LIMITING FACTORS ON A DIESEL ENGINE'S OIL LIFE

Mid-Continent Testing Laboratories, Inc.
PO Box 3388, Rapid City, SD 57709
(605) 348-0111

With today's lubricants, special filters, and oil analysis, it is possible to extend the oil change interval on many diesel engines. Oil analysis gives the facts needed to know exactly when the oil needs changing. However, even with these improvements there are still factors that will limit the maximum oil drain interval. These factors are:

1) % SOLIDS
2) SULFUR ACIDS
3) OXIDIZED OIL
4) SOOT
5) VISCOSITY CHANGE
6) ENGINE PROBLEMS

The factor that reaches its maximum limit first is called the limiting factor. The oil will have to be changed at that time no matter how good the other factors appear.

Each of the factors is discussed below. The discussion first describes the factor, tells how it takes place in an engine, lists the possible damages to the engine, and then outlines how to prevent this factor from limiting the oil change interval. This is useful information when choosing oil type and filters for your engine. Here are two examples:

1) You can easily determine if a synthetic oil will allow you to extend your oil drain interval. Synthetic oils oxidize very slowly. Therefore, if oxidized oil is your limiting factor a synthetic oil may be useful. However, if the % solids or sulfur acids are the limiting factor, a synthetic oil may not help extend the oil change interval.

2) If the % solids is your limiting factor, then a special filter system may allow you to extend your oil drain interval.

% SOLIDS

The % solids are the total amount of particles that are suspended in the oil. The particles consist of soot, oxidized oil, dirt, and other engine deposits. These solids are in the oil due to the high detergent in today's oils. The detergent surrounds these particles and holds them in the oil. This works much like hand soap. The soap surrounds the dirt and carries the dirt away as the hands are rinsed. In the same manner, the oil's detergent holds the particles until the oil is drained. Along with the detergent, a dispersant is in the oil to keep these particles dispersed throughout the oil until it is changed. The detergent picks up the particles before they are large enough to be filtered by the engine's main filter. (Cut open a main filter and notice that it only removes the "sticks and stones".)

Anyone who says their oil still looks clean when they change the oil is probably not using a good detergent oil. This is similar to washing dishes in the same water all week and bragging about how clean the dishwater looks.

The % solids become a limiting factor in the oil's life when the particles start to interfere with the oil's ability to lubricate. Most engine manufacturers state the solids should not be above 5%, actually, we have noticed improvements in wear reduction if the solids are kept below 2%.

A % solids test is included in most basic oil analysis tests. The values are generally reported as % solids by volume.

A bypass filter may prevent the solids from becoming the limiting factor in the oil's life by filtering many of these small particles.

SULFUR ACIDS

Sulfur acids in the oil are corrosive to engine parts and must not be allowed to reach damaging levels. The most common sulfur acid is sulfuric acid (commonly called battery acid).

Sulfur acids are only in the oil because there is sulfur in the diesel fuel. The amount of sulfur in the fuel can vary. This is because some crude oils are naturally high in sulfur. It is difficult and expensive to remove the sulfur as the diesel fuel is produced from the crude oil, so the sulfur remains in the diesel fuel.

When the fuel is burned in the engine, the sulfur is also burned forming sulfur oxides. Of course, most of these sulfur oxides will go out the exhaust and never harm the engine. However, there will be some sulfur oxides that will get into the engine crankcase with the exhaust blow-by. These sulfur oxides will combine with moisture forming sulfur acids.

The oil companies realize that this acid will be a problem, so they put additives into the oil to neutralize the acid. A "base" (the scientific word for alkali) is added to the oil since a base will combine with an acid to form a neutral substance. The oil will need to be changed before all of the base is used-up leaving any additional acid unneutralized.

There are two ways to measure the sulfur acids: infrared scan and total base number (TBN). The infrared scan gives a value from 0 to 100+ stating the percent of the sulfur acids allowed in the oil. A value of 80 would indicate the oil's life is 80% used-up. A valve of 110 would indicate that the oil was run 10% over the maximum allowed.

The total base number (TBN) refers to the amount of base left in the oil. Most oils will generally have a TBN between 6-10 when new. This number will drop as the base is used up neutralizing the acid. The oil should be changed when the TBN falls below 2 for low TBN oils. For high TBN oils, change the oil when the TBN falls below one-half of the new value.

