Condition Monitoring Specialists

TECHNICAL BULLETIN

ISSUE 73

DIESEL EMISSIONS: A BREATH OF FRESH AIR

Part 2 of 2

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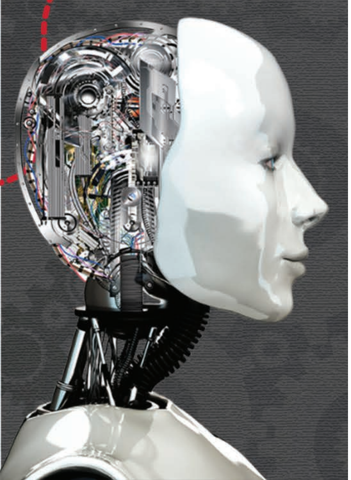
INTRODUCTION

We continue our discussion around reducing air pollution through stricter diesel engine emission standards and techniques. In this *Technical Bulletin* - the second of a two part series – we examine the intricacies of appropriate lubricant viscosity as well as the performance criteria of a range of additives and how they contribute to the war against harmful emissions, or not.

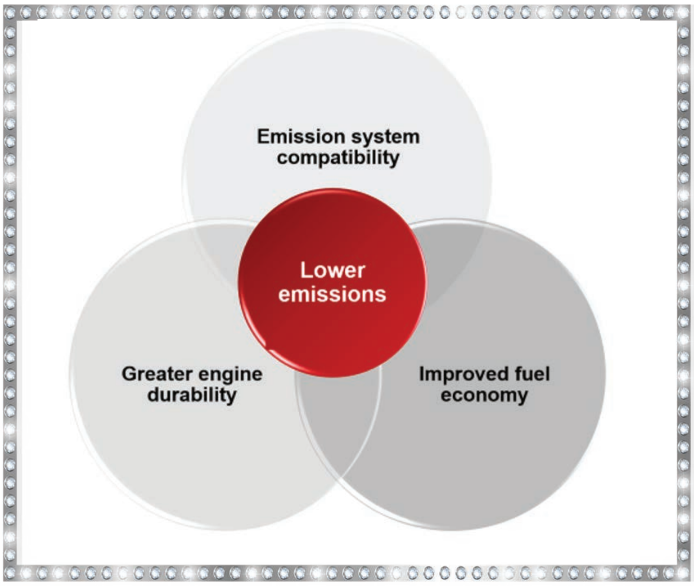
In *Technical Bulletin* 72, we looked at the various diesel emissions produced, the laws governing them, and the technologies utilised to limit these emissions in mitigation of green-house gases and the pursuit of better air quality. Now, we look at how all these developments will change the appetite of the diesel engine.

Commonly-used abbreviations and symbols

Abbreviation	Definition	Symbol	Name
API	American Petroleum Industry	NH_3	Ammonia
ASC	Ammonia Slip Catalyst	CO_2	Carbon dioxide
C-DPF	Catalysed Diesel Particulate Filter	CO	Carbon monoxide
DEF	Diesel Exhaust Fluid	NO	Nitric oxide
DOC	Diesel Oxidation Catalyst	NO_2	Nitrogen dioxide
DPF	Diesel Particulate Filter	N_2	Nitrogen gas
EURO	European Emissions Standards	NOx	Nitrogen oxides
EGR	Exhaust Gas Recirculation	SO_2	Sulphur dioxide
HC	Hydrocarbons		
LNC	Lean Nox Catalyst		
NAC	Nox Adsorber Catalysts		
PM	Particulate Matter		
PAH	Polycyclic Aromatic Hydrocarbon		
SCR	Selective Catalytic Reduction		
SOF	Soluble Organic Fraction		
SAPS	Sulphated Ash, Phosphorus, Sulphur		
TBN	Total Base Number		
VII	Viscosity Index Improver		
ZDDP	Zinc Dialkyl Dithiophosphate		



Change begets change, and with new engine design and the addition of new emission control technologies, naturally comes changes to the fuels and lubricating oils we have to use as well as the addition of new fluids in these 'greener' engines.



