

Diesel Aftertreatment Accelerated Aging Cycle

SwRI Symposium

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Accelerated Ash Accumulation Methodology

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Background (1)

- Emissions Catalysts Primarily Deactivate due to High Temperature and Chemical Interactions (Poisoning)
- Thermal Deactivation is Quite Well Understood
 - Use of Arrhenius rate law widespread
- Poisoning by Fuel and Oil Components / Additives (e.g. S, P) is Still Less Well Understood
- Poisoning of Oxidation and Three-Way Catalysts by Lubricating Oil Components (mostly P) has Been Known for Decades, But Not Well Understood



Background (2)

- **What is Known:**
 - Phosphorus from ZDDP in oil poisons catalysts
 - Sulfur from fuel and oil poisons catalysts
 - Oil detergents can help to reduce poisoning effect
- **What is Not Known:**
 - How the route of oil consumption affects poisoning
 - What effect other oil components have on catalyst activity (calcium, zinc, boron, molybdenum, etc.)
 - How to accelerate oil poisoning effects in a realistic, repeatable way



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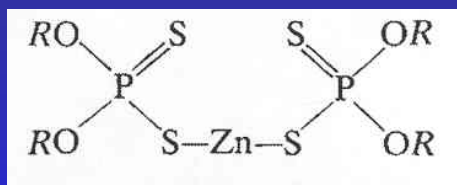
Background (3)

- **Various Studies have Evaluated Acceleration Methods:**
 - APBF-DEC, ORNL, OPEST, DASL/N-TCD.....
- **In Most Cases, they Concluded That Their Results Did Not Match Real World Data**
- **What Method Could be Used that Would Match Real World Data?**
- **Evaluating the Various Studies a Pattern Emerges, and Perhaps a Method to Perform Accelerated Oil Aging that Matches the Real World and is Repeatable**



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P:Zn RATIO DATA (1)



- ZDDP Contains 1 Zn and 2 P atoms
 - P:Zn ratio on atom basis = 2:1
 - P:Zn ratio on weight basis = 1:1.06



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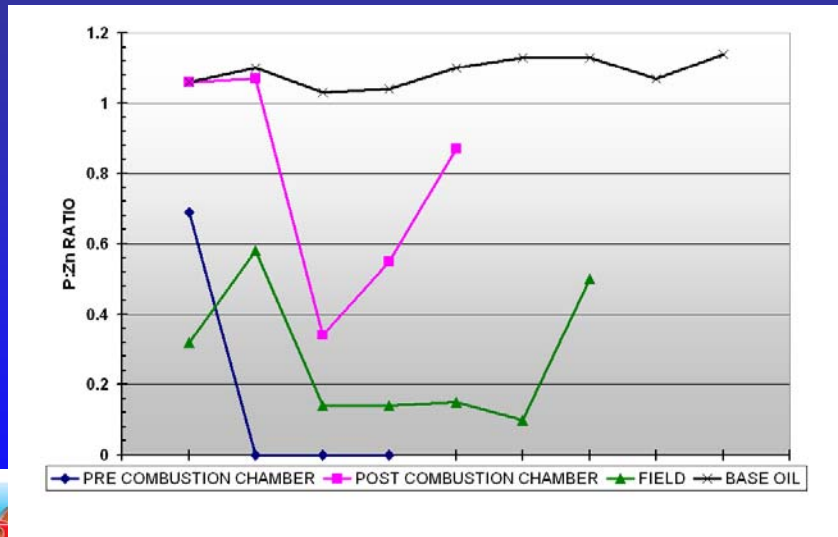
P:Zn RATIO DATA (2)

DESCRIPTION	P:Zn RATIO wt %	Comment
ZDDP	1 : 1.06	
Client FOCAS - in-exhaust injection - TWC	1 : 1.06	same as oil
Client motorcycle data - TWC - field	1 : 0.32	Zn depletion
APBF-DEC reference oil r - base oil	1 : 1.10	
normal oil consumption - engine-out exhaust gas measurements	1 : 0.58	Zn depletion
Fuel-oil blend - engine-out exhaust gas measurements	1 : 0.69	Zn depletion
exhaust manifold injection - engine-out gas measurements	1 : 1.07	same as oil
SAE paper 2005.01.1758 - base oil	1 : 1.03	
Fuel-oil blend* - DOC catalyst analysis	no Zn	Zn elimination
intake manifold injection* - DOC catalyst analysis	no Zn	Zn elimination
exhaust manifold injection* - DOC catalyst analysis	1 : 0.34	Zn depletion
* very high oil rate of 150,000 miles equivalent in 7 hours!!!		
DASL/N-TCD Consortium - base oil (Oil 1)	1 : 1.04	
Ring pack modification - catalyzed DPF (B) inlet	no Zn	Zn elimination
OPEST - base oil Oil A	1 : 1.10	
OPEST 1 - engine(hi speed, lo load), normal oil consumption - TWC	1 : 0.14	Zn depletion
FOCAS Oil A - in exhaust injection - TWC	1 : 0.42 - 1 : 0.55	Zn depl.
FOCAS Oil B - in exhaust injection - TWC	1 : 0.33 - 1 : 0.87	Zn depl.
FORD - base Oil 32	1 : 1.13	
base Oil 33	1 : 1.07	
base Oil 36	1 : 1.14	
NY taxi - Oil 32 field	1 : 0.14	Zn depletion
NY taxi - Oil 33 field	1 : 0.15	Zn depletion
NY taxi - Oil 36 field	1 : 0.10	Zn depletion
bench engine - Oil 33	1 : 0.38	Zn depletion
Ford 4.6L high mileage TWC catalyst - field	1 : 0.50	Zn depletion
Accelerated bench engine, 4.6L V8 - TWC	1 : 0.14 - 1 : 39	??????



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P:Zn RATIO DATA (3)



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P:Zn RATIO DATA (4)

- Normal Oil Consumption = Zn Depletion in the Engine
- Fuel-Oil Blends = Zn Depletion or Complete Elimination
- Intake Manifold Injection = Zn Elimination
- Ring Pack Modification = Zn Elimination
- Exhaust Manifold Injection = Zn Depletion OR Same as Base Oil
- FOCAS Injection = Zn Depletion OR Same as Base Oil



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Accelerated Ash Accumulation Methodology (One Viable Approach)

- Use Oil-in-Fuel and In-Exhaust Injection Combined
 - Both acceleration methods are controllable and repeatable which is key to an effective DAAAC
 - The correct ratio should match real world catalyst deposit ratios
 - analyze field catalysts to determine target ratios
 - Determine maximum acceleration rates based on comparison of products with real world samples

