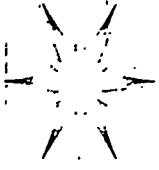


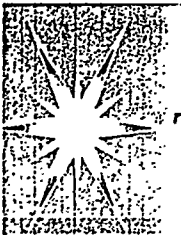
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Tribology Needs for Low Emission Diesel Engine Oils



Frank A. Kelley
Program Manager
Advanced Materials Technology

"Exploring... Low Emission Diesel Engine Oils"
Scottsdale, AZ
January 31 - February 1, 2000



Topics Covered

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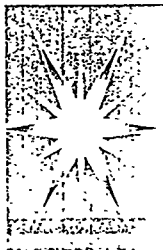
- Needs & Expectations
 - Environmental Acceptability
 - Reduced Operating Costs
- Development Challenges
 - Engine/Lube System Development
 - Specifications and Standards



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Emissions/Environmental Concerns

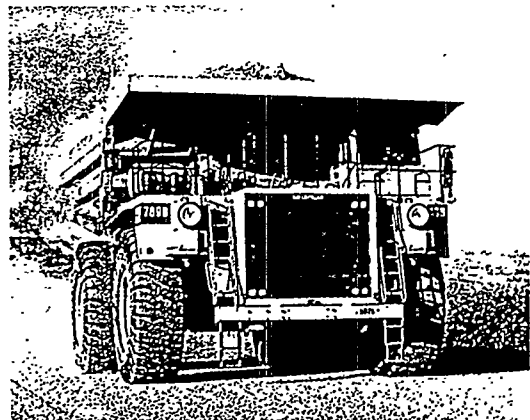
- > Meet Regulations
 - > All Applications
 - > Environmentally Friendly
 - > Biodegradability/Toxicity
 - > Vegetable-based Fluids
 - > Need better high temperature stability
 - > Need better low temperature viscometrics
 - > Synthetics
 - > Need lower cost
 - > Need synergistic additives
 - > Extended Oil Change Periods/Fill-For-Life
 - > Recycling
-



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Reduced Operating Costs

- > Fuel Economy Improvement
 - > Higher Temperatures, Loads and Stresses
 - > Impact on Fluid Performance Characteristics
- > Durability and Reliability
 - > Less Downtime
 - > Enhanced Productivity
- > Fill-For-Life (FFL) Strategy
 - > Long Life Fluids
 - > New Filtration Concepts
 - > On-Board Monitoring
 - > Optimized System Design

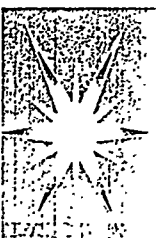
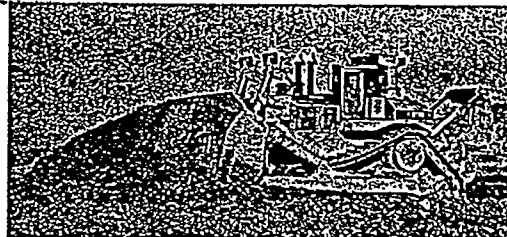




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Customer Expectations

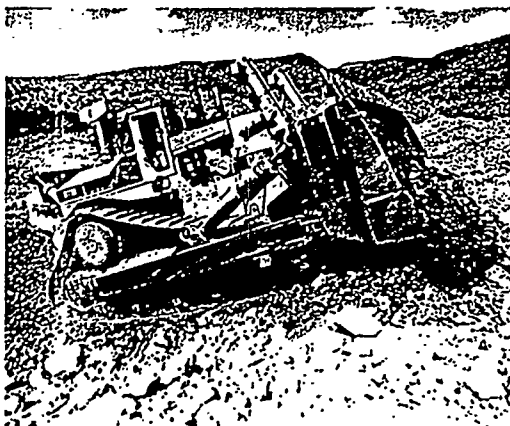
- Truck Engines & Vehicles
 - Lower Operating Cost
 - Improved Fuel Economy
 - Reduced Maintenance
 - Durability/Reliability
 - 1,000,000 Miles/20,000 Hours to Overhaul
 - Reduced Infant Mortality Failures



