

system. Current customer demands are for longer drain intervals on lubricants, extended warranty, and increasing time periods before overhaul are in opposition to the needs to solve the after treatment problems.

Changes in the friction and wear characteristics of the lubricant with age is another area that additional research is needed. The effect on current materials is a factor in this study. Design of the system requires development of information on both the lubricant and material pairs involved. There is considerable data in this area that needs to be revisited prior to undergoing a revolutionary change in the lubricant alone. Engine component design and oil changes need to proceed together.

The removal of sulfur from the fuel raises friction and wear issues for the fuel injection system. Additives will be required to maintain adequate life of this component of the system.

The effect of sulfur removal on other relevant properties such as viscosity, water solubility (important for low-temperature operations) need to be considered in addition to friction and wear.

A related area is that of oil filtration in the engine. This may be one method of controlling the necessary additive levels required for proper lubrication of the system.

## **V. CONCLUSIONS AND RECOMMENDATIONS.**

1. The issue coming out of the workshop with the top priority is to solve the exhaust emissions aftertreatment problems resulting from fuel sulfur and possibly lubricant additives affecting the performance of the system.

It is known that the level of sulfur in the fuel is a problem and a nationally available low sulfur fuel by 2002 will be needed to help solve part of the 2004 problem. An ultra-low sulfur fuel will be required to meet future regulations.

It is not known to what extent the lubricant plays a role. Engine out and catalyst out information using a future engine with EGR, a ultra-low or zero sulfur fuel and a test procedure are essential to resolve this issue.

The DOE DECSE Program is addressing this issue and should be expanded, if necessary, to determine the effect of current lubricants and reduced sulfur and ZDP additive lubricants on the efficiency of the catalyst.

The DECSE Program has an impressive group of industry and government participants and additional funding should be considered to ensure the basic information needed to solve the aftertreatment problems is obtained. To achieve this, the funding of the DECSE lubricant program needs to be increased. The development of PC-9 involving some 10-12 engine and laboratory tests is costing the industry over \$40M. It is not unreasonable to consider increasing the DECSE lubricant budget by \$5M to solve this issue.

2. The second priority that has an impact on the system is the effect of EGR on the lubricant. To develop the next generation of low emission lubricants requires resolving several issues regarding the particulate loading of the lubricant. Unless the particulate can be effectively removed from the recirculated exhaust, the loading of particulate in the lubricant is expected to better than double.

A tribology program to explore the effect of particulate in the lubricant is needed to determine the range of options available to revolutionary changes in the lubricant. This program would take 3 years at \$1 million per year.

3. Alternative fuels and lubricants issues need to be considered in the DECSE program. The DECSE testing program should be expanded to include testing of alternative fuels and alternative fuel blends with low - and ultra low - sulfur diesel fuels. This will resolve some of the emission reduction and lubricant compatibility issues, as well as identifying potential problem areas. This would involve adding an additional \$2 million to the DECSE lubricants program.

4. Development of alternative biodegradable lubricants should be pursued and if commercially ready in time, included in the DECSE lubricants program. This program would take 3 years and \$1.5 million per year.

5. The nature of the particulate emitted from a future EGR engine needs to be determined. The distribution mass and number of the particles and the origin of the nanoparticles is needed. If the nanoparticles are organic or inorganic, catalytic and trap removal are feasible. Characterization of particulate is important to the resolution of health effects issues hanging

over the diesel. The characterization studies would take 3 years and \$1 million, The health effects issues studies will depend on the extent of the studies required and could range from \$1 to over \$10 million per year.

6. Prescreening tools for alternative fuels and blends with low-sulfur diesel fuels and alternative lubricants need to be standardized. This could be done, in part, cooperatively with technical societies. Time would be 5 years at a cost of \$500K per year.

7. Collaboration with existing fuel and lubricant programs is recommended.

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FEBRUARY 21, 2000

**ATTACHMENTS 1 and 2**

***AGENDA  
&  
ATTENDANCE***

# *AGENDA*

USDOE/NREL Workshop  
"EXPLORING LOW EMISSION DIESEL ENGINE OILS"

HOLIDAY INN SUNSPREE RESORT  
SCOTTSDALE, ARIZONA  
JANUARY 30, JANUARY 31 AND FEBRUARY 1

**MEETING AGENDA**

**JANUARY 30, 2000:**

Registration 6-9PM  
Reception (cash bar) 7PM -9PM

**LOCATION**

Apache Foyer  
Navajo 1 & 2

**JANUARY 31, 2000:**

7:30 AM Continental Breakfast Apache A & B  
8:20 Introductory and Administrative Comments - J.Perez Apache A & B

**Session I, "The Diesel Challenge"**

Apache A & B

*Chairperson: K. Shaine Tyson, NREL*

8:30 Welcome - NREL -Shaine Tyson/Wendy Clark  
8:45 Diesel Keynote Speech "*The Diesel Engine Challenge*" Rodica Baranescu,  
NAVISTAR International Transportation Corp.  
9:30 Environmental Keynote Speech "*Low Sulfur Diesel Fuel an Enabling  
Technology for Future Low Emitting Diesel Engines,*" Byron Bunker, EPA  
10:00 Coffee Break