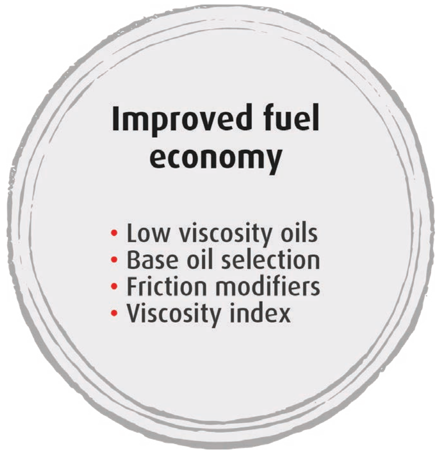
To understand the changing appetite of the beloved workhorse, the diesel engine, we must look at the market drivers shaping this shift in appetite, which are: better emission system compatibility, improved fuel economy and greater engine durability.

Fuel and lubricants manufacturers play a key role in achieving these drivers. **Engine oils and fuels are no longer viewed as merely a consumable**, but rather an integral component of the engine having just as much importance as the hardware itself, and with good reason – they have an incredibly hard job to perform. Engine tolerances, along with increased complexity and performance expectations, create an environment of increased stress in which fuels and lubricants operate.

IMPROVED FUEL ECONOMY

Lubricant manufacturers make use of multiple complex physical and chemical strategies to improve fuel economy - the most common of which is to reduce the viscosity of the oil, which often necessitates the selection of higher quality base oil, combined with the use of additives like viscosity index improver and friction modifiers.

The fuel consumption of an engine is affected by, among other factors, the friction that must be overcome in the engine. While engine friction is affected largely by design considerations, the engine lubricant can also play an important role.



In principle, every engine runs more smoothly and economically with a less viscous (thinner) oil. Yet the thinner the oil, the harder it is to build a hydrodynamic stable oil film which prevents mechanical contact between moving metal surfaces and therefore wear, but this can be off-set by the use of friction modifier and viscosity index improver additives.
The trend toward improved fuel economy has led to the introduction of lower oil viscosity grades such as 5W30 and 10W30 that are now commonplace in heavy-duty diesel engines.

When one talks about engine lubricants, the tendency is to refer to the SAE grading system, which defines both low and high temperature viscosity requirements - typically kinematic viscosity - which is a measure of an oil's resistance to flow under the force of gravity at specific temperatures.

However, there is another important type of viscosity that is associated with increased fuel efficiency: high temperature high shear (HTHS) viscosity, which is a fluid's resistance to flow under conditions resembling highly-loaded journal bearings in fired internal combustion engines.

In an operating engine, the lubricant is exposed to more than just gravity. The lubricant is required to lubricate and protect engine components under hotter and more severe operating conditions, and HTHS dynamic viscosity is the current industry standard that best predicts the oil's behaviour in these operating conditions. It should be noted that engine lubricants can have the same SAE viscosity grade but different HTHS viscosity, so understanding the relationship between these readings is becoming more important - especially as more engine manufacturers move towards lower HTHS engine oils in the drive for improved fuel economy.

> The requirement for lower viscosity oils has also led to changes in base oil selection.

The American Petroleum Institute (API) base oil classification system groups base oils according to their purity and viscosity Index (VI). The system uses physical and chemical parameters to divide all base stocks (oils) into five groups – groups I, II, III, IV and V. However, base stocks, even in the same 'group', may differ widely in their molecular composition, and physical and chemical properties depending on the feedstock and processing parameters used by the refiner.

Group I, II, and III are mineral oils derived from crude oil, group IV is a fully synthetic oil, and group V is for all base oils that are not included in one of the other groups. It must be noted that group III base oils - although crude-derived - are sometimes described as synthesised hydrocarbons (synthetic).

