Understanding Basestocks

HELPING YOU TO CHOOSE THE CORRECT LUBRICANT
Basestocks are broken into FIVE categories of materials with varying degrees of quality and performance characteristics.
Group I (G-1)

Group I oils are manufactured by the solvent-extraction refining technique, which separates oil molecules by size and uses solvents to wash out harmful constituents (some wax, some aromatic species) found in raw crude petroleum.

G-I base oils comprise three primary molecule types (paraffinic, naphthenic and aromatic); a variety of sulfur- and nitrogen-based compounds; a large amount of unsaturated molecules, aromatics and polar compounds. They may contain appreciable sulfur and are responsible for accelerating aging and degradation of finished lubricants.
Some aromatic compounds and sulfur-containing materials behave as natural antioxidants in the absence of specific oxidation-inhibiting agents (additives). But, these can interfere with the function of the primary antioxidants (amines and phenols) added to interrupt the oxidation-reaction processes. Sulfur compounds and aromatic molecule structures are unstable, therefore they tend to react rapidly with oxygen to form various soluble and insoluble oxidation degradation byproducts.

Hydrotreating, a process added in the 1950s, is where hydrogen is added to the basestock at high temperatures and in the presence of a catalyst in order to stabilize the reactive components, improve the color and extend the useful life of the finished lubricant product. This step helped improve product quality but not enough to fully neutralize the aromatic components in the finished products.
Group II (G-II)

Group II base oils follow a processing path similar to G-I products, except that instead of using solvents to extract the problematic compounds, G-II oils are “hydrocracked.”

Hydrocracking techniques, borrowed from fuel-refining processes, are a more severe hydrogen processing method wherein hydrogen is added to the base oil feed at much higher temperatures and pressures than with conventional hydrotreating.

The hydrogen catalytically reacts with the basestock, restructures the naphthenic and aromatic molecules and eliminates sulfur and nitrogen components. This is accomplished through a series of molecular rearrangements (formation of paraffin isomers, breaking of long chain molecules and ring structures).
Group III (G-III)

G-III base oils follow the same hydrogen processing path as the G-II oils. However, they are more severely treated (higher pressure, higher temperature, longer process times).

G-III oils perform on par with, and in some cases superior to, some synthetic Group IV (polyalphaolefin) types.

Prices are higher than G-I or G-II. In fact, the resulting finished lubricants purchase prices range from 3 to 10 times that of G-I or G-II.
Group IV (G-IV)

G-IV base oil stocks are man-made.

This category is reserved for a single type of basestock called polyalphaolefin (also known as PAO and synthetic hydrocarbon).

PAOs are made from ethylene (derived from petroleum) but are not hydrocarbons in the naturally occurring sense.

Prices are higher than G-I or G-II. In fact, the resulting finished lubricants purchase prices range from 3 to 10 times that of G-I or G-II.
Group V (G-V)

G-V base oil stocks are man-made. These base oils are made using a wide variety of hydrocarbon and nonhydrocarbon raw materials. Prices are higher than G-I or G-II. In fact, the resulting finished lubricants purchase prices range from 3 to 10 times that of G-I or G-II.
Basestock key properties to consider:

- Compatibility – degree to which the basestock mixes with other hydrocarbons.
- Additive response – characteristics determining how the base oil and additives work together.
- Viscometrics – measures of viscosity, viscosity index and pour point.
- Safety – flash point and toxicity.
- Consistency – repeatability from batch to batch.
- Oxidation stability – influenced by raw material properties and response to antioxidants.
- Volatility – flash point and NOACK volatility (engine oils in particular).
- Appearance – color, cleanliness and clarity.

