Minimizing Lubricant-Ash Requirement and Impact on Emission Aftertreatment Systems via an Oil Conditioning Filter

Simon A.G. Watson and Victor W. Wong, *MIT*

Darrell Brownawell and Scott P. Lockledge, *Lutek LLC.*

2007 Diesel Engine-Efficiency and Emissions Research (DEER) Conference
August 15th, 2007

Basic Problem and Motivation

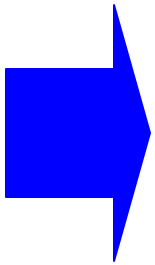
- What is the optimum level of SAPS (from additives) in future oils for adequate engine protection and minimal impact on aftertreatment systems?

- Are there technologies that effectively supplement additive function and increase engine protection

Acid
The Root Cause of Many Lubricant Problems

SOURCES

- Combustion
  - N, S and C-based acids
- Oil Oxidation
  - C-based acids



PROBLEMS

- Corrosion and Wear
- Sludge
- High Viscosity
- Varnish
- Piston Deposits

In most cases – Acid Control Determines Lubricant Life

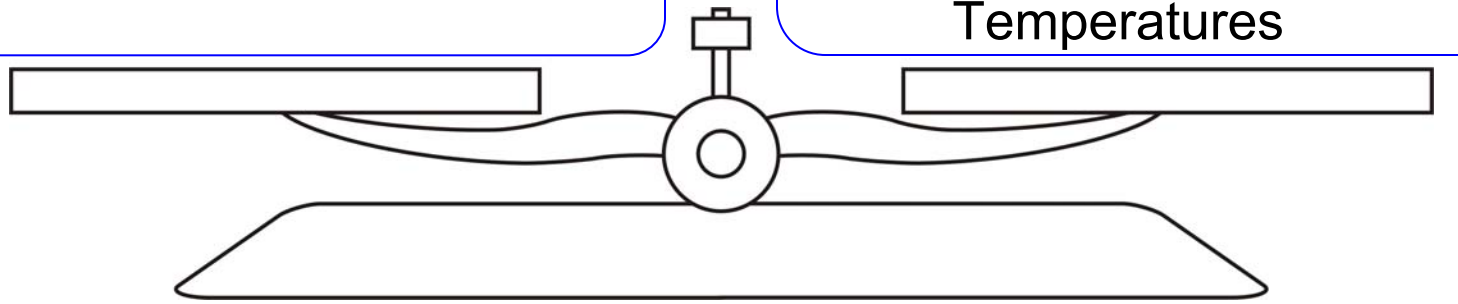
2007+ Emission Control Technologies: Acid Generation and Control

EGR

- Contributes to acid:
  - Exposure (via recirculation)
  - Generation (via Higher Oil Temperatures

ULSD

- Reduces acid:
  - Less S-based acids



- Acid is still key, despite changes in fuel composition and NOx formation
- Greater opportunity for S and N-based acids to reach the lubricant
- More C-based (weak Carboxilic) acids

2007+ Emissions Control Technologies: Acid-Related Aftertreatment Issues

- Lubricant ash neutralizes combustion acid, but fouls DPF's
  - DPF fouling shortens aftertreatment life and increases pressure drop
- New lubricant classification for 2007+ engines is a compromise between lubricant ash and oil drain interval
    - CJ-4: First chemical limits on lubricant ash
  - Oil drain intervals remain the same at best
  - There is a tradeoff between oil drain interval and aftertreatment system life

Old Technologies to Enhance 2007+ Engine Lubrication Systems

- Slow Release Additives
  - Gelled Dispersant/Detergent/Anti-oxidant
  - 25% ash
  - Conflicts with CJ-4 SAPS limits?
  - DPF fouling?

A New Technology to Enhance 2007+ Engine Lubrication Systems

- Strong Base Filter
  - Strong base is anchored in the filter
  - Strong base in filter immobilizes acids
  - Releases nothing
  - Selectively sequesters acids only
  - Removes acids from the used lubricant

Test Program

- Long-duration steady-state testing to examine the effectiveness of the Strong Base (SB) Filter
- Two long-duration tests:
  - Test 1 - Standard oil filter (chemically inert) - 318 hrs
  - Test 2 - Strong base filter – 750 hrs

