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LUBRICANT BASE STOCKS

The base stocks used to formulate lubricants are normally of mineral (petroleum) or synthetic origin, although vegetable oils may be used for specialized applications. Synthetics can be made from petroleum or vegetable oil feedstocks and are "tailor made" for the job they are expected to do.

RELATIONSHIP OF ADDITIVES AND BASE STOCKS

Lubricant base stocks influence additive performance through two main functions: solubility and response. For example, performance of surface active additives such as anti-wear (AV) or extreme pressure (EP) depends largely on their ability to adsorb on the machine surface at the proper time and place. Base stocks with poor solubility characteristics may allow these additives to separate before they can fulfill their intended functions. Conversely, base stocks with very high-solubility characteristics may keep the additives in solution, not allowing them to adsorb.

Additive response depends on base stock composition. Natural sulfur, nitrogen, and phenolic inhibitors are removed along with undesirable materials during base stock refining. Removal of these natural inhibitors often results in reduced oxidation inhibition relative to unrefined oil base stocks. However, the natural inhibitors, as well as the undesirable materials removed during base stock refining, often interfere with additive performance.

Synthetic base oils, depending on their chemical structure, exhibit very specific additive solubility that is different from mineral oils. The most common synthetic base oils are synthetic hydrocarbons, such as polyalphaolefins (PAO), and esters.

Synthetic hydrocarbons can exhibit excellent additive response (or performance), but because they have relatively poor additive solubility (or in other words, they have a tough time holding onto the additives) it's not unusual for synthetic lubricants to not be able to achieve the significant extended oil drains achieved with the LE line of mineral oil base products. Esters vary in additive response and are excellent solvents except for additives that they react with to form undesirable precipitates. Some synthetic oils can be blended with each other or with mineral oil to provide the optimum balance of additive solubility and additive response. In fact, one of the primary reasons you see synthetic and mineral oil "blends" is because the additives are attached to the mineral oil structure, then, when blended with the synthetic oil, are more soluble and hence dispersed throughout the blended oil system.

Because of the ways additives react with different base oils, there is good reason to formulate for specific (or certain) applications by using different types of base oils. Engine oils require different base oils than refrigeration oil products. Even within the engine oils, for example, different base oil types work better for gasoline than for heavy-duty diesel applications.

MINERAL OILS

Mineral stocks are refined by a number of processes of selection from the crude oil barrel. For this reason, the choice of crude is important. Most favored are paraffinic crudes, which give a good yield of high-VI (HV1) stocks, although they also contain a lot of wax. For certain applications, naphthenie crudes are preferred because they yield high-quality medium-VI (MVI) and low-VI (LVI) stocks with very little wax and naturally low pour points.

Distillation under atmospheric pressure removes the gases (propane, butane, etc.), gasoline fraction, and distillate fuel components, leaving a "lube oil fraction" containing the lube oil and asphalt. Further distillation under vacuum yields "neutral distillates" overhead and an asphalt residue. Simple treatment with sulfuric acid, lime and clay turns the distillates into acceptable LVI stocks. For HVI and MVI stocks, some form of solvent extraction is necessary to remove colored, unstable and low-VI components. Finally, wax is removed by dissolving the oil in methylethyl ketone (MEK) then chilling and filtering to yield oils with pour points in the -4° to 14°F (-10 to -20°C) range. At the refiner's option, the oils may be "finished" with hydrogen to remove sulfur, nitrogen and color bodies. This is called hydro finishing.

The viscosity of the finished stocks is determined by carbon chain length and the boiling range of the components. Most refiners settle for three or four stocks from which they blend their range of finished oils.

For solvent extracted HVI oils, VI in the range of 90 to 100 is usual. An alternative refining process, which substitutes deep hydrogen treatment for solvent extraction can yield VIs of over 100. An additional advantage of this approach is that such processes can increase the yield of HVI components from almost any crude. Instead of unwanted LVI components being extracted, they are chemically changed into HVI materials, usually of lower molecular weight. This enables the blender to increase the output of light oils (for instance, for blending SW-30 oils) for which there is a growing market. This also allows for the use of lower quality crudes as feed stock.

