

# The Changing Landscape of Engines, Fuels and Oils

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## Executive Summary

In addition to the day challenges that fleet managers face, there is now a whole new frontier in the world of Fuels, Oils and Engines that require more than just an updated manual. Today's operations are faced with the continued rise for fuel and oil with decreased quality. Fuel quality costs, and changes are coupled with introduction of a multitude of new era bio-fuels, which are being hailed by politicians around the globe as a salvation from the twin evils of high oil prices and climate change.

If you can navigate your way through your fluids, you are now faces with the common knowledge that the new 2007 diesels will burn much cleaner, will run hotter, cost more, and need special fuel, motor oil and servicing. Fuel economy should stay the same or be better, but ultra low-sulfur fuel will cost more and have lower energy content.

When the federal government's latest round of diesel exhaust-emissions regulations take effect and will result in new, heavier engine equipment and substantially higher prices. Many big fleets are stocking up on current models to avoid looming price hikes and added complexity. Clean Air advocates should celebrate the vehicles that will comprise the latter part of the '07 model year. Diesels will burn cleaner than ever, emitting only half the oxides of nitrogen (NOx) and one-tenth the particulate matter (PM) of current diesels. This arguably is a substantial societal benefit, though most users wince at its cost.

Whether you are taking advanted of tax incentives on new equipment, or stocking up on pre emissions engineered efforts, there seems to be a strong "pre-buy: being pushed by a healthy economy which mirrors the run up to the October '02 deadline. As happened then, a sales slump is expected to follow the frenzy. Many buyers will hang back to see how the engines behave, and then slowly return to the market.

Here we hope to shed some light, facts, and suggestions in the areas of:

- Meeting Clean Air Act Requirements
- Investigating and Acquiring Emissions Credits
- Using the New Mandatory Ultra-low Sulfur Diesel Fuel
- Controlling Bacteria, Fungus, or Yeast Contamination
- Declining Engine and Fuel Component Life

## Direction and Impact of the EPA

With various aspects of the EPA 2007 already in effect, the continued direction and further phases and policies will likely impact you and your business operations.

Initiated back in 1970, the clean air act was the beginning of a progressive movement by the Environmental Protection Agency (EPA) with a goal of “clean and healthy air for all”, but primarily affected the automotive industry. This initiative continued and in 1990, a new Clean Air Act was put in place that included a mandate specific to Trucks and Buses that they “must meet stringent diesel particulate emission standards beginning in 1994. Subsequent milestones related to Diesel Trucks were established in 1998, 2002 & 2004, however the most extensive milestones were set for 2007 that are addressed herewith with additional milestones set for 2010 as well.

This 2007 initiative, effective January 1, 2007 calls for the reduction of harmful pollution by 95 percent that has forced the engine manufacturers to comply. New engines produced after this date will not be allowed to produce more than 1.0 ppm NOx, the gasses produced within engine emissions.

This action was based upon the following projections established by the EPA. Following complete integration of this program by 2010, smog causing nitrogen oxide emissions were said to be reduced by as much as 2.6 million tons each year. Up to 110K tons of soot and or particulate matter would also be reduced. They also projected that premature deaths, chronic and acute bronchitis, asthma and other respiratory symptomatic cases would be reduced by a combined magnitude of approximately 750,000 cases per year.

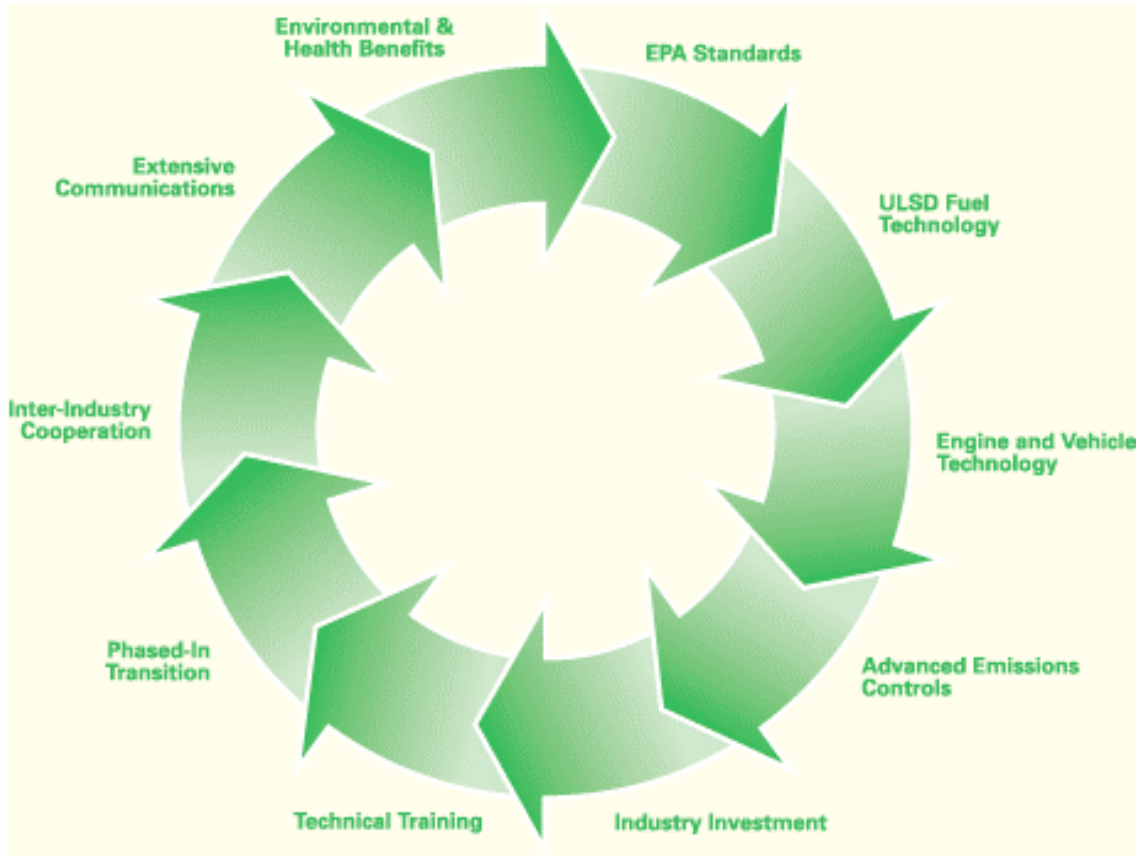
These mandates have resulted in modified engine designs that require additional components and control that provide the required reduction in emissions. The primary means of accomplishing this is via heat and filtration. The integration of this emission reduction system by the Engine Manufacturers has resulted in the following;

- Mufflers, as we know them today, will no longer exist. They will be replaced with a Particulate Trap. Although similar in size, the internal make-up and function will be based upon heat and filtration in lieu of sound dampening. This filter device will be an insulated, double-walled stainless steel vessel with ceramic tubes that will combine with temperatures in excess of 1200o Fahrenheit to burn soot and turn it into ash.
- The increased heat load resulting from the process will likely require additional insulation considerations
- The “system installation” complicates the customization of commercial vehicles due to space constraints. The manifolds and filter installation will consume space normally allocated to fuel tanks and other auxiliary equipment and will likely require reorientation of component layouts.
- Because of the increased heat related to the emission reduction system, radiator sizing is likely to be increased.
- The filter device will require periodic cleaning either via a “core exchange program” or possibly a do-it-yourself cleaning regimen.
- Fuel efficiencies will be adversely affected with estimates at 1% to 3%.
- The cost impact of the engine redesign is projected at \$8K - \$13K per diesel engine

The EPA has established a “Phase-in” approach that begins with the 2007 new vehicles and progresses thru 2010. These EPA Mandates also included a drastic reduction of 97% to the sulfur content of highway diesel fuel (500 parts per million to 15 parts per million). These new diesel fuel regulations and provisions will go into effect in June of 2006 and will be phased-in through 2009 with the likely result of fuel price increasing by as much as 6%.

