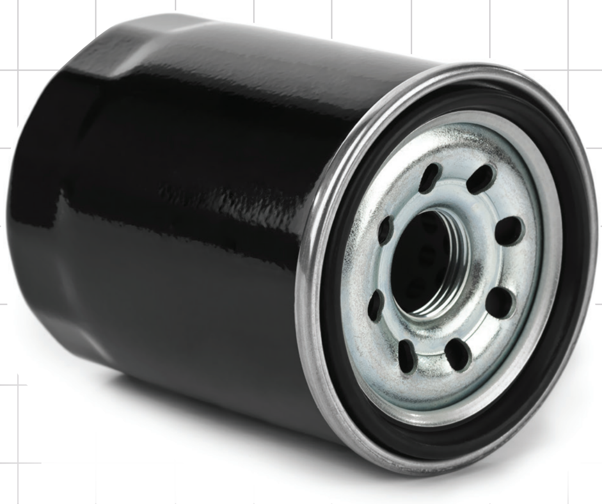
PURDUE EXTENSION

PPP-124

Engine Oils and Their Filters



Understanding Oil Lubrication and Contamination Control

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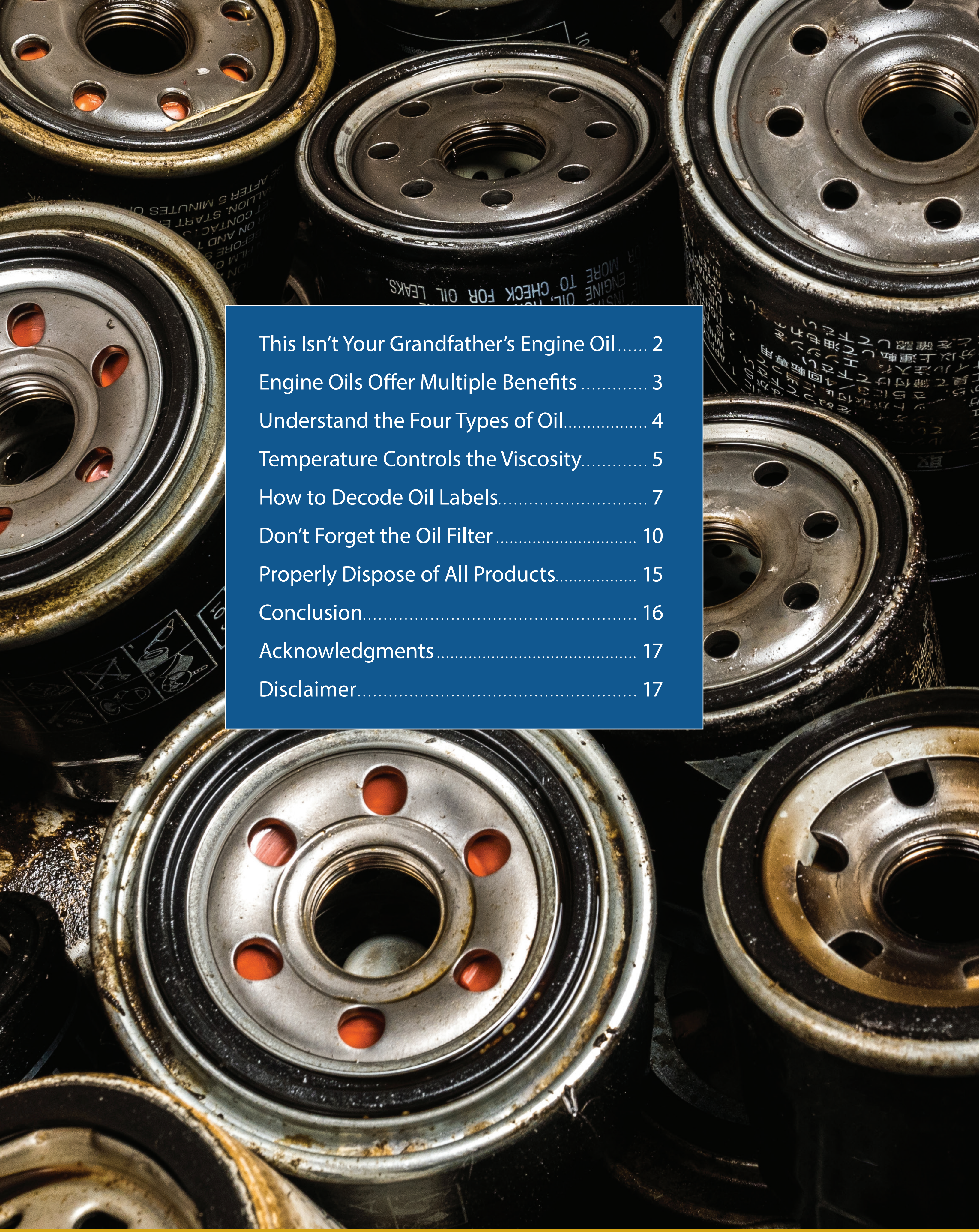


This Isn't Your Grandfather's Engine Oil

A great deal of research and new technology have advanced the fields of oil lubrication and contamination through oil filters. If you still think (as many do), that "All oil filters do the same thing, so why pay more for a brand name?" then it may be time to reconsider.

Lubrication research continues to improve how lubricants (such as oils) protect moving parts, increase fuel economy, and extend the life of your engine. The lubrication industry has continually upgraded the quality of engine crankcase oils, grease (chassis, wheel bearings), transmission fluids, hydraulic fluids, gear oils, and brake fluids.

The thought that all oils are the same implies that a piece of equipment built five years ago requires the same lubricants as the same type of equipment being built today. But fuel conservation, lower emissions, new materials, and better manufacturing (tighter equipment tolerances) all combine to require specialized oils and filters for today's equipment that older models did not have.

As lubrication needs have evolved, trucks, planters, harvesters, sprayers, trailers, and engines depend on the proper oil to keep internal parts operating and functioning properly within the equipment specifications. As equipment specifications change, manufacturer's design and upgrade oil lubricants to meet the new demands. That's why it is important to identify and select the proper oil and filter based on the equipment manufacturer rather than basing your selection on cost.

Performance and compatibility must come first; price should come second.

While lubricants and filters may look similar and be packaged alike, remember that it's what you don't see inside the product that allows it to perform a certain way. Separating products that perform well from those that do not perform as well can be challenging, because the technical information is conveyed in a coded language consisting of numbers and abbreviations. These numbers and abbreviations are the industry standards that lubricant manufacturers use when they build their products.

The purpose of this publication is to demystify these numbers and abbreviations so that you will be able to distinguish the differences between oils and oil filters. Understanding these terms will help you choose the best (which is not always the cheapest or even the most expensive) engine oils and oil filters for your equipment and application. In the long run, choosing the correct oil and filter will increase equipment reliability, enhance operating performance, lower maintenance costs, and extend your equipment's service life.

Start (and End) With the Owner's Manual

The key to selecting the correct lubricants for your equipment begins and ends with the owner's manual. Whether you have a half-million-dollar piece of agricultural equipment or a 300-dollar lawnmower engine, you should use the lubricants the manufacturer recommends and change or apply them when they specify.