**Session II, "Snapshots of Needs" Panel Discussion**

Apache A & B

*Chairperson: S. Goguen*

10:15 -12:00 Panel

- "*New Emissions Regulations-Impact on Engine Design and Oil Formulation,*" - Pat Fetterman, Infinium USA LP
- "*Diesel Emission Catalysts and Filters,*"- Dale McKinnon, MECA  
"*Future API PC-9 Diesel Engine Oil Category,*" - Augie Birke, Equilon Enterprises LLC
- "*Diesel Engine Oil Additives for Low Emission Engines - The Challenges and Consequences,*" Tom Boschert, Ethyl Petroleum Additives
- "*Catalyst Compatible Diesel Engine Oils*"- S.D. Whitacre, Cummins Engine Co. (DECSE Program).
- "*Engine Oil Developments for Advanced Diesel Engines,*" John Fairbanks, DOE

Panel -Audience Discussion

12:00 Lunch

Apache C & D

1:00 - 3:30 Session III, "Engine Oil Technology"

Apache A & B

Chairperson: W. Clark, NREL

- "Base Oil Composition and Performance in Diesel Engine Lubricants,"  
Cliff Mansfield, Equilon Enterprises, LLC
- "The Use of Vegetable Oils as Renewable Basestocks,"  
Sevim Erhan, USDA, NCAUR, ARS
- "Lubricant Additives and Strategies for Low Emission Diesel Oils",  
Steve Hsu, NIST
- "Challenges and Opportunities for Future Engine Oils,"  
Ewa Bardasz, Lubrizol Corp.
- "Tribology Needs for Low Emission Diesel Engine Oils"  
Frank Kelley, Caterpillar, Inc.

(3:30 - 3:45 Break)

Apache A& B

3:45-5:15 Session IV, "Particulate Studies"

Apache A & B

Chairperson: Kevin Stork, ANL

- "Engine Oil Contribution to Emissions"  
Kent Froelund, SwRI
- "Diesel Emissions Controls - NOx / Particulates,"  
John Johnson, MTU
- "Diesel Engine Particulate Morphology: Nanoparticle Formation,"  
Dave Kittleson, U of Minn

5:15 -7:00 PM Reception and Dinner

Apache C & D

7:00-9:00 Session V, Open Forum .

Apache C & D

Chairperson: J. Perez, PSU

*After Dinner Speaker: James Eberhardt, Director, OHVT, USDOE "Overview of the DOE Heavy Vehicles Technologies Program,"*

- Blaine Rhodes - Omni Tech International Projects;
- B. Bailey - CRC Program Overview;
- A. Boehman, Penn State Univ. - Penn State Fuel Additive Projects;
- G. Fenske, Argonne -Review of critical Friction & Wear issues identified at DOE/Argonne Workshop (March 1999);
- M. Khair, SwRI - Sample Analytical Tools for Diesel Catalyst/Lube Oil Additive Studies
- Others - TBD

**FEBRUARY 1, 2000**

**7:30 Registration**

**Apache Foyer**

**8:00 AM Continental Breakfast**

**Apache Foyer**

**8:30 - 10:30 Session VI, "Emerging Issues"**

**Apache A & B**

- *Session Chairperson: G. Fenske, ANL*

- *"Fuel Formulations,"- Brent Bailey, CRC*
- *"Alternative Fuels," K. Shaine Tyson, NREL*
- *"Post Combustion Devices for Diesel Applications , " Magdi Khair, SwRI*
- *"Engine Oil Contribution to Emissions: Emerging Issues" Bill Keys, ORNL*
- *"Market Development Issues for Low Emission Alternative Diesel Engine Oils," - David Smith (Retired Mobil), Creative Energy Products, LLC*

**(10:30 -1045 Coffee Break)**

**Apache Foyer**

**Break-out Workgroups**

<b>Group 1 Apache A</b>	<b>Additives</b>
<b>Group 2 Pima</b>	<b>Basestocks</b>
<b>Group 3 Papago</b>	<b>Alternative Lubricants</b>
<b>Group 4 Zuni</b>	<b>Alternative Fuels</b>
<b>Group 5 Apache B</b>	<b>Catalysts</b>

**10:45 - 12 Noon -Worksessions**

**See Workgroup Assignments in Handout**

**12:00-1:00 Lunch**

**TBD - North Terrace, Pool Patio or Apache C & D**

**1:00 - 2:30 Break-out Workgroups**

**Same as above.**

**2:30 - 2:45 Break**

**Outside: Papago, Zuni, & Pima and one by Apache A & B**

**3:00- 4:30 Break-out Group Reports**

**Apache A & B**

**Wrap-up and Thanks**

**5:00 Adjournment of Workshop.**



## Final Attendee List

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January 30-February 1, 2000

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Low Emission Diesel Engine Oils  
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Low Emission Diesel Engine Oils  
January 30-February 1, 2000