**From the EPA website:**

The latest emission standards and diesel fuel sulfur reductions complement the similar program reducing emissions and fuel sulfur for highway diesel engines and fuel for 2007. The engine manufacturing industry had made great technical strides in adapting efficient emission controls from highway diesel to nonroad applications. At the same time, the manufacturers of this equipment that use these engines have responded by creatively incorporating the new engines and emission controls into their machines. These improvements will continue as stringent new emission standards come into effect in the coming years, coupled with the elimination of most of the sulfur from the diesel fuel used in nonroad equipment.



## The Changes & Effects: Fuel

### **ULSD – Ultra Low Sulfur Diesel**

There is a great deal of information and misinformation on what Ultra Low Sulfur Diesel Fuel (ULSD) is and is not since the change over at the retail pumps in October of last year. The EPA's 2006 diesel fuel regulation limits the sulfur content in highway diesel fuel to 15 ppm (by weight), down from the previous 500 ppm. Refiners were required to start producing the 15 ppm sulfur fuel beginning June 1, 2006 at the terminal level. Highway diesel fuel sold as ultra low sulfur diesel fuel had to meet the 15 ppm sulfur standard as of September 1<sup>st</sup> 2006 for California, and the rest of the country by October 15, 2006.

### **ULSD Timeline & Refuelers**

For retail stations and wholesale purchasers, highway diesel fuel was originally required to meet the 15 ppm sulfur standard by September 1, 2006, however the implementation date was extended to October 15, 2006 because of refinery production and distribution disruptions caused by the hurricanes 01'2005. Refiners can and are also taking advantage of a temporary compliance option that will allow them to continue producing diesel fuel with up to 500 ppm sulfur content in the 20% make up of distilled product by volume of diesel fuel they produce until December 31, 2009. In addition, refiners can participate in an averaging or banking and trading program with other refiners in their geographic area. ULSD will be required for use in off road equipment beginning in 2010.

### **ULSD Processing**

Achieving these ultra-low-sulfur levels requires refiners to perform additional hydro processing and higher-severity hydro treating. These processes reduce sulfur levels but they also affect other fuel properties. Most notably, the fuels lose the natural lubricity provided by some of the polar compounds that are present naturally in the higher specific gravity fuel. Low-lubricity fuels can result in premature wear and even catastrophic failure of fuel system components.

Additionally, severely hydro treated fuels can suffer from other problems. Ultra-low-sulfur fuels can lose natural antioxidants (compounds which keep the fuel from degrading by reacting with oxygen) that help prevent the fuel from forming gums and sludges. This is especially important to understand as these gums and sludges affect moderate temperature operation, not just in cold weather!

### **ULSD Effects**

Fuels' antioxidation properties are particularly important in modern fuel systems. Today's engines and fuel systems run at temperatures that are much higher than even units that were produced as late as 10 years ago. Ultra-low-sulfur fuels can also be more corrosive than conventional fuels, requiring corrosion-inhibiting additives (ACES II has the best engineered blend of anti-oxidants and corrosion inhibitors.) Finally, these fuels can have very low electrical conductivity, causing a safety concern with components such as high-velocity pumps where fuel can be exposed to significant static electrical charges.

Many of the S15 fuels are expected to contain lower levels of aromatics. The change from a higher to a lower aromatics fuel can cause seals to shrink. Aged seals, which do not have the elasticity to adapt to this change, appear to fail sooner. In addition, the new fuels are expected to be more susceptible to oxidation. The resulting oxidation products (Peroxides) could attach to the seal material and cause it to prematurely age.

The primary reason for the EPA to mandate the ULSD fuel specification is it enables catalyst based retrofit technologies such as Diesel Particulate Filters or DPF's and Diesel Oxidation Catalysts or DOC's to operate at maximum emission control efficiencies and effectiveness without premature plugging or outright damage.

Higher sulfur fuels also have higher acidity content, so with the lower sulfur content of ULSD one would think it would create less corrosion. However, fuel-bound sulfur acts as a fuel system lubricant and a microbistat (which retards bacteria, fungus and yeast growth!) The significant reduction of sulfur in ULSD, compared to conventional low sulfur diesel fuel therefore leads to increased wear in all fuel pumps and fuel injectors on new and older vehicles. Elastomer materials used in a-rings, seals and gaskets contained in fuel system components can also be degraded and cause failure.

A typical example would be a start-up problem created by failure of fuel pump seals on varied models of vehicles, plugged fuel filters, and leaking fuel system a-rings. ULSD fuels also exacerbate the need for periodic replacement of fuel dispensing equipment filters to achieve proper sediment and water control.

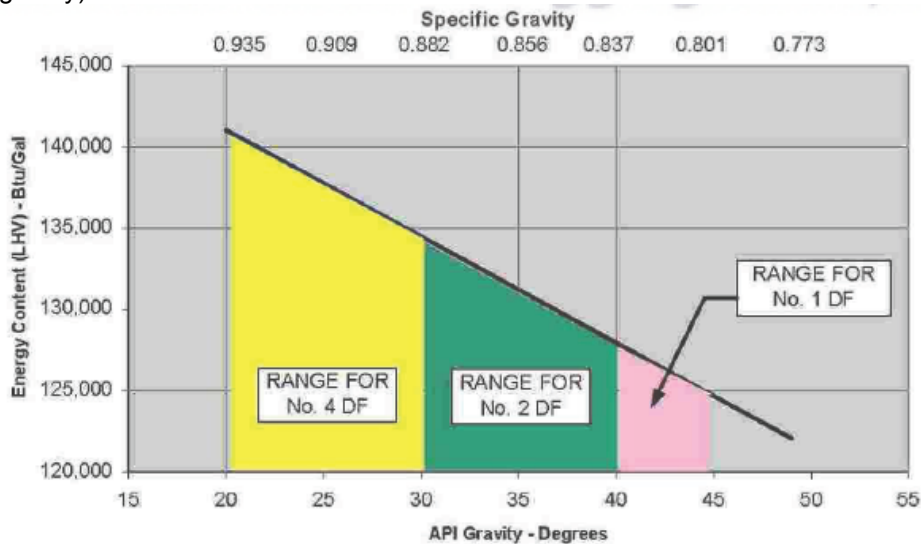
**ULSD BTU**

Other issues created by ULSD are the content of energy or BTU value of the fuel. It has been reported that users are being told by many fuel suppliers of the new fuel that they will experience only a 1% drop in BTU. However, to understand the truth, it is important here to discuss the differences in Energy Content Vs Specific Gravity and API Gravity.

Energy Content is expressed in BTU/Gal or British thermal unit per gallon.

Traditional high sulfur fuels have a higher energy content of 140,000 BTU per gallon, a 45 cetane, and weigh approximately 7.1lbs. per gallon. It has an API gravity of 35.1 with a specific gravity of 0.852 (compared to water = 1.0 or 8.33lbs./gallon).

Specific Gravity and API Gravity; these are related to heat (energy) content, affecting power and economy. Gravity is an indication of the energy content of the fuel. A fuel with a high density (low API gravity) contains more BTU's per gallon than a fuel with a low density (higher API gravity). Refer to the chart below.



Typical ULSD has 132,000 BTU, weighs approximately 6.72lbs per gallon, has an API Gravity Of 41-45.0 and a specific gravity of 0.8075\* (compared to water = 1.0 or 8.33lbs/gallon). These specifications put it in the same range as Kerosene.

As is apparent by the chart, the higher the API gravity and the lower the specific gravity, the less energy is available from the fuel. The volume in the tank is the same, but the energy is definitely reduced. However, it is reduced in more ways than is apparent.

Where 140,000BTUhigh sulfur fuel vs. 132,000 BTUULSD is a difference of only 5.7%,it also matters how the BTU is utilized.

This is where boiling point comes into play. A high sulfur, high specific gravity and low API gravity fuel will reach end point distillation at around 656\* degrees F. This means that the fuels heat value finally was vaporized at 656\* degrees F, whereas ULSD fuel hits boiling point much lower with an end point in the 545 \* degree F range. The heat value difference between them is 111 degrees of actual heat value.

