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Fuel Efficient Bearing Systems

Presented by
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Synopsis

- Summarize resistive forces that exist in freight rail cars
- Narrow our focus to an evaluation of rolling resistance in loaded journal bearings
- Share our analysis of these findings to then identify the key features in selecting fuel efficient bearing systems

Train Energy

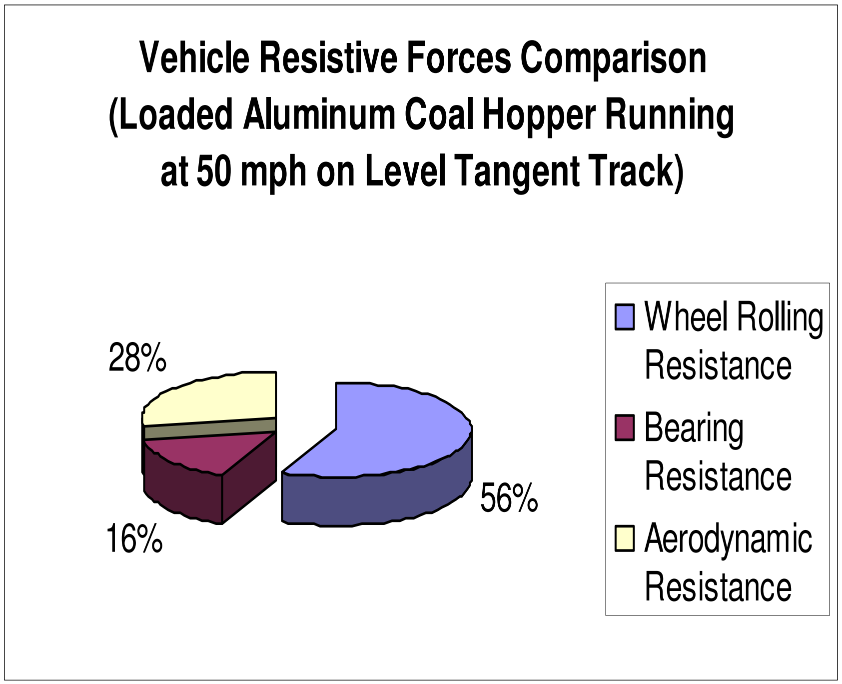
- Locomotive power provides the pulling (pushing) force for the railcars.
- As the train moves much of the generated power is dissipated by the various parts of this complex mechanical system.
- Engine power is lost in:
  - transmission
  - vehicle slip
  - overcoming motion resistance

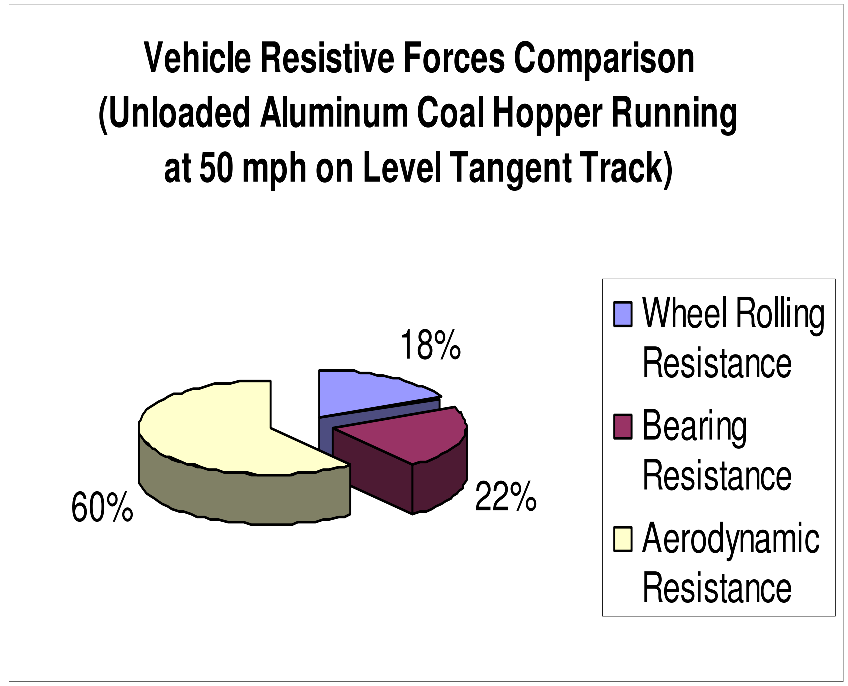
Contributors to Loss of Motive Force

- **No control exists over some resistive forces:**
  - wind speed or direction
  - the established track grade
  - physical effects due to outside temperature.
- **Operating requirements or practices set others:**
  - rate of acceleration
  - use of rail lubrication
  - braking forces.
- **Equipment design features establish a third group:**
  - engine operating efficiencies
  - the equipment's aerodynamic features
  - achieved traction versus undesired drag.