It is critical to follow owner's manual instructions, especially while the equipment is still under warranty. Failing to follow the recommendations can void the warranty.

Engine Oils Offer Multiple Benefits

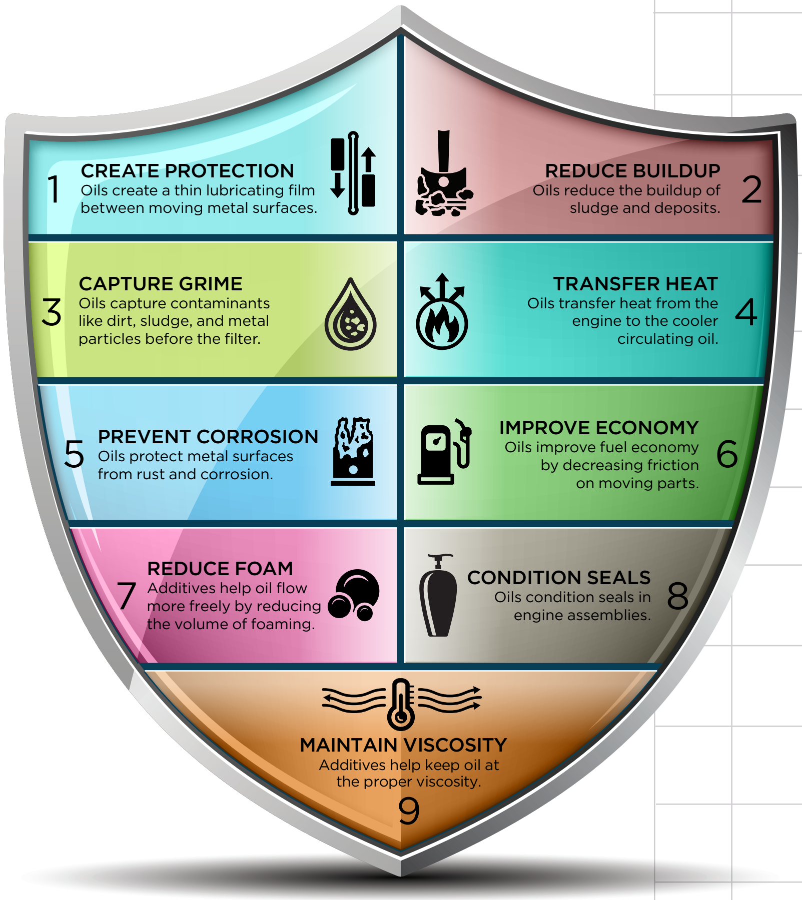
Retailers have shelves filled with multiple brands of engine oils. Each manufacturer claims their product offers one advantage or another over the competitors. Most engine oils, however, are similar in that they are designed to meet basic engine specifications, such as:

- How quickly the oil can lubricate the moving parts in a cold engine
- How well they protect parts at higher engine temperatures
- How soon they break down
- The recommend interval between oil changes

Conventional engine oils begin life as crude oil pumped from underground reservoirs. Raw crude contains impurities that need to be removed and require further refinement to get the oil to a specific viscosity. Conventional engine oils consist of approximately 80 percent refined crude oil (called base oil). The remaining 20 percent are additives that serve numerous purposes, such as enhancing base oil properties, suppressing certain base oil properties, and adding new properties to the formulation. Usually, these additives are what distinctly separate one crankcase oil product from another.

Crankcase oils protect engines by:

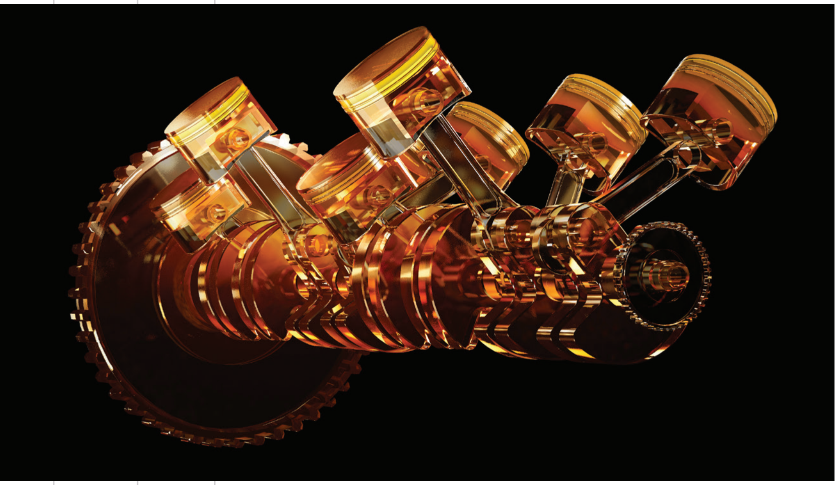
- Creating a thin layer of lubricating film between the metal surfaces that slide or roll against each other. This layer reduces friction and wear.
- Reducing the buildup of internal sludge and deposits.
- Transporting or dispersing contaminants such as dirt, sludge, soot, and metal particles. These contaminants are removed when the oil passes through the filters.



NINE WAYS OILS AND ADDITIVES PROTECT ENGINES

- Transferring the heat generated by the engine into the "cooler" oil circulation.
- Protecting metal surfaces from rust and corrosion.
- Improving fuel economy by decreasing friction between moving parts.
- Helping the oil pump deliver the correct value of oil more effectively by reducing the amount of bubbled air throughout the body of the oil and foam or froth.
- Conditioning engine seals to reduce leaks.
- Maintaining acceptable viscosities (thicknesses) for hot and cold operating temperatures.

And you thought oil was only for lubrication!



Make the Oil Work for You

Make sure to change oil and filters at the intervals the manufacturer recommends. If you wait to change the oil, it's not a linear degradation. In other words, there is a sharp fall-off in engine oil performance.

If you are a short-trip driver, it is probably beneficial to change the oil more frequently. If you are a long-haul driver, you can extend the oil change somewhat. If the vehicle is newer you can extend it. If the vehicle is older, then it will require more frequent oil changes. Many factors influence an oil's life expectancy, but at the end of the day, you need to change the oil and filter at timely intervals to avoid permanent engine damage.

Understand the Four Types of Oil

When you shop for motor oils, there are four group numbers as defined by the American Petroleum Institute (API). The groups (1 through 4) refer to how refined each product is — the most highly refined oils are API Group 4.

