



SynMax Performance Lubricants

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TECHNICAL BULLETIN – API LICENSING.

THE API LICENSING PROCESS AND HOW AND WHY ENGINE OIL STANDARDS ARE DEVELOPED

Gasoline and Heavy Duty Diesel engine oil formulations since the mid 1990's have been in a constant state of change in response to changing industry standard specifications, OEM requirements and consumers needs.

The industry standard specifications often are driven due to governmental legislation, which usually results in new engine technologies and designs being developed.

In turn these new engine technologies and designs result in challenges being placed on the engine oil formulation in the areas of increased oxidative stability, handling of contaminants (e.g. soot), control or prevention of the formation of engine deposits at low and high operating temperatures, emissions systems compatibility, fuel economy and prevention of wear in newer and older engines, while still satisfying the consumer's needs and desires for increased engine oil drain intervals, engine durability and performance.

What Drives the Changes in Gasoline and Diesel Engine Oil Specifications?

The main drivers for recent changes in engine oil formulations and specifications particularly within the United States have come from three sources:

- 1. The Government**
- 2. Original Equipment Manufacturers (OEMs)**
- 3. The Consumer**

1. The Government:

Though the government does not have a direct role in the development of engine oil formulation and standards, it does have an indirect role that influences the development of engine oil formulations and standards through emissions and fuel efficiency regulations.

To meet the stricter emissions and fuel efficiency requirements **OEMs develop new engine technologies and exhaust treatment or after treatment designs that often necessitate the development of new engine oil formulations and specifications.**

In the United States the **Environmental Protection Agency (EPA)** monitors how engine oil standards and their outcome are developed by the lubricant industry in response to their mandates on fuel economy and emissions reductions. Additionally for the EPA to be successful in achieving its goals, it influences market drivers such as consumer awareness for demanding that the latest engine oil specified for a particular application be widely available from distribution channels.

The EPA also requires the OEMs to educate the consumer about the use of the latest engine oil specification throughout the owner's manual. The OEM must also use the engine oil that is widely available for certifying new engines and factory fill these engines with it before it leaves the factory.¹



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The EPA further stipulates that the OEMs, (primarily the passenger car manufacturers), demand the application and use of the of the latest engine oil specification through written specifications in the vehicles owner’s manual and on the engine oil filler caps. It also requires lubricant manufacturers to ensure an adequate supply of the latest engine oil is available in the various distribution channels.² During the development of any engine oil specification the **EPA’s regulations pertaining to fuel efficiency and emissions has been the major driver.**

Emissions Regulations:

The Clean Air Act of 1990 mandated a vast reduction in emissions from both diesel and gasoline powered vehicles. In the United States the EPA sets and implements the requirements for both diesel and gasoline powered vehicles.

To implement and meet these emission requirements OEMs have developed more complex emission control systems For gasoline powered passenger car, light trucks and SUVs manufacturers have fitted vehicles with three way catalytic converters, on-board emission diagnostic devices (OBDS) and emission control units (ECUs), which can be sensitive to combustion by-products from the engine oil.

To protect the emissions systems on gasoline vehicles the engine oil must contain lower levels of phosphorus and sulfur.

For on-road and eventually off-road diesel vehicles OEMs have used retarded engine timing, improved combustion control through pulsed fuel injection, inlet air swirl designs and high pressure injection, decreased piston crevice volume and the recently introduced exhaust gas recirculation (EGR) engines.

All of the advancements in engine designs have introduced more soot, higher engine operating temperatures and acids, thus causing the engine oil to be formulated to handle and deal with these issues.

As diesel emissions standards change into the future; diesel OEMs will also introduce new exhaust after treatment systems such as diesel particulate filters, selectively catalytic reduction, oxidation catalysts and NOX absorbers for reducing emissions.

These devices will require engine oils that contain lower phosphorus, sulfur and sulfated ash levels in order to prevent damage to these emission devices.

Fuel Economy Regulations:

The EPA requires passenger vehicle manufacturers to meet passenger car, light truck and SUV fuel efficiency limits for the Corporate Average Fuel Economy (CAFÉ) rating. This rating is determined with a formula that calculates average fuel economy of an OEM’s entire vehicle mix.

To meet these limits, vehicle manufacturers have developed smaller, higher output engines that put more stress on the engine oil as a result of their higher operating temperatures. Engine oils can also contribute a 1 to 2% improvement in fuel economy by lowering engine friction in favor of higher mechanical efficiency.

However, to maintain these improvements in fuel economy the engine oil must also provide durable fuel economy benefits as it is aged during use.



