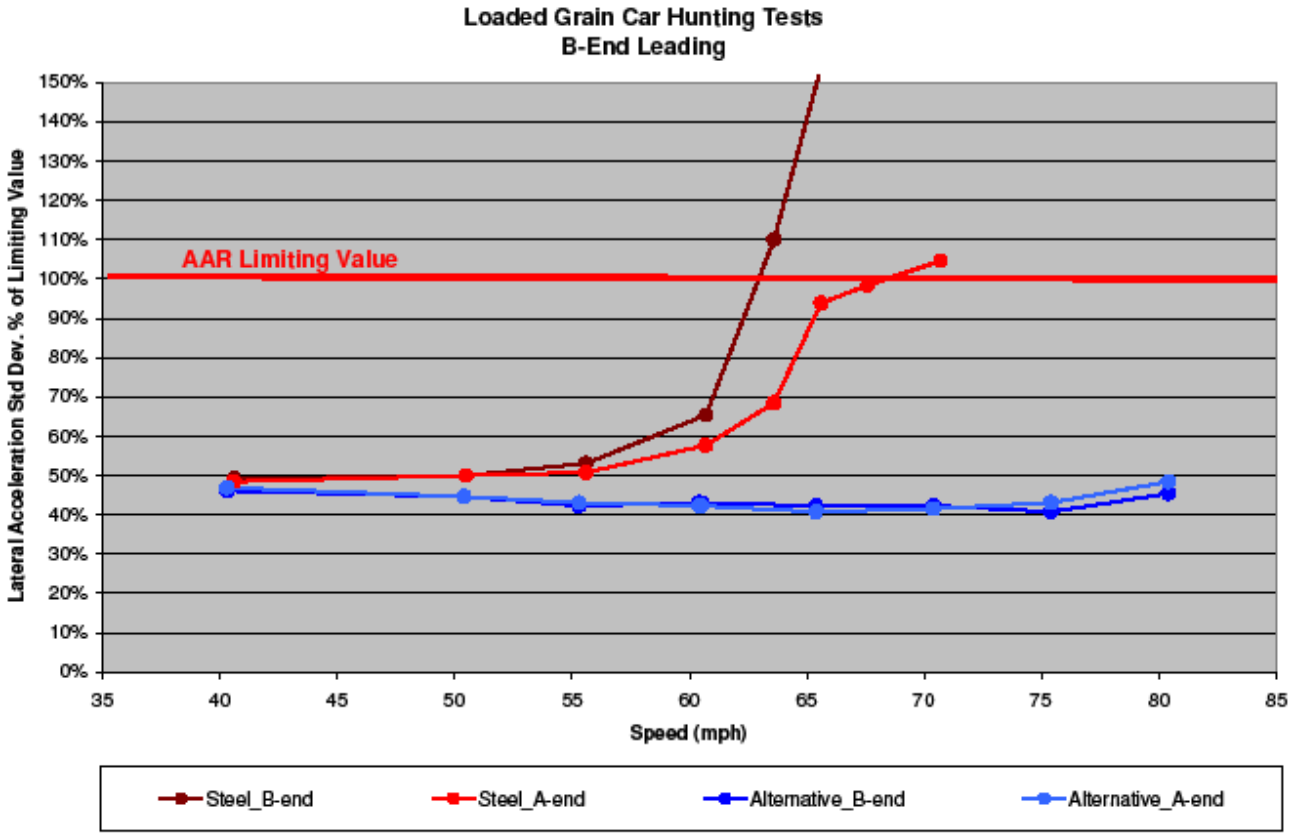


Findings

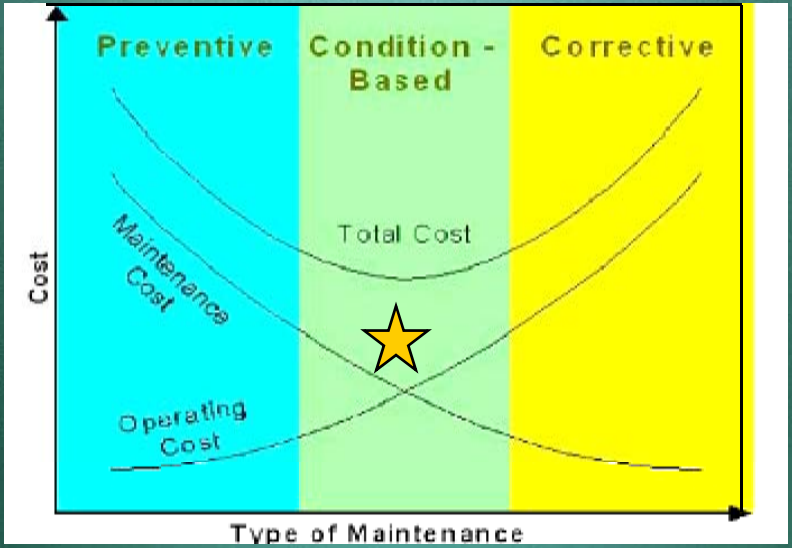
- Softer pad material = higher deflections
- Stiffer pad material = lower deflections
  - Less movement per pound of force
  - Less energy input - reduced hysteretic heating
  - Increase in hunting threshold
- Metal adapters in same car series and service showed uneven wheel / flange wear; M-976 trucks 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

Maintenance Philosophy

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

but…

* Unnecessary maintenance is avoided
* ***Overall cost*** is reduced
* Condition monitoring ***adds cost***

Condition Based Maintenance (CBM)

- 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)

Fleet Maintenance with CBM

- 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