What Is a Motor Oil?

Motor oil is the primary determinant in the durability of an engine. It contains two basic components: **base stocks** and **additives**.

Base Stocks

The base stock is the bulk of the oil. The base stock lubricates internal moving parts, removes heat and seals piston rings.

Motor oil base stocks can be made from: 1) petroleum, 2) chemically synthesized materials, 3) a combination of synthetics and petroleum (called para-synthetic, semi-synthetic or synthetic blend.)

A petroleum base stock consists of many different oil fractions that form the final product. Generally, molecules of a petroleum base stock are long carbon chains that can be sensitive to the stress of heat and "boil off" at relatively low temperatures. Engine temperatures break down these molecular chains, changing the physical properties (such as viscosity) of the motor oil.

The difference with synthetic base stocks is that molecules are uniformly shaped, which makes them more resistant to the stress of heat. Because AMSOIL synthetic motor oils possess these uniformly-shaped molecules, they have a low "boil off" rate. Thus, their physical properties (such as viscosity) do not change.

Additives

The various chemicals that comprise the additive system in motor oils function to provide anti-wear, anti-foam, corrosion protection, acid neutralization, maintenance of viscosity, detergency and dispersancy properties. These are the chemicals that help modern motor oils meet the increasing demands of today's high-tech engines. Their quality varies widely throughout the lubrication industry, ranging from a bare minimum in some oils (to comply with certain requirements) to exceptionally high quality, as in all AMSOIL motor oils.

What a Motor Oil Must Do

Modern motor oil is a highly specialized product carefully developed by engineers and chemists to perform many essential functions. A motor oil must:

- Permit easy starting
- Lubricate engine parts and prevent wear
- Reduce friction
- Protect against rust and corrosion
- Keep engine parts clean
- Minimize combustion chamber deposits
- Cool engine parts
- Seal combustion pressures
- Be non-foaming
- Aid fuel economy.

Improvements in Oil

The quality of motor oil has changed dramatically in the past 30 years, and new demands on lubricants in modern engine design call for oils that meet stringent requirements. Variations in an oil's ability to meet the requirements determine which service classification rating and viscosity grade it receives.

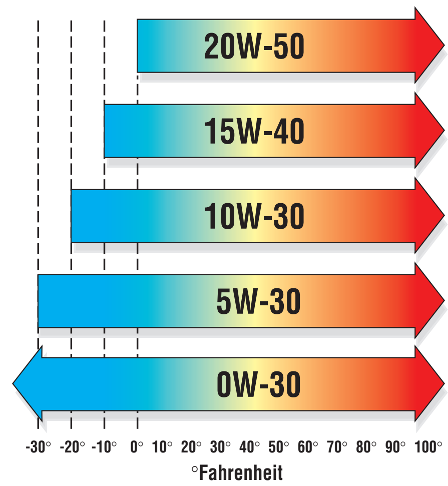
Service classifications are determined by the American Petroleum Institute. Viscosity grades of oils are determined by the Society of Automotive Engineers. These two organizations have set industry standards for motor oils for more than 75 years.

Viscosity

Viscosity, the most important property of an oil, refers to the oil's resistance to flow. The viscosity of oil varies with changes in temperature – thinner when hot, thicker when cold. An oil must be able to flow at cold temperatures to lubricate internal moving parts upon starting the engine. It must also remain viscous or "thick" enough to protect an engine at high operating temperatures. When an oil is used at a variety of temperatures, as it is in most engines, the change of viscosity with temperature variation should be as small as possible.

The measure of an oil's viscosity change is called the **Viscosity Index number (VI)**; the higher the number, the smaller the viscosity change which means the better the oil protects the engine. The number does

SAE Viscosity Grade and Outdoor Temperature



not indicate the actual viscosity in high and low temperature extremes of the oil. It represents the rate of viscosity change with temperature change.

Viscosity improvers are viscous chemical compounds called polymers or polymeric compounds that decrease the rate at which oils change viscosity with temperature. These viscosity modifiers extend a motor oil's operating temperature range and make multi-grade or all-season oils possible. However, low-quality viscosity improvers lend themselves to shearing.

The VI is measured by comparing the viscosity of the oil at 40°C (104°F) with its viscosity at 100°C (212°F). VI can provide insight into an oil's ability to perform at high and low temperatures.

Petroleum-based motor oils require the use of viscosity improvers to meet the low-temperature requirements of SAE 0W, 5W or 10W and the high-temperature requirements of SAE 30 or heavier oil.

Synthetic-based motor oils have a naturally-high viscosity index and require less viscosity improver additive than petroleum oils.

Cold-Temperature Protection

Motor oil must begin to circulate as soon as the engine is started. If oil gets cold enough and begins to solidify, it fails to flow through the oil screen to the pump at engine start and causes bearings and other critical parts to fail almost immediately.

