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Motor Oils - Fuel Economy vs. Wear

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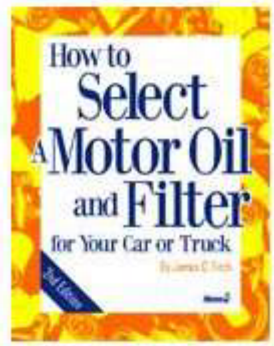
Recommended Reading



Conventional wisdom states that engine oils that increase fuel economy allow less friction and prolong engine life. The purpose of this article is to challenge conventional wisdom, particularly concerning modern (GF-3 ILSAC/API Starburst) engine oils.

Fuel Economy: Does Anyone Really Care?

First, we should face the fact that the American consumer does not appear to care too much about fuel economy. The No. 1 selling passenger vehicle is the Ford F-Series Pickup. Five of the top 10 best-selling vehicles are trucks, and trucks outsell cars. Some of the trucks are called sport-utility vehicles, otherwise known as SUVs, because their owners don't want to admit they are trucks. The mass (size, weight) of these vehicles is not conducive to great fuel economy.

Additionally, consider how most vehicles are driven. Anyone accelerating slowly or driving at the speed limit to conserve energy is a danger to himself and other drivers who are in a much bigger hurry.

Auto manufacturers, on the other hand, are concerned about fuel economy. The manufacturer faces big fines if the fleet of cars it produces falls short of the Corporate Average Fuel Economy (CAFE) requirements imposed upon them by the federal government.

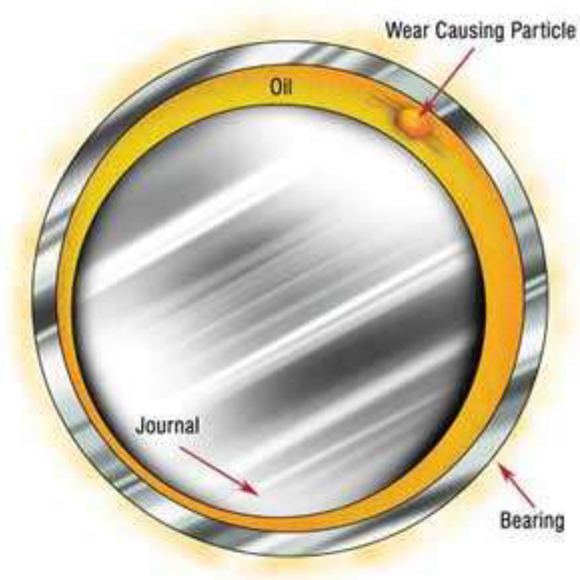


Figure 1. Bearing Wear

The March to Thinner Oils

Thinner oils are being used these days for three reasons: They save fuel in test engines, the viscosity rules have changed, and manufacturers are recommending thinner grades.

The Sequence VI-B is the test used to evaluate fuel economy for the GF-3 specification. The VI-B test engine is fitted with a roller cam where the old Sequence VI test used a slider cam. The old Sequence VI test responded well to friction modifiers, but the Sequence VI-B responds to thinner oils.

The test oil's fuel efficiency is compared to the fuel efficiency of a reference oil in the Sequence VI-B test. To pass, the test oil must improve fuel economy one to two percent, depending on viscosity grade. SAE 5W-20 must produce higher relative fuel efficiency than SAE 5W-30.

It is interesting to note that the reference oil is fully PAO synthetic SAE 5W-30. To qualify for the GF-3 Starburst, ordinary mineral oils had to beat the fuel economy of the full synthetic reference oil. (It seems there is more to fuel economy than a magic base oil.)

Another factor in fuel economy is temporary polymer shear. These polymers are additives known as viscosity index improvers (or modifiers). Polymers are plastics dissolved in oil to provide multiviscosity characteristics. Just as some plastics are tougher, more brittle or more heat-resistant than others, different polymers have different characteristics.

Polymers are huge molecules with many branches. As they are heated, they uncoil and spread out. The branches entangle with those of other polymer molecules and trap and control many tiny oil molecules. Therefore, a relatively small amount of polymer can have a huge effect on oil viscosity.

