Training for Automotive Service Professionals

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CARQUEST Technical Institute®

Vehicle Fluids

Lubricant & Filtration Technologies

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CTI Mission
Our Mission is to conduct world-class training for professional technicians and automotive repair facility owners offered through Advance Auto Parts, CARQUEST Auto Parts and Autopart International stores that will improve their ability to diagnose and repair today's vehicles productively and profitably and to create an enjoyable learning experience while adhering to ASE certification activity standards.

Objectives:

- Discover ***why*** motor oil matters
- Discuss **engine oil issues** and **OEM proprietary oils**
- Explore the differences between **conventional**, **synthetic blend** and **full synthetic oils**
- Review motor oil **additives** and **formulations**
- Understand motor oil **container labeling**
- Explain **industry oil specifications**
- Learn the importance of **oil filter media**
- Discuss the ***right*** **choices** for consumers

Pre-test Questions

1. Common failures on engines equipped with **variable valve time** (**VVT**) systems can be traced to using improper engine oils.

   _____ True _____ False

2. A technician is explaining the differences to a customer between **0W-30** grade oil compared to **10W-30** grade oil and states that they both have the same thickness at operating temperature.

   _____ True _____ False

3. A service advisor is advising a customer to only use a **dexos® 2** approved engine oil on her 2014 Chevrolet Malibu with a 4 cylinder gas engine.

   _____ True _____ False

4. An oil's **viscosity** is defined mainly by the size of the oil's molecules. The smaller molecules' structures are ***thicker*** or ***higher*** (***heavier***) and the larger molecules are ***thinner*** (***lighter***).

   _____ True _____ False

5. **Tribology** is the science behind friction and wear and is helping engineers solve issues with meeting government demands for improving fuel economy to **54.5 MPG** by 2025.

   _____ True _____ False

6. When discussing **engine oil monitoring systems**, engineers have figured out a fairly accurate and reliable way to calculate the remaining oil life without having to actually sample the oil.

   _____ True _____ False

7. Two technicians are discussing the definition of **fluid mechanics**. **Technician A** states that **fluid statics** is the study of fluids at rest. **Technician B** states that **fluid dynamics** is the study of the effect on fluids in motion. Who is correct?

   A. Technician A
   B. Technician B
   C. Both Technician A and Technician B
   D. Neither Technician A nor Technician B

8. The **flow volume of a liquid over a period of time** is known as:

   A. Sabolt Universal Minute
   B. Kinematic viscosity
   C. Lubricant density
   D. Viscosity flow value

9. Which of the following viscosities are the most viscous?

   A. 0
   B. 30
   C. 20
   D. 50

10. The rule for **synthetic blends** (semi-synthetic) oils is that they must have a minimum of _____ percent synthetic oil in them to be considered synthetic blends.

    A. 5
    B. 10
    C. 15
    D. 50

11. When discussing **proper oil filtration** and **micron entrapment media**, which of the following contamination causes the greatest threat to wear sensitive surfaces?

    A. 2-22 microns
    B. 22-30 microns
    C. 32-40 microns
    D. 42-50 microns

12. When discussing the details of an **engine oil report**, one of the most important properties is the:

    A. Anti-freeze in the oil
    B. Fuel in the oil
    C. Total base number (TBN)
    D. Zinc in the oil

Table of Contents

Vehicle Fluids: Lubricant & Filtration Technologies is designed to be an interactive course. The class will participate by actively using provided worksheets and support materials to gain a better understanding of modern day lubricants and filtration technologies. We will discuss advanced gasoline engine technologies which rely on proper OE oil formulations to work properly. We will examine the choices available to the consumer when choosing the correct oil and filter media for their vehicles so we can protect their powertrain warranty. Additionally, we will explore engine oil analysis to fully understand what occurs to the oil in its useful life and how much life is left in the oil at the drain interval.

The Difficult Truth

Did you ever notice how psychologically satisfying it is to ***believe*** that you understand something, but in reality you ***do not***. Technicians often talk about a subject on a car they know little about, yet they wish to engage in a technical conversation without having their facts right or the correct information. When the topic of engine oils comes up in conversation, you can often sense that many technicians really have not put much thought into the subject or they are simply listening to someone else fill their heads with incorrect information. There are many talented automotive technicians, but ***few*** understand **engine oils**. Unfortunately, some people do not understand these concepts.

For example, we know a technician is misinformed when he says, *"I don't use **0W-20** oil because it's too thin, I use **5W-30** oil in all of my customers' cars!"* As an automotive professional, do you know what that statement really means?

As automotive technicians, we should know to use the proper vehicle fluid for each specific vehicle application. In 2001, we witnessed cooling system issues with General Motor's DEX-COOL™ and the plethora of coolants, we were challenged by all the **PAG oil** (**polyalkylene glycol**) and **Ester oils** for our air conditioning compressors since 1997, and now it seems we are being confronted once again with the topic of engine oils. When you are engaged in conversations with technicians and you hear contrasting information, it is important to ask a simple question: *"Where did you get your information?"* Often times this question brings the conversation to a halt because the technicians or shop owner cannot validate their answer.

Technician Confusion

A **0W-30** grade engine oil is ***not*** thinner than a **10W-30** engine oil. Both engine oils have the same thickness at operating temperature. **0W-30** engine oil simply does ***not*** get as ***thick*** when it ***cools*** as the **10W-30** oil. Both oils are still way too thick to lubricate an engine at startup. Confusion occurs because people tend to think of oil ***thinning*** when it gets ***hot***. Many technicians think this thinning with heat is the problem with motor oil. It would be better to think along the lines of oil ***thickens*** when it ***cools*** to room temperature. This confusion can cause many problems with your oil service methods.

Often times we hear about certain OEMs prohibiting a **0W-XX** engine oil that it is too ***thin*** and there is some truth to that. A straight **30** grade motor oil has a thickness of say **10** at the normal operating temperature of your engine. Multi-grade oils such as **0W-30** and **10W-30** also have a thickness of **10** at **212°F**. The difference occurs at **45°F** in the morning when you attempt to start the engine! We will discuss **grades of oils** later in the course.

What Transmission Fluid Would You Use?

Let's say you purchased a 2010 Ford Flex for **$45,000.00** and you need to replace the transmission fluid. The Owner's Manual states that the vehicle requires **Ford Mercon LV** automatic transmission fluid. It also provides a **WARNING:**

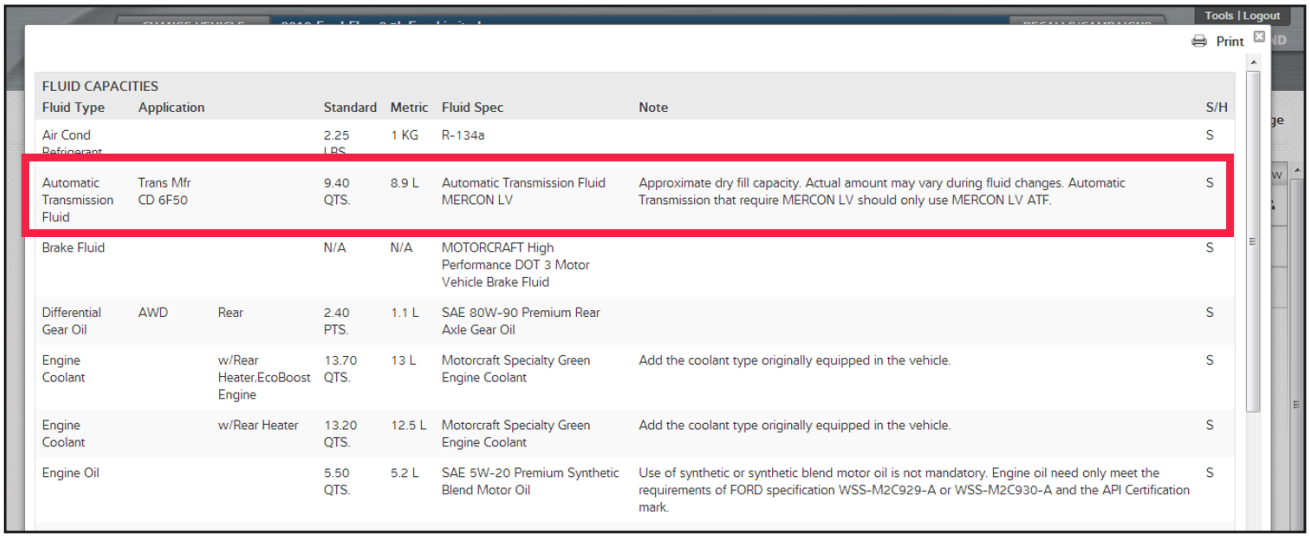
> **WARNING:** ***Use of ANY unapproved fluid can cause catastrophic failure!***
>
> ***What transmission fluid would you put in your 2010 Ford Flex?***

This seems like a pretty straightforward question: ***What transmission fluid would you choose?*** If the consequences were catastrophic transmission failure if you were to choose the wrong transmission fluid, then we would use what the OE recommends. Great, we use the fluid the OE recommends. Then ***why*** would we choose to gamble with our choice of engine oils that go into the engine come into question? It seems pretty straightforward that if the engine came with a specific **full synthetic oil** from the factory, that we should replace that oil by putting back full synthetic oil back into it at the time of service, right?

Well, what we are supposed to be putting back into the engine and what actually goes in are two different things. Let's put aside consumer fraud for one moment and discuss the real issue here. Let's establish that the car's engine requires ***full synthetic oil***, but the consumer does not want to pay the premium price for synthetic oil at the time of service. The shop obliges the customer's request and puts in ***regular conventional oil*** in the engine for say, **five** (**5**) oil changes in a row. The car comes in with about **25,000** - **30,000** miles on it and the **malfunction indicator light** (**MIL**) is **on**. You have a **diagnostic trouble code** (**DTC**) for variable valve timing error in memory. Is it possible that the shop that has changed the oil on this car for **25,000** miles is responsible for this DTC? We can bet money on it that the answer is ***yes***!

2010 Ford Flex Mercon LV

If we take a look at service information for the 2010 Ford Flex, we can see that it specifies **Mercon LV automatic transmission fluid** as the fluid specification. You will also note that it clearly states that automatic transmissions that require Mercon LV transmission fluid should only use Mercon LV automatic transmission fluid.



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FLUID CAPACITIES

Fluid Type	Application		Standard	Metric	Fluid Spec	Note	S/H
Air Cond Refrigerant			2.25 LBS.	1 KG	R-134a		S
Automatic Transmission Fluid	Trans Mfr CD 6F50		9.40 QTS.	8.9 L	Automatic Transmission Fluid MERCON LV	Approximate dry fill capacity. Actual amount may vary during fluid changes. Automatic Transmission that require MERCON LV should only use MERCON LV ATF.	S
Brake Fluid			N/A	N/A	MOTORCRAFT High Performance DOT 3 Motor Vehicle Brake Fluid		S
Differential Gear Oil	AWD	Rear	2.40 PTS.	1.1 L	SAE 80W-90 Premium Rear Axle Gear Oil		S
Engine Coolant		w/Rear Heater,EcoBoost Engine	13.70 QTS.	13 L	Motorcraft Specialty Green Engine Coolant	Add the coolant type originally equipped in the vehicle.	S
Engine Coolant		w/Rear Heater	13.20 QTS.	12.5 L	Motorcraft Specialty Green Engine Coolant	Add the coolant type originally equipped in the vehicle.	S
Engine Oil			5.50 QTS.	5.2 L	SAE 5W-20 Premium Synthetic Blend Motor Oil	Use of synthetic or synthetic blend motor oil is not mandatory. Engine oil need only meet the requirements of FORD specification WSS-M2C929-A or WSS-M2C930-A and the API Certification mark.	S

Transaxle/Transmission Cooling - Specifications

307-02 Transaxle/Transmission Cooling	*2010 Flex*
SPECIFICATIONS	*Procedure revision date: 11/12/2010*

Specifications

Material

Item	Specification	Fill Capacity
Motorcraft® MERCON® LV Automatic Transmission Fluid XT-10-QLV	MERCON® LV	10.3L (10.9 qt) [a]
Motorcraft® MERCON® LV Automatic Transmission Fluid XT-10-QLV	MERCON® LV	11.0L (11.6 qt) [b]

[a] 6F50 transmission.

[b] 6F55 transmission.

General Specifications

Item	Specification
Transmission Fluid	
The use of any transmission fluid other than what is recommended for this transaxle will cause transaxle damage. Refer to the material specification for the correct fluid.	
NOTICE: Do not use water-based cleaners to clean or flush the transmission fluid cooler tubes or transmission damage will occur. Mineral spirits can be used to clean the transmission fluid cooler tubes, providing the transmission fluid cooler tubes are flushed with clean transmission fluid and blown dry with shop air. Use only clean transmission fluid designated for this transaxle and torque converter being serviced.	

Lubricant & Viscosity: Definition

Motor Oil

There are many types of motor oil including: **conventional**, **synthetic blends**, **full synthetic** and **high mileage**. It pays to understand the most basic ingredient of the most important service we provide: **oil and filter service**. This very important service, sometimes delayed or even ignored by consumers, is now being threatened. OEMs are constantly changing their formulas for motor oil with almost every new model, improving ways to control deposits, limiting oxidation and corrosion over the normal oil change interval, increasing fuel economy and on today's vehicles, using a full synthetic proprietary formula that is designed specifically for that OEM. So lets face it, *"It is not our father's oil anymore".*

- **Conventional**
- **Synthetic blends**
- **Full synthetic**
- **High mileage**

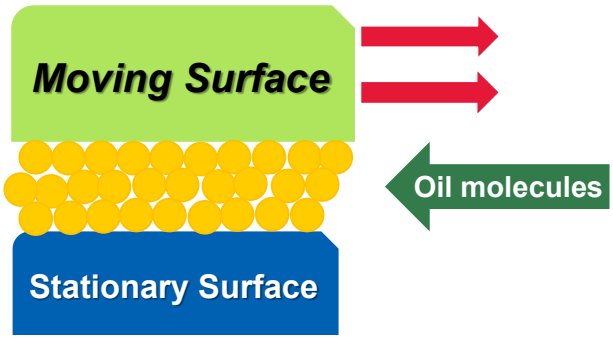
Lubricants

Let's begin with the basic definition of what a **lubricant** is and what it does. Anyone who has ever received a rug burn as a kid while horsing around in the living room wishes they had a lubricant under their knee when it happened. If you bought a used bicycle from a neighbor that was left outside and the pedals did not move because they were rusted solid, you realized in about fifteen seconds that all it needed was some oil drizzled on the sprockets and chain and that bike would have new life restored to it because of lubricant.

By definition, a **lubricant** is a substance such as grease or oil that reduces friction when applied as a surface coating to moving parts. Lubricants in one form or another are used in almost every industry that surrounds us including: medical, industrial, automotive and aviation to name a few. In automotive applications, the function of lubricants is to prevent direct contact between components which helps to reduce wear. They serve as ***coolants***, ***sealants*** and ***corrosion inhibitors*** and reduce noise. Lubricants are selected with reference to specific characteristics that are required at the friction surface.

As you will see, the engine oils we have come to know and the brands we have all used has changed dramatically over the years. One oil you may have trusted for decades may not be able to effectively provide the proper protection today's engine requires.

Oil Molecules & Fluid Mechanics



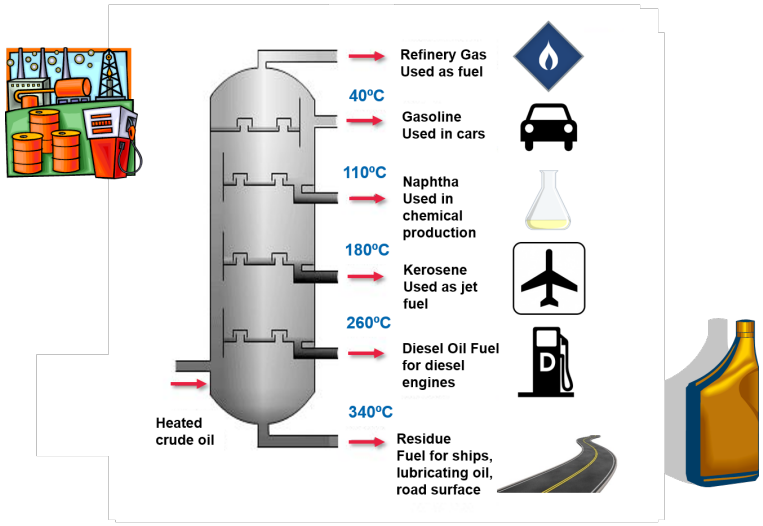
Fluid mechanics is the branch of physics which involves the study of **fluids** (liquids, gases and plasmas) and the forces on them. Fluid mechanics can be divided into **fluid statics**, the study of fluids at rest, and **fluid dynamics**, the study of the effect of forces on fluid in motion. Therefore when discussing fluid dynamics, the effect of forces on fluid in motion, we can think of the motor oil molecules in motion in the engine doing its job of keeping the two surfaces separate and apart from each other.

The oil's **viscosity** is defined mainly by the ***size*** of these oil molecules. The ***larger*** the molecule structures, the ***thicker*** or ***higher*** (heavier) the viscosity. The size and structure of oil molecules vary, so the average molecule size dictates the viscosity, whereas later when we discuss the synthetic oil manufacturing process, you will see it results in consistently sized molecules of an identical structure.

Fractional distillation of crude oil is the first step in the production of many of the materials we have come to rely on today in modern life. All our fossil fuels, virtually all plastics, detergents and commercial alcohols are made from products of this process. Appreciating the process of fractional distillation will further improve our understanding of the sources of fuels and plastics and the limited nature of their availability.

Once obtained from the ground, the oil is transported by ship, truck or pipeline to the refinery. Once the oil reaches the refinery, the work to separate it into useful products begins. Oil refineries are enormously complex and each part of the distilled oil goes through several stages of processing. However, the very first step is to break up the crude oil.

Crude oil is a mixture of many different chemicals. The majority of these are **hydrocarbons** which are molecules made only from the element **hydrogen** and the element **carbon**. The mixture of hydrocarbons contains both alkane and alkene molecules and the length of the chains vary wildly, from **five** carbon atoms long to **60** carbons or more. Since fuels need to be very specific in terms of the length of the carbon chain, the different lengths need to be separated and these different length chains are called **fractions**.



The boiling point of a hydrocarbon fraction, which is the temperature at which it evaporates, is dependent on the length of the carbon chain. Fractions with shorter chains evaporate more easily than those with longer chains. This explains why gasoline, which is mainly made of the **8** carbon molecule octane, evaporates more easily than engine oil which has carbon chains in the range of **20** or more.

In order to separate the different length chains in the crude mix, crude oil is heated to a very high temperature. The temperature is set so that all those fractions with a carbon chain length of **20** and ***below*** are evaporated from the crude mix. The temperature cannot be set higher than this as there is a risk that the lighter fractions will ignite. The remaining liquid, which is composed of only the heavier fractions, passes to a second location where it is heated to a similar temperature, but at lower pressure. This has the effect of making the heavy hydrocarbon fractions more likely to evaporate.

How a Distillation Tower Works:

A distillation tower works by becoming progressively ***cooler*** from the base to the top. All the hydrocarbon fractions start off in gas form, as they have been heated to that point. As the gases rise up the tower, the gas mixture then encounters a barrier through which there are only openings into what is known as bubble caps. The gas mixture is then forced to go through a liquid before continuing upwards. The liquid in the first tray is at a cool enough temperature to allow the heaviest gas fractions to condense into liquid form, while the lighter fractions stay gaseous.

Utilizing this process ensures the heaviest hydrocarbon fractions are separated out from the mixed gas. The remaining gas continues its journey up the tower until it reaches another barrier. Here, the bubble cap process is repeated, but at a ***lower*** temperature than before which then filters out the next lightest set of fractions. This process continues until only the very lightest fractions, those consisting of **1** to **4** carbon atoms remain. These atoms remain in a gaseous form and are collected at the top of the tower. The separation of the heavier elements in the second tower follows exactly the same process, but at lower pressure. At a petroleum refinery, fractional distillation separates a motor oil fraction from other crude oil fractions, removing the more volatile components and therefore, increasing the oil's flash point (reducing its tendency to burn).

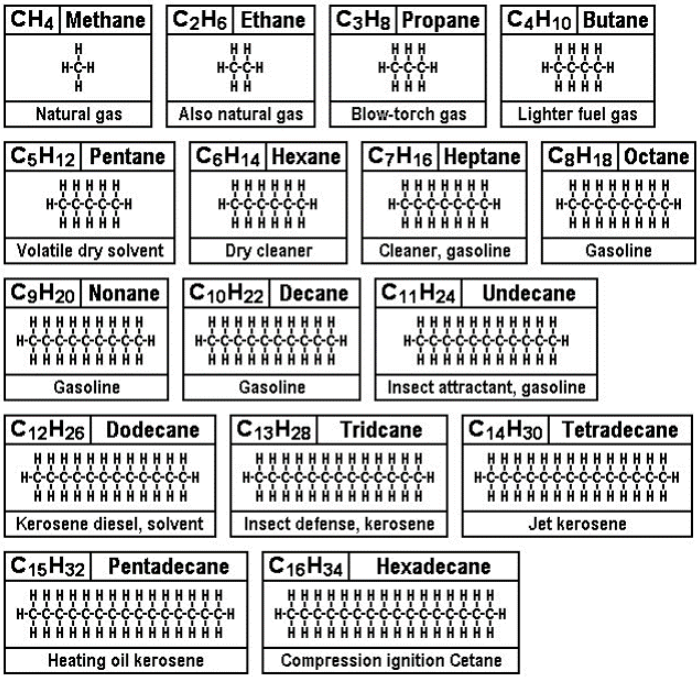
After the Fractional Distillation Of Crude Oil:

The separated fractions still contain a mixture of different hydrocarbons. After their initial separation, the fractions require further processing and purification. Treatment of the initial products of the fractional distillation of crude oil also occurs in the refinery. The results of these processes are the products we use today.

Crude Oil Pipeline

According to the **American Petroleum Institute** (**API**), a barrel of crude oil or petroleum product shipped by pipeline reaches its destination safely more than **99.999%** of the time.

Hydrocarbon Chains



Typically the ***shorter*** the carbon chain, the ***less*** viscous the hydrocarbon. The ***longer*** the chain, the ***more*** viscous the hydrocarbon. For example, consider the viscosity and molecular size in: gasoline, diesel, motor oil and tar.

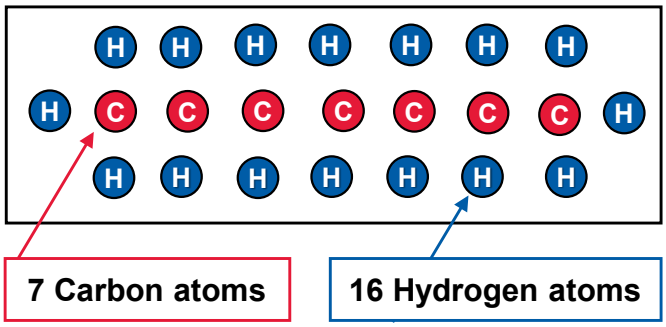
Viscosity ***increases*** with the molecular size and length of a hydrocarbon chain. We will discuss viscosity further later in the course.

C6H14 - Hexane Molecule

Hexanes are significant constituents of gasoline.

C7H16 Hydrocarbon Chain (Heptane)

Fuel is made of hydrocarbon chains. This diagram illustrates what a hydrocarbon chain would look like.



The **H** is our friendly hydrogen atom. The **C** is our friendly carbon atom. Fuel carbon chains are usually **C7H16** through to **C11H24**. **C7H16** means: **7** carbon atoms with **16** hydrogen atoms. This would be a **heptane chain**.

Heavier chains like **C14H30** are used as diesel fuel. Carbon chains above **C20** are tars and heavy oils. The lightest chain is **CH4**. That is **1** carbon and **4** hydrogen (methane).

For normal gasoline, the mixture is somewhere around **C9H20**. Chains of this weight are used as our fuel because they are in a liquid state at normal temperatures, easy to store and transport. They also vaporize easily. If you have ever spilled gasoline on your driveway, you can see how fast it evaporates. In order to burn the gasoline, it must be transported from your tank to the combustion chamber. There the fuel is mixed with the air from your air intake, vaporized, compressed, and BANG...ignited. This process takes place very quickly and continuously to maintain the four stroke cycle of the internal combustion engine.

Paraffin Crude Oil Myths

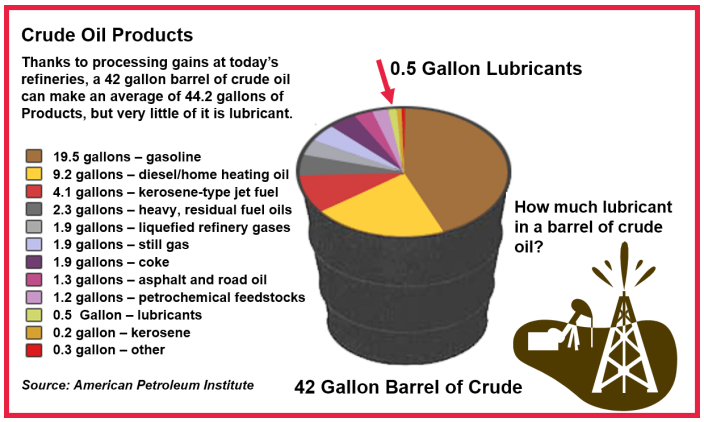
- **Paraffinic motor oils cause wax-like deposits on the underside of the oil fill cap**
- **Paraffinic oils cause engine sludge**
- **Motor oils containing paraffin can leave deposits in the engine**
- **These are myths and are simply not true!**

Facts about paraffin based oils:
There are two basic types of crude oil: **naphthenic** and **paraffinic**. Most conventional engine lubricating oils today are made from paraffinic crude oil. **Paraffinic crude oil** is recognized for its ability to resist thinning and thickening with temperature, as well as its lubricating properties and resistance to **oxidation** (sludge forming tendencies). In the refining process, the paraffinic crude oil is broken down into many different products. One of the products is **wax** and others are: **gasoline**, **kerosene**, **lubricating oils**, **asphalt**, etc. Virtually every oil marketer uses paraffinic base stocks in blending its engine oil products. Many people believe the term **paraffinic** to be synonymous with wax. Some people have the misconception that paraffinic oils will coat the engine with a wax film that can result in engine deposits. No one seems to know how this misconception got started, but it sometimes appears to have taken on a life of its own and it is simply not true. Most major motor oils today are formulated using paraffin-based crude oil. The confusion apparently begins with the fact that our first exposure in life to paraffin was as a wax and the paraffinic molecules can form wax crystals at low temperatures. In lubricating oils, this wax is removed in a refining process called **dewaxing**. Wax is a premium product obtained from crude oil, and in order to ensure they produce the highest quality base stocks available, many oil marketers have processes to remove the maximum amount of wax possible during the refining process. The end result is a motor oil product formulated with premium lubricating base oil. ***They do not leave behind deposits in engines.***

In fact, one of the reasons paraffin-based oils are used is to ensure against such deposits. When motor oil chemists speak of paraffin, they are referring to relatively non-reactive hydrocarbons extracted from crude oil which have excellent oxidation stability. That stability prevents oils from breaking down under extreme operating temperatures and as a result are unlikely to form deposits. Motor oils not formulated from paraffin-based oils use naphthenic-based crude oils and are more likely to leave deposits in engines.

Lubricants in a Barrel of Crude

Many people confuse a crude oil barrel with a traditional **55** gallon drum. There are **42** gallons of crude oil in a barrel.



Motor Oil & Engine Issues

Engine damage stemming from motor oil is increasingly common. It would be difficult to find an OEM that has not had an issue with engine oil. Many times unfortunately, to the eye of the technician, an engine with lots of sludge or deposits gets falsely blamed on oil change intervals.

What would a shop owner or technician say if they told a customer that, *"Your not changing your oil often enough."* To which the customer replies, *" I have changed my oil religiously since day one…every 3-4 thousand miles, what are you talking about? As a matter of fact, Mr. Shop Owner, here are all my receipts for everything that was ever done to the car since I bought it."*

Can you imagine how you would feel and look if you were the shop that did ***all*** the work on this car? We are running into this scenario often and it is going to continue if you do not understand that the oil you have come to know and trust by name for years may not be suitable for your customers' cars today. The oil may not have the level of protection required and therefore, may not be covered under warranty if a problem develops in the engine.

Motor Oil History

When changing oil on a late model vehicle, it is imperative to use the proper type of motor oil for your specific engine.

Understanding a little history regarding the advancements of motor oils may help you make the right choice. Before automobile manufacturers began establishing their own oil quality standards in the 1990s, many owner's manuals referenced oils per the **Society of Automotive Engineers** (**SAE**) and **American Petroleum Institute** (**API**) standards. These sanctioning bodies, such as SAE, API and **ACEA** (**European Automobile Manufacturers Association**) are still responsible for establishing oil standards for motorized vehicles.

Worldwide, there has been increased requirements for vehicle manufacturers to reduce emissions, minimize their carbon footprint and improve fuel economy. It was around the late 1990s and early 2000s that these requirements became more stringent. As a result, new advanced internal combustion engine designs have been engineered to meet emission requirements and fuel mileage demands.

Motor oil plays a crucial key role in meeting emissions and fuel economy requirements. Thus, new advanced cutting-edge synthetic motor oil formulations were created. Around this time (late 2000s), manufacturers began to establish their own unique oil quality standards rather than relying solely on API and ACEA standards. Manufacturers wanted very specific motor oil formulas for their engines. Developing and using their own oil specifications helped to ensure optimal performance. For example: all Audi models model year 2000 and newer require a motor oil that meets a specific Audi quality standard or specification.

Toyota Oil Sludge Issues

Oil sludge refers to a nasty substance that forms in the oil and can range in color from **LIGHT BROWN** to **BLACK** and in texture from ***gooey*** to almost ***solid***. It can form for a number of reasons and typically the color and texture will help to diagnose the issue. We will divide the reasons into two basic groups: **water/coolant intrusion** and **oil breakdown**. Water or coolant in the oil will typically cause a gooey **LIGHT BROWN** sludge resembling a chocolate milkshake in appearance. Coolant intrusion is exactly what it sounds like, coolant in the oil, and is typically the result of a leaking gasket such as the cylinder head gasket, but can also result from a faulty oil cooler. Water can get into the oil as well. Typically, this would be the result of condensation and becomes prevalent on vehicles that do not properly reach operating temperature, thus, not producing enough heat to properly evaporate the condensation from the crankcase. This occurs most often on vehicles that are only taken on short trips or due to a faulty (stuck **open**) thermostat.

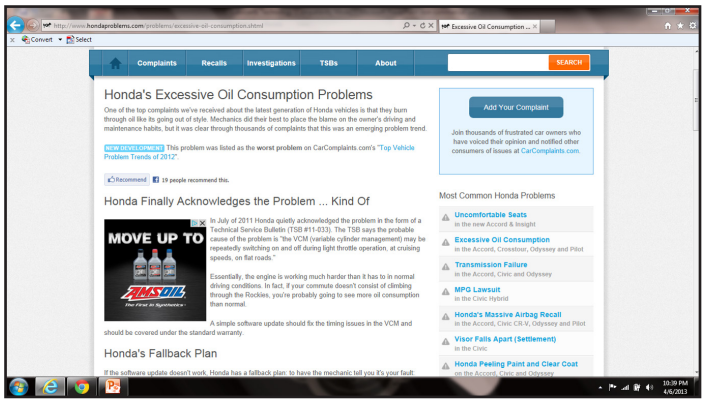
Sludge resulting from oil breaking down is usually thicker and darker. It can be tar-like or almost rock hard, and is usually **BLACK**. Oil breakdown can also occur for several reasons. Heat and combustion gases, usually resulting from blow-by, can cause the oil to break down. The blow-by can also contain a number of contaminants such as unburned fuel, dirt or soot. While modern engine oils contain detergents and are **chemically basic** (pH ***over*** **7**), over time, contaminants and acids that enter the oil along with heat can neutralize the oil and consume the detergents. This is why it is important to maintain a regular, reasonable oil change interval with a high quality

oil that meets the manufacturer's specifications. Removing the contaminants and acids from your engine will prolong the life of the engine, not only by reducing the potential for corrosion or wear due to dirty oil, but also by reducing the potential for engine sludge. In addition to regular oil changes, keeping the **positive crankcase ventilation** (**PCV**) system functioning properly will help alleviate corrosive blow-by gases and moisture from remaining in the crankcase.

Volkswagen Engine Sludge Reports

If you were to ask anyone who is familiar with Volkswagens and Audis about oil sludge, they most likely are familiar with the early 1.8t engines (AEB) that came in Passats and A4s which are known for a notorious engine oil sludge problem. Volkswagen's solution to the problem was to use a larger oil filter, the one for earlier diesel engines, which adds approximately a half-liter of oil capacity.

Honda Technical Service Bulletin Regarding Oil Consumption



No matter what the concern, technicians should at least check any and all **Technical Service Bulletins** (**TSBs**) and/or **System Service Messages** (**SSMs**) when a car comes in for service ***before*** any work is performed. It is the vehicles that you are not aware of that have issues that cause grief down the road for a shop.

Service WARNING: For shops using computerized invoices, be cautious to properly identify any special oils, coolants and additives on the invoice. All it takes is one mistake on a line item that incorrectly names a lubricant or fluid and the customer has recourse to take you to court.

Chrysler 2.7 V6 Sludge Issues

Thousands of written complaints by consumers with Toyota and Chrysler engines regarding oil related damage have been sent to consumer advocate groups and attorneys. These engines suffered catastrophic engine failure in under **70,000** miles. Many of these engines have had serious acid production problems and when the additive package for that engine is changed at the oil change interval and not replenished, that is when the problems begin.

European manufacturers have had their share of oil related issues costing hundreds of millions of dollars as well. The cause once again was the use of non-approved engine oils.

Excerpt taken from a class action law suit filed in district court State of New Jersey:
The plaintiff purchased a 2002 Sebring Sedan on March 27, 2003 from Franklin Sussex Auto Mall, Inc. located in Sussex, New Jersey. Plaintiff purchased her Sebring as a new-demo vehicle with an odometer reading of **10,625** miles. In or about February 2007, the plaintiff's husband was driving her Sebring on a public roadway when, without any prior warning, it seized-up and shut-down due to a catastrophic engine failure. The safety of the plaintiff's husband and other persons on the public roadway were put in jeopardy because of the catastrophic engine failure. The plaintiff's out-of-pocket expenditure for the purported repairs exceeds **$1,500**. At the time of the catastrophic engine failure, the odometer registered about **70,000** miles.

After the engine failure, the Sebring did not restart. It was towed to the Franklin Sussex service facility. The plaintiff sought warranty coverage from Daimler Chrysler Corporation through the Franklin Sussex dealership. Daimler Chrysler denied the plaintiff warranty coverage. The Daimler Chrysler Corporation recommends changing the oil in the vehicles every **7,500** miles or **6** months, whichever comes first, for normal driving conditions, or **3,000** miles or **3** months for more extreme driving conditions. Nonetheless, persons who have complied with these maintenance schedules have experienced engine failure.

Technical Service Bulletin - Must Use 5W-20 Oil

Modern engine valve trains with **variable valve timing** (**VVT**) and/or **variable camshaft timing** (**VCT**) systems rely on the clean proper oil viscosities to operate properly. The VVT actuated oil control solenoids and camshaft phasers on many late model engines are located in the upper half of the engine where clearances and tolerances are tight. It is crucial that the correct oil be used on these engines so that performance and fuel economy are maintained and emissions management is not compromised.

Additionally, many late model V6 and V8 engines are equipped with **active cylinder management** (**ACM**) or **displacement on demand** (**DoD**) systems which is a cylinder modulation technology engineered into the valve-train to shut down specific cylinders at specific engine speeds and loads to improve fuel economy. All of these advanced gasoline engine technologies require the proper oil viscosity and filtration media for these systems to work as they were designed. Engine oiling needs have changed over the years as these engines have evolved. Use the wrong oil (***conventional*** over ***synthetic***) or the wrong service interval and the consumer is going to see early system failures of these modern engine systems with heavy consequences.

CHRYSLER Jeep DODGE **SERVICE BULLETIN**

NUMBER: 09-015-04
GROUP: Engine
DATE: November 4, 2004

SUBJECT:
Engine Oil Viscosity Grades for 5.7L Multiple Displacement System (MDS)

MODELS:

2005	(LX)	300/Magnum
2005	(WK)	Grand Cherokee

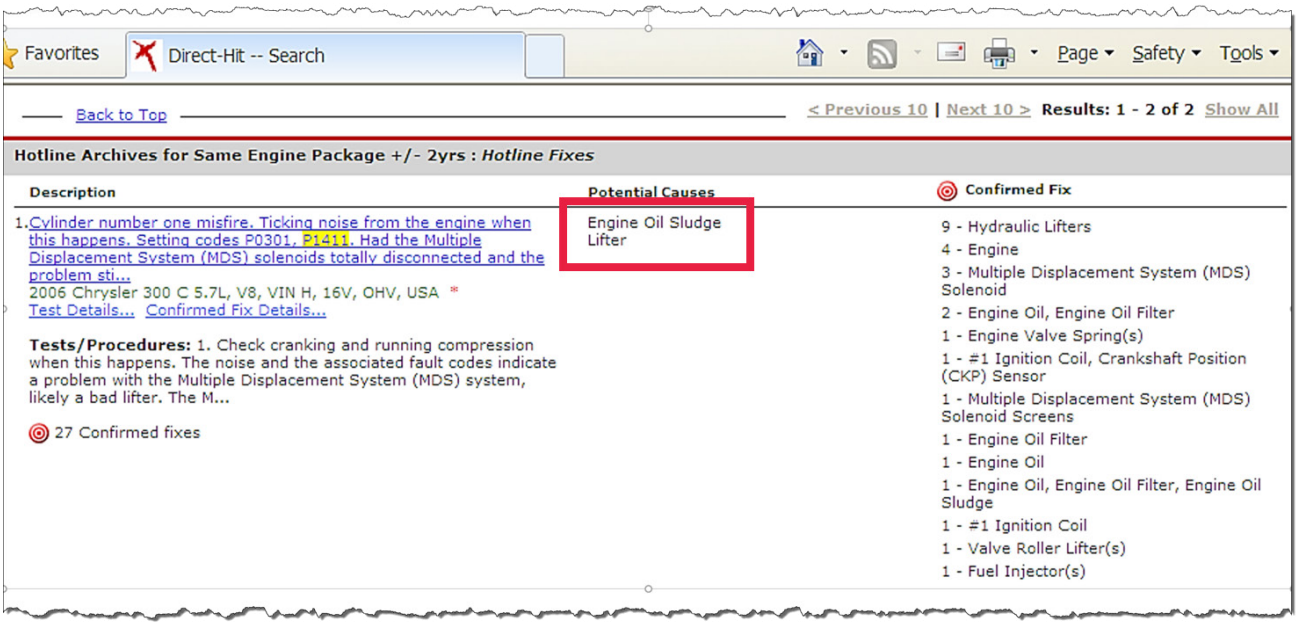
DISCUSSION:
Vehicles with the 5.7L Multiple Displacement System (MDS) **must** use SAE 5W-20 oil. Failure to do so may result in improper operation of the Multiple Displacement System (MDS).

NOTE: This information applies to U.S. and Canada markets only.

NOTE: For additional information refer to the service information or the Owner Manual.

Chrysler 300: P1411 Diagnostic Trouble Code

Here is an example of a **diagnostic trouble code** (**DTC**) **P1411** on a 2006 Chrysler 300 caused by engine oil sludge in the hydraulic lifter displayed on Direct-Hit.



NOACK Volatility Test: ASTM D-5800

The **NOACK volatility test**, otherwise known as American Society for Testing and Materials' **ASTM D-5800**, determines the evaporation loss of lubricants in high-temperature service. **Volatilization** is a term used to describe what happens to a fluid as it is heated to the point it begins to ***boil off***. Upon reaching a certain temperature, oil will begin to lose some of its lighter weight molecules as they boil off and leave heavier weight molecules behind. The more motor oils vaporize, the thicker and heavier they become, contributing to poor circulation, reduced fuel economy and increased oil consumption, wear and emissions. A maximum of **15** percent evaporation loss is allowable to meet **American Petroleum Institute** (**API**) **SL** and **International Lubricant Standardization & Approval Committee** (**ILSAC**) **GF-3** specifications.

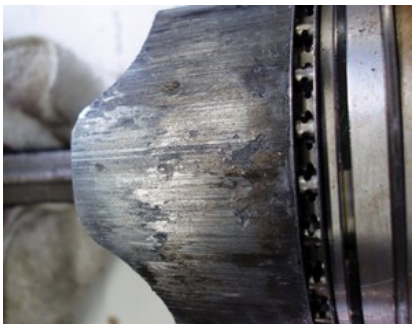
The **ASTM D-5800** (Noack) is a widely accepted method of measuring volatility. Originally developed and used in Europe, the Noack test determines how much weight loss an oil experiences through volatilization.