OXIDIZED OIL

Oil is oxidized when it is exposed to oxygen and the oxygen joins the oil.

This is similar to the way iron oxidizes forming rust. As oil oxidizes, it loses some of its lubricating properties allowing engine parts to wear at a faster rate.

Oxidation is measured with an infrared scan. The values are stated from 0 to 100+ in the same way the values for sulfur are reported. A value of 80 means that the oil's life is 80% used up. While, a value of 110 indicates that the oil was run 10% too long.

If oxidation is the limiting factor on the oil's life, you may have to switch to a synthetic oil to increase the oil drain interval. The main advantage of synthetic oils is that they don't oxidize very fast. However, because oxidation is not usually the oil life's limiting factor, it is not usually necessary to spend the extra money for a synthetic oil.

SOOT

Soot comes from incomplete burning of the fuel. Some soot is always present in an engine's exhaust. Therefore, the blow-by exhaust will carry some soot into the oil. Worn piston rings, lugging, plugged air filter, bad turbo charger, etc. will lead to more soot in the oil. Soot limits the oils ability to lubricate and accelerates engine wear.

Soot is included in the % solids test and can also be measured by an infrared scan. The infrared test for soot gives values from 0-100+ just as the sulfur acid and oxidized oil tests. A value of 80 indicates that the oil has 80% of the maximum soot allowed. While, a value of 110 indicates that the oil has 10% more soot than allowed.

NOTE: This infrared test for soot was developed by Caterpillar and works well for Caterpillar, Cummins, and Detroit Diesel 4 cycle engines. However, Detroit Diesel 2 cycle engines typically have more soot. Therefore, the test values do not correspond well to Detroit Diesel 2 cycle engines.

If soot is the limiting factor in the oil's life, a special filter system may remove the soot. Controlling the soot from forming by cleaning the injectors, adjusting valves, or overhauling the engine may also extend the oil's life.

VISCOSITY CHANGE

Viscosity change is an increase or decrease in the oil's thickness. Multi-weight oils will generally thin out with use, while straight weight oils will generally thicken-up with use (unless effected by fuel dilution, oxidation, or sooting). First, an explanation of why straight weight oils thicken with use will be given, followed by an explanation of what makes multi-weight oils thin with use.

Oil is a petroleum product and petroleum products include anything from gasoline on the light end to tar on the heavy end. Consequently, oil too is made of lighter and heavier parts. During the long exposure to high temperatures in an engine some of the lighter parts will evaporate leaving the heavier parts. This along with oxidation and soot causes the straight weight oil to thicken with use.

Multi-weight oils also have the evaporation of the lighter parts taking place. However, something else is also happening in multi-weight oils that thin the oil. This thinning usually happens faster that the thickening so the net effect is to thin the oil. This thinning is caused by the breakdown of the viscosity improver additive that is used in multi-weight oils. The viscosity improver is a polymer. A polymer is a chain of atoms. When the polymer is cold it coils into a ball. When it is hot the polymer stretches into a long rod. This is why a multi-weight oil has a lower viscosity grade when cold than when hot. (Of course, the oil is still thicker when cold than when hot, because a cold 15 weight is still thicker than a hot 40 weight). Oil thins with use as these polymers are broken forming two short rods instead of the original long rod. This is referred to as "viscosity improver shearing" and is common in most multi-weight oils.

You may notice that some engines will start to use more oil at about 15,000 miles with multi-weight oils. This is due to the thinning of the oil caused by viscosity improver shearing.

To test for viscosity improver shearing the oil must have its viscosity tested at 210 F (100 C). 210 F is the temperature oil is rated at, unless there is a "W" next to the viscosity grade. The "W" indicates the grade is the low temperature grade. (about 0 F) Hence, a 15W - 40 indicates that the oil is a 15 weight a 5 F and a 40 weight at 210 F.

Oil thickening in single weight oils may be reduced by using a synthetic oil. Oil thinning in a multi-weight oil can be reduced by using an oil with a higher-grade viscosity improver polymer.

ENGINE PROBLEMS

Engine problems such as: an anti-freeze leak into the oil, bad air filter allowing dirt to enter the engine, fuel leaking into the oil, water in the oil, or a mechanical failure are all factors that require an oil change along with the necessary repairs.

The primary purpose of an oil analysis program is to spot these types of problems before they become critical to the engine's life. Regularly taking oil samples and keeping accurate maintenance records will keep the severity of these problems to a minimum.