



Diesel TEK, Inc.
White Paper
CL-8 Engine System

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Industry Challenges

Diesel TEK, Inc. was founded in June of 2004 to address significant changes that are occurring within the heavy duty transportation industry. The industry changes that Diesel TEK set out to address are concentrated on emission control devices, like exhaust gas recirculation systems (EGR) or Caterpillar's ACERT system. Additional systems have been implemented such as Diesel Particulate Filter systems (DPF) that utilize diesel fuel that is carried onboard the vehicle. Specific maintenance benefits are also addressed through our entire program. Our Motto is:

A CLEAN ENGINE OPERATES AT PEAK PERFORMANCE

The heavy duty diesel industry has come under increased emissions regulations at the Federal level by the Environmental Protection Agency and with individual States agencies such as the California Air Resource Board. To meet these regulations, the heavy duty diesel engine manufactures are attempting to implement automotive gasoline engine emission technologies to large-scale diesel engines. This has resulted in a myriad of problems resulting in loss of engine power and performance and has not achieved uniform emission results.

Engine manufactures are coping to find a solution to the regulations handed to them by the State and Federal Agencies, who lack workable solutions to their own regulations as well. The State and Federal regulating agencies are penalizing the diesel industry with fines and fees to motivate diesel engine manufacturers to come up with solutions. These same agencies are, at the same time, slowing down startup companies that have viable technologies by creating lengthy and expensive testing protocols.

This has put a strain on innovation and necessary financing for both startup and fully established companies alike. These State and Federal regulation agencies are only allowing grants and other government funding programs to pay for products that the agencies have tested and verified. The testing and verification process can take several years and cost the manufacturer or developer millions of dollars to complete.

This has created a gap between the engine performance required by the state and the technology to achieve it. The result is a host of problems for the heavy-duty diesel industry service providers. A few of the problems facing truck owners, mechanics, service advisors and new/used truck dealers are:

- Elevated soot content in engine oil resulting from the implementation of the EGR system.
- Diesel Particulate Filter regeneration problems stemming from elevated lubrication oil contaminates.
- Increased back-pressure on the engine resulting in additional blow-by of exhaust in the pistons during the combustion process, which leads to increased lube oil contaminates.
- All of these issues shorten the service life of diesel engines.

The above issues are significant problems for diesel operators and the heavy-duty diesel industry. These are further complicated by new complex electronic systems that manage engine performance on new diesel engines coupled with various new emission system controls.

This has resulted in an industry "knowledge and training gap" with diesel service technicians even for basic maintenance procedures. All of this adds additional downtime and costs, making it difficult for transportation companies to stay profitable.

Without new solutions, these issues and problems will grow increasingly complex with increasingly stringent and unworkable new emissions requirements for 2010 and 2013.

Existing Emissions Control Devices

Exhaust Gas Recirculation System

The EGR system was implemented under a Federal mandate in 2004. The use of this emission control device is aimed specifically at reducing Oxides of Nitrogen output in the exhaust from the combustion of diesel fuel.

EGR Systems and Lubricating Oil in Diesel Engines

by David Doyle, CTC Analytical Services

“In recent years, engine manufacturers have been required to reduce the levels of nitrogen oxides (NO_x) in diesel engine exhaust to meet Tier 3 emission standards required by the Environmental Protection Agency (EPA). One of the reasons for this mandate by the EPA is because NO_x has been associated with respiratory disease and cancer. This requirement is accomplished by changes in engine designs that include retarded timing, raised piston rings, selective catalytic reduction and the use of exhaust gas recirculating (EGR).

New engine designs use EGR to control NO_x emissions by recirculating exhaust gases back into the combustion chamber to be burned a second time, thereby reducing emissions associated with health risks. The amount of exhaust gas introduced into the combustion chamber will displace oxygen, creating cooler combustion. In doing this, many of the exhaust contaminants end up in the engine lubricating oil.

Diesel engine oils are now exposed to a higher level of contamination that can degrade the oil and damage engine parts. There is concern that exhaust gas recirculation can have a detrimental effect on engine durability and its effects on the oil. Oils exposed to the EGR environment show an increase in soot content, acid number (AN) and viscosity, while the engine and oil are both exposed to corrosive/acidic gases and particle buildup.