Volvo's Greszler says fuel economy may suffer slightly with the new fuel. "The only issue we've noted in the low-sulfur fuel is a slightly lower power density, meaning less energy per gallon," he says. "You have to burn a bit more of it to get the same [energy] out. We've seen a two- to three-percent difference." Other than that, Greszler says, tests using Volvo and Mack engines show that the engines work well with the fuel.

### **BTU Example**

Another way to look at it is a 1 gallon pan of water on a stove boils away completely when the water reaches 656\* degrees. So the (high sulfur) pan of water would be dry at 656\* degrees. The Ultra low sulfur 1 gallon pan would be boiled dry at 545\* degrees. Assuming it took both pans of water 15 minutes to reach 545 \* degrees and 17 minutes to 656\* degrees, a limited tank of 100 gallons of water for each of the pans would net a longer supply of water to the higher heat value by almost 3.3 hours even though the one pan only had 2 minutes longer to boil. (100 x

$15=1500$   $160 = 25$  hours vs.  $100 \times 17 = 1700$  $160 = 28.3$  hrs, or 11.7%

This means that a 100 gallon fuel tank of high sulfur fuel weighing 710lbs vs. a ULSD tank at 672 lbs or a difference of 38lbs of fuel can last longer even though the volume of fuel is the same.

Since the fuel will burn off quicker to end point, the value of the fuel to produce work is also reduced.  $710-672$  divided by 710 = 5.5% difference in useable extra energy in the fuel.

This means that the total reduction in actual useable fuel is around 5.7% + 5.3% or a total of 11 % reduction in work value. Although all fuels have to meet ASTM D975 with a minimum of 40 cetane, it is important to Know the facts of how each of them burn, and the variability in energy.

### **ULSD Bacteria, Algae and Fungus Issues**

With the new ultra-low fuels coming in the pipeline, filling station, and a diesel tank near you, there has been and will be a great deal of confusion as to what is happening to my fuel, why am I starting to see problems that I never saw before, and how can I solve these issues.

It is common for all stored fuel oils (JP fuels i.e.: jet fuel, NO.2 diesel, as well as NO.4 and NO.6 fuel oils), to be contaminated with bacteria (Pseudomonas), fungi in a form of mold (Cladosporium Resinae and Candida Tropicalis), and yeast. This was traditionally more noticeable on marine vessels and in storage tanks near water and/or in high humidity, but with the new ultra-low fuels drastic reduction of sulfur, which was an acid that retarded growth, we will be encountering it in places thought to be immune from contamination. The typical paradigm of "We don't have a problem" will persist until they see the operational and component failures.

Moisture is what bacteria, fungus , and yeast live in. But like any organism, it needs food and proper environment to survive. Wet, dark and cold places are just perfect. Almost all fuel oils (including diesel fuel), after blending at the refinery level contain some moisture. In addition to

the small level of moisture/water in the "refined" fuel, additional water has access to storage tanks as atmospheric moisture condenses. Additional water can also accumulate from rain seepage in caps and tank vents. Although most storage tanks and storage facilities have the ability to drain the water in storage tanks and systems, not all water can be removed as a portion of the water emulsifies with the fuel. Remember that the new "light fuels" are much more susceptible to absorption of water.

In addition to water, other conditions can cause or increase bacterial growth. Air is one major source. Air can get into the storage tanks through the vents and carry with it dust, debris, other gases, hydrocarbon utilizing bacteria, and moisture. Even in well filtered venting systems, air itself is considered to be a contaminant due to the presence of oxygen which is a contributor to increasing fuel oxidation (breakdown).

Fuels can also get contamination after leaving the refinery from poorly designed tankers, ships, barges or from terminals consisting of older storage tanks which were poorly designed. Remember that we haven't built a new refinery since 1976! Such distribution systems which are not equipped with adequate or efficient water draw-off, or ships and barges which are not designed to allow proper clean-up, can also contribute to bacterial growth. Bacterial growth is like an infection. Unless it is eradicated, it returns very quickly. Shipping tankers that are incapable of complete drainage of water especially after products are dropped-off and tankers are steam cleaned (whereas some water is retained in the tanker), can contaminate subsequent fresh fuel being loaded for delivery! Some ships even use seawater to clean their fuel tanks. Seawater residue will accelerate bacterial growth. Poor maintenance and storage of fill hoses contributes to contamination as debris and other microorganisms build-up in these fuel hoses (especially those left outdoors without capping).

Poor maintenance of the storage tank is a large contributor to bacterial growth and the shortening of the fuel's shelf-life. The sludge and acid produced from bacterial contamination produces corrosion and will result in pitting of the bottom of the storage tanks.

Microorganisms need water to grow and use the hydrocarbons in the fuels as their main source of energy. The fuel/water interaction is the ideal environment for bacterial growth and the area where bacterial contamination is most noticeable. As bacterial growth increases in the fuel water mix, it creates an emulsification of the fuel forming a cloudy, inverted emulsion layer above the fuel and water.

Once contamination is in the storage tank, it will travel to any part of the tank where moisture is present including the top of the tanks (above the fill level) especially in humid areas where condensation levels are high. As the bacteria and fungi increase their reproduction, they produce a biomass, which is not only present in the fuel/water interface, but builds up on the tank walls, filters, manifold system, pumps, etc.

When contamination occurs, the bacteria fungus, and yeast will multiply resulting in a chemical effect that will alter the fuel to a point where it produces acid and sludge (mold and yeast) on the bottoms of the main tanks and the mobile units. The small pits in the tank's surface provide an ideal environment for biofilm formation. Likewise, any small tears or cracks in the tank become an excellent area for biomass build-up too. If the situation continues unnoticed and untreated, fuel from the tank can seep into the ground and contaminate the water supply and the environment.

When contaminated fuel reaches the end users' fuel tank, it can result in serious problems, including clogging fuel filters, fuel line plugging, restricting water separators, anywhere there is a crack or crevice. One of the most astonishing things about these microorganisms is that they love to attach themselves to fuel filters. Since they contain insoluble sediments, the filter will get clogged prematurely, and will result in restricted fuel flow.

This results in difficulties with starting, poor acceleration response, stalling, and, in extreme situations no start at all. Also Injectors and nozzle orifices will get clogged and wear faster. Restricted fuel flow can result in excessive engine wear as inconsistent fuel flow will result in combustion variation increasing piston and cylinder wear and an overall increase in maintenance cost.

When contaminated fuel is burned, it causes an increase in emissions released into the atmosphere (including Particulate Matter, NOx, Hydrocarbons, and Carbon Monoxide.) This is why burning bacteria contaminated diesel fuel will produce an unpleasant odor which smells like rotten eggs. As the biomass clogs the fuel filter, the restriction of fuel flow results in improper and insufficient fuel delivery to the combustion chamber. Too little fuel delivery and/or pressure, causes combustion deficiencies. This results in improper combustion and in addition to power loss and poor engine performance, it will increase the emission levels released into the atmosphere as stated earlier.

Many companies produce a pesticide type biocide that needs special equipment to use such as face mask , nitrile gloves, special tyvek suits etc. Although they do function as a biocide, they do not address the dead tissue that is left over when the biocide is finished . Also, since they are very viscous (thick), they do not mix well, which doesn't attack the cultures on the top of the fuel and the surrounding walls. They also cause the fuel to burn less efficiently. So although they address one problem, they ignore or create other problems.

## Changes & Effects: Oil

In addition to the much publicized requirement for the use of ultra-low sulfur diesel fuel, these new engine/exhaust system combinations will require the use of a new grade of engine lubricating oil. This new oil will carry an American Petroleum Institute designation of CJ-4. Historically, most engine oil upgrades have built off of the previous grades, but this is not the case with the new CJ-4 oil. Due to the operating requirements of the 2007 engines, CJ-4 oil represents a major change in lubrication technology.

