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TECHNICAL BULLETIN

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SUBJECT: Oxidation and Used Oil Analysis

Oxidation and Used Oil Analysis

For decades, one of the most important properties for determining the quality of diesel engine oil and remaining life of diesel engine oils in service was the total base number (TBN), or the ability to neutralize acids from combustion. The TBN of diesel engine oil was critically important, especially when diesel fuels contained higher levels of sulfur, which forms sulfur-acid byproducts when burned. However, today's ultra-low sulfur diesel fuel does not create the same need for acid neutralization from the engine oil. As a result, the starting TBN of an oil is a significantly less important measure of oil quality, and the remaining TBN is a less important measure of remaining oil life for in-service diesel oils.

With reduced acidic combustion products, higher temperatures, leaner combustion and longer OEM-recommended oil drain intervals, a key driver for oil changes is the actual chemical breakdown of the oil molecules themselves by a process called oxidation. Oxidation happens when oxygen or other oxidants react with the engine oil, creating reactive intermediates called "radicals" that can go on to react with other oil molecules to form varnish and sludge, or react further with oxygen to produce acids. As a result, slowing this oxidation process via anti-oxidant additives and keeping oxidation by-products from depositing on engine parts is far more important now than it was before.

Anti-oxidant additives come in many varieties, but all work to slow oxidation processes by one or both of the following mechanisms: (1) by being "sacrificial" fuel for oxidation, generating more stable radical intermediates that do not take place in reactions generating sludge and varnish, or by (2) neutralizing more reactive radicals in the lubricant, stopping the chain reactions forming sludge and varnish. Generally, high quality diesel engine oils contain multiple anti-oxidant additives that work by both mechanisms to control sludge, varnish and contribute to making longer oil drains possible.

Several engine manufacturers have recommended that oxidation, measured by FT-IR, should be more of a condemning factor for oil drain intervals than TBN. The most conservative on-road recommendations are to keep oxidation below 25 units, while some off-road OEMs recommend as high as 40 units as a condemning limit for determining oil life. Quite often, a remaining TBN lower than 3.0mgKOH/g (the typical condemning limit for TBN), does not result in oxidation above these limits – using TBN alone to measure drain intervals can lead maintenance professionals to change diesel oil before it is required, preventing them from further lowering their total cost to maintain engines.

Champion recommends customers keep a close eye on oxidation when setting oil drain intervals. While TBN is still an important data point, it is better understood as a measure indicating an issue with acidic contamination in the engine and should be a concern primarily if low TBN is seen with increases in copper, lead and tin corrosion that exceed OEM limits. As a stand-alone measure, used oil TBN is less useful than wear metal analysis, additive element analysis, oxidation, fuel dilution, viscosity and soot loading in determining the most efficient oil drain intervals for protecting engines and attaining lower equipment maintenance costs.