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SUBJECT: zMAX Micro-Lubricant  
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### **zMAX Micro-lubricant -- the Facts**

zMAX, a commercialized metal interface treatment, is a uniquely processed mineral oil that has demonstrated its ability to *improve fuel economy, reduce engine deposits, and reduce wear* through the process of micro-lubrication. This micro-lubrication improves performance by reducing engine friction, affording an attendant improvement in fuel economy, and reducing engine wear and deposits in critical high temperature sealing areas. Because this unique mineral oil is able to both adsorb onto and absorb (penetrate) into the pores, cracks, and fissures in the engine's metallurgy, a new mechanism of micro-lubrication is offered for improving the overall lubrication and performance in automotive engines.

zMAX is derived from a highly refined mineral oil that undergoes a proprietary process involving specific molecular rearrangement, and has a kinematic viscosity of 11.5 cSt @ 40 °C and 3.00 cSt @ 100 °C, an ASTM color of 30+, a Surface Tension of 27.75 dynes/cm @ 20°C, and an API gravity of 36.6. A comparison of ASTM D2887 distillation results of zMAX versus the mineral oil used in its production shows zMAX having a slightly higher boiling range than mineral oil. Chemical analyses using gas chromatography and mass spectroscopy conducted by Triton Analytics Corporation (Houston, TX) revealed a greater concentration of linear hydrocarbon chains in zMAX than in mineral oil.

Since zMAX is added to the engine oil, a misconception may exist that zMAX is an additive for engine oils. This is incorrect as the SAE J357 OCT 99 Information Report Physical and Chemical Properties of Engine Oils provides this definition “*A lubricant additive agent is a material designed to enhance the performance properties of the*

***base stock or to improve the base stock properties that do not naturally exist with the base stock.***” Clearly, zMAX does neither of these two functions, as it is not designed to improve or enhance any qualities of the engine oil. Introducing it into the engine oil is merely the means to transport zMAX directly to the engine’s metallurgy.

The following contains a compilation of essentially all testing programs supporting those performance claims mentioned above. They are organized into nine sections with a summary for each section given below. The detailed individual reports can be made available upon request.

**Inactivity towards Additives** - Since zMAX may be mistaken as being an additive, laboratory testing to show its non-reactivity when mixed with formulated engine oils would confirm zMAX does not interact/interfere with those additive ingredients in engine oils. The approach taken was to have selected laboratory tests conducted back-to-back first on a fully formulated SAE 5w-30 SJ engine oil without the zMAX followed those same tests on a blend of that oil containing 10% by volume zMAX. Any significant changes in test results would certainly demonstrate some reaction had occurred whereas no change would show zMAX to be “inert” towards the engine oil’s additives.

The laboratory tests selected were those that should reveal any sensitivity to additive interactions or incompatibility. These first eight tests were: ASTM D664 (Total Acid Number), ASTM D2896 (Total Base Number), ASTM D4742 (Oxidation Stability of Gasoline Automotive Engine Oils by Thin-Film Oxygen Uptake), ASTM D130 (Copper Strip Corrosion), FTM Standard 791C Method 3470 (Homogeneity and Miscibility), General Motors 9099P (Engine Oil Filterability Test), ASTM D892 (Foaming Characteristics of Engine Oils), and ASTM D6082 (High Temperature Foaming Characteristics of Engine Oils). The remaining three tests dealt with viscosity and were selected to merely assess the degree of change since adding 10% zMAX would slightly lower the overall viscosity. These remaining tests were: ASTM D5133 (Low Temperature, Low Shear Rate, Viscosity/Temperature Dependence of Lubricating Oil Using a Temperature Scanning Technique), ASTM D445 (Kinematic Viscosity), and ASTM D5293 (Apparent Viscosity of Engine Oil Using the Cold Cranking Simulator).

