

## **Selection of the Right Motor Oil for the Corvair and other Engines**

**By Richard Widman**

*This is the twentieth draft of this paper. The update is to include calculations for a ZDDP additive that is often used to “improve” the oil. It had been a few years since I made any revisions last November, although there really aren’t too many to make other than updating some of the choices and addressing CK-4 oils. Since this paper is still being downloaded at a rate of 4,000 times a month, I decided to add these comments and sources. I have gone back and reviewed available oils from different brands in the market in November 2019. I’m sure there will be additional questions that will arise or points that I haven’t explained to the satisfaction of some readers. Please send your questions or suggestions to [oil@asboman.com](mailto:oil@asboman.com) and I will answer them in the next draft.*

### **Introduction**

My object in this paper is to explain in common language how to protect your engine through the selection of the correct oil. In this explanation I will be summarizing various SAE Technical Papers with the information pertinent to this discussion. For those that are only interested in the short answer, you can jump to the summary. I will not tell you which brand to buy, but what to look for on the label. I will not repeat word for word what is in the pages of the American Petroleum Institute, but put it in the best layman’s terms I can think of. Some people will say that there are not enough graphs and charts; while others will say it is overkill. I hope to strike a balance.

Many questions have been raised about the wear on flat tappet valve trains and other parts of these engines by the reduction of ZDDP in the newer oils (API SN, SM and CJ-4 or CK-4) and the desire to add commercial additives to increase those levels. Here we will investigate the advantages and disadvantages of these oils and additives.

### **History**

In the 1960’s when the Corvair engines were produced, there was basically only one commercially available type of base oil and very little in the way of classification of oil quality. Through the years the American Petroleum Institute (API) in cooperation with the engine manufacturers, oil companies, and car/truck makers have established norms for base oil classification and additive types, levels and effectiveness.

When the current API classification system was developed it classified the oils of 1960 as “SB” for gasoline and “CC” for Diesel engine oils. The higher quality oils of the time, recommended by the Corvair Maintenance Manual, were classified “API Service MS” or “API Service DG”. The “MS” oils were similar to what is known today as “API SC” up until 1968 when improvements were made. These were later classified as “SD” for gasoline engines. The “DG” oils were similar to what is known today as “API CA” for diesel engines. At some point in time the oil companies came out with an additive containing additional anti-wear ingredients. Some oil companies began to sell oils with these products included and called them “supplement 1” oils or HD oils.

GM was a pioneer in raising the phosphorous level of oils from 200 ppm to 800 ppm for certain high horsepower engines with flat tappets in the 50’s and 60’s. I imagine that their additive was designed to raise the level from 200 ppm to 800 ppm, but I was too young at that time to investigate that.

Thanks to a reader of this paper who sent me a can of oil from the late 60’s, I have now had a sample of MM-MS-DG quality oil analyzed. After the brand name they have the word “plus” on the label, which might indicate it was their premium product. The results show that the Zinc was 517 ppm and there was 482 ppm of phosphorous (slightly more than half the level of today’s SN

oils and less than 30% of the level of a CI-4 oil). It also had 807 ppm of Calcium as a detergent and 124 ppm of barium as a demulsifier (which is contrary to current oil production, since it would cause the moisture in the oil to settle out and cause rust in low places instead of evaporate in hot places. As this mixed with lead from the gasoline, it left a big mess in the oil pan.

The base oils used in those oils were fractionally distilled petroleum products using solvents to extract what they could of impurities and wax (paraffin). Today these base oils are called “API group I”. There were different extraction processes used to filter out or extract the paraffin from the oil, resulting in different wax contents in different oils. There was no classification of these base oils, and some had much higher molecular saturation than others, resulting in less evaporation and deposits, while others had high aromatic content and therefore higher acid formation, evaporation and oxidation. Some had too much wax and obtained a reputation of filling the engine with waxy compounds. In general, the Pennsylvania base stocks had less aromatics and produced better products. Today those oils are divided in two sub-categories within the group I category based on their aromatic content.

### Additive Levels

The basic additive package for motor oils designed to reduce wear (anti-wear) is a combination of zinc and phosphorous that is commonly called ZDDP. This is combined with Calcium or Magnesium for cleanliness and anti-acid. This part of the package is referred to as “Detergent/Dispersant”. These additives are polar. That means that one end of each molecule tries to adhere to the metallic surfaces of the engine to keep it clean or keep it from wearing during periods of contact while the other end is saturated with oil.

*It is important to note that the API does not qualify oils based on additive levels, but on performance.* Performance is determined by base oil and additives. As you will see later, different base oils need different levels of additives for optimum performance. It is the combination of additives and base oil that gives performance and protection. The API Service MS of the late 60’s (known as “SC” or “SD” today) oils had only 800 ppm of detergent and approximately 510 ppm (parts per million) of zinc combined with 480 ppm of phosphorous. A good CI-4 oil in the market today has 1200 to 1400 ppm of zinc and 1000 to 1200 ppm of phosphorous. At that time, little was known about the rate of evaporation of different phosphorous compounds and their effect on the length of time that the oil could provide adequate boundary lubrication.

