Motor Oil Viscosity Grades

What does the SAE Viscosity rating on your Motor oil bottle mean?

Most of the time when viscosity is explained words are used that are too technical for the average person to quickly grasp. This leaves them still wondering what the viscosity numbers really mean on a bottle of motor oil. **Simply put, viscosity is the oil's resistance to flow** or, for the layman, **an oil's speed of flow as measured through a device known as a viscometer**. The thicker (higher viscosity) of an oil, the slower it will flow. You will see oil viscosity measurement in lube articles stated in kinematic (kv) and absolute (cSt) terms. These are translated into the easier to understand SAE viscosity numbers you see on an oil bottle.

What does a 5W-30 do that an SAE 30 won't?

When you see a **W** on a viscosity rating it means that this oil viscosity has been tested at a ***Colder*** temperature. The numbers <u>without</u> the **W** are all tested at 210° F or 100° C 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° (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 210° F (100° C) which is engine operating temperature. This allows the engine to get quick oil flow when it is started cold verses dry running until lubricant either warms up sufficiently or is finally forced through the engine oil system. 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.

Obviously, cold temperature or **W** ratings are tested differently than regular SAE viscosity ratings. Simply put, these tests are done with a different temperature system. There is a scale for the **W**, or winter viscosity grades and, depending on which grade is selected, testing is done at different temperatures. See the Tables below for more information.

SAE Viscosity Chart (High Temp) 100° C / 210° F		
SAE Viscosity	Kinematic (cSt) 100° C Min	Kinematic (cSt) 100° C Max
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

Winter or "W" Grades			
SAE Viscosity	Low Temp (°C) Viscosity cP		Kinematic (cSt)
	Cranking Max	Pumping Max (NYS)	100° C Min
0W	3,250 @ -30	60,000 @ -40	3.8
5W	3,500 @-25	60,000 @ -35	3.8
10W	3,500 @ -20	60,000 @ -30	4.1
15W	3,500 @ -15	60,000 @ -25	5.6
20W	4,500 @ -10	60,000 @ -20	5.6
25W	6,000 @ -5	60,000 @ -15	9.3

Basically to determine non-winter grade viscosity using a viscometer, a measured amount of oil at 100° C is allowed to flow through an orifice and timed. Using a table they determine SAE viscosity based on different ranges. Thicker or heavy viscosity oils will take longer to flow through the orifice in the viscometer and end up in higher number ranges such as SAE 50 or SAE 60 for example. If an oil flows through faster being thinner/lighter then it will wind up in a low number range such as SAE 10 or SAE 20 for example. Occasionally it is possible for an oil to barely fall into one viscosity range. For example, an oil is barely an SAE 30 having a time that puts it on the very low side. Then another oil is timed to be an SAE 20 on the high side not quite breaking into the SAE 30 numbers. Technically speaking these oils will be close to the same viscosity even though one is an SAE 20 and the other an SAE 30. But you have to draw the line somewhere and that's how the SAE system is designed.

Another system takes more accurate numbers into account known as cSt abbreviated for centistokes. You'll see these numbers used often for industrial lubricants such as compressor or hydraulic oils. The table above, ***SAE Viscosity Chart (High Temp)***, shows the equivalents for cSt and SAE viscosity numbers. You'll see the ranges for cSt compared to SAE numbers. An oil that is 9.2 cSt will be nearly the same viscosity as an oil that is 9.3 cSt, yet one is an SAE 20 and the other is an SAE 30. This is why the cSt centistokes numbers more accurately show oil viscosity.

Now if you look at the table labeled ***Winter or "W" Grades***, you can get valuable information on how the **W** or winter grade viscosities are measured. Basically, as shown by the chart, when the oil is reduced to a colder temperature it is measured for performance factors. If it performs like a SAE 0 motor oil at the colder temperature, then it will receive the SAE 0W viscosity grade. Consequently, if the motor oil performs like a SAE 20 motor oil at the reduced temperatures (the scale varies - see the chart), then it will be a SAE 20W motor oil.