CJ-4 oil must be clean in terms of the post-combustion residuals it releases into the exhaust system to avoid contaminating the oxidation catalyst or the diesel particulate trap. This requirement places strict limits on the amounts of sulfated ash (maximum 1%), phosphorous (maximum 0.4%) and sulfur (maximum 0.12%) that can be incorporated into the oil formula. The resulting product is referred to as "low-SAPS" oil. In addition, CJ-4 must be able to stand up to higher engine operating temperatures and significantly increased soot loads that result from the increased use of exhaust gas re-circulation to control NOx.

### Sulfated Ash

It's not uncommon for minor amounts of oil to migrate into the engine's combustion chamber. The high heat required for diesel combustion turns that oil into Ash, which is then released into the diesel's exhaust system. There is potential for this ash to prove poisonous to the AFD needed for '07 engines. Consequently, petroleum providers are working to identify additives and detergents for oil that will provide lubricity and additional protection against engine wear, but won't form ash should they get into the combustion chamber.

Lubricants that the industry has used for many, many years will actually block the filters with sulfate ash, thus preventing exhaust gases from flowing through the exhaust pipe. Eventually, the engine will suffocate and not run anymore.

Because the levels of ash sulfate, sulfur and phosphorous must be reduced, if prices remained the same, lubricant performance would be severely compromised and today's drain intervals would be greatly increased.

Another issue for fleet managers is whether or not to use CJ-4 in all of the older engines. CJ-4 may not have as much ash as it needs for older engines. The ability of the oil to keep the soot out of the engine and to keep acids to a lower level is going to be reduced. With the ash and the phosphorous removed, part of the exhaust is going to be recirculated which will create additional acids and soot that are normally not present. It will be necessary to enhance your oil oxidation protection.

### Phosphorous

Phosphorus is the key component for valve train protection in an engine. Valve trains and their components are not especially cheap to replace and this drop in phosphorus content has been a problem for many engines. The reduction in phosphorous is also because it poisons the catalysts. Phosphorous is part of the detergent package and sometimes, depending on who is manufacturing it, it is part of the anti-wear and a way to keep the engine oil from actually cooking or oxidizing.

Changes in ambient temperatures can cause condensation and allow for deposits of water. When you remove the sulfur content, the ash and the phosphorous from the engine oil, it's going to create a sponge. Oil is going to soak up water at a greater rate than it normally would. It is going to be more difficult for engine oil to help reduce that water content.

### **Sulfur**

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### **Zinc DDP**

The Zinc in the Oil functioned as a soft material that polished then sealed the metal surface promoting anti scuff and anti rust. The removal of these materials would of course promote the opposite of the positive effects the material had in the oil.

### **Compatibility & Logistics**

The bad news is that you cannot use the old oil in the new engines. There will be serious issues with engine life. One of the main constituents that is being heavily restricted is anti-wear. The anti-wear chemicals that are currently used in today's lubricants can't be used with the '07 engines because they will cause service problems.

You will be able to use CJ-4 in older engines, however, as the new lubricants are designed to be backward compatible. The only scenario still to be seen is how the new oils will perform under the new operating temperatures. The costs will be greater on the new oils and they will contain more exotic additives to maintain the same level of performance that we expect, but without as many of the active ingredients that have been used.

The new oil specifications have to do with a combination of extra filtration for hotter, tighter, '07 EGR (exhaust gas recirculation) engines. Reduction in sulfur in the fuel is also part of the equation and, "this obviously is going to have some kind of affect on the injectors."

A second issue will be the transition into the new oils, and will you keep the old oils in stock? The issue becomes managing the two oils, and potential confusion as to what equipment is treated with what oil.

### **Cost**

The new CJ-4 / PC-10 oils will cost more than the previous types. They are simply more expensive to develop than the CI-4 oils on today's shelves. This is primarily because the testing requirements to certify PC-10 oils for the market are so high. In addition, the number of tests having to be completed has increased, and these costs will inevitably be passed on to the consumer. Prices will increase because the oil formulation has to have a better oxidation stability package, increased chemistry, and new additives into the oil. Estimates are forecasted to be in the tens of millions just for testing the new oils.

### **EGR Influence**

Additional acids and soot can be expected as well because the '07 engines will have EGR systems. What an EGR system does is take a percentage of the exhaust emissions resubmit it

through combustion. This creates a challenge for new oils as the new specs are reducing the natural physical properties of engine oils. In this scenario the sulfated ash that acts as a natural lubricity agent in engine oil is reduced. The oil will need enhanced chemistry additive packages in these and because of the additional cost of the additive package, the cost of all refined oil products will most likely rise.

The addition of a DPF and double the rate of EGR is going to put a lot more additional load on '07 engines. The result will be spikes in both oil and coolant temperatures. The use of exhaust gas recirculation [EGR] is also going to double in '07 engines, increasing the amount of soot levels the new oils must handle.

### **DRAIN INTERVALS**

Total Base Number (TBN) of the new oils is forecasted to be at a level of 8 or 9, down from the 11 to 13 found in today's truck engine oils. That drop-off in base reserve may lead to more conservative oil drain intervals. Lower base reserve means less acid neutralization capability, making the oil deteriorate more quickly.

## Changes and Effects: Engines

Then again, the new fuel will have a bit less energy content, which could degrade measured tank mileage, and there are questions about its lubrication properties.

### Exhaust After Treatment

Most '07 engines will exhale through an exhaust system equipped with an oxygen catalyst and a diesel particulate filter, or DPF. The catalyst will chemically change certain pollutants into non-harmful substances, leaving water and carbon dioxide (CO<sub>2</sub> is not toxic, even if it is a greenhouse gas blamed for Global Warming). The DPF will trap particulates, or soot, which will periodically burn off. But ash from motor oil will collect in the DPF and must be removed through special cleaning.

Once in buyers' hands, the new diesels will need special care. They'll run hotter, putting more load on trucks' cooling systems, some of which have been beefed up to handle the extra heat. New exhaust filters will periodically heat up to burn off accumulated soot. Engines will burn ultra low-sulfur fuel that is just now becoming available, and is expected to cost more than present fuel. They'll use a newly formulated low-ash motor oil that may also cost more. Eventually the diesels will require new maintenance procedures, which will take some extra time and know-how.

Exhaust heat from high-load highway operations will be enough to burn off soot in a process called passive regeneration, engineers explain. In stop-and-go operations, including what's seen by many construction trucks, extra heat will be needed for what's called active regeneration. This comes from injecting small amounts of fuel into the exhaust stream; when the fuel hits the oxygen catalyst, a reaction causes high heat, which then passes into the DPF and burns off the accumulated particulates.

That generally describes the systems to be used by Cummins, Detroit Diesel (including Mercedes-Benz), General Motors-Isuzu, International (and Ford), Mack and Volvo. The imports — Hino, Isuzu, Mitsubishi Fuso and Nissan UD — are already using such systems in Japan. They will bring them to North America come January. As now, the systems will use exhaust-gas recirculation (EGR), but higher doses of it, to lower cylinder temperatures and reduce formation of NO<sub>x</sub>.

Caterpillar is taking a different approach for '07. It will begin using cooled exhaust-gas recirculation, which it has pointedly avoided since October '02. But Cat's EGR will use filtered exhaust gas taken from the end of the aftertreatment device, not raw gas straight from the exhaust manifold as other builders do. In what's called Clean Gas Induction, a pipe carries gas from the rear of the aftertreatment device to the charge-air cooler. Cat claims its system will let engines stay cleaner inside and therefore last longer.

Cat's '07 aftertreatment will have a DPF, but not an oxygen catalyst. The system injects fuel behind the turbocharger and electrically ignites it, sending flame into the DPF; this burns out accumulated soot. As now, Cat will initially clean exhaust gasses with ACERT equipment, including double turbo chargers on larger models. Cat and other builders will also upgrade fuel-delivery systems and electronic controls; the latter will get more powerful microprocessors and more capable software. All builders' after treatment devices will resemble mufflers and actually muffle combustion noise, so mufflers as such will no longer be used.