### Lubrication

To fully understand the effects of the oil in the engine it is necessary to understand the basics of the four types of lubrication:

1. **Hydrodynamic lubrication:** A cushion of liquid oil surrounds the lubricated item and holds it away from the rest of the parts. When the **proper oil viscosity** is used in a properly built engine at **operating velocities**, the crankshaft is in hydrodynamic lubrication. It has no contact with the bearings. The only physical contact is during startup before velocity is attained or under lugging from improper gear range. If the oil is too thin, it can be displaced and allow contact. If it is too thick it takes longer to get to the bearings and valve train as well as build pressure (the cushion) in the bearings creating additional wear. If the oil shears excessively (loses viscosity) this cushion is broken. Oil pressure is normally measured in the passage to the bearings. **Low pressure means a weak cushion; excessive pressure means too much restriction for adequate flow to all parts.**
2. **Elasto-hydrodynamic lubrication:** During brief moments in the operation of the engine, certain parts, such as the cam pushing on the rockers, create so much pressure that the oil

is momentarily converted to a solid. During these brief moments the oil is passed through the bearing or lubricated surface as a solid, deforming the surface.

3. **Boundary lubrication:** When the oil is displaced completely, cleaned by the oil control rings or sliding action of the valve train, as well as crankshaft bearings during startup until the oil gets to the bearings, the lubrication is provided by the anti-wear additives. These polar compounds are attached to the metal surfaces, although they can be stripped off by continued use in this mode (starved for oil) or fuel in the oil.
4. **Mixed lubrication:** This is a combination of hydrodynamic and boundary lubrication. It occurs between boundary lubrication and hydrodynamic lubrication in the cylinders on startup and shutdown of the engine, in certain parts of the valve train, and other areas where there is minimal full film hydrodynamic lubrication.