The results of these first eight tests revealed zMAX **did not generate any significant changes that would have indicated any additive interaction or some additive/base stock incompatibility**. All of the changes shown were either within the precision limits for the individual tests or in some instances there was no change whatsoever. However, the results obtained from the Homogeneity and Miscibility (H&M) test warrant further comment. This test determines whether fully formulated engine oils are homogeneous and completely miscible with other engines oils they might encounter in service. The presence of zMAX in the SAE 5w30 SJ oil when tested individually against the six reference oils required in the H&M test **did not result in any indication of incompatibility being evidenced**. The results of the remaining three tests (i.e., Gelation Index through the Cold Cranking Simulator) revealed minor changes reflecting the presence of the lighter (i.e., lower viscosity) zMAX component that was fully anticipated. In summary, the testing results revealed the absence of any additive interactions with zMAX. Should zMAX have reacted with the additive package or any of its individual ingredients, there would in all likelihood have been significant changes in all of the tests that were conducted.

**Metal Penetration** - Arch Analytical Services (Cheshire, CT) utilized Auger Electron Spectroscopy to assess the ability of zMAX to penetrate metal surfaces. Tests were conducted on cast iron and aluminum alloy specimens similar in composition to metals used in the production of automotive engines. The metal specimens were immersed in the test fluids for seven to fourteen days under temperature-cycled conditions (i.e., ambient to 100 °C to simulate some modes of an operating engine environment). Comparative tests of zMAX by itself and in blends with a commercial SAE 5w30 SJ formulated engine oil showed the zMAX penetrated both types of metal far deeper than engine oil alone. Although it was not possible to precisely quantify the difference in penetration depths between zMAX and the engine oil, the order of magnitude difference was at least **100: 1**. This ability to soak (i.e., be absorbed) into metal surfaces is the key to zMAX 's effectiveness.

**Carbon Reduction and Dispersion** - A testing program conducted by Savant Inc. (Midland, MI) used the TEOST MHT-4 test procedure, a modification of ASTM D6335 to assess carbon deposit formation. This procedure is routinely used for measuring the ability of fully formulated engine oils to control high temperature deposits and resist oxidation. This test, a requirement for meeting

current SAE/API and ILSAC engine oil performance standards, basically simulates deposit formation in the piston ring belt area of a modern engine by allowing oil to flow over a heated steel tube in an oxidizing atmosphere. Blends of zMAX and two different reference engine oils were made. Again, the metal specimens were exposed to the same preconditioning cycle described above. The two reference engine oils differed in their ability for controlling carbon deposits, one being a high deposit oil while the other being a low deposit oil. The results of these tests revealed a **reduction in carbon deposits** when zMAX was present, with **reductions of 14.6%** and **12.3%** for the low and high deposit reference oils respectively.

In an another laboratory study conducted by Oil-Chem Research Corporation (Bedford Park, IL), sludge from an engine oil pan was mixed with different fluids and heated to 100 °C with vertically hung strips of chromatography paper partially immersed in the sludge/fluid mixtures. Through capillary action, the fluids migrate up the paper. Depending upon the ability of the fluid to disperse the sludge components, the capillary action will transport different amounts and types of carbonaceous matter. Comparative testing of zMAX by itself and zMAX /oil blends versus engine oil, mineral oil, and several major aftermarket additives showed much larger amounts of carbon matter being transported when zMAX was present. This demonstrated the ability of zMAX to disperse engine deposits which was further confirmed in subsequent engine dynamometer testing.

**Friction and Wear Bench Tests** - A series of ASTM bench tests which are used to assess the fundamental behavior of oils to control friction and wear between rubbing metal surfaces were conducted by Savant Inc. (Midland, MI). Six different test procedures which varied both in the mechanical configuration and applied loading were selected. Each procedure was slightly modified by the same preconditioning of metal specimens mentioned above. Multiple testing was conducted. The following compares test results of a commercial SAE 5w30 SJ engine oil without and with zMAX, the **reduction in wear** and **coefficient of friction**, or **increase in time to failure** being a direct result of zMAX.