Differences in base stock composition affect the performance of finished lubricants, consequently, base stocks are considered non-fungible in many lubricant formulations. This is particularly true in high-performance diesel engine oils. Group I base stocks are high in aromatics, sulphur and nitrogen, all of which have a negative impact on lubricant performance and, as performance standards tighten, the impurities in this group will make them unacceptable in many engine oil formulations - especially those formulations designed for modern diesel engines.

These inherent issues with group I base oils have led many formulators to focus on group II/II+ and group III base oils due their lower volatility, aromatic and sulphur contents, better oxidation stability and higher viscosity index.

FRICTION MODIFIERS (FMs)

Friction modifiers are a group of additives that are gaining in popularity. They are typically used in engine oils to lower metal-to-metal friction between interacting component surfaces and in doing so, reduce wear and improve fuel economy.

However, their effectiveness is dependent on the lubrication regime within the engine, which is also affected by engine design. An engine is a very complex system that at any one time can have multiple frictional regimes occurring simultaneously. The typical regimes encountered in this environment are hydrodynamic or full-film lubrication - where two metal surfaces are completely separated by an unbroken lubricant film; boundary lubrication - where occasional metal-to-metal contact takes place between surfaces and, finally, mixed lubrication which is a combination of the other two.

For engine components lubricated hydrodynamically, the friction varies with the viscosity of the oil. The thinner the oil, the less the friction, relatively speaking. For engine components experiencing boundary or mixed lubrication where there is some form of surface contact, FMs are used to effectively reduce friction.

For example, engines with roller follower valve train systems have relatively little boundary lubrication and friction modifiers may not demonstrate significant fuel economy benefit, while engines without roller followers may show more benefit.

VISCOSITY INDEX IMPROVERS (VIIs)

Another additive group gaining in importance as the technical demands placed on engine lubricants continues to grow is Viscosity Index Improvers.

Olefin copolymer viscosity index improver

VIIs are large polymer additives that partially prevent the oil from thinning out (losing viscosity) as operating temperatures increase. They are also responsible for better oil flow at low temperatures, resulting in reduced wear. VIIs contribute to improved fuel economy primarily through shear thinning and viscosity temperature properties.

Properly-designed VIIs support higher lubricant viscosities in the hotter engine operating environments for robust wear protection, while maintaining lower viscosities in moderate engine temperature environments, which provides fuel economy benefits.

As the use of lower viscosity engine oils increases, the role of VIIs in providing wear protection will follow suit. Selection of the correct VII also allows lubricant formulators to meet the minimum HTHS viscosity while lowering kinematic viscosity at the same time.

Finally, combining FMs with the correct VIIs can create a synergistic effect which improves overall engine operating efficiency.

EMISSION SYSTEM COMPATIBILITY

> The most important emission aspect of modern-day diesel engine oil formulation is its compatibility with exhaust aftertreatment technologies.

The chemical composition of a diesel engine oil contains, among other things, sulphated ash, phosphorous and sulphur. These substances form part of the additive chemistry that provides the oil with the following attributes: detergency, neutralisation of acids, anti-wear and anti-oxidants.

Emission system compatibility

- Low SAPS oils
- Sulphated ash
- Phophorus
- Low sulphur oils
- Low sulphur diesel

Unfortunately, these chemicals are proving problematic with the current emission technology on offer and, as a result of these compatibility issues, lubricant manufacturers are facing chemical restrictions which are aimed at protecting emission control systems by limiting the levels of these chemicals used to formulate a lubricant.

This has given rise to a new class of engine oils – low SAPS. The abbreviation SAPS stands for “sulphated ash, phosphorus and sulphur”. A low-SAPS engine oil is therefore an oil with a low proportion of sulphate ash, phosphorus and sulphur. These oils are also designated “low-ash” due to their low tendency to ash formation. The requirement to use low-ash additives in the formulation of modern diesel engine oils may sound simple but developing this sort of oil is a true challenge for every lubricant producer.

