

Diesel Engine Oils - TBN, ULSD, CI-4 vs. CJ-4, Syn Blend CJ-4

Before the advent and wide scale use of Ultra Low Sulfur Diesel (ULSD) fuels, TBN (Total Base Number) additives were raised in lubricant formulations to counteract the corrosive affects caused by the higher sulfur fuels. With the introduction of ULSD (15ppm) the common belief is that a higher TBN formulation is not as critical as it once was. However, in meeting the new environmental regulations, engine manufacturers are having to increase their EGR from approximately 15% to up to 45% meaning that exhaust gas that is re-circulated back into the engine is a major source of acidity in the engine. Therefore, TBN is still required.

Sampling of current TBN oil levels in new oils:

| | |
|--|-----------|
| SERVICE PRO® PREMIUM HEAVY DUTY 15W40 CI-4 | TBN 10-11 |
| SERVICE PRO® PREMIUM HEAVY DUTY 15W40 CI-4+ | TBN 10-11 |
| SERVICE PRO® PREMIUM HEAVY DUTY 15W40 CJ-4 | TBN 10-11 |
| SERVICE PRO® PREMIUM HEAVY DUTY SYN BLEND 15W40 CJ-4 | TBN 10-11 |
| | |
| SHELL ROTELLA T 15W-40 CI-4 + | TBN 11.5 |
| SHELL ROTELLA T 15W-40 CJ-4 | TBN 10 |
| SHELL ROTELLA T 15W-40 CJ-4 SYNTHETIC | TBN 10.6 |
| | |
| CAT DEO 15W-40 CI-4 | TBN 11.3 |
| CAT DEO-ULS 15W-40 CJ-4 | TBN 10.4 |

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Side by Side: CJ-4 vs. CI-4/CI-4 PLUS oil
By Tom Jackson

New fuel rules may change your lube oil choices.

On January 1, by federal mandate, refineries cut the sulfur level for on-road diesel fuel to 15 parts per million from 500 ppm. And all diesel highway truck engines manufactured after this date are now required to funnel their exhaust through what's known as a diesel particulate filter – something akin to a big catalytic converter. The DPFs and the ultra low sulfur diesel fuel work together to reduce exhaust emissions, and the ULSD fuel also helps slow down the buildup of particulate matter inside the DPFs.

But in the testing and development of the 2007 on-highway engines, manufacturers also found that sulfur, ash and phosphorous from burned engine oil clogged up DPFs as well. So for the fourth time in as many years the engine manufacturers and oil industry worked up a new oil standard, CJ-4, with lower levels of ash, sulfur and phosphorous. (A word about nomenclature: CJ-4 is an industry wide specification for a category of oils designated by the American Petroleum Institute. Previous categories included CI-4 PLUS, CI-4 and CH-4, each of which was driven by the needs of low-emissions engine designs.)

By all accounts, the new CJ-4 oils are the best, most robust oil formulations in history. But they are not a slam dunk for all occasions. Some reports indicate that the DPFs may not be clogging as fast as originally anticipated. And the government has not mandated DPFs for off-road machines (yet). So contractors, especially those with mixed on- and off-road fleets, are scratching their heads trying to figure out the best lubrication program for their businesses. Do you stock one oil or two?

Here's a look at the pros and cons of using CJ-4 in a variety of engines and equipment. Keep in mind that regardless of what's said here you must follow the recommendations of your engine manufacturer to maximize the life of the engine, maintain drain intervals and protect your warranty.

Handling heat and soot

The additive packages in oil, the chemicals that neutralize acids and hold soot in suspension, deplete over time. High engine temperatures cause much of this depletion and oil providers have been ratcheting up the thermal stability of their additives ever since the first low-emission, exhaust gas recirculation (EGR) diesel engines were introduced in 2002/2003.

And heat impacts off-road engines much more than on-highway, says Ken Chao, petroleum products support at John Deere Power Systems. "Off-highway engines work much harder in a heavily loaded condition, plus they don't get the cooling effect from highway travel. And every time you raise the temperature 10 degrees Celsius, you double the oxidation rate of the oil."

In order to get the low sulfur, ash and phosphorous levels needed to meet the CJ-4 spec, the oil companies changed to a new group of additives that they say provide the best thermal protection yet. "Regardless of the engine, CJ-4 is a superior oil, says Mark Betner, heavy duty product manager for Citgo Lubricants. "You have a more oxidatively stable oil compared to CI-4 and CI-4 PLUS. And we've seen double the soot handling capability compared to CI-4 PLUS," he says. "If you have a 2003 dump truck, CJ-4 would still be the better oil for it."