Oil analysis has become more important than ever. These changes in diesel engine design, which include EGR systems, are pushing the performance requirements of diesel engine lubricating oil. Testing is becoming critical in monitoring the oil's ability to function properly as well as evaluating the health of the engine. Previous soot limits of 1.5 percent were normal in most heavy-duty diesel engines. Soot limits of three percent are now generally accepted, and higher levels are expected in the future.

In addition to the stress that higher temperatures put on the engine oil, mixture with exhaust gases can act as a catalyst for oxidation and nitration (a form of oxidation) in the oil. A routine oil analysis may start showing an unacceptable increase in viscosity when all other parameters and time on the oil appear normal. An improperly operating EGR system can severely aggravate this problem. Waste gate components in an EGR system can be particularly susceptible to surface scuffing damage. If an exhaust gas recirculating system is not operating properly, the lubricating oil can rapidly deteriorate. Sometimes going so far as to turning the oil into an oxidized, acidic sludge.

Used diesel engine oil testing parameters may focus more on infrared analysis (FTIR) for oxidation, nitration and sulfation than in the past. Previously, diesel engines without an EGR system did not have excessive oxidation and nitration problems unless there were significant mechanical problems or poor maintenance. The catalyzing effects of the contaminants introduced into the engine and its lubricant make the oil much more prone to oxidation, nitration and sulphation. This means the application of FTIR analysis will become a more relevant and useful tool for measuring used diesel engine oil life and serviceability.

With the new engine technology involving EGR systems, oil change intervals may suffer even with the advent of the PC-9 formulation. Condition-based oil change intervals based on standard laboratory analysis may be cut back initially because of increases in oxidation contaminants and soot. Oil change intervals will be proven by the lubricant's ability to handle the added stress by maintaining an acceptable level of alkalinity reserve (base number), proper viscosity limits through dispersancy and antioxidants and wear control.

Once again, oil analysis will be a significant determining factor establishing condition-based oil change intervals with the new developments in engine design and oil formulation. Without acquiring new test data under standard oil analysis conditions, it is hard to predict what limits we are likely to see in the future. Some wear metals relating to the liner, ring and valvetrain, such as chromium, may increase. Soot levels are definitely expected to increase well beyond the nominally accepted level of three percent. Other test parameters such as BN, AN, viscosity, oxidation and nitration will keep the same limits; it is simply a question as to how much faster these limits will be reached."

David Doyle is from Noria Corporation. Our team has decades of cumulative experience in lubricant physical and chemical analysis, tribology, lubricant application and selection and contamination control relating to many different types of equipment and industry sectors including manufacturing, power generation, mobile equipment and pulp and paper. As leading experts in the areas of machinery lubrication, oil analysis, contamination control and tribology, Noria consultants also serve as industry experts in a number of litigation cases.

Diesel Particulate Filter (DPF)

This article, plus many similar references, are available on industry internet sites and print publications covering DPF operation and maintenance methods.

January 2008, Work Truck - Feature Article

What Fleet Managers Should Know About Diesel Particulate Filters

<http://www.worktruckonline.com/Article/Print/Story/2008/01/What-Fleet-Managers-Should-Know-About-Diesel-Particulate-Filters.aspx>

What's Involved in DPF Maintenance?

Although the DPF is designed for long life, eventually the accumulated ash must be removed by special cleaning equipment. What is the typical cycle for the DPF before it needs to be cleaned? "We're looking at least 100,000 miles before having to worry about it," projects Aquaro. Engine manufacturer estimates range from 100,000-150,000 miles in most light- and medium-duty applications.

"The question then becomes do we clean (the DPF) or do we offer a DPF exchange program, replacing it all together?" poses Aquaro. The answer is manufacturer- and truck class-specific. Fleet managers should consult the manufacturer's rep to determine the cleaning/replacement processes for specific trucks.

What costs should can be expected for DPF cleaning/replacement? Estimates range from several hundred dollars to \$2,500 and more.

Fuel, Oil, and Oil Change Intervals Can Impact DPF Life

Here are factors to consider to maximize DPF life.

- **Fuel.** Too much soot leads to premature clogging and change cycles for the DPF. One way to counteract this issue is to focus on removing any controllable sources of soot or particulate matter.