AAR Train Energy Model (TEM)

- TEM model evaluated the vehicle's resistance under various standard operational scenarios.





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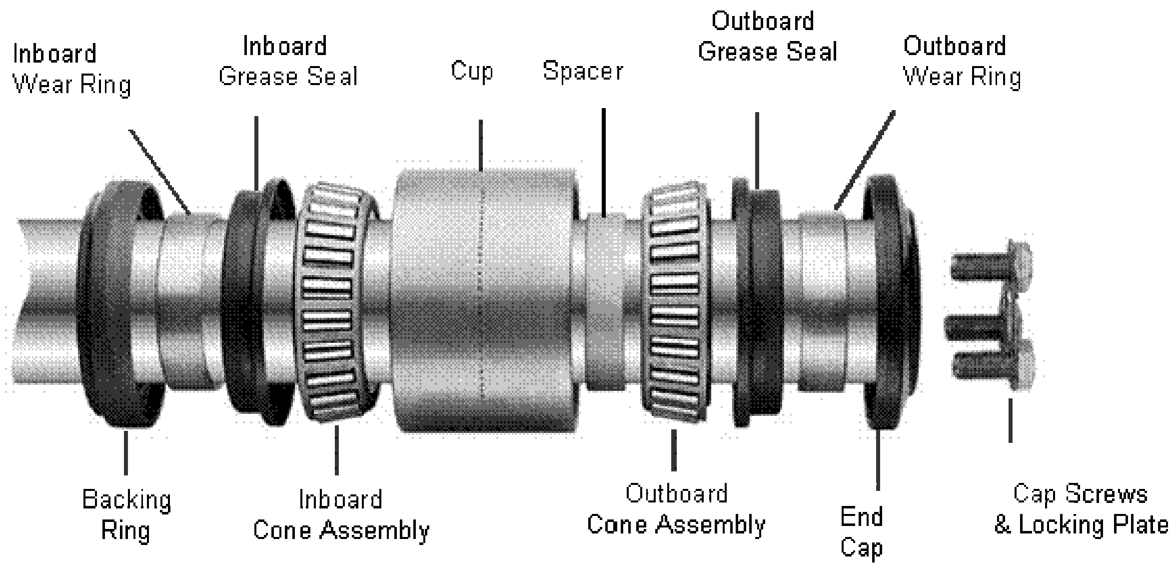
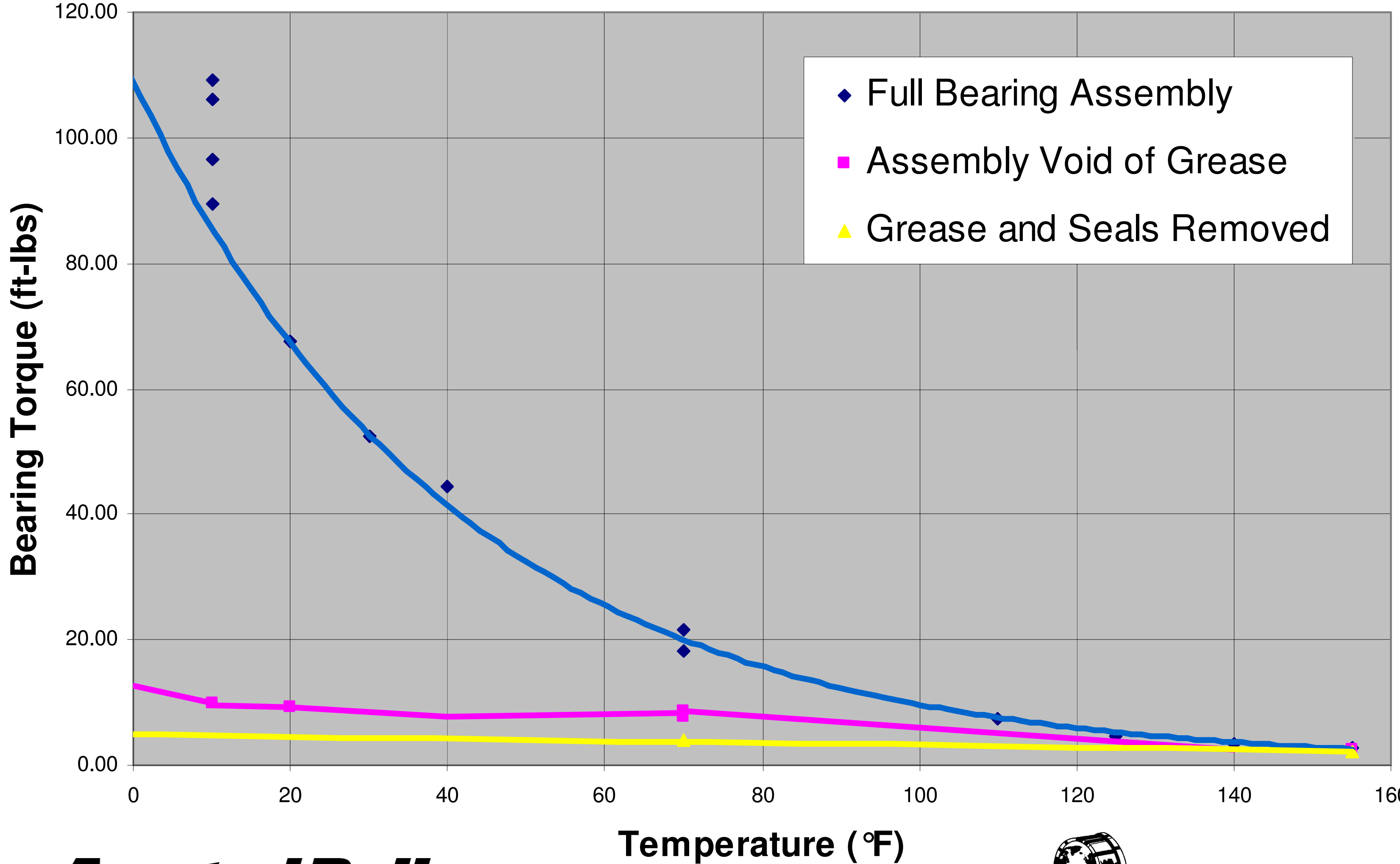
Bearing Rolling Resistance