### Operation and maintenance

Most engine models will run like current ones, though some will run a little slower, and operating rpm might be tighter. So gearing — choosing ratios in transmissions and drive axles — will be

even more important than now. Engine makers will disseminate information on proper spec'ing, which dealers should have. But manufacturers encourage sales people and fleet managers to consult with factory experts if there are any questions about specifications.

Diesels will burn ultra low-sulfur fuel, which refiners have just begun producing, to keep the catalyst and DPF from clogging. Use of higher-sulfur fuel won't necessarily kill the filters, which are made of ceramics and precious metals. But the extra sulfur will hamper their work and soon plug them, requiring premature cleaning or replacement. So, although there's controversy over the new fuel's distribution and storage problems and possible lubricity issues, owners and drivers should be sure that it's the only fuel that goes into tanks.

### **Filter cleaning**

Cleaning ash out of the DPFs will become a new service procedure. In most cases, cleaning will be done by removing the DPF element from the truck — an easy job, partly because parts will be made of stainless steel to resist corrosion, manufacturers say — and placing it on a special machine (though Cat's DPF will come with connections that will allow attaching hoses to clean it right on the chassis).

The console-like machine will blow compressed air at normal shop pressure (about 90 psi) through the filter in pulses; this will take about a half hour, during which the technician can perform other service work on the truck. Removal and reinstallation of the DPF will together consume another half hour and maybe less. Most builders will offer clean DPF elements on an exchange basis, but dealers will probably obtain the simpler and less costly air machines.

Detroit Diesel (which markets and supports M-B diesels) will recommend filter cleaning with deionized water. This will be done on larger, more complex machines at Detroit's remanufacturing centers. In that case, an exchange program will use cleaned filters with dirty filters turned in for core value. Detroit will also allow the air-cleaning method, but says it doesn't work as well as the fluid. A brand-new DPF element, if it's ever needed, will cost hundreds of dollars.

Servicing DPFs won't be needed often, and owners won't have to deal with them until trucks have been run awhile. EPA regulations require at least 150,000 miles of use on a heavy-duty diesel before the first service is required. Engine makers say it might be required at intervals of 200,000 to 300,000 miles for long-haul tractors. Vehicles run in cities, including construction trucks, will require servicing more often, though relatively low annual mileages will stretch out the intervals in terms of time.

### **Exhaust configurations**

Combined catalyst-DPF devices (or just the DPF in Cat's case), which some truck builders call "cans," look like big mufflers but weigh more — 80 pounds or so — manufacturers say. That includes 50 to 60 pounds for the DPF element. They'll usually be mounted under cabs or in vertical stacks. Cans or stacks might need special lifting devices, and those in other under-cab locations might require a creeper and a transmission jack to get to and handle.

Multi-axle dump trucks are the toughest vehicles on which to "package" the cans because pusher axles take up space on the frame. Vertical stacks are the likely solution and, in some cases, the front corners of bodies may need sculpting to make room for the bulky equipment. Asphalt-hauling bodies needing exhaust heat will have to take exhaust gasses from downstream of the DPF, so under-cab fitment is likely for them. The longer the chassis and wheelbase, the easier it will be to accommodate the after treatment parts.

Aftertreatment cans will be wired into engines' electronic control modules, which will monitor the devices' condition and order active regenerations if needed. ECMs will lower horsepower and torque if catalysts or elements get plugged, and even shut down engines in dire cases. Tampering with or removing after treatment devices will cause ECMs to disable engines.

Technicians will thus have to learn how these circuits work and how to troubleshoot and repair them.

Exhaust systems will be "no-touch" items that may not be changed because they will be certified by manufacturers. Dealers and upfitters, who sometimes cut into and alter exhaust systems to make room for installation of special bodies and equipment, must leave the '07s alone. The only thing they can change on an '07 is the tailpipe, manufacturers say. Dual exhausts will disappear from all but high-horsepower diesels, and straight pipes will be illegal because the after treatment devices must remain on the trucks.

Dealers who stock bare chassis and alter them for specific applications might have to plan ahead more. Builders say they'll offer several exhaust configurations for each truck model, and the correct one for the job will have to be spec'd in the order. Manufacturers are not likely to offer kits to change exhaust configurations because that would put dealers or upfitters in the position of certifying exhaust emissions performance — something neither they nor the federal Environmental Protection Agency would want.

### **Training underway**

Engine and truck builders say they've begun training dealer technicians on the new systems. Cat, for example, is trying to eliminate the "fear factor" inherent with new and unknown equipment by producing educational sessions on the Net and CDs, and in its closed-circuit TV broadcasts. All builders have begun printing special literature and training materials, and are preparing to put special tools in dealers' hands.

They say they've also tried to minimize the number of tools needed for servicing. The compressed-air cleaning machine, for example, is a generic design usable for all DPFs. One model is built by tool maker SPX, a name familiar to shop people. It runs on 110-volt power and standard shop air, sits on rollers so it can be moved among service bays, and costs several thousand dollars. Only large truck fleets are expected to buy these machines, as most operators will let dealers handle this specialized maintenance.

## Recommendations

**These are facts, we can't get away from - a business man must adapt himself to the natural conditions as they exist from month to month and year to year.**

*Lee Iacocca,  
Automobile Executive and Author.*

To realize that your operating environment has changed, and then continue the way you always have, will only ensure you that you fall short of the companies that embrace and chase the curve. Inevitably, the group that chases the curve usually buys the other as they are going out of business? The only real way to reduce the impact of inflation is to improve efficiency and reduce consumption. It costs no more to save fuel now than it did a year ago, but the returns are 26 percent greater. The operator training or oil-analysis program that saved a \$25,000 engine failure a year ago will now save a \$30,000 engine failure.

**Be creative. Use unconventional thinking. And have the guts to carry it out.**

*Rockefeller, John D.*

The second thing that we notice in dealing with a multitude of companies is the stumbling block in finding solutions to the problems listed in this white paper is this: in most cases, the person who evaluates solving the issue at hand most always has nothing to gain if a proposed solution is successful, and everything to lose if it fails. Have the resourcefulness to invest into evaluating solution propositions, the sense not to scrutinize your people evaluating them, and the fortitude to implement them if they can help you.

**"The aero-plane is scientifically impossible."**

*Lord Kelvin, 1897-9.  
Royal Society President*

What have you absolutely convinced yourself of, or rather, what does your staff hold as absolute certainties? We live in a world of very smart and gifted innovators, and there exists solutions to the problems at hand. It is unlikely you will achieve the improvements you need by simply working harder. Hence, the "sharpen the saw" analogy used by Steven Covey. Two men who saw continually see decreasing efficiency. Why – the saw blade dulls, and simply working harder won't help. You have to stop and sharpen the saw. I heard this brilliantly put by a former professional athlete who said that the best athletes use the off season to improve. He challenged us to build in time for an off season, focused on getting better at what we do, rather than continuing to just do it. This should be time dedicated to looking for ways to work smarter by adopting new technologies, changing the way we do business and going where we have not been before.

"Seek to develop and use physical measures of performance and steer clear of metrics based on cost; Fuel consumption is a better measure than fuel cost, and component life is a better measure than repair cost. Traditional cost-control and cost-management methodologies presume that input costs will remain at the same level and that you can manage the process by comparing input costs with the value of outputs produced. The reality of all the changes coming our way will greatly skew our traditional assessments of these costs, and the companies that address these concerns may incur solutions costs, but stand to run a greater performance than that of their peers so live the new status quo." *Mike Vorester, Equipment Magazine.*

## **Too Philosophical?**

Perhaps those concepts are not the easy take home and heat it up you were hoping for. In refraining from selling a solution which is outlawed in the “white paper” world, but is inherently what everyone is really doing anyway, here are a list of solutions that you should be looking to implement, through whatever products or methods allow you to do that at the best result and highest return on investment. Hint! Hint!

## **Fuel, Fuel Monitoring & Testing**

Fuel is not fuel, and those who are buying rack are more likely to run the risk of getting whatever quality is available. We suggest that you regularly test your fuel either internally or with a qualified laboratory. If your fueler knows you’re watching, you are less likely to get the occasional questionable load. Provided that you can find a company that meets your needs, establishing relationships with refuelers may prove beneficial for product quality and service.