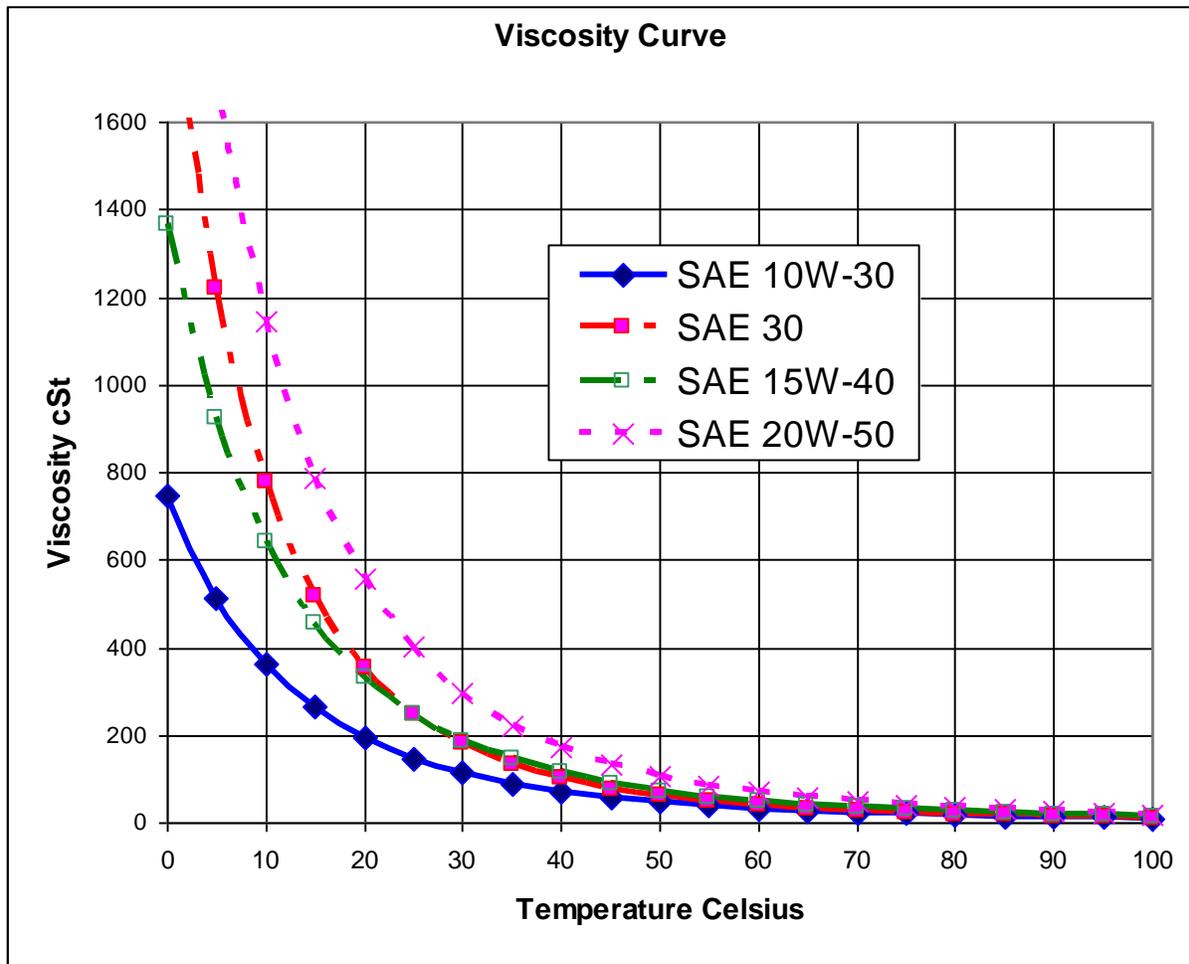
## Viscosity

Viscosity is defined as the *resistance of a fluid to flow*. The more resistance the liquid creates, the higher the viscosity. The higher the viscosity, the higher the fuel consumption, engine temperature, and load on the engine. The most important aspect of an oil is its viscosity. To create the **correct** hydrodynamic cushion for maximum protection for any given velocity, surface area and diameter/tolerance, you need a specific viscosity. In the design of an engine this ideal viscosity is calculated, tested, and then recommended. As mentioned above, an oil too thin will not provide enough hydrodynamic lubrication, and an oil too thick will not flow properly. Eventually, as an engine wears, it may be necessary to compensate by **slightly** increasing this viscosity. “High mileage oils” do this by being in the upper portion of the range for a specific viscosity. The following table shows the different SAE viscosities that meet engine design characteristics. See the [SAE J300](#) table for additional data.

| Oil viscosity at operating temperature (100° C) required by engine design | SAE viscosities to choose from                   |
|---|--|
| 5.6 cSt – 9.6 cSt   | 0W-20, 5W-20, 20                                 |
| 9.3 cSt – 12.5 cSt  | 0W-30, 5W-30, 10W-30, 30                         |
| 12.5 cSt – 16.3 cSt   | 0W-40, 5W-40, 10W-40, 15W-40, 40                 |
| 16.3 cSt – 21.9 cSt   | 0W-50, 5W-50, 10W-50, 15W-50, 20W-50, 25W-50, 50 |

As an example, the 1960 Corvair Service Manual recommends SAE 10W-30 or SAE 30 for most operating conditions anticipated. There were no 5W-30 or 0W-30 oils to recommend in those days, but Chevrolet *apparently* designed this engine to run on oil that is between 9.3 cSt and 12.5 cSt in the bearings. This means that as long as our oil is in that viscosity range, we are minimizing the wear in the engine. When the oil viscosity is *above or below* that range the engine will have additional wear. Here you can see the overall range of viscosities for four commonly used engine oils.

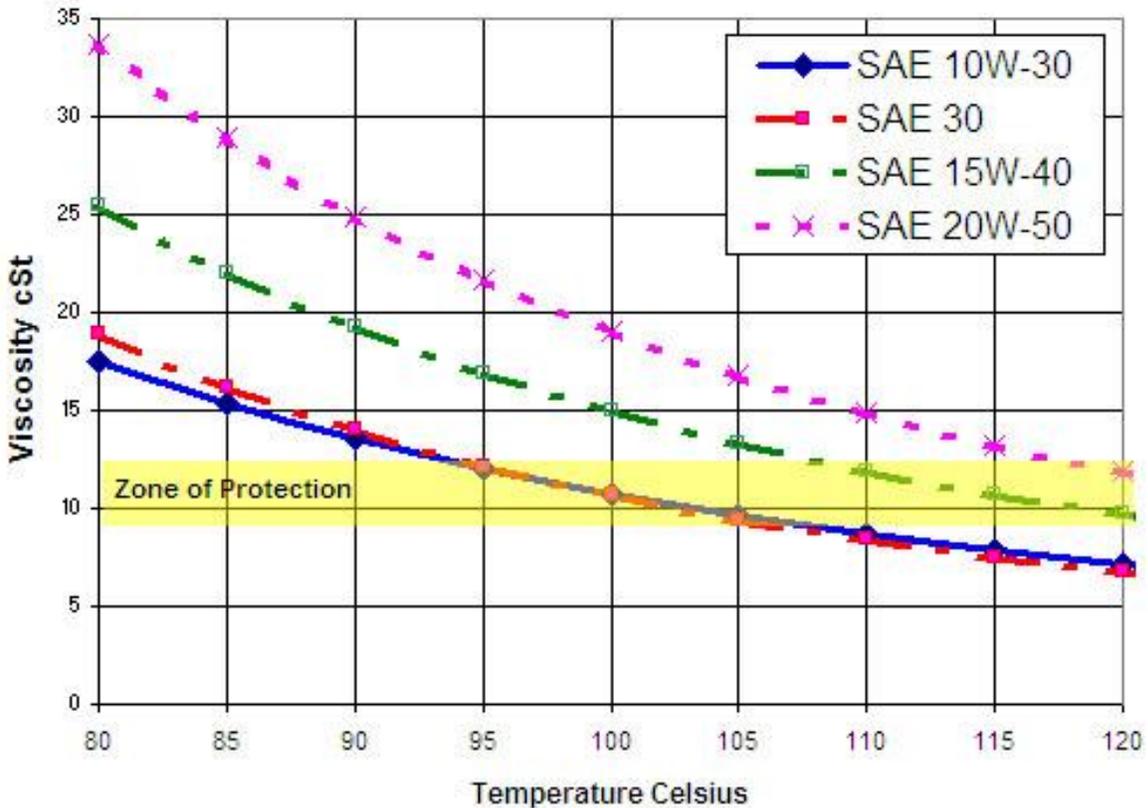
| If the lowest anticipated temperature during the interval in which the oil will remain in the crankcase is: | The following SAE viscosity oils are recommended: | Multi-Viscosity oils recommended: |
|---|---|-----------------------------------|
| 32° F   | SAE 30  | SAE 10W-30                        |
| – 10° F   | SAE 10  | —                                 |
| Below – 10° F   |   | SAE 5W – 20                       |



You can see from this chart that until the engine reaches operating temperature there is very poor lubrication and frequently the oil is going through the bypass valve directly to the bearings without passing the filter (in other cars it goes through the dirty filter and out the bypass valve). During this period, you should refrain from putting the engine under high load or high rpm.