While some additives have organic alternatives containing little or no sulphur and phosphorous and which do not contribute to sulphated ash, some important anti-wear and detergent additives do not have organic alternatives. Until effective replacements are found for those additives without alternatives available, a careful balancing and reduction in the concentrations of SAPS-contributing additives is required to ensure that the engine oil meets all the performance requirements that engines demand.

There are three major mechanisms for possible interference between the lube oil’s components and aftertreatment devices: poisoning, deactivation and accumulation of ash deposits derived from the lubricant’s additive package. We will take a closer look at these mechanisms and the additives that cause them.

SULPHATED ASH

> The term sulphated ash relates to the amount of incombustible metallic ash that remains as a result of engine oil combustion.

This ash is mostly derived from the engine oil’s detergent and anti-wear additive chemistry. Calcium and magnesium-based detergents, and zinc-based anti-wear and antioxidant additives - most commonly Zinc Dialkyl Dithiophosphate (ZDDP) - are the most common sources of lubricant-derived ash.

All engines, even the most modern, consume a small amount of oil as part of their normal operation. The oil is burned in the combustion chamber along with the fuel, and the resulting small amount of residual ash from the oil is later trapped in the diesel particulate filter (DPF). During regeneration, the particulate matter (PM) is oxidised and removed from the filter, but the ash portion from the lube oil cannot be oxidised and remains in the filter, causing the DPF to become irreversibly blocked.

As the ash particles accumulate, they result in irreversible filter blockage, which also increases back pressure to the engine, increasing fuel consumption and decreasing power. Low SAPS oils are formulated to have limits on the maximum sulphated ash allowed in the oil primarily to protect against DPF blockage.

Blocked diesel particulate filter

The ash can occupy a large portion of the filter volume, as it may accumulate in a thin layer along the channel walls or pack in plugs towards the back of the filter channels.

One effect of the ash is to decrease the effective filter volume or filtration area and reduce the filter's soot storage capacity.

PHOSPHORUS

The class of anti-wear, anti-oxidation additives commonly known as ZDDPs have been a mainstay of diesel engine oil formulation and performance for more than 60 years and with good reason - no single additive provides the same benefit as cost effectively as ZDDP. Unfortunately, SAPS limits land a double blow on ZDDPs because this group of additives contains two of the limited substances in low SAPS oils – ash and phosphorus, the former of which we have already discussed.

The operation of catalytic convertors like the diesel oxidation catalysts (DOC) is altered by the phosphorous which is present in large quantities in most high-performance engine oils. Phosphorus can partially volatilise during engine operation and, once in the exhaust stream, degrades the function of the catalyst through poisoning.

Once in the exhaust stream, phosphorus can reduce the efficiency and deactivate the noble metal catalysts by coating and building up on the active catalyst sites, causing irreversible damage that accumulates over time. As a result, increased levels of harmful emissions such as NOx, CO and HCs pass through these catalysts unchanged and into the atmosphere.

To make matters worse, catalyst poisoning by phosphorous can also significantly decrease filtration efficiency of both catalysed (C-DPF) and uncatalysed DPF substrates, which also results in reduced soot regeneration activity.

SULPHUR

Within the diesel engine operating environment, sulphur emissions originate from two sources: from the fuel and from the lubricant.

Lubricant-derived sulphur emissions are under increased scrutiny because of their potential to impact catalyst performance - specifically, the lubricant's contribution to total SO_2 emissions, which has a tendency to significantly hinder NOx adsorber catalyst (NAC) performance.

> Lubricant-derived sulphur can originate from the base oil itself and the additive systems used to blend the lubricant.

Heavy-duty diesel engine oils are composed of approximately 75 to 85% base oil with the remainder made up of additive systems. The sulphur concentration in the base oil can range from zero, as is the case with synthetic base fluids such as polyalphaolefins, to as high as 0.5% by weight in group I base stocks.

The additive systems used are also major sources of sulphur. The sulphur-containing additives used in the formulation of these oils include, primarily, anti-wear agents (ZDDPs) but also corrosion inhibitors, detergents and friction modifiers.

