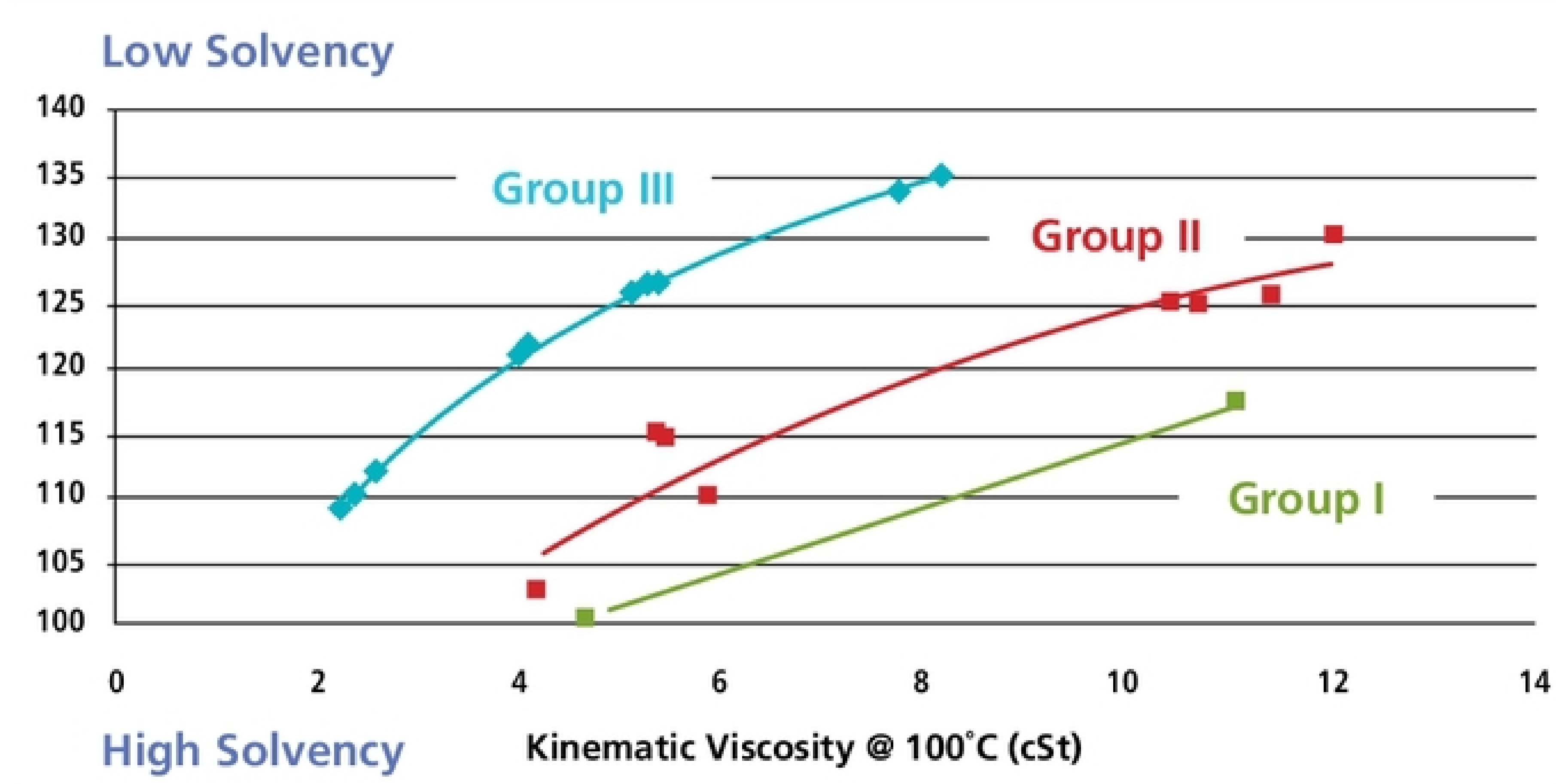
How Solvency Impacts Lube Performance

Solvency — Aniline Point vs. Kinematic Viscosity



Source: Wedlock, D. J., presentation at the 16th ICIS World Base Oils & Lubricants Conference, February 2012

People in the lubricants industry often talk about base oil solvency. But why is it such an important aspect of lubricant performance?