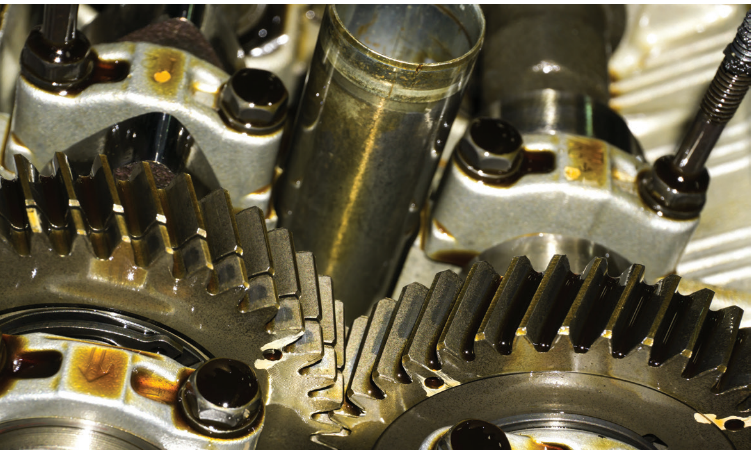
Most often, you will see four types of oil on the shelf, and the API Group number assigned to each type depends on the particular product. The most common oil types (and their API Group numbers) are:

- **Conventional.** Conventional base oils are generally classified as API Group 2, which means they are highly refined from crude oil. In the past, we only used Group 1 motor oils, and a few conventional formulations as base oils. Now there are even further refined oils known as Group 3.
- **Synthetic.** Refiners manufacture synthetic oils using ethylene gas that is extracted from natural gas. Unlike the refined conventional base oils, synthetic oils are free of contaminants. These are mainly classified as Group 4 oils.
- **Blends.** Synthetic oil blends are made by combining oils from API Groups 2, 3, and 4. By definition, these blends cannot contain more than 30 percent synthetic oil.
- **High-mileage.** High-mileage motor oils are formulated for vehicles with approximately 75,000 or more miles. These oils contain specific additives, including seal enhancers, to mitigate internal or external leaks often associated with older engines. Some of these additives work by causing the gaskets, O-rings, and other seals to swell slightly.

Temperature Controls the Viscosity

Temperature determines how easily an oil will flow through an engine and the thickness of the oil lubricating films. The temperature inside a gasoline or diesel engine can reach 300ºF or greater for brief moments. This is important, because at higher temperatures, oils get thin and flow more like water.

In fact, the oil can get so thin that it cannot provide the oil-film thickness that separates the two moving surfaces it is trying to protect. Most parts need to basically "hydroplane," just as worn tires on a wet pavement do. Engines need a minimum viscosity to achieve the separation between parts, but the specific viscosity engines need is based on the specific parts, engines, temperatures, speed, and loading.



When it's cold, oil can thicken and flow more like molasses. When you start an engine under these cold conditions, the oil residue that is protecting your engine components is what was left when you last turned off the engine. When you start an engine in cold weather, there is a brief moment when fresh oil from the oil pan does not flow and circulate in all zones of the engine. It takes more time for the oil to move from the oil pan to fill some vacated cavities, lines, and components that might have been drained slowly while the engine was at rest.

Testing Engine Oil

Whether they have fleet vehicles or tractors, many operators will test their oil to see if they contain any antifreeze, soot, fuel, chrome, or other contaminants that can damage the engine and affect oil performance. What you find in an oil sample analysis allows you to determine whether to change your engine oil and filters earlier or later based on the oil's condition.

You can also use test results to identify a potential problem before it becomes a costly one. For example, if a test reveals that the oil contains chrome, then that may indicate abnormal wear with bearings.

Contact your oil supplier to determine if they will test oil or recommend someone who can.

During start up, there might be metal-on-metal contact — there may be even more if you are using the wrong oil. This is called a *dry start* condition, and is the source of a high percentage of all engine wear. This is why manufacturers recommend that you do not operate your cold engine at a high RPM until the engine oil pressure gauge rises and stabilizes for several seconds.

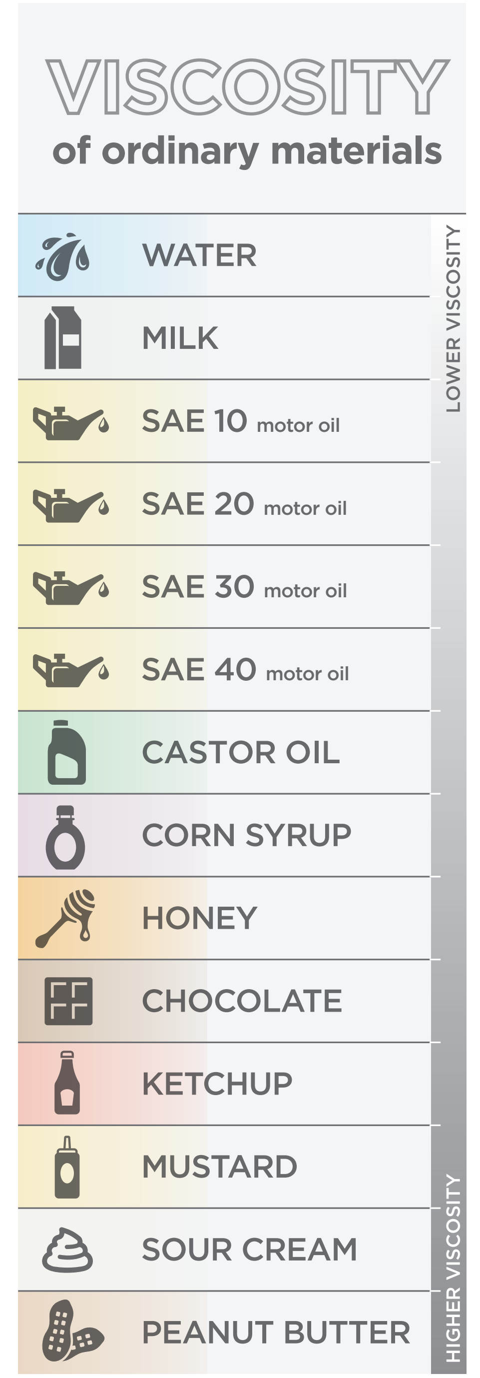
Engineers measure how an engine oil flows across a range of operating temperatures by assigning it a Viscosity Index (VI) rating. Viscosity measures the time it takes for oil to flow through a standard opening such as an orifice or capillary. Left unaltered, an oil can flow like water (low viscosity) when it is at high temperatures, or it can flow like syrup (high viscosity) when it is at cold temperatures.

Think of pouring honey after letting it sit in the refrigerator overnight. The honey will thicken to the point that it barely moves when you turn the jar upside down. If you put the same honey in a microwave and heat it up for a minute, it will flow like water.

Petroleum engineers and chemists formulate oils to accomplish two major goals:

1. To be thick enough to provide a lubricating film at hot temperatures
2. To be thin enough at cold temperatures to move quickly from the oil pan into and through the engine's moving parts

They can accomplish these goals by using additives called *viscosity index improvers* in engine oils. Synthetic lubricants require fewer of these additives, because they have naturally high VIs. The higher the VI, the less viscosity changes with the temperature.



Source: www.vp-sci.com

Are Synthetics Better Than Conventionals?

A Consumers Union study examined the differences between conventional and synthetic oils in New York City taxi cabs. Half the taxis used conventional motor oil, the other half used synthetic oils. The researchers changed the oil in all taxis at the regular scheduled maintenance intervals.

All taxis were driven for 100,000 miles, and then the researchers evaluated the internal engine parts for wear or deposits. The researchers concluded that there were no differences in wear between the engines that used conventional oils and those that used synthetic oils as long as the taxis received their routine oil changes.

There is a consensus that synthetic motor oils may help under extreme conditions — such as when owners do not regularly change filters and oils. Another scenario is when the engine coolant may be weak. These and other extreme conditions might be instances when synthetic oils could outperform a conventional motor oil.

