

**In addition to strength and wear, a third criteria—that of the load capacity of the lubricant—must be considered when figuring gear capacities.**

**W**e consider gear capacities from the effects of loads on strength and wear, but we should not neglect the “third” criteria; the load capacity of the lubricant. This determination is equally complex and can involve more factors than are considered for a material’s load.

The viscosity of the lubricant is high on the list of requirements, and it is well known that the higher the viscosity, the higher the load carrying capability of the oil film. As with most benefits there is a good and a bad side. These include excessive heat generation, churning losses, and particularly at high-speed, lubricant shear. Even so, when conditions are severe, the principle item on any list of required lubricant properties is viscosity.

In the simplest terms, viscosity is the determination of the lubricant’s resistance to “flowability.” The approved definition is: The measure of a fluid’s internal resistance to flow, caused by internal friction between the lubricant’s molecules, when a pressure, stress, or force is applied. The viscosity is that number of seconds required for a measured liquid volume to flow through a specified orifice at a standard condition and temperature range. Viscosity is expressed in two terms: “absolute,” and “kinematic.” The poise is the unit for absolute viscosity, and for practical reasons the Centipoise (cP) is the unit of measurement. Kinematic is the most appropriate gear viscosity because it considers the internal friction. This viscosity is the formerly used dynamic viscosity divided by the fluid’s density at the prevailing


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temperature. The unit of measurement is the Centistoke (cST), which is the multiple of the kinematic viscosity times the fluid’s density. Mineral-based lubricants have a significant decrease in kinematic viscosity with rising temperatures. When higher than normal temperatures occur, the manufacturer’s recommendations may not be applicable. The condition can be improved with the use of polymer additives. However, these polymer/oils have an irreversible loss of viscosity when subjected to loads which can shred the polymer chain.

The accurate measurement of viscosity is affected by temperature, pressure, shear rate, and other factors. The measurement tool is a viscometer, such as the popular Saybolt Universal. This method can accommodate a wide range of fluids and two orifices are used. Readings are then expressed as Saybolt Seconds Universal (SSU), or Saybolt Seconds Furoil (SSF). SSU times being approximately 10 times longer than SSF. The Brookfield viscosity refers to the kinematic viscosity when measured with a

Brookfield viscometer. An approximation of the conversion is provided by the following: SUS @ 100degree F/5 =cST @ degree C.

Older measurement methods are being replaced with more-efficient solid state acoustic wave sensors. A sensor semiconductor of this type weighing 4oz., and smaller than a match box, can provide the different synthetic lubricant conditions, and viscosities over time, from new, used, and contaminated lubricants. These new innovations take the former laboratory required readings into the more practical operating condition. Viscosities in other parts of the world are expressed in different terms, such as British Redwood Seconds (B.S. Standard 4271) and German Engle Degrees (Standard D.2422). The U.S. classification has been developed in a coordinated program by the AGMA, ASTM, and SAE and is known as the ASTM system.

The Viscosity Index (KVZ) indicates how the viscosity changes with temperature. Gear lubricants are usually specified at 100 degree and 210 degree F., and internationally at 40 degree C and 100 degree C. The naphthanic oils have a low viscosity index, and the paraffinic oils are generally produced with a high index that is affected by the refinery process. ISO introduced 18 viscosity grades from ISO VG-2 to ISOVG-1500, and gear lubricants are usually within the range of VG-22 for high speed and VG-320 for epicyclics and rolling mill drives. In high-speed, high-power gears, the journal bearings or the machine—such as a turbine or compressor—dictates the viscosity. 

### ABOUT THE AUTHOR:

William P. Crosher is former director of the National Conference on Power Transmission, as well as former chairman of the AGMA’s Marketing Council and Enclosed Drive Committee. He was resident engineer-North America for Thyssen Gear Works, and later at Flender Graffenstaden. He is author of the book *Design and Application of the Worm Gear*.