1. ASTM D4172 Four Ball Wear Test  
**3 to 11% reduction** in the wear scar diameter
2. ASTM D5183 Four Ball Wear and Coefficient of Friction Test  
**9 to 61 % reduction** in the wear scar diameter

**10 to 14% reduction** in the coefficient of friction

3. ASTM G99 Pin-on-Disk Test  
Up to **2% reduction** in the coefficient of friction
4. Savant Progressive Load Test  
**10 to 22%** reduction in the coefficient of friction  
**29% less weight loss** of the pin
5. ASTM D2714 Block-on Ring Test  
**4 to 13% reduction** in the coefficient of friction  
**31% reduction** in specimen weight loss  
**16% reduction** in wear scar diameter
6. ASTM D5620 Thin Film-on-Vee Block Test  
Up to **300% increase** in time to failure

All of these tests showed improvements in friction (i.e., lowering the coefficient of friction) and reduced wear when zMAX was present giving a strong indication that friction and wear would also be reduced in operating engines. Further, there were no incidents that the presence of zMAX caused any adverse or negative effect in any of these tests.

**Bench Rust Tests** - Using the ASTM D1748 Rust Protection by Metal Preservatives in the Humidity Cabinet procedure, a series of aviation piston engine oils were evaluated by Phoenix Chemical Laboratory Inc. (Chicago, IL) for their ability to prevent the onset of rusting with and without zMAX. The procedure was modified by first incorporating the same preconditioning of metal specimens mentioned above. Using three commercial aviation piston engine oils, the time before the start of rusting was **increased by 10 to 100 %** when zMAX was present in the oil. These results demonstrate the ability of zMAX to provide enhanced surface protection from rusting.

**SAE J1321 Fuel Economy Tests** - Four separate tests on the effectiveness of zMAX to improve fuel economy were conducted using in-use vehicles tested in accordance to the SAE J1321 Joint TMC/SAE Fuel Consumption Test procedure. In summary, the test protocol requires measuring the fuel consumption (by weight to improve accuracy) of a group of test and control vehicles by driving the vehicles over a fixed-length road course or test track at a fixed rate of speed. The test is conducted in two phases, a baseline phase before

any changes are made to the vehicles, and a test phase in which the test vehicles receive a change. The difference in fuel consumption between the baseline and test phases is used to calculate the change in fuel economy. In this case, the test vehicles received the zMAX treatment in the crankcase, transmission and fuel tank. The control vehicles remain constant between the baseline and test phases and are used in the calculations to correct for the influences of ambient weather conditions. A summary of the four tests follows.

1. Claude Travis Associates (Grand Rapids, MI) - This test was conducted on an on-road course with two 1994 Class 8 Trucks powered by Cummins N1 diesel engines. One vehicle received zMAX treatment in the fuel, crankcase and transmission while the other vehicle was unchanged between the base and test periods. The test results showed a **fuel economy improvement of 2.61%** for the test vehicle.

2. Automotive Testing & Development Services, Inc. (Ontario, CA) - This test was conducted with three test vehicles and two control vehicles at the Las Vegas Motor Speedway in June of 2000. A summary of the test results follows.

<u>Vehicle</u>	<u>% MPG</u>
<b><u>Improvement</u></b>	
1992 Plymouth Acclaim, 2.5L to 7.7%	6.4
1999 Chevrolet Malibu, 3.1L to 9.5%	8.8
1995 Ford F-150, 5.0L ~0.1%	

3. Automotive Testing & Development Services, Inc. (Ontario, CA) - This test was conducted with seven test vehicles and one control vehicle at the Las Vegas Motor Speedway in May of 2001. A summary of the test results follows.

