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CENTRAL PETROLEUM COMPANY
Cleveland, OH Walcott, IA

CENTRAL NEWS©

Merry Christmas

Normally when crude oil prices drop below $35 per barrel, oil is the main topic of the day. However, these are not normal times and then again maybe they are.

Currently our country and the world media are fixated for good reasons on the latest Islamic terrorist organizations that have sworn to destroy our nation, Israel and all people having different religious beliefs. These radicalized terrorists are systematically killing both Christians and Islamic people throughout the Middle East and the world.

Since the birth of Christ over 2000 years ago, evil rulers, dictators and the like have attempted to destroy all those who believe in Christianity. However, they have and will continue to fail. America's constitutional right of freedom of religion is the enemy of these terrorists.

We should never take these words "Merry Christmas" for granted because many people in the world aren't allowed to say them in public. In America "Merry Christmas" represents hope for the future, generosity towards others, family gatherings and religious awareness.

It's always a blessing and honor to be able to wish all of you and your families a Merry Christmas and healthy New Year.

Paul T. Webster III

Performance Under Pressure

By Blaine Ballentine

Why Oil?

Why do we use oil in plain bearings?

After the journal spins up, it is actually floating on oil and does not touch the bearing. So, why not use water? Water supports water-skiers. Cars hydroplane in a heavy rain.

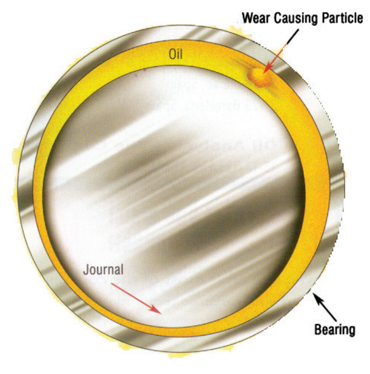


Figure 1. Bearing Wear

Why not use water in plain bearings? It is not because of temperature. Turbines often run at about 100 degrees F. It is not slipperiness. Bearings can be coated with Teflon; some manufacturers coat bearings with unobtainium. The problem with water is that it does not compress, and it does not increase in viscosity when it is compressed.

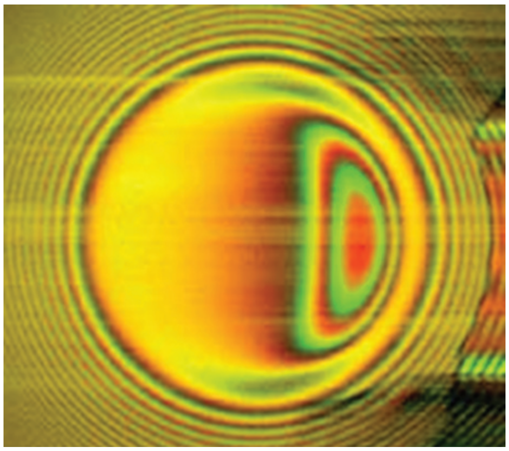
The reason oil works in a plain bearing is that it increases in viscosity when put under pressure. As the journal rotates at startup, it squeezes the little wedge of oil in front of it. The pressure causes the oil to thicken, and the journal climbs up onto the thickened oil. The journal floats on the oil film which is called hydrodynamic lubrication.

> **Hydrodynamic Lubrication** is the lubrication regime in which two sliding metal parts are completely separated by a thick fluid film with no contact between the metal surfaces

How Thick?

As RPM increases, pressure builds at an accelerating rate. At high RPM, pressure becomes extreme in the high load zone of the bearing, perhaps 10,000 psi. The pressures are high enough that it compresses the oil into a solid, temporarily, about the consistency of cheese.

But plain bearings are not where we find the highest loads in lubrication. Ball bearings at high rpm also float on oil. However the area between the balls and the race is really small compared to the surface of a plain bearing. So, the pressure is much higher.



Another place pressures on oil can be astronomical is heavily loaded gears. In these applications, the oil temporarily becomes an extremely hard solid, like a hard plastic. In fact, the oil can temporarily become so viscous that the bearing or gear surfaces actually bend slightly, but the surfaces do not touch. Again, due to the extreme viscosity increase, the parts actually float on oil. This type of lubrication where the surfaces bend while riding on the oil film is called elastohydronamic lubrication.

Pressure-Viscosity Coefficient

> **Elastohydronamic Lubrication**
> A mode of fluid-film lubrication in which hydrodynamic action is significantly enhanced by surface elastic deformation and lubricant viscosity increases due to high pressure

Some oils increase in viscosity more than others when put under pressure. This rate of change in viscosity with increasing pressure is called the pressure-viscosity coefficient.

Pressure-viscosity coefficients are different for different base oil. Paraffin base oil has a higher pressure-viscosity coefficient than PAO (polyalphaolefin) synthetic oil. In other words, paraffin base oil thickens more, and at a faster rate as pressure is applied.