In the Noack test, the oil is heated to **150° C** for a specified period. The lighter oil fractions will ***boil-off***, leading eventually to oil consumption, oil thickening and a loss of performance. The test reports results in the percentage, by weight, lost due to boil-off.

Example: before July 1, 2001, **5W-30** motor oil in the United States could lose up to **22 percent** of its weight and still be regarded as ***passable***. With the **GF-3** specification, the maximum Noack volatility for API licensing is **15 percent**. European standards limit high quality oils to a maximum of **13 percent loss**.

Did You Know?

Acids can deplete the additives in certain motor oils very quickly making the oil unstable. Oil stability is, just as it sounds, the ability of the oil to remain stable. ***What does that mean?*** The combustion process is a complex mix of chemistry and thermodynamics. The combination of the byproducts of combustion, namely heat and gases, work together to create a very harsh environment for engine oil. This can have many negative effects on the oil, mainly oxidation and acidity.



When oil oxidizes, it creates carboxylic acid. In some engines, the presence of sulfur (more common in diesels) can also combine with combustion gases to create sulfuric acid. Either way, the presence of acids in the oil is not good, as acids are corrosive and can react with the metals in your engine. To reduce the acid buildup, oil companies add a **base** to the oil to neutralize the acid. Typically the added base would be an alkali metal or alkaline earth metal and the measurement of base in the oil may be referred to as **alkalinity**. This would be part of the additive package in the oil and calcium is a popular antioxidant/anti-corrosive additive in lubricants. We will discuss antioxidants later in the course.

The best way to test how much life is left in an oil is to have an oil analysis performed where the **TBN**, or **total base number**, is measured. Just as it sounds, this is a measure of the reserve alkalinity, or how much acid-neutralizing capacity the oil still has. We will discuss **total base number** (**TBN**), as well as ways to protect the OEM warranty later in the course.

- **Acids can deplete the additives in certain motor oils very quickly making the oil unstable**
- **Depending on driving conditions, the oil may not even last 3,000 miles!**
- **Many engine failures occur during the warranty period, however, warranty coverage is denied because non-approved oils were the cause**
- **Camshaft life is determined during the first 30 seconds to 2 minutes of engine operation**

Improving Fuel Efficiency

The science of friction, lubrication and wear is called **tribology**. Tribology is a branch of mechanical engineering and materials science that deals with the ***design***, ***friction***, ***wear*** and ***lubrication*** of interacting surfaces in relative motion such as bearings or gears. The relationship between friction, wear and lubrication can solve lubricant issues and help improve fuel economy and efficiency. Tribology is helping engineers meet increasing government demands to increase fuel economy to **54.5** MPG by 2025. New lubricant formulas can increase fuel efficiency by up to **6.5%**.

Today's Advanced Lubricants

GF-6 is an automotive specification for **passenger car motor oils** (**PCMO**) that was developed by **ILSAC** (**International Lubricants Standardization and Approval Committee**).

This specification is intended to:

- **Increase fuel economy**
- **Enhance oil robustness**
- **Expand overall fuel efficiency**
- **Improve wear protection**
- **Reduce engine aeration**

Lower Viscosity Grades:
Recently, improvements in engine hardware and manufacturing technology have allowed the use of lower viscosity grades in passenger car vehicles while maintaining engine durability. Additionally, the demand for better fuel economy has increased both end user and OEM interest in low viscosity engine lubricants. This has led to an increase in the use of **5W-20** and even **0W-20** viscosity grades over the thicker **10W-30** and **10W-40** grades of motor oil. The trend to lower viscosities will continue with the introduction of a new viscosity grade: **GF-6**. **GF-6** is due out in 2016-2017. Potential new viscosity grades of **0W-16** or **5W-16** are currently under development. Prototype oils are currently being tested to see how they will interact with engines.

Why Motor Oil Matters

Engine oils are complex mixtures of base oils and additive components designed to perform a variety of tasks.

Listed below are some important tasks of engine oil:

- **Separates and lubricates all moving parts**
- **Helps reduce engine wear**
- **Helps to prevent deposits from forming on internal engine components**
- **Removes and suspends dirt and contaminants in the oil until these contaminants can be removed at the next oil change**
- **Cools engine parts**
- **Enhances engine fuel economy**
- **Provides protection over a wide temperature range, even helping to protect the emissions system**

In other words, engine oil does a lot more than just lubricate your engine.

Motor oil is an oil used for lubrication of various internal combustion engines. The main function is to lubricate moving parts. However, it also cleans, inhibits corrosion, improves sealing and cools the engine by carrying heat away from moving parts.

Motor oils are derived from petroleum-based and non-petroleum-synthesized chemical compounds. Motor oils today are mainly blended by using base oils composed of hydrocarbons, **polyalphaolefins** (**PAO**) and **poly-internal olefins** (**PIO**), thus organic compounds consisting entirely of carbon and hydrogen. The base oils of some high-performance motor oils however contain up to **20%** by weight of esters.

Why is a motor oil's ability to clean so important?
Dirt is created inside a vehicle's engine as part of the normal combustion process, so keeping engine components ***clean*** is essential. If engine components and oil passages are dirty, vehicle performance and efficiency suffer. Deposits also trap heat inside an engine like an insulating blanket. Motor oil does not just help prevent sludge, oils are designed to clear away sludge, dirt, debris and deposits from engine components and prevent blockages of important oil pathways. The oil suspends the dirt, rendering it harmless until it is removed at the next oil change.

Motor oil reduces friction, minimizes wear and helps to remove heat
Motor oils form a protective film over a vehicle's engine components and have special additives between moving surfaces, preventing contact and reducing drag. This helps an engine operate as quietly and efficiently as the engineer intended. Engine oils carry heat from hot areas such as around the piston rings where temperatures can top **600°F** helping to protect critical parts from intense heat.

Motor oil helps prevent rust and corrosion
Engine oils protect today's engine components from oxidation and the resulting corrosion over the normal oil

change interval. Oil is designed to stand up to extreme conditions and protect the engine from extreme heat and harsh cold winter driving conditions.

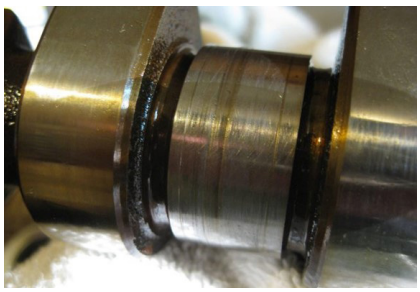
Why is clean so important?
Why is ***clean*** so important in today's engines? Engines are born clean at the factory. In fact, if you were to visit the engine-assembly facilities of state-of-the-art engine builders, you would find that they more closely resemble semiconductor clean rooms. That is because the tolerances in today's engines are tighter than ever and today's engine builders know that clean is crucial.

Clean engines do not stay clean for long
The problem is even pristine engines do not stay pristine for long. Every time you turn your engine **on**, it continuously generates acids, combustion gases, water vapor and fuel byproducts that end up in the oil—the engine's bloodstream. Unchecked, these contaminants may eventually form deposits that can clog oil passages, gum up moving parts and ultimately reduce engine responsiveness. Tighter tolerances **=** less tolerance for dirt and deposits.

Lubricating oil creates a separating film between surfaces of adjacent moving parts to minimize direct contact between them, decreasing heat caused by friction and reducing wear, thus protecting the engine. In use, motor oil transfers heat through convection as it flows through the engine by means of airflow over the surface of the oil pan, an oil cooler and through the build up of oil gases evacuated by the **positive crankcase ventilation** (**PCV**) system. Coating metal parts with oil also keeps them from being exposed to oxygen, inhibiting oxidation at elevated operating temperatures preventing rust and/or corrosion. Corrosion inhibitors may also be added to the motor oil. Many motor oils also have detergents and dispersants added to help keep the engine clean and minimize oil sludge buildup. The oil is able to trap soot from combustion in itself, rather than leaving it deposited on the internal surfaces. It is a combination of this, and some **singeing** (burning) that turns used oil **BLACK** over time.

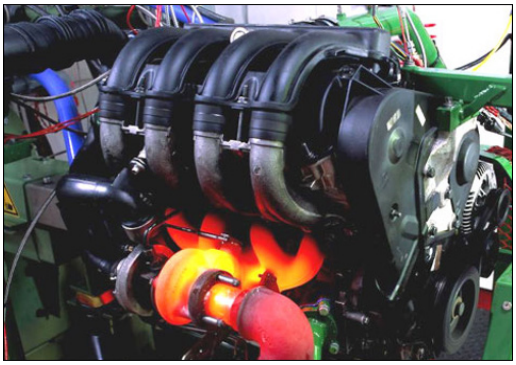
Motor Oil Protects

Motor oil ***coats*** the surfaces of moving parts to physically separate them. It ***protects*** high load surfaces where oil is ***wiped*** from the metal. Motor oil also ***prevents*** corrosion of iron, copper, aluminum, lead and other metals.



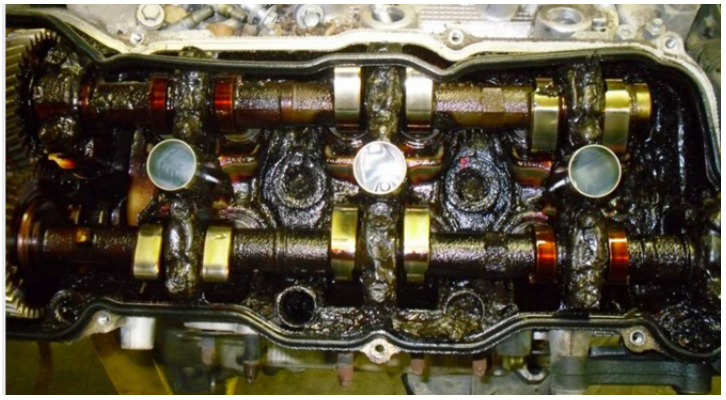
Motor Oil Cools

Motor oil is a lubricant that dissipates heat generated through combustion and friction (up to **350°C** or **662°F**) in the piston area of the engine. Oil also supplements the primary cooling system in water and air cooled engines. In ***cooling*** hot metal, the lubricant must ***not*** oxidize.



Motor Oil Suspends

The oil itself must suspend or contain any sludge or oxidized material held in a harmless suspension until reaching the filter where the oil filter contains or traps any metallic wear particles preventing further damage to fine bearing surfaces. Particles ***not*** trapped by the oil filter may lead to early engine failure.



Motor Oil Cleans

Clean pistons are essential to allow for the free action of piston rings and access of the lubricant to the engine's hot spots. Clean filters are essential to allow for the free passage of oils to the bearings. Oil passages need to be clear for the lubricating oil to reach engine components quickly.

Terms You Need To Know

- **Viscosity**
- **Kinematic viscosity**
- **Hydrodynamic lubrication**
- **Low HTHS rating (High Temperature/High Shear) THIN**
- **High HTHS rating (High Temperature/High Shear) THICK**

Today's automotive and light-duty truck technician needs to be able to explain to a consumer the right choice in oils they put in their vehicles. The formulas, additive packages and proprietary blends seem to be different for every vehicle manufacturer. One thing is for sure, we cannot and should not put ***any*** oils in a customer's car other than what is recommended by the OEM. Putting an oil in the engine that you ***think*** will perform better, or that you bought at a good price is definitely the wrong thing to do and not very professional. Know the facts and be confident in your terminology and by all means: ***tell the truth***. The importance of being educated and informed can only help the sale go a little easier.

When the consumer puts their vehicle in our care and custody, there is a level of trust, respect, professionalism and courtesy that is expected in any professional shop. We need to be able to explain the services we provide and the parts and chemicals we choose are chosen for good reason. We have to understand that consumers may and will shop prices on the internet. As professionals, do we really care how much the oil is on the internet? Probably not, but we may have to explain the differences in costs to our customers so they are educated in their buying decisions. Your customers are in your shop for good reason. They probably trust ***you*** and want ***you*** to

help them make an informed decision about their vehicle's service and/or repair needs. *"We don't change oil, we service the entire car".* The internet has brought a whole new set of circumstances into our world and you sometimes have to explain why your prices may be higher. If a customer says, *"Wow that's expensive".* I say, *"Expensive compared to what?"* What are you comparing your statement about being ***expensive*** to?"

What is Viscosity?

Viscosity can be referred to as the measurement of a fluid's resistance to flow. When a fluid is subjected to external forces, it resists flow due to internal molecular friction. Viscosity is a measure of that internal friction. The viscosity rating of a motor oil is determined in a laboratory by the **Society of Automotive Engineers** (**SAE**) test procedure. The viscosity of the oil is measured and given a number, which some people also refer to as the **weight** (thickness) of the oil. The ***lower*** the viscosity rating or weight, the ***thinner*** the oil. The ***higher*** the viscosity rating, the ***thicker*** the oil. As you will see later, the term **weight** is really misleading and we should be using the term **grade** of oil.

There are other ways to refer to a fluid's viscosity. Some of the more common terms are **thin**, **light** or **low**. These terms suggest how a relatively free-flowing fluid such as water flows. Terms such as **thick**, **heavy** or **high** suggest that the fluid demonstrates a strong resistance to flow. Honey or molasses is a good example of a fluid with a high viscosity. The study of viscosity is known as **rheology**.

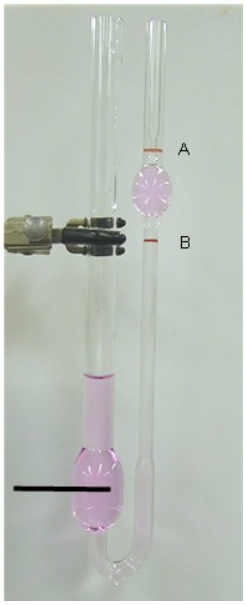
Viscosity can be viewed in two different ways. The first is a fluid's tendency to flow as it is visually seen. One can think of this as the time it takes to watch a fluid pour out of a container. The term for this is **kinematic viscosity** and it is expressed in units suggesting flow volume over a period of time. The most commonly used unit of kinematic viscosity is **centistokes** (**cSt**). The second is a fluid's tendency to flow as is indicated by measured resistance. You can think of this as the energy required to move an object through a fluid. It takes little energy to stir water with a spoon. However, significantly more energy is required to stir honey with that same spoon. The term for this is **dynamic viscosity** or **absolute viscosity** and is expressed in units known as **centipoises** (**cP**).

Another unit of measure is a **Sabolt Universal Second** (**SUS** or **SSU**). You will see **cSt** and **SUS** numbers show up on oil analysis reports. When comparing the viscosity of two different fluids, keep in mind that a centistoke and Sabolt Universal Second are different units, and therefore they cannot be directly compared. The ***temperature*** of the fluid being tested will also affect the outcome. Kinematic viscosity of a lubricant is determined at **100°C** (**212°F**) and/or **40°C** (**104°F**) depending on the grading system being used. For general comparison purposes, the temperature at which the viscosity was determined for the two products must be the same.

How Is Viscosity Measured?

The instrument needed to measure viscosity is the **viscometer**. A viscometer calculates the running time of a determined quantity of oil through a capillary of given dimensions in a small bottle submersed in a bath at constant temperature. Oils reveal different behavior at the same temperature. Viscometers only measure under one flow condition. In general, either the fluid remains stationary and an object moves through it, or the object is stationary and the fluid moves past it. The drag caused by relative motion of the fluid and a surface is a measure of the viscosity.

U-tube Viscometers



Another instrument to measure viscosity is the **Ubbelohde viscometer** (**u-tube viscometer**) which consists of a **U**-shaped glass tube held vertically in a controlled temperature bath. In one arm of the **U** is a vertical section of precise narrow bore (the capillary). Above this is a bulb, with it is another bulb lower down on the other arm. In use, liquid is drawn into the upper bulb by suction, then allowed to flow down through the capillary into the lower bulb. Two marks (one above and one below the upper bulb) indicate a known volume. The time taken for the level of the liquid to pass between these marks is proportional to the kinematic viscosity. Most commercial units are provided with a conversion factor, or can be calibrated by a fluid of known properties. The time required for the test liquid to flow through a capillary of a known diameter of a certain factor between two marked points is measured. By multiplying the time taken by the factor of the viscometer, the kinematic viscosity is obtained.

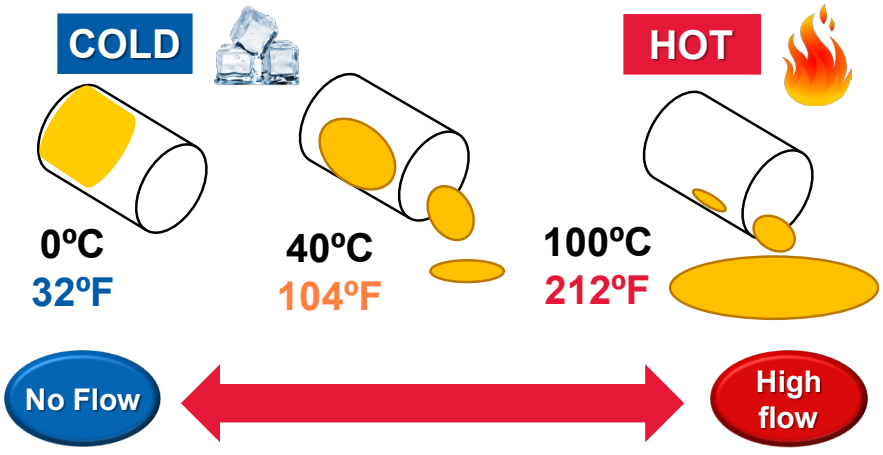
Temperature Affects Viscosity

A fluid's viscosity is important because it is directly related to its load-carrying capabilities. The ***greater*** a fluid's viscosity, the ***greater*** the loads it can withstand. The viscosity of a fluid must be adequate to separate moving parts under normal operating conditions (temperature and speed). Knowing that a fluid's viscosity is directly related to its ability to carry a load, one would think that the more viscous a fluid, the better it is. The fact is the use of a high-viscosity fluid can be just as detrimental as using too light an oil.

Too low (**thin or light**) = **Metal-to-metal contact (friction and wear), poor sealing and increased oil consumption**
Too high (**thick or heavy**) **= Increased fluid friction, Reduced energy efficiency, higher operating temperature and equipment starting difficulties particularly at cold temperatures**

The key is to select a fluid that is not too light and not too heavy.

Fluids (lubricant stocks) ***thicken*** as they are ***cooled***. As their temperature continues to ***decrease***, they will eventually reach a point at which they become no longer fluid. As they thicken, their load-carrying ability ***increases***, but their ability to be circulated becomes significantly impaired. As fluids are ***heated***, they **thin** which ***reduces*** their ability to prevent metal-to-metal contact. Therefore, it is important that equal temperatures be used when discussing or comparing the viscosity of fluids and ambient temperature has very little effect on the oils temperature of a warm engine.



Kinematic Viscosity Definition

A lubricating oil's viscosity is typically measured and defined in two ways: either based on its **kinematic viscosity** or its **absolute** (dynamic) **viscosity**. While the descriptions may seem similar, there are important distinctions between the two.

Kinematic is the study of geometry of motion. An oil's **kinematic viscosity** is defined as its resistance to flow and shear due to gravity (what is seen visually). The **viscosity** of a fluid is its resistance to shear or flow. For a liquid, the kinematic viscosity will ***decrease*** with ***higher*** temperature.

Kinematic Viscosity Experiment

- **High Temperature High Shear (HTHS) at 100°C/212°F**
- **Experiment:** Two containers: one with mineral oil and one with thick gear oil
- **Tip** them over at the same time
- **Question:** ***Which will flow faster?***

_____

Kinematic Measurement

The most commonly used unit of measure for kinematic viscosity is **centistokes** (**cSt**). Oil viscosity measurement in lube articles is stated in **kinematic** (**kv**) and **absolute** (**cSt**) terms – **9.7 cSt**, **12.3 cSt**, etc. **Sabolt Universal Second** (**SUS**) and **cSt** numbers show up in oil analysis reports. These values are translated into the easier to understand SAE viscosity numbers we see on oil containers such as: **10**, **20**, **30**, **40**, **50**, etc.

Kinematic viscosity of a lubricant is determined at **100°C** (**212°F**) and/or **40°C** (**104°F**) depending on the grading system being used. For general comparison purposes, the temperature at which the viscosity was determined for the two products must be the same because the temperature of the fluid being tested will also affect the outcome.

Absolute Viscosity

Absolute viscosity is the energy required to move an object through a fluid. It takes little energy to stir water with a spoon. However, significantly more energy is required to stir honey with that same spoon. The term for this is **dynamic viscosity** or **absolute viscosity** and is expressed in units known as **centipoises** (**cP**).

Now let's consider absolute viscosity and **compare** it to the earlier experiment with the mineral and gear oils.

To measure absolute viscosity:

- **Insert** a spoon into the same containers
- **Use** the spoon to **stir** the two oils
- Then **measure** the force required to stir each oil at the same rate

The force required to stir the gear oil will be ***greater*** than the force required to stir the mineral oil. Based on this observation, it might be tempting to say that the gear oil requires more force to stir because it has a higher

viscosity than the mineral oil. However, it is the oil's resistance to flow and shear due to internal friction that is being measured in this example, so it is better to say that the gear oil has a higher absolute viscosity than the mineral oil because more force is required to stir the gear oil.

High Temperature High Shear (HTHS)

High temperature high shear (**HTHS**) viscosity of engine oils is a critical property that relates to the fuel economy and durability of a running engine. The push behind lowering HTHS viscosity are new global governmental regulations to improve **fuel economy** (**FE**) and lower **greenhouse gases** (**GHG**) in new vehicles. ***Lower*** HTHS viscosity tends to improve fuel economy and ***lower*** greenhouse gases, but ***higher*** HTHS viscosity affords better wear protection, so a careful balance must be found when formulating an engine oil. Sufficient HTHS viscosity is critical in preventing engine wear in the critical ring/liner interface area by maintaining a protective oil film between moving parts.

One method used to measure HTHS viscosity is **ASTM D4683**. Oil is introduced between a rotor and a stator at the test temperature of **150°C** (**302°F**). The rotor experiences a reactive torque to the oils resistance to flow (**viscose friction**) and this torque response level is used to determine the HTHS viscosity. HTHS viscosity by ASTM D4683 has been found to relate to the viscosity providing hydrodynamic lubrication in light duty and heavy duty engines. HTHS viscosity has also been found to relate to fuel economy. Think of the protective oil film as if you are trying to swim. If the film is too ***thick*** like molasses, you can barely move and have to expend a lot of energy; too ***thin*** and you sink to the bottom. What you want is the right balance of support and ease of movement. The oil has to be thick enough to maintain separation of the critical moving parts, but thin enough to allow for fuel efficient operation.

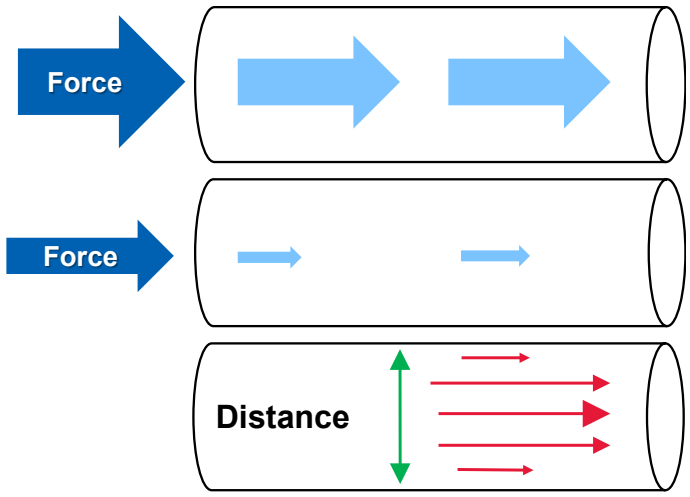
As you will see later in the course, there are **low HTHS ratings** (**thin**) and **high HTHS ratings** (**thick**) engine oils. In addition, the oil can be **long life** (**LL**) or may ***not*** be long life.

Liquids Like Water Have Simple Flow

Normal liquids like water have simple flow. The speed at which water flows through a pipe is directly proportional to the force pushing water through. Liquids do not flow with even velocity through a pipe. This is due to frictional forces between the pipe and the liquid. The difference in **velocity** (**v**) between liquid at the outside of the pipe and the middle, divided by their relative distance is known as **rate of shear** (**G**).

$$G = \frac{\Delta v}{\text{Distance}}$$

Rate of shear (**G**) is proportional to **shear stress** (**F**). The more viscous a liquid is, the more shear stress is required to push it through the pipe.



What Does All of This Mean?

High viscosity liquids need ***more*** shear stress to flow. Low viscosity systems require ***less*** shear stress to flow. For example: water requires ***less*** force to pour compared to honey.

Choose Your Engine Oil Wisely

Using a ***low*** HTHS oil in a ***high*** HTHS application can lead to significant engine damage.

Example: BMW **5W-30/12.2 cSt vs. Castrol Edge 5W-30/9.7 cSt**

Remember: the cSt values from the lab are translated into the easier to understand SAE viscosity numbers: **10**, **20**, **30**, **40**, **50**, **60**, etc. oil containers we buy in the store.

Quiz: Viscosity Difference

1. Which picture demonstrates ***higher*** **viscosity**? ***A*** or ***B***
2. Which picture is ***less*** **viscous**?

Answer: _____

Viscosity Facts

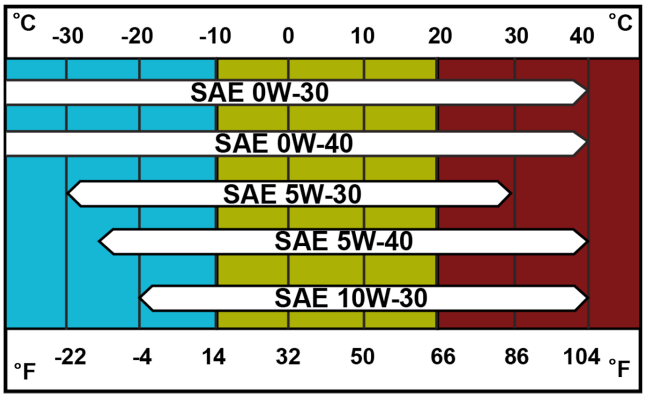
- ***Thicker*** **oils** can lead to ring sticking and cylinder scoring
- ***Thicker*** **oils** are ***not*** generally required in hotter climates
- ***Thinner*** **oils** can ***increase*** bearing and upper valve train wear
- **Oil temperature** is dependent on engine load and ***not*** ambient temperature

Viscosity Scale

Viscosity	Thick vs. Thin
50	Thicker
40	
30	
20	
10	
5	
0	Thinner

Typical OEM Viscosity Chart

Looking at the viscosity chart from left to right, you will notice that it is **BLUE** (***cold***) on the left and **RED** (***hot***) to the right. The SAE grades are listed from **0W-30** to **10W-30** and the **0W-30** does a little better job at low temperature flow than the **5W-30**.



Viscosity Index (VI)

In general, the viscosity of any liquid is sensitive to temperature. **Viscosity index** (**VI**) is used to characterize lubricating oil in the automotive industry. As temperature ***increases***, viscosity ***decreases*** and vice versa. Viscosity index is a parameter that characterizes how a liquid responds to temperature changes. Specifically, it describes the degree to which viscosity changes between the temperatures of **40°C** and **100°C**. An engine oil formulation that exhibits a large viscosity change between these two temperatures has a ***low*** viscosity index, while another oil having a ***less*** dramatic viscosity ***increase*** will have a ***higher*** viscosity index value.

The viscosity of a lubricant is closely related to its ability to reduce friction. Generally, the ***least viscous*** lubricant which still forces the two moving surfaces apart is desired. If the lubricant is too viscous, it will require a large amount of energy to move (as in molasses or honey); if it is too thin, the surfaces will come in contact and friction will ***increase***.

The viscosity index highlights how a lubricant's viscosity changes with variations in temperature. Many lubricant applications require the lubricant to perform across a wide range of conditions in an engine. Automotive lubricants must reduce friction between engine components when it is started from ***cold*** (relative to engine operating temperatures), as well as when it is running (up to **200°C** or **392°F**). The best oils (with the highest viscosity index) will not vary much in viscosity over such a temperature range and therefore, will perform well throughout.

The viscosity index scale was set up by the **Society of Automotive Engineers** (**SAE**). The temperatures chosen arbitrarily for reference are **100°F** and **210°F** (**38°F** and **99°C**). The original scale only stretched between **VI = 0** (worst oil, naphthalene) and **VI = 100** (best oil, paraffin), but since the conception of the scale, better oils have also been produced leading to viscosity indexes ***greater*** than **100**.

Viscosity Index Scale

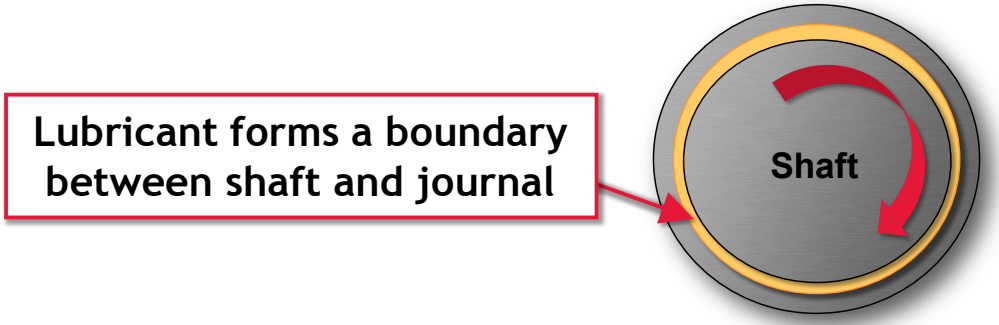
Viscosity index improving additives and higher quality base oils are widely used today which increase the viscosity indexes attainable beyond the value of **100**. The viscosity index of synthetic oils ranges from **80** to ***over*** **400**.

Viscosity Index	Classification
<35	low
35-80	medium
80-110	high
>110	very high

Viscosity index of synthetic oils ranges from **80** to ***over*** **400**

Hydrodynamic Lubrication

Hydrodynamics is complete separation between primary and opposed body. **Hydrodynamic lubrication** is where the motion of the contacting surfaces and the exact design of the bearing is used to pump lubricant around the bearing to maintain the lubricating film. This design of bearing may wear when ***started***, ***stopped*** or ***reversed***, as the lubricant film breaks down. Hydrodynamic lubrication is maintained when sufficient flow of lubricant is maintained in between two components. During operation, the extreme pressure can squeeze oil out from the two components faster than it can flow in resulting in metal-to-metal contact of the surfaces. It is a double edged sword, that ***thin*** oil can flow in ***faster***, but it also gets squeezed out ***faster***. Additionally, ***thicker*** oil is harder to squeeze out, but it does not flow into critical areas as quickly. So, correct oil viscosity is critical to proper hydrodynamic wear protection.



Principle of Hydrodynamic Bearing

SAE Viscosity Ratings

Considering how important the viscosity of engine oil is to maintaining proper oil pressure and resisting wear of engine components, it is not surprising that so much technology goes into precisely dialing in the oil's viscosity over the entire range of temperatures you would expect to see from when you first crank the engine, all the way to operating temperature. Viscosity is just one characteristic related to your oil accomplishing the complex range of duties expected of it on a daily basis.

OEM approved oil may add additional viscosity requirements. A General Motors branded (approved) **5W-30** may be ***thinner*** than a **5W-30** Quaker State oil on the market.

Example: Both Ford and GM add requirements that increase oil life by reducing damage to the oil under low operating temperatures. SAE **0W-30** or a **5W-30** may be significantly ***thicker*** (more viscous) at high temperatures than an SAE **10W-40**.

Viscosity Grade Chart

SAE Viscosity Chart High Temperature 100°C (212°F)		
SAE Viscosity	Kinematic cSt 100°C minimum	Kinematic cSt 100°C maximum
20	5.6	<9.3
30	9.3	<12.5
40	12.5	<16.3
50	16.3	<21.9
60	21.9	<26.1

Whether it is reported in ***centistokes***, ***SUS*** or ***centipoises*** units, the ***higher*** the number assigned, the ***more viscous*** or ***thicker*** the fluid is. A fluid's viscosity or thickness is directly proportional to its internal friction and resistance to flow.

SAE Viscosity Chart (**High Temperature**) shows the equivalents for cSt and SAE viscosity values. We can see the ranges for cSt compared to SAE values. An oil that is **9.2 cSt** will be nearly the same viscosity as an oil that is **9.3 cSt**, yet one oil is an SAE **20** and the other is an SAE **30**. This is why the cSt centistokes numbers more accurately show oil viscosity.

The **High Temperature/High Shear Test** measures a lubricant's viscosity under severe high temperature and shear conditions that resemble highly-loaded journal bearings in fired internal combustion engines. In order to prevent bearing wear, it is important for a lubricant to maintain its protective viscosity under severe operating conditions. The term for this is **dynamic viscosity** or **absolute viscosity** and is expressed in units known as **centipoises** (**cP**). The ***minimum*** **High Temperature/High Shear viscosity** for a **30** grade oil is **2.9 cP**.

SAE **W-XX** ratings are based on cranking and pumping viscosity tests performed at sub-zero temperatures. Both Ford and General Motors add requirements that increase oil life by reducing damage to the oil under low operating temperatures. Many OEMs require a **5W-30** oil with a much higher HTHS viscosity than an SAE **10W-40** requirement.

Stay in Grade

Viscosity index improvers (**VIIs**) are used in multi-grade engine oils, automatic transmission fluids, power steering fluids, gear oils, greases and certain hydraulic fluids. By far, the most common application is for passenger cars and heavy-duty trucks. Over **80%** of all viscosity index improvers sold in the lubricant market globally are used in these applications.

All engine oils must deliver **in-grade** viscosity performance throughout the engine's operating range. To achieve this, engine oil formulators rely on viscosity index improvers to deliver the required viscosity performance in both low shear and high shear environments while exposed to a wide range of lubricant temperatures – ***very cold*** to ***very hot***. The automotive industry has adopted several key tests specifically to quantify an engine oil's performance over a broad range of temperature and shear conditions.

At ***low temperature*** conditions, viscosity index improvers must deliver needed viscosity control when low shear is encountered in the oil sump and lines that carry oil from the sump to the engine. Oil that is too thick at these conditions can cause oil starvation. High shear is encountered in the engine bearings–high viscosities here can result in too much resistance to engine cranking and failure to start the car. The traditional **high temperature** measurement is kinematic viscosity at **100°C** (**kV 100°C**). This defines the oil's SAE high temperature grade. High temperature, low shear conditions are seen in leak paths (oil seals, behind piston rings) and too low a viscosity can affect oil consumption. The **High Temperature/High Shear** (**HT/HS**) **Viscosity test**, which is run using oil heated to **150°C**, measures viscosity and indicates the oil film thickness that might be encountered in bearings, camshafts, etc. under severe high-speed operations. An oil that is too thin under these conditions may not provide the needed lubricant protection which could result in significant wear in these critical engine parts.

- **Motor oil that is measured to have viscosity of *9.5 cSt* at *100°C* will be rated as *SAE 30***
- **Motor oil that is measured to have viscosity of *12 cSt* (or *26% more* viscous) will also be rated as *SAE 30* motor oil**
- **That is why *stay in grade* over the service life of the motor oil is also important**
- **The *best* motor oil will be *SAE 30* when fresh and *SAE 30* when drained out after its use, this is termed as *stay in grade***

SAE Viscosity Standards

Wear protection and ***HTHS viscosity*** are important parameters and are not specified in the SAE viscosity standard. Many European vehicles require ***higher*** HTHS viscosity. SAE **5W-30** rating is split into two very different viscosity categories: **Thick 5W-30 High HTHS** and **Thin 5W-30 Low HTHS**.

Viscosity Breakdown

- **Loss of oil film causes excessive wear**
- **Increased mechanical friction causing excessive energy consumption**
- **Increased heat due to mechanical friction**
- **Increased sensitivity to particle contamination due to reduced oil film**
- **Oil film failure at high temperatures, high loads or during start-ups or coast-downs**
- **HEUI diesel injector failures**

Oil breakdown occurs when the major properties of the oil have changed due to oxidation, deposits, thermal degradation, corrosion, shearing and contamination. This reduces the oil's ability to perform its primary functions of reducing friction, dissipating heat, preventing corrosion and keeping the engine clean. Depending on the application, there are many other problems that can accompany viscosity breakdown of engine oils. Turbocharger lubrication and diesel engine HEUI injection system issues can be affected by use of the wrong viscosity oil or lack of maintenance.

Many people use the term **oil breakdown** to represent what they think is a motor oil that has ***broken down*** and is in need of changing, when in reality, the actual process of oil breakdown is not properly understood. The correct term for this oil breakdown is really due to **shear forces**. An internal combustion engine imparts high shear forces on motor oil which is sandwiched between two rotating or sliding forces under load and heat. Once motor oil has sheared beyond a specific point, it will not revert back to its base structure when it cools down and the shear forces have ceased. This applies to petroleum oils only. Synthetic motor oils are extremely resistant to the detrimental effects of shear forces.

If you look at the molecular structure of motor oil under a microscope, you will see chains of molecules grouped together and linked together. The smaller molecular particles are attached to the larger ones. As oil shears, these smaller molecules break away and align in the chain. As engine heat and shear forces continue and increase, these molecules break away from the base structure and, in the process, provide less and less resistance to wear. If this shearing continues over an extended period of time, engine damage can occur. If shearing is only mild, then when the oil cools down, the structure will revert back to its original structure and still be capable of providing proper engine protection. Multi-viscosity petroleum motor oils are more susceptible to shearing than straight weight petroleum motor oils. As you will see in the next section, synthetic oils are extremely shear resistant and less prone to oil breakdown.

Temporary & Permanent Viscosity Loss

During routine engine operation and through continued use, engine oils are exposed to shearing mechanisms that break down the polymer molecules reducing the oil's molecular weight. This can lead to viscosity loss and a subsequent decrease in oil film thickness. If too severe, this can cause undesired friction and engine wear with oils that are not formulated with the proper viscosity characteristics.

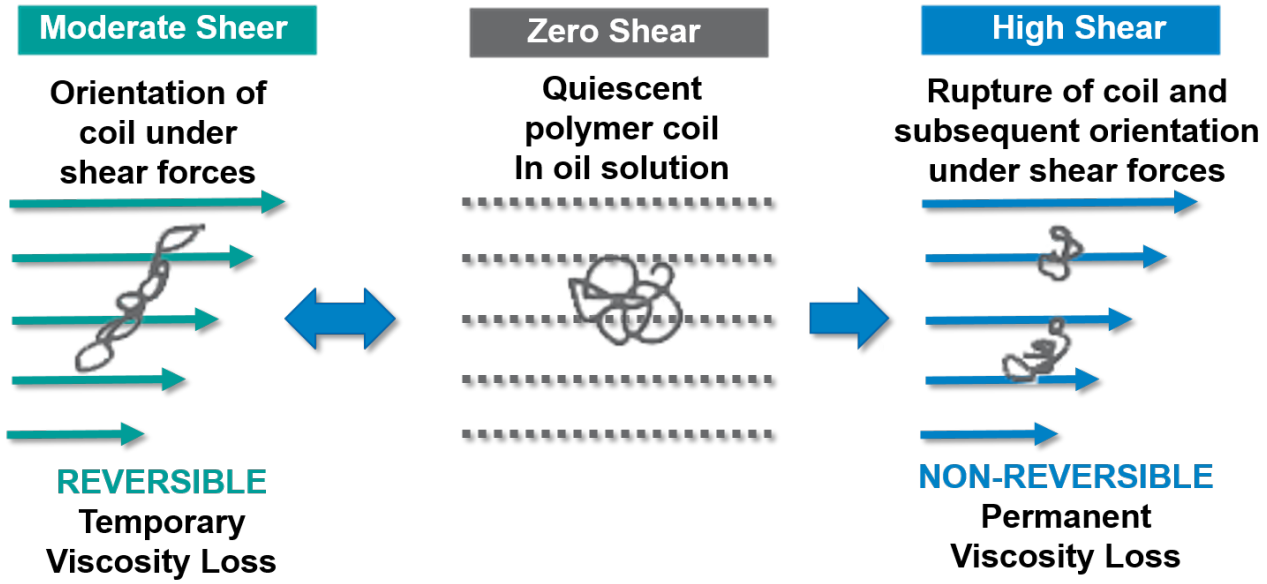
Molecular shearing of lubricating oils typically occurs in very tight spaces between moving parts that are in close proximity to one another. Bearings and ring faces are classic examples of where engine oil shearing can occur. Polymer coils also react to changes in shear or flow-rate in the oil.

As the oil begins to flow, the flexible polymer coil reacts to the velocity gradient within the oil. The coil **deforms** (becomes elongated) and becomes aligned to the direction of flow. The distorted coil impedes the oil's flow less than the original spherical coil did and the oil's observed viscosity falls. This is known as **shear-thinning** behavior.