As the engine approaches operating temperature, we begin to get close to the range of optimum protection, as shown in the following graph. (These are typical values. To graph your own oils, [click here](#).) This next graph shows the zone of protection when an engine is designed for a 10W-30. You could call it the “Goldilocks zone”, as it is not too thin and not too thick.

## Viscosity Curve



We see here that a typical:

- SAE10W-30 engine oil is in the design viscosity between 92° C and 107° C
- SAE 30 is in the design viscosity between 94° C and 106° C
- SAE 15W-40 is in the design viscosity between 108° C and 121° C
- SAE 20W-50 oil is in the designed viscosity range between 118° C and 130° C.

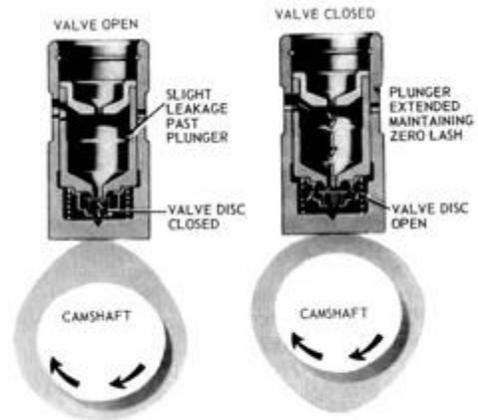
Note that this means an engine with 20W-50 oil is outside of its ideal range of protection from the time it is started until the bearings reach 118° C, causing excessive wear.

The first concept to understand when contemplating the difference between single grade (SAE 30) and multigrade (SAE 10W-30) motor oils is that:

- Single grade SAE 30 is just that. It will thicken up in the cold and thin out in the heat with a fairly steep slope. It is thicker than an xW-30 oil in the cold and thinner at higher temperatures.
- A multigrade 10W-30 depends on its base oil for its strength.
  - A 10W-30 Group I mineral oil is basically a SAE 10 that has polymers that expand and cause resistance when heated to flow more slowly, acting as a SAE 30 in hot areas of the engine.
  - A 10W-30 Group II oil is similar to the Group I oil except that it is much stronger molecularly and therefore uses fewer polymers.

- A 10W-30 synthetic oil is basically a SAE 30 oil that has been created structurally to act as a SAE 10 when it is cold. It does not need polymers.

Also, it is important to note that the thinner the oil, the faster it will pressurize the lifters. All oils will drain out of the lifters from the pressure on them when the engine is off. If too much drains out, it may be time to add an engine cleaner for a thousand miles or so, then a good detergent CI-4 oil. Moving to a thicker oil to reduce the drainage should be considered a temporary step since it can cause other problems and takes longer to re-fill them.



Many people consider lifter noise normal. While a few seconds could be considered normal, any more than that is damaging the engine, especially on a Corvair engine that uses pushrods between the rockers and the lifters. The noise that you hear is the banging of metal, whether internal to the lifter or directly against the ends of the pushrods. That hammering is transmitted from the cam to the valve stem through each of the connected parts. Every little “bang” adds up, causing more fatigue, wear and distortion of the ends of each piece. Even a sliding tappet has increased wear when it receives a hit in the middle of its slide.