Once in the exhaust stream, sulphur can inhibit the effectiveness of the DOC, C-DPF and SCR systems by poisoning these catalysts. This poisoning of the catalyst can increase the conversion of sulphur oxides to sulphates, which in turn increases particulate emissions and accumulation of particulate material. Accumulation of particulate material can also lead to blockage of the NAC and ultimately to reduced engine performance.

Diesel fuel also contains sulphur which, as in the case of lubricants, is also derived from the original crude oil source and can still be present after the refining process.

About 98% of sulphur contained in diesel fuel oxidises in the combustion process to sulphur dioxide (SO_2) which, when released into the atmosphere, contributes to the formation of smog and acid rain.

Sulphur is a pollutant directly, but more importantly, it prevents the adoption of all major pollution control technologies. No significant air pollution reduction strategy can work without reducing sulphur to near zero levels.

Euro-rated diesel engines, specifically Euro V to VI, contribute significantly to engine emission reductions because they have advanced aftertreatment systems for PM and NOx, but these systems are sensitive to the sulphur content in diesel fuel, and for this reason, most engine manufacturers have progressively limited fuel sulphur content to 10 parts per million (ppm), also known as ultralow-sulphur diesel.

Using diesel with a sulphur content higher than recommended results in a myriad of issues for modern exhaust aftertreatment systems, including corrosion of EGR cooling system pipes due to condensation of sulphur compounds, oxidation efficiency degradation of catalysts on DOC and DPF systems and catalyst efficiency degradation of zeolite-based SCR systems.

Finally, DPF regeneration is affected by higher sulphur because it decreases NO_2 formation in DOCs. This leads to performance loss in passive DPF systems that depend on upstream NO_2 from the DOC to oxidise the soot. Higher back pressure and more frequent active regeneration result in higher fuel consumption.

While almost all emission control systems achieve maximum effectiveness at around 10 ppm sulphur or less, some temporary exceedance of these levels can be tolerated without adverse effects. After short-term exposure to sulphur content at 50 ppm, adverse effects on emissions performance can be reversed. However, long-term exposure to 50 ppm sulphur introduces more serious challenges for real-world emissions compliance.

South Africa's fuel improvement initiative, in support of global greenhouse gas reduction agreements, were planned to meet Euro 5 standards by 2017 through the Clean Fuels 2 (CF2) programme, but the programme stalled due to uncertainty around the cost recovery mechanism needed to pay for the required refinery upgrades - which in 2009 was estimated to be to the tune of US $ 3.9 billion.

Local manufacturer Sasol introduced 10ppm diesel to the market in late 2013 as part of the initial roll-out strategy, but to date 10ppm is still not widely available nationwide. Sadly, falling behind on fuel quality limits the availability of new engine technology as low sulphur fuels are key to enabling advanced control technologies and fuel-efficient designs.

Table 2 below summarises the maximum sulphur requirements according to the Euro standard.

Regulatory step	Corresponding maximum sulphur level
Euro II	500ppm
Euro III	350ppm
Euro IV	50ppm
Euro V	10ppm
Euro VI	10ppm

DURABILITY

If all the requirements already covered were not difficult enough for lubricant blenders to contend with, there are also additional trends affecting future diesel engine oil formulations such as increased oil drain intervals, smaller sump levels, higher running temperatures and shear forces - all of which put increased stress on the lube oil.

> The oil inside your engine has become a war-zone!

To support greater engine durability under these punishing conditions lubricants are expected to resist increased oxidation and thermal degradation, keep deposits and sludge to a minimum, keep engine components cleaner for longer as well as neutralise the cocktail of acidic species between drain intervals.

Let's review the additives that have been tasked with turning your can of oil into a bulletproof lubricant.