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The stakes are high

- Customers demand *Optimum* lubricant performance





Development Challenges in Tribology for Low Emission Diesel Oils

- > Reduced SOF & Lower Oil Consumption
 - > New oils/additives
 - > New ring/cylinder designs & materials
- > EGR Systems, Contamination Handling
 - > Catalyst Compatibility
- > Higher Fuel Injection Pressures
 - > Fuel Lubricity & Contamination
 - > Oil Interactions
- > Lubricant Performance Prediction
 - > Ring belt zone
 - > Valve train/Bearings
 - > Remaining Useful Life Of Oil
- > Application of Boundary Lubrication Concepts

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Fluid Performance Characteristics

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- > Deposit Formation Tendency
- > Viscosity
- > Low Volatility
- > Thermal Stability
- > Materials Compatibility
- > Contamination Handling Characteristics





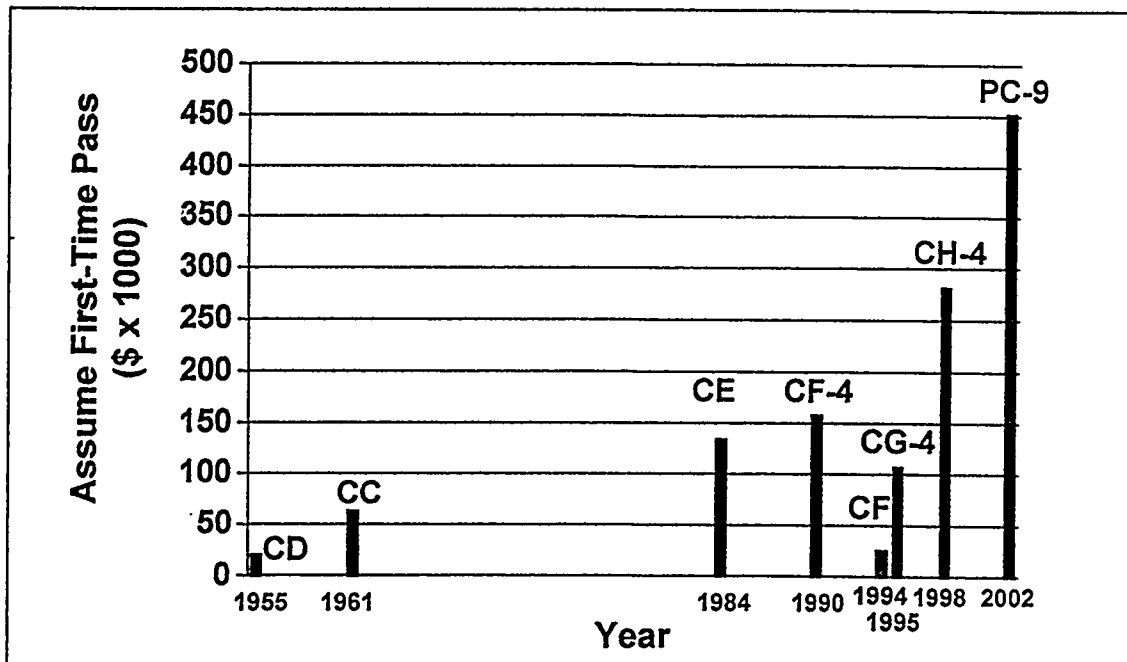
HDD Engine Oil Specifications

<u>API Category</u>	<u>CF-4</u>	<u>CG-4</u>	<u>CH-4</u>	<u>PC-9</u>
Introduced	1990	1995	1998	6/2002
Emissions Std.	1991	1994	1998	2002
Primary Fuel	High S	Low S	Low S	Low S
<u>Critical Engine Tests</u>				
Piston Deposits & Oil Consumption	Cat 1K	Cat 1N	Cat 1P & 1K	Cat 1Q* & 1N
Soot Handling	T-7	T-8	T-8E	T-8E
Ring/Liner Wear	T-6	n/a	T-9	T-10 *
Rolling VTW	n/a	GM 6.2L	GM 6.5L	GM 6.5L
Sliding VTW	n/a	n/a	M11	M11 *
Oxidation Control	n/a	IIIE	IIIE	JDQ-78

* with EGR



HD Oil Development - Testing Costs

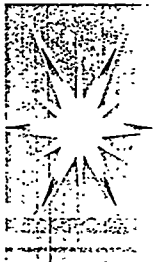




Summary

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- Address Environmental Concerns Proactively and From All Angles.
 - Maintain and Further Enhance Performance Advantages.
 - Work Towards a Higher Level of Sophistication in the Development Process.
 - Identify More Timely, Less Costly Ways to Define Fluid Performance Requirements.
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