Under normal maintenance, driving, and operating conditions, the study concluded there are little differences between conventional and synthetic motor oil.

How to Decode Oil Labels

When you look at engine oil labels, there are two items to look for:

1. The SAE grade
2. The API service rating

The SAE Grade

The Society of Automotive Engineers (SAE) created a numerical numbering system that converts the common units of viscosity (centistoke, cSt) to a numerical system that describes the oil's grade.

Thicker oils have higher viscosity ratings. In practice, the higher the viscosity rating, the higher the SAE number will be for that oil. The SAE ratings move in steps (not linearly).

Oil containers may look alike, but what's inside is very different from one motor oil to the next.

You can easily find the SAE grade on a circular emblem that's generally on the back of a container label. In the center of the emblem is the viscosity grade, which is the same number found on the front of the oil container. In the photo shown on this page, the SAE grade is 5W-30.

The first part of an SAE number (such as 5W) is sometimes called the *front number*. The W in the front number does not stand for "weight" (as many people often refer to it). Rather, the W is an abbreviation that indicates the oil's *wintertime* viscosity.

The first number in the SAE grade (sometimes called the front number) has nothing to do with how tight the engine is built or the tolerances. But the back number has everything to do with both of those factors. The first number is the start-up viscosity in cold weather. Once the engine thermostat opens, the back number is the viscosity that is protecting the engine.

In an SAE number, the front number is between 0W and 25W (OW, 5W, 10W, 15W, 20W, and 25W). The smaller the front number, the thinner the oil is at colder temperatures, which allows the engine to crank more easily and the oil to flow more readily.

The part of the SAE number that follows the W is called the *back number*. The back number is the SAE viscosity grade at higher operating temperatures (defined as 210ºF). There are eight oil viscosity ratings for these higher temperatures: 8, 12, 16, 20, 30, 40, 50, 60. The higher the back number, the thicker the oil remains at the higher temperatures, which can protect engine parts against wear from friction.

In short, an oil is often assigned two viscosities that depend on temperature. Oils that have these two viscosities are called "multi-grade" oils. The oil will have a lower viscosity rating at cold temperatures (for engine startup) and behave as an oil with a higher viscosity at

hot temperatures for better coating and protection of moving parts in the engine.

Any oil will still flow easier as the temperature increases, even though the winter value is lower than the second value. In order to assign the two values (for instance, 5W-30), lubricant formulators test the oil extensively to verify that it meets the requirements of both a 5W at colder temperatures and 30 oil at warmer temperatures. These tests go way beyond common viscosity measurements.

Now, let's compare the numbers that follow the W (the back number).

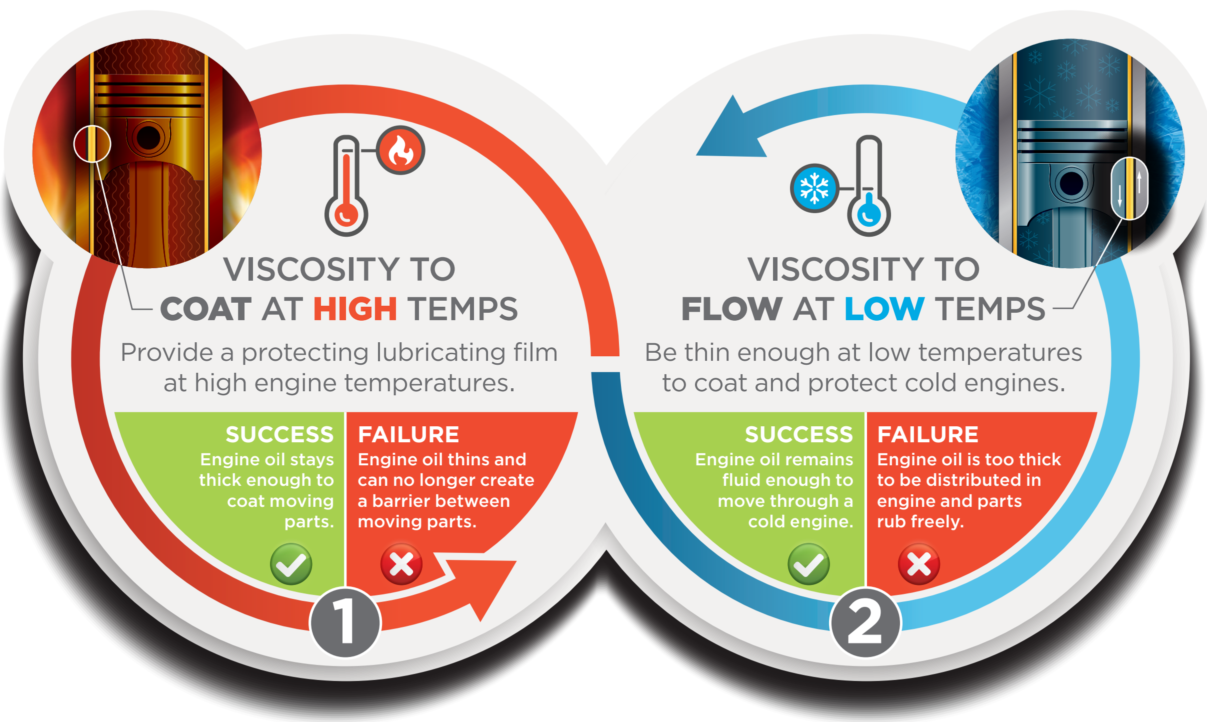
It should now make sense that an SAE-rated 5W-30 motor oil has the same viscosity of a 10W-30 oil at higher temperatures. The difference between these two oils is that the 5W-30 is thinner at colder temperatures than the 10W-30 oil. A 10W-30 oil will perform like an SAE 10W oil at lower temperatures, while the 5W-30 will perform more like an SAE 5W oil.

What's Wrong with This Statement?

"That 5W-30 oil is too thin. Instead, let's use the 10W-30 motor oil."

The back number (30) is the same on both oils, which means they have the same viscosity at higher temperatures as oils tend to thin. What's wrong is that the two oils perform the same at high temperatures.

Most engines require multi-grade oil because of extreme engine temperatures (cold or hot). However, many pieces of equipment (such as lawnmower engines) can easily use an oil with a single grade of oil (such as SAE-30). These single grade oils are recommended when internal temperatures do not vary much between the highest and lowest temperatures, or when the engine is mostly used in warm weather when ambient temperatures are not as cold.



TWO MAJOR GOALS OF OILS IN ENGINES

Hot and cold engines need protection; engine oil must protect under both conditions

Let's look at a real example.

Say that you drive a pickup truck for your daily driving. The owner's manual recommends that you use a 5W-20 oil. But you begin to regularly pull a trailer with a heavy load. Under these conditions, the owner's manual might recommend a 5W-30 oil.

Can you now explain why?

The answer is that you need a heavy oil when the engine is working harder, which in turn will lead to higher internal temperatures of the engine. Many owner's manuals for both vehicles and for small engines (like lawnmowers) include tables to help you pick the correct oil weight based on climate and expected use.