One particular controllable source is the amount of sulfur in fuel. And this is where ULSD comes into play because its sulfur content is only 15 parts per million (ppm), down from the 500 ppm in the previous low sulfur fuel.

A Frequently-Asked-Questions document, produced by International Truck and Engine Corporation and posted on the Ryder Truck Leasing Web site, www.ryder.com, says this: "Misfueling once or twice won't create problems; however, continuous use of diesel fuels containing more than the recommended 15 ppm of sulfur will cause a poisoning effect of the catalyst in the exhaust system and ruin the emissions system, causing the vehicle to break down with costly repair implications and void warranties."

"Anything that goes into the fuel tank," Aquaro warns, "will impact the DPF. So make sure you're putting in the right fuel."

- **Engine oil.** To meet 2007 emissions requirements, engine oil manufacturers have developed a new standard: CJ-4. The standard for pre-2007 oils is CI-4 Plus, which was designed to meet 2004 EPA regulations.

What makes CJ-4 more compatible to 2007 engines? The difference is lower levels of phosphorous, ash, and sulfur. If used in 2007 engines, these additives could prematurely plug up the diesel particulate filter (DPF), increasing maintenance issues.

What are the risks if the previous standard, CI-4 Plus, is used in a 2007 engine? "You may find that you have to replace the DPF at a much earlier than anticipated time," says Dennis Bachelder, senior associate for Engine Oil Licensing and Certification at API, with over 25 years experience in the areas of fuels, lubricants, and exhaust emissions. "You then face performance problems as a result of any backpressure from a plugged-up DPF."

Would this practice void engine warranty? "It's a risk, but that's the call made by the engine manufacturer on a case-by-case basis. But one thing's for sure: replacing the DPF is not cheap and will result in performance problems and cost issues incurred by downtime for the repair," Bachelder explains.

- **Oil change intervals.** "Abide by manufacturer oil change intervals," Aquaro advises. "That can have a huge impact on DPF longevity. If the manufacturer says to change oil at 6,000 miles, you should change it at 6,000 miles. Those numbers aren't just pulled out of the air. Engines are tested extensively to arrive at those intervals." **WT**

Questions and Answers from: Engelhard Corporation

What is the most cost effective way to reduce emissions from existing diesel vehicles?

Studies have shown that a combination of vehicle maintenance and retrofitting with emission control catalysts is the most cost effective way to reduce emissions.

What about re-powering existing diesel vehicles?

Re-powering a diesel vehicle is a viable option but is typically much more expensive than retrofitting with emission control catalysts. However for some applications a re-power is the best option.

What about converting to LNG (liquefied natural gas)?

Converting to LNG is more expensive than retrofitting with emission control catalysts since it typically requires extensive engine modifications and a complete new fuel system (fuel tanks, lines, etc) plus safety equipment.

Can I use a diesel particulate filter to get rid of black smoke?

Black smoke from a diesel engine is a sign of a poorly maintained engine. The solution is to implement proper maintenance procedures, rather than using a diesel particulate filter to try and “cover-up” the problem.

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Oil Company Statements

How does a Diesel Particulate Filter work and how do I care for it?

Shell Rotella T is a trademark of Shell Oil Corp. The following information is from Shell's website.

“On-highway diesel trucks built beginning in January 2007 are equipped with an after-treatment device such as a Diesel Particulate Filter (DPF) to help reduce emissions. The use of Ultra Low Sulfur Diesel (ULSD) fuel is required for all 2007 and newer diesel truck engines as well. Both a DPF and ULSD are necessary to meet stringent emissions limits.

The purpose of the DPF is to capture and eliminate tiny soot and ash particles before they can escape into the air. Soot will attach itself to the wall of the filter and ash from the burned engine oil will accumulate on the face of the filter.

Most DPFs will periodically burn off the soot through a process called regeneration. The regeneration process will be triggered automatically when the truck is moving. The process will clean much of the soot from the DPF, but it will not breakdown all of the particulate matter in the DPF, so periodic cleaning is necessary. The mileage interval for cleaning the DPF is not yet certain as it depends on the amount of particulate matter that accumulates.

However, a minimum mileage amount of 150,000 miles for most on-highway trucks is required by the EPA. If the DPF is not cleaned, it will become clogged with soot and ash, increasing back pressure on the engine to the point that it could eventually stop running.