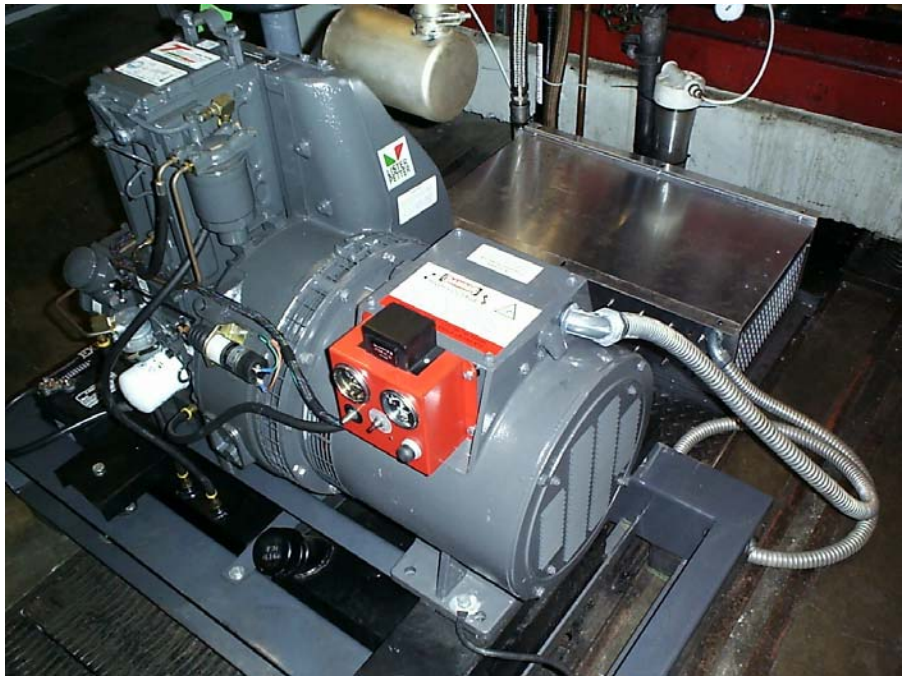
Test Parameters

Load	100% Full Power
Speed	1800 rpm
Fuel	15 ppm S Diesel
Oil Grade	SAE 40W
Sulfated Ash	1.4%