If the cost of fuel hasn’t scared you yet, hang on, because it’s only going one direction. Improvements in fuel efficiencies can only help you and don’t always have to require you to lift the hood and do it all yourself. Look into technologies that can help increase or improve the amount of fuel you consume.

Measuring the fuel delivered is as important as the fuel consumed. Look into investing in either meters or totalizers that will help you validate the loads of fuel you receive, rather than hoping they were correct.

## **ULSD**

Look into finding something to bring back the lost BTU in ULSD which will only help your operations continue to run at the levels you hope for. In addition, realize that you also need to address the growing water and fungus in your bulk tanks. Take the time to study your options here as some of these antibacterial solutions will require guys in masks and potentially harmful substances to your personnel. Look for an easily applicable remedy that causes no compatibility issues or causes you loss of power. These problems may have not been issues for you in your particular geographical location, but with increased water and decreased sulfur, people will begin to see issues that have not previously encountered – hence the quote from Mr. Iacocca.

Unless you make your money fixing engines, you will need more lubrication in your injectors, Pumps and Upper Cylinder than is being supplied by your Fuel Company. That is why even Caterpillar is saying you need one, and no one having taken the time to read this far is the kind of person who believes in doing the minimum of anything.

## **Oil**

You will need to think through how many oils you are going to keep in stock for you fleet, appropriate logistics, and intervals of each. Keep an eye on the newer oils and intervals as the new engines are forecasted to run hotter, and will have enough inherent challenges on longevity. Search for some solutions that help you bring back some of the lost properties of the oil, and on the next rainy day, read up on the science of nano-technology and how it’s being used in relevant applications.

If you don’t already, you should become religious about oil samples. They are the lifeblood and the thermometer of your engine, and rely on them especially when comparing new oils and technologies.

## Engines

All the new engines will be engineered around the reduction of emissions. The effects of running the unburned fuel back through the engine will take its toll and the reality is it's not the manufactures fault. They are being told by the EPA to reduce emissions, and are doing their best to find ways of doing so. The reality is that the issue at hand is the efficiency and totality of combustion in engine. Find a way to more completely consume the fuel molecule at the point of combustion, then more power and torque with fewer emissions is the natural result.

## ETV Verification Process

“The objective of the Voluntary Diesel Retrofit Program Verification Process is to introduce verified technologies to the market as cost effectively as possible, while providing customers with confidence that verified technologies will provide emission reductions as advertised. This verification process will evaluate the emission reduction performance of retrofit technologies, including their durability, and identify engine operating criteria and conditions that must exist for these technologies to achieve those reductions.”  
As quoted by the EPA / ETV.

This is a good place to check in with and see what the EPA is suggesting (in addition to what the manufactures are doing) about how to deal with emissions. What it doesn't tell you is what the OTHER effects are on the engine as a result of implementing these solutions. Their job is to test for the reductions of emissions. Your job is to think through what is logically happening as a result of the process and determine what kind of overall outcome is achieved. What you should be looking for is something that reduces emissions levels WITHOUT taking performance away from the engine, and in a perfect scenario actually helps engines performance.







Keep up with this board and check it from time to time...there may yet be something out there:

<http://www.epa.gov/otaq/retrofit/retroverifiedlist.htm>

Verified Retrofit Technologies

Mfr.	Technology	Applicability	Reductions (%)			
			PM	CO	NOx	HC
<a href="#">Caterpillar, Inc.</a>	Catalyzed Converter/Muffler (CCM)	Highway, heavy-heavy and medium-heavy duty, 4 cycle, non-EGR, model year 1998 - 2003, turbocharged or naturally aspirated engines	20	20	n/a	40
<a href="#">Caterpillar, Inc.</a>	Diesel Particulate Filter	Nonroad, 4 cycle, non-EGR equipped, model year 1996-2005, turbocharged engines with power ratings 130 ≤ KiloWatts < 225 (174.2 ≤ Horsepower < 301.5)	89	90	n/a	93
<a href="#">[Caterpillar, Inc.]<sup>b</sup></a>	[Emissions Upgrade Group] <sup>b</sup>	[Caterpillar model 3306 diesel engines for nonroad applications with model years from 1988 to 1995 with mechanical direct fuel injection.] <sup>b</sup>	[15] <sup>b</sup>	[3] <sup>b</sup>	[27] <sup>b</sup>	[61] <sup>b</sup>
<a href="#">Clean Diesel Technologies.</a>	Platinum Plus Purifier System	Highway, medium heavy- and heavy heavy-duty, 4 cycle,	25 to 50	16 to 50	0 to 5	40 to 50


Verified Retrofit Technologies

Mfr.	Technology	Applicability	Reductions (%)			
			PM	CO	NOx	HC
<a href="#">Inc.</a> 	(fuel borne catalyst plus DOC)	model year 1988 - 2003, turbocharged or naturally aspirated engines				
<a href="#">Clean Diesel Technologies, Inc.</a> 	Platinum Plus Fuel Borne Catalyst/Catalyzed Wire Mesh Filter (FBC/CWMF) System	Highway, medium heavy-duty, 4 cycle, model year 1991 - 2003, non-EGR, turbocharged or naturally aspirated engines	55 to 76	50 to 66	0 to 9	75 to 89
<a href="#">Donaldson</a> 	Series 6000 DOC & Spiracle (closed crankcase filtration system)	Highway, heavy heavy- and medium heavy-duty, 4 cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated engines	25 to 33 <sup>a</sup>	13 to 23	n/a	50 to 52
<a href="#">Donaldson</a> 	Series 6100 DOC	Highway, heavy heavy- and medium heavy-duty, 4 cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated engines	20 to 26	38 to 41	n/a	49 to 66
<a href="#">Donaldson</a> 	Series 6100 DOC & Spiracle (closed crankcase filtration system)	Highway, heavy heavy- and medium heavy-duty, 4 cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated engines	28 to 32 <sup>a</sup>	31 to 34	n/a	42
<a href="#">Engelhard</a>	DPX Catalyzed Diesel Particulate Filter	Highway, heavy-duty, 4 cycle, model year 1994 - 2002, turbocharged or naturally aspirated engines	60	60	n/a	60
Engelhard	CMX Catalyst Muffler	Highway, heavy-duty, 2 cycle engines	20	40	n/a	50
Engelhard	CMX Catalyst Muffler	Highway, heavy-duty, 4 cycle engines	20	40	n/a	50
<a href="#">Engine Control Systems</a> 	Purifier - Diesel Particulate Filter	Highway, heavy and medium heavy-duty; Urban Bus; 4 cycle; model years 1994 - 2003; turbocharged or naturally aspirated; non-EGR engines	90	75	n/a	85
<a href="#">Engine Control Systems</a>	AZ Purimuffler or AZ Purifier Diesel Oxidation Catalyst with ECS closed crankcase	Highway, heavy-duty, 4 cycle, mechanically or electronically injected, turbocharged or naturally aspirated, originally manufactured from 1991 through 2004 model years	40	60	n/a	75