If a motor oil passes the cold temperature or **W** (winter grade) specification for a SAE 15W and at 210° F (100° C) flows through the viscometer like a SAE 40 motor oil, then the label will read 15W-40. Getting the picture? Consequently, if the motor oil performs like a SAE 5 motor oil on the reduced temperature scale and flows like a SAE 20 at 210° F (100° C), then this motor oil's label will read 5W-20. And so forth and so on!

I can't tell you how many times I have heard someone, say that they wouldn't use a 5W-30 motor oil because it is, "Too thin." Then they may use a 10W-30 or SAE 30 motor oil. At engine operating temperatures these oils are the same. The only time the 5W-30 oil is "thin" is at cold start up conditions where you need it to be "thin."

So how do they get a motor oil to flow in the cold when it is a thicker viscosity at 210° F?

The addition of Pour Point Depressant additives (VI) keep the paraffin in petroleum base oils from coalescing together when temperature drops. Pour Point Depressants can keep an oil fluid in extreme cold temperatures, such as in the arctic regions. We will not go into Pour Point Depressing additives at this time except to say they are only used where temperatures are very extreme to keep the motor oil from becoming completely immobilized by the cold temperature extreme. For now we will just discuss the Viscosity Improvers (VI) additives.

Why don't we just use a SAE 10 motor oil so we can get instant lubrication on engine start up?

The reason is simple: it would be a SAE 10 motor oil at 210° F! The lower the viscosity, the more wear will inevitably occur. This is why it is best to use the proper oil viscosity recommended by the auto manufacturer as it will protect hot and at cold start ups. Obviously a 10W-10 motor oil won't have the film strength to prevent engine wear at full operating temperature like a 5W-20, 10W-30 or 5W-30 motor oil for example.

The VI additives have the effect of keeping the oil from thinning excessively when heated. The actual mechanics of this system are a little more complex in that these additives are added to a *thinner* oil so that it will be fluid at a cold temperature. The VI additives then prevent thinning as the oil is heated so that it now can pass the SAE viscosity rating at 210. For example; if you have a SAE 10 motor oil it will flow like a 10W at the colder temperature. But at 210 degrees it will be a SAE 10 giving us a 10W-10 or SAE 10 viscosity rating. Obviously, this is good at cold start up, but terrible at engine operating temperature especially in warmer climates. But by adding the VI additives we can prevent the oil from thinning as it is heated to achieve higher viscosity numbers at 210 degrees. This is how they make a petroleum based motor oil function for the 10W-30 rating. The farther the temperature range, like with a 10W-40, then more VI additives are used. With me so far? Good, now for the bad news.

Drawbacks of Viscosity Improving additives

Multi-grade motor oils perform a great service not being too thick at cold startup to prevent engine wear by providing more instantaneous oil flow to critical engine parts. However, there is a draw back. These additives shear back in high heat or during high shear force operation and break down causing some sludging. What's worse is once the additive begins to be depleted the motor oil no long resists thinning so now you have a *thinner* motor oil at 210 degrees. Your 10W-30 motor oil can easily become a 10W-20 or even a SAE 10 (10W-10) motor oil. I don't have to tell you why that is bad. The more VI additives the worse the problem which is why auto manufacturers decided to steer car owners away from motor oils loaded with VI additives like the 10W-40 and 20W-50 viscosities.

The less change a motor oil has from high to low temperatures gives it a high ***Viscosity Index***. Synthetic motor oils that are made from Group IV (4) PAO base stocks have Viscosity Indexes of more than 150 because they are manufactured to be a lubricant and don't have the paraffin that causes the thickening as they cool. But petroleum based motor oils (Group I (1) & II (2)) usually have Viscosity Indexes of less than 140 because they tend to thicken more at the colder temperature due to the paraffin despite the addition of Viscosity Improving additives. The higher the Viscosity Index number the less thinning and thickening the motor oil has. In other words, high number good, low number bad. Low numbers thicken more as they cool and thin more hot. You see these Viscosity Index ratings posted on data sheets of motor oils provided by the manufacturer.