When the shear stress is removed, the distorted coil resumes its original spherical shape and the oil's viscosity returns to its original value. This shear thinning is therefore termed **temporary viscosity loss**.

Under more extreme (very high) shear conditions, the coil can be pulled apart and the polymer chain broken into two smaller chains. These two smaller chains have less impact on the oil's viscosity than a single large chain, so the viscosity falls in this case as well, especially since the chains also align in the direction of flow. When the shear is removed, the broken polymer chain cannot reform into the single large chain because the coil has been physically and chemically changed. Consequently, the oil's viscosity does not return to its original value, but remains at a lower viscosity. This is known as **permanent viscosity loss**.

Note that larger coils are subject to larger forces when the oil is exposed to shearing stresses. This is because a larger coil has more ***surface*** over which the stretching forces of the oil's viscosity gradient can operate. Larger coils are therefore more easily pulled apart and broken than smaller coils, so therefore, high molecular weight molecules are more vulnerable to permanent viscosity loss.



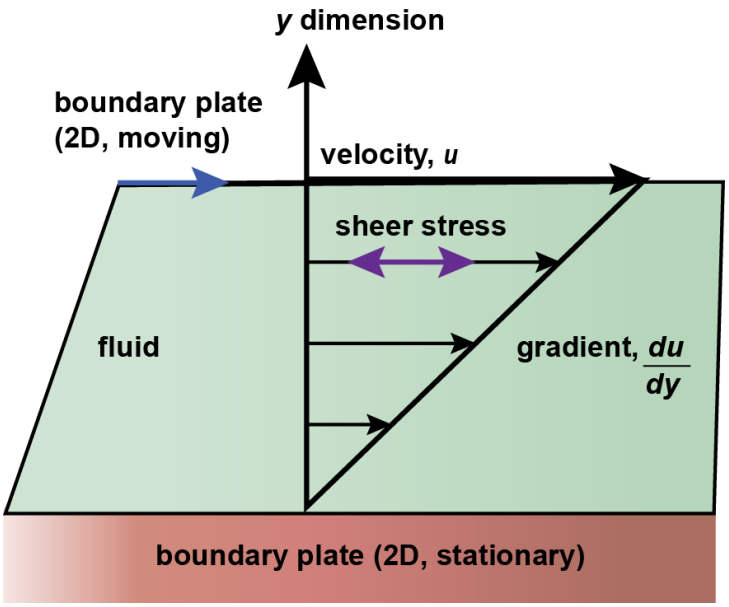
Boundaries Causing Fluid Shear

The viscosity of a fluid is its resistance to **shear** or flow, and is a measure of the fluids adhesive/cohesive or frictional properties. The viscosity will rise due to internal molecular friction within a fluid producing the frictional drag effect. Think of this when you put hand lotion on your hands and rub it in, eventually your skin will absorb a certain amount of the lotion and your hands begin to warm. Friction between the fluid and the moving boundaries causes the fluid to shear. The force required for this action is a measure of the fluid's viscosity. The **shear viscosity** of a fluid expresses its resistance to shearing flows where adjacent layers move parallel to each other with different speeds. If the speed of the top plate is small enough, the fluid particles will move parallel to it and their speed will vary linearly, equally from bottom to top. Each layer of fluid will move faster than the one just below it and friction between them will give rise to a force resisting their relative motion. In particular, the fluid will apply on the top plate a force in the direction opposite to its motion and an equal but opposite force to the bottom plate. An external force is therefore required in order to keep the top plate moving at constant speed.

Fluid friction means the internal resistance of a fluid, its resistance to running, also known as **viscosity**. The oil that separates two surfaces in relative motion is subdivided into superposed layers. During movement, the lower layer remains still while the upper layer runs at the same speed as the moving surface. Falling downwards, the speed gradually lowers because every single layer tends to slow down the movement of the upper layer and pull the lower layer. This sliding of layers causes a gradual loss of speed.

Shear thinning is a term used in rheology to describe non-Newtonian fluids which have decreased viscosity when subjected to shear strain. **Shear thinning** means that the fluid viscosity decreases with increasing shear stress. In other words, fluid motion is initially difficult at slow rates of deformation, but will flow more freely at high rates. Shear-thinning behavior is generally not seen in pure liquids with low molecular mass or ideal solutions of small molecules like sucrose. It is often seen in complex fluids and suspensions like ketchup, whipped cream, blood, paint and nail polish.

Example: When modern paints are applied, the ***shear*** created by the brush or roller will allow them to thin and wet out the surface evenly. Once applied, the paints regain their higher viscosity which avoids drips and runs. Ketchup is a shear thinning fluid caused by the addition of a relatively small amount of xanthan gum usually **0.5%**. Isn't ketchup made from tomato juice? Ever wonder how they get the viscosity up? They add an additive to the juice, in this case xanthan gum.



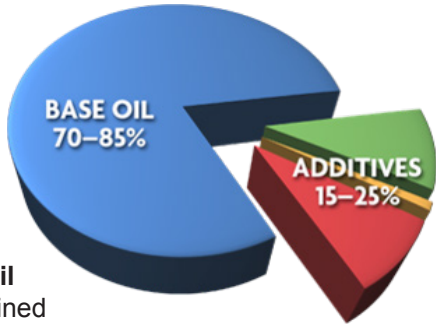
Quiz

Which are the primary functions of motor oil?

A. Improves the combustion of fuel
B. Reduces engine wear
C. Prevents buildup of acids and water vapor
D. Removes dirt and contaminants
E. All of the above

Motor Oil Formulation & Base Oil Characteristics

Motor Oil Formulation



Motor oil is made up of two basic components: **70-85%** oil and **15-25%** additives.

A **base oil** is any petroleum oil, as contrasted to animal or vegetable oils. **Mineral oil** can also be a highly refined petroleum distillate, or **white oil** used medicinally as a laxative and for baby oil. White oil is a highly refined straight mineral oil, essentially colorless, odorless, and tasteless. White oils also have a high degree of chemical stability.

Conventional & Synthetic Oils

Conventional base lubricants use only mineral base oils. Conventional oil may contain unwanted elements such as sulfur and unstable compounds that may evaporate from hot engine surfaces. **Synthetic lubricants** are chemically engineered and have a uniform consistency. They offer consumers properties that mineral oil cannot attain. There are no **viscosity index** (**VI**) improvers added, so there is nothing to wear out. Chemists say the actual oil molecules never wear out. You could almost use the same oil forever. The problem is that there are other additives in the oil and they do get depleted over time. There have been discussions in the industry that if there was a good way to keep oil ***clean***, you could just add a can of additives every **6** months and just change the filter, never changing the oil. This seems a bit risky, but the argument has some merit.

Synthetic Oils

Synthetic oils reduce friction and wear on engine components. They also function dependably at severe temperature extremes. Synthetic oils withstand rigorous and lengthy engine operation without experiencing chemical breakdown. Oil base stocks that are made from synthesized molecules are vastly superior to conventional oils.

Synthetic Oils: Advantages

The technical ***advantages*** of **synthetic** motor oils include**:**

- **Longer engine life**
- **Better lubrication during extreme cold weather starts**
- **Measurably better low and high-temperature viscosity performance at service temperature extremes**
- **Better chemical and shear stability**
- **Superior protection against *ash* and other deposit formation in engine hot spots (in particular in turbochargers and superchargers) for less oil burn-off and reduced chances of damaging oil passageway clogging**
- **Increased horsepower and torque due to less initial drag on engine**
- **Does not contain detergents which decreases evaporative loss**
- **Resistance to oxidation, thermal breakdown and oil sludge problems**
- **Extended drain intervals with the environmental benefit of less oil waste**
- **Improved fuel economy in certain engine configurations**

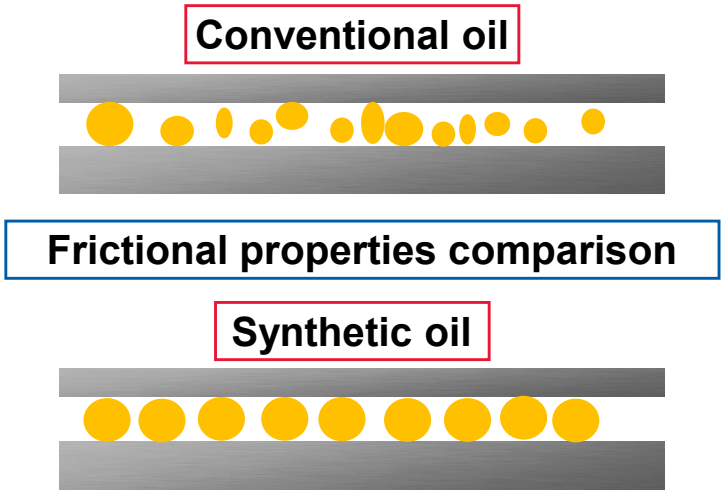
Synthetic Oils: Disadvantages

The ***disadvantages*** of **synthetic** motor oils include:

- **Potential decomposition problems in certain chemical environments (predominantly in industrial use)**
- **Not recommended in automotive rotary engines**
  - **In rotary engines, small quantities of motor oil are injected into the combustion chamber to lubricate the apex seals**
  - **Burned synthetic oil causes gummy deposits on the apex seals**

Synthetic Oil Stability

Older oils were formulated ***without*** seal conditioners. Engine seals harden as they age. Seal conditioners soften the seals and actually make them swell. If an aged engine seal returned to its hardened state, any oil could cause leaks. But since synthetic oils flow easier when ***cold***, that compounds the problem. Engine parts on a cold engine ***contract***. So add in hardened seals and a thinner oil and guess what, you get leaks. Today's synthetic oils have the same seal conditioners as conventional oil. If someone brings up the case that switching to synthetic oil will cause an engine to leak, their information would be outdated by about **25-30** years. Synthetic oil causing oil leaks is a myth.



Conventional vs. Synthetic Oils

Myth 1: Synthetic oil is man made

Fact: The vast majority of synthetic oil is simply crude oil that has been refined further than a conventional oil to a point where there are virtually no impurities and the oil molecules are essentially the same size. Some synthetic base stocks are also synthesized by recombining molecules that are derived from petroleum products. This approach also ensures that there are virtually no impurities and that the oil molecules have the same molecular size. Since synthetic oils have molecules that are essentially the same size, they are more resistant to temperature change and are more chemically stable as well, which increases their life. It also flows better, generally having lower pour points than a conventional oil with the same viscosity.

Myth 2: Synthetic oil allows longer between oil drains

Fact: Simply using a synthetic oil will ***not*** allow for an extended drain interval. However, in conjunction with oil analysis, you could decide whether the synthetic oil is able to perform the needed functions of oil longer than a conventional oil. Generally, synthetic oils will last longer, clean better and protect better than conventional oils. However, other factors such as the amount of dispersants and other additives in the oil limit oil life as well. Simply switching to a synthetic oil does not provide users with a free ticket to extend drain intervals, but with the help of oil analysis and a knowledgeable shop owner or technician, one could benefit from extended drains which will lower total oil purchases and maintenance man hours needed to change the oil.

Myth 3: Conventional oils and synthetic oils are incompatible

Fact: In most cases, conventional oils and synthetic oils are in the same family. For example: diesel motor oils, hydraulic oils, etc. are perfectly compatible. In fact, if you are running a full synthetic oil in your vehicle and you need to top off between oil changes, you could use a quart of conventional motor oil and you would be just fine. A **synthetic blend** is usually just that—a mix of conventional and synthetic base oils. If you consistently use a synthetic oil, but for whatever reason you need to use conventional oil for one oil drain interval, then you would be fine to do so. The OEM would favor the use of the correct viscosity and type (conventional or synthetic) oil as soon as possible to protect the warranty however.

Myth 4: Synthetic blends contain at least 25% synthetic oil

Fact: There is ***not*** an industry standard regarding the ***amount*** of synthetic oil that an oil has to contain in order to be labeled a **synthetic blend**. In fact, a synthetic blend oil could conceivably contain only **1%** synthetic base stock. Some oil companies will even label an oil as ***full synthetic*** even if it actually contains a majority of conventional base oil. Not all oils are the same and not all synthetic oils are the same. You can be assured that a synthetic or synthetic blend is high quality by using major brands in conjunction with an oil analysis program. By sending the oil out to a lab for analysis, one will be able to tell if its performance is in line with a high quality synthetic oil.

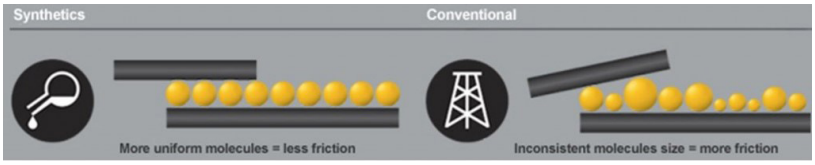
Myth 5: **Synthetic oils are a passing fad**

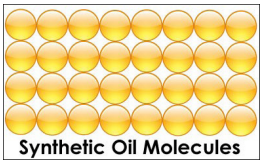
Fact: Synthetic oils are here to stay! In fact, the use of synthetic oils will increase significantly in the coming years. Many engine manufacturers are already calling for synthetic and synthetic blend oils and many more manufacturers will be in the near future. Legislation in the automotive and trucking industries are calling for emissions and fuel efficiency specifications that are only possible with synthetic oils. Additionally, engineering advances in most industries are calling for synthetic oil as well.

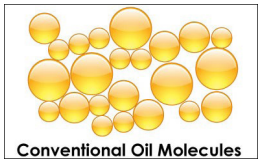
Using synthetic oils generally means using ***less*** oil overall compared to if you were using conventional oil. This is especially necessary as many businesses are now trying to ***go green*** and focus on their environmental impact. Using less oil also means disposing less oil and therefore, reducing your footprint. In other industries, some machines like plastic-injection molders for example, synthetic oils have been shown to reduce energy consumption which also reduces your environmental footprint.

Myth 6: **Advantages of synthetic oils are not worth the higher price**

Fact: Although the price per gallon is higher for synthetic oil versus conventional oil, using synthetic oil can save more on a shop's total cost of operation than what is paid. Using synthetic oils results in better wear protection which means replacing parts less often and extending engine life. Additionally, some synthetic oils are classified as ***energy saving***, so it may decrease fuel consumption.







Synthetic Blends

Semi-synthetic oils, also called **synthetic blends**, are blends of mineral oil with no more than **30%** synthetic oil. Synthetic blends are designed to have many of the benefits of synthetic oil without matching the cost of pure synthetic oil. The rule for blended synthetics is that they must have a minimum of only ***10%*** synthetic oil in them for the oil to be considered a ***synthetic blend***.

Many **synthetic blends** are ***illegal*** outside North America. Ford actually tested and approved their **WSS-M2C925-A** oil which ***is*** a ***synthetic blend*** for North America. Companies engineered a cheaper way to use a base oil **III** stock with some additives and call it ***synthetic***. The industry term for this process is called **hydrocracking**.

The difficult truth here is the marketing of cheaper synthetic blend oils to the public is a great way to sell lots of oil. However, when you think about it, are there really any benefits to your engine from its use? When you compare the average cost of conventional motor oil to a full synthetic motor oil, there may be a difference in price of approximately **$6.00** per quart. When you compare the average cost of a synthetic blend oil to a full synthetic oil, it is only about a **$2.00-$3.00** a quart difference. For the cost difference, we would recommend the consumer opt for the better full synthetic oil product and have peace of mind that their engine is protected.

Castrol/Mobil Oil Lawsuit

In 1999, Castrol won a lawsuit against its competitor Mobil. It was ruled in the suit that Castrol was ***not*** out of bounds calling **Group III** base oils ***synthetic***. After this ruling, almost every major oil company switched their base stock to the more profitable **Group III**. What followed was a disaster for the average consumer, especially those driving German cars still under warranty.

Castrol VS. Mobil

Base Oil Characteristics

Base oil is the name given to lubrication grade oils initially produced from refining **crude oil** (mineral base oil) or through chemical synthesis (synthetic base oil). Base oil is typically defined as oil with a boiling point range between **550°F** and **1050°F**, consisting of hydrocarbons with **18** to **40** carbon atoms. This oil can be either paraffinic or naphthenic in nature depending on the chemical structure of the molecules. There are five specific categories of base oils.

The **base oil** in a motor oil may be **conventional**, **synthetic** or a combination of the two. Demand for synthetic oil is growing due to advanced engines needing high quality oils that are precisely engineered.

The **American Petroleum Institute** (**API**) sets a minimum for performance standards for lubricants. Motor oil is used for the ***lubrication***, ***cooling*** and ***cleaning*** of internal combustion engines. Motor oil may be composed of a lubricant base stock only in the case of non-detergent oil, or a lubricant base stock plus additives to improve the oil's detergency, extreme pressure performance and ability to inhibit corrosion of engine parts. Lubricant base stocks are categorized into five groups by The **American Petroleum Institute** (**API**).

Group I base stocks are composed of fractionally distilled petroleum which is further refined with solvent extraction processes to improve certain properties such as oxidation resistance and to remove wax.

Group II base stocks are composed of fractionally distilled petroleum that has been hydrocracked to further refine and purify it.

Group III base stocks have similar characteristics to **Group II** base stocks except that **Group III** base stocks have higher viscosity indexes. **Group III** base stocks are produced by further hydrocracking of either **Group II** base stocks or hydroisomerized **slack wax**, a **Group I** and **Group II** dewaxing process byproduct.

Group IV base stocks are **polyalphaolefins** (**PAOs**).

Group V is a catch-all group for any base stock not described by **Groups I** to **IV**. Examples of **Group V** base stocks include **polyolesters** (**POE**), **polyalkylene glycols** (**PAG**) and **perfluoropolyalkylethers** (**PFPAEs**). **Groups I** and **II** are commonly referred to as ***mineral oils.*** **Group III** is typically referred to as ***synthetic*** except in Germany and Japan, where they must ***not*** be called synthetic and **Group IV** is a ***synthetic*** oil. **Group V** base oils are so diverse that there is no catch-all description.

Group I & II Base Oils

Group I and **Group II** bases oils are only used in conventional motor oils. They have a viscosity index of **80-119**.

Group 1 oils are minimally refined from crude oils. **Group I** base stocks contain ***less*** than **90%** saturates and/or ***greater*** than **.03%** sulfur and have a viscosity index ***greater*** than or **equal** to **80** and ***less*** than **120**.

Group II oils are more refined. **Group II** base stocks contain ***greater*** than or **equal** to **90%** saturates and ***less*** than or **equal** to **.03%** sulfur and have a viscosity index ***greater*** than or **equal** to **80** and ***less*** than **120**.

Groups III-V Base Oils

Group III through **Group V** can be used in synthetic motor oils as the base oils.

Group III oils are considered to be **synthetic**. **Group III** base stocks contain ***greater*** than or **equal** to **90%** saturates and ***less*** than or **equal** to **.03%** sulfur and have a viscosity index ***greater*** than or **equal** to **120**.

Group IV is comprised of special chemicals called **polyalphaolefins** or **PAOs**.

Group V base stocks include all other base stocks ***not*** included in **Group I**, **II**, **III**, **IV**.

In general, only **1%** to **2%** of a barrel of crude oil is suitable for refining into base oil. The majority of the barrel is used to produce gasoline and other hydrocarbons.

Base Oil Stocks

Group IV and **Group V** base oil synthetics are chemically made from uniform molecules without paraffin and generally do not need viscosity additives. However in recent years, **Group III** based oils have been labeled ***synthetic*** through a legal loophole. These are petroleum based **Group II** oils that have had the sulfur refined out making them more pure and longer lasting.

Group III synthetic motor oils must employ **viscosity additives** being petroleum based.

Group V based synthetics are usually not compatible with petroleum or petroleum fuels and have poor seal swell. These are used for air compressors, hydraulics, etc.

Group IV base stocks are manufactured **polyalphaolefins** (**PAO**) molecules. They are true traditional synthetics which are consistent and durable. **Group IV** PAO based synthetics make the best motor oils. They are compatible with petroleum based oils and fuels plus they have better seal swell than petroleum. Typically PAO based motor oils do not use viscosity index additives, yet pass the multi-grade viscosity requirements as a straight weight! This makes them ideal under a greater temperature range. One advantage of not having to employ viscosity improving additives is having a more pure undiluted lubricant that can be loaded with more longevity and performance additives to keep the oil cleaner longer with better mileage/horsepower.

Group V contains all base stocks that do not fit into **Groups I**, **II**, **III**, and **IV**. This could be ***good***, could be ***bad***.

Group VI is a ***new*** category of motor oils which are **polyinternalolefins** (**PIO**). This is a new European specification similar to a PAO. The **viscosity index** (**VI**) changes as the base stock is blended with additives and will not be the same as the finished product.

Synthetic Base Stocks

Synthetic motor oils are man made oils from the following classes of lubricants:

- **Polyalphaolefin** (**PAO**) **= American Petroleum Institute** (**API**) **Group IV** base oil
- **Polyol ester synthetics**, etc. **=** API **Group V** base oils (non-PAO synthetics including: diesters, polyolesters, alkylated naphthalenes, alkylated benzenes, etc.)
- **Polyinternalolefins** (**Group VI** PIO)
- **Hydrocracked/Hydroisomerized =** API **Group III** base oils. Chevron, Shell and other petrochemical companies developed processes involving catalytic conversion of feed stocks under pressure in the presence of hydrogen into high-quality mineral lubricating oil.

In 2005, production of **GTL**, **gas-to-liquid Group III** base stocks began, the best of which perform much like polyalphaolefin. **Group III** base stocks are widely permitted to be marketed as synthetic motor oil with few exceptions where they are not allowed to be marketed as ***synthetic,*** for example in Germany.

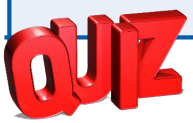
Many oil products marketed in North America as ***full synthetic*** are actually **Group III** base stocks and cannot legally be advertised as ***synthetic*** in Europe. These oils should ***never*** be put into a European vehicle that requires ***synthetic oil***! Technically, they have some advantages over the **Group I** and **Group II** base stocks.

Whether an oil is ***conventional***, ***synthetic*** or a ***blend***, bases oils comprise **75-85%** of motor oil.

Quiz: Base Oils

Please **complete** the following chart in class.

Characteristic	Conventional Oil	Synthetic Oil
Chemically engineered		
Used in motor oils		
Contains unwanted elements like sulfur		
Refined from crude (mineral) oil		
Extremely uniform consistency		
Demand growing for modern engines		

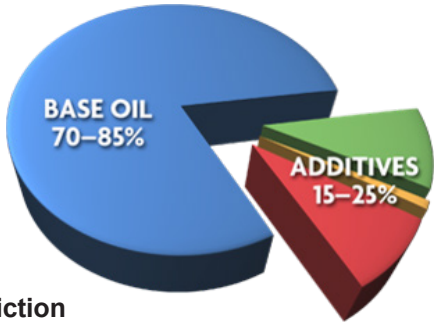


Whether conventional, synthetic, or a blend, base oils make up 75-85% of motor oil

Motor Oil Additives

Motor oil **additives** make up approximately **15%** to **25%** of motor oil which help:

- **Keep the engine clean**
- **Reduce friction and wear**
- **Prevent rust and corrosion**
- **Improve the motor oils overall performance**

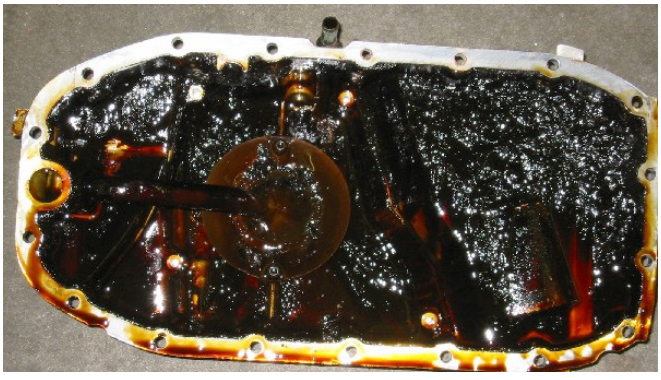


Formulators carefully select the additive for each motor oil product to create the optimal formula for the engine.

Motor oil additives include: **dispersants**, **detergents**, **anti-wear agents**, **friction modifiers** and **antioxidants**.

Dispersants

A **dispersant** helps keep sludge from forming on internal engine parts by suspending contaminants in the oil until they can be safely removed at the next oil change. Dispersing agents are added to lubricating oils used in automotive engines to prevent the accumulation of varnish-like deposits on the cylinder walls and to gasoline to prevent the buildup of gummy residues.



Detergents

Detergents operate on high-temperature surfaces, such as the piston-ring area and the piston under-crown, helping to prevent deposits. These detergents get consumed over the life of your oil change.

Motor oil detergents were introduced in the 1950s. The concept adjusts for the failings of oil filters by attaching to those particles too small to get caught in filters. Instead,the detergent holds the particles ***in*** the oil so they do not deposit on engine parts and cause hot spots. If the oil is used for too long, however, it cannot do its job. Changing oil regularly helps maintain the cleaning process and the benefit of the detergents.

Detergents are critical components of an engine's lubricating oil providing protection. Whether it is a lawn mower, car, or a massive two story marine diesel, engines and other machines do not run by themselves. To perform their everyday functions as well as expected, all their moving parts must be powered and protected with fuels and lubricants enhanced by some of the most technologically advanced additives. Detergents accomplish these functions by chemically reacting with combustion acids and neutralizing them, by inhibiting deposit precursor particle-to-particle aggregation and by inhibiting deposit formation on surfaces. In essence, the detergents function like an ***antacid*** for the engine, neutralizing corrosive combustion acids that would otherwise dissolve key metal parts and eventually lead to engine failure.

Anti-wear Agents

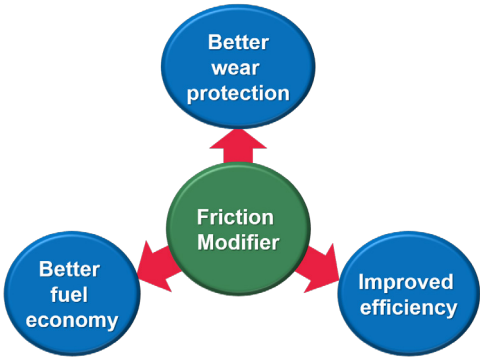
Anti-wear agents form a protective coating on metal surfaces. They also provide an antioxidant boost. Anti-wear agents operate under high temperatures and high load conditions, particularly protecting camshafts, lifters, piston rings and cylinder walls. Anti-wear agents cloak these surfaces in a ***sacrificial layer*** or film, which is consumed in the protective process. Without this sacrificial layer, metal-to-metal contact would occur. Like detergents, anti-wear agents also get consumed over the life of your oil change. This is another reason you should always change your oil at recommended intervals.

In the past, many synthetic and traditional oil companies used zinc/phosphorous combinations to protect against wear. One additive, **zinc dialkyl dithio phosphate** (**ZDDP**) has been used. But ZDDP has been proven to leave deposits in catalytic converters and the EPA has been leaning on oil makers to reduce or eliminate its use. So oil companies have reformulated it in order to meet the newer **GF-5** standards. (We will discuss oil standards later on in the class.)

To meet the new **GF-5** standards, blenders will use more **Group III** base oils which enables them to sell **0W-20** and **5W-20** multi-viscosity oils. To tackle the zinc issue, they will incorporate polyalphaolefin and molybdenum disulfide. The new lower grade viscosities are targeting miles per hour, and should yield better fuel economy. This, however, does not come cheap. ZDDP costs about **$1.00** per pound, but molybdenum costs around **$22-$38** per pound. Its price is high right now due to its demand.

Keep in mind that some off-brand oil companies keep reporting their results based on now obsolete testing procedures–the **engine sequence test**. The new testing procedures are known as the **sequence VI-D test** to measure fuel economy. It requires testing on late model engines, as opposed to older engine designs. The new test also looks at emissions control system protection, testing how much phosphorous remains in the used oil. The newer oils must also meet different tests for seal compatibility as well.

Friction Modifiers



Friction modifiers do what you think; they reduce friction under high loads and high temperatures, helping to maintain peak efficiency and fuel economy. The effectiveness of these additives diminishes over time as the oil ages.

Friction modifier additives affect the frictional properties between two rubbing surfaces. They prevent scoring, reduce wear and noise and can also help to prevent micropitting in industrial gear lubricants. Friction modifiers are commonly used in gasoline engine oils and are added to fluids for automatic and manual transmissions, tractor hydraulic systems, power steering, shock absorbers and metal working applications. In automatic transmission fluids and limited-slip axle lubricants, friction modifiers control torque application through clutch and band engagements.

Antioxidants

Oxidation results from exposure of the oil to oxygen at high temperatures. It is not a good thing. The results of such exposure can accelerate the aging of the oil contributing to oil thickening, sludge and deposits. **Antioxidants** help slow oxidation in the oil to help keep engines running clean. Changes in the design of automotive engines, longer lubricant drain intervals, the use of **exhaust gas recirculation** (**EGR**) in heavy-duty diesel engines and an upgrade to better quality base oils have all contributed to challenging formulators to maintain the antioxidant properties of automotive lubricants.

Sequence IIIG Piston Deposits

Failing Piston Deposit Passing Piston Deposit

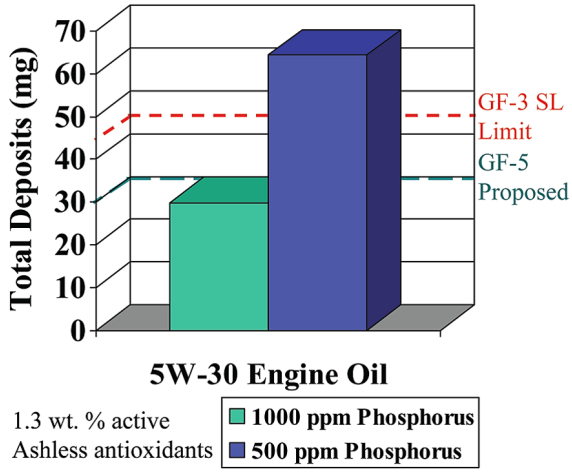
- High level of piston deposit and varnish are usually related to oil oxidation control as demonstrated in the pictures above.

Sequence IIIG Piston Tests

The **sequence IIIG test** simulates high-speed service during relatively high ambient conditions, measures oil thickening and piston deposits during high-temperature conditions and provides information about valve train wear. The sequence IIIG test measures deposits left on pistons under high temperature conditions. A ***failing*** piston deposit is seen on the left while a ***passing*** deposit is shown on the right.

Phosphorus Reduction

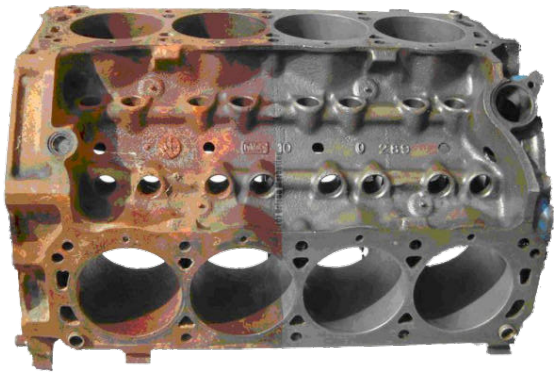
More attention has been placed on the role that antioxidants are playing in extending the life of automotive lubricants and reducing vehicular emissions. **ZDDP** is a very effective antioxidant and antioxidants are required in the engine oil to maintain optimal performance over an extended operating life. Unfortunately, the phosphorus in ZDDP has been implicated in adversely affecting the efficiency of catalytic converters present in modern, environmentally friendly vehicles. This limits the amount of ZDDP that can be used in oil and therefore, restricts its contribution to the overall oxidation performance.



Antifoam Additives

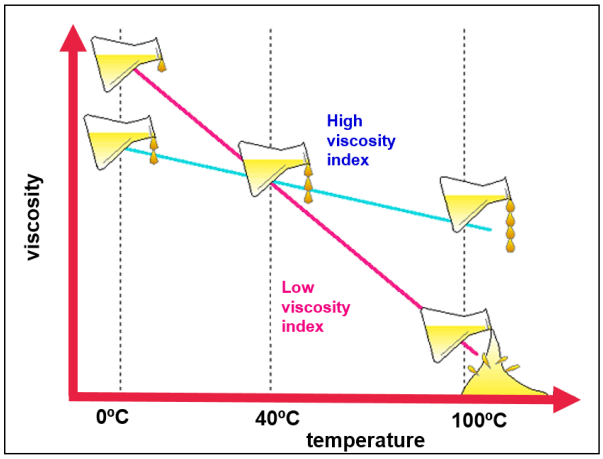
Foam-causing air bubbles create a variety of problems in oil. They make oil harder to pump to vital engine parts, reduce the oil's lubrication effectiveness and inhibit the oil's ability to help keep the engine cool. Foaming oil can result in serious engine damage. An **antifoam additive** helps prevent these problems specifically at high temperatures. Anti-foam agents, **defoamants**, inhibit the production of air bubbles and foam in the oil which can cause a loss of lubrication, pitting and corrosion where entrained air and combustion gases contact metal surfaces. Air in the oil can inhibit heat transfer and impede lubrication.

Rust & Corrosion Inhibitors



It might sound strange, but internal engine parts can be subject to rust and corrosion. **Rust and corrosion inhibitors** coat metal surfaces, protecting against these hazards.

Viscosity Index Improvers



The molecular structure of oil is essentially torn apart by mechanical shear forces. The component of the oil that is affected most by these shear forces is the viscosity improvers. The **viscosity index** measures an oil's ability to resist changes in viscosity as temperature changes. **Viscosity index improvers** utilize polymer additives to help maintain oil viscosity over a wide range of temperatures. The use of viscosity index improvers allows the formulation of multi-grade engine oils such as: **10W-30** and **SAE 10W-30**. The end result of these shear forces is a ***decrease*** in the viscosity of the oil, as well as a ***decrease*** in the viscosity index.

Pour Point Depressants

Pour point depressants are used in multi-grade oils to provide good oil flow at low temperatures. Flow is important in ***cold*** engines as oils that are difficult to pump through the engine require additional energy to circulate, like a clogged artery. This results in added stress on the engine and decreased efficiency.

Making multi-weight oils usually involves adding pour point depressants to thin the base oil adequately so it flows easily when ***cold***, then mixing in viscosity improvers to thicken it at higher temperatures. In many instances, these viscosity improvers may be depleted well before **7,500** mile service life, resulting in a **5W-30** oil becoming effectively a **5W-10** or even a **5W-5** oil.

Chemical Oil Additives

- **Antifoam**: reduces foaming
- **Antioxidant**: reduces oxidation of oil
- **Anti-wear**: reduces friction and wear
- **Corrosion inhibitor**: prevents rusting
- **Detergent**: keeps surfaces free of deposits
- **Dispersant**: keeps deposits in suspension
- **Extreme pressure agent**: prevents stress related scoring and seizure
- **Friction modifier**: alters frictional properties
- **Metal deactivator**: retards catalytic oil oxidation
- **Pour point depressant**: allows oil flow when cold
- **Seal swell agents**: ensures seals do not leak
- **Viscosity index improver**: promotes viscosity stability

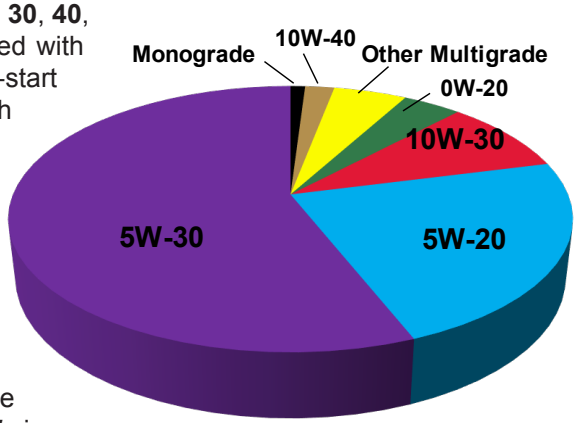
Quiz

What do additives help the motor oil do?

A. Reduce friction and wear
B. Help keep the crankcase full
C. Prevent rust and corrosion
D. Keep the engine clean
E. Enhance the combustion process

Motor Oil Grades & Service Standards

The **Society of Automotive Engineers** (**SAE**) has established a numerical code system for grading motor oils according to their viscosity characteristics. SAE viscosity gradings include the following, from low to high viscosity: **0**, **5**, **10**, **15**, **20**, **25**, **30**, **40**, **50** or **60**. The numbers: **0**, **5**, **10**, **15** and **25** are suffixed with the letter **W** designating their ***winter,*** not ***weight*** or cold-start viscosity at lower temperature. The number **20** comes with or without a **W** depending on whether it is being used to denote a ***cold*** or ***hot*** viscosity grade. Kinematic viscosity is graded by measuring the time it takes for a standard amount of oil to flow through a standard orifice at standard temperatures. The longer it takes, the higher the viscosity and thus, higher SAE code.



Example: **5W** means ***cold*** temperature viscosity and **30** means the high temperature viscosity. The ***higher*** the number, the ***thicker*** the oil. The advantages of a low **W** viscosity number is obvious. The quicker the oil flows ***cold***, the ***less*** dry running. ***Less*** dry running means much ***less*** engine wear.

When you see a **W** on a viscosity rating, it means that this oil viscosity has been tested at a ***colder*** temperature. The numbers without the **W** are all tested at **210ºF** or **100ºC** which is considered an approximation of engine operating temperature. In other words, a SAE **30** motor oil is the same viscosity as a **10W-30** or **5W-30** at **210°F**

(**100°C**). The difference is when the viscosity is tested at a much colder temperature. For example, a **5W-30** motor oil performs like a SAE **5** motor oil would perform at the cold temperature specified, but still has the SAE **30** viscosity at **210ºF** (**100ºC**) which is engine operating temperature. This allows the engine to get quick oil flow when it is started cold versus dry running until lubricant either warms up sufficiently or is finally forced through the engine oil system.

For comparison's sake, SAE **5W-30** and SAE **0W-30** will flow better at even lower temperatures than **10W-30** while still providing protection at high temperatures. Just remember, the **W** stands for ***winter***. Another way of looking at multi-viscosity oils is to think of a **20W-50** grade oil as a **20** weight oil that will not thin more than a **50** weight would when hot.

A ***thinner*** motor oil is also essential for easy starting, particularly in cold weather and for proper lubrication once the engine starts. Thinner oils enable more fuel economy than thicker oils; this is why OEMs specify them. Thinner oils, such as **SAE 5W-30** will flow faster than heavier motor oils during start-up and initial engine operation and will help protect the engine. The viscosity grade(s) recommended by the vehicle manufacturer depends somewhat on engine design. Engine manufacturers have spent considerable time and expense experimenting with different viscosity grades and have indicated in the owner's manual the grades they feel will best protect the engine at specific temperatures. While one manufacturer's engine may require a SAE **10W-30**, another manufacturer's engine may require a SAE **5W-20** viscosity grade. This is likely due to different tolerances within the engine or other engine design factors.

- **5W-30 oil grade example**
- **5W = viscosity grade when *cold***
- **W = *winter***
- **30 = viscosity grade when *hot* or at operating temperature 212°F or 100°C**

Oil Grade Thickness

Let's look at a **30** grade oil and how the viscosity of this grade of oil varies with temperature.
Forget the numbers on that oil container for now. A **0W-30** grade oil is ***not*** thinner than a **10W-30** oil. They both have the same thickness at operating temperature. The **0W-30** oil simply does not get ***as thick*** on cooling as the **10W-30** oil. Both are still way to ***thick*** to lubricate an engine at startup.

Take a look at the chart. Lets say the automotive engineers usually call for their engines to run at **212°F** oil and water temperature with an oil thickness of **10**. This is the viscosity of the oil, not the ***weight*** or ***grade*** as labeled on the oil can. Lets stay away from those numbers as they are confusing. We are talking about oil thickness, ***not*** oil can labeling. We are only discussing the thickness of the oil that the engine requires during normal operating conditions.

Temperature°F	Thickness
302	3
212	10
104	100
32	250

Do not refer to the **W** as **weight**
It is a **grade** of oil

The engine is designed to run at **212°F** at all external temperatures from Alaska to Florida. You can get in your vehicle in Florida in September and drive all the way to Alaska arriving in November. The best thing for your engine would be that it was never turned **off**, you simply kept driving day and night. The oil thickness would be uniform, it would always be **10**. Right? In a perfect world, the oil thickness would be **10** at all times and all temperatures. If the thickness of oil was **10** when you entered your car in the morning and **10** while driving it,

that would be perfect. You would not have to ***warm up*** your engine. You could just get in the car and step on the gas. There would be little wear and tear on your engine, almost none. Unfortunately, this is not the case. The night before when you drove home from work, the car was up to the correct operating temperature and the oil was the correct thickness, **10**. Over night, the engine cooled to room temperature and the oil thickened. It is **60°F** in the morning now. The oil thickness is now around **150**. It is too thick to lubricate an engine designed to run with an oil having a thickness of **10**. Making sense yet?