<u>Vehicle</u>	<u>% MPG</u>
<b><u>Improvement</u></b>	
1996 Kia Sephia	4.6
1996 Ford Escort Wagon	3.3
1996 Ford Taurus	6.6
1989 Ford Crown Victoria	3.6
1995 Ford F-150 P/U	0.2

1997 Chevrolet Lumina	4.7
1995 Chevrolet Astro Van	2.5
Average % Improvement -	<b>3.6</b>

4. Gerald H. Keller, Consultant (Palos Heights, IL) - This test was conducted with eight test vehicles and one control vehicle at the Chicago Motor Speedway in June of 2001. A summary of test results follows.

<u>Vehicle</u>	<u>% MPG</u>
<b><u>Improvement</u></b>	
1991 Mazda, 2.2L	12.7
1988 Toyota Corolla, 1.6L	2.4
1986 Chrysler LeBaron, 2.2L	14.9
1994 Oldsmobile Cutlass, 3.4L	2.8
1991 Mercury Cougar, 3.8L	2.6
1989 Toyota Camry, 2.0L	4.8
1985 Dodge Van, 225 CID	0.9
1990 Chevrolet Beretta; 3.1L	3.1
Average % Improvement -	<b>5.5</b>

These test results show a wide range in the change of fuel economy due to zMAX. Since all of these vehicles had seen a relatively high level of road use (odometers ranged from 43 to 226,000 miles), the engines had accumulated carbon in the critical sealing areas. Thus, the ability of zMAX to penetrate the metal surfaces and improve engine sealing resulted in improved engine efficiency.

A statistical analysis of the data generated from the SAE J3121 fuel economy tests conducted by Automotive Testing & Development Services, Inc in June 2000 and May 2001, and the Chicago test conducted by Gerald Keller in June 2001 was performed. The method used in this analysis involved the “*Dependent Samples t-Test*” methodology and is widely used where the significance of an observed change in two populations of data is to be measured. Applying this methodology, each of the three SAE J3121 fuel economy tests conducted on zMAX **afforded statistically valid improvements in fuel economy.**

**Vehicle Emissions Tests** - Two vehicular emission test programs have conducted with zMAX and are described below.

1. Automotive Testing & Development Services, Inc. (Ontario, CA) -

This test program employed five vehicles that were obtained from a rental agency. The vehicles were a 1996 Ford Escort, 1989 Ford Crown Victoria, 1995 Ford F-150 P/U, 1997 Chevrolet Lumina, and a 1995 Chevrolet Astro Van. After inspection and lubricant changes, the vehicles were base-lined for their emissions levels using the FTP 40 CFR-86 procedure. After a second lubricant change, the vehicles were treated with zMAX and the emissions tests were repeated. At this point the vehicles were returned to the rental agency and allowed to accumulate mileage for a thirty-day period at which point the vehicles were emissions tested again. This cycle was repeated for an additional thirty-day period affording sixty days of road use. The average results of these emissions tests are summarized in the following table.

	<u>% Reduction</u>		
		<u>HC</u>	<u>CO</u>
<u>NOx</u>			
After 30 days of road use			
-9.7%	-15.3%	-9.7%	
After 60 days of road use			
-4.8%	-4.8%	-8.3%	

The **reductions in all three pollutants** is a significant event and is attributed to the action of the zMAX in cleaning carbon from the engine's critical sealing areas and parts of the emission control system such as the oxygen sensor.

2. Gerald H. Keller, Consultant (Palos Heights, IL) - These tests were conducted on the same vehicles as used in the SAE J1321 fuel economy tests (June 2001) using the BAR 90 procedure. This is the procedure recommended by EPA for state emission surveillance purposes. The eight test vehicles were tested for their emissions at the start and end of the fuel economy testing which represented about 1,500 miles accumulated after adding zMAX. The average change in HC and CO levels are shown below. The NOx data is not considered since the BAR 90 procedure does not apply load to the vehicle, and thus NOx data has little significance for on-road emissions levels.

% Reduction

HC emissions @ idle

**-42.2%**

HC emissions @ 2500 rpm

**-76.0%**

CO emissions @ idle

**-52.9%**

CO emissions @ 2500 rpm

**-52.2%**

**Engine Dynamometer Testing** -A variety of different stationary engine dynamometer tests have been conducted on zMAX providing information on fuel economy, power, wear, blow-by, and deposits. These tests are summarized below.

