SCANIA

Scania Oil Technical Paper

November 2019

If your engine could choose

Issued by Scania Parts November 2019

Content

1. **Introduction: Why Scania Oil?**
2. **The role of oil in high-performance engines**
   a. Baseline characteristics and properties:
      i. Wear protection
      ii. Temperature range
      iii. Cleaning capacity
      iv. Engine compatibility
      v. Minimal impact on after-treatment systems
      vi. Zero toxicity
3. **Understanding base oils and additives**
   a. What are base oils?
      i. API base oil categories
   b. Functions and properties of additive packages
      i. Anti-wear/extreme pressure additives
      ii. Dispersants
      iii. Detergents
      iv. Antioxidants
      v. Corrosion and rust inhibitors
      vi. Friction modifiers
      vii. Anti-foam
      viii. Anti-swell agents for seal materials
      ix. Our point depressants
   c. Viscosity modifiers
4. **How oils are tested and approved**
   a. Understanding oil specifications
      i. Industry specifications
      ii. OEM specifications
   b. Field testing vs. laboratory testing
5. **Unique features of Scania Oil**
   a. Tailor-made for Scania high-performance engines
      i. Scania-approved oil formulation codes
      ii. Scania Quality Assurance
      iii. Supplier screening
      iv. Scania Research & Development
   b. Using non-approved oils on Scania vehicles
6. **The value of Scania Oil**
   a. Core benefits of Scania Oils
      i. Protection
      ii. Drain interval
      iii. After-treatment system
      iv. Oil consumption
      v. Fuel consumption
      vi. Emission legislations and environmental assessment
   b. Total operating economy
7. **Additional information**
   a. Scania engine oils features and criteria framework
   b. Fuel economy calculation

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1. Introduction: Why Scania Oils?

Many years ago, oil was considered insignificant to the performance and economy of the vehicle. Over the years, oils have developed in both stature and composition, partly driven by a demand to meet the powertrain's increasing complexity, and partly owing to an evolution of the science, testing and specification across the oil industry.

Through the availability of base oils, additives and viscosity modifiers, engine and transmission oils now offer greater flexibility in meeting the exact requirements of the vehicle. This is extremely relevant when we consider the performance demands of Scania vehicles.

The quality of oil can vary across markets and manufacturers. In addition, existing specification frameworks are generally considered to be sub-optimal against Scania's high-performance power trains. This was the challenge which Scania set out to address when it first began to formulate oils more than twenty years ago. Scania R&D has since precision engineered one of the industry's most rigorously tested and approved oil ranges for each of the Scania engine families.

Engineered for optimal performance and operating economy

Scania formulates its blends to provide the best possible performance and total operating economy, balanced with the cost of the oil. As a result, Scania Oils are proven to offer:

- Reduced fuel consumption and by extension fuel bills
- Maximised oil drain intervals tailored to Scania hardware
- Full protection of the powertrain leading to increased component lifespan and higher residual values
- Maximised change interval of expensive aftertreatment systems
- Minimized oil consumption
- Full compliance with chemical legislations and minimised environmental impact

In achieving this, Scania has gone far beyond industry standards when testing and specifying oil blends. In addition to bench testing, oil blends are subjected to real life applications in different operation types and climates. This presents a realistic testing scenario and consequently more reliable data in assessing the suitability and performance of oil blends.

No other oil blends are tested in real life applications on Scania vehicles. This places Scania in a unique position to formulate, test and specify the perfect oil blend for Scania engines, axles and gearboxes.

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2. The role of oil in high-performance engines and transmissions

Most of today's vehicle components are engineered on the key performance indicators of optimal efficiency and high-performance operation. As a consequence, many components in today's powertrains have tolerances of less than a thousandth of a millimetre and are increasingly manufactured from new demanding materials with specific requirements in relation to oil.

The technical development of these parts is placing new demands on engine and transmission oils, qualifying the oil as one of the most crucial components in today's high-performance powertrains. To gain optimal operating economy, high-performance engines and transmissions require carefully tested oil blends in order to facilitate maximum performance and durability.

Baseline characteristics and properties

The basic function of oil is to create a thin, slippery barrier between two moving metal surfaces in order to:

- reduce friction, carry away impurities and dissipate heat, thus preventing wear and improving fuel economy.

Aside from these baseline characteristics, it is crucial that oils can also exhibit and retain the right viscosity (thickness) at different operating temperatures in order to ensure the correct oil film thickness on all components at all times. In addition, an effective oil will also prevent any negative impact on vehicle after-treatment systems, such as the catalytic converter and particulate filter, and will also protect itself against degradation thereby allowing for longer oil drain intervals.