Interesting

Viscosity

- **A 30 grade oil has a viscosity of 3 at 302°F (150°C) and *thickens* to 10 at 212°F (100°C)**
- **It further thickens to a viscosity of 100 at 104°F (40°C) and is too *thick* to measure at the freezing point of 32°F (0°C)**
- **Starting to make sense?**
- **Engineers have long known that 90% of engine wear occurs at start-up**

Remember viscosity is a measure of the resistance of a fluid, liquid or gas, to flow. Fluids with high viscosity, such as molasses, flow more slowly than those with low viscosity, such as water. Redundant ***yes***, but for a reason. As mentioned earlier, viscosity of oil varies with its ***temperature***.

Engineers have long known that **90%** of engine wear occurs at startup, so If we are interested in engine longevity, then we should concentrate our attention at reducing engine wear at start up. Oils are chosen by the manufacturer to provide the right thickness at the normal operating temperature of the engine. Let's say the average engine oil temperature is **212°F**, the boiling point of water. On the track that temperature may reach **300°F**. It is important to realize that these are two different operating environments and require different oils. The one thing that is no longer important is the ambient temperature once the engine is at normal operating temperature.

Oil Container Confusion

Oils are divided into **grades**, ***not*** weights, such as a **10**, **20**, **30** or **40** grade oils. This represents the viscosity range at **operating temperature**, but it is ***not*** the actual viscosity as we saw earlier. The issue is that viscosity is temperature dependent. Motor oil container labels include lots of information regarding the standards the oil is designed to meet.

Asian & European Specifications

Which oil you purchase and install into your vehicle should at the very least meet industry and OEM standards. An **industry standard** would be an API approved oil. An example of an OEM performance specification would be Ford **WSS-M2C945-A** (**5W-20**). The API starburst does ***not*** confirm OEM compliance or even correct viscosity.

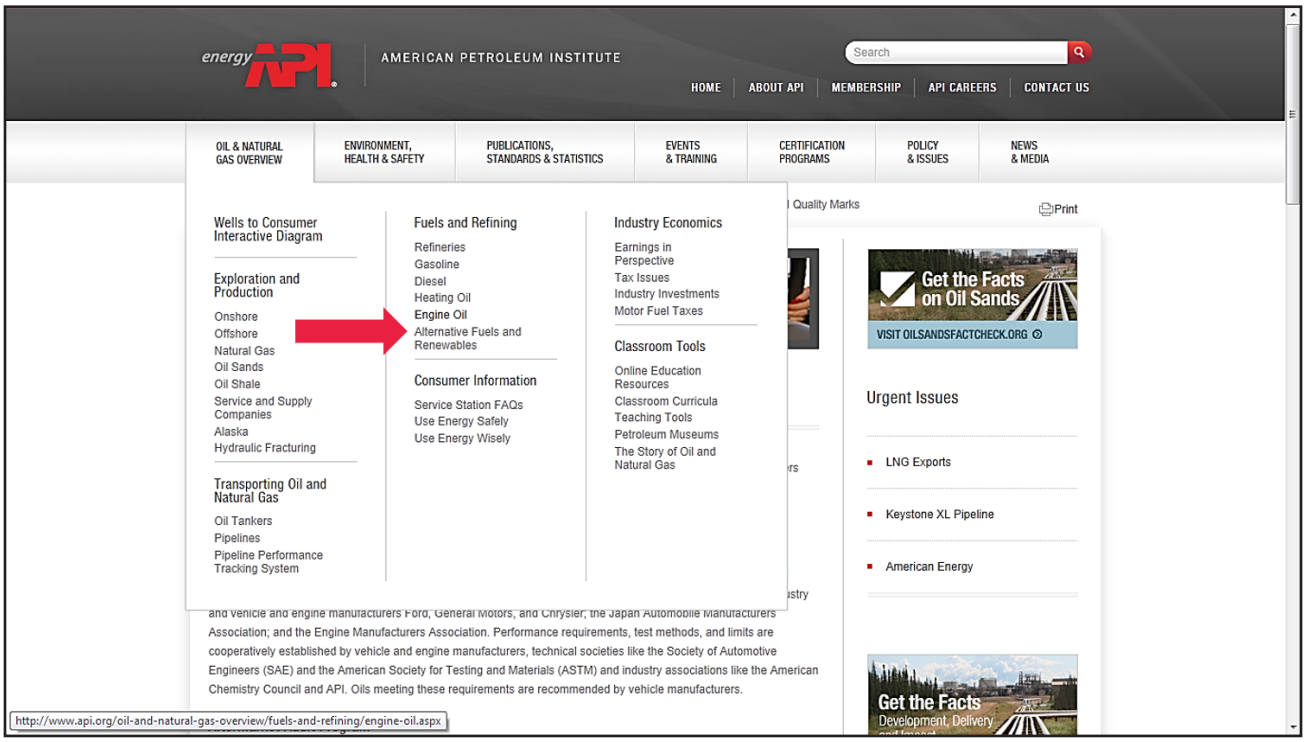
American Petroleum Institute (API)

energy API®

AMERICAN PETROLEUM INSTITUTE

API's **Engine Oil Licensing And Certification System** (**EOLCS**) is a voluntary licensing and certification program that authorizes engine oil marketers who meet specified requirements to use the API Engine Oil Quality Marks. Launched in 1993, API's **Engine Oil Program** is a cooperative effort between the oil and additive industries and vehicle and engine manufacturers: Ford, General Motors, Chrysler and those represented by the Japan Automobile Manufacturers Association and the Engine Manufacturers Association. The performance requirements and test methods are established by vehicle and engine manufacturers, technical societies and trade associations such as the **American Society for Testing and Materials** (**ASTM**), **Society for Automotive Engineers** (**SAE**) and **American Chemistry Council** (**ACC**).

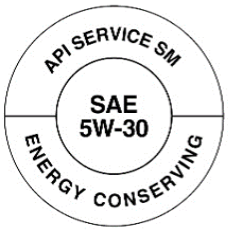
The Engine Oil Program is backed by an ongoing monitoring and enforcement program that ensures licensees adhere to program requirements. This includes running physical, chemical and performance tests on licensed engine oils and verifying that the API-registered marks are properly displayed on containers and convey accurate information to consumers. Approximately half of the program's more than **500** licensees are based in the United States and the other half are spread among more than **50** countries. More than **8,000** products now display **API marks**.



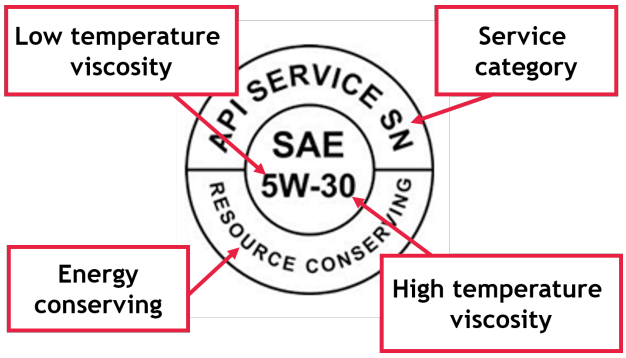
The API Starburst

API's **engine oil quality marks**: the API service symbol ***donut*** and certification mark ***starburst*** help consumers identify quality engine oils for their gasoline and diesel powered vehicles. Oil container labels are marked with information to help consumers know the oil they are purchasing meets specific standards. The **API starburst** does ***not*** confirm OEM compliance or even correct viscosity. The **API/ILSAC numbers/letters** indicate the appropriate application for the product. The **API certification mark** tells consumers if an oil meets the most up-to-date requirements for passenger vehicles as outlined in the latest ILSAC specification. Oils that carry the API certification mark are energy-conserving and are suitable for all previous model years. The mark must be displayed on the front of licensed motor oil product packaging.

API and ILSAC approval does ***not*** meet the minimum requirements of most automakers. API approval ***no longer*** meets the ***minimum*** requirements of most OEMs. **ILSAC approval** is a baseline that only meets the requirements of ***some*** American and Asian OEMs. Unfortunately, API and ILSAC both ***fail*** to meet the minimum requirements of many vehicles.



The API Service Symbol



The API service classes have two general classifications: **S** for **service/spark ignition** (typical passenger cars and light trucks using gasoline engines) and **C** for **commercial/compression ignition** (typical diesel equipment). Engine oil which has been tested and meets the API standards may display the **API service symbol** (also known as the ***donut***) with the service designation on containers sold to oil users.

The latest API service standard designation is **SN** for gasoline automobile and light-truck engines. The **SN** standard refers to a group of laboratory and engine tests, including the latest series for control of high-temperature deposits. Current API service categories include **SN**, **SM**, **SL** and **SJ** for gasoline engines. All previous service designations are obsolete, although motorcycle oils commonly still use the **SF/SG** standard. All the current gasoline categories, including the obsolete **SH**, have placed limitations on the phosphorus content for certain SAE viscosity grades (the **xW-20**, **xW-30**) due to the chemical poisoning that phosphorus has on catalytic converters. Phosphorus is a key anti-wear component in motor oil and is usually found in motor oil in the form of zinc dithiophosphate. Each new API category has placed successively lower phosphorus and zinc limits, and thus has created a controversial issue of obsolescent oils needed for older engines, especially engines with sliding (flat/cleave) tappets. API and ILSAC, which represents most of the worlds major automobile/engine manufacturers, states API SM/ILSAC **GF-4** is fully backwards compatible and it is noted that one of the engine tests required for API **SM**, the sequence **IVA** is a sliding tappet design to test specifically for camshaft wear protection.

Not everyone is in agreement with backwards compatibility, and in addition, there are special situations, such as ***performance*** engines or fully race built engines, where the engine protection requirements are above and beyond API/ILSAC requirements. Because of this, there are specialty oils out in the market place with higher than API allowed phosphorus levels. Most engines built before 1985 have the flat/cleave bearing style systems of construction, which is sensitive to reducing zinc and phosphorus.

Example: in API **SG** rated oils, this was at the **1200-1300** ppm level for zinc and phosphorus, where the current **SM** is ***under*** **600** ppm. This reduction in anti-wear chemicals in oil has caused premature failures of camshafts and other high pressure bearings in many older automobiles and has been blamed for premature failure of the oil pump drive/camshaft position sensor gear that is meshed with the camshaft gear in some modern engines.

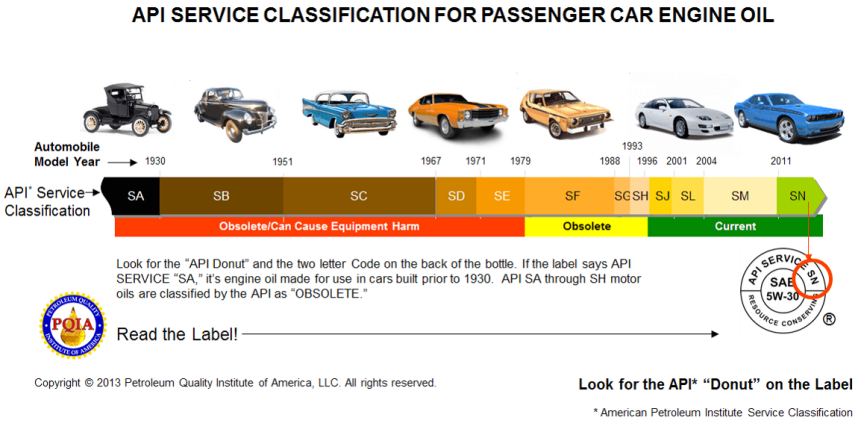
Look on the back of any bottle of motor oil to see if it meets OEM quality and performance standards set by the API. If it does, it will display the **API service symbol**, sometimes called the **API donut**, which shows the oil's latest service category and viscosity ratings and whether it rates as an energy conserving oil.

The **service category** refers to the range of vehicles that can use a given oil, determined by the vehicle's date of manufacture. Recent service categories include **SN** for 2011, **SM** for 2005-2010 and **SL** for 2001-2004.

API Service Classifications

There are six **diesel engine service designations** which are current: **CJ-4**, **CI-4**, **CH-4**, **CG-4**, **CF-2** and **CF**. Some manufacturers continue to use obsolete designations such as **CC** for small or stationary diesel engines.

In addition, API created a separated **CI-4 PLUS** designation in conjunction with **CJ-4** and **CI-4** for oils that meet certain extra requirements, and this marking is located in the lower portion of the API Service Symbol. It is possible for an oil to conform to both the gasoline and diesel standards. In fact, it is the norm for all diesel rated engine oils to carry the ***corresponding*** gasoline specification. For example, **API CJ-4** will almost always list either **SL** or **SM**, **API CI-4** with **SL**, **API CH-4** with **SJ**, and so on.



Never use an oil with an earlier service rating than is recommended by the OEM.

Rotella T SAE 15W-40 Diesel

What Oil Should We Use?

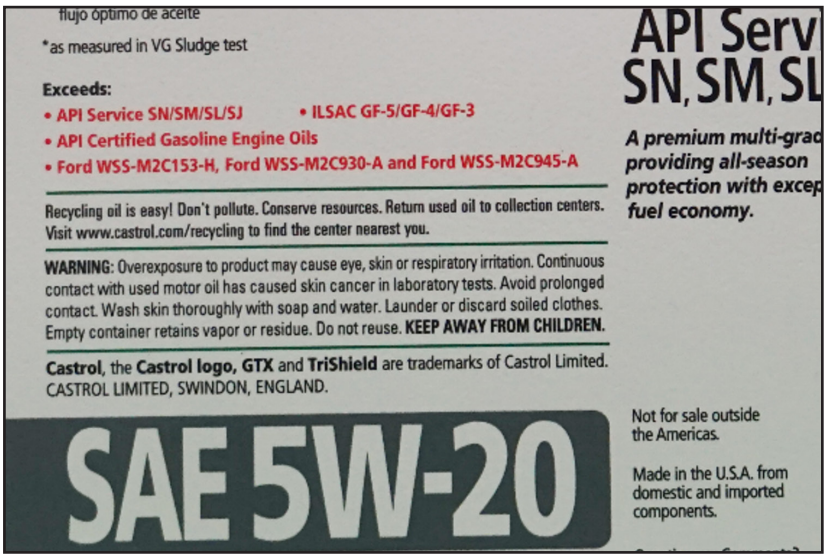
Look at industry specifications. **Examine** OEM specifications. Some oils meet API and ILSAC specifications, but ***do not*** meet the OEM specification. **Select** oils that meet OEM specifications to protect the vehicle's warranty. **Look** at the label to determine ***which*** oil meets OE specifications.

5W-20 Oil Example

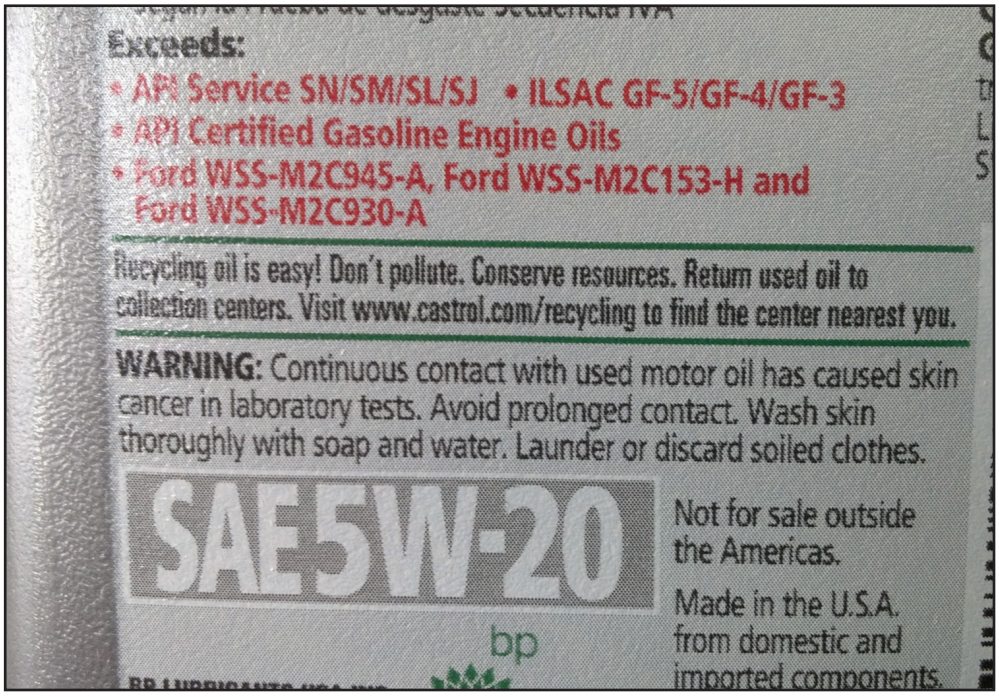
- **Lets examine a typical 5W-20 oil OEM specification**
- ***Which oil meets or exceeds the OE specification?***

Pennzoil SAE **5W-20** conventional oil: _____

Castrol SAE **5W-20** conventional oil: _____



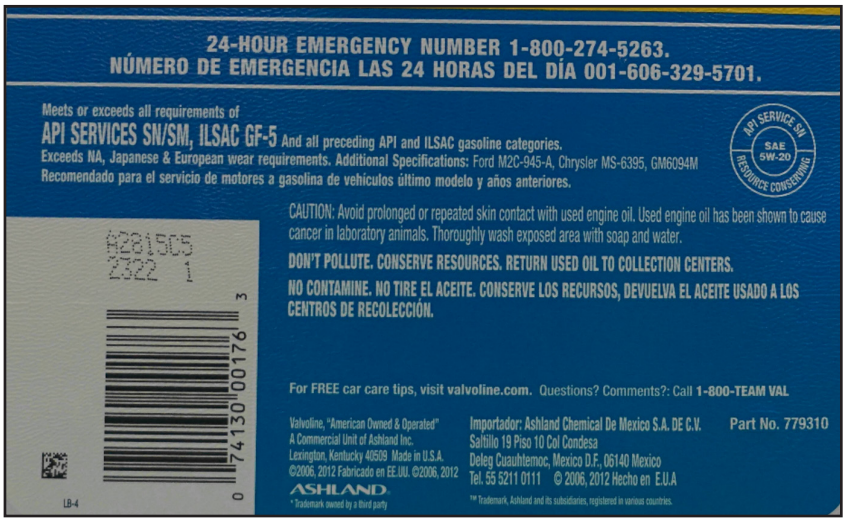
Castrol SAE **5W-20** synthetic blend part synthetic motor oil: _____



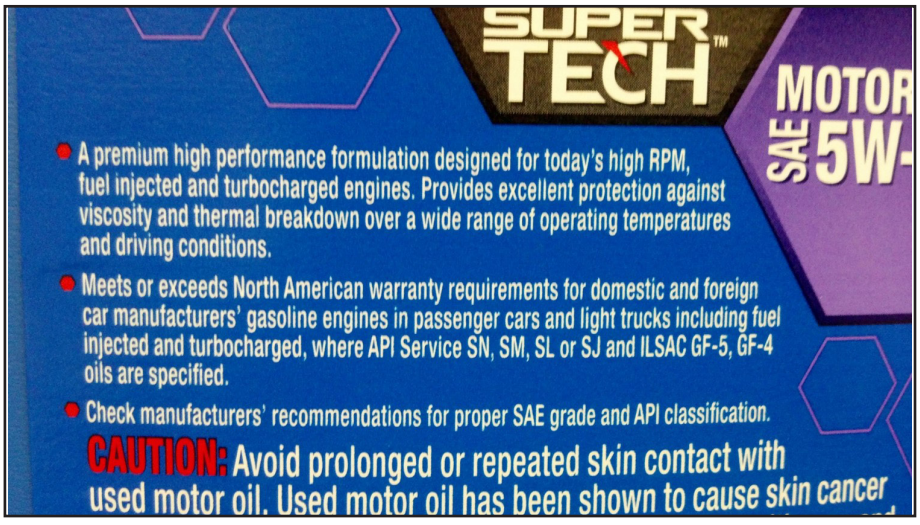
Castrol EDGE SAE **5W-20** full synthetic oil:

_____

Valvoline SAE **5W-20** conventional oil: _____



Super TECH SAE **5W-20** oil: _____

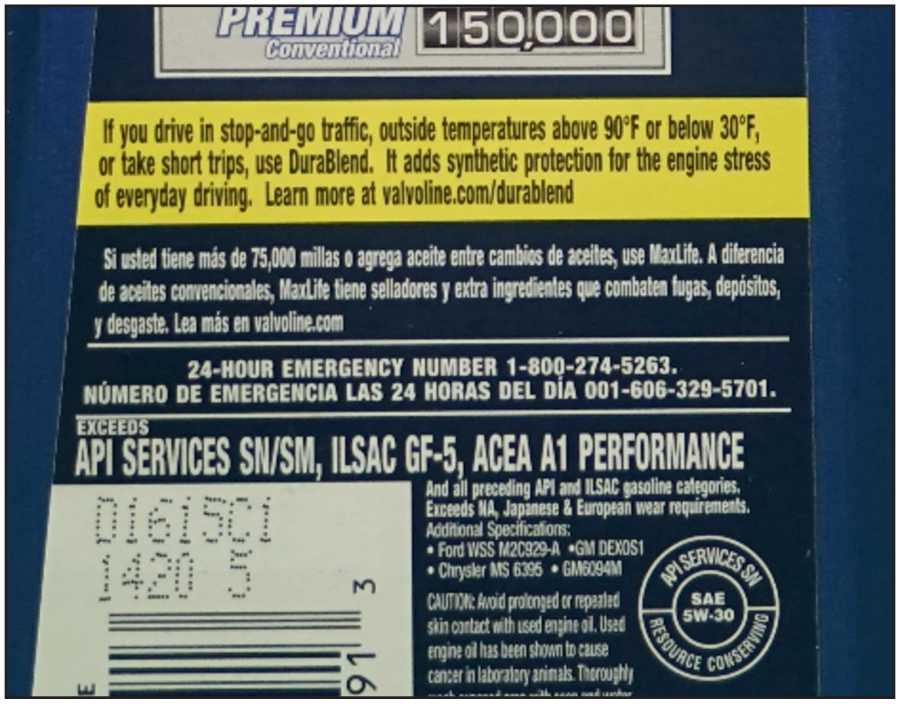


Now, let's take a look at a variety of **5W-30** oil. Ford Motorcraft **WSS-M2C946-A** specification synthetic blend SAE **5W-30** oil:

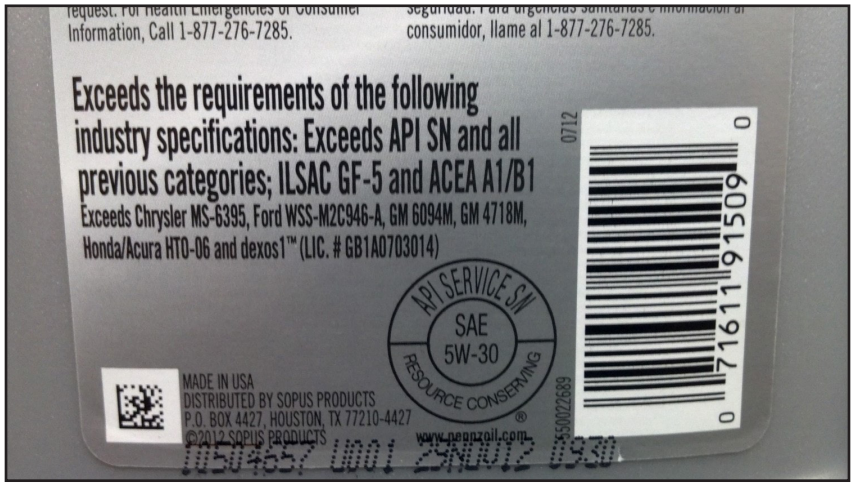
Pennzoil SAE **5W-30** synthetic blend oil: _____

Quaker State SAE **5W-30** conventional oil: _____

Valvoline SAE **5W-30** DuraBlend synthetic oil: _____



Pennzoil Platinum full synthetic **5W-30**: _____



API - Motoroilmatters.org

Motor Oil Matters (**MOM**) is a program from the American Petroleum Institute that will help you identify motor oil distributors and oil change locations that provide API-quality motor oil. The **MOM mark** is a sign you are receiving a high-quality product that meets API performance requirements. The program is designed for everyone that has an interest in oil quality— motor oil marketers, distributors, oil change locations and consumers. API already licenses oil marketers and manufacturers that meet API performance requirements and is now accepting licensing applications from distributors and installers. Motor Oil Matters is the American Petroleum Institute's new program for licensing motor oil distributors and oil change locations. MOM has one main goal: to make sure that consumers receive high-quality oil. This is accomplished by maintaining a secure chain-of-custody for motor oil from the marketer all the way to the vehicle. The MOM mark will help identify distributors and oil change locations committed to providing motor oil meeting the performance standard recommended by most vehicle and engine manufacturers.

ILSAC

ILSAC, **International Lubricants Standardization and Approval Committee**, was formed in 1992 by **AAMA** (**American Automobile Manufacturers Association**, representatives of Daimler Chrysler Corporation, Ford Motor Company and General Motors Corporation) and **JAMA** (**Japan Automobile Manufacturers Association**) to define the need, parameters, licensing and administration of lubricant specifications. Together with the **Tripartite system** (**API**, **SAE** and **ASTM**) they formed **EOLCS**, the **Engine Oil Licensing and Certification System**. ILSAC oils often carry the **API Service Symbol** (donut) including the **Energy Conserving** designation and/or **API Certification Mark** (starburst).

The **ILSAC GF-1** standard indicates the oil meets both API **SH** and the **Energy Conserving II** (**EC-II**) requirements. It was created in 1990 and upgraded in 1992 and became the minimum requirement for oil used in American and Japanese automobiles.

ILSAC GF-2 replaced **GF-1** in 1996. The oil must meet both API **SJ** and **EC-II** requirements. The **GF-2** standards requires **0W-30**, **0W-40**, **5W-20**, **5W-30**, **5W-40**, **5W-50**, **10W-30**, **10W-40** and **10W-50** motor oils to meet stringent requirements for phosphorus content, low temperature operation, high temperature deposits and foam control.

An **ILSAC GF-3** oil must meet both API **SL** and the **EC-II** requirements. The **GF-3** standard has more stringent parameters regarding long term effects of the oil on the vehicle's emissions system, improved fuel economy and improved volatility, deposit control and viscosity performance. The standard also requires less additive degradation and reduced oil consumption rates over the service life of the oil.

ILSAC GF-4 is similar to the API **SM** service category, but it requires an additional sequence **VIB Fuel Economy Test** (ASTM D6837).

ILSAC GF-5 was introduced in October 2010 for 2011 and older vehicles. It was designed to provide improved high temperature deposit protection for pistons and turbochargers, more stringent sludge control, improved fuel economy, enhanced emission control system compatibility, seal compatibility and protection of engines operating on ethanol-containing fuels up to E85. (Valid until September 30, 2011. Use **GF-5** where **GF-4** is recommended.)

New GF-6 Specification

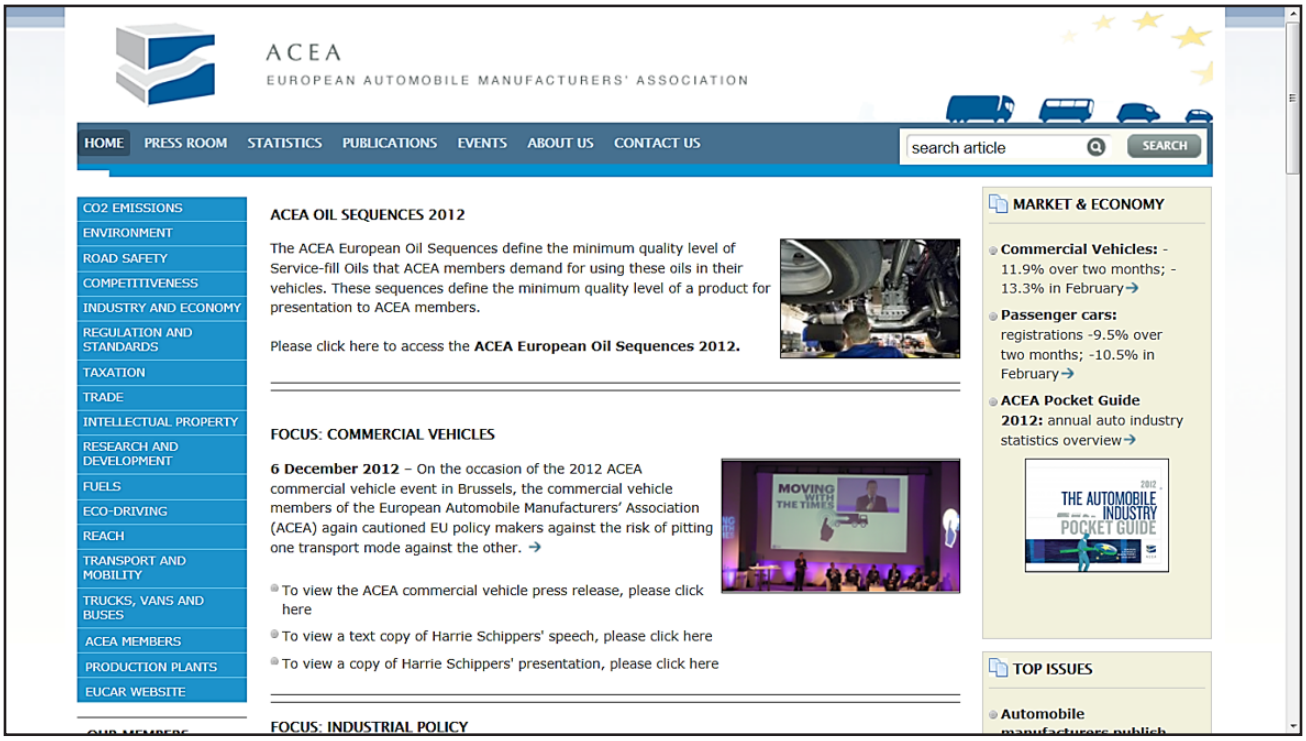
A new specification: **GF-6** has been under development since 2011. Automotive technology advancements has led to the need for updated motor oils. There will be a **GF-6A** and a **GF-6B**. Currently, it looks like **GF-6A** and **GF6-B** will come to market at the same time, September 30, 2016. Some 2017 vehicles will be factory-filled with **GF-6**.

European Automobile Manufacturers Association (ACEA)

The **European Automobile Manufacturers Association** (**ACEA**), founded in 1991, represents the interests of the fifteen European car, truck and bus manufacturers at EU level. Its membership consists of the major international automobile companies working together in an active association to ensure effective communication and negotiation with legislative, commercial, technical, consumer, environmental and other interests. The members of ACEA are competitors in the automobile market place and support free and fair competition as a trade policy and a legal concept. ACEA is an **Economic Interest Grouping**. Its headquarters are based in Brussels and made up of the Secretary General and the Secretariat. In 1995 and 2004, ACEA opened additional offices in Tokyo and Beijing. The Board of Directors is composed of the Chief Executive Officers (CEOs) of the automobile companies which are members of the Grouping.

Europe and the United States differ greatly when it comes to setting engine oil specifications. In Europe, vehicle manufacturers play the major role in developing lubricant specifications. Made up of **15** major European truck, bus and car manufacturers, the European Automobile Manufacturers Association, ACEA, publishes its engine oil

specifications as **ACEA European Oil Sequences**. In the United States, lubricant manufacturers play the major role in developing engine oil specifications. Comprised of more than **400** corporations, the American Petroleum Institute (API) publishes its specifications as **API Service Categories**. In the U.S., the **American Society of Testing and Materials** (**ASTM**) and its **classification panels**(one for gasoline and one for diesel) set test limits to establish engine oil quality. Each classification panel is headed up by a lubricant or additive company. ACEA specifications are different from API specifications in that OEMs are free to expand on them.



- **ACEA is controlled by auto manufacturers that have very specialized interests in protecting modern engine designs**
- **The *weakest* ACEA approval is more stringent than the *strongest* API approval**
- **ACEA specifications are different from API specifications in that OEMs are free to expand on them**
- **Most oils marketed in the U.S. *do not* meet the most exacting ACEA standards**

Because vehicle service is a more highly regulated industry throughout most of Europe, manufacturers can more readily dictate the types and even brands of oils and filters that are used. Most oils marketed in the U.S. do not meet the most exacting ACEA standards at this time.

If you are not prepared to provide an oil meeting the manufacturer's exact specifications, you and your customer must be prepared for the consequences. At the very best, you will have to drastically shorten the oil service interval. At the very worst, you may have to buy a new engine for your customer, so the consumer needs to be educated. They must understand the potential outcome of the ***no frills* $14.95** oil change is ***no real*** bargain in the long term. Think about having all your oil services written out and help customers choose the right oil for the vehicle based on the OE's recommendations. Once customers are educated, the sale goes a lot easier. Remember earlier we said some people will never be able to or want to understand these concepts, well shops need to make a decision as to whether or not to bow to the customer's request for the economical oil and filter service and potentially live with the consequences of their actions. It really is a very simple concept, but unfortunately, we hear over and over and over again, how the ***customer*** only wants the low cost option.

ACEA Ratings

ACEA ratings for 2004+ applications:

A1/B1: stable, stay-in-grade oil intended for use at extended drain intervals in gasoline engines and car and light van diesel engines specifically designed to be capable of using low friction, low viscosity oils with a high temperature/high shear rate viscosity of **2.6** mPa-s for **xW/20** and **2.9** to **3.5** mPa-s for all other viscosity grades. These oils are unsuitable for use in some engines. **Consult** an owner's manual or handbook if in doubt.

A3/B3: stable, stay-in-grade oil intended for use in high performance gasoline engines and car and light van diesel engines and/or for extended drain intervals where specified by the engine manufacturer, and/or for year-round use of low viscosity oils, and/or for severe operating conditions as defined by the engine manufacturer.

A3/B4: stable, stay-in-grade oil intended for use in high performance gasoline and direct injection diesel engines, but also suitable for applications described under **A3/B3**.

A5/B5: stable, stay-in-grade oil intended for use at extended drain intervals in high performance gasoline engines and car and light van diesel engines designed to be capable of using low friction low viscosity oils with a **High temperature/High shear rate** (**HTHS**) viscosity of **2.9** to **3.5** mPa-s.

ACEA revised their ratings in 2002, 2004, 2007, 2008, 2011, etc. They may contain the year in the suffix.

- **A1-99:** *obsolete*
- **A1-02:** *obsolete*
- **A1/B1-04**
- **A1/B1-07**

These ***are all*** different ratings.

ACEA Low Sulfated Ash Phosphorus-Sulfur

ACEA has added reduced **SAPS** ratings

- **C1** extremely low SAPS (**A5/B5**)
- **C2** low SAPS (**A5/B5**)
- **C3** low SAPS (**A3/B3**)
- **C4** extremely low SAPS (**A3/B3**)
- Once again, these are all much more stringent than any API or ILSAC requirement

SAPS stands for **sulphated ash**, **phosphorous**, **sulfur**. Low SAPS basically shows up as lower sulphated ash level on a specification sheet. **1.36** would be **full SAPS**. **1** would be **mid/lower SAPS**. Lower levels of SAPS are desired in order to protect modern day emissions systems. The way lower SAPS is achieved is typically by reducing the additive levels in the oil.

C1: stable, stay-in-grade oil intended for use as catalyst compatible oil in vehicles with **diesel particulate filters** (**DPF**) and **three way catalysts** (**TWC**) in high performance cars and light van diesel and gasoline engines requiring low friction, low viscosity, low SAPS oils with a minimum HTHS viscosity of **2.9** mPa-s. These oils will increase the DPF and TWC life and maintain the vehicle's fuel economy. **WARNING**: these oils have the lowest SAPS limits and are unsuitable for use in some engines. **Consult** an owner's manual or handbook if in doubt.

C2: stable, stay-in-grade oil intended for use as catalyst compatible oil in vehicles with DPF and TWC in high performance car and light van diesel and gasoline engines designed to be capable of using low friction, low

viscosity oils with a minimum HTHS viscosity of **2.9** mPa-s. These oils will ***increase*** the DPF and TWC life and maintain the vehicle's fuel economy.

C3: stable, stay-in-grade oil intended for use as catalyst compatible oil in vehicles with DPF and TWC in high performance car and light van diesel and gasoline engines with a minimum HTHS viscosity of **3.5** mPa-s. These oils will increase the DPF and TWC life.

WARNING: these oils are unsuitable for use in some engines. **Consult** an owner's manual or handbook if in doubt.

C4: stable, stay-in-grade oil intended for use as catalyst compatible oil in vehicles with DPF and TWC in high performance car and light van diesel and gasoline engines requiring low SAPS oil with a minimum HTHS viscosity of **3.5** mPa-s. These oils will increase the DPF and TWC life.

WARNING: these oils are unsuitable for use in some engines. **Consult** an owner's manual or handbook if in doubt.

Low SAPS basically will show up as lower sulphated ash level on a specification sheet. **1.36** would be full SAPS and a **1** would be mid/lower SAPS. Lower levels of SAPS are desired in order to protect modern day emissions systems. Lower SAPS is achieved by reducing the additive levels in the oil.

OEM Proprietary Oil Ratings

Proprietary oil ratings often address special engine protection requirements that are ***not*** addressed by **API**, **SAE** or **ILSAC** ratings.

The bottom line is that European motor oils are different because the classifications are different. In the United States, **API** and **ILSAC** regulate gasoline motor oils where the current specification supersedes the previous specification in most every instance. In this country, **API SN** and **ILSAC GF-5** are the two current specifications. In Europe, the **ACEA** regulates motor oils. There are eight active specifications for gasoline combined with light duty diesel oils alone, which are: **ACEA A1/B1**, **A3/B3**, **A3/B4**, **A5/B5**, **C1**, **C2**, **C3**, **C4**. Differences between them vary from shear stability to sulfated ash content, to extended drain intervals.

Ignoring proprietary requirements has resulted in catastrophic engine damage and denial of warranty coverage. Most times, unless you can identify an approved oil, the OEM oil product is our safest choice. One thing you will find in both markets is that as engine technology advances, the demands on motor oil continue to be even greater and there are reasons why an increasing number of makes and models are recommending synthetics. Looking for the donut is going to be insufficient in the U.S. You will need to focus on those other details. The question is no longer, *"Is it good for Volkswagens?"* It is now a question of ***which*** Volkswagen specification the oil is good for. ***Does it meet VW 504.00/507.00?***

General Motors

- **GM proprietary ratings:**
  - **GM 6094M**
  - **GM 4718M**
  - **LL-A-25**
  - **LL-B-25**
  - **GEOS-A/dexos1**
  - **GEOS-B/dexos2**
  - **All these GM specifications exceed ILSAC requirements**

GM dexos® is a Global Specification

In 2011, General Motors announced a new oil requirement called **dexos®**. The specification was uniquely designed to complement the exact requirements of GM's advanced engine technology. GM has found that using substandard oil can affect engine performance and unlicensed products have not gone through GM's rigorous testing process.

While fuel economy is one of the drivers in the dexos design, GM really wanted a more robust oil. Simply put, GM wants an oil that is consistent throughout its life. That is because the GM oil life monitoring system will determine when to change oil based on the number of cold starts, engine RPMs, engine load, etc. These are all the factors that affect engine oil life.

If you can't depend on the oil to be consistent throughout its life, then you can't depend on an oil life monitoring system!

dexos1 APPROVED

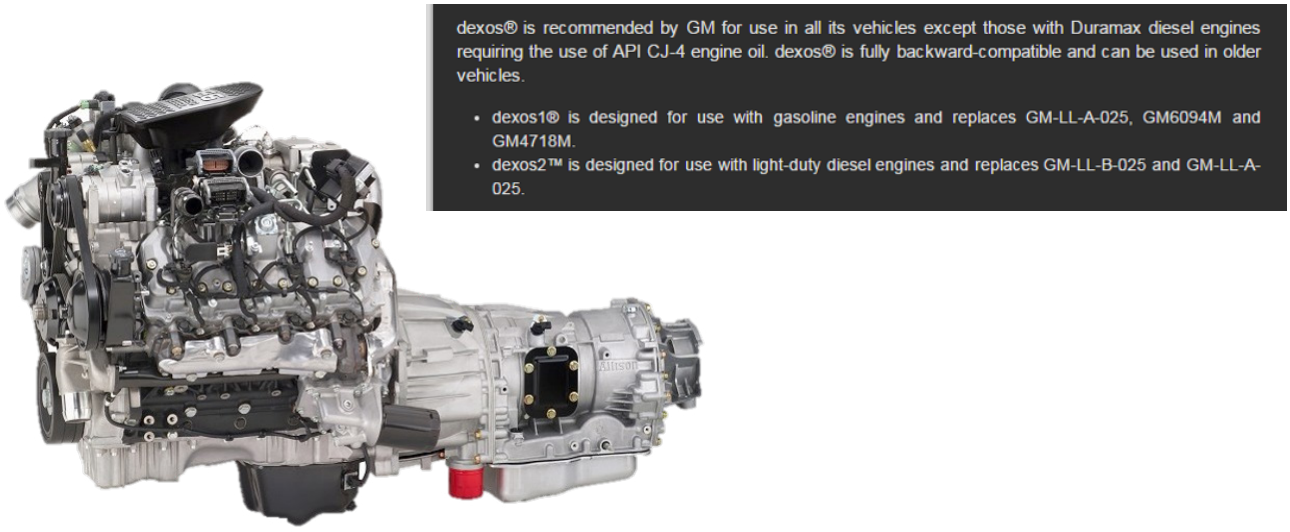
Gasoline

dexos2 APPROVED

Diesel

Not for Duramax Diesels

Dexos 2 is for all GM light duty diesels ***except*** the Duramax. This image is from the gmdexos.com website. Remember, that this is a global specification and considers all of General Motor's diesel platforms sold worldwide.



dexos Specifications

General Motors says their new oil performance specification is better than the new **GF-5** specification which also goes into effect this fall. GM says dexos will be required in all 2011 and newer GM engines and it will be backwards compatible with older engines that use **SM** oils.

