



API CK4/FA4

By Blaine Ballentine, Lubrication Engineer

Every new API oil specification begins with a statement of need from the engine manufacturers. In the case of CK4 and FA4, the need is to help meet government regulations for improved fuel economy in heavy duty trucks.

The increased fuel economy comes partly from changes to the engine, which generally runs at lower RPM with taller gearing. The new oil classifications enable the new engines to survive.

The most fuel efficient new engines can also use thinner oil. Viscosity is defined as “resistance to flow, so thinner oil requires less energy to pump it through the engine and less drag as parts drag through it.

CJ4 is being replaced by CK4, which is fully compatible with older engines. The thinner oil is likely to cause accelerated wear in older engines, so it was given the strange notation, FA4.

Thin and Thinner

Here is where it gets weird, and potentially dangerous to the uninformed. CK4 and FA4 are both available in 10W-30. However, the FA4 10W-30 is thinner than CK4 10W-30. They both have a kinematic viscosity between 9.3 to 12.5 cSt. at 100° C., but they are differentiated by HTHS (High Temperature High Shear) viscosity.

Engine manufacturers prefer HTHS because it more closely approximates the viscosity of the oil in the bearing at high temperature. The HTHS test is run

at 150° C. (302° F.) and viscosity is measured by drag on a rotor. Do not think of it as a shear test, because the shear induced by the rotor is temporary. Just think of it as another way to measure viscosity. CK4 requires a minimum HTHS viscosity of 3.5 cP. FA4 requires a HTHS viscosity between 2.9 and 3.5 cP.

CK4 VS CJ4

API specifications are a battery of engine tests and bench tests that an oil formulation must pass to qualify. Most of the tests for CK4 remain the same as for the previous CJ4 specification.

Probably the most significant change was the oxidation test, which was previously run in a gasoline engine (Sequence IIIG test) and is now run in a diesel engine (Mack T13 test). The test method for aeration is more precise, and better able to predict success in unit injectors. And the shear stability test is more stringent, now employing the Kurt Orbahn 90 pass injector test.

You will probably recognize the Orbahn 90 pass injector test because we have used it for years in showing the shear stability of our 15W-40s and Multi Purpose Hydraulic & Wet Brake Oil in our literature. In the test, viscosity is measured, the oil is run 30 or 90 passes through a diesel injector nozzle, and viscosity is measured again. The loss in viscosity is expressed as a percentage.

Although we cannot claim that CK4 makes a quantum leap forward, the industry can claim

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improved protection from oxidation, piston deposits, wear, and shear loss.

CK4 VS FA4

The only difference between CK4 and FA4

HTHS	
CK4	FA4
>3.5	2.9-3.5

is HTHS viscosity. FA4 has to pass each of the same engine tests and bench test with the same limits, except for the HTHS test.

Although there is only a small improvement from the new CK4 15W-40, defeating all the same engine tests with an extra thin 10W-30 required significant improvements in additive technology. Oxidation control and wear prevention become much more challenging with a really thin fluid film.

Universal Oils

One of the changes with CK4 and FA4 is with “universal oils” or “mixed fleet oils” where the same oil is used in both diesel and gasoline engines. In the past, if the “C” specification (for Compression ignited engines) appeared before the “S” specification (for Spark ignited engines), such as CJ4/SM, the 800 ppm phosphorus limit intended to protect catalytic converters in passenger cars was waived. If an “S” spec is included with CK4 or FA4, it is required to have no more than 800 ppm phosphorus.

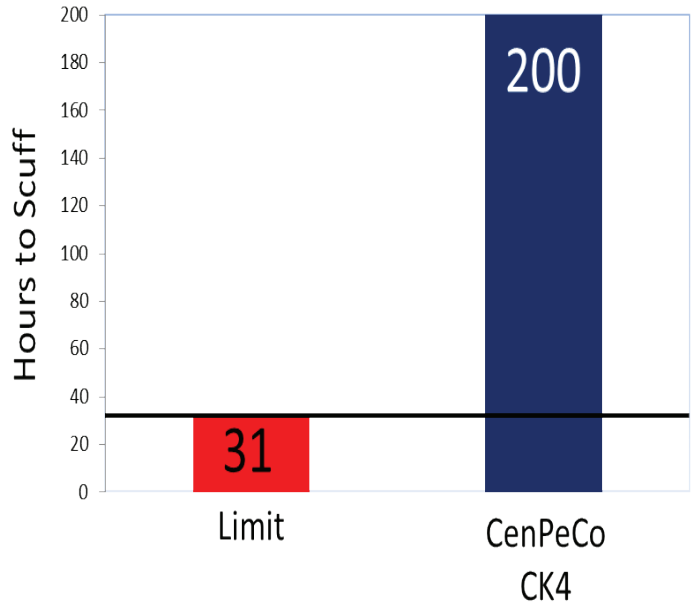
Scuffing

So, they decided to use a really thin oil with limited zinc-phosphorus anti-wear additive in a heavy duty engine—what could go wrong? Well, the film could be so thin that the little microscopic peaks on the surface of the rings and cylinders could weld together and tear each other apart.