The role of oils has developed far beyond only providing lubrication. Today's vehicle oils are increasingly precision engineered to ensure that they exhibit specific properties throughout high-performance operation. We achieve this through an optimised combination of base oils and additive packages.

The individual characteristics and properties of high-performance oils are explained below.

i. Wear protection

The characteristics of base oils can naturally offer some protection against wear. However, to ensure the levels of wear protection demanded by modern high-performance engines and transmissions, lubricant additives are required.

Throughout the powertrain, moving metal surfaces regularly come into contact with each other, generating heat and causing wear. To counter this, anti-wear and friction-modifying additives are added to the oil. These additives are engineered to react with hot metal surfaces in order to form a protective film on the component's surface, resulting in reduced wear and in some cases, as with Scania Oil, reduced fuel consumption.

ii. Temperature range

The viscosity grading (thickness) is a crucial feature of the powertrain oil's properties and necessary to minimize friction and wear. However, the natural properties of oils mean that its viscosity will naturally decrease as its temperature increases. Its flow characteristics change, meaning it will flow more easily and form thinner films on engine and transmission components. For optimum engine and transmission performance, the viscosity would ideally remain unchanged at all temperatures.

Engine oils can be required to operate in ambient temperatures as low as -300C and, while in operation can reach far beyond +1000C. Within this temperature range, the degree to which the oil's viscosity grade is affected

should be minimal. This is achieved by adding viscosity modifiers to the base oil in order to retain the oil's intended flow characteristics in both low and high temperatures.

iii. Cleaning capacity
Variations in temperature can cause degradation of the oil's lubricant, resulting in the production of varnish or lacquer type deposits on components, and in extreme cases carbon-like deposits. To counter this, stabilisers such as antioxidants are added to the base oil.

In general, the engine is a very aggressive environment for oil. It is attacked by hot combustion gases which also contain soot that gets into the oil. Dispersant additives are blended with the base oil to stop the soot from building numerous small lumps which, over time, can cause oil thickening, engine sludge and piston deposits.

In addition, detergent additives are also a necessary element to help keep the engine clean.

iv. Engine and transmission compatibility
A modern high-performance engine and transmission contains many different materials. In addition to steel, a number of components are manufactured from aluminium, copper and lead as well as elastomers in sealing elements. In addition, a variety of coatings are now used on components, such as chromium, DLC (diamond-like carbon), polymers and ceramics. As such, oils must exhibit the same lubricant compatibility with each of the engine's various materials and coatings, without causing any damage such as corrosion or other chemical attack.

v. Minimal impact on after-treatment systems
Exhaust after-treatment systems such as the catalytic converter, which meet the latest emissions requirements are complex, expensive and sensitive to damage. As such, high-performance engine oils must be engineered to protect the performance and lifespan of such systems.

Under normal operation some oil gets into the combustion chamber, is burned and enters the exhaust system. Here elements which are present in the lubricant can interact with the catalyst system and reduce its performance. For example, phosphor and sulphur can poison the catalyst, and metallic ash (from calcium, magnesium, zinc and other metallic additives in the lubricant) can block the particulate trap.

This can be countered by applying strict chemical limits on additives, to ensure the best balance between oil performance and minimal impact on the after-treatment system.

vi. Zero toxicity
To ensure the health and safety of operators in workshops and production plants, high-performance engine transmission oils should contain no toxic or hazardous compounds or elements. In addition, clear guidelines should be provided to ensure safe handling in the workshop and by vehicle operators.

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3. Understanding base oils and additives

High-performance oils comprise three main components which work together to give the oil the performance it needs. These three components are:
- The base oil
- The additive package
- The viscosity modifier

In modern high-performance engine and transmission oils, the percentage which each of these components comprises will often vary, depending on its purpose and the engine family it is engineered to serve.

Irrespective of the composition, the quality of the base oils and additives contributes significantly to the performance of the lubricant. However, this inevitably also affects cost. When engineering a high-performance oil, it is important to match the right quality base oil with the right additive package to produce an oil with high quality in relation to its price. Ultimately, this improves the vehicle's overall total operating economy, which includes protecting the engine and transmission from breakdown, optimising oil drain intervals, minimising the fuel and oil consumption as well the impact on the after-treatment system.

a. What are base oils?