Motor oil also plays a key role in helping diesel engines and emissions control systems function properly. Premium CJ-4 motor oils, such as Shell Rotella® T with Triple Protection™ technology, help keep your engine clean and provide optimum durability of the DPF. These oils are able to handle high soot levels and minimize the amount of ash that accumulates in the DPF. “

Delvac is a trademark of Exxon Mobil Oil Corp. The following information is from the Mobil Delvac website.

Although Mobil Delvac officially came to market in 1925, its technology was being researched and developed well before that. As early as 1913, we were already holding equipment builder meetings and forming the alliances that are so important in the creation and ongoing refinement of Mobil Delvac technology. Over the years, this, of course, has led to current Mobil Delvac technology obtaining over 2,000 builder approvals and endorsements from over 300 different OEMs.

Mobil Delvac technology was developed to help extend the life of heavy-duty engines. With over 80 years of collaborative efforts with original equipment manufacturers, rigorous testing and millions of dollars invested in research, that goal not only remains the same, but is also achieved successfully year after year as we continue to conduct collaborative research with equipment builders to assess lubricant needs and ensure warranty protection.

To say the engine oils of today are vastly different from the engine oils of years past would be an understatement. Pollution control requirements are changing more frequently and are becoming exponentially more stringent as we pass into the 21st century. Today, the engineers and formulation scientists at our prestigious global research facility in Paulsboro, New Jersey are working exhaustively to create the next generation of products that deliver high performance and long engine life while also meeting the next level of stringent pollution control requirements: API CJ-4. ExxonMobil realizes that this new requirement has all users of heavy duty diesel engine oils very concerned and asking many questions as to exactly how this new requirement will impact their business, but rest assured that, no matter your question or concern, Mobil Delvac is up to the challenge.

The New API Performance Level CI-4

To meet the NOx emission requirements, most heavy-duty diesel engines will be equipped with cooled exhaust gas recirculation (EGR) after-treatment systems. EGR replaces some of the intake air in the combustion chamber with exhaust gas to lower the peak flame temperature, reducing the NOx level. These systems allow more advanced fuel injection timing for better fuel economy, but they also introduce corrosive acids (e.g., sulfuric acids) from sulfur in the fuel and nitric acid into the engine. Likewise, the change in flame characteristics along with the recirculation of exhaust gases cause increased soot build-up in the crankcase.

As a result, lubricants formulated to protect engines equipped with EGR systems should be able to control higher operating temperatures and soot loads and neutralize more acids to prevent corrosive wear in the power cylinder components - cylinders, rings and bearings.

Oils claiming API CI-4 must demonstrate the following characteristics: ·

- Soot-handling capacity ·
- Ability to neutralize acids (alkaline reserve) ·
- Thermal stability ·
- Oxidation stability ·
- Corrosion protection ·

To meet these requirements, lubricant manufacturers have reformulated their products, increasing the level of basic additives (as determined by base number), as well as improving the base oil quality to better control the effects of EGR by-products.

The Diesel TEK Solution

Diesel TEK is committed to addressing the diesel emission issues with common sense and internationally patented maintenance products, applications and procedures.

By reviewing the collected information within this report and comments from fleet owners, service providers and industry experts we can agree with our company motto that:

A CLEAN ENGINE OPERATES AT PEAK PERFORMANCE

Review of the industry information from API, SAE, Laboratories, Training experts, Failure analysis experts and dealership technicians we can conclude the following to be factual:

1) EGR devices cause diesel engines to operate at higher temperatures placing additional stress on engine lube oil and its ability to lubricate engine components. EGR devices cause more soot and other contaminant formation within the engine under normal diesel operation.

2) DPF operation can be adversely affected by an overload of soot and other contaminants found to occur by normal diesel operation.

3) A solution to the problem could be to change the diesel engine lube oil every 6,000 miles or follow the Diesel TEK recommended service schedule of cleaning the engine during every third PM Service.

4) Common sense would dictate that removing soot and other known crankcase contaminants as a regular maintenance practice will reduce downtime from EGR Systems, DPF and regeneration problems that are plaguing all engine manufactures & service providers today.