Advantage: CJ-4.

Neutralizing acidity

In addition to running hotter, the 2002/2003 EGR engines created a more acidic environment. To combat this, the oil companies formulated CI-4 and CI-4 PLUS with a higher "TBN," the industry term for total base number, or the amount of "Rolaids" for the engine as it were. The acidity came from sulfur in the fuel, but with the cut from 500 ppm to 15 ppm sulfur for all on-highway fuels, the engine acidity issue just about vanished – at least for most highway trucks. (The higher EGR rate, however, will introduce more nitric acids into the crankcase to deplete TBN.) Knowing this, the oil companies formulated the CJ-4 oils with a lower TBN.

The ideal TBN number depends on who you ask. Some engine manufacturers prefer more alkaline reserve, a higher TBN, in their oils than others – yet another good reason to check with your OEM about the preferred or required oil specs.

But the issue gets complicated for mixed fleets with off-road equipment and 2007 on-road trucks. "Until June 2007, there are still going to be some pockets of high-sulfur fuel available for off-road equipment," Chao says, "and CI-4 was designed for this high sulfur fuel." CJ-4 was formulated with enough alkaline reserve to combat 500 ppm fuel, but not the high sulfur 5,000 ppm fuel. CJ-4 won't cause anything drastic to happen in an off-road engine burning high sulfur fuel, but it would likely require you to shorten your drain intervals. "And nobody wants to pay a higher price and reduce service intervals," Chao says.

Advantage: CI-4 for off-road equipment burning high sulfur fuels. A tie otherwise.

Costs

CJ-4 costs more, anywhere from 5 to 30 percent depending on the brand. But keep in mind total costs, including drain intervals. One of the goals in formulating CJ-4 was to at least meet the drain interval performance of CI-4 and CI-4 PLUS. But each engine manufacturer is going to have its own recommendations that you'll have to factor in. Once the sulfur levels in off-road fuel drop from 5,000 ppm to 500 ppm in June, it may be more cost effective over the long term to put CJ-4 in all your trucks and equipment if it can be shown that it extends drain intervals – as a premium oil should.

Advantage: Depends on service intervals.

Cleaning the DPF

With the Environmental Protection Agency breathing down everybody's necks, the technology for the 2007 on-highway engines developed so quickly that some questions remain as to how much maintenance the DPFs are going to require. The EPA requires the filters to last at least 150,000 miles before cleaning. That appears to be a target that will be easily met.

"I have not seen a single data point where people used CI-4 PLUS in a 2007 on-highway engine that actually failed the EPA requirement for 150,000 miles," says Chao. "So its no big deal to use CI-4 PLUS oil and meet that limit." Cummins has said it will allow highway engine customers the flexibility of using CJ-4 with a projected DPF cleanout at 200,000 to 400,000 miles or CI-4 with a DPF cleanout every 150,000 to 350,000 miles.

Advantage: CJ-4 extends maintenance intervals on the DPF, but to determine the value of this you have to balance the cost of the oil with the cost of more frequent service intervals.

Wildcards

Given the shortened time frame the engine manufacturers and oil companies have had to work with, there are still a lot of unanswered questions – especially regarding the DPF. The amount of oil an engine burns depends on its design and age. A new engine with tight seals and rings burns less oil and hence will push less particulate matter into the exhaust stream, Betner says. An older engine will create more. "If you're going to keep an engine for a million miles you might find you will have to clean the filter more often," Betner says.

And different CJ-4 formulations will contain different additives that clog the DPF in different ways. "Ash that collects in the DPF can have a different packing density," Chao says. "If one formula results in a low packing density, it won't affect the backpressure as much because it's more porous. A more densely packed ash will have a pronounced effect on backpressure."

Conclusion

If you're running 2006 or older trucks and off-road equipment there is no urgent need to migrate away from CI-4 or CI-4 PLUS oils. These are robust oils in their own right. But when you buy your first 2007 or later model on-highway truck, you'll need to decide if you want to stick with the old oils and clean the DPF more frequently, or step up to CJ-4. (But again, there is no choice unless your 2007 engine manufacturer approves the use of the older oils.) Then you have to make a decision whether or not to stock and use two different types of oil or go with a one-oil solution and recoup the extra cost of CJ-4 with extended drain intervals or increased engine and component life.

| On-Highway Engine | Aftertreatment System | Fuel Sulfur Content | Recommended Engine Oil |
|-------------------|---------------------------------------|-------------------------|------------------------|
| 2007 & Newer | Yes – Diesel Particulate Filter (DPF) | ULSD <15 ppm (Required) | CJ-4 |
| Prior to 2007 | Yes – Diesel Oxidation Catalyst (DOC) | LSD or ULSD | CI-4 or CJ-4 |
| | None | LSD or ULSD | CI-4 or CJ-4 |

For greater CJ-4 performance...