As oil is forced between a bearing and journal, many polymers have a tendency to align with each other, somewhat like nesting spoons. When this happens, viscosity drops. Then when the oil progresses through the bearing, the polymer molecules entangle again and viscosity returns to normal. This phenomenon is referred to as temporary shear.

Because the Sequence VI-B test responds to reductions in viscosity, oil formulators rely on polymer shear to pass the test. A shear stable polymer makes passing the GF-3 fuel economy test much more challenging.

New rules defining the cold-flow requirements of SAE viscosity grades (SAE J300) became effective in June 2001. The auto manufacturers were afraid that modern injection systems might allow the engine to start at temperatures lower than the oil could flow into the oil pump. Consequently, the new rules had a thinning effect on oil.

The auto manufacturers now recommend thinner oils for their vehicles than in the past. Years ago, SAE 10W-40 was the most commonly recommended viscosity grade, later migrating to SAE 10W-30. SAE 5W-30 is most popular now, but Ford and Honda recommend SAE 5W-20. It is likely that more widespread adoption of SAE 5W-20 and other thin oils may occur to help comply with CAFE requirements.

Because of the change in cold-flow requirements and the fuel economy test pushing formulators toward the bottom of the viscosity grade, today's SAE 10W -30 oils are more like yesterday's (GF-1 spec) SAE 5W-30 oils. On top of that, there is a trend toward auto manufacturers recommending thinner grades. This seems ridiculous. SUVs and trucks, with their inherently less-efficient four-wheel drive and brick-wall aerodynamics, need powerful, gas-guzzling engines to move their mass around in a hurry. In response, auto manufacturers recommend using thin oils to save fuel. Incredible!

Viscosity and Wear

Thinner oils have less drag, and therefore less friction and wear. Right? Perhaps in the test engine or engines that experience normal operation. But somewhat thicker oils may offer more protection for more severe operations such as driving through mountains, pulling a boat, dusty conditions, short trips, high rpm, overloading, overheating and overcooling.

Any abrasive particles equal to or larger than the oil film thickness will cause wear. Filters are necessary to keep contaminants small. The other side of the equation is oil film thickness. Thicker oil films can accommodate larger contaminants.

Temperature has a big effect on viscosity and film thickness. As a point of reference, one SAE grade increase in viscosity is necessary to overcome the influence of a 20°F increase in engine temperature. At a given reference point, there is approximately a 20°F. difference between viscosity grades SAE 30, 40 and 50. SAE 20 is somewhat closer to 30 than the other jumps, because SAE 30 must be 30°F higher than SAE 20 to be roughly the equivalent viscosity.

In other words, an SAE 20 at 190°F is about the same kinematic viscosity as an SAE 30 at 220°F, which is about the same viscosity as an SAE 40 at 240°F. This approximation works well in the 190°F to 260°F temperature range. One might be surprised at the slight amount of difference between straight viscosity vs. multiviscosity oils with the same back number (for example, SAE 30, SAE 5W-30, and SAE 10W-30).

If an SAE 50 oil at 260°F is as thin as an SAE 20 oil at 190°F, imagine how thin the oil film becomes when you are using an SAE 5W-20 and your engine overheats. When an engine overheats, the oil film becomes dangerously thin and can rupture.

Ford is bumping up against its CAFE requirements and recommends SAE 5W-20 oil for most of its engines in the United States. It claims SAE 5W-20 is optimal for fuel efficiency and wear.

To determine if SAE 5W-20 oils provide the same level of protection as SAE 5W -30 oils, Dagenham Motors in England, one of the largest Ford dealers in Europe, was consulted. SAE 5W-30 is required for warranty purposes in England, and SAE 5W-20 is not even available. If SAE 5W-20 were better for both fuel economy and wear, why would Ford not recommend it for its same engines in Europe?

Antiwear Property Changes

Another change that occurred in passenger car motor oils with GF-2 and GF-3 is a more stringent limit on phosphorus, which is part of the zinc phosphate (ZDDP) antiwear additive. The auto manufacturers are concerned that phosphorus will deposit on surfaces of the catalytic converter and shorten its life.