The original engine oils were composed entirely from base oil (sometimes also called the base stock). Today, base oils remain the largest component in engine oils, however over time they have become blended with additives and viscosity modifiers to improve performance.

The base oil is a hydrocarbon (or sometimes hydrocarbon ester) fluid of the right viscosity, which forms the basis for the lubricant. Alone, it cannot provide all the properties needed to lubricate a modern high-performance engine. As such, it provides the solvent system to ensure the performance of the various additive packages.

Lower-quality lubricants use a base oil that is derived from crude oil. The fraction of crude oil that has a higher boiling point than diesel/heating oil is used as base oil. After fractionation, the base oil is cleaned to remove impurities and waxes which can cause problems for the oil at low temperature.

Higher-quality base oils can be produced by hydro treatment of these mineral base oils, which removes sulphur and rearranges the hydrocarbon molecules to produce molecules with better lubricant properties. This helps to provide better flow characteristics at low temperatures.

Synthetic and semi-synthetic oils
Oils can generally be categorised as synthetic or semi-synthetic, although the definition of each is largely open to interpretation.

Hydrocarbons with the right viscosity, volatility and other properties can be produced synthetically by polymerization of olefins such as decene, to produce poly-alpha-olefin (PAO), or by esterification (ester base oils). These synthetically produced oils tend to be more expensive, however offer very high performance.

Semi-synthetic is often a term used to describe oils that use a mix of PAO and crude oil-derived base oils. They are sometimes also used to refer to oils based on hydrotreated base stocks, such as Group III base oils.

I. API base oil categories
The American Petroleum Institute (API) base oil classification system offers a framework to distinguish between the different types of base oil available in the market. In this system, base oils are categorised according to their sulphur content, saturates content and viscosity index. See below API base oils categories:

Group I
Group I base oils are mineral base oils that have undergone simple refinery processes such as solvent extraction to remove wax molecules and also some aromatic, sulphur or nitrogen-based molecules which can affect oxidation. Group I base oils may still contain many impurities and molecules

with undesirable properties. These base oils offer the poorest properties for oxidation, viscosity and volatility. They are not used in high-quality formulations and are not the basis of any Scania-approved lubricants.

Group II
Group II base oils have undergone additional hydro-processing treatment to further reduce the content of undesirable components such as aromatic and sulphur-based molecules, as well as improving the properties of the base oil. Scania considers Group II base oils still not good enough for its high performance high-performance engines or transmissions.

Group III
Group III base oils are more severely hydrotreated to reduce the amount of sulphur-based and aromatic components to a very low level, as well as crack and reform many of the molecules to produce desirable properties. Scania considers Group III base oils to have an excellent balance of good antioxidants, viscosity and volatility performance. As such, they serve as the basis for some of Scania's approved lubricants.

Group IV
Group IV base oils are synthetic polyalphaolefins (PAO) derived from 1-decene, and not directly derived from mineral oils. It is considered to offer many excellent properties, however, is not widespread on the market because of its cost. Owing to its superior qualities, Scania uses Group IV base oils to formulate its low viscosity oils such as Scania Oil LDF-4. It is also used to formulate high-quality transmission oils for extended drain intervals, for example the Scania Oil STO 2:0 for Scania axles and gearboxes.

Group V
Group V base oils are those that do not fit in any of the above groups, owing to their chemical or viscometric properties not aligning with the other groups' requirements or, more commonly, because they are specially synthesised base oils such as esters. Group V base oils are not widely used, mainly because of their cost. However, they are sometimes used in small quantities to provide special performance features.

b. Functions and properties of additive packages

High-performance oils are engineered using a variety of different additives, each performing a specific function, in order to protect the engine or transmission, facilitate optimal performance and prolong the life of the oil itself. These carefully blended formulations of many different additives are called additive packages, sometimes called ad packs. They are designed and supplied by specialist lubricant additive companies and also by some major oil companies.

The formulation of additive packages can be a complex and highly specialised process. Some additives, while providing a performance benefit in one area, can also have a negative impact in other areas.

Crucially, each additive also has an optimum treat-rate range (dose or concentration) for optimal performance. When engineering or formulating additive packages, it is also necessary to take into account any chemical restriction, such as phosphorus and sulphur content, as well as matching the additive package to the base oil. Ensuring the cost-effectiveness also plays a role as part of this process. The below additives can be found in a modern high-performance engine- or transmission oil.