The API Service Rating

The circular emblem on the back of a motor oil container will also contain the American Petroleum Institute (API) Service Classification. The API code forms the top of the circle. As engine technology has advanced, the oils they require had to change to meet temperature, tolerances, and metals used in their construction. In addition, manufacturers now incorporate additives into the oil for better performance.

There are two general categories of an API service rating:

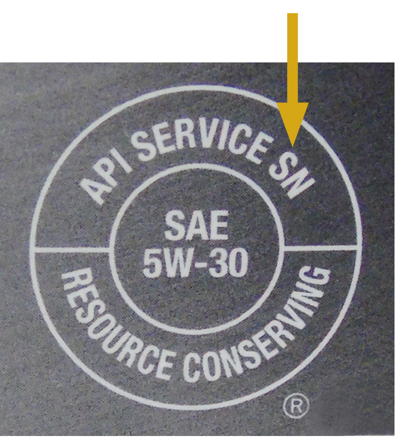
1. **S** for spark-ignited or service engines for cars and trucks that use gasoline.
2. **C** for compression-ignited diesel engines.

Never use an API oil classified for a gasoline engine (S) into a diesel engine, because they do not have the additives diesel engines require. It is best to stick with the oil designed for gasoline engines at least as long as the equipment or vehicle is under warranty. Some lubricants are formulated for both.

For diesel engine oils, the first oils were API coded CA, and they have evolved to CK.

After the letter will be a number, typically a 4 or 2. The 4 indicates a 4-stroke engine while a 2 indicates a 2-stroke engine.

We do not recommend after-market additives for engine oils without first checking with your engine manufacturer. If the formulators would have felt there was a need for additional additives and chemistries, they would have added them to the engine oil to begin with. What's more, additives could void vehicle and equipment warranties.



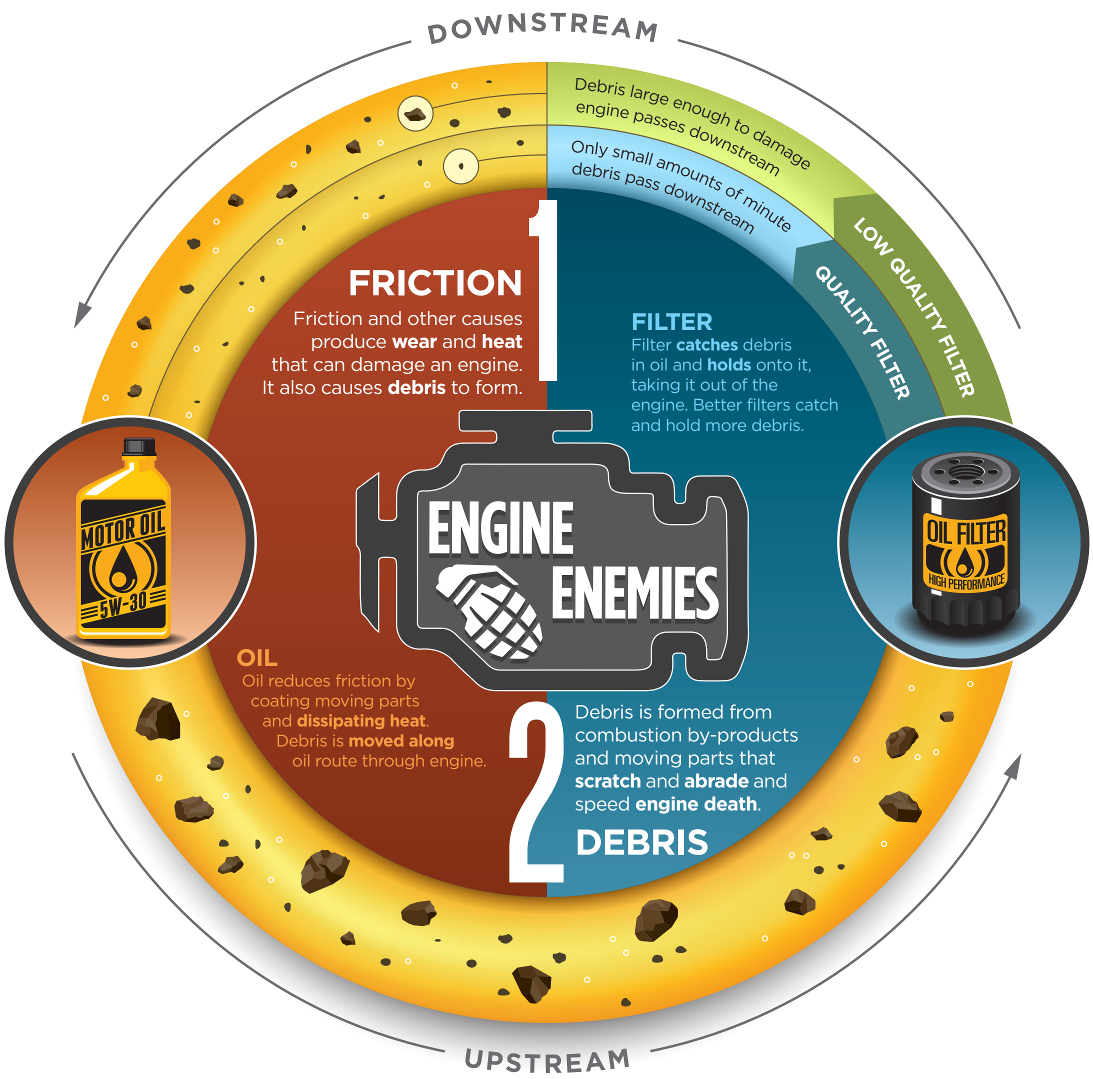
Don't Forget the Oil Filter

Many operators never give the oil filter a second thought — as if it isn't very important to an engine. It's common to replace the used engine oil with a high-quality oil, then turn around and pick the cheapest filter possible. Some even try to save money by replacing the filter every other oil change. So, it might come as a surprise that if you had to choose between buying a better oil or a better filter, it is often better to spend money on a better filter.

Remember that the main purpose of oil is to coat metal parts that move. While oil circulates throughout the engine, it will pick up small pieces of debris that can wedge into narrow gaps. The debris that lodges between moving parts can pit and abrade metal. This circumvents the protection the oil is supposed to provide.

The oil and filter must work together to protect the engine from these microscopic, abrasive metal flakes that are by-products of combustion, dirt, and dust. If you install a less effective filter, or leave a filter on too long, it can be just as bad as operating an engine with oil past its prime.