Pour point is an indicator of the ability of an oil to flow at cold operating temperatures. It is the lowest temperature at which the fluid will flow.

Modern refining techniques remove most of the wax from petroleum oil, but some wax-like molecules remain. These wax-like molecules are soluble at ambient temperatures above freezing, but crystallize into a honeycomb-like structure at lower temperatures and cause oil circulation problems.

Pour point depressants keep wax crystals in the oil microscopically small and prevent them from joining together to form the honeycomb-like structure. They lower the temperature at which oil will pour or flow and are found in most motor oils designed for cold-weather use. As synthetic motor oils do not contain those wax crystals, they do not require pour point depressant additives.

Wear Protection

Since one of an oil's main functions is to prevent friction and wear, **anti-wear additives** are part of the chemical composition of an oil. These additives protect engines by bonding to metal surfaces and forming a protective film layer between moving parts that are vulnerable to friction and wear when an engine is first started and before the oil begins to circulate completely. While this protective film doesn't entirely eliminate metal-to-metal contact of moving parts at start-up, it minimizes the effects of contact.

Oxidation

Because excessive engine heat causes chemical breakdown of oil, which in turn results in permanent thickening of the oil, **oxidation inhibitors** work to limit the impact of oxidation. Oil oxidation produces acidic gases and sludge in the crankcase. These gases combine with water in the crankcase to corrode and rust the engine. Corrosion prevention is especially critical in diesel engines.

TBN

An oil's ability to neutralize acids is expressed by its **Total Base Number (TBN)**. The greater the number, the greater the amount of acidic by-products the oil can neutralize. A high TBN is particularly important in extended drain interval oils, such as AMSOIL motor oils, because they neutralize acids, and more of them, for a longer period of time.

Most oils for diesel engines in North America have a TBN between 8 and 12. AMSOIL manufactures several diesel oils with a TBN of 12.

Detergents

In the same way that some chemical compounds are used to prevent engine rust and corrosion, other chemicals are added to motor oil to help prevent combustion by-products from forming harmful sludge or varnish deposits. **Detergents** are added to motor oil because combustion causes carbon build-up and deposit formation on the pistons, rings, valves and cylinder walls. Carbon and deposits affect engine temperature, oil circulation, engine performance and fuel efficiency. Detergent additives clean these by-products from the oil. Some combustion by-products slip past the piston rings and end up in the motor oil, which can clog the engine's oil channels.

Dispersants

While detergents help minimize the amount of combustion by-products, **dispersant** additives keep those by-products suspended in a form so fine they minimize deposits. They keep the oil in the engine clean while they prevent the build-up of carbon or deposits from burned and unburned fuel and even from the oil itself. Eventually, these suspended particles are removed by the oil filter.

Anti-Foam

The addition of **silicone** or other compounds in very small amounts makes most oils adequately foam-resistant. It's important to minimize foaming in motor oil because tiny air bubbles are whipped into motor oil by the action of many rapidly moving parts, resulting in a mass of oily froth that has very little ability to lubricate or aid in the cooling of the engine. These compounds weaken the air bubbles, causing them to collapse almost immediately upon forming, allowing the oil to continue to protect the engine.

Seal Swell

All motor oils must be compatible with the various seal materials used in engines. Oil must not cause seals to shrink, crack, degrade or dissolve. Ideally, oils should cause seals to expand or "swell" slightly to ensure continued proper sealing.

Heat Dispersal

Another function of motor oil is to cool the engine. The radiator/antifreeze system is responsible for about 60 percent of the engine cooling that takes place. This cools only the upper portion of the engine, including the cylinder heads, cylinder walls and valves.

The other 40 percent is cooled by the oil. The oil is directed onto hot surfaces, such as the crankshaft, main and connecting rod bearings, the camshaft and its bearings, the timing gears, the pistons and many other components in the lower portion of the engine that directly depend on the motor oil for cooling.

Engine heat is created from friction of moving parts and the ignition of fuel inside the cylinder. Oil carries heat away from these hot surfaces as it flows downward and dissipates heat to the surrounding air when it reaches the crankcase.

Lubricating an engine actually requires a very small amount of motor oil compared to the amount needed to ensure proper cooling of these internal parts.

The oil pump constantly circulates the oil to all vital areas of the engine.

Classification Systems

Oil is classified by two systems. One system determines the oil's viscosity (the SAE grade), and one determines its performance level, which oil to use in what type of engine (the API class).

SAE Grade

The Society of Automotive Engineers (SAE) Viscosity Grade is a system based on viscosity measures taken from a variety of tests. It developed 11 distinct motor oil viscosity classifications or grades: SAE 0W, SAE 5W, SAE 10W, SAE 15W, SAE 20W, SAE 25W, SAE 20, SAE 30, SAE 40, SAE 50 and SAE 60. These are single-grade or single-viscosity oils.