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2. Original Equipment Manufacturers (OEMs) :

When OEMs make engine and vehicle design changes, new engine oil performance standards are often required to match them. ***These new designs can have a significant impact on the performance of the engine oil.***

Passenger Car Engines

OEMs in recent years, passenger car have developed smaller and higher out-put engines to meet the stricter fuel economy standards. These smaller engines decrease the vehicle's weight to improve fuel economy; however, they also put more stress on the engine oil.

These engines impact the engine oil's formulation performance in the following ways:

- **Increased heat:** An increase in oil temperatures can accelerate the rate of oxidation, nitration and deposit formation. Oxidation and nitration degrade the engine oil. They also encourage the creation of more acid and increase the viscosity of the engine oil.
- **Increased pressure and speed:** The increased pressures and speeds in high-output engines make it harder for the engine oil to maintain an adequate lubricant film to prevent metal-to-metal contact. These stresses can accelerate the amount of wear on the valve-train. Passenger car OEMs must also ensure that emission control devices are protected from the detrimental effects that engine oils can have on them.

Since a 100% seal between the piston rings can never be achieved a certain amount of engine oil will enter the combustion and be burned. Therefore the **engine oil must contain lower amounts of phosphorus and sulfur to protect emission systems** during the life of the vehicle, while still maintaining protection against wear.

Diesel Engines

For on-road highway diesel engines, diesel OEMs have used retarded engine timing, improved combustion control through pulsed fuel injection, inlet air swirl designs and high- pressure injection, decreased piston crevice volume and the **recently introduced exhaust gas recirculation (EGR) engines to meet stricter diesel emission limits.**

These formulation design changes have resulted in:

- **Increased soot levels:** Soot can cause abrasive wear as it accumulates in the engine oil. It can also increase the viscosity of the engine oil.
- **Increased acid levels:** Higher acid levels in the engine oil accelerate the depletion of the engine oil's alkalinity reserve (also know as TBN) and increase the risk of corrosion.
- **Increased engine operating and oil temperatures:** An increase in temperature can accelerate the rate of oxidation and deposits. Oxidation degrades the engine oil. It can also generate acidic by-products and cause the viscosity of the oil to increase.

Some diesel OEMs such as Caterpillar, Cummins, Mack, and Detroit Diesel also create and recommend their own engine oil performance standards when needed or desired performance



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levels are not met by current API engine oil standards. Often these OEM performance standards are developed in response to problems that may be occurring in the field or the need to protect older engine designs.

3. The Consumer:

The consumer of gasoline and diesel engines often times demands that the engine oil being used provides increased oil drain intervals and increased engine durability and life. Therefore the engine oil must provide these benefits.

It must have the ability to be used for longer drain intervals while still providing the protection against wear, deposit formation, resistance to oxidation and fuel economy benefits over the entire life of the vehicle.

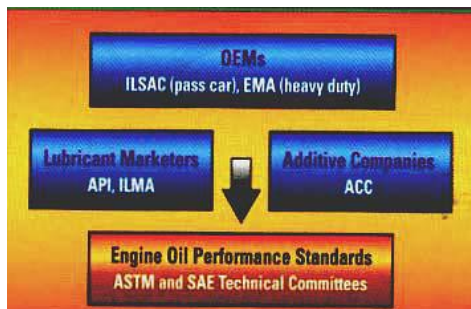
How Engine Oil Performance Standards Are Developed?

A number of standard guidelines have been developed to define the overall capability for gasoline and diesel engine oils to prevent wear, deposit formation, and oil deterioration. The principal guidelines are those established by:

A. American Petroleum Institute (API) in conjunction with the Society of Automotive Engineers (SAE), the American Standard for Testing Materials (ASTM) and ILSAC.

B. ILSAC (International Lubricant Standardization and Approval Committee) composed of North American and many Japanese automobile manufacturers.

C. Individual OEMs



In the United States the American Petroleum Institute (API) and ILSAC establish engine oil performance standards in cooperation with OEMs, oil marketers, additive companies and testing laboratories. Each of these industry groups play a different role and provide significant input during the various stages of the development, the definition and adoption of the standards and test methods used for a particular engine oil performance standard.

The OEMs request new performance standards when there are changes in customer's needs or engine and design changes to meet government regulations. Any requests for a new standard are placed



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through the **Alliance of Automotive Manufacturers (AAM)** or the **Engine Manufacturers Association (EMA)**.

The Society of Automotive Engineers (SAE) reviews the request to determine if there is a need to create a new engine oil standard. If a need is identified, the development timelines for the new standard are determined. These timelines can be affected by factors such as consumer needs, regulatory deadlines, lubricant technology challenges and the need to recover developmental costs.