This was Detroit Diesel’s concern. They developed a DD13 engine test for ring and cylinder scuffing. Scuffing is detected by crankcase pressure which increases greatly from blowby.

An off-the-shelf CJ4 10W-30 oil was tested in the DD13 Scuffing Test and failed. Detroit Diesel’s DDC93K222 (CK4) and DDC93K222 (FA4) specifications are above and beyond API specifications because they require passing the DD13 Scuffing Test.

DD13 Scuffing Test

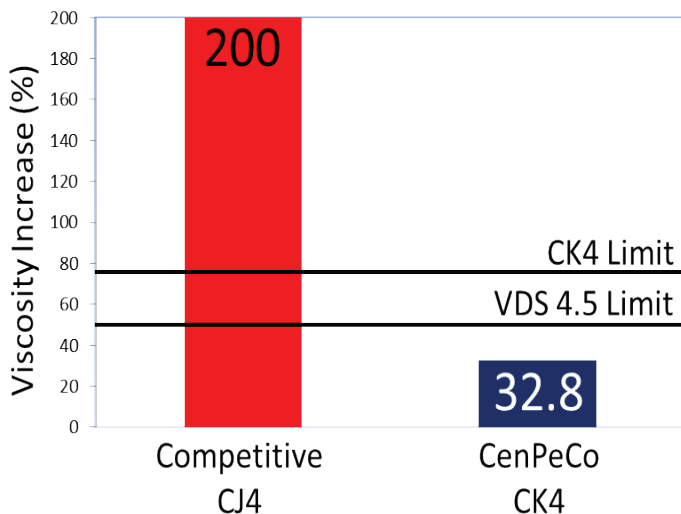


More OEM Specs

Volvo/Mack and Cummins also have specifications more stringent than the API’s. The difference is in the T13 oxidation test. Where the API allows up to a 75% increase in viscosity, Volvo/Mack and Cummins limit the increase to 50%.

Mack T-13

(ASTM WK52873)



Ford

Ford is the market leader in Class 4 through 6 trucks, which are like really big pickup trucks—box trucks and delivery trucks. Ford sells more than all of its competitors combined.

Ford was never interested in FA4, fearing additional wear. They were also uninterested in low phosphorus oil, and never really understood why the industry was pursuing them.

Of course, the reason the industry pursued low phosphorus formulations is customers with both diesel and gasoline engines in their fleets want a universal oil. They want a universal oil, but overall, they are not willing to pay more for it, and they certainly do not want it if they have to sacrifice wear.

Throughout the process of CK4 development, Ford expressed concern about valve train wear with low phosphorus formulations. Then just before the specification was released, everyone was shocked when Ford issued a service bulletin because they had seen excessive wear in some of their engines with low phosphorus oils. The service bulletin recommended CJ4 or an oil meeting Ford M2C171-F1 (see Dec. 2016 Central News for details).

One would think there would not be an issue because of the similarity in the CJ4 and CK4 tests. However, some manufacturers embraced

“universal oils” and others significantly lowered their zinc phosphorus content. The valvetrain wear Ford experienced was with oils containing less than 1000 ppm phosphorus.

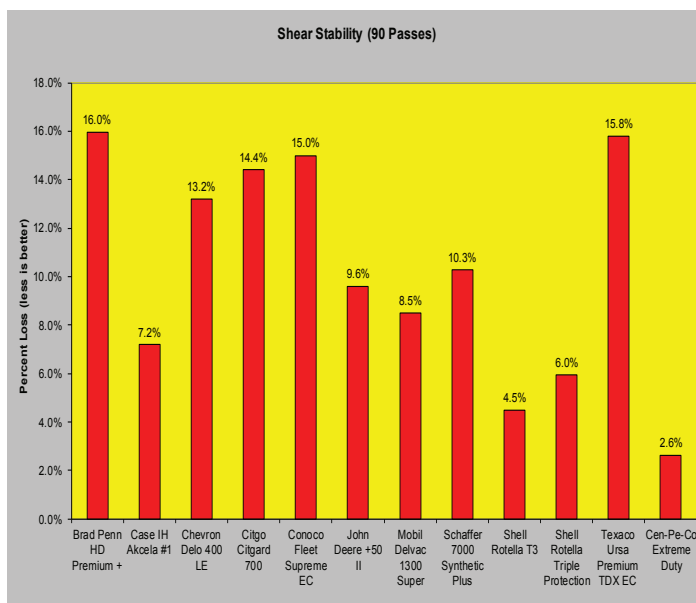
Reading between the lines, do not use oils with less than 1000 ppm phosphorus in a Ford diesel, and certainly stay away from any mixed fleet oil, such as CK4/SN or FA4/SN. In fact, a prudent person would probably want higher phosphorus levels in any diesel engine, but particularly those with flat tappet cams.

