Don’t Ignore Viscosity Index when Selecting a Lubricant

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Too often the viscosity index (VI) is disregarded as a lubricant selection parameter. One reason is simply because it is poorly understood. Some people think the viscosity index is incorporated in the ISO Viscosity Grade, but it is not. It stands alone as an independent lubricant performance differentiator.

We all know that viscosity is the single most important physical property of a lubricant. It is a crude measure of a lubricant’s molecular constitution from the standpoint of hydrocarbon chain size. Viscosity is determined by creating friction between the molecules from fluid movement. The higher the intermolecular friction (longer molecular chains), the higher the viscosity.

Viscosity determines film thickness and film strength in machines. It also influences other important factors such as those in the table below.

FACTOR	REASON
Wear rate and machine life expectancy	Viscosity influences boundary, mixed-film and full-film lubrication (Stribeck curve)
Lubricant temperature and lubricant life expectancy	Mechanical and fluid friction cause heat, which shortens lubricant life
Machine sensitivity to particle contamination	Thin films increase a machine’s contaminant sensitivity
Energy consumption	Mechanical and fluid friction consume more energy
Extreme cold and high temperature conditions	Influences part movement (e.g., crankability) and chemical stability (e.g., oxidation)
Fluidity	Ease at which lubricants reach vital frictional zones in machines

The Effects of Viscosity

However, a lubricant’s viscosity is meaningless unless the temperature is noted, i.e., the temperature at which viscosity is measured. Conversely, machines don’t care about temperature as it relates to viscosity (loosely speaking). Minimum, maximum and optimum viscosity requirements demanded by machines don’t take temperature into account. Instead, a machine’s viscosity requirement is based on such things as component design (e.g., bearing), loads and speeds. You may recall that the well-known Stribeck curve doesn’t have a temperature variable.

That said, because machines require a certain viscosity, and temperature is known to have a dramatic influence on viscosity, it is imperative that you take the average operating temperature and temperature range into account when selecting viscosity. Remember, the ISO Viscosity Grade system only reports viscosity at a single temperature: 40 degrees C. Most importantly, for any candidate oil, you need to know how viscosity changes relative to a change in temperature.

The viscosity index was developed for this purpose (ASTM D2270) by E. Dean and G. Davis in 1929. It is an empirically derived, unitless number. Based on the methodology, Pennsylvania crude (paraffinic) was set as a benchmark at one extreme, representing low viscosity changeability relative to temperature. At the other extreme was Texas Gulf crudes (naphthenic). If a lubricant was similar to the Pennsylvania crude, it was assigned a VI of 100. If it was similar to Texas Gulf crude, it was assigned a VI of 0. Halfway in between was a VI of 50, and so forth. The higher the VI, the more stable the viscosity across a range of temperatures (more desirable). The temperatures used to determine the VI are 40 degrees C to 100 degrees C.

An Internet search on “viscosity index calculator” will direct you to several Web pages. You can use these calculators in a variety of ways. For instance, if you know the viscosity of a lubricant at two different temperatures, you can use the calculator to give you an estimation of the VI. Better yet, you can enter a single known viscosity (and temperature) and VI (commonly found on a lubricant’s product data sheet) to calculate the viscosity of the same lubricant at any other temperature (say, a machine’s operating temperature).

Lubricants with VIs as low as minus 60 are available today. Other lubricants can have VIs ranging over 400. However, the vast majority of lubricants on the market will have VIs in the range of 90 to 160.

Let’s take a look at two different oils that share one common property - they’re both ISO VG 150. However, one of these oils (Oil A) has a VI of 95 (mineral oil), while the other (Oil B) has a VI of 150 (synthetic). Now let’s examine the viscosity of these oils from minus 20 degrees C (minus 4 degrees F) to 100 degrees C (212 degrees F). This is shown in the table below.

89% of lubrication professionals consider an oil’s viscosity index when selecting a lubricant, according to a recent survey at machinerylubrication.com

Comparing the 95 VI oil to the 150 VI oil, there is a 236-percent difference in viscosity at minus 20 degrees C and a minus 25-percent difference at 100 degrees C. Of course, there is no difference at 40 degrees C. As mentioned previously, the machine dictates the viscosity requirements based on its design and operating conditions. These conditions influence temperature, which in turn influences viscosity, which influences the protection provided.

Many machines use a common lubricant across numerous frictional zones and have varying loads, speeds and temperatures. Outdoor mobile equipment typically works under these challenging conditions. For such machines, there is no easy way to identify optimum viscosity by a theoretical calculation. Instead, the ideal viscosity is estimated using actual field measurements by applying a trial-and-error approach (simply testing with different viscosity oils and measuring temperature and wear protection).