- The sources of tapered roller bearing turning resistance are generated in three areas:
  - **rolling/sliding contact** including cage interactions
  - **lubricant effects** such as churning and viscous drag
  - **seal drag**



Temperature vs. Start-Up Torque



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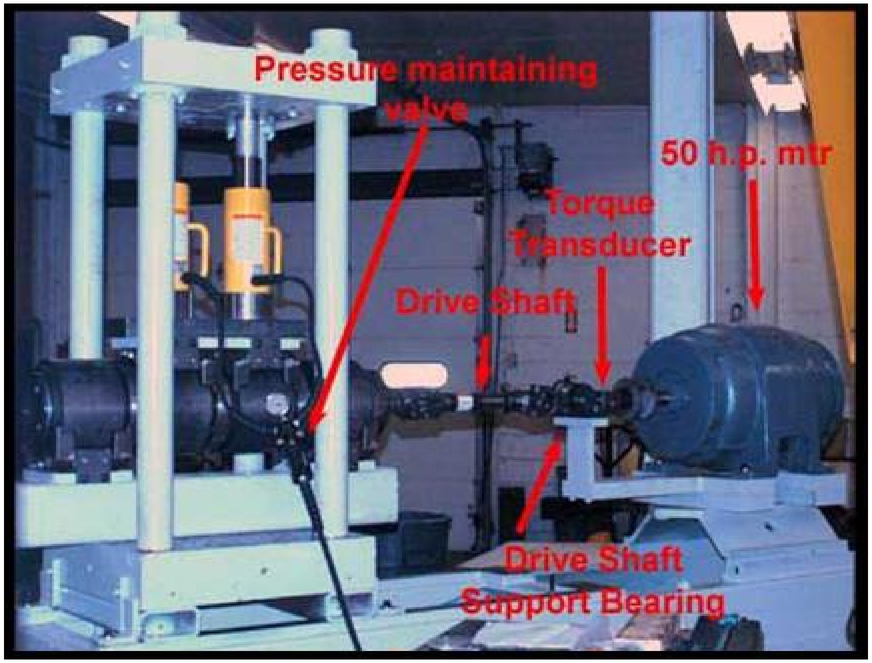
Rail Sciences Loaded Bearing Test