DETERGENTS

Detergents are cleaning agents that contain metals. They work at high temperatures in the combat zone of the engine (pistons, rings, liners and valves) to reduce or remove deposits on surfaces and also in the bulk of the oil. They also neutralise acidic compounds formed during the combustion of diesel or due to base oil oxidation. The all-important Total Base Number (TBN) of the oil is an expression of this neutralisation ability. The amount of TBN an oil contains is based on the intended application and fuel used, specifically the amount of sulphur in the diesel.

The majority of metallic detergents is based on either calcium or magnesium attached to an oil-soluble organic soap - typically sulphonates, phenates or salicylates.

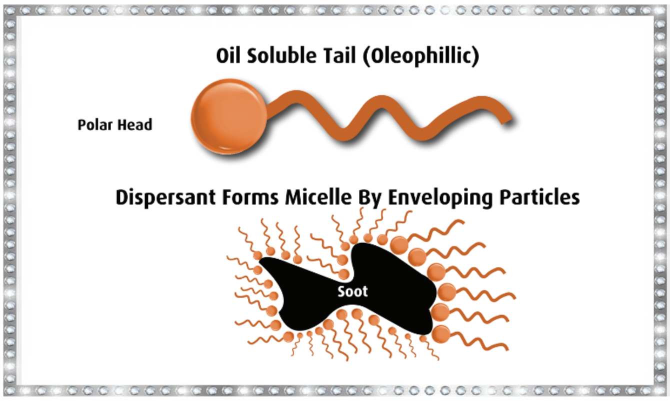
However, because magnesium-based detergents provide a higher TBN per unit of sulphated ash produced, they are now favoured in formulations.

A reduction in TBN is expected with many low SAPS oils. While the TBN of new oil is important, the ability of oil to retain TBN over extended drain intervals is arguably more critical than the absolute value in the new oil. As already discussed, the introduction of low SAPS oils goes hand in hand with the use of low sulphur fuels, which should produce less sulphur-derived acids in the oil. With this in mind, it could be argued that the base number of low SAPS oils does not need to be as high. However, the lower amounts of sulphur-derived acids that the oil is exposed to could be partially offset by higher acid dewpoints from higher EGR rates, by higher amounts of nitric acid and from oxidation acids resulting from higher engine oil temperatures. TBN will therefore still need to be maintained at a level to provide adequate protection against these acids.

DISPERSANTS

Dispersants are non-metallic, ashless cleaning agents that inhibit sludge-formation by keeping insoluble contaminants like soot dispersed in the lubricant and preventing them from coating metal surfaces.

The soot particles themselves are sub-micron in size when formed, but with progressive fuel usage, large quantities of these particles are continually deposited in the oil and will eventually agglomerate. Dispersants now have to fight a battle on two fronts – with the use of EGR systems and with the requirement to increase oil drain intervals.



As already discussed, the EGR system recirculates a small amount of cooled exhaust gas back into the combustion chamber which lowers the combustion temperature, which in turn reduces the NOx gases. However, recirculating exhaust gas also creates a multi-pass opportunity for soot to accumulate in the engine oil.

Extending oil drains also increases soot levels in the oil. If soot is not adequately dispersed by the engine oil, it can cause sludge to form on rocker and front engine covers, bearings to fail, valve bridges and fuel injection links to wear, and filters to plug. The durability of the lubricant and additive system in relation to the ability to disperse soot and maintain a regime of reduced wear has led to significant changes in additive formulation.

Increasing concentration of soot contamination causes a variety of problems, including sludge formation, higher operating temperatures, loss of anti-wear performance, increased viscosity and filter plugging. Added to this the additional soot loading increases the strain on the dispersant's ability to function optimally.

In response to this issue, lubricant blenders have had to increase the treat rate of this additive and these days dispersants are typically one of the major components making up between 30 to 60% of the additive package.

However, as lubricants move to lower viscosity for enhanced fuel economy the thickness of the polymeric-based dispersant becomes problematic, and use of higher treat rates of thicker dispersants complicates formulation resulting in the use of lighter base stocks, which in turn can result in higher volatility lubricants.