- Anti-wear/extreme pressure additives
- Dispersants
- Detergents
- Antioxidants
- Corrosion and rust inhibitors
- Friction modifiers
- Anti-foam
- Anti-swell agents for seal materials

c. Function of a viscosity modifier

The viscosity modifier package contains the viscosity modifier which is already dissolved in the base oil. This is normally Group I base oil, but for higher quality oils, like Scania Oils, it is dissolved in Group III or higher quality base oils. A pour point depressant is also generally added to this package, although it can also be supplied separately.

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4. How oils are tested and approved

General market oils are oils that haven't been approved by Scania. However, most of them will have been tested to demonstrate that they meet certain basic oil specifications. These specifications require both bench testing and engine testing to prove that the oil has the right level of performance.

Bench testing is the first and simplest level of lubricant testing. These quick laboratory tests measure the physical properties of the oil, such as viscosity and volatility, and provide a chemical analysis of its contents; including sulphur, phosphorus, ash content, and total base number (TBN).

There are also simple bench tests that measure additional performance parameters like oxidation resistance and elastomer compatibility. However, these tests are not performed in an engine environment and, as such, it can be argued offer unreliable performance data.

Market general oils, such as those based on ACEA specifications, require oils to pass an engine test. These tests, often conducted in laboratories over short periods, stress the oil in a way which intends to simulate the effect of driving for a whole oil drain period. Typically, the oil specification will stipulate a number of different tests. Between them, they will analyse all the properties of an oil, such as wear control, oxidation control, and the ability to keep the engine clean. These tests offer a fairly effective level of protection, however, they are conducted over short periods and do not offer a true representation of the challenges faced by the vehicle in a real application environment.

It is also important to note that such tests are not always conducted on Scania engines!

a. Understanding oil specifications

Oil specifications contain a number of tests, each with the aim to ensure that the oil can meet the necessary performance standards as defined by the specification.

There are two categories of specifications: those regulated by industry associations such as the European Automobile Manufacturers Association (ACEA), and those regulated by original equipment manufacturers such as Volvo, MAN, Mercedes etc. The latter is a different process to oil re-branding, whereby a general oil, developed to meet industry specifications, is marketed using a vehicle or component manufacturer's brand name.

Most oils marketed for commercial heavy-duty diesel applications have passed tests for a mixture of industry and OEM specifications. Scania Oils have been tested and approved to meet industry specifications, but in addition are also engineered according to the Scania approval system and optimized uniquely for Scania vehicles.

i. Industry specifications
Industry specifications are set by industry associations such as ACEA, API (the American Petroleum Institute) and JAMA (Japan Automobile Manufacturers Association). In Europe, ACEA specifications are more common, while in the US and most of the rest of the world the API specifications are more widely used.

The current ACEA specifications define four different categories of oil:

1. ACEA E4: designed to give acceptable performance for normal drain length in modern diesel engines. It is a full SAPS oil, which means it does not have reduced levels of sulphated ash, phosphorus and sulphur (SAPS), and isn't suited to vehicles with particulate traps.

2. ACEA E6: defines an oil with improved oxidation performance which is also a reduced SAPS oil, so it is better suited to vehicles with particulate traps and SCR NOx reduction after-treatment systems.

3. ACEA E7: provides a higher level of wear and oxidation control than E4 oils. It is also a full SAPS oil.

4. ACEA E9: oils that have a similar performance to E7 oils but are reduced SAPS.

The engines used to test ACEA performance are a mixture of European (Daimler) and US (Mack and Cummins) engines.

The API issues new oil categories every five to ten years as older categories gradually become obsolete. Today the current top-quality categories are API CI-4 Plus (full SAPS) and API CJ-4 (reduced SAPS). Full details of all these ACEA oil categories can be found on ACEA's website.

Although all these ACEA or API oils will adequately lubricate Scania engines, they are not optimised for Scania engines and cannot provide the level of protection or the long drain performance required for optimal performance of the Scania engine.

ii. OEM specifications
Many vehicle manufacturers, like Scania, have their own specifications and approval systems. Each of these includes additional tests or has stricter limits than the standard tests used to define an oil. Each manufacturer will conduct their own unique oil tests with their own engines. For example, Volvo approved oils will not have passed tests designed for optimal oil performance in Scania engines.

Most importantly, unlike Scania tested oils, none of these other OEM specifications require field trials, something which is generally considered as the most effective way to test the true performance of an oil, especially for extended drain intervals.

