

Valuing Viscosity: Behind the Science to Get the Best for Your Car

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Viscosity: it's the most basic quality of any motor oil, and the one with which many of us are most familiar and think we know the most about. But do we really? For example, what does SAE 10W-40 really mean? Is a 5W-30 motor oil really thinner than a 10W-30? What's the difference between a multigrade motor oil and a single grade oil? Why do we have so many grades? And, most importantly, what's the best viscosity grade to run in your customers' cars?

Different viscosities, different points

The viscosity of any fluid is the measure of its frictional resistance to flow. The higher the viscosity, the higher the friction for a given flow. We see this friction as the effort to move one lubricated part relative to another - for example, the power required to rotate a crankshaft in its bearings - or the pressure difference required to create a certain flow, like the oil pressure required to move oil through an engine's oil passages.

When it comes to lubrication, it's the viscosity of the oil between the parts you want to lubricate that really matters. And this is where things start to get complicated, because engine oils don't behave as simply as we might like.

In fact, the viscosity of an oil is not constant at all - it depends upon the temperature, the pressure, and the actual strain rate or shear stress in the flowing oil, in the region of interest. The result? The viscosity of your engine oil is different depending on whether the oil is in your oil pan, under your valve lifters, or in the crankshaft bearings.

Measuring viscosity - and why

Oil viscosity is commonly defined and tested using four different methods, yielding four separate measures of viscosity: kinematic, high-temperature high-shear-rate, cold cranking simulator viscosity, and cold pumpability. These parameters have important implications regarding how an oil functions and under what conditions.

1. Kinematic viscosity, which measures the viscosity of an oil as it flows under the force of gravity, has been the most common measurement of oil viscosity for many years. Measurements are taken at two temperatures representative of oil in the oil pan of a warm engine: 40° C and 100° C. Because oils become thinner at higher temperatures, these two measurements also are used to quantify this relationship between viscosity and temperature, producing a number called the Viscosity Index (VI). The higher the VI, the less the viscosity change for a given change in temperature. For motor oils, a high VI usually is a good thing. The most common test for kinematic viscosity is American Society for Testing and Materials (ASTM) Method D 445.
2. High-temperature high-shear-rate (HTHS) viscosity is an indicator of a motor oil's resistance to flow in the narrow spaces between rapidly moving parts in fully

warmed up engines. The most common test here is ASTM D 4683, which simulates the conditions found in an engine's crankshaft and connecting rod bearings, as well as other narrow regions. This measurement has important implications for such factors as engine fuel economy, valvetrain wear and bearing protection.

3. Cold cranking simulator viscosity simulates the viscosity of an oil in crankshaft bearings when trying to start during a cold winter morning. The test is important in determining if an engine can be cranked over fast enough, when very cold, to start. ASTM Method D 5293 simulates an oil's cranking resistance when cold, and thus indicates the lowest temperature at which an engine is likely to start.
4. Cold pumpability looks at the resistance of an oil to pumping through the engine after a cold weather start. The most widely used test is ASTM D 4684, also known as the Mini-Rotary Viscometer method. If an oil's viscosity becomes too high, pumping may be a problem. Viscosity here becomes an important factor in determining whether the engine runs with proper lubrication after starting in severe cold.

The meaning behind the grade

Based on the viscosity measures described above, the Society of Automotive Engineers (SAE) has created their viscosity classification standard for engine oil: J300. Under this standard, a collection of viscosity grades are defined in terms of limits on different measures of viscosity. Table 1 shows these limits for each grade.

Grade	Cold Cranking (CCS)	Cold Pumping (MRV)	Kinematic Viscosity, 100°C		HTHS, 150 °C
			(cSt)	(cSt)	
unit	(cP @ T °C)	(cP @ T °C)	(cSt)	(cSt)	(cP)
-	Maximum	Maximum	Minimum	Maximum	Minimum
0W	6200 @ -35	60,000 @ -40	3.8	-	-
5W	6600 @ -30	60,000 @ -35	3.8	-	-
10W	7000 @ -25	60,000 @ -30	4.1	-	-
15W	7000 @ -20	60,000 @ -25	5.6	-	-
20W	9500 @ -15	60,000 @ -20	5.6	-	-
25W	13000 @ -10	60,000 @ -15	9.3	-	-
20	-	-	5.6	<9.3	2.6

30	-	-	9.3	<12.5	2.9
40	-	-	12.5	<16.3	2.9 (0W-40, 5W-40, 10W-40)
40	-	-	12.5	<16.3	3.7 (15W-40, 20W-40, 25W-40, 40)
50	-	-	16.3	<21.9	3.7
60	-	-	21.9	<26.1	3.7

The table shows that there are two types of SAE viscosity grades: those with a "W," and those without. Those with a "W" have upper limits on low-temperature cranking and pumping viscosities, and a lower limit on kinematic viscosity. Those without the W have upper and lower limits on kinematic viscosity at 100°C and HTHS at 150° C, but have no low-temperature viscosity limits. So, W grades pertain largely to low-temperature performance (think of the W as meaning "winter"), while non-W grades relate only to high-temperature performance.

For the W grades, note that the pumping limits are specified at 5° C below the cranking limits. This is done to ensure that if an oil allows an engine to start, the oil will pump throughout the engine, as well. If this were not the case, severe engine damage could result.

Single grades and multigrades

An engine oil can be classified as either single grade or multigrade. Oils that meet only W or only non-W grade requirements are called single grades, while those that meet the requirements of both are called multigrades. Examples of single grade oils are SAE 30 and SAE 10W, while SAE 5W-30 and SAE 20W-50 are examples of multigrades.

The reason we have both single grade and multigrade oils is largely historical. The earliest engine oils were all non-W single grades, but as the requirement for oils to work well under both low and high temperatures evolved, W grades and multigrades emerged. In terms of viscosity, the biggest difference between a multigrade and a single grade is that the multigrade must not become too viscous at low temperatures, while still meeting the requirements of its high temperature grade - in other words, multigrades exhibit less viscosity change with temperature than most single grades.

Thus, a typical 5W-30 motor oil has the same approximate kinematic viscosity as a SAE 30 grade oil at 100 ° C, but it's viscosity at very low temperatures, while thicker than when hot, is much less than the 30 grade. This is achieved by formulating multigrades with a higher Viscosity Index than typical for single grades. So, while a 5W-30 oil will

allow a modern car to start at temperatures as low as -30°C , the typical SAE 30 oil would be too thick to either crank or pump at that temperature.

So what's the best grade for you?

Given all of the different viscosity grades available, which is best for your customers' cars? To determine this, you need look no further than the vehicle owner's manual or application guide for that vehicle. In all but rare circumstances, the best viscosity grade is the one recommended by the manufacturer.

As you might guess by now, most experts prefer a multigrade oil, because of the wider temperature range over which such oils work. However, using the correct multigrade is also important, because one lighter than recommended may not provide adequate engine protection, while a heavier one will reduce fuel economy and performance, and may increase oil temperatures in critical regions like bearings.

The bottom line? Use the specified quality of oil in the recommended SAE viscosity grade and the result is your customers will enjoy the best that their vehicles have to give.