As already mentioned, VI improving additives can shear back under pressure and high heat conditions leaving the motor oil unable to protect the engine properly under high heat conditions and cause sludging. Also there is a limit to how much viscosity improving additives can be added without affecting the rest of the motor oil's chemistry. Auto manufacturers have moved away from some motor oils that require a lot of viscosity improving additives, like the 10W-40 and 20W-50 motor oils, to blends that require less viscosity additives like the 5W-20, 5W-30 and 10W-30 motor oils. Because stress loads on multi viscosity motor oils can also cause thinning many racers choose to use a straight weight petroleum racing motor oil or a PAO based Synthetic which do not have the VI additives. But only the Group IV (4) PAO based synthetics generally don't need VI additives.

Read on to learn why:

What about synthetic motor oils? Do they need Viscosity Additives?

Group IV (4) and Group V (5) base oil (synthetics) are chemically made from uniform molecules with no paraffin and generally don't need Viscosity Additives. However, in recent years Group III (3) based oils have been labeled "synthetic" through a legal loophole. These are petroleum based Group II (2) oils that have had the sulfur refined out making them more pure and longer lasting. Group III (3) "synthetic" motor oils must employ Viscosity Additives being petroleum based.

Group V (5) based synthetics are usually not compatible with petroleum or petroleum fuels and have poor seal swell. These are used for air compressors, hydraulics, etc. It's the Group IV (4) PAO based synthetics that 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 use no 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.

How do I know what motor oil is a Group IV (4) based PAO synthetic motor oil?

As more and more large oil companies switched their "synthetic" motor oils to the less expensive/more profitable Group III (3) base stocks it has become much easier to identify which are PAO based true synthetic. Of the large oil companies, only Mobil 1 Extended Performance, as of this writing (12-16-2012), is still a PAO based true synthetic. The rest, including regular Mobil 1 and Castrol Edge have switched to the cheaper/more profitable Group III (3) petroleum based "synthetic" motor oil. AMSOIL Synthetic Motor Oils are PAO based true synthetic motor oils with the exception of the short oil drain OE and XL synthetic motor oils sold at some Auto Parts Stores and Quick Oil Change Centers. This leaves more than 20 PAO based true synthetic motor oils manufactured and marketed by AMSOIL with only a few Group III (3) based synthetic motor oils identified by the "OE" and "XL" product name.

So as you can see, the average performance of motor oils can be affected by how they change during their service life. Multi grade petroleum can lose viscosity and thin causing accelerated wear as the VI additives shear back. Straight weight petroleum (i.e. SAE 30, SAE 40) thicken a lot as they cool meaning longer time before lubricant reaches critical parts on cold starts, but have no VI additives so they resists thinning. However, they can degrade and thicken as heat and by products of combustion affect the unsaturated chemistry. Group III (3) synthetics resists this degradation much better, but being petroleum based employ some VI additives which is a negative and typically don't have as good performance in the volatility viscosity retention areas. Only the Group IV (4) PAO base synthetics have the saturated chemistry to resist degrading when exposed to the by products of combustion and heat, plus typically employ no VI additives making them very thermally stable for longer periods. For this reason the Group IV (4) synthetics maintain peak mileage and power throughout their service life Modern motor oils are a marvel of chemistry to be sure. There are a lot more additives in play than the few mentioned here.

Plus there are some auto manufacturers like Mercedes, BMW and Volkswagen that have unique oil standards for their cars. You need to read your owner's manual clearly to be sure you are using the proper oil for your application.

Tip:
Changing your motor oil at regular intervals is the key to a healthy engine.