Once the need for a new engine oil performance standard is established work on the development of the tests for the new standard is begun.

American Standard for Testing and Materials (ASTM) and SAE through their technical committees verify the technical needs for the new standard and ultimately recommend the tests and performance limits to define the standard.

The ASTM and SAE in cooperation with ILSAC, the OEMs and **Japan Automobile Manufacturers Association (JAMA)** formalize the specification tests that are needed to define the new standard.

Tests are used to certify engine oils against a performance level standard consist of a set of engine sequence tests, laboratory bench tests, physical, and chemical tests.

Engine sequence tests consist of a series of laboratory engine tests using production engines. These engine sequence tests assess one or more performance parameters, such as piston deposits, valve-train wear, fuel efficiency, oil consumption, etc.

- **The laboratory bench tests** determine the engine oil's relative performance parameters on corrosion protection, elastomeric compatibility, oxidation stability, rust protection, foaming tendency and evaporation loss.
- **The physical tests**, which consist of a number of laboratory bench tests, determine the physical properties of the engine oil. These physical tests assess the engine oil's properties such as viscosity, pour point, foaming tendency and evaporation loss due to volatility.
- **The chemical tests** consist of laboratory bench tests, which are used to determine the chemical properties of the engine oil such as additive elements, total base number (TBN) and sulfated ash. Engine oils may also be tested for phosphorus, sulfur and sulfated ash content to determine if they are compatible with emission treatment systems.

After the tests and performance limits are established the specification language for the new standard is developed. First API and/or ILSAC develops a drafts a specification and solicits reference and prototype oils to be tested. Industry organizations such as ASTM, the **Independent Lubricant Manufacturers (ILMA)** and the **American Chemistry Council (ACC)** review the draft specifications and any available test data on the prototype and reference oils. API/ILSAC reviews these industry comments and collect data on demonstration oils in order to finalize and issue the standard.

Once the specification is finalized, the **API establishes the licensing protocol for the new standard.**



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The API then administers their voluntary Engine Oil Licensing and Certification System (EOLCS) program.

The EOCLS system includes a formal licensing agreement executed by oil marketers with the API. Within this system, candidate oils must be supported by engine testing in accordance with the ACC's Code of Practice for **Multiple Testing Acceptance Criteria (MTAC)** and base oil read-across guidelines.

API also administers the Aftermarket Audit Program to prevent mislabeling on oil containers and to ensure that licensed engine oils adhere to and meet the technical specifications of the engine oil standard.

API Licensing Process

API administers the licensing and certification of engine oil performance standards through the Engine Oil licensing and Certification system. **This system's purpose is to define, certify and monitor engine oil performance.**³

- **To qualify for a license or certification** engine oil marketers must submit an application in which they identify each product's brand name, viscosity grade and API category being licensed.
- **They must attach data sheets reporting the chemical and physical properties** of each viscosity grade for each brand name being submitted.
- **Candidate oil must be supported** by engine testing using the ACC's Code of practice and must comply with the API's base oil interchange/viscosity read across guidelines.
- **Marketer must sign an affidavit that test data is available** to support the performance claims.

If the candidate oil qualifies, the oil marketer must enter into a formal licensing agreement to display the API Certification Mark (Starburst) and/or API Service (Donut) on their oil containers.

They must also pay licensing and annual royalty fees associated with engine oil licensing and certification. Licensed and certified engine oils are subject to review by the API's Aftermarket Audit Program.

API Symbols

Once the engine oil is licensed the marketer can then display the API's engine oil symbols on its containers. The API labeling system consists of two symbols: the API Service Symbol and the API Certification Mark.

API Service Symbol

The **API Service symbol, which is commonly called the Donut**, is used for both diesel and gasoline engine oils. The Donut is designed to provide specific information to the consumer regarding the engine oil's viscosity grade, the service classification and specific information such as if the engine oil meet energy conserving capabilities or supplemental specifications such as API CI-4 Plus. The Donut can be placed anywhere on the container.



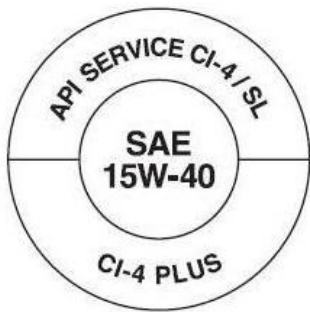
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The API Donut is divided into three parts:

1. **Top half** describes the engine oil's **service classification and performance level**.
2. **Center** identifies the **engine oil's viscosity**.
3. **Bottom half** tell whether the oil has demonstrated **energy-conserving properties** in a standard test in comparison to a reference oil or meets a supplemental specification.