SERVICE PRO® PREMIUM SYNTHETIC BLEND 15W40 CJ-4 ENGINE OIL

DESCRIPTION: SERVICE PRO® Premium 15W0 CJ-4 Synthetic Blend Engine Oil – CJ-4 represents the highest level of engine protection and performance ever built into a new lubricant specification. It was designed for all diesel engine applications, including today's emission controlled engines with EGR and diesel particulate filters using Ultra-Low Sulfur Diesel fuel (<15 PPM Sulfur) (ULSD) and Low Sulfur Diesel (LSD). It is formulated with a blend of synthetic and conventional base oils to provide improved wear protection, deposit and oil consumption control, soot-related viscosity control, prevention of viscosity loss from shearing, used oil low-temperature pumpability and protection from thermal and oxidative breakdown. It also contains a sophisticated additive system that is specifically designed to improve the protection of advanced emission control systems such as diesel particulate filters. It is suitable for use in almost all foreign and domestic diesel engines for both the latest 2007 emission compliant and older engines. Always consult your owner's manual for proper application.

APPLICATIONS: SERVICE PRO® Premium 15W-40 CJ-4 Synthetic Blend Engine Oil meets API Service Classification CJ-4, CI-4 PLUS, CI-4, CH-4, CG-4, CF-4, CF/SM, SL, SJ, SH. It has received OEM Approvals for Mack EO-O Premium Plus 07, Volvo VDS-4, DDC Power Guard Oil Specification 93K218, Cummins CES 20081, Renault RLD-3, ACEA E7-04. It is recommended for Caterpillar ECF-1, ECF-2, ECF-3, 20077, 20076, Mack EO-N Premium Plus 03, Mack EO-N Premium Plus, EO-M Plus, EO-M, Mercedes Benz 228.3, Man 3275, DDC/MTU Series 2000/4000 category 1 and 2 engine performance, Volvo VDS-3, DHD-1, ACEA E5 and E3, JASO DH-2.. It can also be used in applications recommending Allison C-4 and Caterpillar TO-2 specifications.

- BENEFITS:**
- Excellent soot-viscosity control
 - Outstanding oxidation stability
 - Synthetic Blend Formulation
 - Universal product for mixed fleet operations
 - Minimizes valve train wear
 - Excellent low temperature properties helps speed cold starts

| Service Pro 15W-40 Test Results: | | CJ-4 | SYN BLEND CJ-4 |
|--|-------|-------------|-----------------------|
| API CJ-4, CI-4 PLUS, CH-4, CG-4, CF-4, CF/SM, SL, SJ, SH | | X | X |
| Caterpillar ECF-1, ECF-2, ECF-3 | | X | X |
| Cummins CES 20081, 20077, 20076 | | X | X |
| Mack EO-O Premium Plus 07, Mack EO-N Premium Plus 03, EO-N Premium Plus, EO-M Plus, EO-M | | X | X |
| Mercedes Benz 228.3 | | X | X |
| MAN 3275 | | X | X |
| DHD-1, ACEA E7 and E5 | | X | X |
| Volvo VDS-4, VDS-3 | | X | X |
| DDC Power Guard 93 K218 | | X | X |
| DDC/MTU Series 2000/4000 1 and 2 engine performance | | X | X |
| Allison C-4 | | X | X |
| Global DHD-1 | | X | X |
| JASO DH-2 | | X | X |
| Renault RLD-3 | | X | X |
| | | | |
| Product Data | Test | Typical | Typical |
| @ 40° C, cST | D445 | 118.2 | 115 |
| @ 100°C, cST | D445 | 15.4 | 15.5 |
| Viscosity Index | D2270 | 130 | 142 |
| Pour Point °C (°F) | D97 | -36 (-33) | -45 (-49) |
| Flash Point °C (°F) | D92 | 238 (460) | 238 (460) |
| Neutralization No., TBN-E | D2896 | 10 | 10 |
| Sulfated Ash, wt.% | D874 | 1.0 | <1.0 |
| Cold Crank Simulator, cP | D5293 | 6620/-20°C | 6210/-20°C |
| Mini-Rotary Viscometer TP1, cP | D4684 | 23700/-25°C | 19700/-25°C |