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## Final Attendee List

Low Emission Diesel Engine Oils  
January 30-February 1, 2000

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Low Emission Diesel Engine Oils  
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## Participant Roster By Last Name

For Meeting: LOW Low Emission Diesel Engine Oil

Name	Reg Id	Company Name
Rene Abarcar	622736	Energetics, Inc.
Niall Ainscough	622757	Castrol International
Brent Bailey	622795	Coordinating Research Council
Rodica Baranescu	622875	NAVISTAR
Ewa Bardasz	622735	The Lubrizol Corporation
Mike Berg	622785	Octel Starreon LLC
Mark Bezek	622752	Sunoco Lubricants
Barry Bhatt	622754	NOXTECH Inc.
Augie Birke	622747	Equilon Enterprises LLC
Andre Boehman	622744	Penn State University
Stacy Bond	622768	PerkinElmer Auto Reserach
Thomas Boschert	622729	Ethyl Corporation
Briana Bowen	622786	Octel Starreon LLC
William Buscher	622775	Texaco Global Products
Paul Cassidy	622932	Ricardo Inc.
Wes Cherry	622742	SUNOCO
Dick Clark	622756	American Petroleum Institute
Joe Corby	622791	Pennzoil-Quaker State
Mark Davanport	622745	Conoco
Bjorn Dexell	622784	Volvo Truck Company
Sevim Erhan	622779	U.S. Department of Agriculture
John Fairbanks	622782	U.S. Department of Energy
Zenneth Faye	622796	Sask Canola Development Comm.
George Fenske	622772	Argonne National Laboratory
Pat Fetterman	622774	Infineum USA L.P.
Chris Fox	622728	Ergon-West Virginia, Inc.
Kent Froelund	622797	SwRI
Redescal Gomez	622725	PDVSA Intevep

Name	Reg Id	Company Name
John Graham	622773	Cummins Engine Company
Marv Hart	622767	Century Lubricants Company
Jeff Hazle	622639	National Petrochemical & Refiners
Steven Herzog	622748	Rohmax USA, Inc.
John Hillier	622933	Ricardo Consulting Engineers Ltd.
Steve Howell	622794	MARC-IV
Steve Hsu	622746	NIST
Aimin Huang	622637	Equilon Enterprises LLC
Joe Jobe	622755	National Biodiesel Board
Duane Johnson	622638	Colorado State University
John Johnson	622766	Michigan Technological University
Kris Kaushik	622636	Equilon Enterprises LLC
Frank Kelley	622778	Caterpillar Inc.
Bill Key	622763	Oak Ridge National Laboratory
Magdi Khair	622762	Southwest Research Institute
Jim Kinder	622937	Ferro Corporation
Dave Kittelson	622790	University of Minnesota
Richard Klein	622761	Chevron Chemical
Brian Lawrence	622726	Infineum USA LP
Vince Livoti	622734	Ciba Specialty Chemicals
Paul Machiele	622934	US EPA
Cliff Mansfield	622783	Equilon Enterprises
Sam McCahon	622793	National Biodiesel Board
Harrison McCoy	622841	Southern States Power Company
Dale McKinnon	622799	MECA
Michael McMillan	622635	General Motors R&D Center
Alan Millard	622751	Infineum USA LP
Bill Needelman	622750	Pall Corporation
Lowell Norris	622743	Exxon Mobil Corporation
Charles Passut	622765	Ethyl Corporation
Joe Perez	622776	Penn State University
Jimmy Rasco	622634	Ergon Refining, Inc.
Blaine Rhodes	622758	Omnitech International, Ltd.

<b>Name</b>	<b>Reg Id</b>	<b>Company Name</b>
Stephen Roby	622840	Chevron Products Company
William Runkle	622730	The Valvoline Company
Mayur Shah	622739	The Lubrizol Corporation
John Shipinski	622753	Toyota
David Smith	622777	Creative Energy Products
Eivind Stenersen	622845	Donaldson Company Inc.
Mark Stevens	622625	Infineum USA LP
Kevin Stork	622727	Argonne National Laboratory
Brian Swinney	622759	Petro-Canada
John Tao	622626	Air Products and Chemicals, Inc.
Shaine Tyson	622627	National Renewable Energy Lab
Cy Vaggi	622935	Ferro Corporation
Wim van Dam	622936	Chevron Chemical Company LLC
Cliff Venier	622839	Pennzoil-Quaker State
Michael Voorhies	622792	U.S. Department of Energy
Chuck Walker	622760	Chevron
Peg Whalen	622628	National Renewable Energy Lab
Shawn Whitacre	622624	Cummins Engine Company
Lewis Williams	622722	The Lubrizol Corporation
Richard Winsor	622769	John Deere

**Total Number of Attendees for LOW: 81**