There will be two versions of dexos: **dexos1** for gasoline engines and **dexos2** for diesel engines. The specification calls for a high quality synthetic base stock with additives that provide high temperature, high sheer characteristics to reduce friction for better fuel economy, to reduce piston ring deposits and sludge and to extend oil life (necessary for use with GM's Oil Life Reminder System).

Because it uses high quality synthetic base stocks, dexos and other brands of oil that meet GM's dexos specification will likely cost **30-60%** more than conventional motor oil. GM will license other brands that meet their specification. **Pennzoil Platinum**, **Quaker State Ultimate Durability** and **Mobil 1** all claim to meet the new dexos specification now in their SAE **5W-30** viscosity grade motor oils.

Trademark & Icon

There are many authentic licensed dexos™ products readily available at retail outlets, service repair shops, quick lube operations and GM service centers. dexos™ licensed products are easy to identify. Only oils displaying the **GREEN** or **BLUE** dexos™ trademark and icon on the front label have been certified and licensed by GM as meeting the demanding performance requirements and stringent quality standards of dexos™. Simply look for the **dexos™ icon** on the front label and the **11** digit alphanumeric dexos™ license number on the back label. Unless an oil package displays these two markings, the engine oil is not an authentic, licensed dexos™ product and is not recommended for use in GM vehicles.

5W-30 dexos™ Features

- **Exceeds ILSAC GF-5 requirements for new cars under warranty**
- **Outstanding resistance to viscosity and thermal breakdown at high temperatures**
- **Protects against sludge and varnish formation**
- **Protects against rust and bearing corrosion**
- **Low volatility for reduced oil consumption**
- **Highly resistant to aeration and foaming**
- **Formulated to protect turbochargers and emission control system catalysts**
- **Formulated for use in vehicles operating on ethanol-containing fuels up to E85**

dexos Certificate of License

Pictured on the right is a dexos certificate of license to prove the oil meets rigorous quality requirements for dexos1® engine oil.

GM

dexos1

Certificate of License

issued to

CARQUEST

This document certifies that the company named above is authorized to use the General Motors dexos1® trademark in conjunction with the fluid specified below:

License No.:	RB1A1130028	Expiration Date:	December 31, 2014
Formulation Code:	77 / 20000	License Region:	North America
Viscosity Grade:	5W-30	Marketing Name:	CARQUEST Full Synthetic

This fluid has met the rigorous quality requirements for dexos1® engine oil. The company named above has agreed to maintain the terms of and comply with the quality standards set forth in the dexos® Licensing Program Policies and Procedures and Licensing Agreement. The license number and a date code within the expiration date shown above must appear on all container labels of licensed product.

Should there be any questions regarding this license, please contact the Center For Quality Assurance, administrator of the dexos® Licensing Program:

Center For Quality Assurance
4800 James Savage Road
Midland, MI 48642 USA
T: +1 989 496 2399
F: +1 989 496 3438
E: dexos@CenterForQA.com
www.CenterForQA.com

Rebecca Cox
Authorized Signature

February 14, 2014
Date

Subscribed and sworn to before me this:
14th day of February, 2014
YoVonne Decarla Starks, Notary Public
County of Saginaw, State of Michigan, USA
Acting in the County of Midland, State of Michigan, USA
My Commission Expires: January 28, 2020

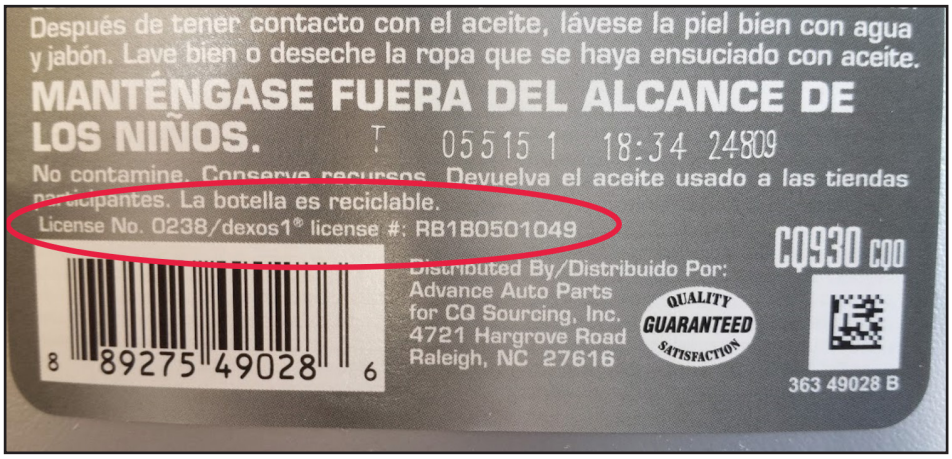
Rev: 20110114

Form D6 Certificate of License

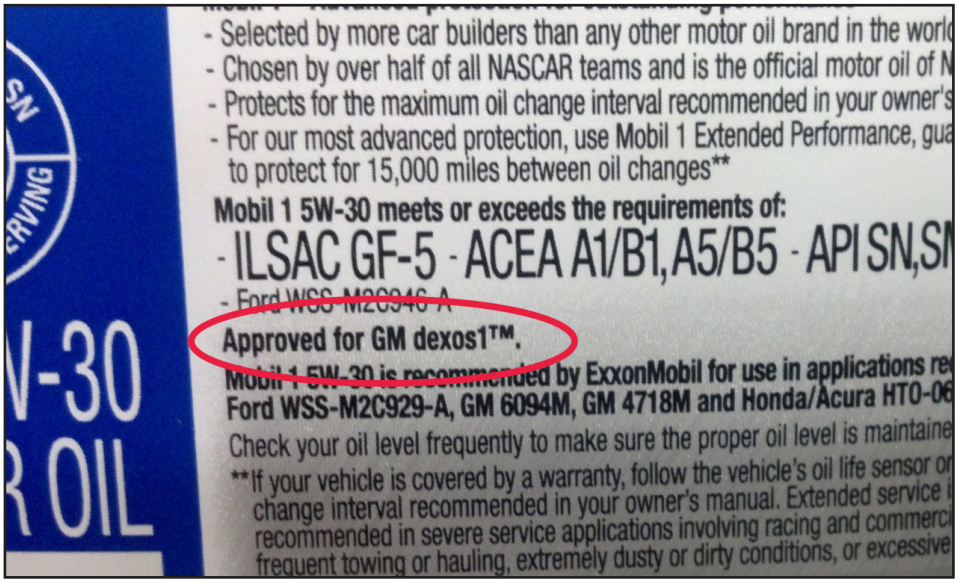
AC Delco dexos™

Many technicians believe that the dexos specification is a full synthetic oil, it is ***not***. It is a **synthetic blend**. The AC Delco container clearly identifies it as a synthetic blend.

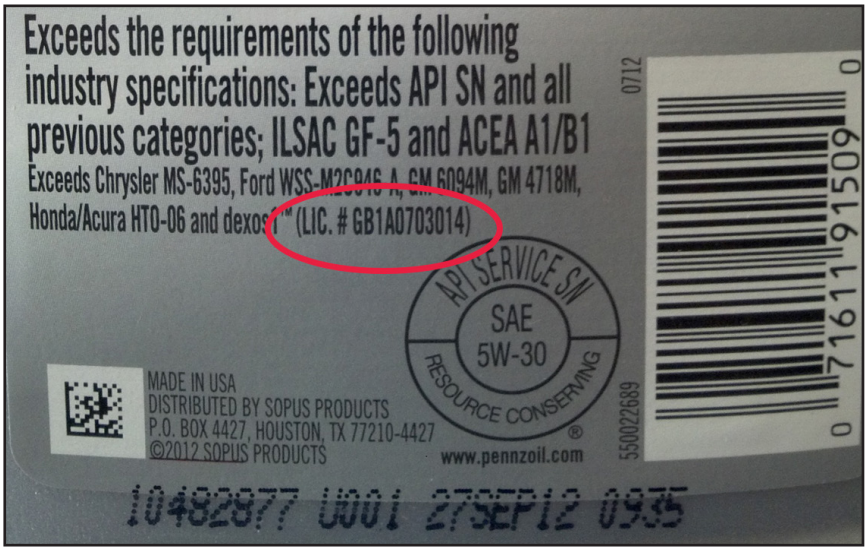
CARQUEST Branded dexos™



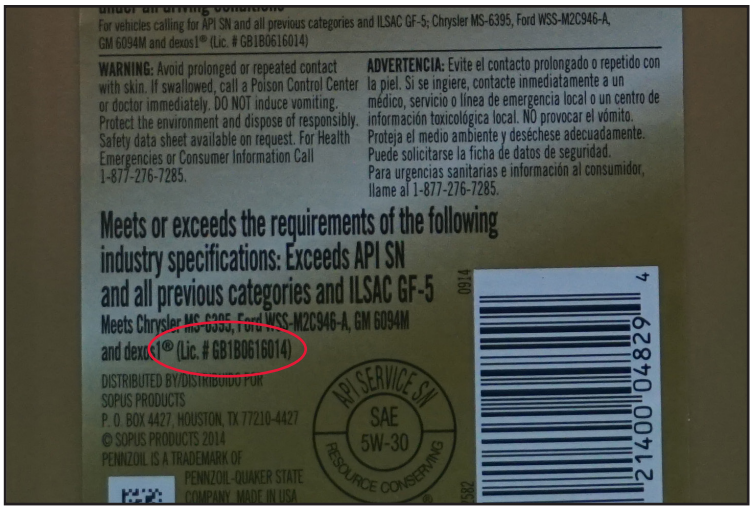
Mobil 1 Meets GM Specifications



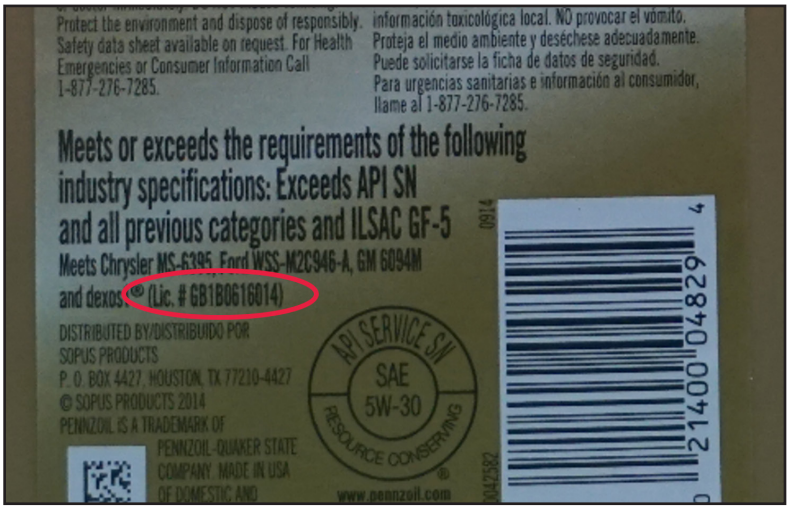
Pennzoil Platinum dexos™



Pennzoil Synthetic Blend dexos™



Quaker State dexos™



Royal Purple 5W-30

Ford Specifications

- **Ford proprietary specifications:**
  - **WSS-M2C153-H (pre-2004 5W-20)**
  - **WSS-M2C929-A (5W-30)**
  - **WSS-M2C930-A (5W-20)**
  - **WSS-M2C913-A/B (Generally 5W-30)**
  - **WSS-M2C931-B (5W-50)**
  - **WSS-M2C945-A (5W-20)**

Motorcraft SAE 5W-20

Ford Issues New Oil Specification

With the help of BP Castrol, Ford has created a proprietary engine oil for its innovative 1.0-liter, three-cylinder EcoBoost engine – 3/7/2012. Ford recommends SAE **5W-20** oil now for virtually all gasoline-fueled Fords in Europe. The new specification is **WSS M2C948 B**.

Chrysler Specifications

- **Chrysler proprietary specifications:**
  - **MS 6395 M**
  - **MS 6395 N**
  - **MS 6395 Q**
  - **MS 6395 R**

BMW Specifications

- **BMW engines proprietary specifications:**
  - **BMW LL-98**
  - **BMW LL-01**
  - **BMW LL-04 LOW SAPS**
  - **All of these specifications are much more stringent than any API or ILSAC ratings**

BMW High Performance Synthetic Oil is recommended for scheduled engine oil changes and BMW requires High Performance SAE **5W-30** Synthetic Oil* (BMW part number **07 51 0 017 866**).

BMW Long-life rating **LL-01** Approved Synthetic Oils for the U.S. Market:

- **Castrol Syntec European Formula SAE 0W-30**
- **Mobil 1 SAE 0W-40**
- **Pennzoil Platinum European Formula Ultra SAE 5W-30**
- **Valvoline SynPower SAE 5W-30**

Use only oils with an API rating of **SM** or ***higher***.

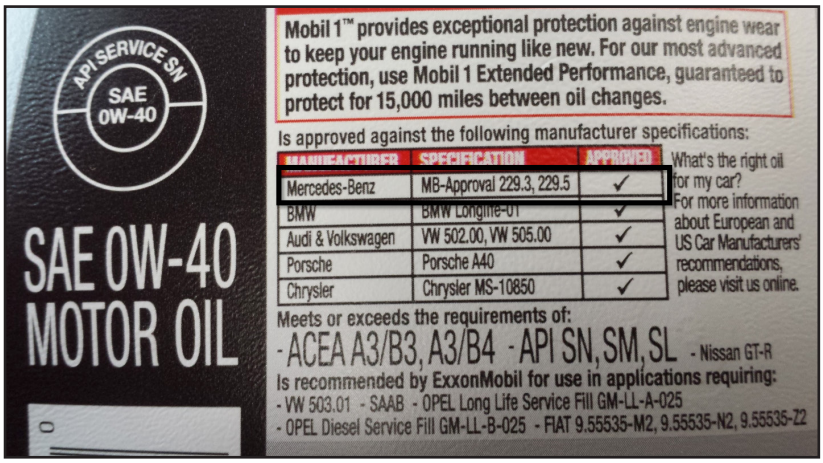
The choice of the right SAE grade is based on the climatic conditions in the region in which you normally drive your BMW.

Mercedes Benz Specifications

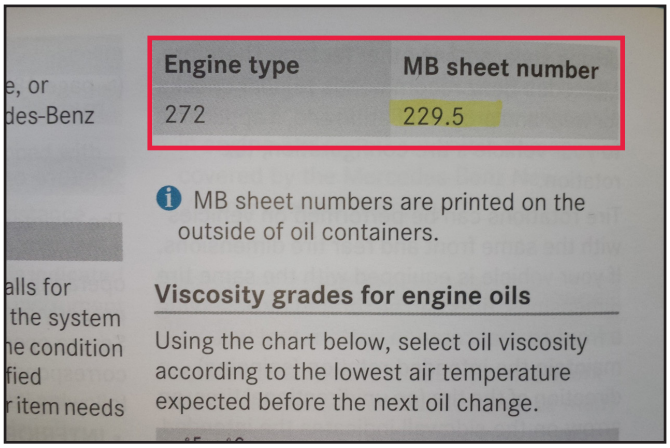
- **Mercedes Benz proprietary specifications:**
  - **MB 229.1 for 1998 and later models**
  - **MB 229.3 for FSS oil monitor systems**
  - **MB 229.31 with Low SAPS 229.3**
  - **MB 229.5 for 2005+ AMG and MMS vehicles**
  - **MB 229.51 Low SAPS 229.5 for LD Diesels (blue-tec) engines**
  - **All of these specifications are much more stringent than any API or ILSAC ratings**

Mercedes-Benz

Mobil 1 0W-40 Euro Formula



2010 MB GLK 350 Oil Specification



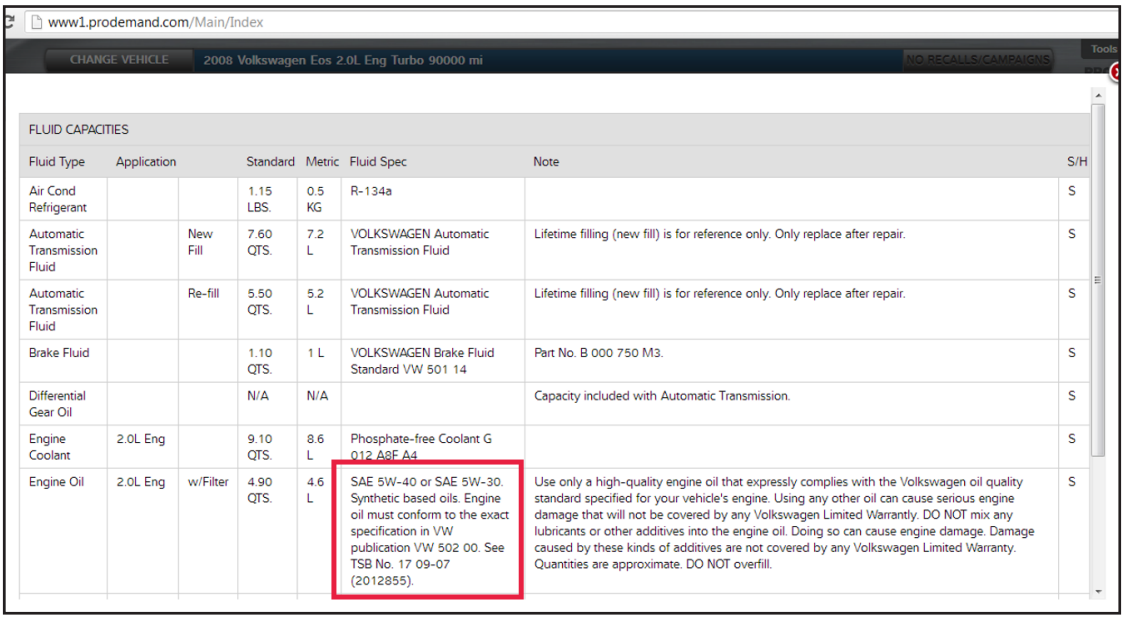
Volkswagen/Audi Specifications

- **VW/Audi proprietary specifications:**
  - **VW 502 is the minimum requirement for all 1998+ North America VW/Audi gas engines**
  - **VW 503 and 503.01 are European Specifications**
  - **VW 504 LL with Low SAPS and High Fuel Efficiency and replaces VW 502**

VW 501.01 Conventional motor oils suitable for some Volkswagen engines built before model year 2000. This is an old oil specification and is applicable to engines built before model year 2000 (up to August 1999). Oils with an approval made post March 1997 were given an alternative, later VW specification.
VW 502.00 Oil for gasoline engines. Successor of **VW 501.01** and **VW 500.00** specification. Recommended for those which are subject to arduous conditions. It must not be used for any engines with variable service intervals or any which are referred to under other specifications.
VW 503.00 Long-life gasoline engine oil for VW cars with WIV (system for longer service intervals). Also meets **ACEA A1**, **SAE 0W-30** or **5W-30** specification.
VW 503.01 This specification is specifically for Audi RS4, Audi TT, S3 and Audi A8 6.0 V12 models with outputs of more than 180 bhp, running with variable service intervals (**30,000** km or **2** years). Now superseded by the **VW 504.00** specification. **VW 504.00** The **VW 504.00** specification supersedes the **VW 503.00** and **VW 503.01** specifications.
VW 504.00 oils are suitable for engines meeting the demands of Euro IV emissions standards.
VW 505.00 Passenger car diesel engine oil specification, minimum performance level **CCMC PD-2**. Lists viscosities SAE **5W-50**, **10W-50/60**, **15W-40/50**, **20W-40/50** requiring **13%** maximum evaporation loss and SAE **5W-30/40**, **10W-30/40** requiring **15%** maximum evaporation loss.
VW 505.01 Special engine oil for VW turbo diesel engines with pump-injector-unit and for the V8 common rail turbo diesel engines. Meets ACEA **B4** SAE **5W-40** specification.
VW 506.00 These oils are suitable for diesel engines with extended service intervals of up to **50,000** km /**2** years. Not for use on engines with a single injector pump. Oil change is indicated by the electronic service indicator. Viscosity is SAE **0W-30**.
VW 506.01 These oils are especially for **Pumpe-Düse** (unit injector or **PD** engines) running on extended service intervals (**30,000** - **50,000** km/**24** months). Oil change is indicated by the electronic service indicator.
VW 507.00 Low SAPS oils suitable for Euro 4 engines and almost all VAG diesel engines from 2000 onwards with extended service intervals, unitary injector pumps and also **Pumpe-Düse** (**PD**) engines. Excludes V10, R5 engines and VW commercial vehicles without fitted **DPF** (**diesel particulate filters**) – these must use a **506.01** specification oil.
VW 508.00 This standard is not yet released. It will probably require a low SAPS oil with energy conserving properties.

- **Volkswagen/Audi requires:**
  - **VW 505 for *all* TDI Diesels**
  - **VW 505.01 for all TDI-PD Diesels**
  - **VW 506 and 506.01 are European specifications**
  - **VW 507 is the newest specification and replaces all others for Volkswagen/Audi**
  - **According to VW/Audi, the 2.5L R5 and 5.0L V-10 engines should still use 505.01 oil**

Mitchell ProDemand

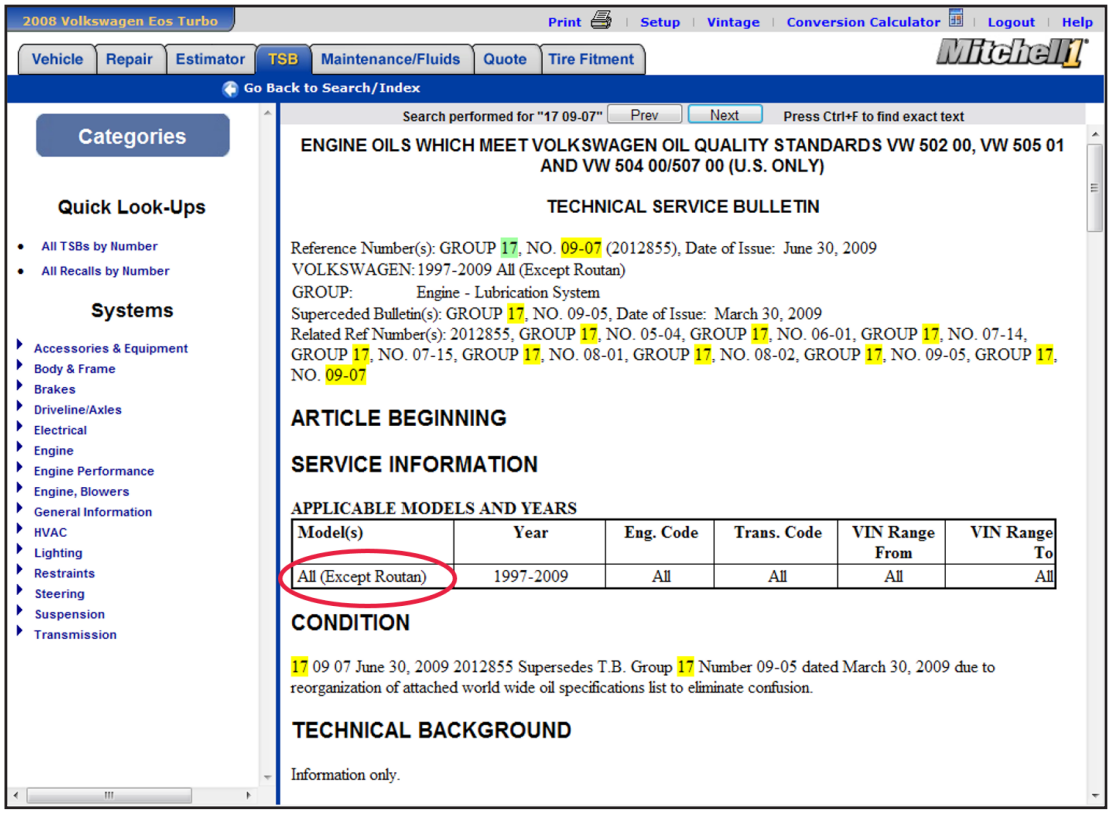


FLUID CAPACITIES

Fluid Type	Application		Standard	Metric	Fluid Spec	Note	S/H
Air Cond Refrigerant			1.15 LBS.	0.5 KG	R-134a		S
Automatic Transmission Fluid		New Fill	7.60 QTS.	7.2 L	VOLKSWAGEN Automatic Transmission Fluid	Lifetime filling (new fill) is for reference only. Only replace after repair.	S
Automatic Transmission Fluid		Re-fill	5.50 QTS.	5.2 L	VOLKSWAGEN Automatic Transmission Fluid	Lifetime filling (new fill) is for reference only. Only replace after repair.	S
Brake Fluid			1.10 QTS.	1 L	VOLKSWAGEN Brake Fluid Standard VW 501 14	Part No. B 000 750 M3.	S
Differential Gear Oil			N/A	N/A		Capacity included with Automatic Transmission.	S
Engine Coolant	2.0L Eng		9.10 QTS.	8.6 L	Phosphate-free Coolant G 012 A8F A4		S
Engine Oil	2.0L Eng	w/Filter	4.90 QTS.	4.6 L	SAE 5W-40 or SAE 5W-30. Synthetic based oils. Engine oil must conform to the exact specification in VW publication VW 502 00. See TSB No. 17 09-07 (2012855).	Use only a high-quality engine oil that expressly complies with the Volkswagen oil quality standard specified for your vehicle's engine. Using any other oil can cause serious engine damage that will not be covered by any Volkswagen Limited Warranty. DO NOT mix any lubricants or other additives into the engine oil. Doing so can cause engine damage. Damage caused by these kinds of additives are not covered by any Volkswagen Limited Warranty. Quantities are approximate. DO NOT overfill.	S

Technical Service Bulletin

This is a Technical Service Bulletin affecting the oil quality standards for 1997-2009 Volkswagen vehicles. The Volkswagen Routan uses a Chrysler powertrain and is not covered by this bulletin.



ENGINE OILS WHICH MEET VOLKSWAGEN OIL QUALITY STANDARDS VW 502 00, VW 505 01 AND VW 504 00/507 00 (U.S. ONLY)

TECHNICAL SERVICE BULLETIN

Reference Number(s): GROUP 17, NO. 09-07 (2012855), Date of Issue: June 30, 2009
VOLKSWAGEN: 1997-2009 All (Except Routan)
GROUP: Engine - Lubrication System
Superceded Bulletin(s): GROUP 17, NO. 09-05, Date of Issue: March 30, 2009
Related Ref Number(s): 2012855, GROUP 17, NO. 05-04, GROUP 17, NO. 06-01, GROUP 17, NO. 07-14, GROUP 17, NO. 07-15, GROUP 17, NO. 08-01, GROUP 17, NO. 08-02, GROUP 17, NO. 09-05, GROUP 17, NO. 09-07

ARTICLE BEGINNING

SERVICE INFORMATION

APPLICABLE MODELS AND YEARS

Model(s)	Year	Eng. Code	Trans. Code	VIN Range From	VIN Range To
All (Except Routan)	1997-2009	All	All	All	All

CONDITION

17 09 07 June 30, 2009 2012855 Supersedes T.B. Group 17 Number 09-05 dated March 30, 2009 due to reorganization of attached world wide oil specifications list to eliminate confusion.

TECHNICAL BACKGROUND

Information only.

Land Rover, Jaguar & Volvo

Land Rover, Jaguar and Volvo vehicles have adjusted oil requirements for North America. Engine oil must meet the minimum ILSAC specification **GF-4**, API **SL**, or ACEA **A1/B1**. Lower quality oils may not offer the same fuel economy, engine performance, or engine protection and Volvo recommends Castrol. Depending on your driving habits, premium or synthetic oils may provide superior fuel economy and engine protection. Always consult the Volvo owner's manual for recommendations on premium or synthetic oils.

Low HTHS (THIN) Ratings

- **ACEA A1/B1, A5/B5, C1 and C2**
- **GM 6094M, 4718M and dexos1**
- **Ford WSS-M2C153-H/929-A/930-A**
- **ILSAC GF3/4**
- **Honda HTO-06**
- **A 5W-30 oil with these approvals would be a THIN 5W-30**

High HTHS (THICK) Ratings

- **ACEA A3/B3, A3/B4, C3 and C4**
- **VW 502, 503.01, 504, 505, 505.01 and 507**
- **MB 229.3, 229.5, 229.31 and 229.51**
- **BMW LL-98, LL-01, LL-04**
- **GM LL-B-25, dexos2**
- **A 5W-30 oil with these approvals would be a THICK 5W-30**

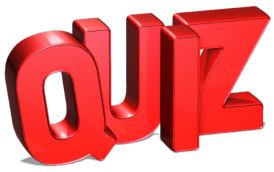
The Oil Change Has Changed

Long drain compatible vehicles are generally equipped with service computers which may decide to order an oil change sooner if the operating conditions are less than optimal, e.g., too many cold starts, too many short trips, etc.

Long Life Oil Ratings

- **ACEA A/3/B3, A3/B4, A5/B5, C1, C2, C3, C4**
- **VW 503, 503.01, 506, 506.01, 504, 507**
- **Mercedes Benz 229.3, 229.5, 229.31, 229.51**
- **BMW Long Life (LL-98/01/04)**
- **GM LL-A-25, LL-B-25, dexos1 and dexos2**

Quiz



Connect the terms in the left hand column with the descriptions on the right.

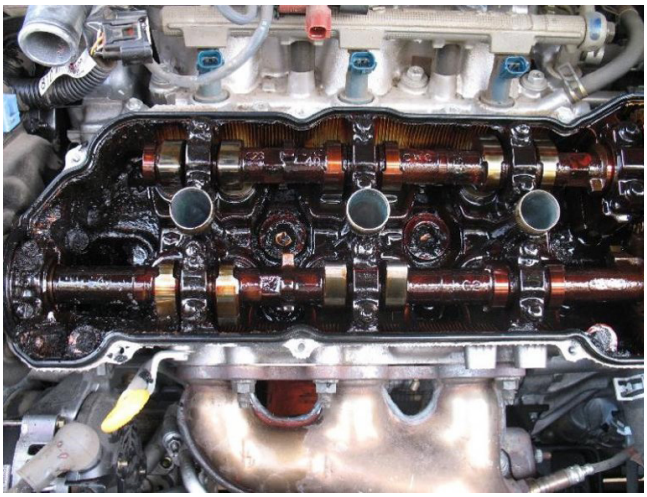
A. SAE 0W-30	■ GM certification rating for LD diesel engine oil
B. CJ-4	■ Oil grade
C. dexos1	■ Service rating for a diesel engine oil
D. dexos2	■ GM certification for a gasoline engine oil
E. SN	■ Service rating for gasoline engine oil

Engine Oil Service & Oil Life Monitors

Why Do We Change Oil Regularly?

Changing the oil at regular intervals removes contaminants that may form deposits if left in the engine. It also replaces the additive package to continue protecting the engine while maintaining optimum viscosity for improved fuel economy.

Regular Oil & Filter Service Prevents This



Threats to Motor Oil Effectiveness

High temperatures ***increase*** the rate at which motor oil reacts with contaminants. When possible, oil temperature should be maintained ***below*** **220°F**. The cooling system temperature required for water to vaporize out of the oil is **185-195°F**. The ideal cooling system temperature for oil is therefore approximately **195°F**. Oil temperature is usually **10°F - 25°F** ***hotter*** than coolant temperature. Fuel and moisture are effectively removed at oil temperatures of between **215°F - 220°F**.

High pressure can squeeze the oil out from between moving parts which can be a threat to motor oil effectiveness.

Mechanical shearing can also be a threat. Some molecules in lower viscosity index numbers can be degraded by the valve train and oil pump.

Contaminants are also produced in the normal operation of the engine.

Contaminants

For every **100** gallons of gasoline burned in an engine, these byproducts are produced:

- **90-120** gallons of water
- **3-10** gallons of unburned gasoline
- ½ to **2** pounds of soot and carbon
- **1-4** pounds of sulfuric and nitric acid

A measurable percentage of these byproducts end up in the crankcase oil potentially contaminating the oil. When dispersed properly in oil, the filter can trap the larger particles. Contaminants too small to be filtered are removed with the engine oil change. If the oil does not disperse contaminants properly into the oil, or if the oil does not get changed, the suspended particles begin to settle out of the oil forming sludge and damaging deposits.

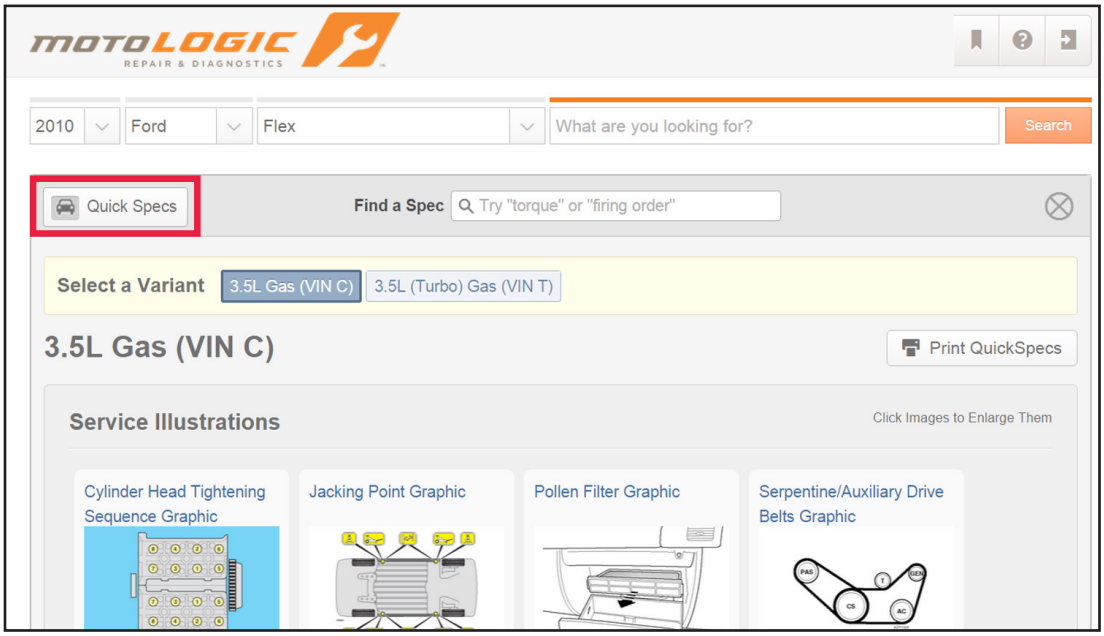
Changing Engine Oil

Selecting the correct oil for the engine is critical. Oil that is too ***thick*** at ***low*** temperatures is slow to reach critical engine components immediately after the engine is started. Delayed lubrication results in severe and irreversible wear at precision-fit components. The wrong grade of oil can also cause performance problems. Thick oil can cause engine valves to hang **open** too long creating misfire conditions that can illuminate the **CHECK ENGINE LIGHT** and store diagnostic trouble codes in the vehicle's computer. Hybrid vehicles are especially sensitive to this issue of oil that is too viscous. Make sure you use oil that meets the current specification per the OEM, otherwise you may not be replenishing the additive package that came with the OE oil. Oils are specially blended for use in different engines. The wrong oil can damage the engine. **Check** the owner's manual and **follow** its recommendations. If the owner's manual is not with the vehicle, **look** it up in your information system.

MotoLOGIC Quick Specs

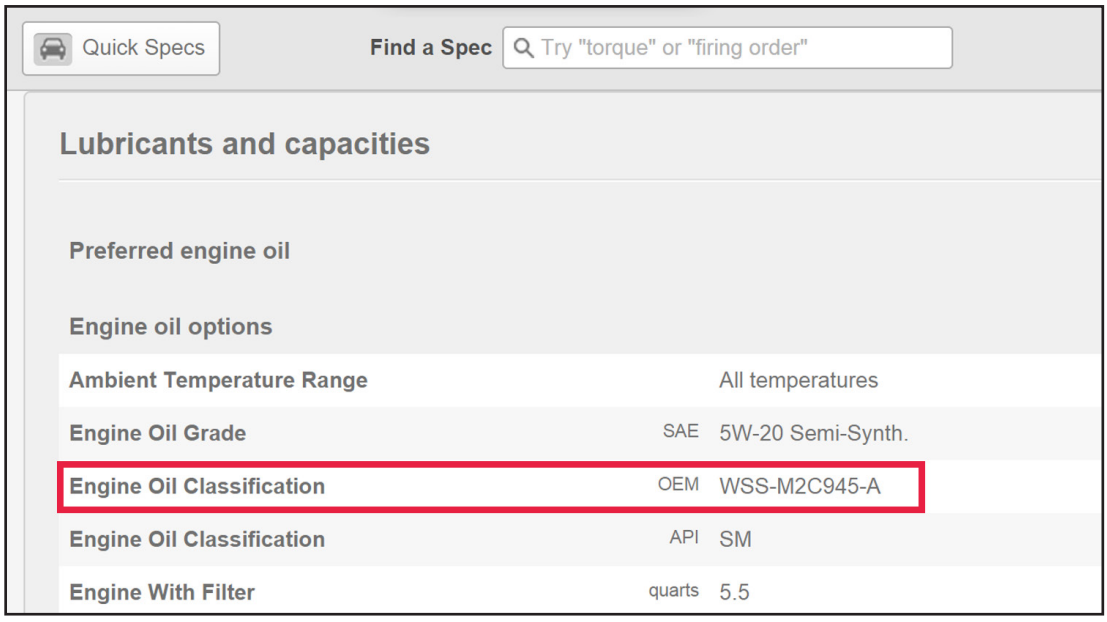
MotoLOGIC has a very nice feature called **Quick Specs** in the left hand corner of the screen. When you scroll down, you will find the OE's lubricant specifications. As with many information systems, the specifications are

sometimes there and sometimes they are in a different location, or they may not be there at all. If that is the case, we should look in the owner's manual for the proper engine oil specification. Many Asian manufacturers do not even have their own specification. They simply state in the owner's manual, as long as it meets API **0W-20** and **GF-5** specifications, it is satisfactory for use in their engines.