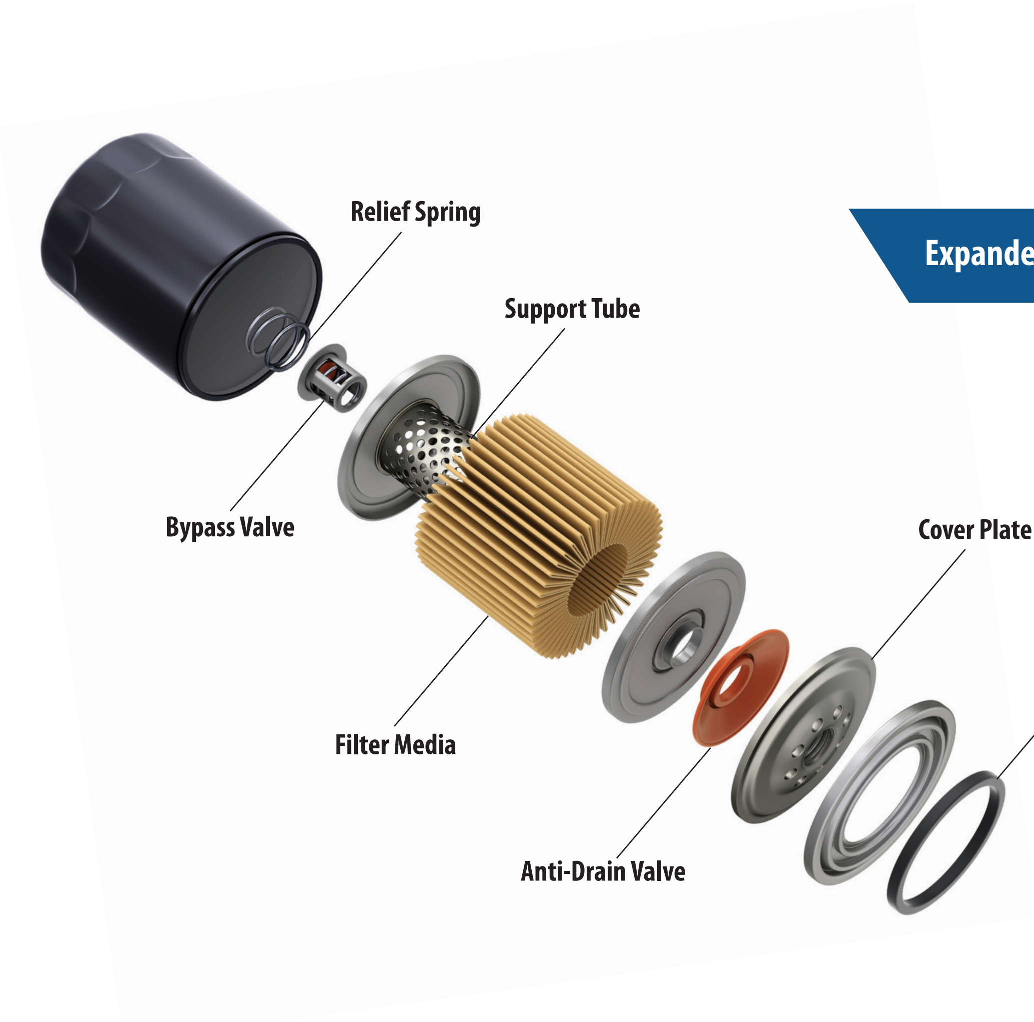
An underperforming filter can negate the protection a premium oil provides, and so accelerate engine wear, affect reliability, and diminish service life. The takeaway



THE VITAL IMPORTANCE OF THE OIL FILTER

It is essential for engine longevity to catch and hold debris that is large enough to damage the engine. It's not just about the oil.

Expanded View of a Typical Oil Filter



Take care not to introduce external debris from oil fill devices. This may seem like a minor detail, but in fact, it is very important.

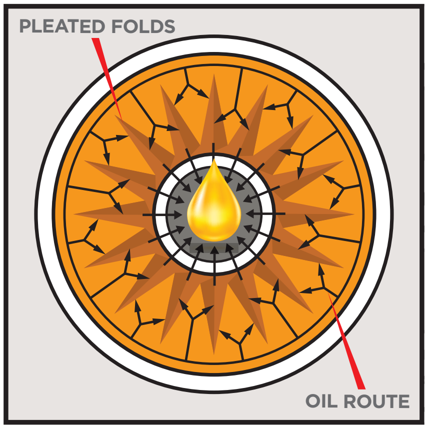
message is that an oil's ability to protect the moving parts in an engine from wear is only as good as the filter and its ability to remove contaminants from that oil.

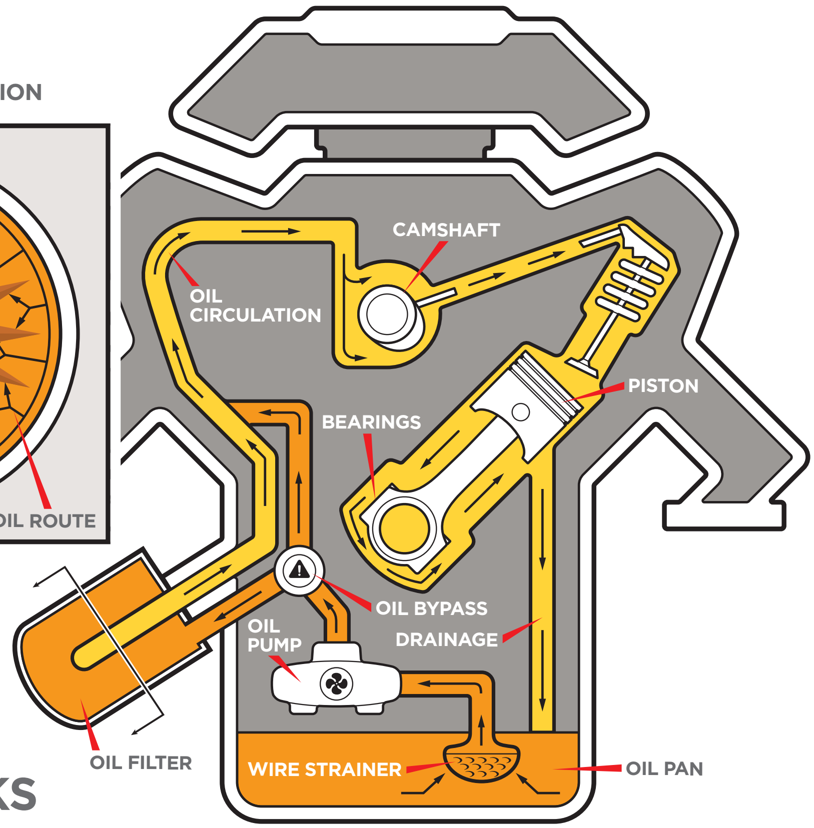
The filter capture efficiency measures how effectively the filter removes debris from oil. A filter also has to have enough holding capacity to retain all the debris until the next oil and filter change. Vehicles that operate in dusty environments might be better off with filters that have considerably higher dirt-holding capacity or those operators might change filters more frequently.

To better understand how a filter removes and retains particles, it's important to understand the filter's design and how oil moves in and out of the canister.

How Oil Flows

The filter is located between the oil pump and engine. When the engine is running, it first pulls oil from the bottom of the oil pan through a wire cloth strainer, and then pumps it to the filter. Once to the filter, the oil will pass under pressure through the smaller inlet port that forms a concentric circle around the opening at the top of the filter.





HOW AN OIL FILTER WORKS

Most oil filters have an outside to inside flow. Oil starts on the outside of the pleated filter elements and flows inward to the center tube. The pleated filter medium can be made of paper, glass fibers, or a blend of both.

Inside the filter, the oil follows the path of least resistance — it first goes through the largest pores of the filter paper (media) and into the perforated center tube. Over time, as the larger pores become blocked, the oil is forced through smaller pores until all of the pores are plugged. The filtered oil will exit through the center port and on to the engine through a series of manifolds to reach different parts of the engine. Oil then flows down into the pan by gravity where it begins the journey again.