VHVI BASE STOCKS

Very High Viscosity Index (VHVI) base stocks are the result of a two stage hydro-treating refining process. These oils are also called Unconventional Base Oils (UCBO) by some base oil refiners, but this is purely a marketing term.

Two stage hydro-treating is a process whereby the feedstock is treated with hydrogen under high pressure of approximately 3000 psi and temperature at approximately 750°F (400°C) in the presence of a catalyst. This extreme process removes sulfur, nitrogen, and oxygen impurities, and converts aromatic hydrocarbons into saturated paraffinic compounds. This material is further processed by hydro-dewaxing to improve low temperature fluidity. After processing through the first stage of hydro-treating, the base oil is stabilized by the second stage of the hydro-treating process called hydro-finishing. The resulting base oil is a very pure colorless oil with a stable molecular structure.

VHVI base oils are still mineral oil based, but have unusually high viscosity index characteristics. Their viscosity index (VI) may range from 110 to 130. These two stage hydro-treated base stocks also have very low oil volatility which gives them desirable characteristics for certain applications such as gasoline engine oils which are requiring reductions in oil volatility and better oil oxidation resistance.

The two stage hydro-treating refining process can be used to produce base oils of different quality levels due to its flexibility. The API has categorized base oils by their sulfur content, level of saturates, and Viscosity Index (VI). The table below defines these categories. API Group II and Group III base oils can both be derived from the hydro-treating process. The VHVI Group III base oils from the two stage hydro-treating process are similar to PAO synthetics in terms of viscosity, oxidation resistance and low temperature performance. Just like synthetics, the two stage hydro-treated base oils can have some drawbacks in terms of additive solubility, lack of natural oxidation inhibition and response of additives. These drawbacks require formulators to have a great deal of experience with these types of base oils in order to overcome the possible problems that could arise from the use of these two

API BASE OIL CATEGORIES

	%		%	
CATEGORY	**SULFUR**		**SATURATES**	**VI**
GROUP I	>0.03	And/or	<90	80-120
GROUP II	<=0.03	And	>=90	80-120
GROUP III	<=0.03	And	>=90	>=120_
GROUP N	All polyalphaolefins			
GROUP V	All others not included above			

SYNTHETIC BASE STOCKS

Synthetic processes enable molecules to be built from simpler substances to give the precise or desired oil properties required. The main classes of synthetic material used to blend lubricants include:

Type	**Principle Applications**
Olefin Oligomers (PAOs)	Automotive and Industrial
Dibasic Acid Esters	Aircraft and Automotive
Polyol Esters	Aircraft and Automotive
Alkylated Aromatics	Automotive and Industrial
Polyalkylene Glycols	Industrial
Phosphate Esters	Industrial

With the exception of polyalkylene glycol fluids and some diesters, the above listed synthetics have viscosities in the range of the lighter HVI Neutral mineral oils. Their viscosity indexes (VIs) and flash points, however, are higher and their pour points are considerably lower. This makes them valuable blending components when compounding oils for extreme service at both high and low temperatures.

The main disadvantage of synthetics is that they are inherently more expensive than mineral oils, and are in limited supply. Esters suffer the further disadvantage of greater seal-swelling tendencies than hydrocarbons; so, caution must be exercised in using them in applications where they may contact elastomers designed for use only with mineral oils.

Polyalphaoletins are the most widely used synthetic lubricants in the U.S. and Europe. They are made by combining two or more decene molecules into an oligomer, or short-chain-length polymer. PAOs are all-hydrocarbon structures, and they contain no sulfur, phosphorus or metals. Because they are wax-free, they have low pour points, usually below -40°F (-40°C). Viscosity grades range from 2 to 100 cSt, and viscosity indexes for all but the lowest grades exceed 140.

PAOs have good thermal stability, but they require suitable antioxidant additives to resist oxidation. The fluids also have limited ability to dissolve some additives and retain them in the finished oil product, plus they tend to shrink seals. Both problems can be overcome by adding a small amount of ester base stock.