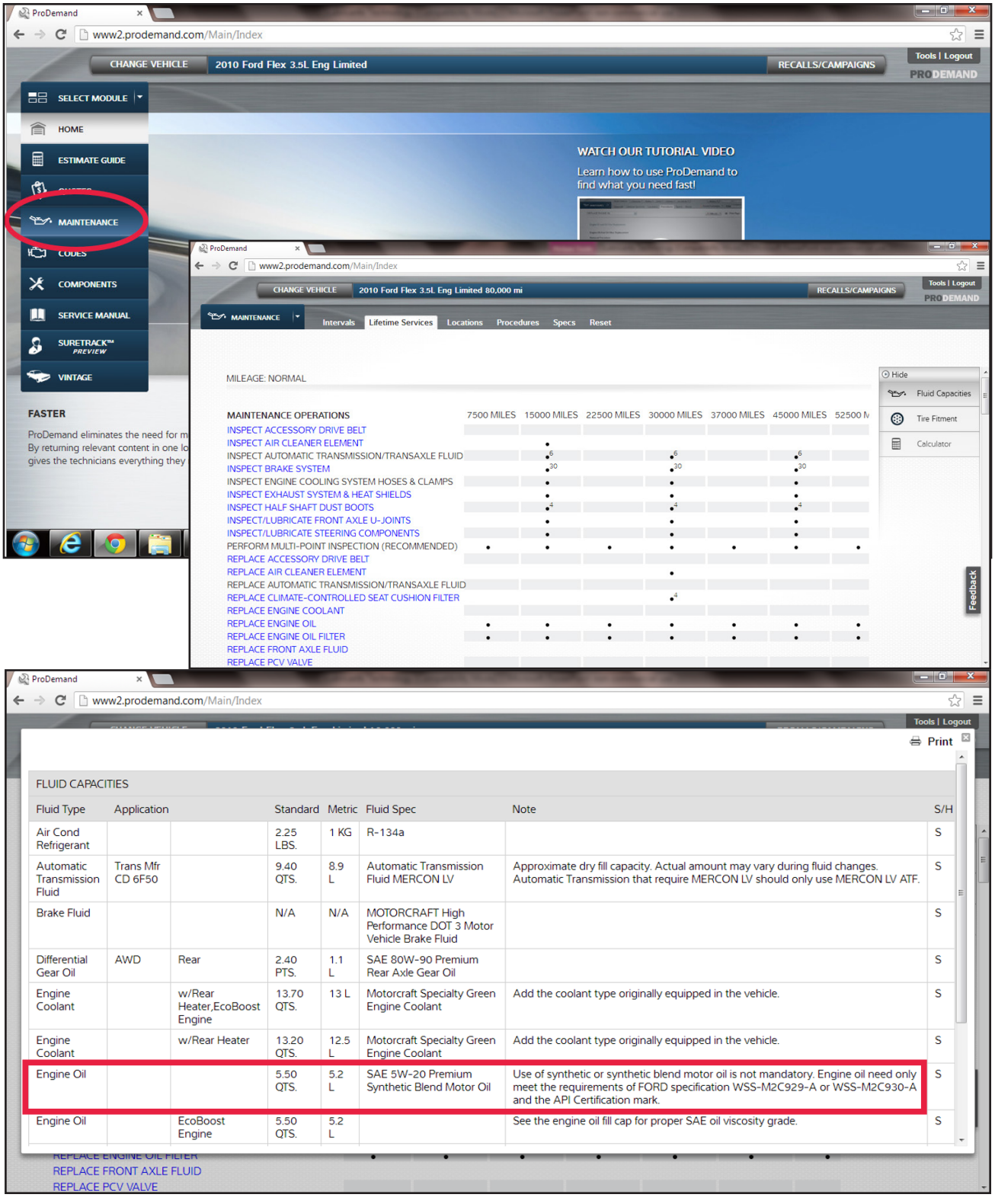
Lubricants Quick Specs

This example of service information is for a 2010 Ford Flex with a 3.5L V6 engine and shows the actual Motorcraft **WSS-M2C945-A** oil specification. This is not difficult at all to find on the back of the oil container. If the oil that your using meets the specification, it is usually printed right on the container label. However, if your using a bulk oil supplier, you may have to ask the supplier for this information. **Note**: just because the oil meets industry oil specifications, does not mean it is going to meet the OEM oil requirements.



Mitchell ProDemand

Mitchell ProDemand has a nice feature under the **MAINTENANCE** selection. It provides users access to fluid specifications for the vehicle selection.



Engine Oil Service

Torque Specifications

BMW requires technicians to torque the drain plug to **25 Nm** (**18.4 ft-lb**). The same torque specification is for the oil filter cap which is written on the oil filter housing.

Acura torque specifications state to **put** a new washer on the drain bolt, then **reinstall** the drain bolt **tightening** the drain bolt to **19** lbf/ft (**39** Nm, **4.0** kgf/m).

Checking Filter for Abnormalities

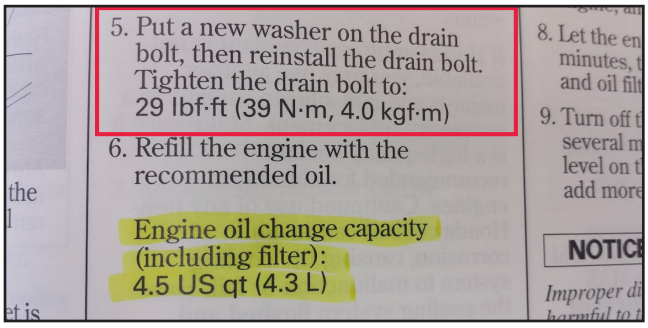
The oil filter should always be checked for abnormalities.

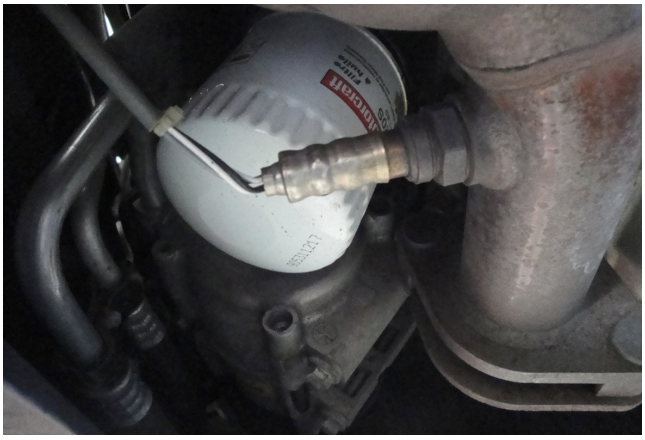
These three photographs illustrate draining the oil, inspecting the drain plug and gasket (many OEMS require the gasket be changed at each oil change), and replacing the oil filter.

New Drain Plug Gasket

Tighten to Specification

Some OE oil drain plugs are hollow and will break clean off as to not allow the oil pan threads to be stripped.





Oil Filter Installation

Coat the oil filter gasket with a small amount of fresh motor oil.

2011 Toyota Highlander: 3.5L V6 Oil & Filter Service

This is an example of a regular service on a 2011 Toyota Highlander. The oil and filter change takes a little longer than the average vehicle due to the method of how the oil filter is serviced. It is a cartridge type filter and the aftermarket and OE filter has all of the O-rings, drain plug gasket, filter and drain valve in the oil filter box.

Oil Maintenance Minder

On newer vehicles, there is no longer a need for a reminder sticker to remind the consumer of when to change the oil. This particular customer is following the Toyota recommendations and maintaining their vehicle using the **Oil Maintenance Minder** located on the dashboard. This vehicle does ***not*** use an **oil life monitor**. It is simply a mileage or time based reminder. In this customer's case, it reminds them to change the oil on the Toyota interval set on this car to approximately **5,000** miles.

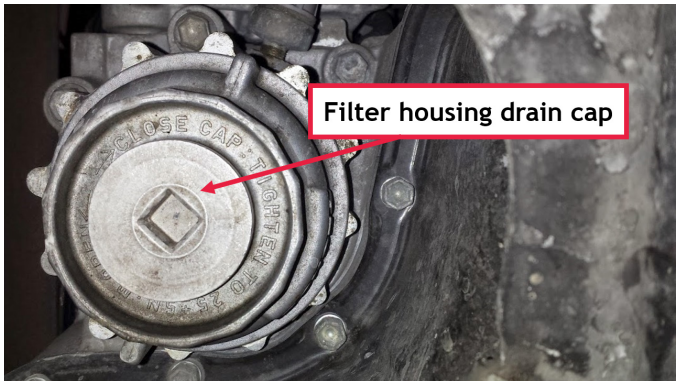
As stated directly on the oil cap, this engine requires **0W-20** full synthetic motor oil.

The **drain plug gasket** is supplied with the new oil filter in the box.

All of the aftermarket filter kits we looked at came complete with the O-rings, drain plug gasket and the oil drain tube for the oil filter housing. The filter media is a whole different story. We will discuss filter media and entrapment technologies later in the course.

How long can it take to change oil and a filter?

On this vehicle, we need to remove the oil filter housing cover. Be sure to add approximately **10-15** extra minutes to your service time.



A special oil filter housing tool, a **24 mm** socket, is required to perform the service.

Reset the oil life monitor.

Summary

- We have discussed the primary **functions** of motor oil
- The **composition** of motor oil
- Differences between **conventional** and **synthetic** motor oils
- **Additives** used in motor oils
- **Oil grades**, **standards** and **labeling**
- ***Why*** it is important to change oil regularly

Basic Service Questions

- **Do we change motor oil using the 3K standard? (***Be careful here!)*
- **Do we offer a range of oil service changes to meet the needs of our customers?**
- **As the vehicle ages, should we offer the benefits of *high mileage* motor oils?**
- **If the OEM recommends *full synthetic oil*, which oil do we use?**

It was not too long ago that almost every auto manufacturer recommended that the oil in your vehicle's engine be changed every **3,000** miles or **4,828** kilometers. Using oil past that interval meant the engine would begin to fill with sludge, which would not only degrade performance, but leave the moving parts at risk for damage.

That is no longer true. Modern detergent oils, improved oil viscosities and better engineering in general now allow cars to go approximately **7,500** miles or **12,070** kilometers between oil changes. Yet you will still hear the **3,000-mile/4,828-kilometer** figure quoted widely, especially by salesmen trying to sell you oil. Consumer Reports has debunked this myth, stating that unless you drive your car under extreme conditions, and especially if you always drive it in stop-and-go traffic, going **7,500** miles/**12,070** kilometers between oil changes should not harm your engine in any way.

Service Categories

As technicians we need to know what defines **normal service** and what defines **severe service**. For example, a very large, well known local dealers association got themselves into some trouble when they suggested that driving in the northeast is consider ***severe service***. The owner's manual of the vehicle is the best place to look for this information.

Oil Consumption Issues

Who determines ***normal*** and ***abnormal*** oil consumption?

What is considered ***normal*** oil consumption?

Oil consumption can fall into two categories: **leakers** and **burners**. Obviously, if a vehicle has a bad enough oil leak, you will see oil on the ground, on the chassis and the undercarriage. Let's say the vehicle is a ***burner*** and the customer is just not paying attention to ***how much*** oil the car is burning. You take it in for an oil service and did not realize you only drained **3** quarts of oil out of the vehicle. So, we fill it up the vehicle to the proper **5** quart oil fill capacity, start it up and the engine begins to ***knock*** because it spun a bearing … right there in the bay … right after the oil change! ***Not your fault right?*** Guess again! We hope you have good insurance coverage because it is pretty difficult to confirm consumer neglect, but much easier to point blame at technician incompetence.

It would be easier to explain up front to Mr. and Mrs. Neglect that this is the third time we have changed your oil and you were down by at least two quarts of oil. The engine has a problem and needs to be addressed, otherwise serious damage can occur if this problem continues.

We do not have to look further than the owner's manual to determine what is considered **normal oil consumption** for a vehicle. Always **check** for any **technical service bulletins** (**TSBs**) relating to oil consumption related complaints. The consumer may have to go back to the dealer if they have a complaint and the vehicle is still under warranty!

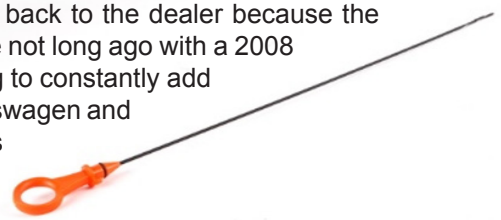
The ***rate*** of **normal oil consumption** depends on several factors, some are:

- **Size of engine**
- **Viscosity (thickness) of the oil**
- **Service rating of the oil**
- **Engine rpm during use**
- **Engine temperature**
- **High mileage engines**
- **Worn connecting rod bearings**

Abnormal Oil Consumption

A loss of one drop of oil every **30** feet results in a loss of about three quarts of oil every **1,000** miles. Excessive crankcase pressure can and will cause excessive oil leakage. ***Always*** **inspect** the PCV system for proper operation ***before*** performing any other engine testing.

Many OEMs have had oil consumption issues. The OEM must determine with their methods and diagnostic processes, what is ***abnormal*** vs. ***normal*** oil consumption. Due to the latest **Corporate Average Fuel Economy** (**CAFE**) standards, some OEMs have moved to low friction piston rings which has increased oil consumption. It is also a good practice to **check** that the engine has the correct dipstick.



If a vehicle requires frequent topping off of its oil due to excessive oil consumption, we may need to suggest having the vehicle brought back to the dealer because the customer may have recourse from the automaker. We had this issue not long ago with a 2008 Volkswagen Eos where the customer was complaining about having to constantly add oil to the engine. We printed the Technical Service Bulletin from Volkswagen and sent the customer back to the dealer along with receipts for oil changes and oil purchased between oil change intervals. The dealer fixed the car at ***no charge*** due to the fact she had the receipts showing and proving the consumption. Obviously, if there is not a technical service bulletin supporting a known issue, the customer may ask whether the vehicle is eligible for repairs under any customer satisfaction campaign or technical service bulletin. Even then, the dealer may want to conduct an **oil consumption test** ***before*** offering to perform repairs under warranty.

The oil consumption test measures how much oil a vehicle consumes over several weeks of driving. If the vehicle's oil consumption ***exceeds*** the manufacturer specifications and it is still under its original powertrain warranty, the dealer should repair or replace the engine free of charge (which is what occurred with the 2008 Volkswagen Eos). Some extended warranties will cover the problem. However, if the vehicle is consuming oil, but at a rate less than the manufacturer guidelines state is ***excessive***, the customer may be in for a long legal battle with the manufacturer. If that is the case, you may want to **consult** an attorney regarding ***lemon law*** statutes. Also, **check** to see whether your vehicle is a part of an excessive oil consumption class-action lawsuit already in progress.

Consumer Reports Article

This article by Consumer Reports focused on **498,900** vehicles from the 2010 to 2014 model years, many of which are still under their powertrain warranty. Several engines emerged as the main offenders: Audi's 2.0-liter turbocharged four-cylinder and 3.0-liter V6, BMW's 4.8-liter V8 and twin-turbocharged 4.4-liter V8, and to a lesser extent Subaru's 3.6-liter six-cylinder and 2.0 and 2.5-liter four-cylinder engines. Those engines are in models such as the Audi A3, Audi A4, Audi A5, Audi A6 and Audi Q5, BMW 5, BMW 6 and BMW 7 series and BMW X5, Subaru Forester, Subaru Impreza, Subaru Legacy and Subaru Outback. The worst case showed that overall

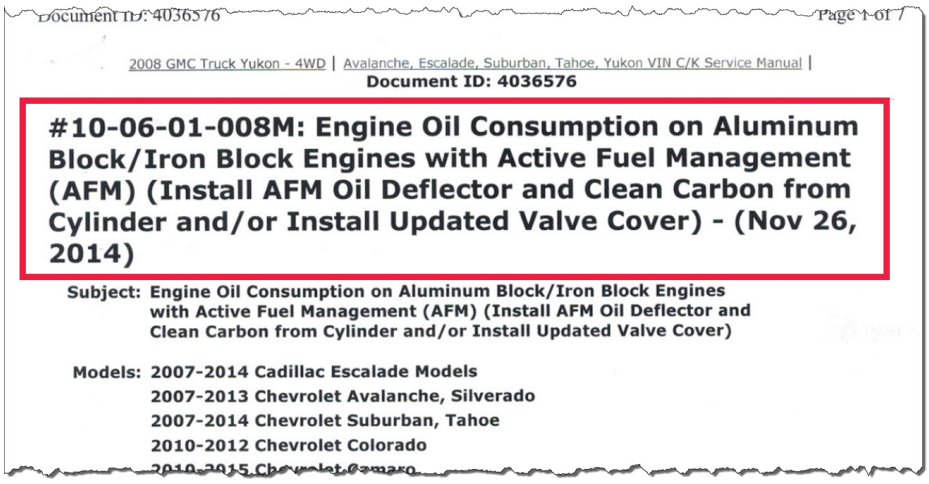
owners of BMW 5 Series vehicles with V8 engines were **27** times as likely to suffer excessive oil consumption as owners of an average vehicle. Already, some manufacturers are facing off against angry consumers who are finding that car makers are not backing up their products.

The article went onto explain: ***How much is too much?*** Audi, BMW and Subaru stick firmly to the statement that oil consumption is a normal part of a vehicle's operation. Subaru considers a quart burned every **1,000** to **1,200** miles to be acceptable. Certain Audi and BMW vehicle standards state that a quart burned every **600** to **700** miles is reasonable. If a driver has to add a quart of oil once per month, that can mean adding up to **7** to **9** quarts of oil between oil changes. Those costs due to excessive oil consumption can add up because automakers more frequently require synthetic oils that can cost upwards of **$9.00** per quart, in addition to the expense of the routine oil changes. The Consumer Reports data does not show a direct connection between increased oil consumption and other engine problems, but the survey data concerning **10** model years did show that if a car burns oil early in its life, it will burn even more as it ages. In tracking oil consumption by model year, engine families show increased consumption with each successive year on the road. Having to add oil is not a problem that will necessarily strand you by the side of the road if you are vigilant about monitoring your oil levels, but Consumer Reports went on to say, *"We think it's a serious problem that automakers should address."* Not all engines suffer from this problem. In fact, the data shows that owners of **98%** of 2010 to 2014 cars did not have to add oil between changes, but the cars that do burn oil, do so furiously. Even if only **2%** of vehicles sold since 2010 have this problem, that still represents about **1.5 million** vehicles on the road. Consumer Reports believes that any engine that burns oil between changes should be repaired under the powertrain warranty, but automakers often shield themselves in the fine print of their owners' manuals.

Technical Service Bulletins (TSBs)

Searching databases for **Technical Service Bulletins** (**TSBs**) has become an everyday task. When the customer complaint is ***oil consumption***, it is good to know that a solution is a repair away. Printing out the service bulletin and showing it to the customer adds credibility and value to the repair work. Besides, if it is covered under any extended warranty, we have to determine that ***before*** we make the decision to approach the customer with a price.

Inform customers of their options…it is their car, it is their problem and it is their money!



The 3K Oil Change Sticker

We need to be a little service conscience on the subject of **oil change reminder stickers**. Remember, the customer may be using their oil life monitor to determine when the oil needs to be changed and question why you are recommending an oil change at **3,000** miles and the oil life monitor says they have **60%** oil life remaining. You know what the OEM will tell the customer when it comes to their oil life monitor and your service recommendations? They may suggest the consumer begin looking for a new auto repair shop and/or technician.

On Jiffy Lube's website, they explain to the consumer the correct choices for oil is based on OEM specifications.

What are Jiffy Lube® service recommendations based on?

The majority of Jiffy Lube service recommendations are based on your owner's manual.

Don't I need to go to my dealer to maintain my warranty?

No. While automakers are using stronger language when speaking to vehicle maintenance, the term "Requirement" generally refers to regular maintenance as designated by the owner's manual.

However, who does the service is not a determining factor. When Jiffy Lube performs automotive maintenance, we follow the exact stipulations set forth by the manufacturer's recommendations.

It is important to note that manufacturers warranties do vary. Please consult your manufacturer to confirm.

How do I decide whether to use conventional, semi-synthetic or synthetic oil?

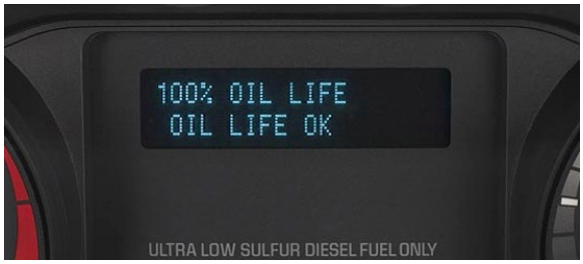
Please consult your owner's manual. Be sure to match the specification listed in your owner's manual to that listed on the container of the motor oil. The name or type of motor oil (conventional, synthetic, or synthetic blend) is incidental to meeting this specification.

Examples of Specification designation are:

- Ford WSS M2C930-A and WSS-M2C929-A
- GM 6094M and 4718M
- Chrysler MS 6395Q
- Mercedes Benz 229.51 and 229.31 non AMG
- VW 505.00, 502.00 504.00, and 507.00
- Acura HTO-06

Oil Life Monitor Basics

Here are two examples of oil life monitors: the photograph on the left indicates that the vehicle is equipped with **100%** oil life and that the oil life is ***OK***, the photo on the right indicates **87%** oil life remaining.



The **oil life indicator** lets a driver know when it is time for an oil change based not only on ***mileage***, but on actual ***conditions*** that affect the quality of the oil. Depending on the vehicle manufacturer and the specific equipment used, oil indicators come in two basic varieties: **algorithm-based** and **direct measurement**. Algorithm-based oil indicators measure lots of factors and then plug the resulting numbers into a formula. Based on the answer to this complex, ongoing math problem, the indicator display informs the driver whether the oil is ***OK***, is close to requiring replacement, or needs replacing immediately. Interestingly, with these types of indicators, there are no sensors to detect the quality of the oil itself. Instead, they combine data on how many miles have been driven, the temperature variations during that time and data about how much work the engine has performed. Typically, the indicator (monitoring system) will receive such data from the **powertrain control module**, or **PCM**. Engineers have figured out a fairly accurate and reliable way to calculate the remaining oil life this way without having to actually sample the oil.

Direct measurement oil life indicators measure the condition of the oil basically opposite of the approach of the first system. This method uses sensors to sample the oil and determine its remaining life based on any of the following:

- **Conductivity**: how easily electric current passes through the oil (typically, the lower the electrical resistance, the more contaminants are in the oil)
- **Mechanical properties**: piezoelectric sensors can tell how thick the oil is by the force feedback it gives when sloshing around
- **Soot concentration**: dirty oil's days are definitely numbered
- **Presence of water**: water is an impurity in oil, since it hampers the oil's effectiveness and can corrode metal surfaces

Different oil monitoring system manufacturers may use a combination of these measurement techniques. Typically, the information will display as a digital readout on the vehicle's instrument cluster. The display can feature a **GREEN**, **YELLOW** or **RED** style status bar with **RED** indicating the ***change oil now*** zone. It could be a percentage, displaying a text message, something like ***60 Percent Oil Life Remaining***, or it might just be a light or a message that just comes **on** automatically when it is time for an oil change.

Oil life monitor's **algorithm** is implemented to extend the mileage between oil changes. It reduces the overall operating costs of vehicle ownership. It also minimizes the environmental impact of waste oil disposal. Oil life monitors ***do not*** use oil quality sensors, it is entirely software-based.

Oil Life Monitor Modifications

Some oil life monitors can be adjusted by the consumer. Adjustments can be made to differing service intervals which usually involves accessing the menu of the driver information center and changing the service interval. Many times adjustments are made in **10%** increments ***up*** or ***down***.

Oil Life Monitors Issues

Some oil life monitors monitor ***less*** parameters and may not work as reliably as others. Monitors manufactured by General Motors appear to work very well. Short trip driving may have difficulty. Some OEMS (Land Rover/ Jaguar) have a **capacitance sensor** located in the oil pan. These sensors will not work properly unless the right oil is chosen and used.

General Motors Oil Life System

General Motor's **Oil Life System** (**OLS**) is a computer-based algorithm that assesses engine oil condition and optimizes oil change intervals based on vehicle and environmental operating conditions. The GM Oil Life Monitor System is not a mileage counter. It is actually a computer based software algorithm that determines when to change oil based on engine operating conditions. There is no actual oil condition sensor; but rather, the computer continuously monitors engine operating conditions to determine when to change the oil. Over the years, millions of test miles have been accumulated to calibrate the system for a variety of vehicles. The system was first introduced in 1988 and is now equipped on more than **10 million** GM vehicles.

Benefits of the GM Oil Life System:

- **Saves customers time and money while protecting their investment**
- **Simplifies decisions about frequency of oil changes and other required maintenance**
- **Makes it easy for customers to have their vehicle's oil changed and all routine maintenance performed during the same service visit**
- **Lowers overall operating costs because oil is changed only when necessary**
- **Reassures consumers that their engine is always running with good oil which improves the long term performance and reliability of their vehicle**

GM Oil Change Interval Expectations

- Highway driving **7,000** to **12,000** miles
- Urban driving **4,000** to **6,000** miles
- Trailer towing **5,000** to **7,000** miles
- **Short trip service**: (less than two miles) **3,000** to **4,000** miles
- **Typical mixed service**: **4,000** to **7,000** miles

The more a vehicle is used for ***short trips*** or ***trailer towing***, the more frequently the oil needs to be changed. GM test data shows the oil life system extends oil change intervals without risks to the engine as well.

Vehicle testing oil analysis measured four different oil characteristics to determine the extent of oil deterioration:

1. Oxidation stability
2. Acidity (TAN)
3. Alkalinity (TBN)
4. Viscosity change

Edmunds Article: April 23, 2013

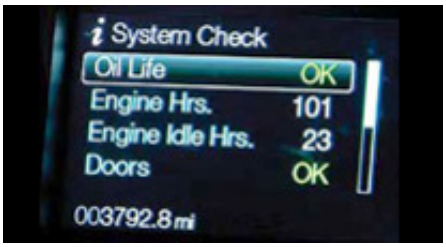
Oil chemistry and engine technology have evolved tremendously in recent years, but you would never know it from the quick change behavior of American car owners. Driven by an outdated **3,000** mile oil change commandment, they are unnecessarily spending millions of dollars and spilling an ocean of contaminated waste oil.

Today's Oil is Going the Distance
While the car servicing industry is clear about its reasons for believing in the **3,000 mile oil change**, customers cling to it only because they are largely unaware of advances in automotive technology. Among 2013 models, the majority of automakers call for oil changes at either **7,500** or **10,000** miles based on a normal service schedule, more than double the traditional **3,000** mile interval. The longest oil change interval is **15,000** miles for all Jaguar vehicles. The shortest oil change interval is **5,000** miles in some Hyundai and Kia models with turbo engines and Toyota vehicles that call for non-synthetic oil. Toyota has been shifting its fleet to **10,000** mile oil change intervals using synthetic oil.

Today's oil life monitoring systems notify the driver when an oil change is required and are based on the way the car is driven and the conditions it encounters. **Sixteen** of **34** car makers now use oil life monitoring systems in their 2013 model year vehicles including all three domestic automakers. That represents a majority of the vehicles sold in the United States.

Edmunds Article: April 23, 2013
One GM vehicle Edmunds drove went **13,000** miles ***before*** the monitoring system indicated the need for an oil change. They sent a sample of that oil to a lab for analysis. The results showed that the oil could have safely delivered at least another **2,000** miles of service.

Intelligent Oil-Life Monitor™ (IOLM)



2011 and newer Fords are equipped with **Intelligent Oil-Life Monitors** (**IOLM**). With the IOLM, there is no more guessing when your vehicle needs an oil change. More than likely, if you stayed on top of your required maintenance duties, meaning you changed your oil every **3,000** or **5,000** miles. With the introduction of the IOLM, now you will be able to take your vehicle in for an oil change based on actual operating conditions. The IOLM will be available on most vehicles under **8,500** lbs. **gross vehicle weight rating** (**GVWR**). Additionally, it will be on all new 2011 model year 6.7L Power Stroke® Diesels on the Super Duty® model. That translates into over **90%** of the 2011 model year Ford, Lincoln and Mercury vehicles sold.

The oil life monitor adjusts the oil change interval according to how the customer operates their vehicles. It uses the engine operating conditions to precisely calculate service intervals. The customer's actual engine oil change interval will depend on the operating conditions. The IOLM does not use oil quality sensors, it is entirely software based and uses actual engine operating conditions to calculate the oil change interval by using an algorithm. This means the system must be reset after an oil change. Not doing so will result in a premature **OIL CHANGE REQUIRED** message.

Frequency: Depending on driving conditions, oil change intervals are approximately:

- Up to **10,000** miles - Normal commuting with highway driving
- **5,000** – **7,500** miles - Trailer tow/high-load driving
- **3,000** – **5,000** miles - Short trip usage, extreme cold or hot temperature

Note: Actual mileage will depend on your specific driving conditions. Under normal conditions, drivers will receive an **OIL CHANGE REQUIRED** message at up to **1** year or **10,000** miles from the previous oil change.

Ford Maintenance Schedule

Ford Recommended Normal Maintenance Schedule

Filter Type	6.7L Engine	6.4L Engine	6.0L Engine	7.3L Engine
Air Filter	Check air restriction gauge at every oil change. Replace as needed.	Inspect filter minder every 10,000 miles (16,000 km). Replace as needed.	Inspect filter minder every 7,500 miles (12,000 km). Replace as needed.	Inspect filter minder every 5,000 miles (8,000 km). Replace as needed.
Fuel Filter(s)*	22,500 miles (36,000 km) (Every 3rd oil change)	20,000 miles (32,000 km)	15,000 miles (24,000 km)	15,000 miles (24,000 km)
Oil Filter and Oil	Check Message Center.	10,000 miles (16,000 km)	7,500 miles (12,000 km)	5,000 miles (8,000 km)

Intelligent Oil Life Monitor has an algorithm that determines when to change oil and is based on ***vehicle operating conditions***. The system will display a message in the instrument cluster message center when an oil change is required.

Ford Oil Minder System - OMS

Ford's **OMS** - **Oil Minder System** displays a message in the instrument cluster message center when to change the oil. The interval is determined by time or mileage. There is ***not*** an algorithm to compensate for operating conditions.

Many manufacturers use both types of oil change reminder systems to alert the driver of when an oil change is due. Many systems simply calculate the ***time*** or ***mileage*** from the last oil change reset. These systems ***do not*** use any algorithm based logic to compensate for engine operating conditions.

Ford Service Interval Chart

Scheduled Maintenance Summary by Vehicle Line

2011 Model Year

Vehicle	Service Interval	Message Center	Interval
Mustang	IOLM As Indicated	IOLM	IOLM adjusts the oil change interval according to vehicle operating conditions. Can be up to 1 year/10,000 miles.
Edge MKX	IOLM As Indicated	IOLM	
Flex MKT	IOLM As Indicated	IOLM	
Taurus MKS	IOLM As Indicated	IOLM	
Escape/Mariner	IOLM As Indicated	IOLM	
Fusion/MIlan/MKZ	IOLM As Indicated	IOLM	
F-150	IOLM As Indicated	IOLM	
Explorer	IOLM As Indicated	IOLM	
F-Super Duty Diesel	IOLM As Indicated	IOLM	
Fiesta	OMS 1 year/10,000 miles	OMS	1 year/10,000 mile interval
Hybrid Escape/Mariner	OMS 1 year/10,000 miles	OMS	
Hybrid Fusion/Milan/MKZ	OMS 1 year/10,000 miles	OMS	
Expedition/Navigator	OMS optional 6 months/7,500 miles	OMS*	6 month/7,500 mile interval
F-150 6.2 Liter Lariat/Harley Davidson	6 months/7,500 miles	OMS*	
Transit Connect	6 months/7,500 miles	No	Commercial vehicle
F-Super Duty Gas	6 months/7,500 miles	OMS*	

2010 Ford Flex 3.5 V6

When the oil life monitor on this Ford is set to **100%**, the PCM will have the oil change interval reminder trigger at about **7,500** miles. With the oil life monitor set to **60%**, the trigger for the oil change will begin at approximately **4,000** miles which is the lowest it will go.

When the oil is ready to be changed, the oil life monitor display will say **ENGINE OIL CHANGE SOON**. When you have driven approximately **400-500** miles beyond that, the display will now say **OIL CHANGE REQUIRED**, which is triggered when the oil life is at about **5%**.

Ford Flex Oil Life: 28%

The oil life monitor percentage can be checked at anytime by pressing the appropriate button on the dashboard. Usually, an **INFO** button takes the user through a menu of choices and displays the percentage of life the oil has at that time.

Ford Flex: Oil Life Monitor Math

The vehicle is in the shop for an oil and filter service.
The vehicle is equipped with an **oil life monitor**. The factory default for the oil life monitor is **100%**. The oil life monitor can be adjusted to trigger the driver alert from **100%** down to **50%** in **10%** increments. The **100%** default is approximately **7,500** miles or **12** months. Currently, the oil life monitor is set for **60%** which triggers the reminder for oil service at approximately **4,400** miles. The math seems to be pretty close to the interval and here is an example:

- Last oil service date was **3/11/2013** and the mileage was **76,665**
- The **CHANGE OIL SOON** message came on at **80,984** – difference was **4,319** miles
- The **OIL CHANGE REQUIRED** message came on at **81,400** – difference was **416** miles

If the driver of the vehicle takes several short trips during the oil interval, the oil life monitor will trigger the change oil message earlier due to short trip driving conditions.

2010 Ford Flex Service History

The oil life monitor on the Ford Flex is a good representation of how a good oil life monitor should work. It is advising the customer of ***when*** the oil should be changed and ***warning*** them when it ***needs*** to be performed. This system works correctly as long as the customer and the service provider understand that the only time the oil life monitor should be **RESET** is when the vehicle is serviced and ***never*** before that.

- Oil life monitor set to **100%**
  - **90,500** miles- **CHANGE OIL SOON** - **On**
  - **90,920** miles - **OIL CHANGE REQUIRED** - **On**
  - **420** mile difference
  - **106,965** miles - **CHANGE OIL SOON** - **On**
  - **107,375** miles - **OIL CHANGE REQUIRED** - **On**
  - **410** mile difference

Ford Flex: Oil Life Monitor Field Study

- Oil life monitor set to **100%** - **7,500** miles
  - **CHANGE OIL SOON** triggered on 2/17/14
    - **114,756** miles
  - **OIL CHANGE REQUIRED** triggered 2/17/14
    - **115,130** miles (**374** mile difference)
  - **Last service**: 12/7/13 - **107,631** miles
    - 115,130 – 107,631 = 7,499 Miles
  - **Vehicle serviced**: 2/20/2014 at **115,566** miles

The oil was sent to the lab for analysis.

Customers & Oil Life Monitors

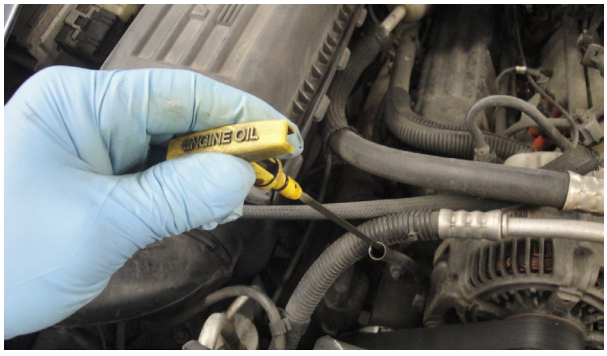
As technicians, many of us change a customer's oil without paying any attention to ***how much oil*** is coming ***out*** and going into the drain bin. It is important to **check** and **monitor** the amount of oil coming out of the vehicles we service due to the fact the consumer may never check their oil.

Let's say you are changing oil on a customer's vehicle for the first time and they completely forgot about the first extended oil change interval at **7,500** miles. The repair order states the car has **15,500** miles on it now and it is in your bay for an oil change. You may be the first technician changing the oil on this car for the first time. ***What? How does this happen!*** It occurs on a daily basis. What happens if the customer reset the oil life monitor **7,000** miles ago and actually forgot that they never changed the oil?

The oil life reminder informs the driver ***when*** to change the oil. It does ***not*** dismiss an owner from the responsibility of checking the oil. Unfortunately, customers are often very misinformed regarding proper vehicle maintenance procedures. Customers' lack of service due diligence can hurt us as shop owners and technicians if we do not take the time to inform, educate and explain the importance of proper vehicle maintenance to them. For example, how many people misunderstood tire pressure monitoring systems when they were first introduced?

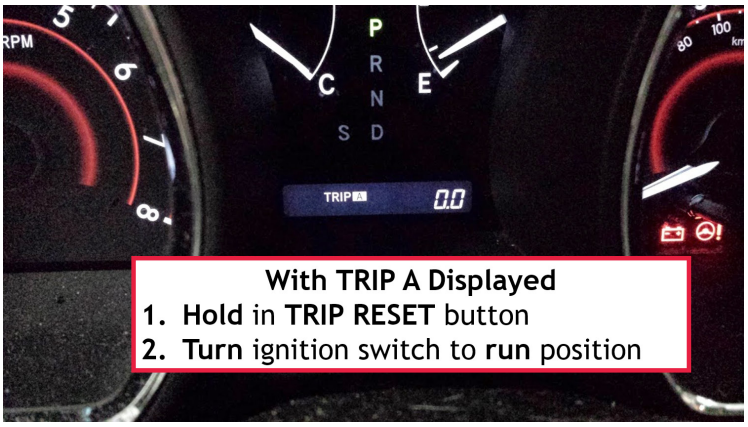
Checking Engine Oil

Do not assume every customer knows how to check their oil.



2011 Toyota Highlander Oil Reminder

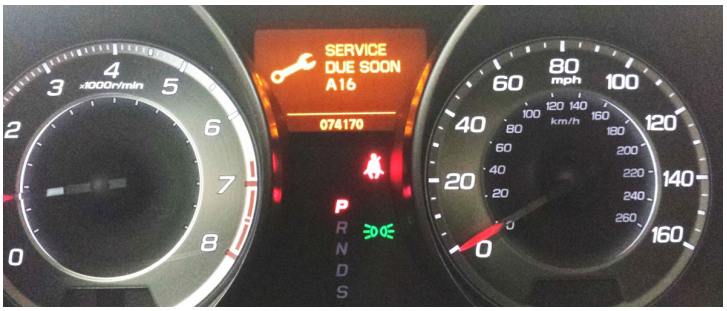
This is a photograph of an oil reminder on a 2011 Toyota Highlander. To reset the oil reminder on this vehicle, first display **TRIP A**. With **TRIP A** displayed, **hold** in the **TRIP RESET** button and **turn** the ignition switch to the **RUN** position.



Trip Reset Procedures Vary

Trip reset procedures vary by vehicle manufacturer, year, make and model.

2011 Acura MDX



Acura uses specific numbers on the driver 's information screen to indicate which service needs to be completed, and once the service is completed, a certain procedure must be followed to reset the service indicator/oil life monitor. As shown in the photograph on the right, **1** means **perform** oil and filter service, and **6** means change the differential oil.

2011 Acura MDX: Complete Service

When performing an **oil and filter service**, pay attention to service details such as resetting the oil life monitor. Here are two photographs of the oil life monitor on a 2011 Acura MDX. This customer's business was earned by performing exceptional ***service***. This customer was routinely going to an Acura dealership for their service needs and two times in a row the dealership failed to reset the customer's oil life monitor. The customer had to return to the dealership and wait for a technician to come out and perform the reset procedure. Incidentally, according to the customer, the dealer informed them that they should not worry about servicing the car when the oil life monitor triggers the service request. They said, *"We don't pay any attention to that."* They told the customer to simply look at the window sticker. Interesting enough, the dealership never put an oil change reminder sticker on the customer's window. The careless, incomplete service from this particular dealership drove the customer to find a new service provider. This example proves our point of knowing how important these systems are to the driver/operator and what customers' expectations are when they bring their vehicle in for service. Always **respect** your customer's wishes by providing them with a ***complete*** service. ***Do not*** forget to reset the oil life monitor.

Service: 2010 Mercedes Benz GLK 350

Example: 2010 Mercedes Benz GLK 350 in the shop for an oil and filter service. The customer sold this vehicle not long after this service.

When should oil life monitors be reset?

> **Engine oil and filter change**
>
> Change the engine oil and oil filter every 10,000 miles or 1 year. If oil consumption should increase, determine the cause and take necessary corrective steps. Do not reset the Maintenance System service indicator if the oil level is adjusted or changed outside the interval of 10,000 miles or 1 year.

Oil life monitors should be reset ***after*** a ***complete*** oil and filter service. Oil life monitors should ***not*** be reset if the oil level is adjusted by adding additional oil outside a complete service.

Engine oil and filter change maintenance information is found in every vehicle's owner's manual. According to the Mercedes owner's manual, the engine's oil and filter should be changed every **10,000** miles or after **one** year. If oil consumption should ***increase***, determine the cause and take the necessary corrective steps. It specifically states: *"Do not reset the Maintenance System service indicator if the oil level is adjusted or changed outside the interval of 10,000 miles or 1 year."*

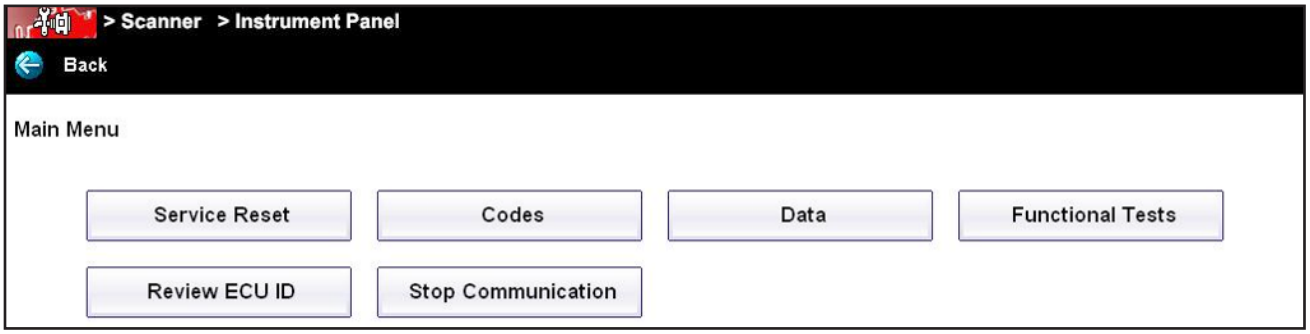
A4 Service Exceeded Message

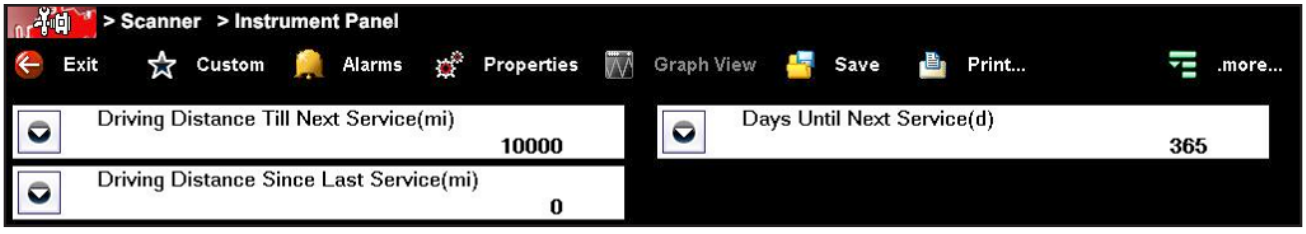
Mercedes Benz's oil life monitor will actually keep track of when you need an oil change and if the interval was exceeded by how many days. ***Do you think they may use that information to deny warranty?*** If you answered ***yes***, you are ***correct***.

