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TECHNICAL TOPICS

LUBES 101 – WHAT YOU NEED TO KNOW TO PURCHASE ENGINE OILS – TODAY AND TOMORROW

by John Martin

Diesel, gasoline, and natural gas engine oils are all going to be changing by 2016. With the current regulatory emphasis on improving fuel economy, which also reduces greenhouse gas (GHG) emissions, engine oil scientists will be redesigning and reformulating all three oils to enable improved fuel economy.

When the Federal government enacted fuel economy regulations for heavy trucks starting in 2014, diesel engine builders in the Engine Manufacturers Association (EMA) asked the lube oil industry to help them meet future requirements by developing a new diesel oil performance category (currently called proposed category 11 or PC-11) which would define oils providing better fuel economy. Another goal is increased compatibility with biodiesel fuels. Development has been underway for at least two years now.

Diesel Oils – New PC-11

The initial change that will be made to diesel oils to improve fuel economy is to lower the viscosity. When engines are properly lubricated, a hydrodynamic film exists between engine components. Larger engine component clearances (primarily crankshaft bearing clearances) require higher viscosity oils to maintain hydrodynamic lubrication. Racers build engines with extremely tight clearances in order to reap the horsepower benefits of pumping low viscosity oils, but diesel engine builders have just recently started to research reduced bearing clearances. Since most (83%) North American diesel oil is SAE 15W-40, preliminary effort has been focused on reducing oil viscosity to improve fuel economy in these engines.

No doubt, future developments will include research into using friction-modified oils to further improve fuel economy. The compatibility with biodiesel fuel is being ignored at this time. The new PC-11 category will most likely specify two oils: a low viscosity oil for use in 2015 and later model year engines and a more viscous oil for use in older engine designs. Look for two completely new diesel engine oils which should yield improved fuel economy by 2016.

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Gasoline (passenger car) Oils

New passenger car engine oils called API SP and ILSAC GF-6 are also being developed for introduction in 2017. The major driver for these new oils is fuel economy and fuel economy retention throughout the oil change interval. Passenger cars already utilize friction-modified oils, but these additives can sometimes be depleted prior to the oil being changed, particularly with extended oil change intervals. Japanese auto manufacturers have been pointing this out to us for several years now.

Environmentalists are also asking for a further reduction in oil phosphorus levels from the current GF-5 maximum of 800 ppm % wt. Their objective is to extend catalytic converter service life, but I've seen no evidence of field problems. Reduced phosphorous limits means reduced extreme pressure (EP) protection for highly loaded engine components. Although new engine designs can reduce component loading to deal with reduced phosphorus oils, existing engines are vulnerable. High performance valve trains are particularly susceptible.

Natural Gas Oils

In the absence of universal standards, oils for engines using natural gas have traditionally been developed directly with engine OEMs. Natural gas burns much cleaner, but much hotter, than diesel fuel. So natural gas engine oils need to be much more oxidatively stable than diesel oils, and they need far less detergency and dispersancy. Natural gas engine manufacturers will have to investigate fuel economy for engines operating under stop-and-go conditions as well as steady state service.

"Universal" Oils

For years fleet operators have been utilizing "universal oils" in both diesel and gasoline fueled engines. But Honda now favors SAE 0W-16 oils for their new passenger car engines, and I doubt that current diesels can survive on oils that thin. I also doubt that highly stressed fuel injection components can achieve satisfactory service life on oils containing less than 800ppm phosphorus. Using an oil which meets current API diesel oil specs in a gaseous fuel engine is wasting money. In 2016 I think fleet operators will concentrate on using the optimum engine oil for each engine/fuel combination. As I mentioned, with the need for two different viscosity diesel oils and with the lower viscosity gasoline numbers, the universal engine oil should die in 2016.

Other Concerns

TDR readers need to be especially careful since Cummins B engines using flat tappet cam followers will continue to want to use friction-modified oils. Typically, engines using roller cam followers don't like friction-modified oils, because if the roller ever once slides across the cam lobe, it will stop rolling and start sliding. Failure is then imminent. That's the main reason roller cams require much stiffer valve springs than flat tappet cams.

Another concern is that some friction modifiers will attack "yellow" metals (copper and bronze). Modern passenger car engines haven't utilized yellow metals for years for that reason, but diesel engines often use copper thrust washers in certain areas. New engines can be designed without the use of yellow metals, but existing engines will still have them.