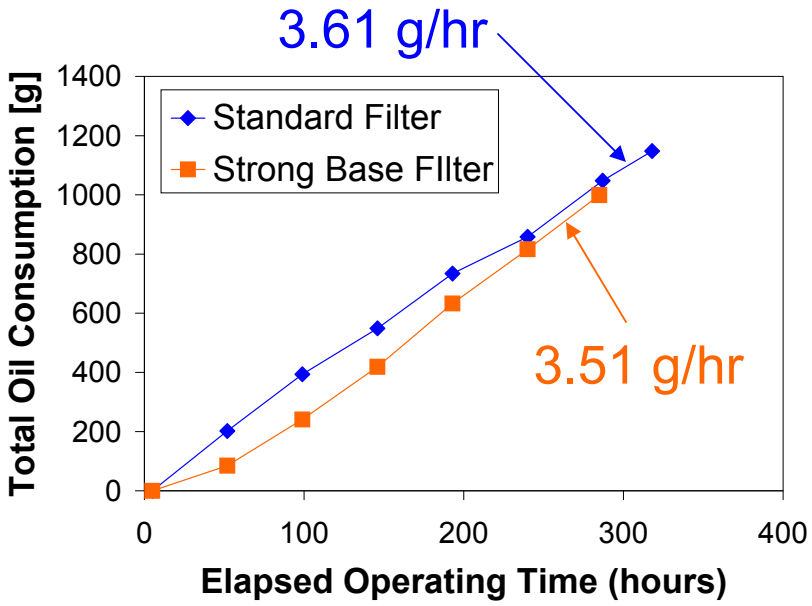
Test Engine

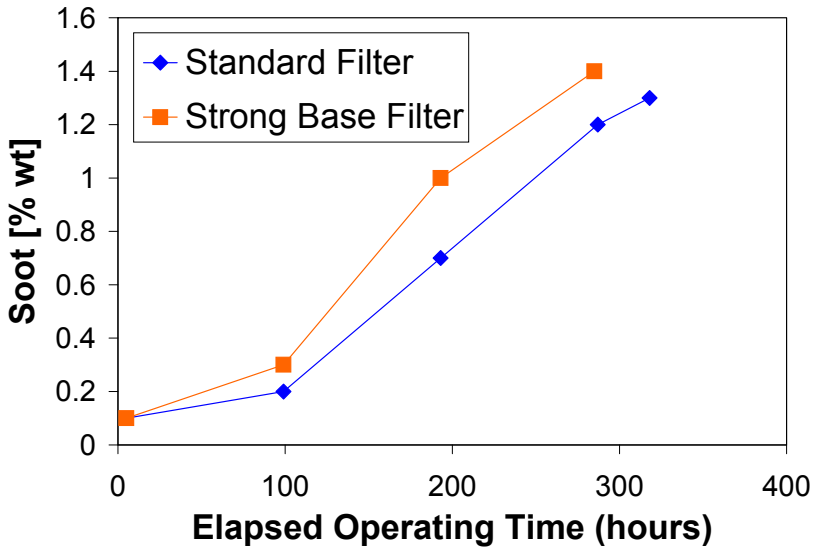
Lister Petter TR1 Generator Set

- Specifications:
  - Single Cylinder
  - Maximum Power 5.5 kW
  - Displacement 0.773 L
  - Naturally Aspirated
  - Direct Fuel Injection
  - No EGR
  - Sump Capacity 2.4 L