Solvency affects many aspects of base oil performance, including suitability as a process oil, lubricant/fuel interactions, deposit control in engines, thickener requirements in grease formulations and seal swell among others. It is also often cited as a technical benefit for naphthenic base stocks relative to paraffinic stocks.

Solvency is the ability of a base oil to solvate; that is, to surround or dissolve another chemical species at the molecular level. That species may be an additive component or a contaminant such as water or a lacquer precursor.

To quantify base oil solvency, the concept of the aniline point was developed as the ASTM D-611 method series. Simply stated, the test measures the temperature at which a base stock (nonpolar) and aniline (polar) become a single phase fluid rather than remain in their normal two phases, where the base stock usually sits on top of the aniline.

Higher temperatures are required to drive the two phases together in conventional solutions. Therefore, the lower the temperature that produces the single phase, the higher the solvency of the base stock for the aniline. The assumption is that this solvency parameter for aniline correlates with all other polar species dissolving in the base stock.

The solvency of a finished lubricant is dominated by base oil solvency characteristics by weight of numbers. If a hydrocarbon base oil limits the solvency of a finished lubricant, this effect can be modified by using solvency boosters such as esters or synthetic aromatic base stocks that have significantly higher solvency power. However, any modifications to the overall solvency power of a finished lubricant should be undertaken with extreme caution, since significant changes can alter, for example, the integrity of antiwear layers in an engine or powertrain.

Crankcase lubricants are faced with accumulated fuel residues, mainly as blow-by from unburned fuel, particularly in cold engines, causing fuel dilution of the lubricant. In an ideal world, this would be a temporary phenomenon where all the fuel would evaporate from the lubricant as the engine reached normal operating temperatures. That is true by and large, but trace contaminants remaining from even minimal fuel dilution can cause significant solvency effects.

Gasoline fuel tends to have substantial aromatic content to produce the

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required octane rating. As a result, the very polar polycyclic aromatics from the fuel fraction often accumulate in the base oil after fuel dilution because the solvency power of more polar base stocks, particularly API Group I, resist the evaporative effects of high operating temperatures. The polycyclic aromatics can contribute to health and safety issues of used gasoline engine lubricants.

In diesel engines, which are faced with increasing levels of esters from various biodiesel fuels, lack of volatility of an ester fraction can lead to buildup in the lubricant and possible gelation. The higher the solvency of the base oil, the higher that buildup is likely to be.

Both gasoline and diesel engine lubricants will broadly benefit from the lower solvency of Group II and Group III base oils relative to Group I base stocks. Grade-for-grade, the aniline point follows the order Group I < Group II < Group III. But it's not all bad news for Group I base stocks because deposit control can be moderated through base oil solvency. And in some heavy duty diesel engine cleanliness tests, Group I stocks boosted piston cleanliness through the solvency effect.

Also, in large slow-speed two-stroke marine diesel engines, it has long been known that a key requirement of cylinder oil was the ability to handle asphaltenes derived from the residual fuels used. This largely favors Group I base stocks through solvency dissolution of asphaltenes, providing a dual benefit in this sector where only Group I base stocks routinely contain the high-solvency bright stock component needed to blend the heavy monogrades still favored by most marine engine original equipment manufacturers.

Solvency is also critical for additives, which are usually marketed either as individual components or as preformulated packages, usually in a diluent base oil. Commonly, low base oil viscosity grades are used as diluents. This is not only because the formulator does not want to influence final finished lubricant viscosity too much, but also because a low viscosity grade has significantly higher solvency for the additive.

This applies irrespective of the base oil API Group. It is simply that smaller, low-viscosity grade base oil molecules are more similar in size to the molecules we understand as conventional industrial solvents. Solvency for additives is critical considering that some additive concentrates approach 50 percent active matter.

So, when using the term solvency, you need to know that it can work for you and against you. But it is critical nonetheless! □