1. Service Classifications and Performance Levels.

Top of the Donut shows the engine oil's performance level for gasoline and/or diesel engines. The letter "S" followed by another letter (for example SL) refers to a engine oil suitable for gasoline engines. The letter "C" followed by another letter/and or number (for example CI-4) refers to engine oils suitable for diesel engines. .

When the engine oil meets both "S" and a "C" classification the "C" classification, is always displayed first.

2. SAE Viscosity Grade.

Center of the Donut shows the engine oil's SAE viscosity grade. Viscosity is a measure of the engine oil's flow characteristics, or thickness at certain temperatures.

The low-temperature viscosity (the first number 15W in a SAE 15W-40 and 5W in a SAE 5W-30 engine oil) indicates **how quickly an engine will crank in winter and how well the engine oil will flow to lubricate critical engine parts art low temperatures.**

The lower the number the more easily the engine will start in cold weather.

The high temperature viscosity (the second number, 30 in SAE 5W-30 engine oil and 40 in a SAE 15W-40) **provides thickness & body for good lubrication at operating temperatures.**

Multi-grade engine oil (for example a SAE 5W-30 or SAE 15W-40) provides good flow capabilities for cold weather but still retains thickness for high-temperature lubrication.



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Single grade engine oil (as single number in the center of the donut for example SAE 30) is recommended for use under a much narrower set of temperature conditions than multi-grade engine oils.

Operators should refer to their owner's manual in order to select the proper viscosity grade for the ambient and operating conditions at which the equipment will be used.

3. Energy Conserving or Supplemental Categories

The **bottom of the donut** tells whether the engine oil has energy conserving properties when compared against the reference engine oil in Sequence VIB test. Oils labeled as "Energy Conserving" have passed this test.

Widespread use of engine oils with this designation should result in an overall savings of fuel in the vehicle fleet as a whole, but a particular vehicle operator may not experience a fuel savings as a result of using these oils due to many different variables such as the mechanical condition and maintenance of the engine, operating conditions and driving habits.

The "Energy Conserving" designations apply only to engine oils intended for use in passenger cars and other light duty vehicles and applies primarily to SAE 0W-20, 0W-30, 5W-20, 5W-30 and SAE 10W-30 viscosity grade engine oils.

Starting in 2004 the bottom of the donut can also be used to display if the engine oil meets a supplemental specification to an existing API Service Classification. Currently on the API Supplemental Service Classification CI-4 Plus can appear at the bottom of the donut.

API Certification Mark:



The API's star shaped Certification Mark is commonly called the **Starburst**. This symbol tells consumers that the engine oil meets the most up-to-date requirements for gasoline powered vehicles as outlined by the latest ILSAC Specification (Current GF-4). Engine oils carrying the Certification Mark are energy conserving and are suitable for all previous model years. The mark is always displayed on the front of the container. The API Certification Mark remains the same for a given application even if a new minimum engine oil performance standard is developed by ILSAC. Many passenger car automobile manufacturers recommend and specify the use of engine oils that carry the API Certification Mark.



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All engine oils that are licensed through the API must display the API Service Symbol (Donut).

Those engine oils that display the API Certification Mark (Starburst) must meet additional requirements above those service classifications used for the API Donut.

Gasoline engine oils that meet both the API and ILSAC Standards are engine oils that are preferred for and specified for use gasoline vehicle OEMs. API licensed engine oils that meet Starburst requirements must display both API symbols.

The API symbols compare as follows:

The Donut Symbol

- Is displayed on all API licensed products.
- Applies to either gasoline or diesel engine oils
- Engine Oils displaying this symbol:
- May or may not be energy efficient.
- May meet older and/or newer performance standards.
- May or may not be suitable for engines that require previous performance standards.

The Starburst Symbol

- Is displayed on only some API licensed products.
- Applies to gasoline engine oils only.
- Engine oils displaying this symbol:
- Meet the most up-to-date performance standards set by ILSAC.
- Must be energy efficient, so only certain viscosity grades are eligible.
- Must be suitable for all previous performance standards.

API Service Classifications

The API Service Categories are named with an alphanumeric system that consists of two letters that sometimes are followed by a number.

- **First letter** is always either “S” for gasoline engine service or “C” for commercial diesel engine service.
- **Second letter** increases sequentially with each new category as engine oil evolve to match new performance requirements.
- **Number 2 or 4** may also follow the two letters in the “C” classification to identify if the engine oil is formulated for two-stroke or four-stroke diesel engines.

Currently there are 3 active API “S” service classifications for passenger car engine oils.