Equalizing Film Thickness

A few years ago, research was performed for lubricant performance in gearboxes that began with equating the elastohydronamic film thickness of a synthetic base oil with a mineral oil. The synthetic oil selected was polyalphaolefin, or PAO, which is the type of base oil found in premium grade engine oils. The temperature chosen was 80 degrees C. (176^{o} F.), as it is somewhat typical of gearbox operating temperature.

> **Pressure-Viscosity Coefficient** is the rate of increase in viscosity as pressure increases

The viscosity of the mineral oil was 18.1 cSt. at 100 C. To match the same film thickness under pressure at 80^{o} C., the viscosity of the PAO synthetic oil had to be 24.1 cSt.

SAE grades are not as precise as centistokes, but they are more meaningful for most people. In SAE terms, it took an SAE 140 synthetic oil to provide the same film thickness as SAE 90 mineral oil. In motor oil terms, it took an SAE 50 synthetic oil to provide the same protection under load as SAE 40 mineral oil.

Application

Knowing that our pure paraffin base oil creates a thicker film under pressure than a synthetic, can we recommend a lower viscosity grade? For example, can we recommend SAE 80W-90 in applications calling for a synthetic SAE 75W-140?

Be careful. Even if the cold temperature performance of 80W-90 is appropriate for startup temperatures, remember that the viscosity only builds to that of synthetic 75W-140 at elastohydronamic pressures. The bearings will not experience the same loads as between the gears.

However, our paraffin base oil has greater film strength. If a trucker hauls potato chips and light bulbs across Kansas, he may as well use our 75W-90 synthetic gear lube and take advantage of the extended drains. If he fills his tanker until he hits the weight limit and then drags it across the mountains, we recommend our HyTorque 80W-90.

Our motorsports clients often ask about synthetic oils, because synthetics are often perceived to be the best. But paraffin base oils and synthetic base oils have different pressure viscosity coefficients, and when their engines are screaming and the bearing loads are severe, our paraffin base oil provides more film.

Viscosity build under pressure makes plain bearings work, and paraffin base oils build viscosity faster than synthetic.

Synthetic oils have their place with their superior cold temperature flow and better oxidation stability, which is why we use them in many of our products. But when loads become high, our pure paraffin base oil punches above its weight.

It took an SAE 140 synthetic oil to provide the same film thickness as SAE 90 paraffin base oil. It took an SAE 50 synthetic oil to provide the same protection under load as SAE 40 paraffin base oil.

Reference

"Selecting Oils with High Pressure-Viscosity Coefficient," by Robert Errichello, *Machinery Lubrication,* 3/2004, p48.

SAE Viscosity

By Austin Madesian

The Society of Automotive Engineers (SAE) determines an engine oil's viscosity by the SAE J300, a standard that was created in 1911 and has been continually updated ever since. This article is an update of the July 1993 edition of the Central News and is intended to give some insight into the SAE J300 and it's tests.

The J300 provides guidelines by which an engine oil is classified by using four different tests. Two tests measure low temperature viscosities (ASTM D 5293 and ASTM D 4684) and two tests measure high temperature viscosities (ASTM D 445 and ASTM D 4683).

The first low temperature test, ASTM D 5293, is better known as the Cold Crank Simulator or CCS. This test helps simulate an engine oil's cranking performance during a low temperature start-up. A sample of oil is subjected to a very cold temperature between -5°C and -30°C (23°F and -23°F) for three minutes. A rotor is then spun in the oil and the rotor's speed is measured to determine the engine oil's viscosity. This test is represented in the second column to the right in Table 1.

Cannon CSS-2100 Automatic Cold Cranking Simulator.

The second low temperature test, ASTM D 4684, is a test used to determine an engine oil's pumpability. In the early 1980's there was an outbreak of catastrophic engine failures due to extremely cold weather. Some engine oils thickened and gelled in these conditions. Engines would start but they would seize within minutes due to oil starvation because the pump systems were incapable of pulling the cold and gelled oil out of the oil pans. The result was a rash of engine failures, warranty claims, and motor oil recalls. The ASTM D 4684 was developed to indicate the lowest temperatures that engine oils can be continuously and adequately supplied to the oil pump inlet.

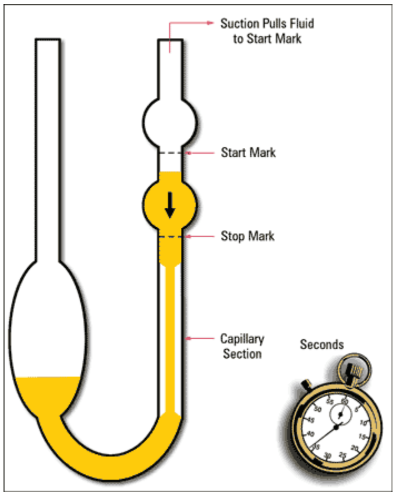
The ASTM D 4684 raises the engine oil's temperature to 80°C, then slowly lowers the temperature for about two days. This slow cooling is important because it is more likely to create a gel than if the oil were quickly cooled. The test is finished when either the Borderline Pumping Temperature is reached or an Air Binding Failure occurs.

