Fuel Dilution Surfaces as Issue in Some Modern Diesel Applications

AMSOIL has documented two separate fuel dilution issues in modern diesel applications, one of which has forced the company to reduce its drain interval recommendations in a few applications using Premium CJ-4 Synthetic Diesel Oils (DEO, DME).

Fuel Dilution

Fuel in the oil reduces the oil's life expectancy and effectiveness. Because diesel fuel is a natural solvent, fuel dilution in motor oil causes a decrease in viscosity which may lead to an increase in engine wear. The following can occur if fuel enters the crankcase and contaminates the oil:

- Reduced oil viscosity
- Reduced oil film strength
- Increased engine wear (particularly in the cylinder/ring area)
- Increased volatility
- Weakened lubricant detergency
- Accelerated lubricant oxidation
- Varnish formation
- Acid formation/corrosion
- Low oil pressure

The most notable concern with increased fuel contamination is reduced viscosity and the effect it has on oil performance.

Issue One: Mechanical Deficiencies

AMSOIL has documented increasing fuel dilution levels in 2007 and newer Caterpillar C13 and C15 on-highway engines. Caterpillar has recognized its fuel dilution problem as noted in a special instruction titled *Determining the Cause of Fuel Dilution of Engine Oil for On-Highway Engines (C13, C15).* The document states that mechanical deficiencies (i.e. leaking seals on the body or sleeve of unit injector, cracked body of unit injector, leakage from the drive shaft seal on the fuel transfer pump, etc…) are probable causes for fuel dilution.

A tolerable level of fuel dilution was present in 2007 engines; however, newer engines exhibit excessively high fuel dilution. Caterpillar is aware of the relationship between fuel dilution and viscosity loss and has stated the following:

> "Fuel dilution that is greater than 4 percent will usually cause viscosity that is less than the specified viscosity grade. For example, 15W-40 oil with 4 percent fuel dilution will have a viscosity of less than 12.5 cSt."

Even though Caterpillar realizes that fuel dilution has an adverse effect on viscosity, the company has not corrected the mechanical deficiencies that are causing the high fuel dilution rates. Instead, Caterpillar revised its guidelines for used oil viscosity to "slightly less than the limits of the SAE viscosity grades" (See **Table 1**).

Viscosity Grade	SAE Viscosity Guideline (cSt)	Revised Caterpillar Viscosity Guideline (cSt)
SAE 40	12.5 cSt – 16.3 cSt	Greater than 11.5 cSt
SAE 30	9.3 cSt – 12.5 cSt	Greater than 8.5 cSt

Table 1 – Viscosity Guidelines at 100˚C

In addition to viscosity loss, high fuel dilution also causes accelerated oxidation. Oxidation, combined with a significant loss in viscosity, can shorten engine life.

Forced Drain Interval Adjustment

Although AMSOIL Premium Diesel Oils have shown the ability to maintain integrity in some fuel-dilution conditions, the unresolved mechanical issues have forced AMSOIL, as a precautionary measure, to adjust its drain interval recommendations for 2007-present Caterpillar C13 and C15 on-highway engines.

In these applications, AMSOIL recommends changing AMSOIL Premium API CJ-4 Synthetic Diesel Oils (DEO, DME) at the manufacturer-recommended drain interval. Drain intervals may be extended further through oil analysis.

For all pre-2007 Caterpillar C13 and C15 on-highway engines, the drain interval has not been affected (3 times the original equipment manufacturer's recommendations, not to exceed 50,000 miles/600 hours, or one year).

Issue Two: DPF Regeneration

AMSOIL has also documented increasing levels of diesel fuel dilution in the engine oil of 2007-2009 light-duty diesel pickups from all major vehicle manufacturers. Research indicates that fuel dilution is increasing due to the use of post-fuel injection during the diesel particulate filter (DPF) regeneration process. The issue, however, is not prevalent enough at this point to warrant an adjustment in the drain interval recommendation of AMSOIL Premium Diesel Oils.

Regeneration Process

Current emissions legislation set by the Environmental Protection Agency (EPA) mandates that all 2007 and newer on-highway diesel-fueled vehicles come equipped with a DPF. A DPF is generally a honeycomb-like filter positioned in the exhaust stream to collect particulate matter and soot to prevent it from exiting the vehicle. DPFs are highly efficient and can usually remove 80-90 percent of particulate matter from diesel exhaust. When the filter is near its capacity, soot trapped in the filter is burned, freeing the plugged media and enabling the filter to remain serviceable. The process of burning the residual matter is termed regeneration and can be either active or passive.

Active regeneration uses raw diesel fuel as a combustion source to burn the accumulated soot and clear the filter. Active regeneration is accomplished using either in-stream or in-cylinder injection. In-stream injection systems inject raw diesel fuel directly into the exhaust stream before it reaches the DPF. In-cylinder injection systems inject raw diesel fuel directly into the cylinder on the exhaust stroke. The unburned fuel evaporates and travels down to the DPF to burn out the soot built up in the filter.