CenPeCo’s Perspective on FA4

Central Petroleum Company has been dedicated to making the best heavy duty lubricants possible. Because of our orientation toward stopping wear, it is really hard for us to embrace the extra thin FA4.

Apparently, the off-road heavy equipment manufacturers are having the same resistance to FA4 that we are, because none of them are recommending it.

As we have worked with chemical manufacturers to upgrade CenPeCo Extreme Duty to CK4, we asked each of them what happens if CK4 15W-40 is used where FA4 10W-30 is recommended. They all gave us the same answer, “You will use a little bit more fuel and get a little bit less wear.”



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If enough customers ask for FA4, we will add it to our line, but at the time of this writing we have no plans to introduce an FA4 product.

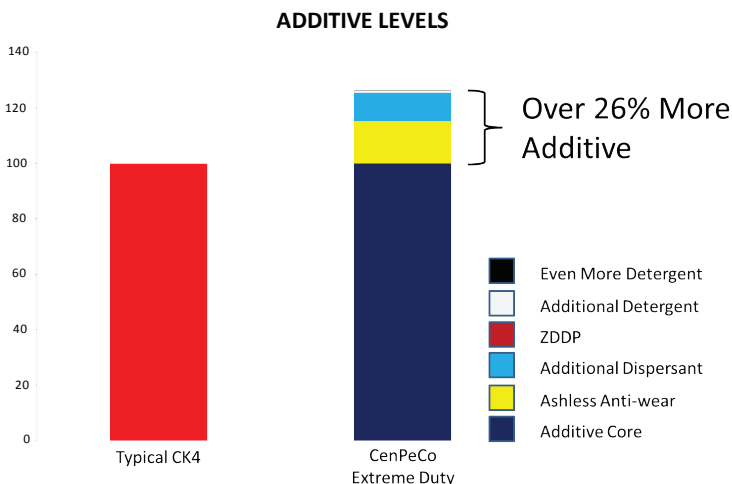
Lower viscosity oil makes the biggest difference where pumping and churning losses are the highest as a percentage of the total energy consumption. Thinner oil makes its biggest contribution to fuel economy in lightly loaded engines that do a lot of idling.

The fuel savings is less, perhaps insignificant, in engines that are heavily loaded. A line-haul truck is more likely to benefit from this oil fuel savings than a tanker truck, farm tractor, or bulldozer.

CenPeCo Extreme Duty

The way we see it, the real value of FA4 is that it forced the industry to develop better anti-oxidants and non-phosphorus anti-wear additives to defeat the engine tests with extra thin oils. We can use this new technology, these enhanced components, to make a superior 15W-40.

We have upgraded CenPeCo Extreme Duty to CK4. It also meets Detroit Diesel's, Volvo/Mack's, and Ford's more stringent requirements. But we did not stop there.



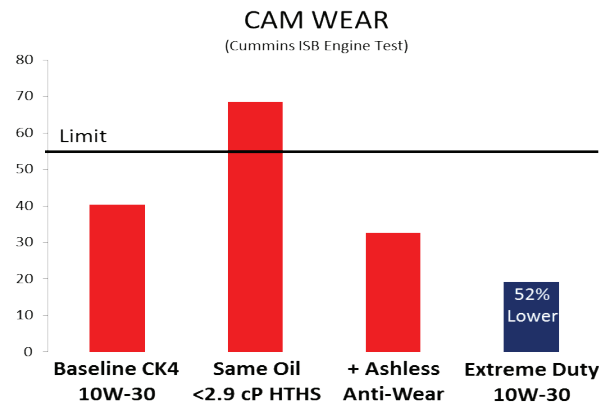
We added additional dispersant for longer drain protection.

We added as much zinc phosphate (ZDDP) anti-wear additive as we could without exceeding the ash and phosphorus limits. But, since phosphorus does limit the amount of zinc anti-wear additive we can put in, we enhanced anti-wear performance with ashless anti-wear additive.

We added as much detergent as possible while complying with the 1% ash limit to protect engine surfaces.

Total the enhancements above, and we have more than 26% more additive than needed to comply with the CK4 and manufacturers' specifications.

We have not changed our paraffin base oil, or our polymer. Although the industry claims better protection from shear loss by using the Orbahn 90 pass injector test, probably only the bottom feeders were affected. The test requires 15W-40 to have a viscosity of at least 12.9 cSt. after the 90 pass test. Big whoop. To put this in perspective, SAE 40 is defined by 12.5 to 16.3 cSt. at 100° C. Even the worst oil in our shear stability study discussed in the October 2012 Central News lost 16% to our 2.6% and still remained above 12.9 cSt.



Those of you that have been through several of the specification changes with us will remember that the new spec was not a big deal for us. Either we already met the new spec with our existing product, or we would make a minor tweak. This one is different because FA4 development brought about new technologies that we added to CenPeCo Extreme Duty.