(According to the type of machine to be lubricated and how the basestock supports the needs of the machine’s components.)
Additive Types and Functions

Individual additives impart chemical or physical reactions that create three different types of responses. An individual lubricant additive may:

• Enhance existing favorable base oil properties (viscosity, pour point, water release).
• Suppress existing unfavorable base oil properties (oxidation and corrosion control).
• Impart properties to the lubricant that the base oil cannot provide (EP, AW performance).
Lubricant manufacturers use a variety of additives to support the basestock or add new properties. There are a few standardized recipes that lubricant manufacturers might use to create the common lubricant types:

- AW (antiwear)
- EP (extreme pressure)
- R&O (rust and oxidation inhibited)

For this reason, it is always best to avoid mixing different brands of lubricants, even within a particular viscosity grade and additive type.
### Specific additive properties:

- **Viscosity modifiers (VI improvers for high temperatures; pour point depressants for low temperatures)**
- **Wear resistance additives (EP and AW)**
- **Oxidation inhibitors**
- **Demulsifiers**
- **Foam inhibitors**
Viscosity modifiers help change the viscosity behavior of the lubricant across a temperature range. All base oils thin as the temperature rises. Viscosity modifiers help to slow the thinning process so it becomes possible to use a lighter grade of oil for a cold-start requirement and still have sufficient oil thickness at normal operating temperature to protect the machine surfaces. The indicator for use of a viscosity modifier is the label’s ‘W’ designation. A 80W90 gear oil is one designed to behave like 80-weight gear oil during cold start-up and perform like 90-weight oil once the machine has reached its normal operating temperature.

Pour point depressants help a lubricant stay fluid to lower temperatures than would otherwise be possible. Some lubricant base oils, particularly synthetics, remain fluid to extremely low temperatures (-40 F) and do not require any help in this area. Most petroleum base lubricants are either paraffinic or contain sufficient paraffin stocks and have a waxy component that causes the lubricant to solidify at low temperatures. The higher the viscosity grade, the higher the temperature at which the lubricant will solidify. Pour point depressants prevent the waxy component (paraffin wax) from crystallizing which, in turn, lowers the point at which the lubricant solidifies.
Wear resistance ... the difference is the way in which the two vary in function and the amount of protection each offers.

ANTI-WEAR ADDITIVES

• Intended to prevent ongoing wear due to light-to-moderate metal contact.
• Form resilient films on metal surfaces. (Think about the layer of tarnish that forms on silver eating utensils.)
• Often include zinc phosphorous chemicals that absorb onto the metal surface to create an organo-metallic oxide layer. The tarnish-like layer is easily rubbed off when the opposing metallic surfaces interact. The malleable oxide layer reforms and rubs away continuously, at low operating component temperatures, leaving the machine component’s metal surface intact.
• AW additives afford only mild wear protection.

EXTREME PRESSURE ADDITIVES

• Intended to prevent seizure of surfaces due to severe metal contact.
• Chemically react with a metallic surface after a destructive scoring or adhesive contact event, which produces spike temperatures.
• Go to work at the localized hot surface. The EP agent, typically a sulphur-phosphorous compound, chemically reacts with the hot area forming a softer organo-metallic oxide layer that is more forgiving than the underlying metal layer.
• Once the additives bond, they are removed, after another adhesive or abrasive event scours away the organo-metallic film and underlying metal surface.
Oxidation Inhibitors

These are provided to extend lubricant life cycles and reduce the formation of oxidation reaction byproducts in the sump. The primary driver for determining the type and amount of oxidation inhibitors is the base oil quality and type.

High operating temperatures, high moisture and air concentrations and the catalytic effects of wear metals all increase the need for oxidation inhibitors.

The greater the additive treatment, the more complex the additive balance and the greater need for oxidation inhibitors.
Demulsifiers

These help the lubricant release moisture, which is important when the equipment is operating in very humid climates or in a plant atmosphere that is wet or humid. For example, paper mills, steel mills and food-processing operations have significant exposure to water-based process fluids.

Although oil is hydrophobic, it still retains a certain amount of water from the atmosphere. Even at low levels moisture is particularly harmful to lubricated components and increases wear from cavitation, adhesion and abrasion.

In addition, when mixed with heat and wear metals, moisture rapidly accelerates the rate of oxidation. Moisture control is one of several critical contamination control parameters.
Foam Inhibitors

These help prevent accumulation of air (formation of a foam layer) in the oil sump. Air contains oxygen, which is a primary cause of oxidation.

Foaming increases the extent of air-to-oil surface contact and increases oxidation. Low viscosities do not require foam-release agents. Medium to heavy grade oils (ISO 150 and higher) tend to retain air and benefit from foam inhibitors.

Foam inhibitors are one of the few additives that can be replaced if/when they are stripped from the lubricant through filtration or normal use.
Sources cited