5) New engines are assembled in clean room type environments and serviced in the same clean environments at professional service centers across the globe. When reviewing an oil sample report, how can a service technician agree with “acceptable” levels of lube oil contaminants? In engine manufacturer’s reports under the heading “by-pass filtration systems” reports have been published on advanced filtration techniques and their findings support our premise that “a clean engine operates at peak performance.” Our premise is further supported by studies conducted by the SAE and General Motors regarding filtration: “changing a standard oil filter to a 5-micron filter will increase the engine service life by greater than (50) fifty percent”.

Diesel TEK has invested thousands of man-hours and performed the Diesel TEK Engine Flush on thousands of trucks, busses and off-road equipment ranging from very old and dirty engines to late model EGR/DPF equipped engines. There has been no negative feedback on our field research. No complaints. No failures. No leaks. The most common comment that we hear is “Where can I have this service performed?”.

Many other field research comments have been reported to us as follows:

- **My oil pressure returned to what it was when the truck was new.**
- **The operating temperature has gone down.**
- **My truck pulls up hills and grades better or in a higher gear.**
- **My engine doesn't smoke anymore.**
- **My engine runs smoother.**
- **My fuel mileage has increased by X.**

(Please note that we make no claims. We will report the results on this subject when performed by an official laboratory.)

These are anecdotal comments reported from drivers, equipment operators and commercial ship owners. Diesel TEK makes no claims regarding fuel mileage, oil change intervals or any other maintenance or performance service benefits operators will experience with our products and services. Such benefits will be determined by service maintenance providers based on actual experience and oil company and engine manufacturer technical data based specified service standards.

The Diesel TEK System has significantly reduced opacity and Particulate Matter (PM) in both real world applications and in certified laboratory testing. A practical review of our achievements will indicate that a diesel engine producing less exhaust contaminants will perform better and should realize a measurable increase in fuel economy.

The Diesel TEK®CL-8 Engine System uses concentrated cleaning detergents found in high quality diesel motor oil. The system connects to the diesel engine through a unique CAMTEK adapter system to the oil filter housing and back-flushes the heated cleaning solution through the engine and oil galleys, evacuating the solution through a specially designed adapter in the oil pan drain plug.

The Diesel TEK®CL-8 Engine System cleans out carbon, soot; sludge and other contaminate buildup from inside diesel engines. Thus it removes the particulate matter that is emitted into the environment through the standard lubricating process.

Initial testing of the Diesel TEK CL-8 Engine System at California Environmental Engineering Laboratories, an EPA & California Air Resource Board certified laboratory in Santa Ana, California, was completed on a 1991 400hp Detroit Series 60 diesel engine in February, 2009.

After completing the Diesel TEK Engine Service on the engine, the emissions test showed the following results:

Total Hydrocarbons	-16%
Carbon Monoxide	-53%
Particulate Matter	-65%
Fuel Economy	+2%

The reduction of Hydrocarbons, Carbon Monoxide and Particulate Matter coupled with the increase in fuel efficiency indicates that the clean engine is able to operate at a higher efficiency resulting in more complete combustion of the fuel. On road testing supports this theory as drivers regularly report that the oil pressure is higher and the engine runs cooler after being serviced.

The Diesel TEK CL-8 Engine System

With increasingly stringent Federal and Regional regulations during the next two decades, Diesel TEK has a valuable and economically viable solution to the environmental demands being placed on the heavy-duty diesel industry and those who provide service and support.

Our products are simple and cost effective for an already working service system. The Diesel TEK program reduces black soot, PM10, and PM2.5, which is commonly referred to as “opacity” in non-DPF equipped diesel platforms. Reducing PM/opacity inside the combustion process results in increased fuel mileage, which provides an economic return for operators while creating a cleaner environment.

Lower emissions promote better health. This particulate matter in diesel smoke contains cancer-causing compounds that lodge in the body. Numerous health studies link this harmful substance to missed days of work, asthma and numerous other health related issues as well as loss of life.

Diesel exhaust is considered the number two cause of global warming results in considerable environmental pollution.

The Diesel TEK CL-8 Engine Service System assists the function of the EGR and DPF systems that are currently being utilized on a majority of the current diesels in service today.

A CLEAN ENGINE OPERATES AT PEAK PERFORMANCE!