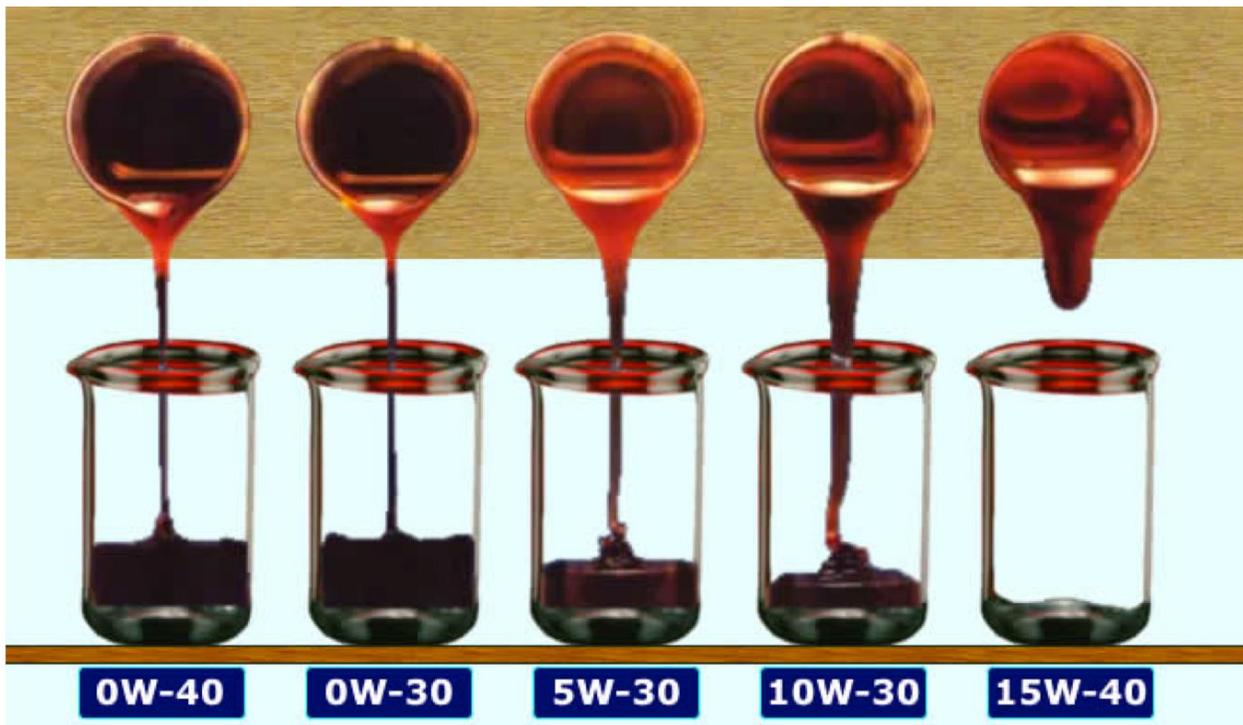


Assuming the valves are properly adjusted, there should be no “play” in the system and therefore nothing to hammer. Outside of the “normal” slight drain of the oil that will fill back up quickly on startup with the correct viscosity oil, the causes of lifter noise are:

1. Actual mechanical damage in the camshaft lobe or the lifter itself. This is physical damage that retards the free movement. This may be caused by fatigue or continuous pounding, as well as corrosion from sitting several months or years with old oil.
2. Broken parts within the lifter. This can be caused by fatigue or cavitation and implosion of air bubbles in the oil. Air bubbles are caused by oil levels too high or too low, poor seal of the oil pickup tube to the block, or poor quality oil.
  - An API SJ oil is allowed to produce 200 ml of foam in a 5 minute test, and after a 1 minute rest it must settle down to 50 ml.
  - An API SL oil is allowed to produce only 100 ml of foam in that test, and after the 1 minute rest it must settle down to 10 ml.
3. Carbon particles in the lifters, blocking the passages or the seal of the valves or ports. These particles form in different parts of the engine, frequently in the rocker area from heat after shut-down of the engine or overheating. Turbo equipped cars are more prone to carbon buildup since the drivers frequently shut off the engine without letting the turbo cool off first. The excessive heat then carbonizes the oil in the turbo bearing, sometimes causing it to seize if the engine is restarted before it completely cools. Carbon particles migrate to wherever they want. Low quality oil or excessively high metallic anti-wear

additives (ZDDP, Moly, etc.) in the oil increase the deposits. See below for the need to balance cleanliness with anti-wear.

4. Wax, sludge, or varnish deposits causing internal parts to stick. This is typical of an engine that sits for long periods (months to years) without use. The oil oxidizes where it is, forming varnish deposits. Running an engine too cold or many short trips without a longer/hotter trip weekly or so will also lead to sludge.
5. A foreign substance (gasket material, nuts, bolts, oil bottle seals, carbon, etc.) blocking an oil passage, restricting flow to the lifter.
6. Low oil pressure from a defective oil pump (or gasket too thick), low oil level or foaming. The bypass valve in the oil pump might also be stuck open from carbon particles or foreign matter.
7. High oil flow resistance. On a cold start the oil is much more viscous than at other times, creating a lot of resistance to flow through the pickup screen and passageways. The oil has a hard time passing through the cellulose oil filter, frequently causing the bypass valve to open (this is when a synthetic oil filter would be better). Then it has to travel to the oil cooler where it may also have to use the bypass valve. Finally, it travels through the galley to where it can fall by gravity to the lifters. The thicker the oil, the slower it travels. Note how the different oils flow in this picture *when they are cold*. The 0W-40 and 0W-30 have practically all poured out of their test tubes and into the recipients. The 5W-30 is about half finished, the 10W-30 slightly behind, and the 15W-40 is still trying to get out of its test tube. A straight SAE 30 is slower to flow than the 15W-40.



If you are using an oil that flows properly at startup temperatures, a cleaning treatment with one of the engine cleaning products mentioned should correct any problems of carbon, sludge and varnish. If that does not work, you can try raising the viscosity to try to seal the gap caused by cavitation within the lifter, but in reality, you need a new lifter or need to find the problem with the oil flow and pressure. Allowing the noise to continue will cause more damage in the long run.

There are many anecdotal stories of lifter noise going away by raising viscosity. Sometimes it is due to better sealing of the damaged surfaces. Sometimes this is really because the new viscosity is also a new brand. Sometimes this new brand has more detergency. Sometimes even within the same viscosity grade the lifter noise can go away by changing brands when one brand is at the top end of the range (a 10W-30 around 12 cSt) and the other is in the lower end of the range (closer to 10 cSt for a 10W-30) for that viscosity.