Mercedes Benz Approved Mobil 1

Scan Tool OLM Reset

Some oil life monitors may be reset using a scan tool. This is an example of resetting the monitor on a 2010 Mercedes Benz GLK 350 bidirectionally using a Snap-on Verus scan tool.



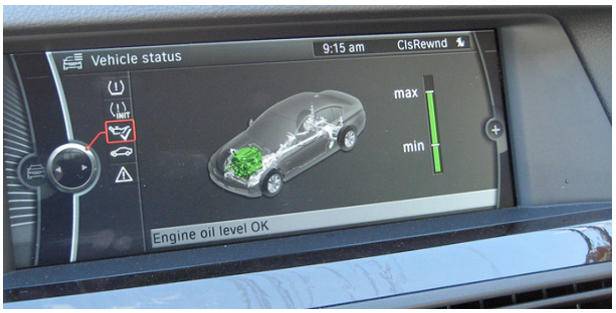


2008 BMW X5 4.8i

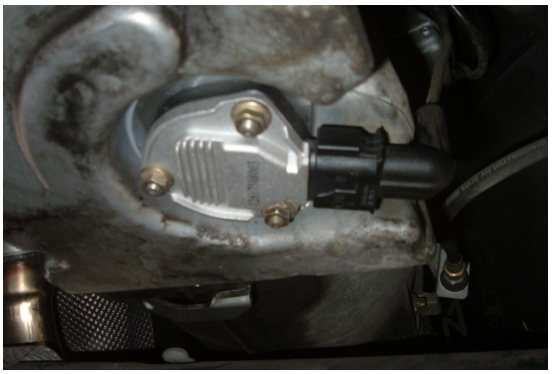
The BMW X5 notifies the driver when the oil level in the engine has reached a minimum level. **Note**: it also let's you know it is due for a quart of **5W-30** synthetic motor oil.

2011 BMW 528i

In this picture, we can see that the engine oil level is ***OK*** on this 2011 BMW 528i.



Oil Temperature & Level Sensor



The electronic level sensor is located in the engine sump mounted to the oil pan. The probe of the level sensor contains two temperature sensing elements: one senses the oil temperature, the second one is heated to **50°F** (**10°C**) ***above*** the temperature of the engine and then allowed to ***cool***.

The length of time it takes to ***cool*** the heated element is how the sensor determines the engine oil level. When the oil level is ***high***, the oil covers a larger portion of the probe submersed in the oil sump. The engine oil around the probe absorbs the heat of the heated element quicker than if the oil level is low. A small microprocessor in the base of the sensor produces a pulse width modulated signal proportional to the oil level. The pulse width will ***increase*** as the oil level ***drops*** in the sump. Based on the oil temperature, the LEDs on the dashboard in the tachometer will illuminate at ***cold*** engine start and slowly diminish as the oil temperature ***increases***. One **AMBER** and **RED** LED will always remain **on** to remind the driver of maximum rpm limitation.

Rethinking Our Core Oil Service

One thing is certain, ***do not*** go against OEM service recommendations. Warranty denial at the dealership level is pretty high.

Are there any ***value added*** services we can recommend during an **oil service**?

Do not call it an **oil change**. **Periodic maintenance and inspection service** sounds more professional.

Periodic maintenance and inspection service is a vehicle service that should be scheduled based on ***time*** or ***miles driven*** that is used to ensure regular preventive service that includes: inspection/replacement of filters,

lubrication, an oil change, correction of all tire pressures and a visual inspection to detect worn or damaged components that may affect the performance of the vehicle or compromise the safety of the vehicle.

What do you think of this shop owner's testimonial?

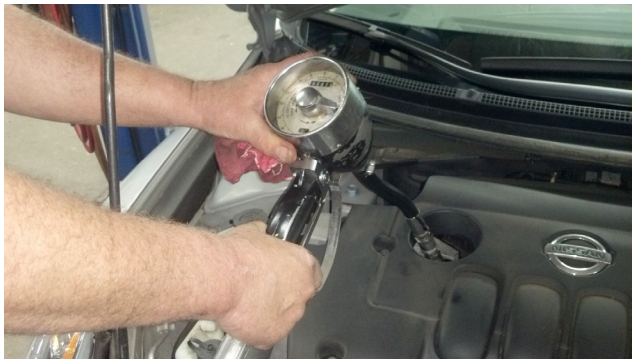
> *I call my service a **Comprehensive Vehicle Service**. It includes a premium oil and filter change, lubricating chassis fittings (where applicable), vacuuming the interior, cleaning windows inside and out and applying Rain-X™ to the windshield, applying silicone to all vehicle weather-stripping, lubricating all door, hood and trunk lid hinges, and cleaning out all exterior rain channels. We check and set all tire pressures to specification and reset the TPMS if applicable. We also check all fluids and add as necessary, we record and document all vehicle services in the appropriate Manufacturer Recommended Maintenance Schedule Booklet. Our customers actually **ask** for the service by name once their acclimatized to the benefits of performing it.*

Additionally, in the northern states, it may be wise to inspect the chassis and body for perforation damage due to servicing a vehicle where salt brine, **calcium chloride** (**$CaCl_2$**), **magnesium chloride** (**$MgCl_2$**) **potassium chloride** (**KCl**) or some combination of any or all of these elements is sprayed on the roads in winter months. Some states have vehicle body inspection rules that prohibit a vehicle from receiving an annual inspection sticker due to excessive rust.

We ***do not*** want to jeopardize any customers' vehicles with oils that are ***not*** meeting the performance standards.

- **Do we have or need indemnification clauses from our suppliers?**
- **Would we think of installing *economy* oil filters on our customers' vehicles or *premium*?**
- **Why would you put a *full synthetic* oil in an engine and pair it with an *economy* filter?**

Bulk Oil Issues



For shops utilizing ***bulk oil*** from suppliers, suppliers may have to supply installers with a specification sheet indicating that the oil they are purchasing meets and/or exceeds OEM oil specifications.

High Mileage Oils

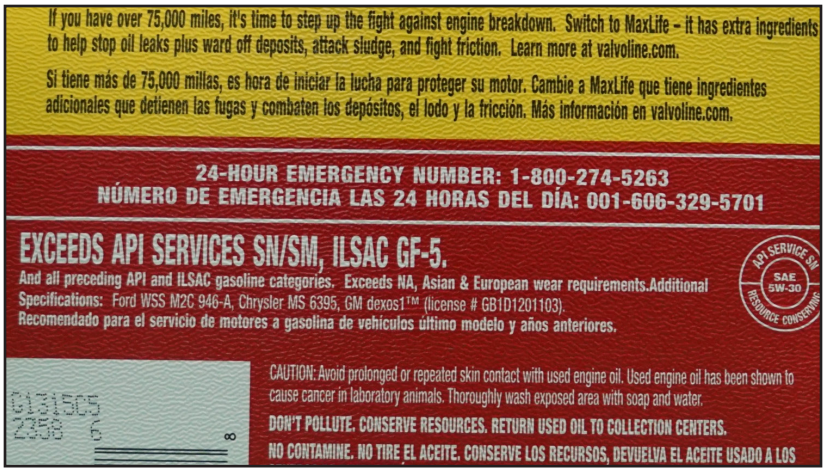
It seems like ***high mileage oils*** are marketed towards service intervals of **75,000** miles. These oils generally contain special chemicals like **seal conditioners** to help reduce leak rates.

Who would be a good candidate for this type of oil?

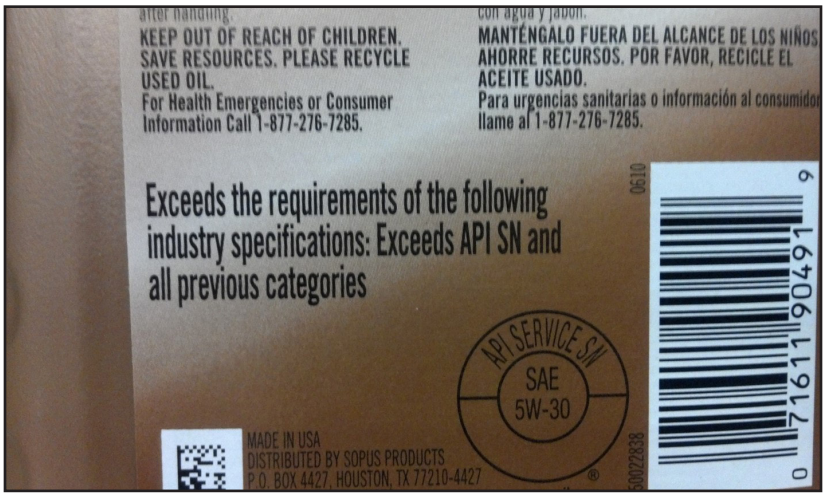
Does using a high mileage oil place a vehicles out of warranty?

Castrol 5W-30 High Mileage Oil

Valvoline MAX Life



Pennzoil High Mileage 5W-30



Shop Marketing Language

We mentioned earlier that customers do not care how much you know, until they know ***how much you care***. Explaining the benefits of proper maintenance to customers should be a long term goal for us and the customer. There are many reasons why our customers should have their vehicle on a maintenance plan according to the manufacturers' recommendations.

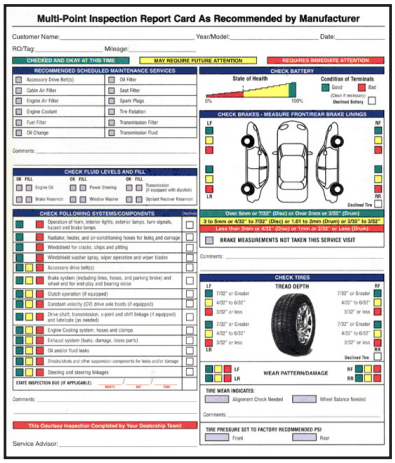
"Your car is one of your largest investments, so let us help you protect it."

*"**Factory Recommended Automotive Maintenance Schedules** can help extend the life of your car and prevent high-cost auto repairs."*

"*At our facility, we understand how important your car is to you and we know just what preventive maintenance your car needs."*

*"We can help you determine and follow your car's **Manufactures Maintenance Schedule.**"*

Multi-point Inspection Sheet Every Car



- **Complete a multi-point inspection sheet for every vehicle**
  - **Inside**
  - **Outside**
  - **Under-the-hood**
  - **Under-the vehicle**
  - **Written report**

Providing professional service is important. **Complete** a **multi-point inspection sheet** for the vehicles you service.

Here is an example service statement:

*We care about your car and your safety. Ask us for a **Multi-point Courtesy Check**. We will look inside, outside, under-the-hood and under-the-vehicle and then offer you a written report. Remember, the more you know about your car's condition, the better your ability to maintain its safety.*

Many variations of vehicle inspection forms are available at no cost off the internet.

Discussion Scenarios: George

As service professionals, we need to recommend the right products to customers based upon their specific vehicle needs. Let's explore a couple of service scenarios.

- **George loves his 2011 Ford F-250**
  - **George uses his truck every day to haul large loads and tow trailers for his construction business**
  - **He knows it's a tough business in a competitive market and wants his truck to last**

What oil would we recommend for George's Ford?

A. Full synthetic
B. Synthetic blend
C. Conventional oil
D. High mileage vehicle oil
E. Tell George to sell the Ford and buy a Dodge Ram pick-up

Customer Expectations: Joanne

School teacher, mother of three, Joanne is pretty caring of her vehicle and she really does not want to spend a lot of money on her Toyota.

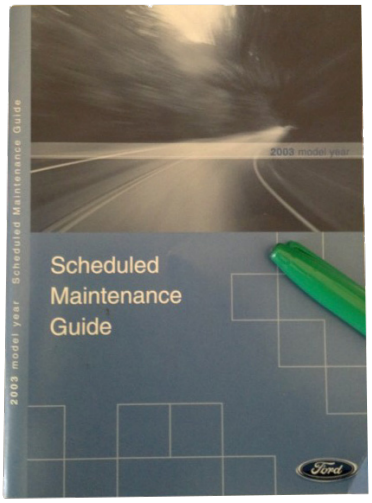
- **Loves and plans on keeping her vehicle**
- **Does not want to spend more money than necessary on today's service**
  - **2000 Toyota**
  - **205,000 miles**
  - **Rough condition**
  - **Dipstick full, not burning oil**
  - **Vehicle maintained**

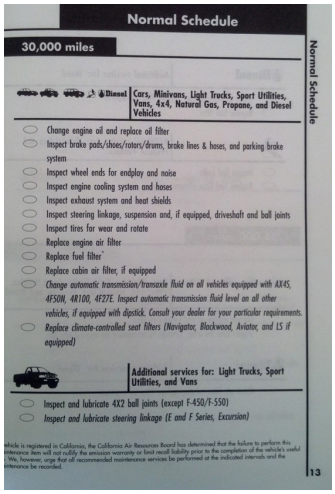
What oil do we recommend for Joanne?

A. Full synthetic
B. Synthetic blend
C. Conventional oil
D. High mileage vehicle oil
E. Tell Joanne to buy a new car

Maintenance Schedules (MSMS)

Manufacturer suggested maintenance schedules (**MSMS**) are a great way to educate consumers about the required maintenance that their vehicles deserve. It is nice to have computer invoicing, but when the customer wants to see at a glance what was done two months, two years ago, they just open the book and it is all there in one convenient location.





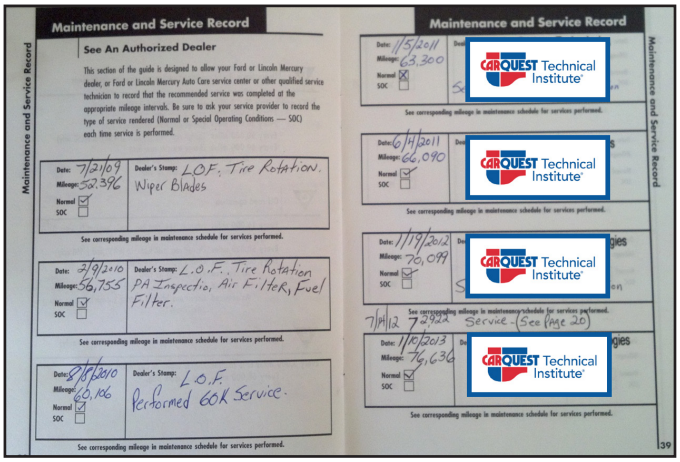
Having customers on a maintenance schedule has significant benefits:

- **They service the car on their terms**
- **It may reduce breakdowns and inconvenience due to potential problems being noted early in the vehicle's life cycle**
- **The shop can explain the minor and major service intervals up front so the customer can budget accordingly**
- **The shop can send out reminder cards based on the mileage or time intervals for the recommended service**
- **It keeps the flow of work steady for the shop**

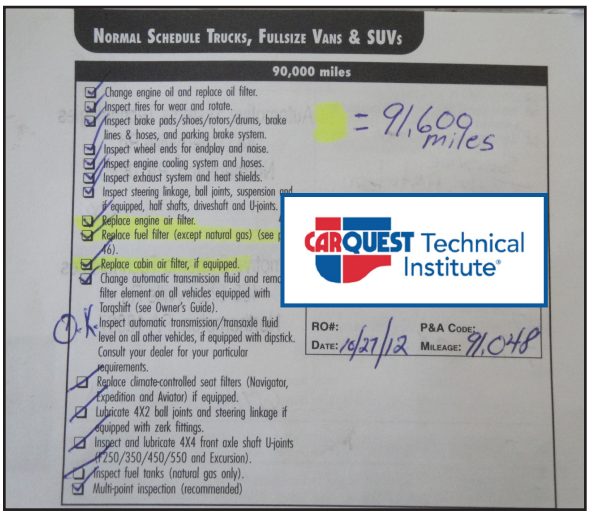
- **Parts can be ordered in advance which reduces wait times for customers, especially the *waiters* for minor services**
- **Resale value increases (If the vehicle is sold, the potential buyer will see the vehicle service history, which adds peace of mind that it was cared for and maintained properly.)**

Write It In Their Book

All services should be noted in the customer's **Maintenance and Service Record** booklet. Anything that does not fit in the space provided can be placed into a service folder. Service records, state inspection reports and sublet items can be conveniently placed in one convenient location. If a customer is tech savvy, there are smartphone applications that you can use to send the reports or services to for the customer to see.



Here is an example of a completed maintenance report for a vehicle at **90,000** miles.



Oil Filtration Technology & Warranty Information

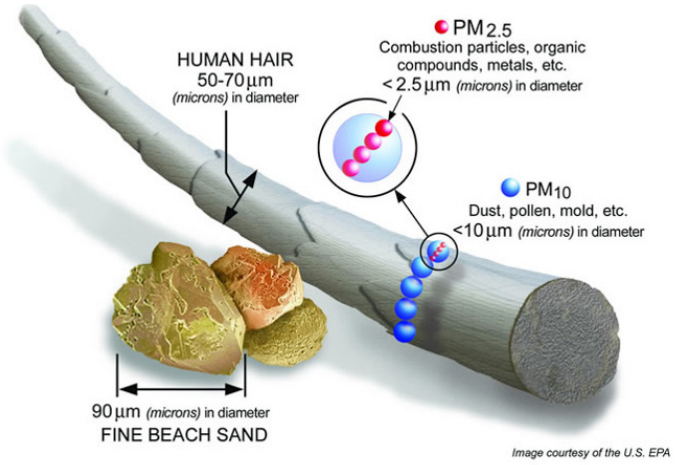
Oil Filtration Technology

A great deal of emphasis is placed on the importance of using the most advanced high-quality lubricants, but superior filtration is often taken for granted. The general attitude displayed by many consumers is to use whatever is cheapest, even when they have invested in superior lubricants. Without filtration, byproducts from the combustion process and abrasive materials ingested from the air will ultimately destroy an engine.

Most economy or bargain oil filters are designed to last **3,000** miles. Open them up and you may find cardboard end caps, cellulose filter media and nitrile anti-drainback prevention valves. That is what you get for **$3.00**, but that may not cut it for today's advanced engines using synthetic lubricants that are designed to last longer between fills.

If you cut open an OEM's or even the higher-end aftermarket oil filters such as: CARQUEST (**BLUE** box), Champion

Labs, Wix, and Fram's extended guard, you will find metal end caps, silicone anti-drainback valves and synthetic filter media. ***What do high-end oil filters cost?*** **$8.00** and ***up***. However, these high-end filters are tested and rated for **7,000** to **10,000** miles. ***How is that economy priced filter looking now?*** By the way, food for thought as we found out, many quick oil change places will put synthetic oil back in your engine if it came with it. However, the chances are almost **100%** that they will install a **$3.00** filter. So ***yes***, they will use the same quality filter for both a ***regular*** and ***synthetic*** oil change.



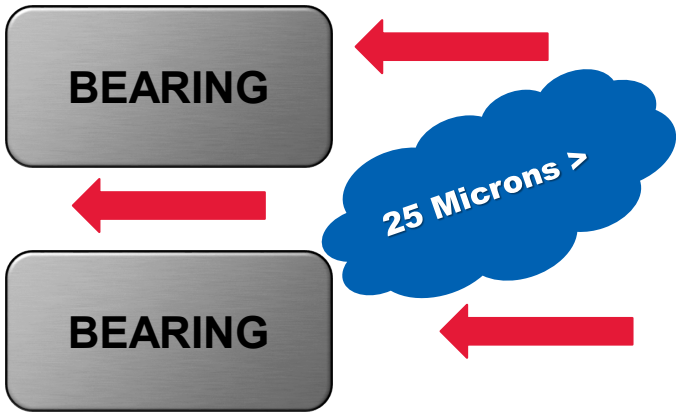
Microns

A **micron**, or **micrometer** (**µ**), is a very small unit of linear measurement. **One** micron is equal to **one millionth of a meter**. **25** microns is equal to **0.001 inch**. The diameter of a human hair is **50 - 70** microns. Wear-sensitive surfaces have clearances of between **2** and **22** microns.

To appreciate how small these particles are, one must first understand the measurements involved in their classification. To better put this in perspective, consider that the diameter of a human hair is **50-70 microns**.

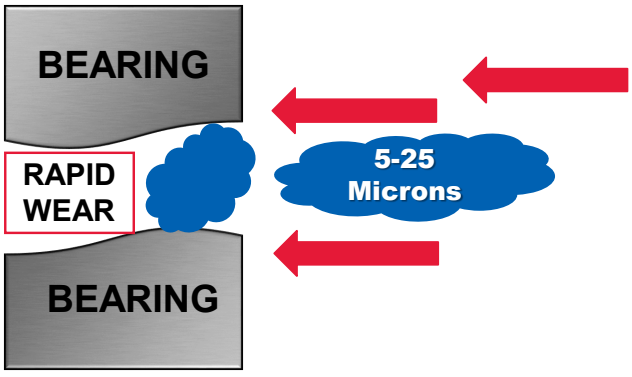
Particle Micron Filtration

The level of damage particles cause to an engine is directly related to the ***size*** of the particles. The oil stream within the engine flows between wear-sensitive surfaces that usually have clearances of between **2** and **22** microns. It is contaminants in this size range that pose the greatest threat as they can slip between moving components causing a great deal of wear.



Large particles are particles measuring **½"** or larger. They pose little threat to engines because they are easily removed by the air filter.

Medium particles are particles measuring **25 µ** to **½"**. While they are of greater concern than large particles because they are more difficult to remove, the threat they pose is diminished since they are still larger than many of the clearances within an engine. Their size will not allow them to enter the contact areas between many components to promote accelerated wear.



Small particles are particles measuring between **5** and **25 µ**. Small particles are of greatest concern because they can penetrate the clearances between wear-sensitive components and promote accelerated wear. Because they are so small, they are also difficult to remove from the oil stream.

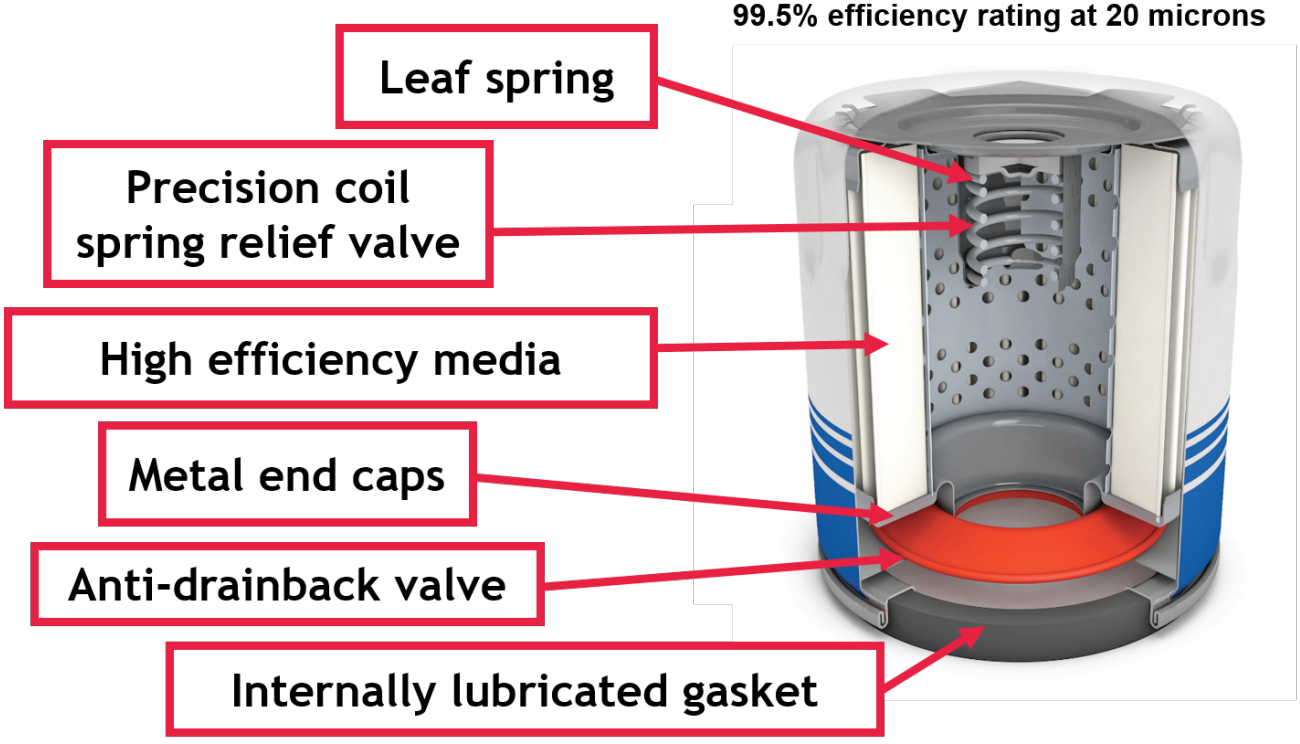
Oil Filter Construction

Oil filters may be the most familiar and yet the least understood of all automotive filters. There is a lot more going on beneath the domed can of the spin-on filter than meets the eye.

A look inside the **CARQUEST Premium oil filter** proves our point. CARQUEST premium filters keep oil cleaner for longer periods of time and meet all new car warranty requirements. They are built to meet or exceed OE specifications for long-lasting engine protection.

- **Leaf spring**
- **Precision coil spring relief valve**: on a cold start up, oil can be too thick to filter. To prevent the engine from starving, the relief valve opens when the pressure builds enough to force the calibrated spring downward allowing unfiltered oil into the center tube through the top.
- **High efficiency media:** high efficiency and durable cellulose/synthetic blended media for better engine protection and longer drain intervals
- **Metal end caps**
- **Anti-drainback valve**: The silicone rubber anti-drainback valve keeps oil from draining out of the filter when the engine is shut down, ensuring an adequate supply of oil when the engine is started again. The silicone anti-drainback valve has three times the durability versus nitrile for engine start-up protection. Silicone also resists heat hardening, cracking and leaks. This is a key point on vehicles with long service intervals. The longer a filter is in service, the more important its ability to withstand punishment becomes.
- **Internally lubricated gasket**: the seal gasket is internally lubricated to provide better torque removal and easy replacement

CARQUEST Premium Oil Filter
99.5% efficiency rating at 20 microns



Economy Oil Filters

Economy oil filters make some type of compromise compared to ***premium*** quality oil filters to minimize cost. Many **standard filters** are built to meet OE specifications for fit, form and function while also meeting new car warranty requirements. However, not all filters are constructed to the same standards.

OEM Oil Filter Questions

When comparing the OEM oil filter to the aftermarket filters, many different design features are discussed such as:

- **Large media area**: Provides optimal capacity and efficiency
- **Fluted case end**: Helps make removal easier
- **Well bonded end plates**: Helps keep consistent pleat spacing
- **Perforated steel center tube**: Helps prevent collapse under pressure

Toyota OE Filter

Here is a photograph depicting a Toyota OE filter both used and new.

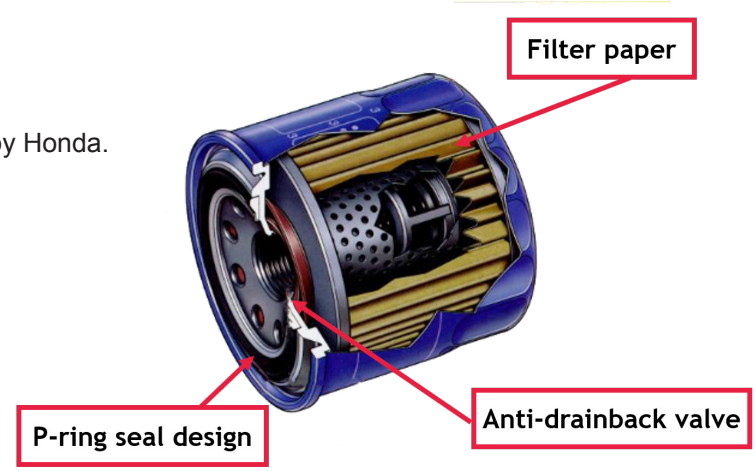
Mercedes Benz: OE Filter vs. Aftermarket

These photographs make a comparison between a Mercedes Benz OE oil filter versus an aftermarket oil filter.

Can you see a difference?

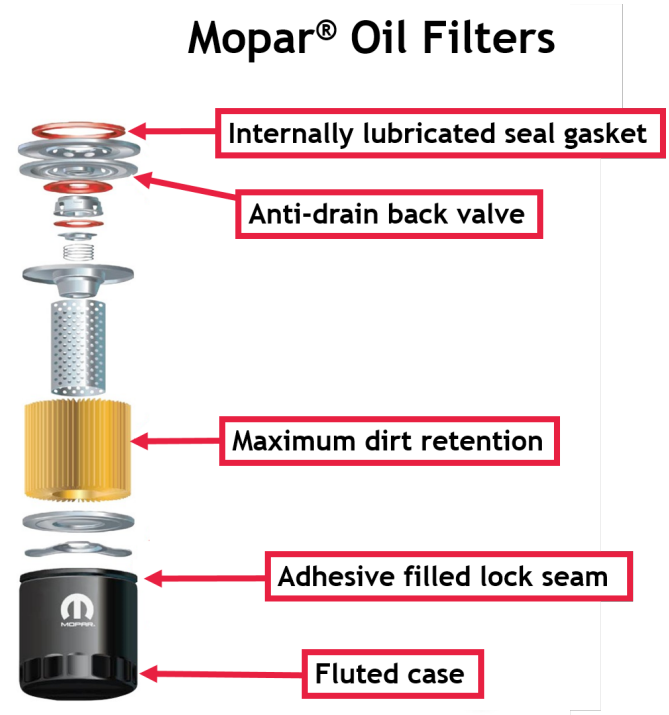
Honda Oil Filter

Here is a cutaway depicting an oil filter used by Honda.



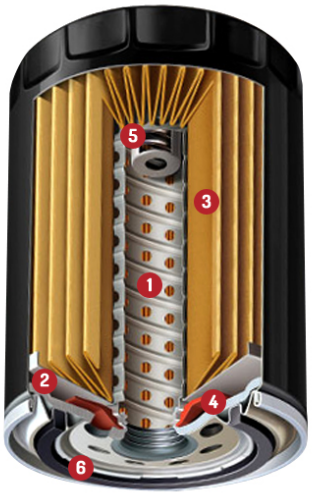
Mopar Oil Filter

Here is a breakdown of a Mopar oil filter.



Premium Oil Filters

Many believe that ***premium*** engine performance requires a ***premium*** oil filter. Bosch premium oil filters not only fit the same way as original OE filters, they utilize an exclusive blend of natural and synthetic materials in the media for superior oil filtration and increased engine protection. With **99%** efficiency, the Bosch premium oil filter traps both large and microscopic particles from entering the engine. With a media that can hold up to **14** grams of dirt and particles, motorists can count on premium engine protection.



	Feature	Benefit
1	Metal spiral-wound center tube	Reinforces internal strength for durability
2	End caps	Prevent trapped contaminants from reaching your engine
3	Premium media	Media blend provides 99%* filtration efficiency
4	Silicon anti-drain back valve	Protects against dry starts and doesn't dry out
5	Relief valve	Prevents oil restriction and ensures proper oil flow
6	Nitrile sealing gasket	Internally lubricated gasket has long life and will not dry out

OEM Filters

Even with all of the advances in lubrication and engine technology, ***filtration*** is as important today as it ever was. The combustion process produces byproducts that slip into the oil stream and external contaminants are introduced into the engine in a variety of ways. The challenge for filter manufacturers is balancing flow, efficiency and filter life. In order to stop particles in the **2** to **22 µ** range, the pores in the cellulose media used in many filters are too small to allow adequate oil flow.

OEM filter features include:

- **Large media area**
  - **Provides optimal capacity and efficiency**
- **Fluted case end**
  - **Helps make removal easier**
- **Well bonded end plates**
  - **Help keep consistent pleat spacing**
- **Perforated steel center tube**
  - **Helps prevent collapse under pressure**

SAE Filtration Synthetic Fibers

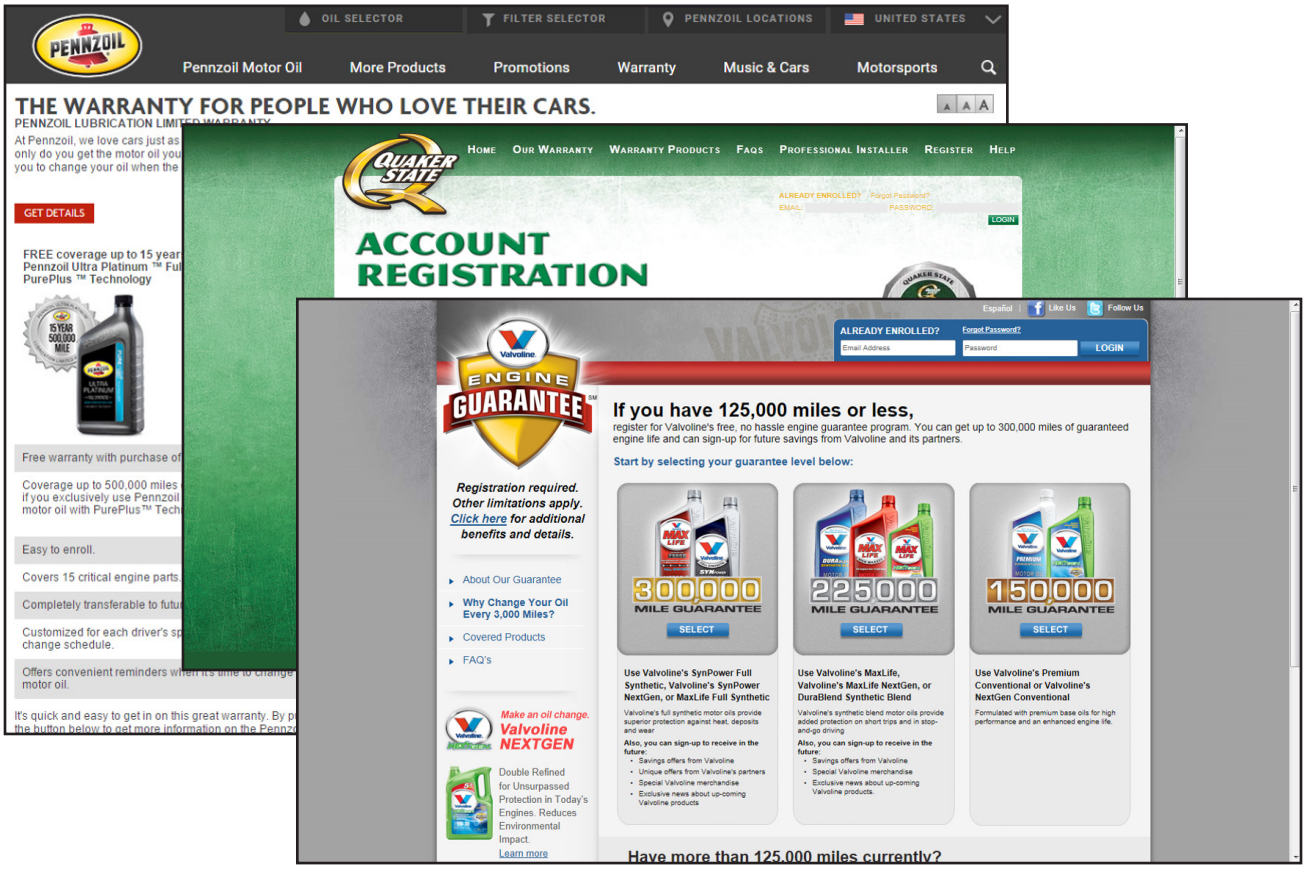
In the 1988 *Correlating Lube Oil Filtration Efficiencies With Engine Wear* technical paper published by the **Society of Automotive Engineers** (**SAE**), the relationship between oil filtration levels and abrasive engine wear was established. Testing determined that wear was reduced by as much as **70%** by switching from a **40 µ** filter to a **15 µ** filter. The SAE conducted tests on a heavy-duty diesel engine and an automotive gasoline engine and both provided consistent results.

The SAE paper on filtration discusses the introduction of synthetic fibers into the oil filter market which offer *"the capability of achieving high levels of filtration without the traditional sacrifice of dirt holding capacity and increased flow restriction."* Today, a new level of filtration has been reached with synthetic nanofiber technology. While today's filters offer even greater performance, the message then was the same as it is now: removal of particles measuring **2** to **25** µ is the key to controlling engine wear and there is a direct correlation between oil filter efficiency and engine wear. To establish a relationship between levels of filtration and engine wear rates, the SAE used a variety of oil filter types in its tests. Three glass filters and one traditional cellulose-media filter were used in the diesel tests, while one cellulose, one glass and two glass/cellulose-blend filters were used in the gasoline engine tests. The micron rating of each oil filter was determined and testing was conducted according to SAE guidelines.

Oil Filter	Micron Rating At 98% Efficiency	Media Composition
	Diesel	
A	40	Cellulose
B	15	Glass
C	8.5	Glass
D	7	Glass
	Gasoline	
E	40	Cellulose
F	30	Glass/Cellulose
G	25	Glass/Cellulose
H	15	Glass

Is Warranty Important to Our Customers?

Various oil manufacturers provide warranties or guarantees to their customers.



Aftermarket Performance Warranty

Meeting the criteria for most aftermarket performance warranties is pretty simple. First, your vehicle must be within the ***mileage criteria***. **Complete** a warranty application, many are now available online. **Keep** all receipts and all service invoices. Following these simple steps will allow you to drive with peace of mind.

Oils & Emissions Warranty

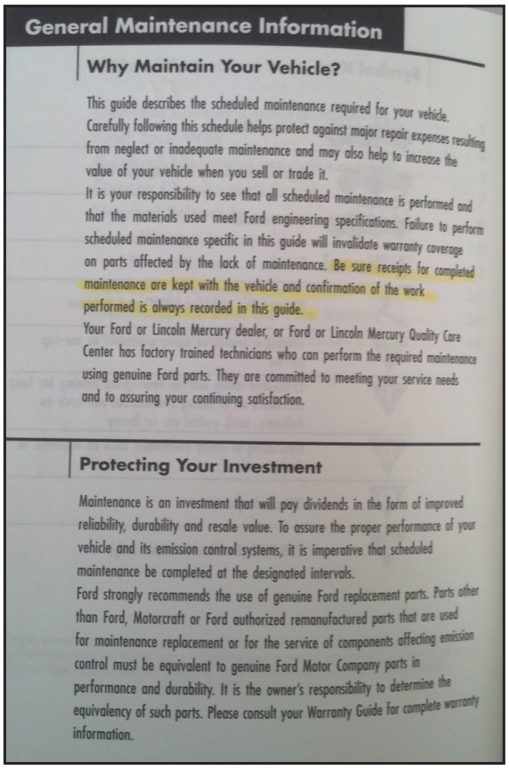
Can a catalytic converter be damaged by engine oil?

Emissions Warranty Liability

Failing to use low SAPS oil and changing oil more frequently accelerates this type of catalyst failure. Warranty claims may be denied if other than low SAPS are used. Many vehicles 2005 and newer: have **80–150** k mile emissions warranty coverage.

Tips to Avoid Warranty Issues

- **Make sure the customer reads the warranty**
- **Customers should be aware of the warranty period**
- **Customers should service the vehicle at the recommended intervals**
- **Owners should maintain *all* service records**
- **Under the Magnuson-Moss Act: it is illegal for manufacturers or dealers to claim the warranty is void because someone else did the work**



General Maintenance Information

Why Maintain Your Vehicle?

This guide describes the scheduled maintenance required for your vehicle. Carefully following this schedule helps protect against major repair expenses resulting from neglect or inadequate maintenance and may also help to increase the value of your vehicle when you sell or trade it.

It is your responsibility to see that all scheduled maintenance is performed and that the materials used meet Ford engineering specifications. Failure to perform scheduled maintenance specific in this guide will invalidate warranty coverage on parts affected by the lack of maintenance. Be sure receipts for completed maintenance are kept with the vehicle and confirmation of the work performed is always recorded in this guide.

Your Ford or Lincoln Mercury dealer, or Ford or Lincoln Mercury Quality Care Center has factory trained technicians who can perform the required maintenance using genuine Ford parts. They are committed to meeting your service needs and to assuring your continuing satisfaction.

Protecting Your Investment

Maintenance is an investment that will pay dividends in the form of improved reliability, durability and resale value. To assure the proper performance of your vehicle and its emission control systems, it is imperative that scheduled maintenance be completed at the designated intervals.