While not a concern with your Cummins B-series engine, I'm also concerned about the use of very low viscosity oils with high pressure unit injection systems. In my work with the racing industry, we often observe pushrod tip and rocker arm failures caused by inadequate lube oil film strength when using extremely low viscosity oils in high EP situations. One racer I know puts grease on pushrod tips before every run to provide sufficient film strength to protect the valve train while he runs low viscosity oils at high RPMs to gain horsepower. I don't think TDR readers would want to put up with that level of maintenance.

A final concern is the EPA's relentless pressure to reduce phosphorus in lube oils to extend catalyst life. Passenger car oils will most likely go to 600ppm or less phosphorus by 2016. This means zincdithiophosphate (ZDP) levels will go below minimum levels needed to protect existing flat tappet cams and lifters. These oils will be unacceptable for use in flat tappet Cummins B engines.

THE SCIENCE (AND POLITICS) OF OIL

Before explaining a way out of this mess, please allow me to go on a rant about the science (and politics) of oil formulation.

When I started at Shell Development in 1965, Diesel and passenger car motor oils were much simpler and easier to understand. Auto manufacturers, diesel engine builders and lube oil suppliers worked closely with the American Petroleum Institute (API), the American Society for Testing and Materials (ASTM), and the Society of Automotive Engineers (SAE) to specify and develop new engine lubes only on the basis of technical need. Oils were developed by analyzing actual field failures and designing laboratory engine tests which would replicate these field failures. Everyone worked closely together as if they were a team without much dissension among participants—or, as my English friend would say "All singing, all dancing." (You must say this with a British accent!)

Then the Environmental Protection Agency (EPA) got involved in chemical regulations, and the game became more adversarial and political. Unfortunately, auto manufacturers and Big Oil at first resisted the EPA's efforts. This got lawyers involved, and it created the hatred that environmentalists still feel for Big Auto and Big Oil. You must first realize that the EPA couldn't care less about your internal combustion engines. These ultra left-wingers are only concerned with clean air, even if it causes all transportation to stop dead in its tracks. They are not friends of motorheads like us!

The EPA first flexed its muscles when North American passenger cars began utilizing catalytic converters in 1975 to reduce CO and HC emissions. Some laboratory engine dynamometer tests using oils highly overdosed with ZDP extreme pressure (EP) additives showed that the phosphorus could melt and form a glaze over the face of the catalyst substrate, rendering it less effective over time. No field tests ever corroborated these lab test findings, but the EPA flexed its muscles anyway and pushed for new lube oil chemical restrictions to minimize phosphorus, therefore ZDP, content. They've been on this bandwagon ever since, and no one has ever successfully limited their powers.

When the oil embargo hit in the mid-'70s, both the EPA and the public began clamoring for better fuel economy. By the '80s auto manufacturers started pushing for the specification of new oil performance categories, which provided improved fuel economy. This brought us friction-modified passenger car oils.

Passenger Car Oil Evolution

Oil marketers and auto manufacturers now had two new performance issues to deal with. Since there wasn't sufficient knowledge available at the time the API, the ASTM, and the SAE began developing new oil performance categories as quickly as they could.

By the late '80s the American Automobile Manufacturers Association (AAMA) decided the oil industry either wasn't moving rapidly enough or wasn't addressing some of their specific needs. So they formed their own trade association, the International Lubricants Standardization and Approval Committee (ILSAC), to make sure their supposed needs were being addressed. They later changed their group's name to the Alliance of Automobile Manufacturers (AAM).

The traditional API approach defined general automotive/car performance level categories labeled as API SG, SH, etc., up to the current API SN. The ILSAC members from the AAM, which included European auto manufacturers and the Japanese Auto Manufacturers Association (JAMA), specified new performance categories labeled as GF-1, GF-2, etc., up to the current GF-5. (Usually the GF categories can be satisfied by meeting one or two additional requirements over the API specified tests.)

After much flapping of wings, the auto manufacturers and the oil industry learned to coexist, and the paired specification system (SL/GF-3, SM/GF-4, etc.) prospered through five performance upgrades and considerable R&D expense through early 2011. It seems these upgrades occur every four years, and there is no end in sight. Table 1 outlines that history.