Dibasic acid esters are synthesized by reacting an acid and an alcohol. Diesters have more varied structures than PAOs, but like PAOs, they contain no sulfur, phosphorus, metals or wax. Pour points range from -58 to -85°F (-50 to -65°C). They are low to medium VI fluids.

Advantages of diesters include good thermal stability and excellent solvency. They are clean-running in that they tend to dissolve varnish and sludge rather than leave deposits. In fact, diesters can remove deposits formed by other lubricants.

Proper additive selection is critical to prevent hydrolysis and provide oxidative stability. In addition, special chemically resistant seals are recommended.

Polyol esters, like diesters, are formed by the reaction of an acid and an alcohol. "Polyol" refers to a molecule with two alcohol functions in its structure; examples include trimethylolpropane (TMP), neopentylglycol (NPG), and pentaerythritol (PE).

Polyol esters contain no sulfur, phosphorus or wax. Pour points range from -22 to -94°F (-30 to -70°C) and viscosity indexes from 120 to 160. The fluids have excellent thermal stability and resist hydrolysis somewhat better than diesters. With the proper additives, polyol esters are more oxidatively stable than diesters and PAOs. Seal-swell behavior is similar to that of diesters.

Alkylated aromatics are formed by the reaction of olefins or alkyl halides with an aromatic material such as benzene. The fluids have good low-temperature properties and good additive solubility. Viscosity index is about SO for fluids with linear molecules and zero or lower for fluids with branched side chains. Thermal stability is similar to that of PAO, and additives are required to provide oxidative stability.

Polyalkylene glycols (PAGs) are polymers of alkylene oxides. Lubricant performance and properties of a particular PAG depend on the monomers used to manufacture it, molecular weight, and the nature of the terminal groups. Thus, a wide range of properties are possible. Some PAGs are water soluble. Also PAGs are not compatible with mineral oil.

In general, PAGs have good high-temperature stability and high viscosity indexes, and they can be used over a wide temperature range. They exhibit low deposit formation and tend to solubilize their decomposition product. Like other synthetics, PAGs require additives to resist oxidation.

Phosphate esters are synthesized from phosphorus oxychloride and alcohols and phenols. They are used both as base oils and as antiwear additives in mineral and synthetic lubricants. Thermal stability is good, and pour point ranges from -13 to 23°F (-25 to -5°C). However, viscosity index is extremely low, ranging from 0 to -30, which limits their high-temperature capabilities.

SUMMARY

Lubrication Engineers ®, Inc. formulates its broad line of industrial and automotive lubricants using all types of base oils. These include solvent extracted hydro-finished and two stage hydro-treated mineral oil base stocks and many synthetic base stocks.

Lubrication Engineers, Inc., unlike many major oil companies, has no direct ties to a refinery. Major oil companies who are also in the refining industry are frequently driven to formulate their products based on the output of their refinery. With this approach, the quality of the finished product can be compromised because of the best base stock for the product may not be produced by the corporate owned refinery. Lubrication Engineers is free to choose the best base stock from any production source.

Our years of blending experience have taught us that certain products provide better additive response, lubrication and wear protection when formulated with specific base stocks. The success of our MULTILEC® line and high temperature grease products, as well as our automatic transmission fluid and new SW-30 passenger car motor oil (PCMO), is an indication of our formulating expertise with two stage hydro-treated base stocks.

We have learned to over-come problems, from years of research and development with many types of base stocks. This gives us an advantage and continues to make LE the "Leaders in Lubricants" when it comes to formulating high quality, high performance industrial and automotive lubricants. We recognize the importance of formulating lubricant products that, by design, retain or hold onto their additives so that extended oil drains and grease relubrication frequencies are consistently achieved. We've demonstrated in laboratory tests and field performance that additives play a significant role in enhancing base oil performance. LE utilizes its ISO 9001 Certified Quality System to develop consistent R&D and manufacturing methodologies that produce lubricants that are unsurpassed in quality and performance, and that deliver cost savings and performance to the user; benefits that are simply unattainable by any other petroleum or synthetic lubricants available anywhere.

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