

DEO Additives for Low  
Emission Engines  
The Challenges and Consequences

DOE Conference: Low Emission Diesel Engine Oils

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Diesel Engine Oils (DEO)  
Perform Many Functions

- Wear Reduction
  - In boundary and hydrodynamic lubrication
- Friction Reduction
- Cooling
- Anti-corrosion
- Cleaning Action
- Sealing
- Hydraulic media



## Diesel Engine Oils (DEO)

### Perform Many Functions

- Base oils alone cannot provide these functions
- Requires use of additives
- Additives can comprise as much as 20% or more of a Multi-grade DEO formulation



## Types of Additives Typically Found in DEOs

- Detergents & Detergent/Inhibitors
  - Sulfonates
  - Phenates, Salicylates
- Dispersants
  - Nitrogen and Hydrocarbon based
- Anti-wear
  - Zincdithiophosphate (ZDDP) predominate
- Rust and Corrosion Inhibitors
  - Detergents, ZDDP, Triazoles, Thiodiazoles



## Types of Additives Typically Found in DEOs

- Anti-oxidants
  - ZDDP, Phenates, Phosphonates, Salicylates
  - Phenolics, amines, carbamates, copper compounds, molybdenum compounds
  - Many A/O's are sulfur containing
- Anti-foam
  - Silicone oils
- Friction Modifiers
  - Various
- Viscosity Index improvers & PPD's
  - Hydrocarbon and oxygen based



## Additive Package Development Evolutionary Rather than Revolutionary

- ZDDP first used in 1941
- Succinimide type dispersants widely adopted in 1970's
- Most additives are variations of known compounds and have evolved over the last 30 years - little 'revolutionary' development



## Additive Package Development Evolutionary Rather than Revolutionary

- Advantages of Evolutionary Approach
  - No radical change from year to year
  - Extensive history of field performance
  - Engines and metallurgy designed with knowledge of engine oil limitations
  - In the past decade, oil changes yield better performance - backward compatibility
  - Plants, processes, application remain common

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## DEO Additives Harmful to Aftertreatment?

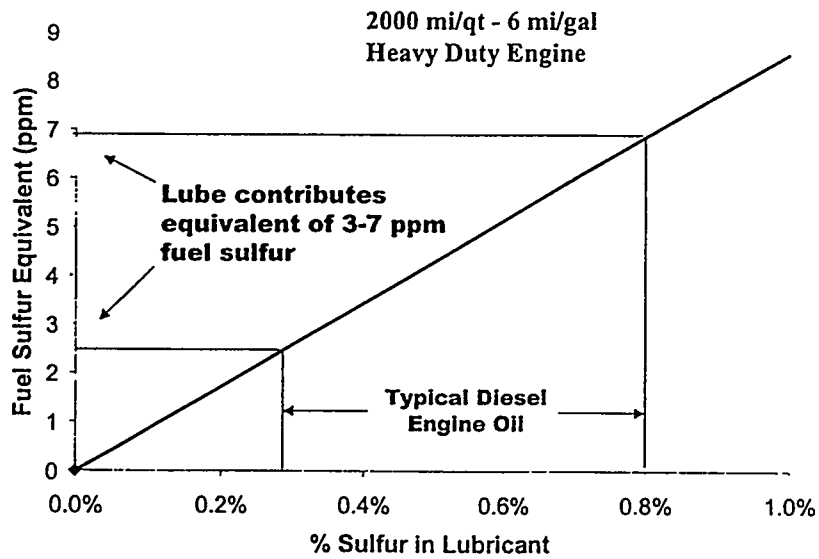
- There are a number of paths to developing low emission engines.
- Some of the more promising aftertreatment systems are currently harmed by products of combustion coming from sulfur, phosphorous and metallics from the additives
- In general if sulfur can be decreased, other metallics will decrease also

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### Typical DEO Formulation

<u>Component</u>	<u>% wt. Sulfur</u>
ZDDP	0.20 - 0.25
Detergent	0.05 - 0.25
Other (A/O, VII, FM)	0.0 - 0.10
Total	0.25 - 0.60
Typical Group II Base Oil	0.001 - 0.003

### Lube Oil Sulfur Contribution



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## How Could we decrease Metallics into Aftertreatment Systems?