Scania Oils are always approved for the respective Scania engine. However, the same cannot be said for general market oils. ACEA usually releases new editions of the approval specifications every second year, meaning that an oil fulfilling current ACEA requirements can potentially become outdated within a matter of years. In addition, the oils used today may not meet the requirements of the next ACEA update. As such, there always exists an approval expiry risk when using general market oils.

b. Field testing vs. laboratory testing

Even though oil companies test and certify their lubricants to industry standards and other OEM specifications, oils vary considerably in quality. This is true even in the higher quality categories - all oils in the category are not the same quality. However, Scania tested many different oils in order to identify the best ones – and then created an even higher quality standard for Scania Oil.

A key part of the approval process is the Scania field test.
Carefully conducted field tests allow Scania to develop, engineer and evaluate a range of oils with high quality which are optimised according to Scania vehicles and application conditions.

As we've explained, general market oils which are tested in short durations and under laboratory conditions is not enough. The oil needs to be tested in trucks and buses running in real field conditions that simulate real-world stresses on engines and the oil; such as engine braking, polluted air, asymmetric road vibrations, variations in speed, load and temperature. Such parameters are difficult to replicate in a laboratory environment.

Scania Long Drain Field Test Standard
It is also essential to test the oil for the entire oil drain period. To do this, Scania has developed the Long Drain Field test standard (LDF). Long drain means that the oils and engines are tested for double the recommended mileages. For example, an ordinary long haulage truck would normally require an oil change every 60,000 km; however, in Scania LDF field trials, the oil runs for 160,000km before it is changed. The full test runs for two oil drain periods and the engine parts are examined after 320,000km. In total, it can take up to two or three years to develop a new Scania Oil using the LDF trial.

There are other differences between the Scania LDF trial and laboratory tests. After testing an potential oil in the engine, axle or gearbox for approximately 2-3 years, the lubricant is examined for soot content and chemical changes that could reduce its ability to protect the powertrain. The engine or gearbox is also completely disassembled. It takes several weeks for Scania experts to examine the parts and assess their condition. If the slightest trace of deposits or wear is found, this results in the oil being rejected.

In the oil industry, Scania specifications are widely considered to be acutely rigorous and tough to pass. As testament to this, only a small percentage of all oils tested are actually approved.

There are more than 800,000 Scania vehicles on the road and some 250,000 of them are connected. The massive amounts of data collected from these vehicles gives Scania the ability to constantly measure Scania Oil performance in real-world application and provides actionable insight as to how they can be further improved.

5. Unique features of Scania Oil

For more than 20 years, Scania has developed, field tested, engineered and specified oil blends for each of its engine families as well axle and gearboxes.

Scania applies more than just industry standards when testing and specifying oil blends for the Scania powertrain. In addition to bench testing, oil blends are subjected to real-life application in Scania vehicles. This presents a more realistic testing scenario and consequently more reliable data in assessing the suitability and performance of oil blends.

In addition, Scania will only formulate oils which offer greater value to the end user than the added cost of the oil. As an example, while fuel economy oils may be more expensive than oils without a fuel economy benefit, the overall cost of the fuel saved is guaranteed to be greater than the additional cost of the oil. The same applies to Scania oils which are engineered to offer long drain capability.

Below, we present a summary of the various aspects which differentiate Scania Oil from other oils on the market.

a. Tailor-made for Scania high-performance engines

Modern powertrains have become acutely technical in their design. This, in part, has led to significant differences between the designs of different manufacturers' powertrains.

Scania develops its own engines, axles and gearboxes based on the principles of an optimal total operating economy. Scania Oil is designed and developed by Scania Research & Development based on clearly defined technical requirements aligning to the principles of the total operating economy.

Critically, field testing is carried out by Scania engineers to ensure the optimal performance of the oils on each Scania engine family throughout standard application. This allows Scania to conduct a proper evaluation of the oil's suitability for Scania powertrains and thus provide customers with greater value.

Among other benefits, this results in an extended lifespan of the Scania powertrain, increased fuel economy, longer service intervals, and greater operational temperature range compared to other oils of the same viscosity grade.

i. Scania-approved oil formulation codes
To control and secure the quality of the product, each approved Scania Oil formulation is assigned a unique formulation code which details its unique recipe. This code is used to communicate the unique composition of each Scania Oil, in addition to ensuring the exact same quality and integrity of the oil across markets and sub suppliers.

The Scania-approved oil formulation code refers to the additive package, viscosity modifier and also the base stock. There are strict protocols in place which ensure that, when manufacturing Scania Oil, only these Scania R&D-approved formulations must be used.

ii. Scania Quality Assurance
Tests are continuously conducted to ensure that the quality of the product is consistent over time and continues to meet the requirements established by Scania. Tests are performed on every batch of oil that is produced, ensuring that only oils of the right quality are used for Scania vehicles.