ANTI-OXIDANTS

Oxidation is a form of irreversible chemical deterioration of the lubricant. It is caused by the base oil combining with oxygen, sulphur and nitrogen to form harmful compounds. It can also be caused by additive depletion, contaminants in the oil such as metal particles, soot, fuel and glycol as well as increased operating temperatures.

Oxidation creates oil-insoluble high-molecular-weight molecules that increase the viscosity of the lubricant, accelerate wear and eventually lead to varnish-formation, typically on pistons and valves in engines. These varnish deposits can cause valve and ring sticking, eventually leading to accelerated wear.

Badly oxidised engine oil

The use of EGR systems can increase the rate at which the oil oxidises as many of these systems rely on the engine's coolant system to reduce exhaust gas temperatures, which increases the engine running temperature. This elevates the engine oil sump temperature, which in turn puts more demand on the lubricating properties of the oil. Exacerbating the situation is the added requirement of increased oil drain intervals, which means the oil needs to be in use for longer.

The base oil itself cannot protect against the detrimental effects of oil oxidation and for this reason engine oils contain anti-oxidants. Anti-oxidants are a group of additives that minimise oxidation and deposit-formation by targeting particular steps in the oxidation reaction. They decompose reactive hydroperoxides and free radicals before they lead to oxidation of the base oil.

There are two types of antioxidants: primary and secondary antioxidants. Primary antioxidants are free radical scavengers typically comprised of aromatic amines and hindered phenolics. Secondary antioxidants are peroxide decomposers typically composed of phosphites and certain sulphur-containing compounds.

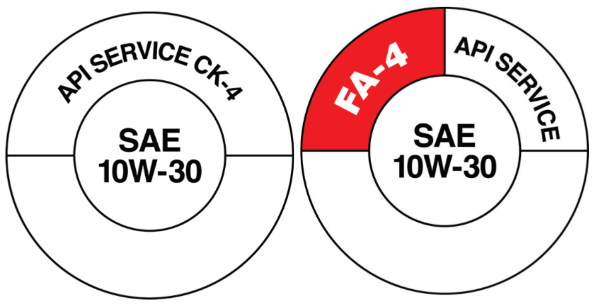
With the restriction in phosphorus-containing additives like ZDDP and increased oxidation control requirements, formulators have turned to incorporating higher levels of ashless antioxidants in their blends.

Ashless-type oxidation inhibitors have helped to replace the oxidation performance of ZDDPs, with recent additive systems making use of aminic and phenolic chemistries. The use of molybdenum-based chemistry for improved antioxidancy performance has also gained popularity in recent years.

Given the ever-changing landscape in the lubricant industry and these stringent oil quality requirements, it became apparent that a new heavy-duty engine oil category would be required. As a result of this, the API introduced two new standards to take into account the latest technology in diesel engines. API CK-4 and FA-4 first appeared in the API service symbol donut in 2017. These new service categories improve upon existing standards by providing enhanced protection against oil oxidation, engine wear, piston deposits, shear stability as well as providing better compatibility with emission-controlling devices.

API CK-4 was introduced to reflect the upgraded performance benefits beyond API CJ-4 for engine lubricants with a minimum HTHS viscosity of 3.5cP. New API CK-4 lubricants must pass more stringent oxidation and aeration limits with increased shear stability, providing greater protection for heavy-duty diesel engines. CK-4 is backward-compatible with older API categories like CJ-4.

API service symbol donut



The API FA-4 fuel efficiency category requires lubricants to pass the same performance tests as API CK-4, with the addition of a HTHS viscosity limit of between 2.9 and 3.2cP, to deliver increased fuel efficiency benefits whilst maintaining engine protection. The FA-4 category is not backward-compatible. Evolutionary approaches will continue to play a role in lubricant formulations of the future. However, real step-out changes in the additive technologies are currently taking place to address the longer term needs of the industry. Hopefully, it can be seen that such changes will affect not just one or two classes of additives, but every major type of additive component used in oil formulations. All of this makes for trying times in the lube kitchen.