### **Base oil**

There are several different base oils available to formulate motor oils. The base oils used in the 1960's were what we call today API Group I, although some fall in the high aromatic sub-classification and some in the low aromatic sub-classification (This difference is important when we discuss additives). Today Group I oils (considered mineral oils, or "dino" oils) continue to be marketed, but in the US it is more common to find API Group II (still considered to be mineral oils), some API Group II+, more API Group III (considered "synthetic" after Mobil lost an argument against Castrol), and mixtures of API Group IV and V (traditional synthetics). The original synthetics were pure Group IV base stocks, and due to lack of solvency did not mix well with the residuals of Group I and Group II oils and shrunk oil seals, creating the concept (Myth) that you cannot change to synthetics after using mineral oils.

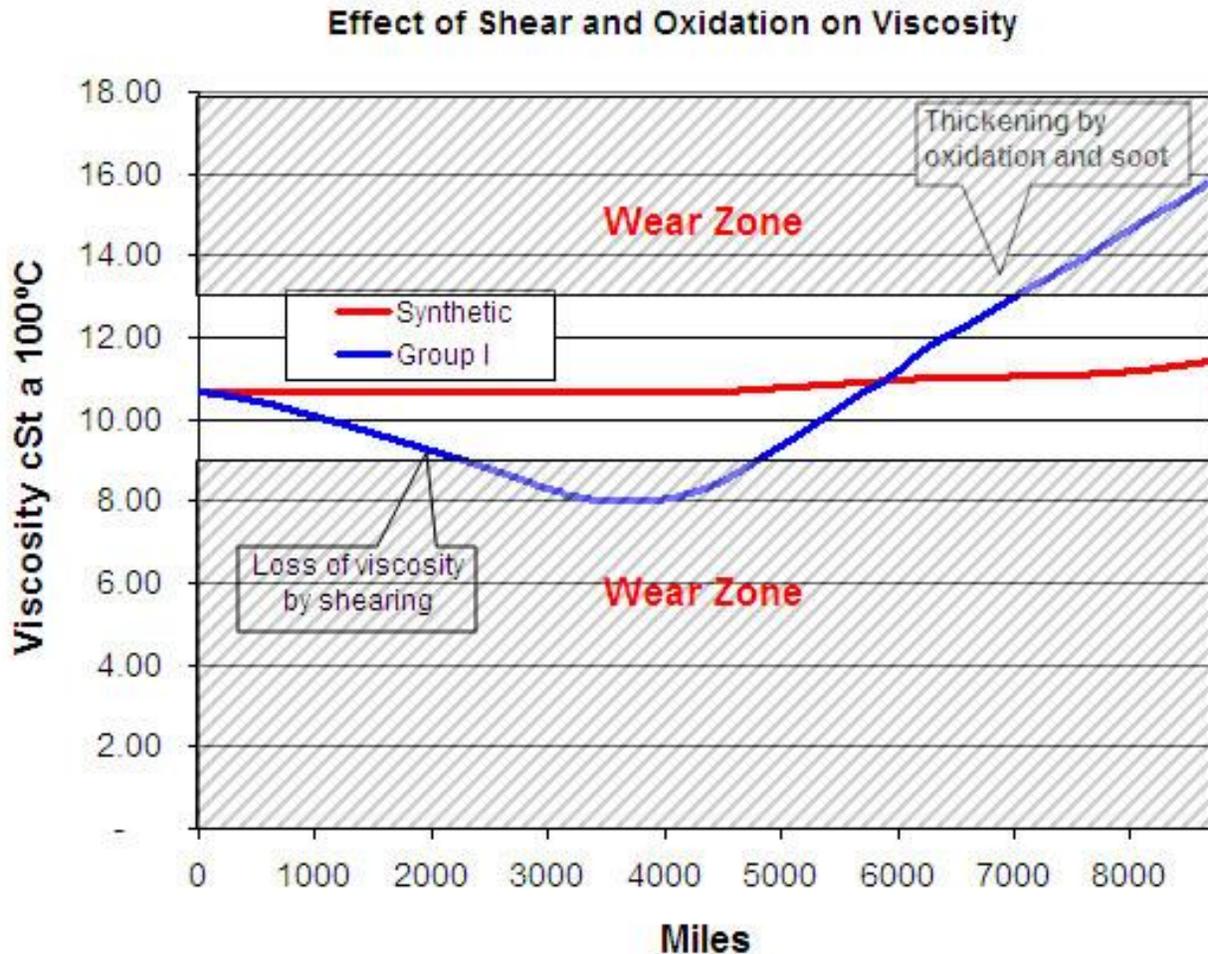
- Group I oils are solvent refined and normally low in natural viscosity index, although some oil fields produce better grades than others. They have 20 to 30% aromatics, high nitrogen and sulfur.
- Group II oils are hydroprocessed oils (or solvent refined and then hydrotreated). Normally 92% to 99% of the molecules are saturated in the bombardment of hydrogen, creating a clean, stable base oil and eliminating almost all aromatics, sulfur, and nitrogen.
- Group II+ oils are hydroprocessed to a quality somewhere between Group II and Group III.
- Group III oils are severely hydroprocessed, creating base oils that under some conditions give equal performance to traditional synthetic oils.
- Group IV oils are PAO (Polyalphaolefin) synthetics. These are excellent lubricants but have very low solvency when used by themselves, not mixing well with other oils, additives or contaminants, and causing hardening of seals and gaskets. Fully formulated PAO based oils use esters or other ingredients to increase their solvency.
- Group V oils are everything else synthetic. In general, the esters and diesters of various formulations are used to mix in small percentages with PAO oils to give them the necessary solvency and help them maintain a clean engine, softening the seals to avoid leakage. The category also includes other types of oils used for specialty products or to thicken group I, II, III or IV oils.