Passive regeneration requires exhaust gas temperatures of approximately 600°C (1100°F). These relatively high exhaust gas temperatures occur naturally in trucks operating under heavy load and can be used to burn the soot out of DPFs. Passive regeneration does not increase fuel consumption the way active regeneration does because, by design, it does not require the injection of additional fuel to increase exhaust temperatures.

"Less-Costly" Alternative

All class 8 over-the-road tractors and medium-class applications use active regeneration via in-stream injection. In this method, diesel fuel used to burn soot in the DPF does not reach the crankcase, leaving the oil uncontaminated.

Light-duty diesel pickup manufacturers (Dodge, Ford, GM) have opted for a less-costly in-cylinder injection system. With in-cylinder injection systems, some raw diesel fuel injected on the exhaust stroke can wash directly past the rings and into the crankcase, mixing with the oil. Regular washing of cylinders is a source of fuel contamination in the crankcase and is not conducive to long-term engine protection. Used oil analysis results from 2007-2009 light-duty diesel vehicles showed some elevated fuel dilution, but at tolerable levels.

2010 NOx Requirements

EPA emission mandates taking effect in 2010 require the reduction of nitrogen oxides (NOx) to .2 grams per brake horsepower (g/bhp). To meet this limit, engine manufacturers will use either selective catalytic reduction (SCR), NOx adsorbers or advanced exhaust gas recirculation (EGR).

Most over-the-road truck and tractor manufacturers will use SCR technology, with International the only major manufacturer to use advanced EGR technology. Neither system is expected to increase fuel dilution. Light-duty turbo-diesel pickup manufacturers appear to be moving forward with the relatively new NOx adsorber technology first used by Dodge in its 2007 diesels to meet 2010 NOx requirements. Ford and GM have not yet released vehicles that meet 2010 NOx limits.

Like DPFs, NOx adsorbers need to be regenerated. However, they require more fuel to regenerate than DPFs do, which may compound the fuel dilution problem.

Higher Fuel Dilution Levels

In Dodge light-duty turbo-diesel pickups, the combined regeneration requirements of the DPF and NOx adsorber technologies are causing fuel dilution of the engine oil. Model-years 2007-2009 Ford and GM applications also show higher levels of fuel dilution, which may increase in 2010 emission-compliant models if similar technology is adopted.

Although model-year 2007-2009 light-duty diesels are experiencing higher fuel dilution than previous model years, regeneration cycles vary based on service (engines operating in severe service conditions do not actively regenerate as often as engines operating in normal service conditions), and some applications are affected more than others. While not all 2007-2009 light-duty diesel vehicles develop this problem, fuel contamination can reduce oil viscosity and decrease film thickness. Other concerns include significantly reduced fuel economy, accelerated engine oil oxidation, increased volatility and overfilling of the oil sump.

AMSOIL Maintains Drain Interval Recommendations for Premium Diesel Oils

AMSOIL Premium Diesel Oils have shown the ability to maintain integrity in the face of fuel dilution in 2007-2009 light-duty diesel applications and continue to be recommended for three times the vehicle manufacturer recommendation, not to exceed 50,000 miles/600 hours or one year. However, it is recommended that owners of 2007-2009 Dodge, Ford and GM light-duty diesel vehicles perform regular oil analysis as a precautionary measure. If oil analysis reveals greater than 5% fuel dilution, AMSOIL recommends changing the oil. The company will continue to closely monitor this situation, and if deemed necessary, will adjust recommended drain intervals in these applications.

New Simplified Diesel Oil Drain Recommendations

In order to simplify recommendations, AMSOIL Series 3000 Synthetic 5W-30 Heavy Duty Diesel Oil (HDD), Synthetic 15W-40 Heavy Duty Diesel and Marine Oil (AME) and Synthetic 10W-30/SAE 30 Heavy Duty Diesel Oil (ACD) now carry a three times the OEM recommendation similar to the recommendation for AMSOIL Premium Diesel Oils. The AMSOIL Product Recommendation and Drain Interval Guide (G1490) and all relevant data bulletins are being revised to reflect these changes.

	All Pre-2007 Applications	2007-Present Personal Light Truck Vehicles with Diesel-Fueled Engines	2007-Present Heavy-duty On/Off-Road Applications, Fleet, Marine and Motor Homes with Diesel Engines
DEO DME	3X OEM recommendations, not to exceed 50,000 miles/ 600 hours or one year.	3X OEM recommendations, not to exceed 50,000 miles/ 600 hours or one year.	3X OEM recommendations, not to exceed 50,000 miles/ 600 hours or one year.*
HDD AME ACD	3X OEM recommendations, not to exceed 50,000 miles/ 600 hours or one year.	-.- -.- -.-	-.- -.- -.-

*Except in 2007-present Cat C13 and C15 applications. In those applications, follow OEM recommendations.