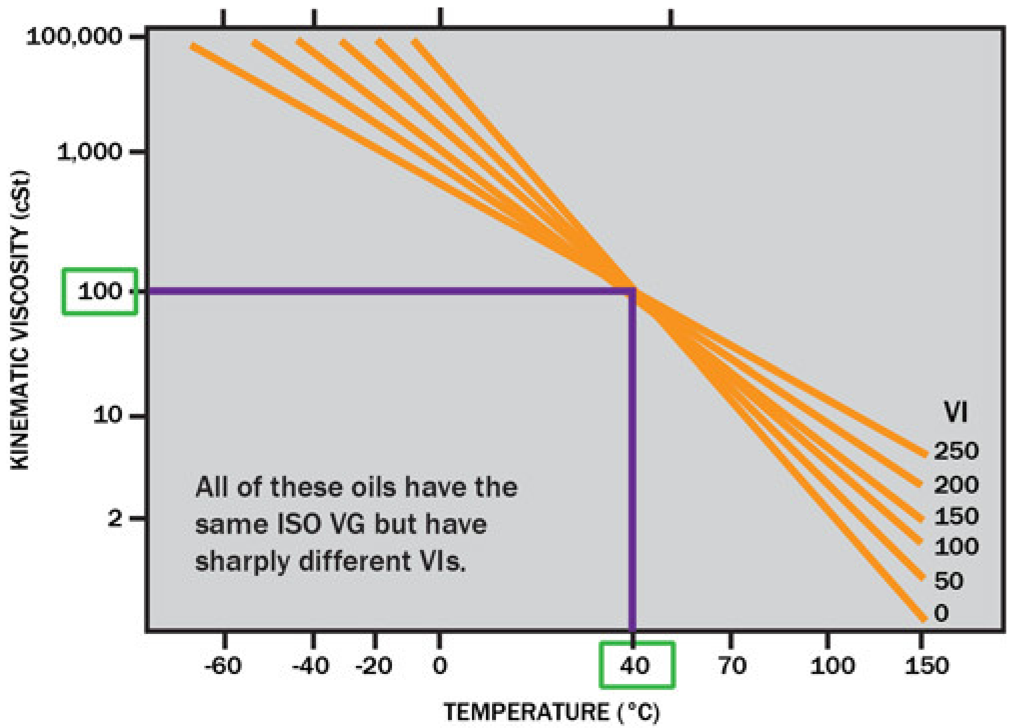
TEMPERATURE DEGREES	-20° C (-4° F)	20° C (68° F)	40° C (104° F)	60° C (140° F)	80° C (176° F)	100° C (212° F)
Oil A, VG 150: Viscosity (cSt) at VI = 95	37,000	550	150	56	26	15
Oil B, VG 150: Viscosity (cSt) at VI = 150	11,000	435	150	65	34	20
Viscosity difference between Oil A and Oil B	+236%	+26%	0%	-14%	-23%	-25%

Comparison of Two Different Oils with the Same Viscosity Grade

For machines of constant load, constant speed and constant ambient temperatures, the ideal viscosity very often results in the lowest stabilized oil temperature. Oils of lower or higher viscosities (than the optimum viscosity) will typically increase the oil's stabilized temperature due to either churning losses (too much viscosity) or mechanical friction (too little viscosity).

If conditions are not constant (variable loads, variable speeds, variable ambient temperatures, etc.), then there is a need for not only the optimum viscosity but also a high viscosity index to stabilize the optimum viscosity. The more variable the conditions, the greater the need for high VI oils.

Also, keep in mind that for a great many machines there has been no past experimental or theoretical effort to identify the optimum viscosity. Viscosity selection is more of a wild guess. This too calls for a high VI lubricant.



You must also consider that the ISO Viscosity Grade system (ISO 3448) is based on 50-percent increments between grades. As such, if you go from ISO VG 100 to VG 150, it is a 50-percent jump. When the viscosity options are all 50 percent apart, it is difficult to achieve precision lubricant selection. These large viscosity steps are further magnified at lower temperatures. This is yet another reason to select high VI lubricants.

High or Low Viscosity Index?

A lubricant may merit having a high VI for one or more of the following reasons:

- The optimum viscosity is not known
- Varying loads and speeds exist
- Varying ambient temperatures exist
- To boost energy efficiency
- To boost oil service life (lower average temperature)
- To boost machine service life (fewer repairs and downtime)

Cheaper, lower VI lubricants may make sense if:

- Speeds and loads are constant
- Temperature is constant (constant ambient temperature or a heat exchanger is in use)

- The optimum viscosity at the operating temperature is known and is consistently achieved

An oil’s VI can also tell you useful information about a lubricant’s formulation, including the type and quality of base oils. For instance, highly refined and pure mineral oils will have correspondingly higher VIs. Certain additives, such as viscosity-index improvers and pour-point depressants, influence VI as well. Remember, oils loaded with VI improvers, especially of certain types, are prone to permanent loss of VI and viscosity over time. There are ASTM tests for measuring the VI stability of lubricants exposed to high shear.

Viscosity index values are on almost all product data sheets for commercially available lubricants. This simple number is there for a reason and should be strongly considered when writing a specification for lubricants in nearly all machine applications.

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