CLR Engine Testing - The CLR engine is a single cylinder carbureted engine which develops peak power output of 16.5 hp @ 3000 rpm. This engine has been used for many years in petroleum product research and development activities to assess the influence of new product formulations on engine performance. The engine is currently used by the petroleum industry for qualification to SAE/API/ILSAC engine oil standards. Although this single cylinder engine is used primarily for measuring bearing weight loss and shear stability of multigraded oils, it nonetheless is an excellent laboratory engine capable of providing additional engine performance measurements (e.g., fuel consumption, horsepower, etc.) as evidenced by the large number of technical papers in the literature citing the use of this engine.

Ten (10) different evaluations of zMAX have been conducted with this engine. Each evaluation consisted of two tests, a baseline test on an engine oil without zMAX followed by a second test where the same oil and fuel were treated with zMAX. The tests used a modification of standard industry protocols, the L-38 (ASTM D5119) and the Sequence VIII (ASTM D6709). The major modification was to introduce an engine-preconditioning phase in the procedure for initially allowing zMAX to be absorbed. This modification, a ten hour preconditioning period, was used on both the baseline and zMAX tests to insure both tests were being conducted identically. The results of these tests, which were conducted by Auto Research Labs, Inc. (Chicago, IL) and later by the Oil-Chem Research Corporation (Bedford Park, IL), are as follows.

a. SAE 50 Aircraft Piston Engine Oil + 5% zMAX and 12 oz. zMAX in the fuel (modified L-38 test procedure)

**8.3% increase** in power

**8.5% improvement** in fuel efficiency (bsfc)

**17.0% reduction** in blow-by

Piston skirt **wear reduced** from **9.5% to 3.5%**

Intake valve stem **wear reduced** from **18% to 7%**

Exhaust valve stem **wear reduced** from **3% to 1%**

Intake valve **deposits reduced** from **5% to 2%**

Exhaust valve **deposits reduced** from **3% to 1%**

b. Pennzoil SAE 10w30 SJ + 8.5% zMAX and 12 oz. zMAX in the fuel (modified Sequence VIII test procedure)

**7.6% increase** in power

**6.6% improvement** in fuel efficiency (bsfc)

**4.3% reduction** in blow-by

**69% reduction** in exhaust valve guide wear

Increase in top ring gap reduced from 0.0001 to 0.0 inches

Used oil **wear metals reduced** by **over 50%**

Fewer deposits on piston lands, grooves and skirts

c. MotorCraft SAE 5w20 SJ + 5.0% zMAX and 12 oz. zMAX in the fuel (modified Sequence VIII test procedure)

**3.8% increase** in power

**2.8% improvement** in fuel efficiency (bsfc)

**69% reduction** in exhaust valve guide wear

Increase in second ring gap reduced from 0.0002 to 0.0001 inches

Used oil **wear metals reduced** by **over 50%**

Fewer deposits on piston lands, grooves and skirts

d. MotorCraft SAE 5w20 SJ + 8.5% zMAX and 12 oz. zMAX in the fuel (modified Sequence VIII test procedure)

**5.2% increase** in power

**4.2% improvement** in fuel efficiency (bsfc)

**3.5% reduction** in blow-by

**57% reduction** in exhaust valve guide wear

Increase in top ring gap reduced from 0.0001 to 0.0 in.

Used oil **wear metals reduced by over 50%**  
Less deposits on piston lands, grooves and skirts

e. MotorCraft SAE 5w20 SJ + 8.5% zMAX and 12 oz. zMAX in the fuel (modified Sequence VIII procedure). In this test, the baseline phase was run as usual. Then, instead of reassembling the engine with new parts and engine cleaning as was done in the previous four tests, the engine was measured and reassembled with the used parts from the baseline phase.