Evaluation by an Independent Test Laboratory



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Test Procedure

- Test at three loads.
  - 1,200 lb per bearing (low load)
  - 5,200 lb per bearing (empty car)
  - 35,700 lb per bearing (286,000lb car)
- Test from 5 mph to 80 mph
  - (36-inch diameter wheel)
- Initial bearing run-in 15,000 miles

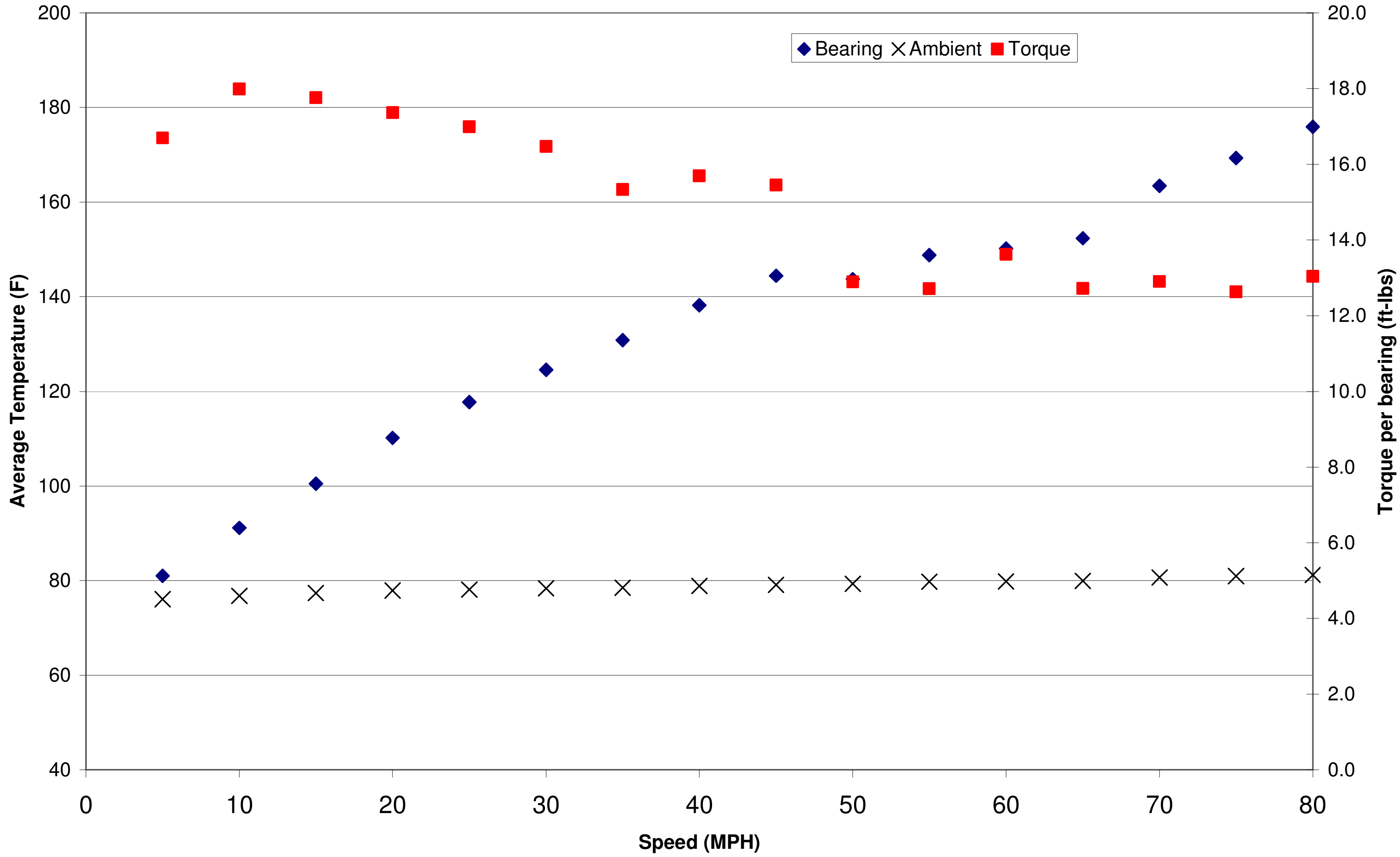
Test Procedure (continued)