All Scania Oil suppliers are required to fulfil the ISO technical specification standards which are a composition of many different standards. In addition, suppliers must also comply with "Scania Customer Specific Requirements", a stringent set of standards, developed by Scania, to ensure high product quality and minimal environmental impact.

The proportion of some substances could be as low as <0.1 mass percent. This naturally imposes high demands on the production process and quality control.

iii. Supplier screening
To ensure compliance with Scania's high standards as well as sustainable business practise, all Scania Oil suppliers are required to undergo a screening process, carried out by Scania's purchasing department. A driver for this is the long-term commitment which Scania expects from their suppliers, and the requirement that they align with Scania's strategies, principles and philosophies.

iv. Scania Research & Development
Scania Research & Development (R&D) works continuously to develop new Scania Oil specifications which deliver on the many parameters of the vehicle's total operating economy.

As part of this, Scania commits to numerous long-term research and development collaborations with industry oil suppliers and specialist additive companies. These collaborations are designed to align with Scania's broader R&D approach to constantly improve and cater to the increasing demands of the Scania powertrains. They also serve to enable the development of new, innovative products that offer value to vehicle operators, such as low-viscosity, fuel economy oils.

Using non-approved oils on Scania vehicles

Scania Oils are developed and tested in Scania vehicles and optimised according to their individual requirements. The correct oil quality and drain interval of Scania Oils enables the high durability, performance, total operating economy and high reputation of Scania vehicles and engines. For this reason, there can be no warranty when using oils that do not meet Scania specifications or standards.

Using sub-optimised market oils on Scania vehicles can cause any number of issues on the Scania powertrain. This can ultimately cause unplanned and longer downtime due to advanced repairs.

Below, we summarise the general reported issues when using non-approved oils on Scania vehicles.

i. General powertrain issues when using non-approved oils
- Severe risk of engine or transmission damage or failure, especially if attempting to extend the oil drain interval
- Reduced service intervals and, in some cases, more frequent unscheduled repairs, resulting in vehicle downtime
- Damage to components in the after-treatment systems
- Higher fuel consumption as a result of the sub-optimised viscometric properties of the oil
- Higher oil consumption
- Filters have a tendency to clog
- Loss of warranty if the vehicle is still in the warranty period

ii. Reported engine issues when using non-approved oils
- Reduced total base number (TBN) and increased acid build-up in the oil, leading to soft metal corrosion and increased piston deposits
- Increased engine sludge, leading to blocked oil filters and in some cases blocked oilways
- Turbocharger deposits in the case of a closed crankcase ventilation
- Oil mist separator deposits
- Increased piston deposits leading to stuck rings and bore polishing

iii. Reported transmission issues when using non-approved oils
- Wear or breakdown of gear teeth, bearings (both axles and gearbox) and the synchronization
- Wear or breakdown of seals
- Poor lubrication in cold weather starts

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6. The value of Scania Oils

Through rigorous research, development and testing, Scania Oils are specially engineered to surpass industry benchmarks for oil and fuel consumption, as well as ensuring minimal wear on engine and transmission components as well aftertreatment systems.

Below, we summarize the parameters against which Scania Oils are developed, tested and evaluated.

a. Core benefits of Scania Oils

i. Protection
The engine and transmission on Scania vehicles is carefully monitored throughout field trials to measure and evaluate the protection provided by Scania Oil.

This also includes a comprehensive analysis of operation types, driving conditions and climates

ii. Drain interval
Scania Oil drain intervals are evaluated and optimised through field trials. This process is also used as a basis for setting Scania service parameters regarding the oil drain interval.

Oil drain intervals with Scania Maintenance with Flexible Plans are maximised for each individual vehicle. This means that the consequences when using the wrong oil grade can be severe. As a prerequisite, the Scania Maintenance with Flexible Plan stipulates that vehicles must use Scania Oil.

iii. After-treatment system
Scania Oil is developed to minimise the wear and extend the lifespan of expensive after-treatment systems such as the catalytic converter and particle trap.

iv. Oil consumption
The consumption rate of Scania Oil is rigorously evaluated throughout field trials to ensure it remains ahead of industry benchmarks and thus contributes to an optimal total operating economy of the vehicle.

v. Fuel consumption
All Scania Oils are engineered to deliver optimized fuel consumption which results in minimised fuel bills and greater fuel economy of the vehicle owner. This is achieved primarily by ensuring the correct viscosity and temperature range of the oil according to the engine and application requirements.

