BASE OILS

The base oils used to formulate lubricants are normally of petroleum or synthetic origin, though even vegetable oils may be used for specialized applications.

Mineral derived base oils constitute almost 90% of the total production, and hence we will focus more on this category of base stocks.

1. Mineral Base Oils Are Hydrocarbons Derived From Crude Oil
2. They Vary in Many Key Properties Depending on Crude Source and Processing
3. They Comprise the Bulk (75-99.5%) of Most Lubricants.
4. Need Additives to Modify Properties to Become Effective Lubricants
5. Its quality is most critical for final product.
6. It is the result of a series of separation processes that remove undesirable components.
MANUFACTURING PROCESS (MINERAL STOCKS)

The overall process of manufacture of base oil from crude oil is depicted below.

A brief description of each of these processes is given in the following.
1. Atmospheric Distillation
   i) Various fuel components.
   ii) Long Residue' is left that contains lube oil and asphalt.

2. Vacuum Distillation
   i) Vacuum must, otherwise the atmospheric residue decomposes at 370°C.
   ii) Fractions of increasing boiling range, molecular weight, and viscosity.
   iii) Typical boiling range 300 - 500°C.
   iv) Average molecular weight range 225 – 700.

3. De-asphalting
   i) Paraffins, Naphthenes & Aromatics preferentially dissolved.
   ii) This contains ‘Bright Stock’.
   iii) Asphaltenes taken off from bottom.

4. Solvent Extraction
   i) Solvent selectively removes aromatic compounds by preferential solubility.
   ii) Aromatic extracts used in Chemical & rubber process area.
   iii) Raffinates are ‘Solvent Neutral’ oils.
   iv) Improves Viscosity - Temperature characteristics.
5. Dewaxing
   
   i) Chilling the oil with dewaxing solvent to cause the wax to crystallize.
   
   ii) Then, separation of solid from the liquid by filtration and / or centrifuging.
   
   iii) Improves fluidity at low temperatures.

6. Hydrofinishing
   
   i) Catalytic reaction of hydrogen with oil molecules.
   
   ii) Mild Hydro treating at approx 300°C and 500 psig.
   
   iii) Removes chemically bound sulphur, oxygen & nitrogen.
   
   iv) ‘Severe hydro treating’ at 325°C & 1500 psig.
   
   v) Saturates even aromatic molecules and polar compounds. But, cracking can be a problem.
SYNTHETIC BASE STOCKS & TYPES

Synthetic base oils are made from petroleum or vegetable oil feedstock, and are mostly customized for the end application they are expected to work in. The examples of such base oils include:

1. Polyalphaolefins or PAOs
2. Dibasic Acid Esters
3. Polyol Esters
4. Alkylated Aromatics
5. Polyalkylene Glycols or PAGs
6. Phosphate Esters

BASE OIL CLASSIFICATION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
<th>Group IV</th>
<th>Group V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturates</td>
<td>&lt; 90%</td>
<td>&gt; 90%</td>
<td>&gt; 90%</td>
<td></td>
<td>All base stocks not in Group I, II, III, IV</td>
</tr>
<tr>
<td></td>
<td>and / or</td>
<td>and</td>
<td>and</td>
<td>PAOs</td>
<td></td>
</tr>
<tr>
<td>Sulphur</td>
<td>&gt; 0.03%</td>
<td>≤ 0.03%</td>
<td>≤ 0.03%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and</td>
<td>and</td>
<td>and</td>
<td></td>
<td>Chemical Reactions</td>
</tr>
<tr>
<td>VI</td>
<td>≥ 80 &lt; 120</td>
<td>≥ 80 &lt; 120</td>
<td>&gt; 120</td>
<td>Other synthetics, esters &amp; napthenes (VI &lt; 80)</td>
<td></td>
</tr>
<tr>
<td>Remarks</td>
<td>Most solvent extracted and de-waxed HVI base stocks</td>
<td>Most severely hydroprocessed HVI base stocks</td>
<td>VHVI, Hydro-processing + Catalytic Isomerisation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks:
- Most solvent extracted and de-waxed HVI base stocks
- Most severely hydroprocessed HVI base stocks
- VHVI, Hydro-processing + Catalytic Isomerisation
- Chemical Reactions
- Other synthetics, esters & napthenes (VI < 80)
TYPICAL PROPERTIES OF BASE OILS – API Grouping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
<th>Group IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturates, %</td>
<td>65 – 85</td>
<td>93 – 99</td>
<td>95 – 99</td>
<td>99+</td>
</tr>
<tr>
<td>Aromatics, %</td>
<td>15 – 35</td>
<td>&lt; 1 – 7</td>
<td>&lt; 1 – 5</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Sulphur, ppm</td>
<td>300 – 3000</td>
<td>5 – 300</td>
<td>0 – 30</td>
<td>-</td>
</tr>
<tr>
<td>VI</td>
<td>85 – 105</td>
<td>95 – 118</td>
<td>123 – 150</td>
<td>125 – 150</td>
</tr>
<tr>
<td>Viscosity @ 100 °C, cSt</td>
<td>4 – 42</td>
<td>4 – 12</td>
<td>4 – 8</td>
<td>4 – 70</td>
</tr>
<tr>
<td>Point Point, °C</td>
<td>-15</td>
<td>-15</td>
<td>-15</td>
<td>-45</td>
</tr>
</tbody>
</table>

EXAMPLES OF TYPICAL BASE OILS

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>KV</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVI SPINDLE</td>
<td>10 – 12 cSt, at 40 °C</td>
<td>95 Min.</td>
</tr>
<tr>
<td>150 SN</td>
<td>27 – 32 cSt, at 40 °C</td>
<td>95 Min.</td>
</tr>
<tr>
<td>500 SN</td>
<td>9 – 11 cSt, at 100 °C</td>
<td>95 Min.</td>
</tr>
<tr>
<td>150 BS</td>
<td>30 – 33 cSt, at 100 °C</td>
<td>95 Min.</td>
</tr>
</tbody>
</table>

GROUP II HYDROCRACKED BASE STOCKS VIS-À-VIS GROUP I BASE OILS

1. **Oxidation Stability** - Longer Oil Life
2. **Low Temperature Performance** - Better Pumping
3. **Soot Dispersancy** - Less Oil Thickening, Engine Wear, and Filter Plugging
4. **Volatility** - Lower Oil Consumption
5. **Greater Purity** - Less for the Additive Package to ‘Clean Up After’
6. **Other Benefits**
   
   i) **Viscosity Index** - High VI Reduces VI Improver Requirement (Multigrades)
   
   ii) **Color** - ‘Water White’ appearance makes for light colored, consumer friendly lubricant