**7.0% increase** in power  
**6.6% improvement** in fuel efficiency (bsfc)  
**0.2% reduction** in blow-by  
**92% reduction** in exhaust valve guide wear  
Used oil **wear metals reduced by over 50%**

A statistical analysis of the data generated from the CLR/ Sequence VIII engine testing conducted on the above four tests (i.e., numbers 1b through 1e) was performed to assess the individual hourly horsepower and fuel efficiency readings. The method used in this analysis involved the “*Dependent Samples t-Test*” methodology and is widely used where the significance of an observed change in two populations of data is to be measured. Applying this methodology on each of the four engine tests run on zMAX at different concentrations and with different oils has shown the changes in horsepower (bhp) and fuel efficiency (bsfc) were statistically different at a 99% confidence level. This analysis provided evidence that the **observed improvements in these parameters were real and not simply due to test variability.**

f. Mobil 1 SAE 10w30 SJ + 8.5% zMAX and 12 oz. zMAX in the fuel (modified Sequence VIII test procedure)  
**7.2% increase** in power  
**6.6% improvement** in fuel efficiency (bsfc)  
**17.4% reduction** in blow-by  
**10.8% reduction** in bearing weight loss  
**18.1% reduction** in ring weight loss

g. Mobil 1 SAE 10w30 SJ + 8.5% zMAX and 12 oz. zMAX in the fuel (modified Sequence VIII test procedure) repeat of the above test to demonstrate repeatability of method.

**6.5% increase** in power  
**5.8% improvement** in fuel efficiency (bsfc)  
**30.1% reduction** in blow-by  
**25.3% reduction** in bearing weight loss  
**52.1% reduction** in ring weight loss

h. Amsoil SAE 10w30 SJ + 8.5% zMAX and 12 oz. zMAX in the fuel (modified Sequence VIII test procedure).

**2.5% increase** in power  
**2.4% improvement** in fuel efficiency (bsfc)  
**12.1% reduction** in blow-by  
**94% reduction** in valve guide bore wear  
**37.3% reduction** in bearing weight loss  
**12.1% reduction** in ring weight loss

i. Pennzoil SAE 5w30 SJ + 8.5% zMAX and 12 oz. zMAX in the fuel (modified Sequence VIII test procedure).

**4.4% increase** in power  
**4.3% improvement** in fuel efficiency (bsfc)  
**7.5% reduction** in blow-by  
**16.7% reduction** in bearing weight loss  
**58.0% reduction** in ring weight loss  
**97% reduction** in valve guide bore wear

j. Pennzoil SAE 5w30 SJ + 8.5% zMAX and 12 oz. zMAX in the fuel (modified Sequence VIII test procedure) repeat of the above test conducted approximately one year later.

**4.1% increase** in power  
**3.9% improvement** in fuel efficiency (bsfc)  
**3.8% reduction** in blow-by  
**32.7% reduction** in bearing weight loss

Ford 2.0L Engine test - For this test, a new (1,000 miles) Ford 2.0L engine from a 2000 Ford Escort was mounted on an engine dynamometer testing stand at Oil-Chem Research Corporation, fully equipped for engine parameter control and continuous data monitoring. The test procedure consisted of running the engine at conditions which simulated 65 mph (2500 rpm and 26.0 hp load). The fuel rate was allowed to float to what ever level the engine's power control module would dictate. The engine was first base-lined on Pennzoil SAE 5w30 SJ oil for 14 hours with the power output controlled to 26.0 hp. Without changing the oil,

the crankcase and fuel were treated with 12 oz. of zMAX.

The engine was then run for a preconditioning phase consisting of one hour run periods followed by 5 to 12 hours soak periods. After ten run/soak cycles, the engine was again run for 14 hours at the same conditions as the baseline phase. The difference in fuel efficiency resulted in a **2.3% improvement** due to zMAX.