These grades designate the specific ranges that the particular oil falls into. The "W" indicates the grade is suitable for use in cold temperatures. (Think of the "W" as meaning "Winter".) The classifications increase numerically, readily indicating the difference between them and what the difference means. Simply put, the lower the number, the lower the temperature at which the oil can be used for safe and effective protection. The higher numbers reflect better protection for high-heat and high-load situations.

> ***Think of the "W" in a motor oil's classification as meaning "Winter."***

Single-grade oils have a limited range of protection and, therefore, a limited number of uses.

With today's well-refined, high viscosity index oils, however, an SAE 20 oil usually will meet the viscosity requirements of SAE 20W and vice versa. Those that do are classified SAE 20W-20.

This multi-grade or multi-viscosity ability increases an oil's usefulness, because it meets the requirements of two or more classifications.

Examples of multi-viscosity oils are SAE 5W-30, SAE 10W-30, SAE 15W-40 and SAE 20W-50. The number with the "W" designates the oil's properties at low temperatures. The other number characterizes properties at high temperatures. For instance, a multi-viscosity or multi-grade oil such as 10W-30 meets the 10W criteria when cold and the 30 criteria once hot. SAE 10W-30 and SAE 5W-30 are widely used because under all but extremely hot or cold conditions, they are light enough for easy engine cranking at low temperatures and heavy enough to protect at high temperatures.

API Class

The American Petroleum Institute (API) developed a classification system to identify oils formulated to meet the operating requirements of various engines. The API system has two general categories: S-series and C-series.

The **S-series service classification** emphasizes oil properties critical to gasoline- or propane-fueled engines. If an oil passes a series of tests in specific engines (API Sequence tests), the oil can be sold bearing the applicable API service classification. The classifications progress alphabetically as the level of lubricant performance increases. Each classification replaces those before it. SM oil may be used in any engine, unless the engine manufacturer specifies a "non-detergent" oil.

SA and SB are non-detergent oils and are not recommended for use unless specified.

Cars from model-years 1980 to 1989 require SF oils, while cars from model-years 1990 to 1993 require SG oils.

New cars beginning with the 1994 model year require oils with an API SH performance rating. Beginning with model-year 1997, new cars require an API SJ oil. The year 2001 brought the introduction of SL oils. SM category is the most recent classification. It was introduced Nov. 30, 2004. SM oils are designed to provide improved oxidation resistance, improved deposit protection, better wear protection and better low-temperature performance over the life of the oil.

SJ, SL and SM are the current API classes. SJ, SL and SM oils are widely available and ensure the best engine protection available.

C-series classifications pertain to diesel engines. They are: CA, CB, CC, CD, CD-II, CE, CF, CF-2, CF-4, CG-4, CH-4, CI-4, CI-4 PLUS and CJ-4. All are obsolete except CF, CF-2, CH-4, CI-4, CI-4 PLUS and CJ-4 performance rated oils.

Not all C-series classifications supersede one another. The current classifications, CF and CF-2 are specified for different applications.

CF for Indirect-Injected Diesel Engine Service. Service category CF denotes service typical of indirect-injected diesel engines and other diesel engines that use a broad range of diesel fuels in off-road applications, including diesel fuel with greater than 0.5 percent sulfur by weight. CF oils may be used in place of CD oils.

CF-2 for Two-Stroke Diesel Engine Service. This service category is typical of two-stroke engines requiring highly effective control over cylinder and ring-face scuffing and deposits. CF-2 oils may be used in engines for which CD-II oils are recommended.

CH-4 for Four-Stroke Diesel Engine Service. CH-4 is required for high-speed, four-stroke engines designed to meet 1998 exhaust emission standards. CH-4 oils are specifically compounded for use with diesel fuels ranging in sulfur content up to 0.5% weight. Can be used in place of CD, CE, CF-4 and CG-4 oils.

CI-4 PLUS for Severe-Duty Diesel Engine Service. CI-4 PLUS typically is required in high-speed four-stroke diesel engines used in heavy-duty on- and off-highway applications. CI-4 PLUS oils are especially effective in engines designed to meet 2002 exhaust emission standards. CI-4 PLUS oils may be used in place of CD, CE, CF, CF-4, CG-4, CH-4 and CI-4 oils.

CJ-4 for 2007 and newer diesel Engines. CJ-4 was developed to address special concerns about emission control engines and their operation on ultra-low-sulfur diesel fuel (ULSD).

These classification systems aim to help motorists choose the right oil for their needs. The choice depends on the engine, the outdoor temperature and the type of driving the engine must withstand.