Motor Oil Base Stocks and Additives

Motor oil is composed of base stocks and additives. The base stocks are either petroleum or synthetic and the additives are chemicals designed to satisfy the functions listed above, depending on engine type and duty.

Base Stocks

Base stocks are derived from two sources: petroleum (crude oil) and synthetics. Within these sources there are several levels of quality. The old saying oil is oil is simply not true and potentially misleading. All oils are classified into groups with the lowest quality oils forming Group I and the highest quality forming Group VI (Group VI oil is not used in automobiles). The amount of refining (purification) and the Viscosity Index determines where the oil falls on the scale. Presently almost all petroleum oils are being made from Group II oils. This is a significant change since, not so very long ago, most petros were Group I. Some petroleum oils are made from partially hydrocracked Group II oils. Synthetic motor oils come from Group III, IV and V oils. In a later edition of Lube Notes, I will go into greater detail on the specific differences between the various groups of base oils. For now, I just want you to know that there are levels of quality in base stocks.
After a base stock is chosen, then additives (chemicals) are selected to provide
Anti-wear, anti-foam, anti-oxidation detergency and dispersancy characteristics and to neutralize acid, prevent corrosion and maintain viscosity. To understand motor oil, it is necessary to take a closer look at base stock properties and these additives and how they relate to the vital functions of motor oil.

Viscosity

Viscosity refers to the resistance-to-flow of the oil and is the most critical property of lubricating oil. Viscosity varies with temperature, being greater at colder temperatures and less at warmer temperatures; in other words, it is thicker when cold and thinner when hot. If motor oils are too viscous (thick) at engine start they make starting the engine more difficult. This is especially true of diesels. Conversely, if the oil thins too much at high temperatures, it does not provide adequate wear protection. The measure of oil's change in viscosity with respect to temperature is referred to as Viscosity Index (VI). The higher the VI rating, the more stable oil's viscosity is with regard to changes in temperature, which means oil will thicken less at colder temperatures and will thin less at hotter temperatures. Additives, referred to as VI Improvers are used to increase the VI, making the oil less reactive to temperature changes. Petroleum oils require significantly more VI Improvers than synthetic oils because synthetics inherently possess a higher VI.

Cold Temperature Performance

The viscosity of oil must not be so high at cold temperatures that it inhibits starting or fails to flow to the critical lubricating points in the engine.
Pour Point, a term helpful in determining oil's ability to avoid these occurrences, is defined as the lowest temperature at which a fluid will flow. Petroleum oils naturally contain waxes that crystallize at low temperatures causing the oil to rapidly thicken and lose its ability to flow. Pour Point Depressants are chemicals that prevent wax crystals from joining together and thickening the oil. These chemicals are added to all petroleum oils with winter ratings, which are signified by a "W" as in 10W-30. Synthetic oils are wax free with very low pour points and so do not require pour point depressants.

Heat Removal

Motor oil removes approximately 40% of the engine heat. The radiator system removes 60% but the entire lower portion of the engine is cooled only by oil. Engine lubrication could easily be accomplished with much less oil in the crankcase but additional volume is necessary to provide oil flow for heat removal.

Wear Protection

A principal function of lubricating oil is to prevent wear. Referring back to the lubricating regimes discussed in Issue One of maxx TORQUE, boundary lubrication is the challenge in the internal combustion engine. Anti-wear additives are designed to bond to the surfaces of the metal to protect the surfaces when the lubricating film of oil cannot maintain separation of the moving surfaces. Made usually from zinc and phosphorus compounds, these anti-wear additives act as soft, solid lubricants that prevent steel-to-steel contact. Anti-wear additives create a protective film on the moving parts and are critical for protection during start up and during heavy loads.

Oxidation

Oxygen is an extremely chemically reactive element and when it reacts with oil it produces sludge and varnish deposits and causes oil thickening. When oil operates at elevated temperatures, oxidation is accelerated. Compounds formed by the by-products of combustion and oxidized oil form acids that contribute to rust and corrosion. This corrosion process is more critical in diesel engines than gasoline. Oxidation Inhibitors are added to oil to reduce oxidation. Petroleum oils react highly with oxygen, whereas synthetics are nearly inert, and react very little with oxygen.

Total Base Number

Total Base Number (TBN) refers to an oil's ability to neutralize acid. TBN is measured on a scale of one to 13: the higher the number the greater the capacity to neutralize acids. A high TBN is required for extended drain interval oils and most diesel oils should have a TBN between eight and 12.

Detergents

The combustion process by-products form sludge and varnish deposits in the engine. Deposits can cause hot spots in the engine, affecting its performance and fuel economy. Detergents are added to aid in removing these deposits.

Dispersants

Combustion by-products, such as carbon, are maintained in solution by dispersants, reducing deposits. Dispersants are designed to keep the by-products in the oil until the filtration system can remove them. Dispersants and Detergents work hand in hand to keep the engine clean.

Anti-Foam

Imagine a blender whipping your motor oil and you will get a pretty good picture of how the oil is whipped by the rapidly moving parts in the engine. As the oil is whipped, it traps air. The resulting foam has very poor lubricating properties. Chemical additives such as silicone are added in near trace amounts to reduce foaming. The effect of these anti-foaming additives is to weaken the air bubbles, allowing them to collapse more quickly, thus reducing the amount of foaming that occurs.

Seal Swell

Seals come in various sizes, shapes and materials. It is necessary for motor oils to not only be compatible with the materials, but to nourish the seals. Seals should not degrade, dissolve, crack or shrink. As an additional benefit, some, but certainly not all, oils even cause a little swelling of the seal.

Motor oil is certainly more than just refined crude in a bottle; it is a marvelous product that is the result of years of research and millions of hours of use. Motor oils have improved constantly from the days of whale oil and

animal fats so that today’s oils accomplish multiple tasks and not merely lubrication. In my next edition of Lube Notes, I will look at API and SAE classifications.