### **Shear Strength**

One of the arguments often given to avoid the shearing of oils is to reduce it by using single grade oils. It is interesting that in several studies that have been done over the years, single grade oils have had up to a 30% increase in consumption over their multigrade counterparts. This is assumed to be going past the oil control rings when the piston is going down and trying to scrape it off of the cylinder walls.

The viscosities shown above are nominal when the oil is new. Once in use, the oil suffers two different shear conditions as well as thickening conditions:

1. **Permanent shear:** A cheap oil that depends on polymers for its multigrade properties begins to lose viscosity between 1000 and 1500 miles of use, falling out of its viscosity range. As it continues to be used beyond 2000 miles it typically thickens from oxidation and by 5000 or 6000 miles it may be out of range on the top end again. If it does not get overheated and over aerated, instead of oxidizing and thickening it may continue to lose viscosity.



In engines that depend on gears for timing (rather than timing belts and chains) there is often a tendency to shear at a very high rate. This is not as big a problem in Corvairs because the timing gears are larger in diameter, slowing their contact and milling action.

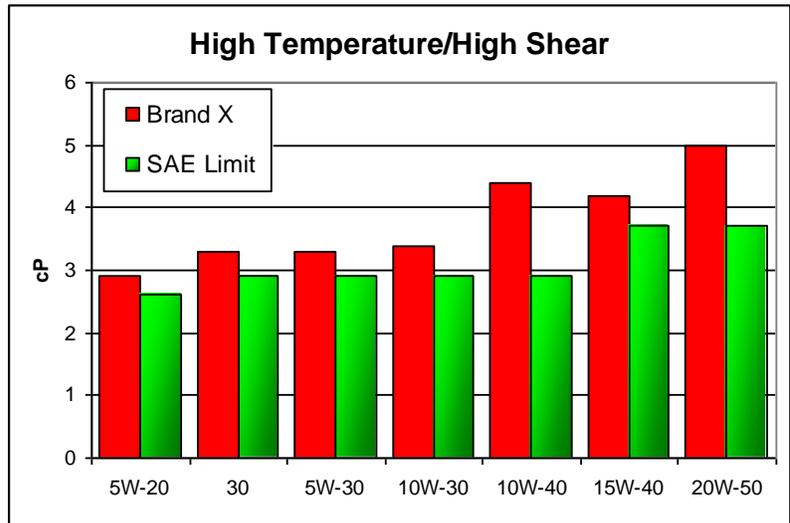
In addition to its use as an anti-wear agent, ZDDP is used in the oils to reduce oxidation. Reduced levels will lead to excess thickening and the formation of acids.

2. **Temporary shear:** When an oil is under high pressure, as it is under the cams, the bearings and the rings, the polymers collapse. In the rings the oil can often get as hot as 150°C in many engines. To check the quality of the oil a test is run called the HT/ST (High Temperature/High Shear). This is where we see one of the differences in the quality of the base oil. Oil that thins out under these conditions will return to its nominal viscosity, but while it is under pressure it offers less protection.

In this graph we can see that the shear limit of the SAE 30, 5W-30, 10W-30, and 10W-40 are identical ([SAE J300](#)). They are all allowed to shear down to the same viscosity.

A low quality 10W-40 can officially behave like a 5W-30 in the bearings, rings, valve train and other areas of stress in the engine. If this 10W-40 is a mineral oil, the polymers will temporarily shear, leaving the protection at the thickness of the 5W-30.

In this example, the Brand X 10W-40 is synthetic. It therefore behaves like a SAE 40 under stress.



### Evaporation

All oils are tested for evaporation for 1 hour in an oven at 250° C in a test called NOAK. An SJ oil is allowed to have 20% evaporation. An SL oil is allowed only 15%, and an CI-4 or later diesel oil is only allowed 13%. Many synthetic oils are around 5% to 8%. The higher the number, the thicker the oil gets in service and the more you will have to add.

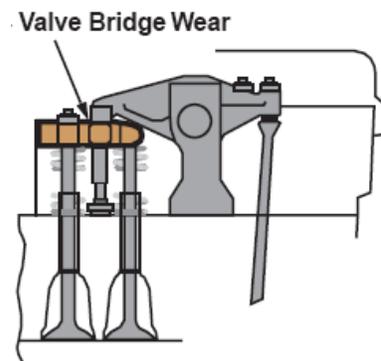
### Additives

The development of additives has continued throughout the years. From the approximately 250 ppm of zinc combined with 200 ppm of Phosphorous that were used for the better oils of the 1960's to more than 1000 ppm of each used today (normally zinc is about 100 ppm to 150 ppm (+/- 10%) higher than phosphorous).