Table 1

Historical Gasoline Lube Oil Specifications

Initiated	Year API	Specification ILSAC	
Obsolete Specs.	1972	SE	
	1980	SF	
	1989	SG	
Current Specs. (for Diesels only)	1994	SH	
Current Gasoline Specs.	1997	SJ	GF-2*
	2001	SL	GF-3*
	2005	SM	GF-4*
	2011	SN	GF-5
Under Development	2016	SO/SP?	GF-6

*obsolete

In spite of all this "to-ing and fro-ing," here are the facts you need to know to intelligently purchase automotive/car lube oils. First, pay no attention to the marketing hype. Look at the API "donut" symbol (see Figure 1) on the back and the ILSAC "starburst" symbol (see Figure 2) on the front of the container. It will show the highest performance specification that container of oil meets. The only currently active API specifications are SJ, SL, SM, and SN. Only ILSAC GF-5 is currently active. ILSAC GF-4 was discontinued one year after GF-5 was introduced. The thing to remember here is that the later the specification, the better the oil performance in all aspects except valve train protection. Currently look for SN/GF-5, because the later the specification, the better your fuel economy should be. These are currently the best oils for your late model passenger cars without valve train modifications.

However, if you have an older engine design or you have altered the valve train (high lift cam, etc.), all bets are off! You should take one of two possible approaches to select oils for these engines. You can choose one of the myriad of Hot Rod (see Figure 3) or Racing oils which are out there, because they all have higher ZDP levels to protect flat tappet cams and lifters. Although these oils are expensive, they are not nearly as expensive as a replacement cam and lifters. If you want to be terrified, talk to the folks at Comp Cams about how many cams they see returned because the lube oil offered inadequate extreme pressure protection. That's one of the reasons why Comp Cams offers their own proprietary lube oils—to reduce the number of returned, failed cams.

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Figure 1. The API Donut

Figure 2. The ILSAC Starburst

Figure 3. A Typical Hot Rod Oil

Diesel Oils' Evolution

For many years new diesel engine oils were developed as field problems indicated a need for improved oil performance. Cummins discovered in the late '70s that multigrade oils provided improved oil economy over straight grade oils in the field and SAE15W-40 oils became the majority. The current, highly dispersant diesel oils were developed because Mack had a soot problem when fuel injection timing was retarded to meet exhaust emissions standards. The diesel Engine Manufacturers Association (EMA) and the tripartite (API, ASTM, and the SAE) worked together very well until about 2002.

When diesel engines started using catalytic converters to reduce exhaust emissions, the old "reduce the phosphorus" bugaboo started up, and the EPA started pushing engine builders and lube oil suppliers around much as they had with automotive/car oils. I was at a Technology and Maintenance Council (TMC) meeting in 2004 where four very large fleets reported their field experience with traditional diesel oils and catalytic converters in field tests lasting for at least 200,000 miles per unit. Not one of them reported a lube-related failure of their catalysts using higher levels of ZDP! But the EPA doesn't deal in facts. They enjoy disrupting anything to do with internal combustion engine builders or Big Oil.

As I reported at length here in the TDR (Issue 76 and Issue 57), in the 2006 time-frame the EPA insisted that a new oil performance category, API CJ, be developed to reduce the sulfated ash content of diesel oils to below 1% wt max. This effectively places a limit on the amount of detergency and ZDP a diesel oil can contain, and translates into reduced performance, no matter what anyone tells you. Since you can no longer obtain CI-4 diesel oils, TDR readers are currently forced to purchase API CJ-4 diesel oils.

Editor's note: Gotcha, Mr. Martin. Actually, TDR writer John Holmes corrected me with a clarification about the CI-4 diesel oil's availability. Holmes noted that, while you can't bop into Wallyworld or your local PepZone and find CI-4, it can be purchased at specialty mail order outlets such as Amsoil.

In closing, a new diesel oil performance category (or two) will be enacted in 2016 to improve fuel economy. These oils will be lower viscosity, friction-modified oils. But, as I said before, I'm worried about existing engines already in service. The EMA and the SAE have already come to realize that two oils should be developed: a low viscosity, friction-modified oil for new engine design, and a higher viscosity, probably non-friction modified oil for engines already in service. I'll keep you informed as events unfold.

John Martin
TDR Writer

Editor's note: John Martin will "keep you informed as events unformed as events unfold." If you'll turn to page 127, TDR writer Kevin Cameron will give a briefing on what the new oil category PC-11 means to manufacturing processes and, ultimately, to you.