A mechanical adaptation built into engines is to reroute the oil flow when the filter gets clogged. There is a fail-safe bypass value on the engine block just in case the flow is severely reduced from a clogged filter. This allows oil to continually flow even when the filter is plugged. It's important to remember that the oil lubricating the engine will be unfiltered when it is in this bypass mode.

Dirt-holding Capacity and Capture Efficiency

It's true that oil moving through a filter is more or less universal, but that doesn't mean all filters are created equal when it comes to capturing and retaining debris from the oil. How efficient an oil filter is can vary sharply between manufacturers, and even between brands offered by a single company (in other words, budget-priced filters and high-performance filters). One thing is certain: Just because you see the filter described as "deluxe," "high-performance," "super-efficient," or just "darn good" it doesn't mean you're getting a premium product.

There are two criteria that influence oil filter performance and cost:

1. Dirt-holding capacity
2. Capture efficiency

Both of these properties are determined when the filter is tested using ISO 4548-12—*Methods of Test for Full-flow Lubricating Oil Filters for Internal Combustion Engines*. This ISO testing procedure provides important details that allow us to make side-by-side comparisons of different filters.

DIRT-HOLDING CAPACITY

A filter's dirt-holding capacity defines how long the filter will function before it goes into bypass mode. Filters used with synthetic oils that are rated for 15,000 miles will obviously stay in use longer, so they must be able to hold more than a filter that is designed to be replaced at intervals of 3,000 or 5,000 miles.

When you purchase or select a filter, one approach is to buy a filter that is rated for the miles you expect to drive between oil changes with sufficient margin for error. Don't forget to consider dusty conditions when looking at a filter (if it will be dusty, there will be more dirt to collect).

Another approach is to find out how much debris the filter can trap. The ISO test measures the grams of debris the filter can collect before it no longer functions. You'll find large differences between filters that can capture 14 grams of dirt and those that can capture 28 grams. A filter that can hold twice the amount of debris is often more expensive.

During the ISO test, technicians progressively introduce laboratory test dust upstream of the filter. They monitor oil pressure, which will rise slightly as the filter loads with dirt. Once it reaches the terminal pressure drop (determined by the filter maker), they terminate the test. They calculate the total amount of dirt removed by the filter from the total amount that they introduced.

CAPTURE EFFICIENCY

Another important measure of oil filter quality is known as the *beta ratio*. This measure describes the filter's particle capture efficiency at different sizes. Manufacturers use different average pore sizes for the filter's media. The media require finer pore sizes to remove the smaller, micron-sized particles. Those finer pores can be more expensive than coarser media that have larger pores.

The test conditions for determining the beta ratio are the same as the conditions for the capture efficiency. The two tests occur at the same time. During the test (done on a laboratory test stand), oil flows from the test reservoir though the filter and back to the same reservoir.

While technicians add the controlled stream of laboratory test dust, a pair of special sensors (called *particle counters*) are positioned upstream and downstream of the filter. Because the filter removes particles of various sizes, the concentration of particles that are upstream of the filter will always be higher than the concentration downstream.

The beta ratio is the ratio of these two concentrations:

$$\text{beta ratio} = \frac{\text{number of particles upstream}}{\text{number of particles downstream}}$$

For any given particle size (such as 10 micrometers) the higher the beta ratio, the better the filter's capture efficiency. For instance, if ten particles greater than 10 microns (micrometers) are counted upstream of the filter and only one of these particles is counted downstream, then the beta ratio is 10 (10/1).

You can convert the Beta Ratio to efficiency as:

$$\text{capture efficiency (\%)} = \frac{\text{beta ratio -1 x 100}}{\text{beta ratio}}$$

The beta ratio and the capture efficiency have no value unless we know precisely the size of the microns being evaluated in the test (10 microns for instance). Working film clearance between the piston ring and cylinder wall in engines is extremely small — maybe as little as 10 microns. Debris in the 10-micron range can cut or scratch metal as the particles roll between opposing surfaces. Particles larger than 10 microns will not fit into the smaller gaps and will be swept aside. Smaller particles will generally flow through the gap with the oil.

Consider that a standard oil filter removes particles that are larger than 40 microns. It's been demonstrated that particles that average 10 microns can produce four times more wear on rods, rings, and bearings than particles larger than 20 microns.

Can you see the problem?

General Motors reported that a filter that captures 30-micron particles or larger reduced engine wear by 50 percent over a 40-micron filter. A 15-micron filter reduces engine wear by 70 percent over a 40-micron filter.

This is why experts often measure and report capture efficiency based on how well the filter removes 10-micron particles or larger. It is worth noting that this performance property is a large component of the premium price you're paying for high-end filtration.

Back to the capture efficiency. A filter that has a 95 percent capture efficiency of particles larger than 20 microns means it will remove 95 percent of particles that are equal to or larger than 20 microns on a single pass.

Experts generally agree that an oil filter should have a beta ratio of 100, which is a 99 percent capture efficiency for 10-micron or larger particles (100 -1/100 = .99 x 100 = 99%; see Table 1).

Unlike the markings on an oil container, finding information about a filter's beta ratio and capture efficiency is often difficult to locate on the filter's package or manufacturer's website. Most likely, you will have to ask the supplier for the capture efficiency and beta ratio of the filters you purchase. But the answer to this single question could greatly prolong the life of your equipment.

Table 1: Beta Ratio and Efficiency

Beta Value	Efficiency (%)	Particles Upstream	Particles Downstream
2	50.0000	100,000	50,000
4	75.0000	100,000	25,000
10	90.0000	100,000	10,000
20	95.0000	100,000	5,000
40	97.5000	100,000	2,500
60	98.3333	100,000	1,667
75	98.6667	100,000	1,333
100	99.0000	100,000	1,000
125	99.2000	100,000	800
150	99.3333	100,000	667
200	99.5000	100,000	500
300	99.6667	100,000	333
500	99.8000	100,000	200
1,000	99.9000	100,000	100
2,000	99.9500	100,000	50
4,000	99.9750	100,000	25
5,000	99.9800	100,000	20
10,000	99.9900	100,000	10
20,000	99.9950	100,000	5
50,000	99.9980	100,000	2

Always completely drain oil containers and filters before disposing of them in the trash.

Properly Dispose of All Products

Everyone should store used oil for proper disposal.

It goes without saying that we all need to dispose of used oil and oil filters so that we do not contaminate land or water. One quart of oil has the potential to contaminate up to 250,000 gallons of drinking water or produce an oil film over a 2-acre pond. With the high risk for affecting water, mismanaging used oil drained from an engine or oil remaining in a filter or jug is not an option.

The key to properly managing oil filters is to completely drain them before disposal.

Even small actions (such as making sure that you completely drain devices or funnels) will help keep the environment cleaner.

Conclusion

The oil and filters you choose greatly affect your equipment's reliability and life expectancy.

If you intend to run equipment to the end of its useful life or extend its normal service life, then you really need to educate yourself about the oils and filters you use in that equipment. Consider the money you have invested in purchasing trucks, sprayers, mowers, planters, combines, and other equipment. That investment should convince you that knowing more about the oils and filters you use to protect that equipment is a high priority.