Shaw Dynamometer Engine Services - This test was conducted on an engine dynamometer test stand using a Chevrolet 468 CID engine. The engine was first base-lined for high output conditions through a controlled acceleration ramp while monitoring torque and horsepower. zMAX was added to the crankcase at a treat rate of 7.5% and 2.0 oz. was poured into the carburetor. The **measured power** of the engine **increased** by **1.1 to 4.2 %** (depending upon the engine rpm) after the zMAX treatment.

Yamaha 600 Legend Test- A 1200cc Yamaha engine was mounted on an engine test stand at Oil-Chem Research Corporation. Horsepower and torque were measured at speeds from 6,000 to 10,000 rpm in 1,000-rpm increments. After obtaining baseline data, zMAX was added through the carburetion system and the engine run for a short period followed by a four-day soaking period. The engine was run again through the rpm range. The average **increase in horsepower and torque** after the zMAX treatment was **6.4%** and **6.3%** respectively.

Labeco Equipment Corporation - A single cylinder 17.6 CID engine (the predecessor to the CLR engine discussed earlier) was run at two test conditions, 2,700 rpm and either 50" or 75" boost in inlet air pressure. Oil and water temperatures were controlled to 195 and 270 °F respectively. All other engine settings were for best power output. The zMAX was added to the crankcase at a treat level of 5% and 1% was put in the fuel. The indicated horsepower **increased by 2.8 to 6.1 %**, while the fuel consumption **decreased by 3.8 to 8.2%** after zMAX treatment.

Armour Research Institute - This test was run a 6-cylinder Chevrolet engine using the L-4 procedure for oil oxidation. The test oil, a SAE 50 aviation piston engine oil, was first evaluated for its viscosity characteristics after the 36-hour test. The test was repeated with the same oil but containing 5% zMAX. At the

end of the test, the viscosity of the untreated oil increased by 89% while the viscosity of the oil with zMAX increased by **only 16%**.

Cummins Michigan, Inc. - This test facility has the capability to test a full size truck on a vehicle dynamometer and measure power output at highway speeds. The test vehicle from the Claude Travis Associates SAE J1321 fuel economy test discussed earlier was base-lined at this facility before the zMAX treatment, and then tested again after 7000 miles of road use. The truck was developing **~7% more** horsepower during this second test, which showed zMAX had restored power in the engine.

**Controlled Field Tests** - Two controlled field evaluations of zMAX have been conducted and are summarized below.

Executive Helicopter Inc. (Chicago, IL) - This company had a fleet of helicopters which were powered by Lycoming HIO 360 CIA engines and operated out of Chicago Midway Airport. One of these units received regular treatments of AvBlend (the same formulation as zMAX with a different trade name) and the engine received overhauls at 1,000 hours of operation by Blueprint Aircraft Engines, Inc. The normal routine for engine overhaul at 1,000 hours is to oversize and/or re-chrome piston cylinder walls to restore the proper dimensions. During the use of AvBlend, it was observed that cylinder wear (bore size, out-of-roundness, choke) was essentially still at new factory specifications, and the exhaust valves and guides were free of deposits, and also had minimal wear (.001 inch increase in valve/guide clearance). Because of these findings, the FAA approved the extension of time between overhauls in several increments up to 1,500 hours while the AvBlend was being used. The cylinders from this engine were continuously monitored until they were retired after 7,800 hours of use. Normally, cylinders can only achieve one overhaul cycle before they need oversizing and/or re-chroming. Based on this field demonstration, the FAA granted approval for the use of AvBlend as a supplement to the crankcase oil. This is the only product of its kind which has received such an approval.

Scheibert Energy Company (Honolulu, HI) - This company is in the business of power generation on the island of Oahu. Part of the plant equipment uses Hercules 8.8L V-6 propane fired engines in a cogeneration station. zMAX was added to oil, a Shell Rotella SAE 40, at a concentration of ~3%. After the addition of zMAX,

the engine efficiency **increased by 17.3%**. Also, exhaust temperature was **reduced by 120 °F**. These changes were observed during the entire 5,000-hour service period.