- Beginning of Test
  - 5 mph
    - Run for 5 minutes
    - Check average bearing temperature
      - Check for temperature increase of less than 0.07°F/min
      - Data is collected at 2 Hz for 2 minutes
      - Results averaged 120 samples
  - Speed increased by 5 mph and procedure repeated
- Entire 5 to 80 mph test is repeated on same bearings with seals removed.

Observations

- Under these conditions,
  - Torque increases with:
    - Increasing load
    - Increasing speed
    - Decreasing temperature
- Bearings were allowed to reach 'their own' steady-state temperature.
  - Simple example of what happens when a bearing hunts for its steady state temperature.
    - Torque -> heat -> lower torque -> lower heat ->higher torque-> etc.

Typical Bearing Data



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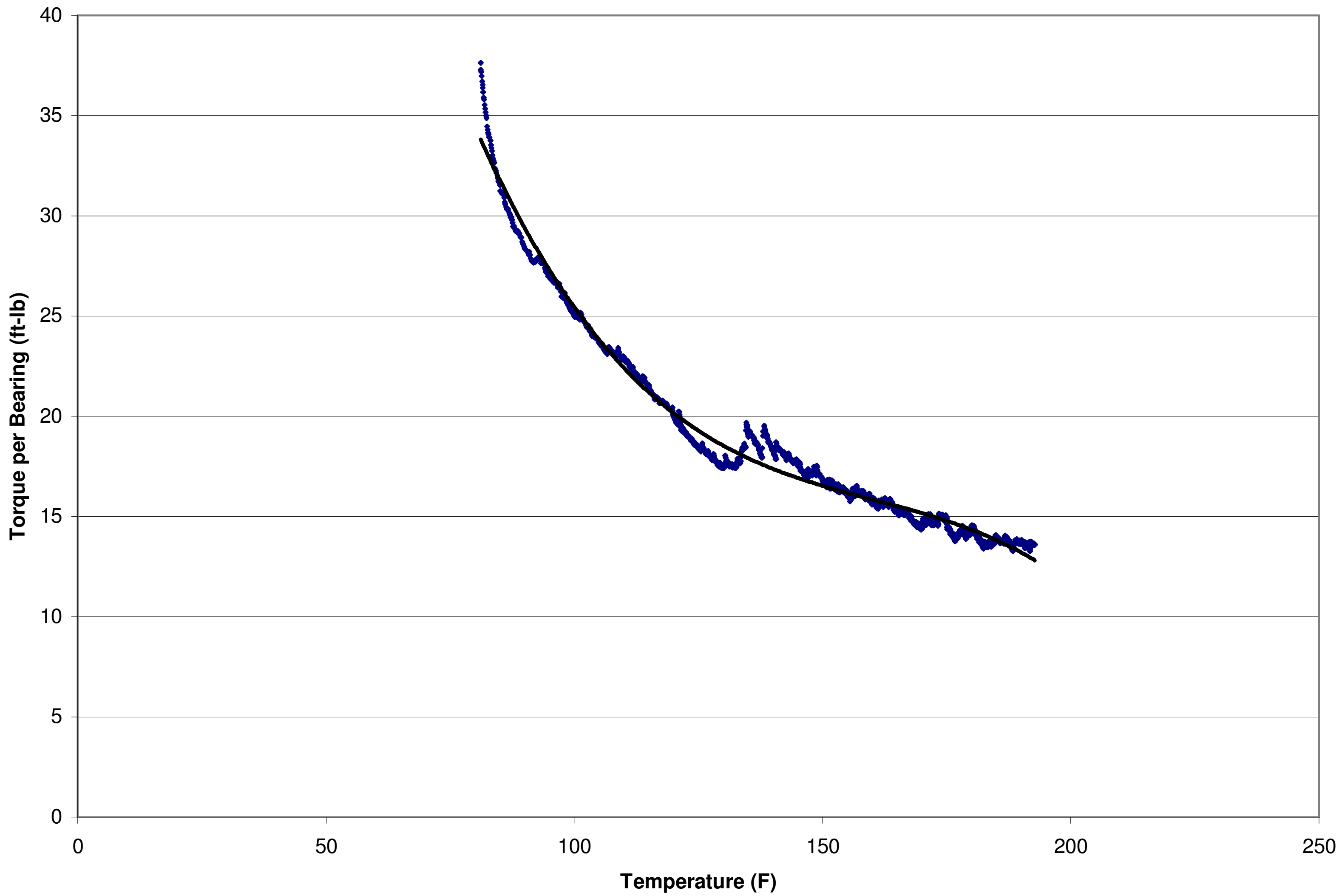
Typical Torque versus Temperature