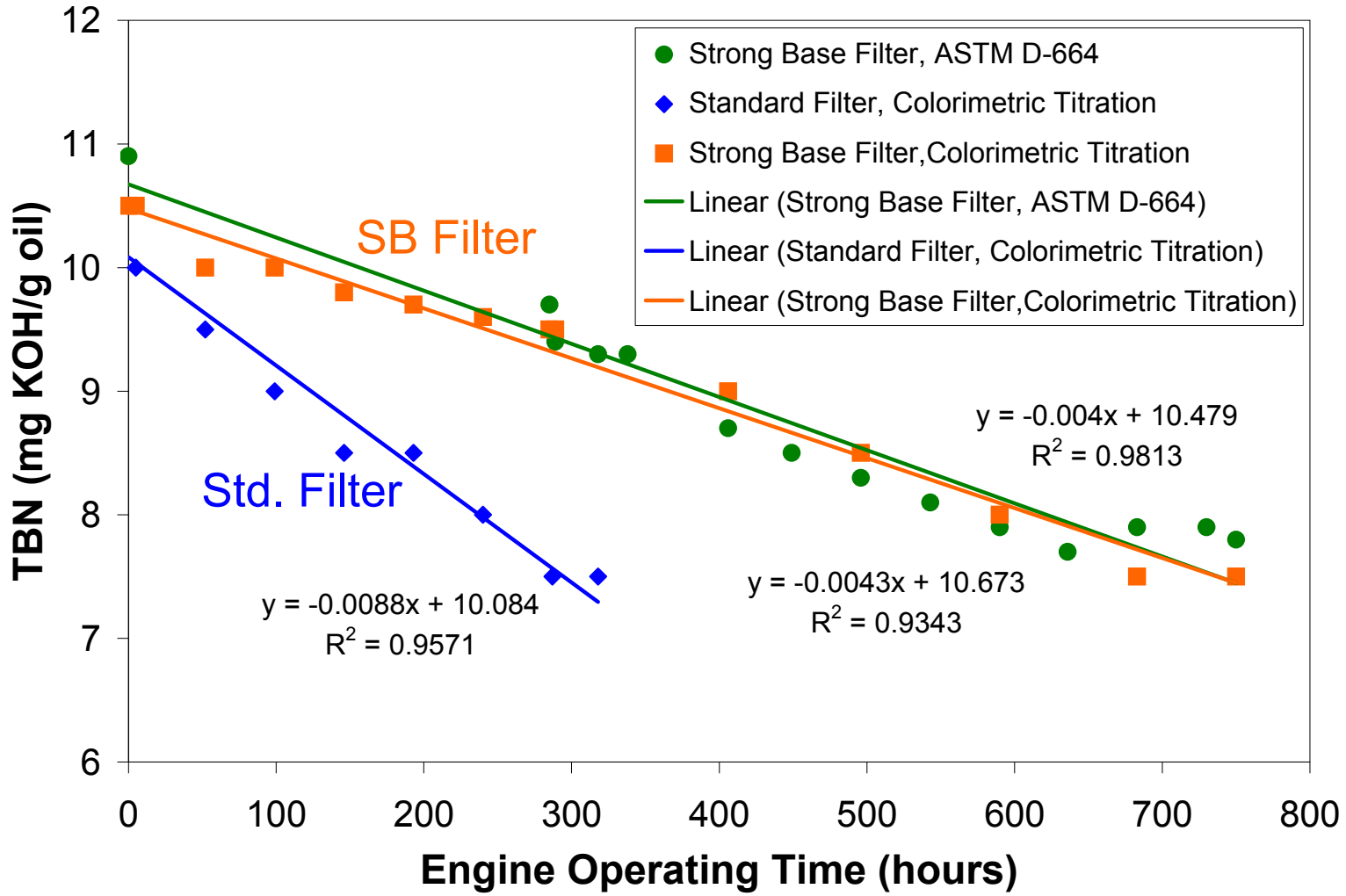
Similar Engine Conditions in Both Tests



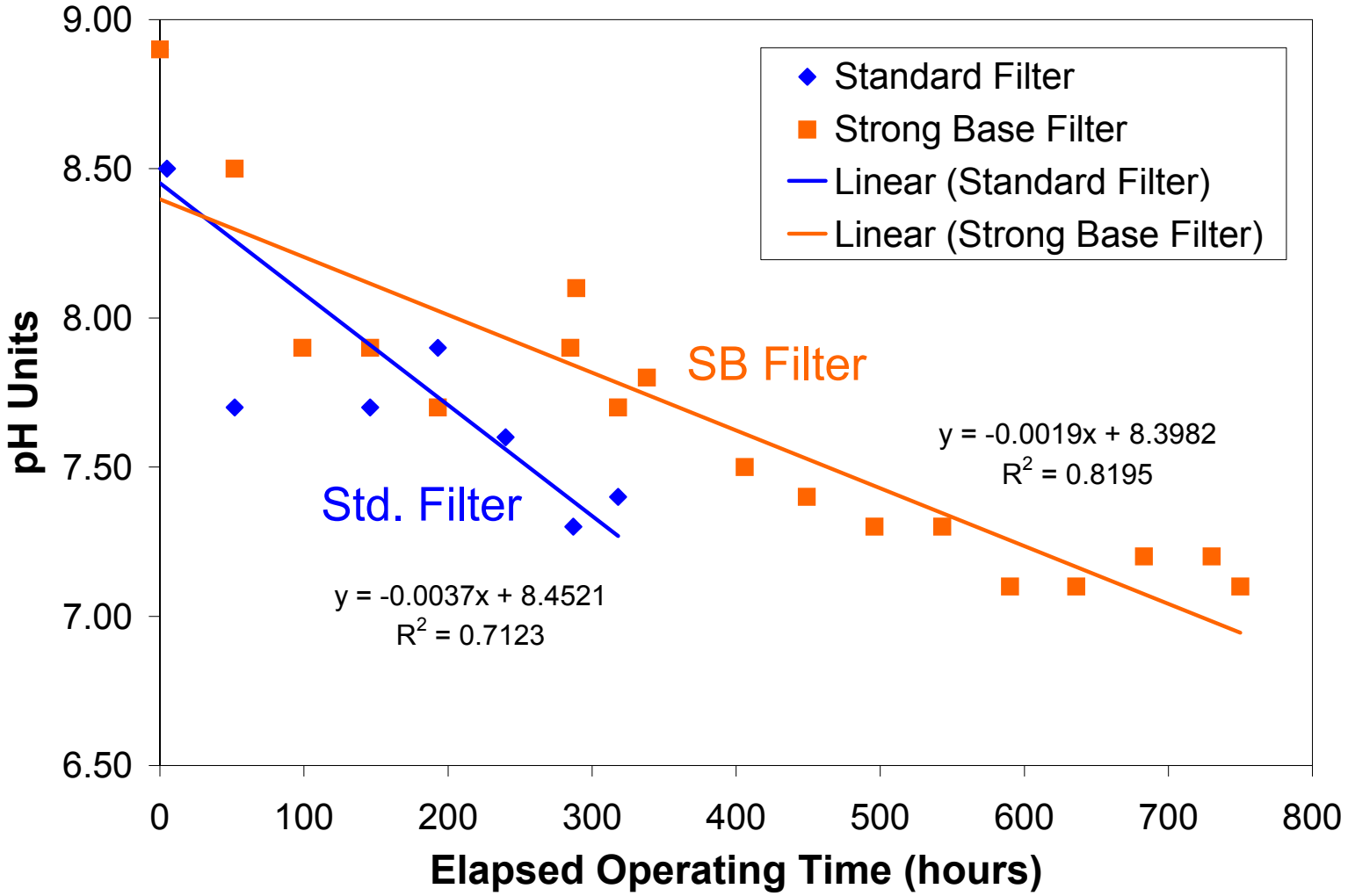


- Mean oil temperatures in both tests are equal
- Mean fuel consumption in both tests are equal