Ford strongly recommends the use of genuine Ford replacement parts. Parts other than Ford, Motorcraft or Ford authorized remanufactured parts that are used for maintenance replacement or for the service of components affecting emission control must be equivalent to genuine Ford Motor Company parts in performance and durability. It is the owner's responsibility to determine the equivalency of such parts. Please consult your Warranty Guide for complete warranty information.

2011 Ford FAQ sheet:

Do I still need to keep my receipts for my oil changes?

Yes, make sure that receipts for completed maintenance work are retained with the vehicle and confirmation of maintenance work is always entered in the **Maintenance Scheduled Log**. The log is located in the **Scheduled Maintenance** chapter of your **Owner Guide**. It is your responsibility to make sure that all of the scheduled maintenance is performed and that the materials used meet Ford engineering specifications. ***Failure to perform scheduled maintenance as specified will invalidate warranty coverage on parts affected by the lack of maintenance.***

Engine Oil Analysis: Oil's Trip to the Lab

Test Driving an Oil Analysis

- **Did you ever wonder if you are changing the oil after the right number of miles?**
  - **Analyzing the oil in your car is like sending a sample of your blood to the lab**
- **By detecting specific wear metals in the oil, experts can tell which engine parts might be in danger of malfunctioning**
- **The aviation industry does this constantly**

The best way to test how much life is left in an oil is to have an **oil analysis** performed where the **TBN**, or **total base number**, is measured. Just as it sounds, this is a measure of the reserve alkalinity, or how much acid-neutralizing capacity the oil still has.

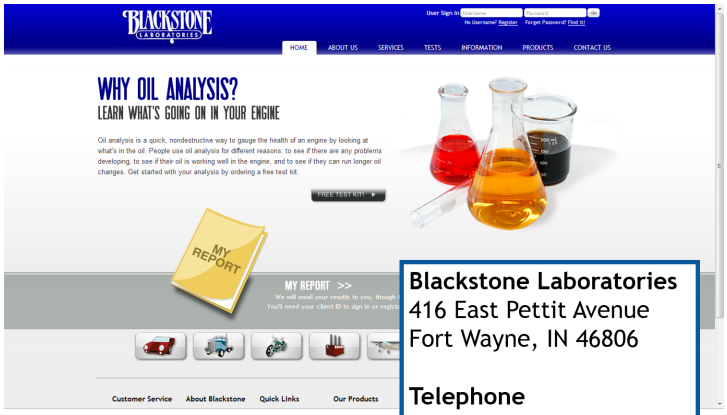
The spectrometer results can be very helpful in diagnosing what exactly is going on in your engine. The levels of common additives such as: calcium, phosphorus and zinc will give you an idea of how depleted the additive package in the oil has become. The levels of wear metals provide an idea of the condition of things like bearings and piston rings. For example, if you see an elevated level of copper or aluminum, it may indicate bearing wear. On the other hand, piston ring wear may show up as elevated chromium levels.

The Blackstone Labs analysis report also lists an explanation of what the different levels may indicate, recommendations as far as extending your oil change interval (may require TBN test), or things to keep an eye on in the future. Regular oil analysis will allow one to see how these levels have changed over time and allow for the tracking of conditions of the parts inside your engine. They do ask for some of the vehicle information such as: make, model, engine, mileage, etc. They seem to be very knowledgeable about some of the common problems with the engine in question, such as the issues with camshaft wear in some of the **TDI** (**turbocharged direct-injection diesel**) engines. All in all, an occasional oil analysis is a good way to stay apprised of the condition of your engine, as well as your oil. It is a great way to keep an eye on wear and potentially prevent damage. It is always easier to solve a problem when you know that the problem exists and what that problem is.

Blackstone Laboratories

Blackstone Laboratories will measure some of the physical properties of the oil including: flash point, viscosity and percentage of insoluble solids present. They also offer a variety of other tests which are listed along with applicable pricing on their website.

You can order a free container kit from Blackstone Laboratories @www.blackstone-labs.com. Once you send in the sample, the fee is **$25.00** for the test. If you want the **total base number** in the report, it is an extra **$10.00**.



Blackstone Laboratories
416 East Pettit Avenue
Fort Wayne, IN 46806

Telephone
260/744-2380 (8-5 EST)

Oil Report Interpretation

Here is an example of an oil report from Blackstone Laboratories

BLACKSTONE LABORATORIES

OIL REPORT

LAB NUMBER: G73098 **UNIT ID:**
REPORT DATE: 4/24/2015 **CLIENT ID:**
CODE: 20/501 **PAYMENT:** CC: Visa

UNIT

MAKE/MODEL: Ford 3.5L Duratec V-6
FUEL TYPE: Gasoline (Unleaded)
ADDITIONAL INFO: 2010 Flex

OIL TYPE & GRADE: Pennzoil Platinum 5W/20
OIL USE INTERVAL: 8,115 Miles

CLIENT

COMMENTS

: All is well at 170,027 miles. Wear metals are low and flat, just like we're used to seeing. The TBN is a little higher this time at 4.2 and there's no excess fuel or coolant present. A longer oil run should be no problem for this car and since you put a lot of miles on it, a longer run is going to save you some money in the long run. Try 10,000 or 11,000 miles on the next oil and check back. This engine wears so nicely that should be no problem.

Elements in PPM

This portion of the report lists the elements found in the oil in ppm.

ELEMENTS IN PARTS PER MILLION	MI/HR on Oil	8,115	UNIT / LOCATION AVERAGES	8,144	7,843	7,482	7,943	7,100	UNIVERSAL AVERAGES
	MI/HR on Unit	170,027		161,912	153,768	137,982	145,925	130,000	
	Sample Date	04/10/15		02/08/15	12/10/14	07/20/14	10/17/14	05/30/14	
	Make Up Oil Added	1 qt		1 qt	1 qt	0 qts	1 qt	0 qts	
	ALUMINUM	2	2	3	2	2	3	2	4
	CHROMIUM	0	0	0	0	0	0	0	0
	IRON	7	7	6	6	7	9	6	11
	COPPER	3	5	4	4	5	6	4	25
	LEAD	0	0	0	0	0	0	0	2
	TIN	0	0	1	0	2	0	0	1
	MOLYBDENUM	51	52	52	49	58	58	52	62
	NICKEL	0	0	0	0	0	0	1	0
	MANGANESE	1	1	1	1	1	1	1	5
	SILVER	0	0	0	0	0	0	0	0
	TITANIUM	0	0	0	0	0	0	0	5
	POTASSIUM	3	2	4	3	2	1	2	2
	BORON	2	4	6	6	2	2	4	56
	SILICON	8	10	10	9	12	11	12	15
	SODIUM	6	6	7	4	8	5	4	60
	CALCIUM	2509	2487	2506	2476	2494	2680	2576	2129
	MAGNESIUM	9	12	9	12	12	12	16	174
	PHOSPHORUS	639	613	597	605	626	682	623	678
	ZINC	780	742	730	688	745	811	779	779
	BARIUM	0	0	0	0	0	0	0	1

Properties

Here we can a list of the properties.

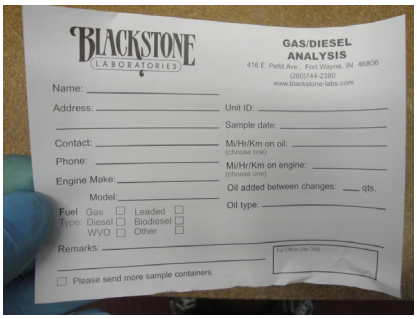
PROPERTIES		Values Should Be*						
	SUS Viscosity @ 210°F	53.3	46-59	53.4	52.4	52.9	53.6	52.4
	cSt Viscosity @ 100°C	8.28	6.0-10.2	8.29	8.01	8.16	8.35	8.00
	Flashpoint in °F	405	>355	405	395	420	395	435
	Fuel %	<0.5	<2.0	<0.5	<0.5	<0.5	<0.5	<0.5
	Antifreeze %	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Water %	0.0	<0.1	0.0	0.0	0.0	0.0	0.0
	Insolubles %	0.2	<0.6	0.1	0.1	0.3	0.3	0.1
	TBN	4.2	>1.0	3.5	3.3	3.7	3.6	2.7
	TAN							
	ISO Code							

The Oil Analysis Test

Total base number (**TBN**) is the measurement of a lubricant's reserve alkalinity which aids in the control of acids formed during the combustion process. The ***higher*** a motor oil's total base number, the more effective it is in suspending wear-causing contaminants and ***reducing*** the corrosive effects of acids over an extended period of time.

- **TBN (total base number) is used to measure the deterioration of the oil by assigning a number that is usually between 0 and 8**
- **2000 Mitsubishi Galant - 80,000 miles on its four-cylinder engine (3K on the oil)**
- **The 3K-mile oil still had plenty of life left in it**
- **The TBN of the 3,000 mile oil was 3.7**

When your oil sample is collected, you can send it via regular mail to the lab and if they have your e-mail address on file, they will e-mail you the results the day they analyze it. They will then send you a hard copy of the analysis report in the mail as well.

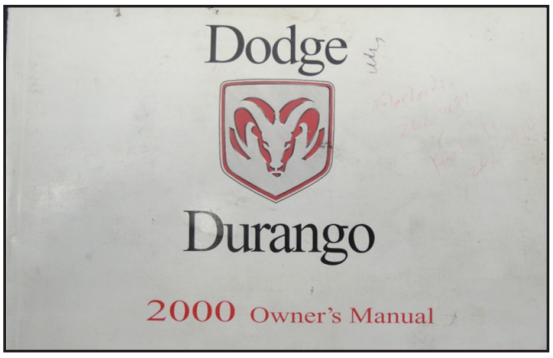


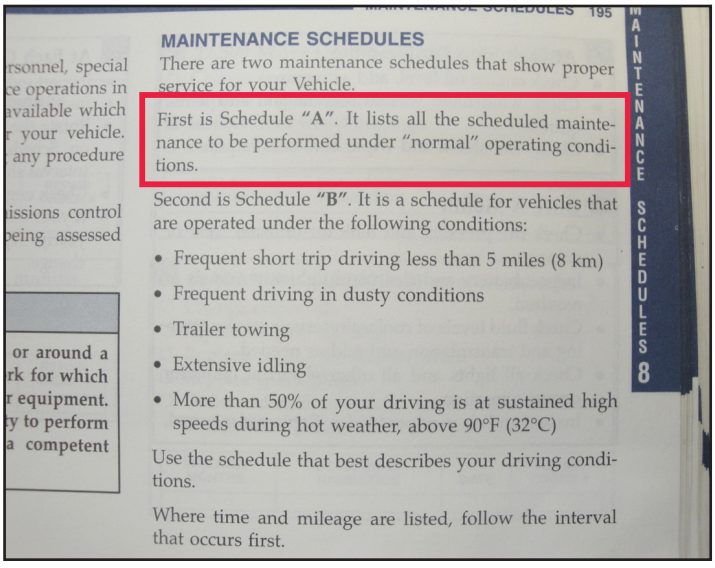
2000 Dodge Durango

- **164,000 miles on the vehicle**
- **4,000 miles on the oil**
- **Serviced regularly**
- **Customer wants to get about another two years out of this Dodge**
- **Lets see if were doing a good job with oil**
- **10W-30 is recommended by Dodge**

Look Up The Specifications

The **Owner's Manual** is a good place to start if your looking for the engine oil specifications, capacities, maintenance schedule and service history.

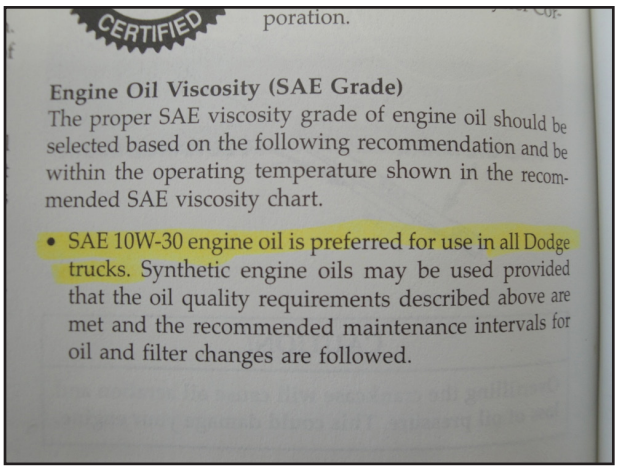


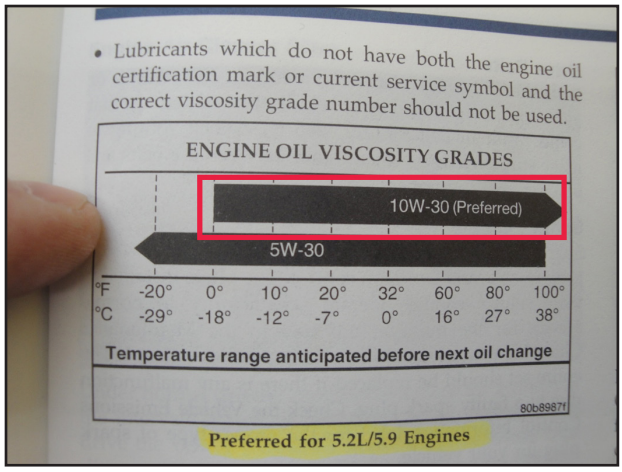


This truck is on **Maintenance Schedule A**. We always use the schedule that best describes the driving conditions that the consumer will operate the vehicle under. For some, it may be a mileage and for others, due to less use, they may have to be serviced by time.

SAE 10W-30 is Preferred for 5.9L

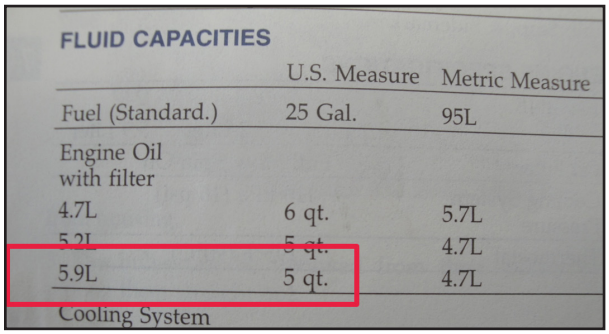
We are using conventional **10W-30** CARQUEST oil in this vehicle.





Fluid Capacities

According to the Owner's Manual, this vehicle requires a simple **5** quart oil fill with a new filter.



The Oil Fill

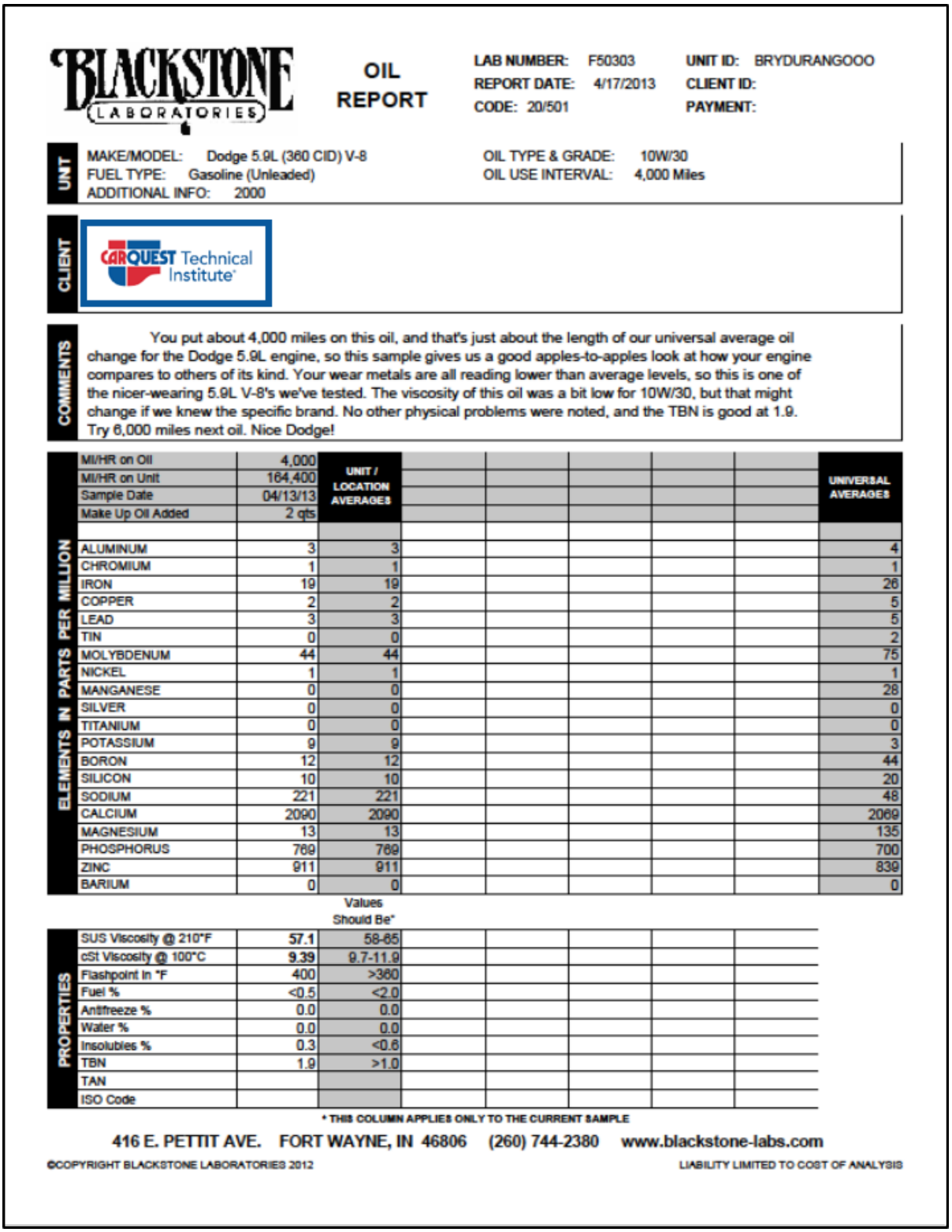
After the Oil Change

After the oil is changed, we **check** the level of the oil to ensure a proper fill. It is important to look at the oil level before an oil change is started as well.

Here, we have the oil sample labeled and ready to go the lab.

Dodge Durango Test Results

This is the **analysis report** we received for our Dodge Durango.



BLACKSTONE LABORATORIES

OIL REPORT

LAB NUMBER: F50303 UNIT ID: BRYDURANGOOO
REPORT DATE: 4/17/2013 CLIENT ID:
CODE: 20/501 PAYMENT:

UNIT

MAKE/MODEL: Dodge 5.9L (360 CID) V-8
FUEL TYPE: Gasoline (Unleaded)
ADDITIONAL INFO: 2000
OIL TYPE & GRADE: 10W/30
OIL USE INTERVAL: 4,000 Miles

CLIENT

CARQUEST Technical Institute

COMMENTS

You put about 4,000 miles on this oil, and that's just about the length of our universal average oil change for the Dodge 5.9L engine, so this sample gives us a good apples-to-apples look at how your engine compares to others of its kind. Your wear metals are all reading lower than average levels, so this is one of the nicer-wearing 5.9L V-8's we've tested. The viscosity of this oil was a bit low for 10W/30, but that might change if we knew the specific brand. No other physical problems were noted, and the TBN is good at 1.9. Try 6,000 miles next oil. Nice Dodge!

ELEMENTS IN PARTS PER MILLION

		UNIT / LOCATION AVERAGES						UNIVERSAL AVERAGES
MI/HR on Oil	4,000							
MI/HR on Unit	164,400							
Sample Date	04/13/13							
Make Up Oil Added	2 qts							
ALUMINUM	3	3						4
CHROMIUM	1	1						1
IRON	19	19						26
COPPER	2	2						5
LEAD	3	3						5
TIN	0	0						2
MOLYBDENUM	44	44						75
NICKEL	1	1						1
MANGANESE	0	0						28
SILVER	0	0						0
TITANIUM	0	0						0
POTASSIUM	9	9						3
BORON	12	12						44
SILICON	10	10						20
SODIUM	221	221						48
CALCIUM	2090	2090						2069
MAGNESIUM	13	13						135
PHOSPHORUS	769	769						700
ZINC	911	911						839
BARIUM	0	0						0

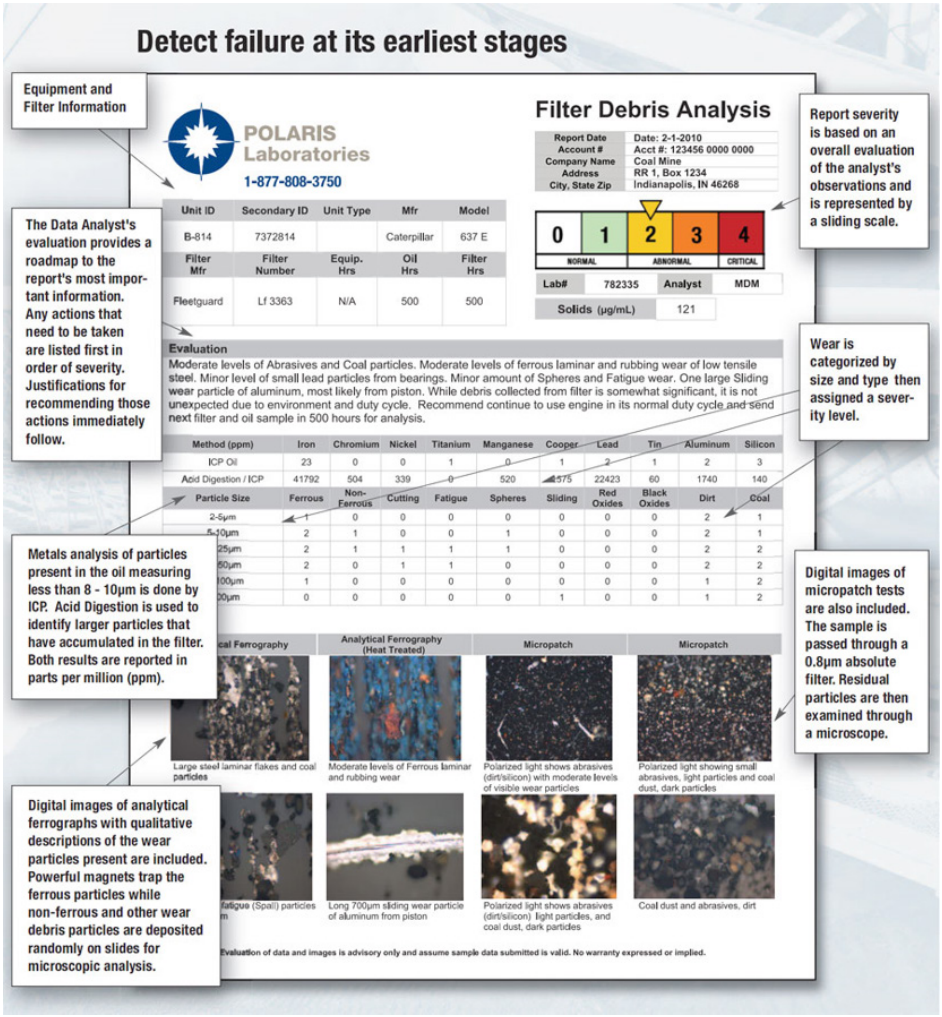
PROPERTIES

		Values Should Be*					
SUS Viscosity @ 210°F	57.1	58-65					
cSt Viscosity @ 100°C	9.39	9.7-11.9					
Flashpoint in °F	400	>360					
Fuel %	<0.5	<2.0					
Antifreeze %	0.0	0.0					
Water %	0.0	0.0					
Insolubles %	0.3	<0.6					
TBN	1.9	>1.0					
TAN							
ISO Code							

* THIS COLUMN APPLIES ONLY TO THE CURRENT SAMPLE

416 E. PETTIT AVE. FORT WAYNE, IN 46806 (260) 744-2380 www.blackstone-labs.com

Filter Debris Analysis



Castrol Labcheck Next Generation

What is Castrol Labcheck Next Generation? Castrol Labcheck Next Generation is a state-of-the-art used oil analysis program that helps manage fleets more effectively and efficiently. Through ongoing analysis of used oil samples, Castrol allows you to pinpoint and solve equipment problems by providing a full range of information that can support your operations and maintenance decisions.

Their carefully monitored used oil analysis program helps maintenance managers effectively:

- **Maximize component life**
- **Pinpoint problems *before* failure occurs and reduce downtime and overall operation costs**
- **Plan maintenance schedules according to priority**
- **Review trends in equipment**
- **Establish guidelines for improvement**
- **Optimize drain intervals**
- **Make thorough and justified resale and purchasing decisions**
- **Implement a severity-based maintenance program**

Wix Filters Oil Analysis Kit

Engine Oil Marketing & Oil Supplements

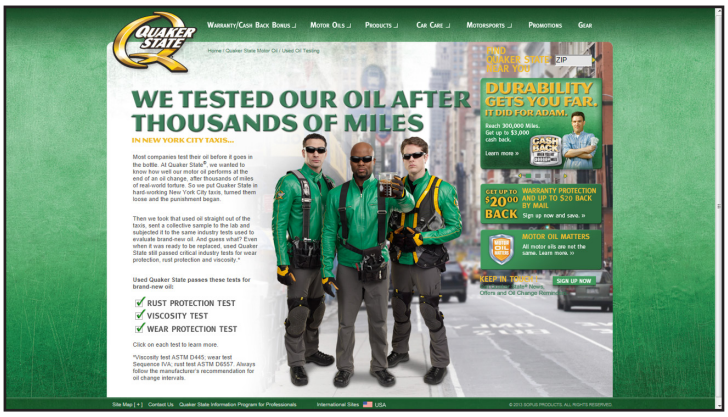
Marketing & Celebrity Endorsements

Depending on your taste in music, the artists you like and the catch phrase the company uses to entice you, you may buy the oil that they endorse. Many people have a connection between music and the cars they drive.

Pennzoil does an excellent job of offering a wide variety of advertising and this campaign works well to support our disabled American Veterans.

If you are a NASCAR fan, Quaker State may appeal to you.

Quaker State – ASTM D445 Test



The **ASTM D445** (**KV 100**) **test** measures an oil's ability to maintain viscosity even at high operating temperatures, a crucial aspect of engine protection. Modern engines use motor oil as a hydraulic fluid and depend on motor oil viscosity to help ***float*** metal surfaces away from each other on a **hydrodynamic wedge**—a thin film of motor oil that keeps metal parts separated and engines functioning properly. Maintaining viscosity means an oil stays in grade and does not thin out prematurely which could lead to metal-to-metal contact. **KV** refers to **kinematic viscosity**, the **100** refers to the Celsius temperature at which the viscosity of the oil is measured. The used Quaker State® **SAE 5W-30** that was tested after thousands of miles in New York City taxis was so durable that it still met the KV 100 standard for brand-new oil which means it still retained critical engine protection at high temperatures, still functioned as an SAE **5W-30** oil and still maintained a critical film of oil on engine parts to prevent metal-to-metal contact inside your engine — even when it was ready to be replaced. **Note**: in multi-grade oils, the higher number always refers to its viscosity at higher operating temperatures, the lower number refers to its viscosity at lower operating temperatures or startups. So in the case of an SAE **5W-30**, the KV 100 test would determine its ability to function as a 30-weight at higher operating temperatures. It is easy to remember which number is which; the **W** next to the lower number stands for **winter**.

New Packaging for Engine Oils

The **Castrol E-Pack** is 24 quarts /6 gallons in each

- **Color-coded viscosity call outs allows for easy product grade identification**
- **Each pack includes a chart for easy tracking of used quarts**
- **Cardboard box folds down for easy recycling**
- **The bag and spout can be discarded with little to no residual oil**

Oil change service is completed more quickly vs. using quart bottles, saving precious time for you and the customer. Secondly, think of all the plastic that will be saved by moving towards a system such as this.

Shell Ecobox

Shell is introducing the Ecobox™. Ecobox™ can help owners and operators of oil change facilities more efficiently store, manage and deliver oil to their customers' vehicles. The bag containing the oil in the Ecobox™ carton is designed to help improve speed and ease of use compared to bottles, as it drains quickly, leaves minimal residual oil behind and requires less handling than quart bottles.

Oil is easily dispensed from the specially engineered box and valve and then transferred to the engine crankcase by a custom-designed Ecobox™ pump system. The Ecobox™ carton can reduce storage space in shops, as it is about one-half the size of the equivalent volume of single-quart cases.

As the number of viscosity grades installed locations are required to keep on hand continues to increase, the Ecobox™ system can allow installers to offer a wider range of specialty oils to meet customers' needs by making it easy to stock and install a number of different motor oils without the need for bulk storage.

The plastic liner results in **89%** less plastic landfill waste than the equivalent **24** quart plastic bottles and the Ecobox™ carton is fully recyclable. The Ecobox™ pump system provides motor oil delivery that helps improve many operational tasks associated with dispensing oil using individual quarts. Shell plans on introducing the Ecobox™ for its Pennzoil and Quaker State oil products.

6 Gallon Motor Oil Ecobox

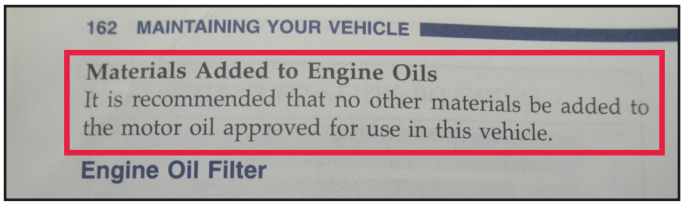
Engine Oil Supplements

Many engine oil supplements are readily available. Take your pick, they are all out there and will continue to be marketed to the public.

Most new oil requirements have eliminated the need for additional supplements. What you may not know is that all these additives may already be in the oil, and putting in more may actually dilute what's already there and lessen the oil's effectiveness. Any reputable brand of motor oil will come with additives that improve its viscosity index and detergents that keep your engine free of sludge. Most oils will also include rust retardants to prevent corrosion and chemicals to protect metallic surfaces. Even trusted professional supplements can cause issues on late model engines. If you are using the correct formulated oil product, you probably do not need any aftermarket oil supplements.

Note: Many OEMS prohibit use of oil additives. Always **check** the owner's manual to see if it has any special additive needs, but this is unlikely in anything except some of the most exotic high-performance engines.

Dodge Oil Notice



According to this Dodge Owner's Manual, it is recommended that no other materials be added to the motor oil approved for use in this vehicle.

Recycling Used Oil

More than **3** billion quarts of oil are consumed by cars and trucks annually in the United States. Reclaiming that oil after use would help assure it does not damage the soil and water in local ecosystems. Considering that just **1** gallon of used oil can contaminate up to **1** million gallons of water, it is essential to dispose of used oil the right way.

When changing a vehicle's motor oil, the used motor oil is of critical concern since each gallon of motor oil that is disposed of improperly can contaminate up to a million gallons of drinking water. Some local government agencies classify used motor oil as a hazardous substance, as it often contains carcinogenic substances. It is recommended to check with your local government recycling and waste authorities on what to do with used motor oil.

Valvoline NextGen Oil

On Monday, Feb. 27, 2013, Matt Kenseth scored another milestone for the iconic race team with his win at the Daytona 500. The victory signified not only the first Sprint Cup win of the season for Roush Fenway Racing and its 300th NASCAR victory, but also its first checkered flag since making the switch to Valvoline's NextGen recycled motor oil technology, made with **50%** percent recycled oil.

Summary

Motor oil does more than simply lubricate. OEM proprietary formulas will continue to challenge us to select the correct oil for our customers' vehicles. Oil change service is continuously ***changing***. Make the correct choices in oils to extend the longevity of vehicles. Performance, emissions and fuel economy are all affected by motor oil. So, get the facts. Stay up to date on lubrication and filtration technologies and be aware that the OEMS are constantly changing oil formulas

Now go ***change*** your oil.

Glossary of Terms

Additive: A compound mixed to the base oil in order to modify its properties or performance.

Antifoam additive: An additive to reduce the foaming of petroleum products. Additives may be silicone to destroy the surface bubbles or polymer to reduce the count of small internal bubbles.

Anti-wear additive: An additive that creates a thin layer with good adhesive properties in order to prevent metal-to-metal contact at high-load spots.

Ash: Metallic residue formed due to the high temperature in the combustion chamber or on other engine parts.

Base oil: Usually refined crude oil fraction or selected synthetic base stock. Additives are mixed to them during lubricant manufacturing.

Catalytic converters: Oxidizing catalytic converters remove hydrocarbons from the exhaust gas while reducing catalytic converters reduce the NOx emissions. Both types contain noble metal (platinum, palladium or rhodium), which can be poisoned by lead or phosphorous present in fuel or lubricants.

Centistoke (cSt): The worldwide unit of kinematic viscosity.

Corrosion inhibitor: An additive that protects the lubricated metal parts from the chemical attacks caused by water or other contaminants.

Detergent additive: An additive mixed to fuel and lubricants in order to keep the engine clean. The most used detergent additives in motor oils are metallic soaps that have enough base reserves to neutralize the acids formed during engine operation.

Dispersant additive: An additive which keeps the solid contaminants in colloid suspension, thus, prevents the oil sludge and varnish buildup on the engine parts. This additive is usually non-metallic (ashless) and it is used together with detergent additives.

DPF (diesel particulate filter): The DPF is a physical filter that reduces the solid particle content of the exhaust gases.

EGR (exhaust gas recirculation): A system designed to reduce NOx emissions. It recirculates the exhaust gas back into the intake manifold, thus, diluting the fuel/air mixture and reducing the temperature and NOx formation.

EP additive: Lubricant additive that prevents the seizing of the sliding surfaces under extreme pressure conditions.

Flash point: Minimum temperature at which a fluid will support instantaneous combustion, but before it will burn continuously. The flash point is an important indicator when determining the fire and explosion hazard of a petroleum product.

Friction: The resistance that occurs when one object is moved on another object. The friction depends on the smoothness of the sliding surfaces and on the force used to press them on one another.

HTHS (High Temperature High Shear) Viscosity: A measure of a fluid's resistance to flow under conditions resembling highly-loaded journal bearings in fired internal combustion engines, typically **1** million per second at **150 °C**.

Hydro-finishing: Hydrogen treatment of crude oil in order to saturate the molecules and increase stability.

Kinematic viscosity: The fluid's resistance to flow when affected by gravity. Usually measured on **40 °C** or **100 °C**.

Lubrication: The reduction of friction and wear using a friction-reducing layer. This layer can be liquid, solid or plastic.

Multi-grade oil: A motor or gear oil that meets the requirements of more than one SAE viscosity grade and thus, it can be used in a wider temperature range.

Oil sludge: Thick, dark residue with mayonnaise-like consistency, which builds up on the non-moving inner parts of the engine. Insoluble contaminants in the oil accelerates its buildup.

Oxidation: Occurs when the petroleum product reacts with oxygen. The process is accelerated by heat, light, metallic catalysts, water, acids or the presence of solid contaminants.

Oxidation stability: A petroleum product's resistance against oxidation. It affects product life both in storage and in use.

Pour point: Indicates the fluidity of the oil or fuel on low temperature. It is the lowest temperature on which the fluid still flows.

Pre-ignition: Pre-ignition is the combustion of the fuel/air mixture that occurs in internal combustions engines before the spark plug fires. Typical reasons are the hot fuel or the lubricant buildup in the combustion chamber. It reduces engine power and it can damage the engine.

Pumpability: A low-temperature property of the oil, which determines to what extent is the oil capable to flow to the pump on low temperatures.

Refining: A series of processes through which the crude oil is converted into a petroleum product. Such processes include: thermal cracking, catalytic cracking, polymerization, alkylation, reforming, hydrocracking, hydroforming, hydrogenation, hydrogen treating, solvent extraction, dewaxing, de-oiling, acid treating, clay filtration and deasphalting.

Ring sticking: Ring sticking occurs when the piston ring sticks into the groove due to excess contamination.

Saybolt Universal Seconds (**SUS**): A measure of lubricating oil viscosity in the oil industry. The measuring apparatus is filled with specific quantity of oil or other fluid and its flow time through standardized orifice is measured in seconds. Fast flowing fluids (low viscosity) will have low value; slow flowing fluids (high viscosity) will have high value.

Synthetic lubricants: Lubricants that are made of specifically composed chemically reacting substances that has pre-determined properties and characteristics.

Total base number (**TBN**): The amount of acid required to neutralize the lubricant's basicity expressed in KOH equivalent.

Total acid number: The required amount of KOH to partially or fully neutralize the petroleum product's acidity.

Tribology: Science branch dealing with friction, wear and lubrication.

Varnish: Thin, insoluble non-wipeable layer on the internal parts of the engine. It can cause the sticking and breakdown of internal moving engine parts.

Viscosity: A fluid's resistance to flow.

Viscosity index: The relationship between a fluid's viscosity and temperature. Fluids with a higher viscosity index change their viscosity to a lesser degree due to the change of temperature.

Viscosity modifier: Lubricant additive, usually a polymer that provides beneficial rheological properties to lubricating oils such as reducing the tendency of an oil's viscosity to change with temperature.

Post-test Questions

1. When discussing the details of an **engine oil report**, one of the most important properties is the:

   A. Anti-freeze in the oil
   B. Fuel in the oil
   C. Total base number (TBN)
   D. Zinc in the oil

2. A technician is explaining the differences to a customer between **0W-30** grade oil compared to **10W-30** grade oil and states that they both have the same thickness at operating temperature.

   _____ True _____ False

3. Which of the following viscosities are the most viscous?

   A. 0
   B. 30
   C. 20
   D. 50

4. Common failures on engines equipped with **variable valve time** (**VVT**) systems can be traced to using improper engine oils.

   _____ True _____ False

5. The **flow volume of a liquid over a period of time** is known as:

   A. Sabolt Universal Minute
   B. Kinematic viscosity
   C. Lubricant density
   D. Viscosity flow value

6. A service advisor is advising a customer to only use a **dexos® 2** approved engine oil on her 2014 Chevrolet Malibu with a 4 cylinder gas engine.

   _____ True _____ False

7. Two technicians are discussing the definition of **fluid mechanics**. **Technician A** states that **fluid statics** is the study of fluids at rest. **Technician B** states that **fluid dynamics** is the study of the effect on fluids in motion. Who is correct?

   A. Technician A
   B. Technician B
   C. Both Technician A and Technician B
   D. Neither Technician A nor Technician B

8. An oil's **viscosity** is defined mainly by the size of the oil's molecules. The smaller molecules' structures are ***thicker*** or ***higher*** (***heavier***) and the larger molecules are ***thinner*** (***lighter***).

   _____ True _____ False

9. When discussing **proper oil filtration** and **micron entrapment media**, which of the following contamination causes the greatest threat to wear sensitive surfaces?

   A. 2-22 microns
   B. 22-30 microns
   C. 32-40 microns
   D. 42-50 microns

10. **Tribology** is the science behind friction and wear and is helping engineers solve issues with meeting government demands for improving fuel economy to **54.5 MPG** by 2025.

    _____ True _____ False

11. The rule for **synthetic blends** (semi-synthetic) oils is that they must have a minimum of _____ percent synthetic oil in them to be considered synthetic blends.

    A. 5
    B. 10
    C. 15
    D. 50

12. When discussing **engine oil monitoring systems**, engineers have figured out a fairly accurate and reliable way to calculate the remaining oil life without having to actually sample the oil.

    _____ True _____ False

NOTES:

CARQUEST Technical Institute®

Please take a few minutes to complete this form.It is the only way we can make the changes YOU want. Remember this is your class!

Dates of Class:_____ **Instructor:**_____

Class Name:_____ **Region #:**_____

Please check the appropriate boxes.

1. Please rate how well the subject matter of this course met your expectations:
   Excellent ☐ Good ☐ Fair ☐ Poor ☐
2. Please rate how well this class will help you improve your skills:
   Excellent ☐ Good ☐ Fair ☐ Poor ☐
3. Please rate the likelihood that you will apply what you learned back at your shop:
   Excellent ☐ Good ☐ Fair ☐ Poor ☐
4. Please rate the likelihood that you will recommend this class to another technician:
   Excellent ☐ Good ☐ Fair ☐ Poor ☐
5. Please rate how well the instructor covered the subject matter:
   Excellent ☐ Good ☐ Fair ☐ Poor ☐
6. Please rate the instructor's knowledge of the subject:
   Excellent ☐ Good ☐ Fair ☐ Poor ☐
7. Please rate the instructor's ability to deliver the subject:
   Excellent ☐ Good ☐ Fair ☐ Poor ☐
8. Please rate the instructor's ability to answer questions:
   Excellent ☐ Good ☐ Fair ☐ Poor ☐
9. Taking everything into consideration, would you say this class was:

   Very worthwhile ☐
   Worthwhile ☐
   Somewhat Worthwhile ☐
   Not worthwhile ☐

For what other subjects would you like CTI to develop classes?

_____

_____

May we follow up regarding your comments? Yes ☐ No ☐

(Optional)
Name _____

Shop _____

Phone _____

City _____

Comments:

_____

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