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RSI General Test Conclusions

- The bearing test rig has repeatability and reproducibility in measuring the rotational resistance of the test bearings.
- The greatest controlled variable to rotational resistance is **load applied** on the bearing.
- The largest influence on rotational resistance is **temperature** of the bearings.
- Contribution to rotational resistance from the seals is approximately **constant with respect to rotational speed** at a given load.
- The [percentage] contribution of rotational resistance due to seals decreases with an increase in load.

RSI Torque & Temperature Findings

- The Brenco Class F bearings with labyrinth seals on average **stabilized at a significantly lower temperature** than the Brenco Class F bearings with either optimized/no garter spring **(11ºF)** or standard **(22ºF)** radial lip seals.
- The Brenco Class F labyrinth seals averaged **1.0 lb.ft. less torque** per bearing than the Brenco Class F with optimized /no garter spring seals and **2 ft.lbs. less torque** per bearing than the standard radial lip seals at equivalent temperatures.
- Overall, the Brenco Class K labyrinth seals **require 1.4 lb.ft. less torque** per bearing than the Brenco Class K optimized radial lip seals.

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Fuel Consumed and Operating Cost Comparison for Available Class K Seals

Bearing and Seal Type	RSI Bearing Testing		Fuel Consumption	Operating Cost
	Seal Torque (ft-lb/set)	Seal Temp (ºF)	Fuel/Mile (Gal/mile)	Annual Fuel (Dollars)
Competitor A - Premium Class K	3.2	13.7	3.04E-4	60.80
Competitor A - Standard Class K	4.7	23.4	4.465E-4	89.30
Competitor B - Premium Class K	5.9	39.35	5.60E-4	112.10
Competitor C - Premium Class K	3.45	28.8	3.278E-4	65.55

- **46% savings** in fuel due to seal drag from lowest to highest torque design
- Equates to $50 savings per bearing per year at fuel cost of $2.00 per gallon

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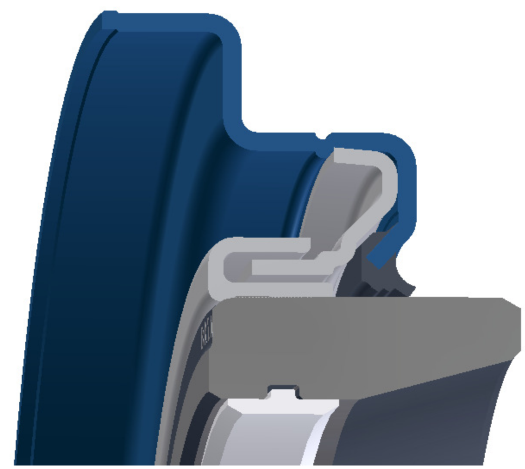
Findings from TEM Simulation

- Western coal route simulation results
- Low torque labyrinth vs. standard established for radial lip seal equipment
- 1.6% TEM calculated fuel savings
- 0.4 gallons per 1000 miles per bearing



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Areas Identified for Improvement

- Roller bearings have a direct effect on the operating efficiency of a train
- The three most critical items to achieve more fuel efficient bearings are:
  - high reliability bearing components to eliminate unscheduled train stops
  - grease selection for cold climates
  - seal selection for high utilization services

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