According to Scania data, using Scania Oil in the engine, gearbox and the axle can return an average fuel saving of up to 5% compared with general market oils.

vi. Emission legislations and environmental assessment
Scania Oil is engineered to comply with the applicable emissions legislations and thus ensure the lowest possible impact of the vehicle on the environment.

Many substances can do harm when released into the environment. They can accumulate in humans and wildlife. They can also chemically react with one another, producing new substances with new risks.

To ensure responsible chemical use, Scania Oils are evaluated by Scania's environmental department to regulate that they do not contain any harmful substances such as those which may be hazardous to handle. An example of this would be to ensure that the substances contained in the oil are not allergenic, and that it does not contain substances on the Scania black and grey list.

Importantly, Scania only procures chemicals from EU-based suppliers for EU applications. This ensures that Scania is not an importer of chemicals into the EU region.

Scania's standards are continually updated to keep pace with scientific findings and regulation.

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b. Total operating economy

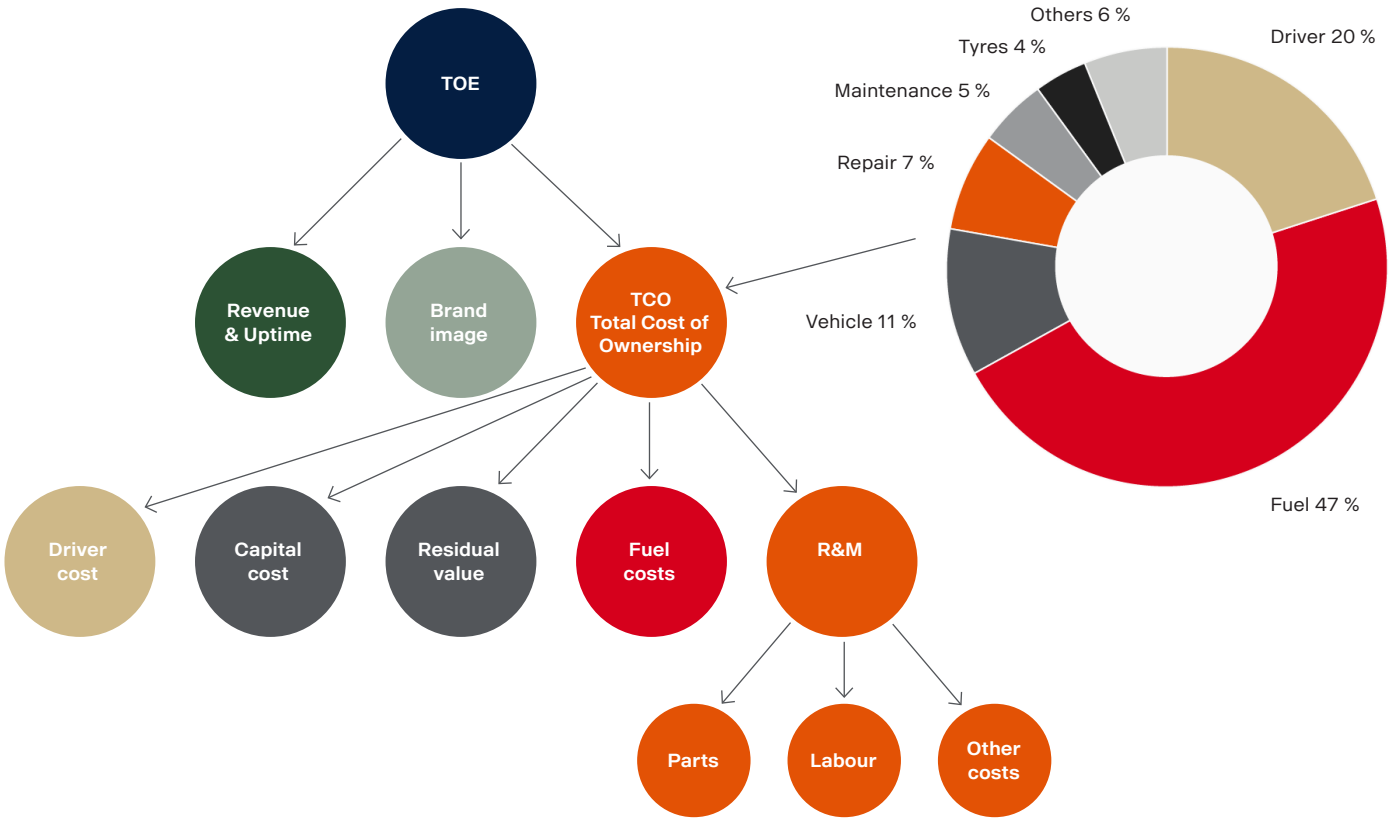
The Scania focus on the total operating economy incorporates the total cost of ownership for a vehicle (such as downtime, maintenance, repair, insurance, financing, depreciation and other costs), however it also includes total revenue and vehicle uptime. This offers a more accurate representation of the overall cost benefit following the aggregation of all expenditures and revenues.