DEF

And finally, A new addition to the buffet on offer to the most discerning of diesel engines is diesel exhaust fluids (DEF). As already mentioned, SCR technology uses a reductant known as a DEF, which is injected into the exhaust gas to help reduce NOx emissions, over a catalyst. Aqueous urea is the preferred reductant of choice in modern SCR systems. Most people know DEF by its more commercialised name of AdBlue or, in South Africa, Air1 which is supplied by Engen Petroleum.

Air1 is aqueous urea solution which comprises 32.5% urea and 67.5% deionized water.

The water acts as a solvent to ensure the solid urea, which is in the form of colourless crystals, becomes a liquid solution. Air1 is non-toxic, odourless and perfectly safe to handle.

The Air1 is injected from the vehicle's dedicated storage tank into the exhaust pipe, which is usually situated in front of the SCR catalyst, but downstream of the engine. As it is heated in the exhaust, the Air1 changes into ammonia (NH_3) and carbon dioxide (CO_2). When the nitrogen oxide (NOx) gases from the exhaust pipe react inside the catalyst with the NH_3, the harmful NOx molecules in the exhaust are converted into harmless nitrogen (N_2) and water, which is released to the atmosphere as steam.

Air1 consumption varies depending on the particular aftertreatment system of the exhaust gases, but also on driving style and driving conditions. Air1 dosing into the exhaust system is typically between 3 to 5% of the fuel consumed.

Purity requirements for SCR catalyst reductants are high and among the specific requirements, metals such as sodium, potassium, calcium, magnesium, copper, zinc, iron or chromium - as well as the content of ash-forming phosphates - must be kept at low levels in SCR-grade urea. As a result of these purity requirements, storage and handling of these reductants is of utmost importance.

With widespread adoption of highly-efficient SCR systems, diesel engines are likely to become a more significant source of urea demand globally.

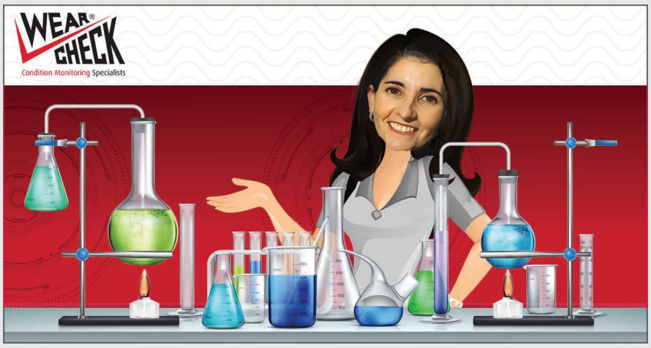
THERE IS NO PLAN B

It is widely acknowledged that there is more to be done in the drive to further reduce harmful gases, improve air quality and mitigate the effects of global warming. Limits on emissions in the heavy-duty engine sector are expected to become more stringent in the future and further engine hardware changes, the expansion of current technologies and the introduction of new emission control devices are among the options being explored. The road to zero harmful emissions is not going to be an easy one, but it is one that we, as a civilisation, must travel in order to safeguard the future of this beautiful blue marble we call home. As former UN secretary General Ban Ki-moon famously said during the 2016 United Nations Climate Change Conference-

"There is no plan B because there is no planet B!"

Diesel engine emissions standards introduced around the world have undoubtedly had a major impact on reducing pollutants so it's not all doom and gloom. To give you an idea of how far we have come – 30 years ago, one heavy on-highway truck produced the same level of particulate matter as 100 heavy goods vehicles produced in 2019. Now isn't that a breath of fresh air?

About the writer...



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Steven joined WearCheck in 2008 as a diagnostician and worked her way up to the position of senior diagnostician, during which time she diagnosed her millionth used oil sample in addition to running oil analysis training courses for customers in several countries. In 2015, Steven was promoted to the position of Technical Manager.

Planet-friendly option

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