- Use Group II or higher base oils
- Decrease ZDDP, detergents, and other additives, or substitute with new additives
- Improve engine oil consumption
- Negate metallics by traps or other treatment before they move into aftertreatment devices

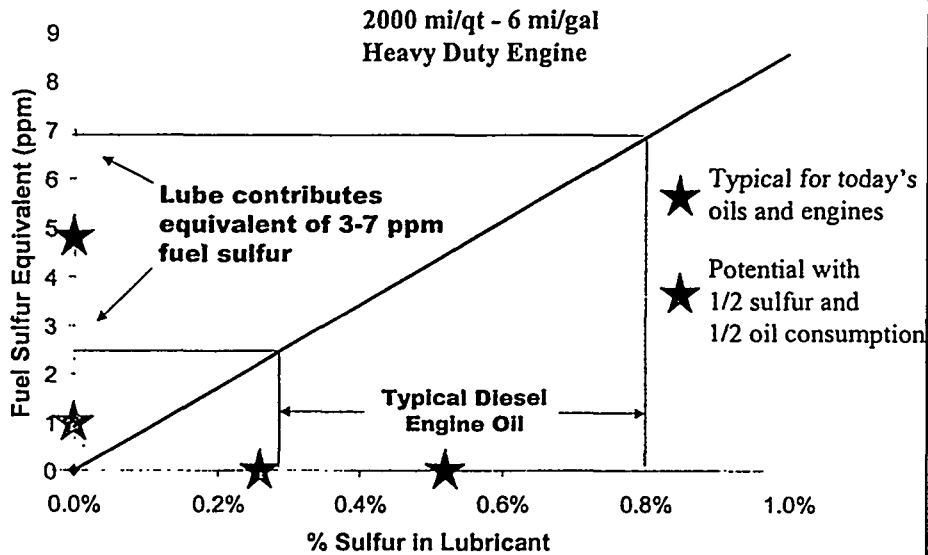


## How will we decrease Metallics into Aftertreatment Systems?

- Lets ASSUME we need to cut the sulfur contribution of lube oil by a factor of 4
  - Improve engine oil consumption by 2X
  - Cut the sulfur in engine oil additives by 1/2
  - Use of group II base oils



## Lube Oil Sulfur Contribution



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## Challenges of reducing DEO sulfur by 1/2

- Reduction of most effective anti-wear - ZDDP - replacement?
- Reduction of most detergents and some types of A/O's, FM's and VII's - replacement?
- Engine metallurgy and design must take into account these reductions
- Durability, combustion processes, pressures and temperatures all must be studied
- Proof of performance

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## **The Consequences of 1/2 Sulfur DEO**

### **Oil Suitable for Low Emission Engine Only**

- Limited Backward Compatibility**
- Different Drain Interval?**
- Different engine metallurgy?**

**Older Classification oil in new engine could harm the aftertreatment**

**New 'revolutionary' additives rather than evolutionary - will not have comfort factor from long history of use**

**Decreased oil consumption will strain oil in sump**



## **Summary**

- Additives are necessary for DEO performance
- Additives and formulations have evolved over many years giving large factor of safety
- Several aftertreatment technologies; those with higher success factors require low sulfur, phosphorous & metallics in engine exhaust
- If DEO must decrease sulfur in oil by 1/2
  - Many challenges, potentially revolutionary additives
  - A number of substantial risks
- We must strive to minimize the challenges and Risks





## Summary

- The oil and additive industry can & will respond to the challenge for low sulfur, phosphorous and metallics in engine oils - we have seen this in the passenger car side
- Because of the risks involved we must carefully weigh all the options before we commit to this path