Verified Retrofit Technologies

Mfr.	Technology	Applicability	Reductions (%)			
			PM	CO	NOx	HC
	ventilation (CCV) system with Low Sulfur Diesel Fuel (30 ppm S max)	which meet a 5 or 4 g/bhp-hr NOx standard with open crankcase ventilation and no after treatment engines				
<a href="#">Engine Control Systems</a>	AZ Purimuffler or AZ Purifier Diesel Oxidation Catalyst with Low Sulfur Diesel Fuel (30 ppm S max)	Highway, medium heavy-duty, 4 cycle, model years 1991 - 2003 Cummins and Navistar/International engines originally manufactured with no aftertreatment, turbocharged or naturally aspirated, non-EGR engines	40	40	n/a	70
<a href="#">Engine Control Systems</a>	AZ Purimuffler or AZ Purifier Diesel Oxidation Catalyst with Low Sulfur Diesel Fuel (30 ppm S max)	Highway, heavy heavy-duty, 4 cycle, model years 1991 - 1993 Cummins engines originally manufactured without exhaust aftertreatment, turbocharged or naturally aspirated, non-EGR engines	35	40	n/a	70
Engine Control Systems	AZ Purimuffler AZ Purifier	Highway, heavy duty, 2 cycle engines	20	40	n/a	50
Engine Control Systems	AZ Purimuffler AZ Purifier	Highway, heavy duty, 4 cycle engines	20	40	n/a	50
<a href="#">International Truck &amp; Engine Corp.</a>	Green Diesel Technology-Low NOx Calibration plus Diesel Oxidation Catalyst with Ultra Low Sulfur Diesel (ULSD)	Highway, light heavy-duty, 4 cycle, Navistar/International engines, model years 1999 - 2003 in the following families: XNVXH0444ANA, YNVXH0444ANB, 1NVXH0444ANB, 2NVXH0444ANB, 3NVXH0444ANB	0 to 10	10 to 20	25	50
<a href="#">Johnson Matthey</a>	Catalyzed Continuously Regenerating Technology (CCRT) Particulate Filter	Highway, heavy-duty, urban bus, 4 cycle, non-EGR model year 1994 - 2006, turbocharged or naturally aspirated engines.	90	85	n/a	95
<a href="#">Johnson Matthey</a>	Continuously Regenerating Technology (CRT) Particulate Filter	Highway, heavy-duty, 4 cycle, model year 1994 - 2006, turbocharged or naturally aspirated engines	90	85	n/a	95

Verified Retrofit Technologies

Mfr.	Technology	Applicability	Reductions (%)			
			PM	CO	NOx	HC
<a href="#">Johnson Matthey</a>	CEM™ Catalytic Exhaust Muffler and/or DCC™ Catalytic Converter	Highway, heavy-duty, non-urban bus, 4 cycle, non-EGR model year 1991 - 2003, turbocharged or naturally aspirated engines	20	40	n/a	50
Johnson Matthey	CEM Catalyst Muffler	Highway, heavy-duty, 2 cycle engines	20	40	n/a	50
<a href="#">Lubrizol</a>	PuriNOx Water emulsion fuel	Highway & Non-road, heavy-duty, 2 & 4 cycle	16 to 58	-35 to 33	9 to 20	-30 to -120
<a href="#">Paceco Corporation</a> 	MES diesel particulate filter (MES-DPF)	Pre-1996 nonroad, 4-cycle, heavy-duty diesel engines in the 225 - 450 kW (NR7) power range in electrical generation applications	39	90	n/a	95
Various	<a href="#">Biodiesel</a> (1 to 100%)	Highway, heavy-duty, 2 & 4 cycle	0 to 47	0 to 47	-10 to 0	0 to 67
Various	<a href="#">Cetane Enhancers</a>	Highway, heavy-duty, 4 cycle, non-EGR-equipped engines	n/a	n/a	0 to 5	n/a

## About Hoss Equipment



Hoss Equipment Company is a global leader in the rebuilt and used heavy equipment industry. Our high-quality rebuilt and used heavy construction equipment includes Caterpillar, Komatsu, Hitachi, Volvo, Terex, Dresser, and many more.

Hoss Equipment Company is also a franchise dealer in new heavy construction equipment, parts and service in several geographic territories for Terex, Link-Belt, O&K, Unit Rig, Klein, and Payhauler, among others. With over \$50 million in inventory, we have the used heavy equipment you need available for shipping anywhere in the world today. Contact Hoss for more information on the Hoss Custom Rebuild Program and special extended warranties.

### New, Used & Custom Rebuilt Heavy Equipment

FEATURED MANUFACTURERS	FEATURED EQUIPMENT TYPES
<a href="#">CATERPILLAR</a>	<a href="#">CRAWLER-TRACTORS</a>
<a href="#">HITACHI</a>	<a href="#">HYDRAULIC-EXCAVATORS</a>
<a href="#">KOMATSU</a>	<a href="#">TRUCKS-RIGID-FRAME-END-DUMP</a>
<a href="#">TEREX</a>	<a href="#">WHEEL-LOADERS</a>
<a href="#">Other Available Manufacturers</a>	<a href="#">Other Available Types</a>



HITACHI CONSTRUCTION MACHINERY

**KOMATSU**

**DURATRAY**

**ACES**  
American Clean Energy Systems, Inc.

Since 1990, Hoss Equipment Company has been a leading independent global dealer of large new and used heavy construction and mining equipment. We provide new, rebuilt and used heavy equipment solutions for highway construction, mass excavation, landfill, quarry/aggregate, coal mining and other surface mining applications including precious metals.

Hoss sales professionals average more than thirty-years of industry experience each in the heavy construction and mining equipment industries. Each will provide you with the information you need, the equipment selection you expect and the "one company, one call, one total solution" peace of mind you deserve.

The company specializes in medium-to-large units including crawler-tractors, off-highway dump trucks, mass and hydraulic excavators and shovels, wheel loaders, motor scrapers, motor graders, off-highway water equipment, and compactors. Whether you need a single piece of equipment or an entire fleet, we can provide you with reliable earth-moving equipment that can be

custom configured with the features you need. Our inventory includes only the finest in earth-moving equipment from Caterpillar, Hitachi, Dresser, Komatsu, Euclid, Terex, Link-Belt, O&K, Klein, and more. We have the inventory you need in-stock today.

## REBUILT HEAVY EQUIPMENT

The Company's fastest growing product line is the "Hoss Custom Rebuild": These are selected used machines rebuilt from the 'ground up' to like-new condition. By participating in the Hoss Custom Rebuild (HCR) program, you'll receive the finest rebuilds in the industry at a fraction of the cost of a new machine.

- Each HCR unit is rebuilt to stringent OEM rebuild guidelines;
- Most rebuilds average just 60% of the price of a new machine;
- Hoss Custom Rebuilds provide the same productivity as new machines; and
- Most of our rebuilds carry a 1-year, 2,000 hour limited Powertrain warranty. Our extended warranties can be serviced throughout the world.

OTHER MANUFACTURERS	OTHER EQUIPMENT TYPES
<a href="#">AG-CHEM</a>	<a href="#">AGGREGATE / SCREENS</a>
<a href="#">ALLIED WIZEE</a>	<a href="#">ATTACHMENTS &amp; MISC.</a>
<a href="#">ATHEY</a>	<a href="#">BACKHOES</a>
<a href="#">ATLAS</a>	<a href="#">BOOMS / STICKS / CYLS - EXCAVATOR / SHOVELS</a>
<a href="#">BALDERSON</a>	<a href="#">BUCKETS</a>
<a href="#">BIG TEX</a>	<a href="#">BUCKETS - EXCAVATOR / SHOVEL</a>
<a href="#">BISCO</a>	<a href="#">BUCKETS - WHEEL LOADER</a>
<a href="#">CARON</a>	<a href="#">CABLE REELER</a>
<a href="#">CAT/BALDERSON</a>	<a href="#">COAL DOLLY</a>
<a href="#">CAT/ITRAC</a>	<a href="#">COMPACTORS (LANDFILL)</a>
<a href="#">CAT/TIGER</a>	<a href="#">COMPACTORS (SOIL)</a>
<a href="#">CEC</a>	<a href="#">CRAWLER DRILLS</a>
<a href="#">CF</a>	<a href="#">CUTTING EDGES</a>
<a href="#">CHEVROLET</a>	<a href="#">CYLINDERS</a>
<a href="#">CUMMINS</a>	<a href="#">DEMOLITION/PROCESSING EQUIPMENT</a>
<a href="#">DEMAG</a>	<a href="#">DIFFERENTIALS</a>
<a href="#">DIAMOND</a>	<a href="#">ENGINES</a>
<a href="#">DRESSER</a>	<a href="#">FINAL DRIVE</a>
<a href="#">DRESSER/KOMATSU</a>	<a href="#">FORKLIFTS</a>
<a href="#">DRILTECH</a>	<a href="#">FORKS</a>
<a href="#">DYMAX</a>	<a href="#">FUEL/LUBE BODY</a>
<a href="#">ESCO</a>	<a href="#">LOADER ARM ASSYS &amp; PARTS</a>
<a href="#">EUCLID</a>	<a href="#">LOADER FRAMES</a>
<a href="#">FORD</a>	<a href="#">MAIN FRAMES</a>
<a href="#">GEITH</a>	<a href="#">MISCELLANEOUS</a>
<a href="#">GENESIS</a>	<a href="#">OFF HIGHWAY BELLY DUMP TRAILER DOLLIES</a>