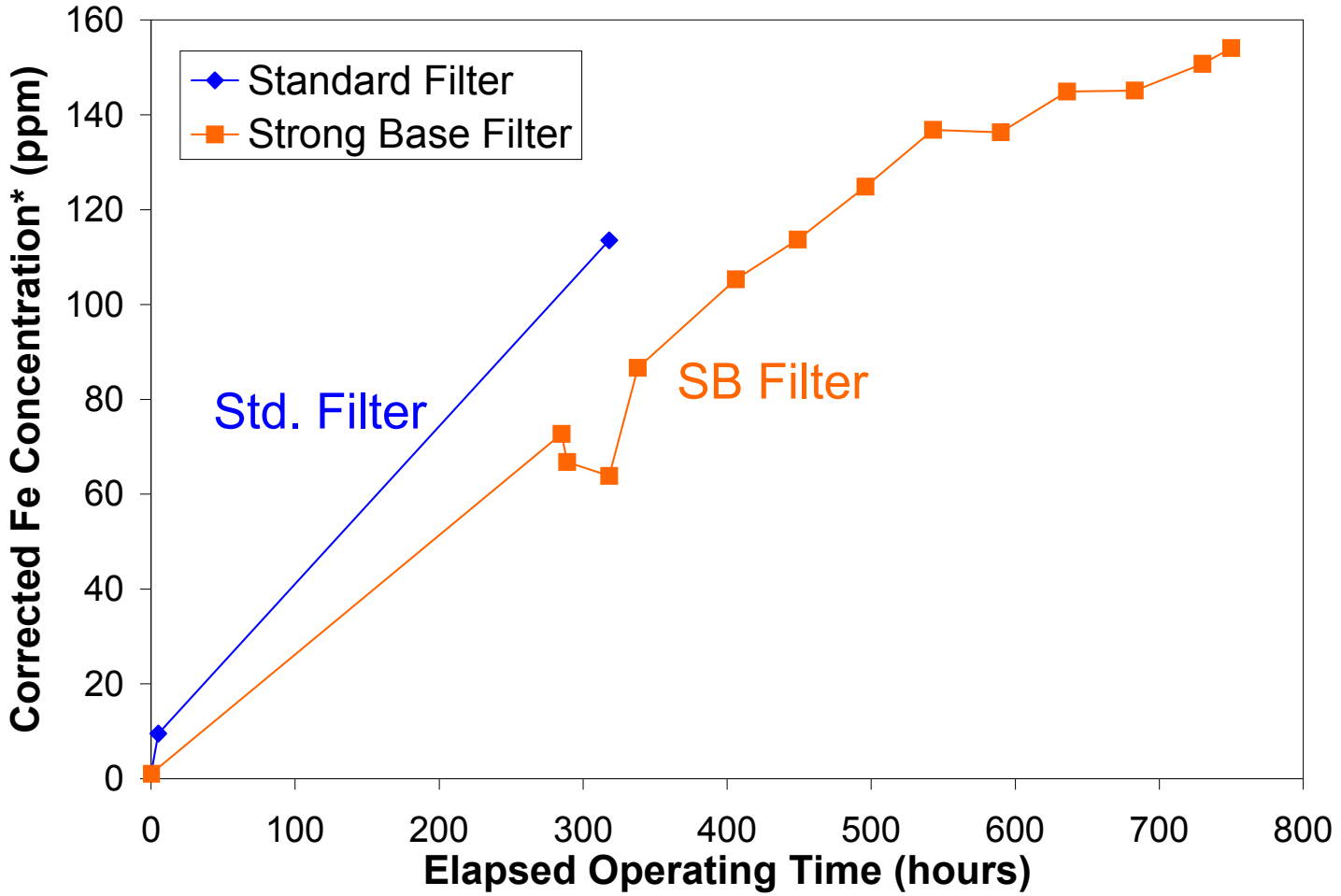
Improved Total Base Number Retention



Lower Acidity in the Lubricant

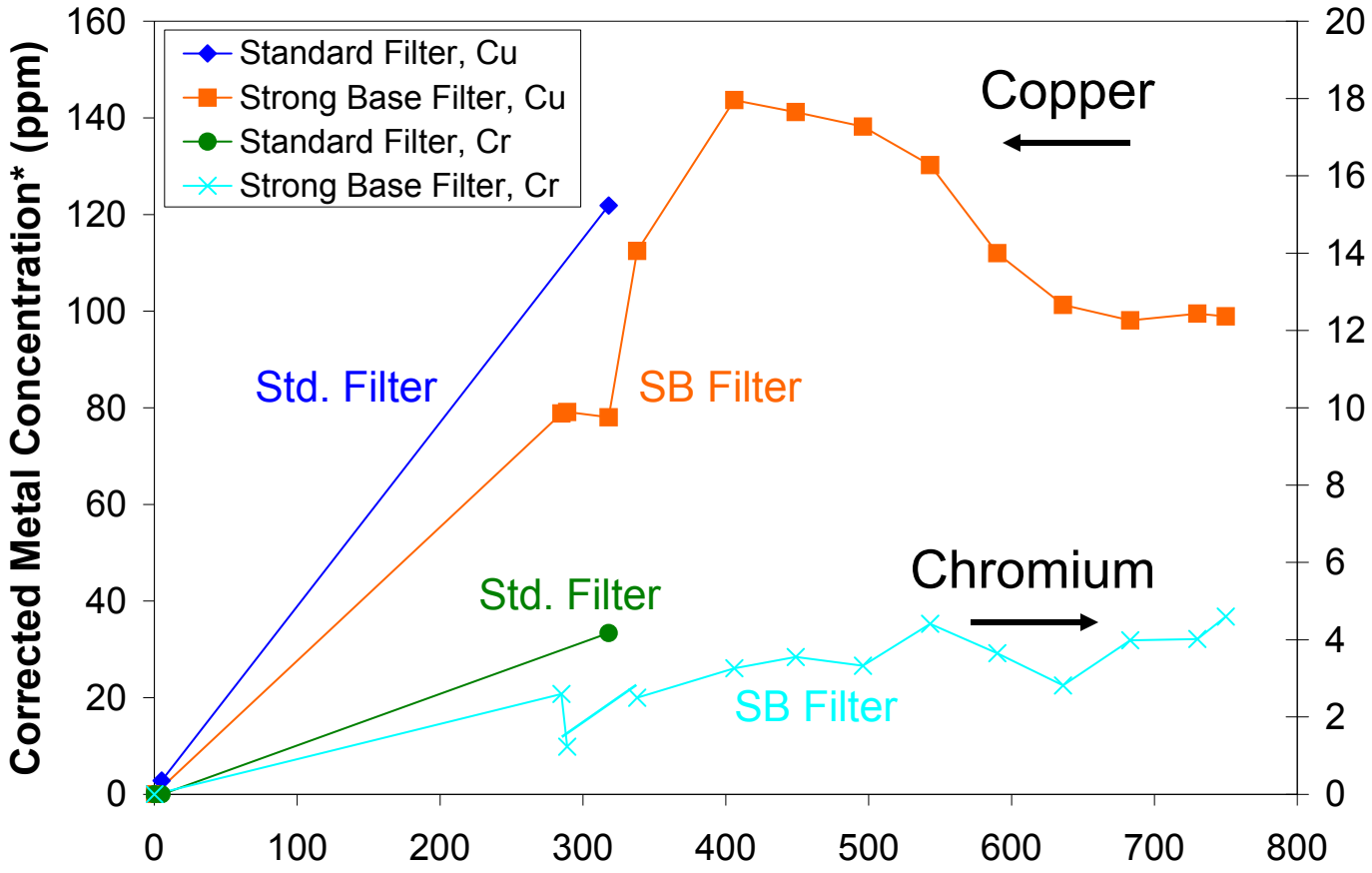


Reduced Accumulation of Wear Metals



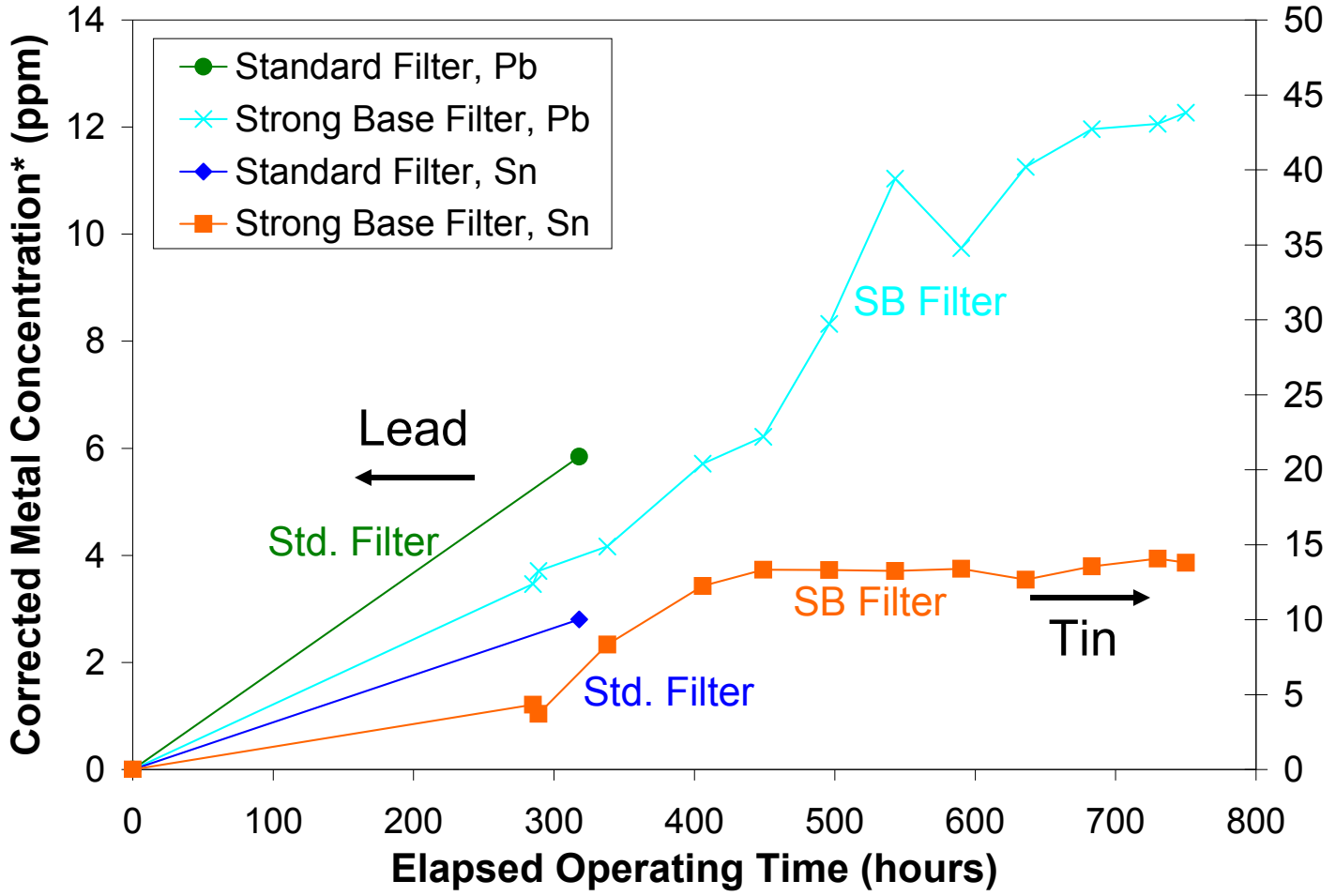
*Concentrations are corrected for base oil volatility

Apparent Reduction in Bearing and Piston Ring Wear



*Concentrations are corrected for base oil volatility

Apparent Reduction in Bearing Wear



*Concentrations are corrected for base oil volatility

Conclusions

- Acids are the cause of many lubricant problems
- Acid control continues to be a significant issue
  - Due to increased dependence on emissions control systems and new low SAPS requirements
- The strong base filter is a unique technology that selectively sequesters acid in the lubricant
- Tests with the strong base filter show a substantial improvement in TBN retention
- Results also indicate an apparent improvement in piston ring and bearing wear
- The advantages of the strong base filter may be used as some combination of extended oil drain interval and lower lubricant ash level, which results in less DPF fouling

Acknowledgements

This research is supported by the MIT Consortium to Optimize Lubricants and Diesel Engines for Robust Emission Aftertreatment Systems

We thank for the following organizations/companies for their support:

- Caterpillar
- Chevron
- Ciba Specialty Chemicals
- Cummins
- Department of Energy
- Ford
- Komatsu
- Lutek LLC.
- Sud-Chemie
- Valvoline