Technical topic

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Hydraulic fluid shear stability

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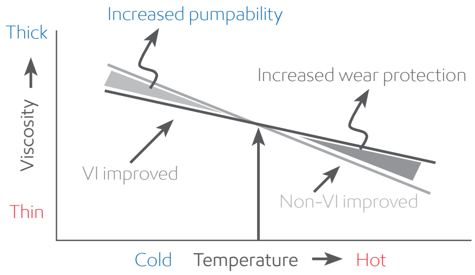
Machinery and the lubricants that protect them are often exposed to a wide variety of ambient and operating temperatures. As a result, lubricants are often required to maintain good pumpability at low temperatures and sufficient film strength at high temperatures. Prime examples are hydraulic fluids used in industrial and mobile equipment applications that operate in a wide range of environments and temperatures. It is not difficult to find a lubricant to meet these requirements, but there can be performance concerns if the fluid is not properly formulated. Fluids with a wide operating temperature range are often formulated with special viscosity-improver additives to improve both high- and low-temperature viscometrics, and these additives are subject to shearing forces that can reduce their effectiveness in service.

The viscosity-temperature relationship

The viscosity of lubricants changes with temperature. As temperature rises, viscosity decreases, and as temperature decreases, viscosity increases. A measure of the relative rate of change of viscosity with temperature is referred to as the fluid's viscosity index, or VI.

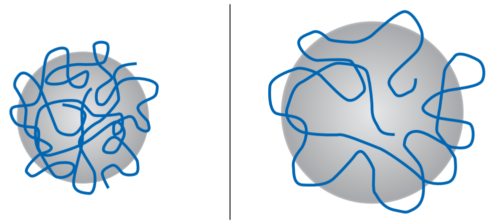
VI is a number used to quantify the change of viscosity with respect to temperature. The viscosity of a fluid with high VI does not change as rapidly with temperature when compared with a lower-VI fluid. Many non-VI-improved, called monograde, mineral hydraulic oils will have VIs from 90 to 110. The VI of most synthetic oils is often above 140 without VI improvers.



What is VI?

Viscosity-index improvers

The VI of a fluid can be enhanced through the use of specialized additives called viscosity-index improvers. These additives are typically high-molecular-weight polymers designed to minimize the temperature's impact on viscosity.



Low temperature: VI-improver molecules contract

High temperature: VI-improver molecules expand

Shear stability measurements

There are three commonly used methods for determining the shear stability of a high-VI fluid.

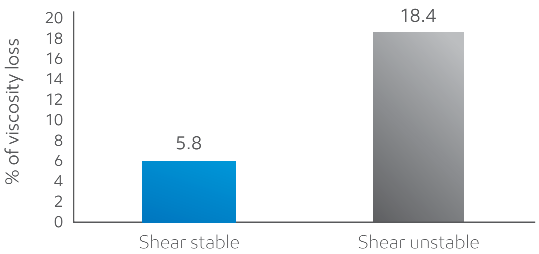
DIN 51382—The Bosch Injector Test is run through 250 cycles at 2550 psi and the change in viscosity is measured.

Hydraulic fluid shear stability

ASTM D5621—The sonic shear test functions by shearing the sample hydraulic fluid in a sonic oscillator for 40 minutes and measuring the change in viscosity.

CEC L-45-A-99—The KRL Tapered Roller Bearing test is becoming the test of choice of many OEMs around the world, as it is considered the most severe and offers the best correlation to actual field performance. Test oil is run in a fitted, tapered roller bearing for 20 hours under design load. Before and after, viscosities are compared for the percentage of viscosity loss.

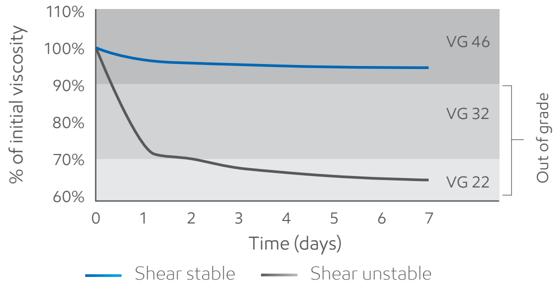
The graph below shows a 12.6 percent reduction in viscosity shear loss from a shear-unstable oil to a shear-stable oil as tested in the KRL Tapered Roller Bearing test.



20-hour KRL test (CEC L-45-A-99)

Shear stability application testing: Hydraulic pumps

While laboratory tests provide useful data on shear stability of hydraulic fluids, another method is to measure shear stability in an operating hydraulic pump. Testing in a hydraulic pump replicates the forces and conditions encountered in everyday use. In the example below, data was collected from two fluids in a Vickers 25VQ Vane Pump test rig run at 138 bar (2000 psi) and 52°C (125°F) for 168 hours.

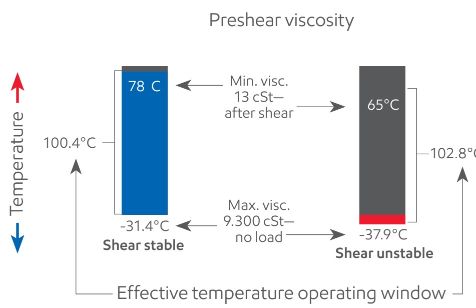


Initial viscosity

In this example, the shear-unstable, high-VI hydraulic fluid suffered a nearly 30 percent viscosity loss in just two days and falls out of the International Standard Organization (ISO) viscosity grade (VG) in less than one day of pump operation. On the other hand, a more shear-stable formulation retains consistent viscosity for the duration of the test. The differentiation has a significant implication in the lubrication and operation of a hydraulics system.

Impact of shear stability: Temperature operating window (TOW) and "afternoon fade"

Excessive permanent shear, as shown in the previous example, has serious implications for a hydraulic system. As shear increases, the fluid's TOW decreases. The TOW of a hydraulic fluid is a measure of the minimum and maximum temperature operating range. A hydraulic fluid's TOW is dependent on initial VI. The effective TOW seen in the field is also impacted by shear stability as illustrated below, where a shear-stable fluid has a broader TOW than a less shear-stable fluid of higher VI.



TOW

Conclusion

The ability of a hydraulic oil to maintain optimum viscosity under a wide TOW can be achieved with a shear-stable, high-VI hydraulic fluid. Well-formulated, shear-stable, high-VI hydraulic fluids have been tested to maintain optimum lubricant viscosity, maintaining a wide TOW and preventing a decrease in volumetric efficiency.