<a href="#">GFACTO</a>	<a href="#">OFF HIGHWAY BELLY DUMP TRAILERS</a>
<a href="#">HENSLEY ADCO</a>	<a href="#">OFF HIGHWAY BOTTOM DUMP TRAILER</a>
<a href="#">HERCULES</a>	<a href="#">OFF HIGHWAY BOTTOM DUMP TRAILERS-COAL</a>
<a href="#">HOLLAND</a>	<a href="#">OFF HIGHWAY END DUMP TRAILER</a>
<a href="#">HOLT</a>	<a href="#">OFF HIGHWAY LOWBOY EQUIPMENT TRAILERS</a>
<a href="#">HOSS</a>	<a href="#">PUSH BLOCKS</a>
<a href="#">IMAC</a>	<a href="#">RECLAIMER/STABILIZER</a>
<a href="#">INGERSOLL-RAND</a>	<a href="#">RECYCLER/STABILIZER</a>
<a href="#">INTERNATIONAL</a>	<a href="#">REMOTE-VIDEO-SURVEILLANCE</a>
<a href="#">IRONWOLF</a>	<a href="#">SCRAPER BOWLS</a>
<a href="#">ITM</a>	<a href="#">STICKS / BOOMS</a>
<a href="#">JCB</a>	<a href="#">TIRE MANIPULATOR</a>
<a href="#">JONES</a>	<a href="#">TORQUE CONVERTER</a>
<a href="#">KAWASAKI</a>	<a href="#">TRANSMISSIONS</a>
<a href="#">KELLY</a>	<a href="#">TRUCK BEDS</a>
<a href="#">KLEIN</a>	<a href="#">TRUCKS (BELLY DUMP)</a>
<a href="#">LETOURNEAU</a>	<a href="#">TRUCKS (BUCKET)</a>
<a href="#">MEDFORD</a>	<a href="#">TRUCKS (END DUMP-ELECTRIC)</a>
<a href="#">MEGA</a>	<a href="#">TRUCKS (FUEL / LUBE)</a>
<a href="#">MEGA/MAGNUM</a>	<a href="#">TRUCKS (FUEL/LUBE-OFF HIGHWAY)</a>
<a href="#">MICHIGAN</a>	<a href="#">TRUCKS (GENERAL)</a>
<a href="#">MICHIGAN/VME</a>	<a href="#">TRUCKS (WATER-OFF HIGHWAY - ARTICULATED)</a>
<a href="#">MISC</a>	<a href="#">TRUCKS (WATER-OFF HIGHWAY) - TANK ONLY</a>
<a href="#">MITSUBISHI</a>	<a href="#">UNDERCARRIAGES</a>
<a href="#">MODERN WELDING</a>	<a href="#">WATER TOWER</a>
<a href="#">MRS</a>	<a href="#">WATER WAGON (TANK ONLY)</a>
<a href="#">O&amp;K</a>	<a href="#">WHEELS</a>
<a href="#">PAYHAULER</a>	<a href="#">WINCHES</a>
<a href="#">PEINER</a>	<a href="#">CRANES</a>
<a href="#">PEMBERTON</a>	<a href="#">MOTOR GRADERS</a>
<a href="#">REX/CMI</a>	<a href="#">MOTOR SCRAPERS</a>
<a href="#">RIMPULL</a>	<a href="#">WATER WAGONS</a>
<a href="#">RIPCO</a>	<a href="#">TRUCKS-WATER-OFF-HIGHWAY</a>
<a href="#">ROCKLAND</a>	<a href="#">TRAILERS &amp; TRUCK BEDS</a>
<a href="#">SHUTTLELIFT</a>	<a href="#">TRUCKS (OFF HWY CHASSIS ONLY)</a>
<a href="#">SOUTHWEST</a>	<a href="#">TRUCKS-ARTICULATED-DUMP</a>
<a href="#">SVETRUCK</a>	<a href="#">COMPACTORS (SOIL DRUM)</a>
<a href="#">TALBERT</a>	<a href="#">WHEEL-DOZERS</a>
<a href="#">TELEDYNE (BTI)</a>	<a href="#">HYDRAULIC SHOVELS</a>
<a href="#">TEREX/O&amp;K</a>	<a href="#">RIPPERS</a>
<a href="#">TIMBERLAND</a>	<a href="#">BLADES</a>
<a href="#">TRILECTRON</a>	<a href="#">CRAWLER-LOADERS</a>

[UNIT RIG](#)

[VME](#)

[VOLVO](#)

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## About American Clean Energy Systems



American Clean Energy Systems, Inc. (ACES) was established to provide customers with a product line to meet the needs created by the Clean Air Act. It is our goal to develop products which will dominate the diesel, gasoline, and lubricant markets. Through the continued commitment of ACES, and the revolutionary technology of liquid engineering, we maintain continued dedication to our customers by providing performance SECOND TO NONE!

ACES has often been referred to as the "Microsoft of Diesel Fuel Treatment Technology". This is based on the understanding of our products' revolutionary performance and emission reductions. The ACES family is not only dedicated to fulfill our goals but is honored to provide a positive impact on the environment by leading the world into the "Liquid Engineering" (PDF file) revolution. ACES is committed to helping our country reduce our dependency on foreign oil imports. Our Mission Statement

We are always asked about our "secret" ingredient. Our secret ingredient is COMMITMENT. Commitment to being the world leader in fuel and oil technology. Commitment to customer service excellence. Commitment to the environment. Commitment to the ACES family of distributors. We want to be the company our customers love doing business with. Every transaction must be 100% win/win. We are not interested in the quantity of customers... we are interested in the quality of our customers' commitment to their maintenance program.

Many companies, who are proactively dealing with these same issues, have partnered with American Clean Energy Systems, Inc. (ACES) and their solution through "Liquid Engineering". Fuel and oil additives of the past are like the once revolutionary telegraph making leaps and bounds at that particular time in history. Older technology of additives causes a chemical change to the fuel or oil when added. ACES products are not additives, they are catalysts, and catalysts make a physical change to fuel or oil added. Therefore, ACES has developed new technology through "Liquid Engineering" allowing ACES fuel and oil catalysts to change engineering now and in the centuries to come. ACES products are changing today's world just like the cell phone has transformed communication.

ACES fuel catalysts have been proven to help older engines to meet new emission standards while providing increased fuel savings. These same products replace lost lubricity while eliminating fungus, bacteria, and yeast contamination, both of which will extend engine life, increase fuel mileage, and reduce emissions. Through the use of ACES "Liquid Engineering" the money saved on fuel expenses and engine maintenance will pay for the ACES fuel catalyst over and over again. Read more about ACES diesel fuel and gasoline catalysts.

ACES oil catalysts will extend engine life by providing a "wet-start" reducing engine wear and decreasing necessary maintenance. Tests have shown that a reduction in engine temperature by 1°F will extend engine life by 2%. ACES "Liquid Engineering" reduces oil temperature up to 15°F extending engine life up to 30%. Read more about ACES oil catalysts.

These companies and countless others are saving thousands, even millions of dollars, using ACES "Liquid Engineering" systems rather than traditional mechanical engineering.

Join these companies in the growing "Liquid Engineering" revolution by becoming a loyal ACES customer.

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Chevron <http://www.chevron.com/products/prodserv/fuels/diesel/ulsd.shtml>

ASTM Testing International [www.astm.org](http://www.astm.org)

### Construction Equipment Magazine:

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