This is important when considering the cost benefit of Scania Oil. In instances where it may appear to offer an insignificant benefit against the total cost of ownership, particularly when compared with other market general oils, it is in fact designed to offer a significant cost benefit against the vehicle's total operating economy. This has been proven to offer the vehicle operator with a significant value return over the long term.

The value of Scania Oil on the vehicle's total operating economy exist in the following three proof points:

– *Reduced downtime:* The longer service intervals offered by Scania Oil can increase the uptime of the Scania vehicle, offering a significant revenue benefit as the vehicle can spend more time in operation.
– *Reduced fuel consumption:* The optimised viscosity and increased temperature range of Scania Oils contribute to an overall greater fuel economy. For example, Scania data supports a fuel saving of about 5% where Scania LDF-4, STO:2 G and STO:2 oils are used compared to market general oils.
– *Increased component performance and lifespan:* The optimised wear resistance properties of Scania Oils contribute to increased lifespan of the engine's components and, in particular, the after-treatment system components. For example, Scania LDF-4 Oil is proven to extend the replacement interval for diesel particulate filters by a factor of two. This alone can result in a significant immediate cost saving.

Impact on TOE (Total Operating Economy)



7. Additional information

a. Scania engine oils features and criteria framework

Scania Oil E7 15W-40
- Scania Oil E7 is developed for markets requesting ACEA E7 oil quality level - Scania Oil E7 meets Scania´s minimum oil quality level
- Scania Oil E7 is not suitable for use in engines with particulate filter
- Valid for normal oil drain intervals
- Valid for inline as well V8 engines

Scania Oil BEO-2
- Scania Oil BEO-2 is specially developed for the Scania ED95 bioethanol engine
- It provides extended drain intervals and is superior in terms of performance with regard to engine service life

Scania Oil LDF-3 10W-40
- Scania Oil LDF-3 10W-40 is developed to provide best total operating economy for Scania Euro V engines but It is also valid for Scania Euro VI engines with after-treatment system
- It allows extended drain intervals
- Scania Oil LDF-3 10W-40 works just as well with fuel of poor quality (high sulphur content)
- Scania Oil LDF-3 10W-40 is valid for inline- as well V8 engines

Scania Oil LDF-4
- Scania LDF-4 is specially developed to provide best operating economy for Scania Euro VI engines
- Valid for CNG and LNG engines
- It allows extended oil drain intervals
- It allows extended DPF change intervals
- Scania Oil LDF-4 is a low viscosity engine oil and reduces the fuel consumption hence reduces the fuel bills and the environmental impact
- Must be used with high quality fuel. Max 10ppm sulphur.

b. Fuel economy calculation

To calculate the increased fuel economy offered by Scania Oils, we have produced a cost savings example based on real life application using Scania LDF-4 engine oil.

Our savings example is based on long-haul vehicle with 180,000 annual kilometres (km) and an average diesel consumption of 25 litres for every 100 km. As diesel prices generally vary across outlets and markets, we have based our case on official fuel price data from the DKV. Our calculation takes in to account several oil changes during a 36-month period.

The calculation includes a provision for one diesel particulate filter change instead of two.

Calculation 36 months

Fuel	Improved consumption, 1%	1,350 l
Diesel price	1,547 Euro/l	
Cost saving on diesel	2,088 Euro	
Oil change	Number of oil changes	7
	Volume per oil change	40l
	Oil cost LDF-4 vs LDF-3	+1 Euro/l
DPF (diesel particulate filter)	1 instead of 2	-820 Euro**
Saving 36 months:		2,628 Euro***

*) Actual savings depend on operating conditions, current fuel and oil prices.
**) Dealers are free to set their own prices.
***) Formula: 3 years x (180,000 km x 2,5 l/10km x [local fuel price in Euro]) + 820 Euro – (7 oil changes x 1 Euro price premium x 40 liters)