Service categories CI-4 and CI-4 Plus are designed specifically for use in EGR engines that meet the 2002 exhaust emissions standards.



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October 15, 2006, API began certifying diesel oils against a new Service Category API CJ-4. API CJ-4 describes oils for use in high-speed four-stroke cycle diesel engines designed to meet 2007 model year on-highway exhaust emission standards as well as for previous model years.

These oils are especially effective at sustaining emission control system durability where particulate filters and other advanced after treatment systems are used. Most “C” categories usually include the performance properties of all the earlier performance categories and are “backward” compatible.

The exception to this rule is the API CF-2 service category for severe-duty, two-stroke cycle diesel engine service. Engine oils that meet API CF-2 may be used in place of engine oils from the earlier API CD-II, but may not meet the requirements of earlier service categories such as API CE and CF-4, which were designed for four-stroke engine applications.

ILSAC (International Lubricant Standardization and Approval Committee) Specifications

The standards developed by ILSAC are the basis for API and automotive industry standards for passenger car engine oil quality.

The ILSAC specifications incorporates the various ASTM engine sequence and laboratory bench tests used to qualify an engine oil as meeting a certain “S” category, but they may include more stringent pass/fail limits and additional test methods, such as fuel economy tests than those used to qualify an engine oil a meeting a certain “S” classification.

The most current specification is ILSAC GF-4, which became active on July 31, 2004.

Previous specifications, which are now obsolete, include GF-1, GF-2, and GF-3. ILSAC GF-4 is backward compatible with all previous GF categories. Although the ILSAC GF standards apply only to a limited set of viscosity grades-namely SAE 0W-XX, 5W-XX and 10W-XX multi-grades, where “XX” can only be 20,30,40,50 and 60, practically speaking only the –20 and –30 grades stand any chance of passing the fuel economy requirements that have been set by the ILSAC GF specifications.^{5,6,7}

Because of the requirements for ILSAC GF-4, particularly in the area of fuel economy **only SAE 0W-20, 0W-30, 5W-20, 5W-30 and 10W-30 viscosity grades can meet both the requirements of ILSAC GF-4 and API SM Service Classification..**

API SM service classification parallels the ILSAC GF-4 standard in all respects except for the fuel economy requirements. In fact **as applied to these ILSAC specified SAE viscosity grades; there are virtually no differences between the two standards.**

This results in for the first time, all SM qualified engine oils that are marketed under the SAE viscosity grades that are defined in the ILSAC GF-4 **standard being required by the ILSAC/Oil Committee to also meet the stricter chemical limits for phosphorus and sulfur and fuel economy limits of the ILSAC GF-4 standard.** Where ILSAC defined SAE viscosity grades are not used or specified the definition of the **API SM Service Classification excludes any form of chemical limits** for sulfur and phosphorus.



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OEM Specification for U.S. automotive manufacturers and foreign automotive manufacturers that export their engines express requirements for their engines in terms of API or ILSAC Engine Service Categories and by viscosity grade.

Manufacturer's of heavy-duty diesel engines either publish their own specifications or employ API Categories to define the desired performance levels for engine oils used in their engines.

Some OEMs create and recommend their own engine oil performance standards when a need or a desired performance level is not met by a current API Service Classification.

API standards represent a voluntary benchmark for minimum engine oil performance.

While the API tries to encompass all the OEM's engine oil performance needs, this is not always possible due to constantly changing equipment designs and how these engine oils are actually performing in the field. **OEM specifications represent a higher level of performance than the API standards and in many areas exceed those required for a particular service category.**

The OEM standard or specification sets tougher engine sequence limits or additional engine sequence testing in order to protect the OEM's engine during service and provide performance benefits beyond those of standard API categories. **OEM performance standards are primarily found in heavy-duty diesel applications.**

Why Some API Service Classifications Become Obsolete?

- **New engine oil service categories** have to be created whenever engine performance requirements change.
- **Older service categories become obsolete** if a new category is developed and the new category includes performance properties required to replace them.
- **For gasoline service classifications** the latest category is designated as an improvement on or a replacement for all prior categories.
- **For diesel engine oil service categories**, new categories cannot always include the performance properties of all of the prior categories.
- **API currently has seven active categories to match different types of equipment and operating conditions.** For example, diesel engine oils can be formulated for two- or four-stroke applications, moderate or severe service or high or low sulfur fuels.

Also, some of the older service classifications are kept active if there is a market demand. This is because many older diesel engines are still in service and in some markets; engine oils that meet older service categories may be preferred for these older engines because they cost less than engine oils that meet the newer engine oil service classification.



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