The Borderline Pumping Temperature, which is represented by the third column to the right on Table 1, is defined by 600P (60,000 cP) and an Air Binding Failure is when excessive force is needed to cause the oil to flow properly. The temperature that the oil is at when the test is finished is what determines the SAE grade.

The first high temperature test, ASTM D 445, is what determines the Kinematic Viscosity of an engine oil. In this test, the oil is pulled into a viscometer tube then heated to 100°C. Each viscometer has two marks, one above the other. The time that it takes the heated engine oil to fall from one mark to the other is measured, and each viscometer is calibrated so that the time in seconds can be converted to centistokes (cSt). If we use Table 1 we can determine that an SAE 15W-40 would have a kinematic viscosity that falls between 12.5 and <16.3 cSt.

The final test in the J300 is the ASTM D 4683, commonly known as the High-Temp High Shear (HTHS) test. This test measures the high-shear rate absolute viscosity. In this test, engine oil is heated to 150°C and a rotor is spun within the oil. The oil's resistance to the rotor's torque is measured and is used to calculate the oil's viscosity.

This test was put into place to assure a good balance because a lower viscosity allows the engine's parts to move more



freely which gives a higher rate of fuel efficiency. However a higher viscosity provides better wear protection for the engine, but it slightly inhibits fuel efficiency. Essentially the manufacturers want to ensure that the oil is thick enough to give proper separation between the engine's moving parts.

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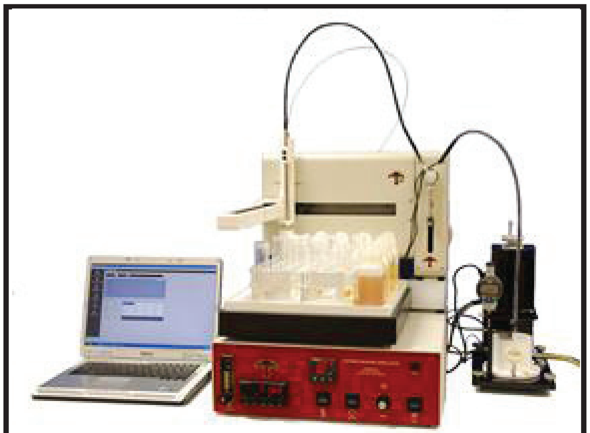
This test was put into place to assure a good balance because a lower viscosity allows the engine's parts to move more freely which gives a higher rate of fuel efficiency. However a higher viscosity provides better wear protection for the engine, but it slightly inhibits fuel efficiency. Essentially the manufacturers want to ensure that the oil is thick enough to give proper separation between the engine's moving parts after temporary shear at high temperatures.



Tapered Bearing Simulator (TBS) Viscometer used to perform the ASTM D 4683 High-Shear Rate test.

So how are these tests used to determine an engine oil's classification? We can use Table 1 to see how each test is used as the guidelines for classification. For example, a 15W-40 oil tests within the following specifications: a low temperature cranking grade of no more than 7,000 at -20°C, a low temperature pumping grade of no more than 60,000 at -25°C, a Kinematic Viscosity that falls between 12.5 and 16.3 and a High Temp-High Shear rate of 3.5.

One thing that you may find interesting is that Cen-Pe-Co's S-3 15W-40 meets the cold temperature pumpability requirements for a 10W oil. However since the lowest cranking grade that it satisfies is the 15W, it must be classified as 15W-40 according to the SAE.

Included for the first time in the 2015 SAE J300 is

SAE Viscosity Grade	Low Temperature Cranking (cP)	Low Temperature Pumping (cP)	Kinematic Viscosity (cSt)		High Temp-High Shear (cP)
			Minimum	Maximum	
0W	6,200 @ -35°C	60,000 @ -40°C	3.8		
5W	6,600 @ -30°C	60,000 @ -35°C	3.8		
10W	7,000 @ -25°C	60,000 @ -30°C	4.1		
15W	7,000 @ -20°C	60,000 @ -25°C	5.6		
20W	9,500 @ -15°C	60,000 @ -20°C	5.6		
25W	13,000 @ -10°C	60,000 @ -15°C	9.3		
16			6.1	<8.2	2.3
20			6.9	<9.3	2.6
30			9.3	<12.5	2.9
40			12.5	<16.3	3.5
40			12.5	<16.3	3.7
50			16.3	<21.9	3.7
60			21.9	<26.1	3.7

Table 1

the new grade SAE 16. The previous lowest grade was SAE 20. The addition of SAE 16 is just the first step towards the trend of engine oils dropping in viscosity in efforts to improve fuel economy while still maintaining wear protection. The SAE plans to implement grades SAE 12 and SAE 8 in the near future as well.

The SAE J300 is the industry standard for determining an oil's viscosity and provides the guidelines for how an oil must be classified. While the J300 was initially developed over 100 years ago, it has been updated many times. It will only see more changes and updates as breakthroughs in engine oils are made.

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