This is a complicated issue, and the deposits depend on the specific ZDDP chemistry and the finished oil formulation. The industry was unsuccessful in designing an engine test for an oil's catalytic converter deposit forming tendencies. Therefore, the auto manufacturers set an arbitrary limit for motor oil of 0.1 percent phosphorus.

Antiwear additives are important in the absence of a hydrodynamic film, such as in the valve train. The antiwear additives are activated by frictional heat, which causes them to react with the hot surface and form a chemical barrier to wear.

The mechanism by which phosphorus deposits form on catalytic converter surfaces is not fully understood. It does not correlate directly with oil volatility or oil consumption. On the other hand, if engine wear causes oil consumption to increase, the risk of forming phosphorus deposits in the converter would increase dramatically. It seems that preventing wear and oil consumption should be a priority.

In the past, oil formulators could make a premium product by simply adding more ZDDP. A similar move today would result in an oil formulation that would not support new car warranties.

Short-term Thinking

As wear increases, the efficiency of an engine declines. Valve train wear slightly changes valve timing and movement. Ring and liner wear affect compression. The wear hurts fuel efficiency and power output by an imperceptible amount at first, but then the difference in fuel economy between an SAE 10W-30 and SAE 5W-20 is hardly noticeable. Efficiency continues to decline as wear progresses. Perhaps optimizing wear protection is the way to reduce fuel consumption over the life of the engine.

Certainly engines that have experienced significant ring and liner wear benefit from thicker oils. Thicker oil use results in compression increases, performance improvements and reduced oil consumption.

High-mileage oils are a relatively new category of passenger car motor oils. These products typically contain more detergent/ dispersant and antiwear additives than new car oils. They typically contain a seal swell agent and are available in thicker viscosity grades than most new cars recommend. “High mileage” seems to be defined by “as soon as your car is out of warranty.”

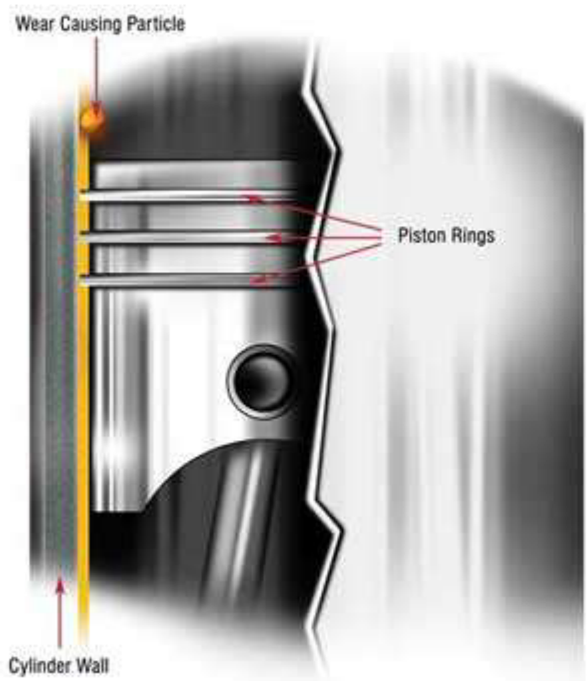


Figure 2. Ring Wear

What To Use

Although thinner oils with less antiwear additive outperform more robust products in the 96-hour fuel economy test, it is not clear that such products save fuel over the useful life of the engine.

Every fluid is a compromise. Oils recommended by the auto manufacturers seem to compromise protection from wear under severe conditions to gain fuel economy and catalyst durability. It is important to recognize that to use a product that offers more protection from wear will most likely compromise your warranty. Thicker oils also compromise cold temperature flow, which may be of concern depending upon climate and season.

The best protection against wear is probably a product that is a little thicker (such as SAE 10W-30 or 15W-40) and has more antiwear additives than the oils that support the warranty. The best oil for your vehicle depends on your driving habits, the age of your engine and the climate you drive in, but it is not necessarily the type of oil specified in the owner’s manual or stamped on the dipstick.

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