You can go cheap and save money now. But in the long run, it may cost more when your equipment breaks down and is prematurely damaged due to the wrong oil or and underperforming filter.

You can just as easily overspend on exotic oils and fancy oil filters that deliver little return on investment — or the benefit will only be gained by the next owner of the equipment after you sell it.

This is why it is important to remember: Select lubricants more on what the lubricant is designed to do rather than its cost.

Think performance first, price second. By making better selections, you should expect increased fuel economy, lessened emissions, and extended life expectancy of equipment.

Oils have come a long way since the 1960s. They last longer and maintain their viscosity better under strenuous conditions. But choosing the wrong oil for the wrong application can be costly. Read the owner's manual for your vehicle to be sure you purchase oil, and realize what all the numbers on the jug of oil mean before you dump just any old oil into your equipment.

Going cheap and saving money in the short run may cost you big in the long run!

Acknowledgments

Thanks to Dawn Minns for graphic design. Thanks also to the following individuals who provided valuable comments and suggestions that improved this publication.

Tom Bechman, *Indiana Prairie Farmer*
Dave Bordner, Bordner's Truck Repair and Alignment
Dennis Mungle, CountryMark
Jud Scott, Consulting Arborist, LLC
Brad Shelton, Purdue University

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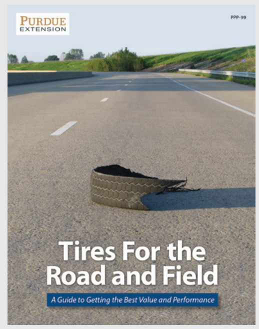
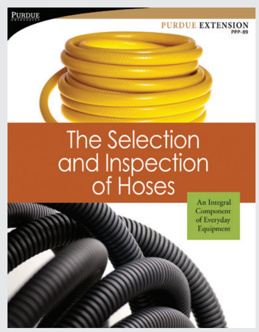
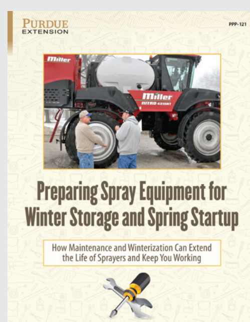


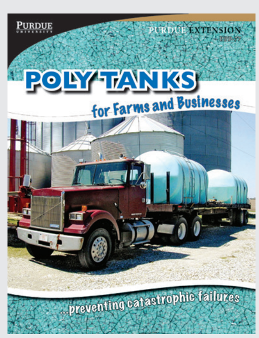
Tires for the Road and Field: A Guide to the Best Value and Performance (Purdue Extension publication PPP-99) provides information about selecting the right tires.



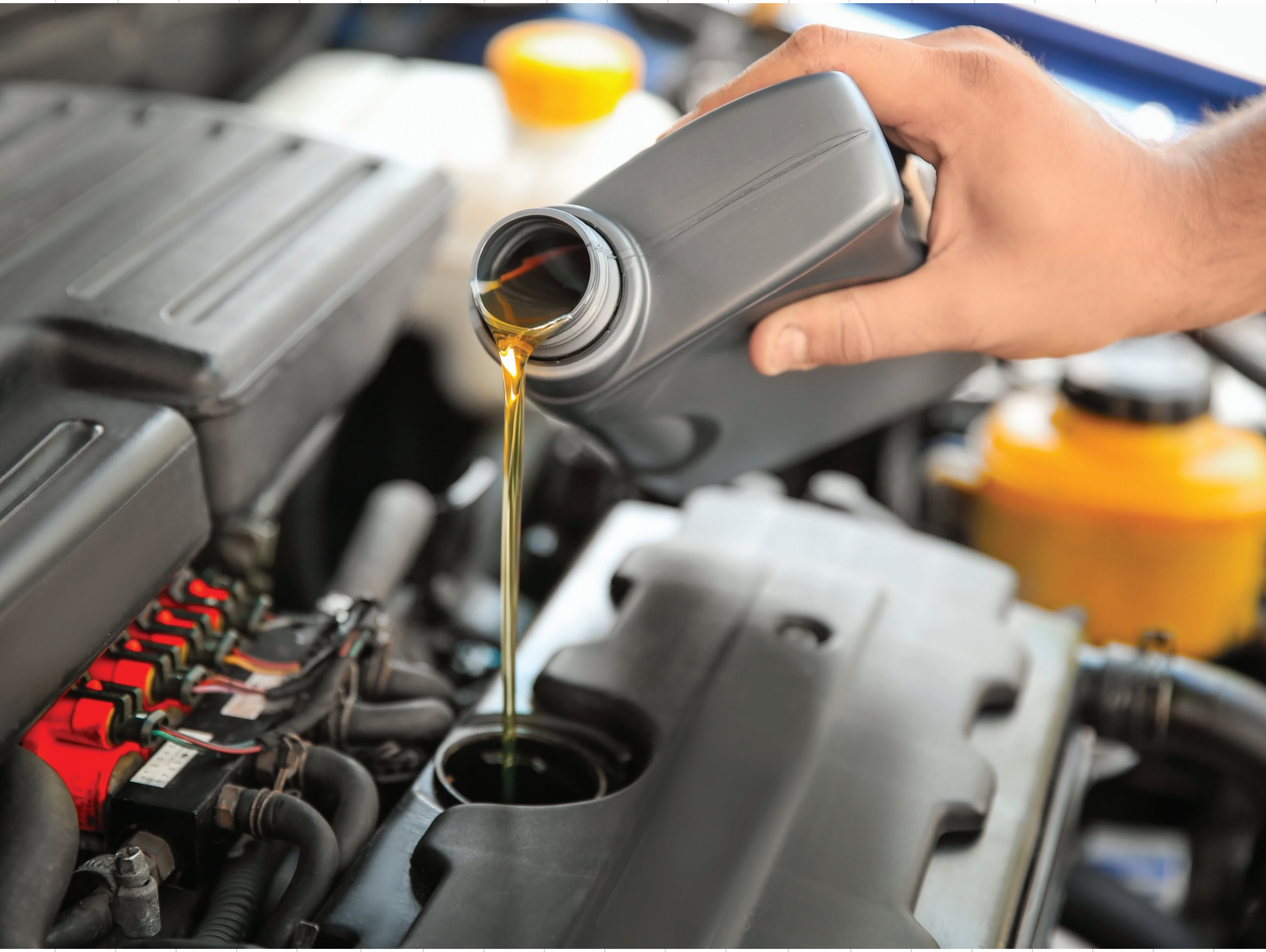
The Selection and Inspection of Hoses: An Integral Component of Everyday Equipment (Purdue Extension publication PPP-89) provides details about caring for hoses to optimize performance and extend the life of your equipment.



Preparing Spray Equipment for Winter Storage and Spring Startup: How Maintenance and Winterization Can Extend the Life of Sprayers and Keep You Working (Purdue Extension publication PPP-121) describes how to prepare your equipment for the off-season.



Poly Tanks for Farms and Businesses (Purdue Extension publication PPP-77) describes how to select, use, and transport poly tanks.



January 2019/REV 2020