Before we get into detail on additives it is important to understand that the quality of the base oil affects the performance of the oil so much that in general *a Group II oil will have better performance with 10% less additives than a Group I oil*. This means that looking at an oil analysis report and trying to judge quality by the quantity of additives does not work.

The formulation of a high-quality oil that optimizes cleanliness and wear is a science that has taken many years and tests to determine.

To examine the effects of different additive mixtures with different base oils we will start with the API study for the development and approval of oils for the CH-4 (diesel) category. The API spent \$4 million on this study. Aside from the complexity of additive and base oils used, one of the tests used is in a Cummins engine with a slider/follower valve train, looking for wear on the sliding components like we have in Corvairs.

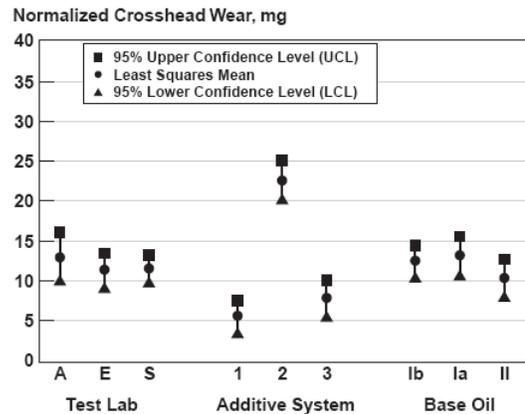


To start the test, they selected 3 base oils: one Group I high in aromatics and sulfur (1b), one Group I (1a) low in aromatics and sulfur, and one Group II base oil (basically free of aromatics and sulfur). With these three base oils they used three different additive packages that had been developed for optimum performance, preparing a total of 9 oils to test.

### Crosshead Wear

In this test, additive system #2 showed

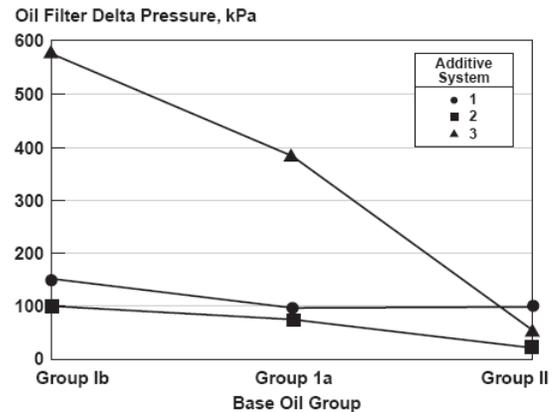
- The highest crosshead wear in the valve train (23 mg vs 6 mg and 8 mg).
- The lowest oil filter restriction (48 psi vs 100 psi and 175 psi).
- The least amount of sludge in the oil pan and rocker covers (a rating of 9 vs 8.85 and 8.8 on a scale of 10).



The group II oil showed the lowest crosshead wear, while there was not much difference between the two group I oils.

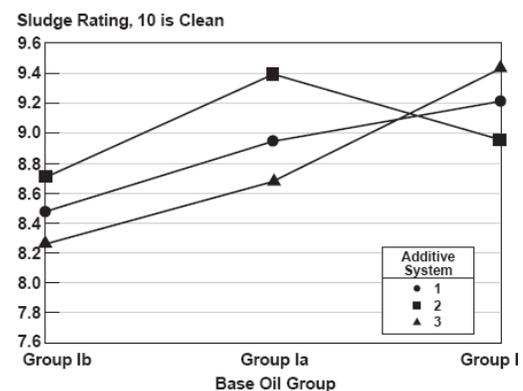
### Increase in Oil Pressure from soot

When the additives and base oils are combined in the filter pressure differential test, we see that additive system 2(■) was the best of the three in group II oils and the worst of the three in group I oils, especially those with high aromatics and sulfur. *This indicates a tremendous risk of pushing the oil filter bypass valve into an open mode when the wrong additive is added to a group I base oil.*



### Sludge Rating (rocker covers and oil pan)

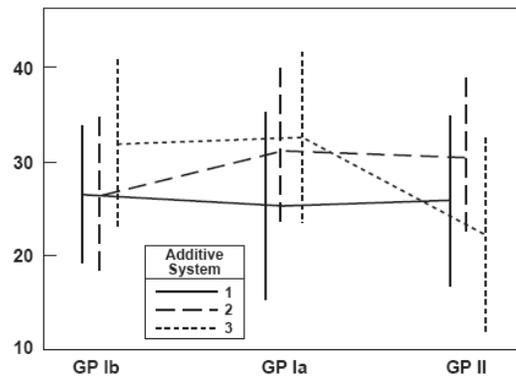
When we look at the combined base oils and additives in terms of sludge formation, we find that additive system 2(■) was the best of the three when combined with the two group I base oils, but the worst when combined with the group II base oil. The best performing additive system in a group II oil was system 3(▲).



### Average Cylinder Liner Wear

This test uses a Mack engine. When we look at average cylinder wear from the combination of additives and base oils, we find that system 1 permitted the lowest wear in all three base oils, while system 3 was best in group I oils and worst in group II oils.

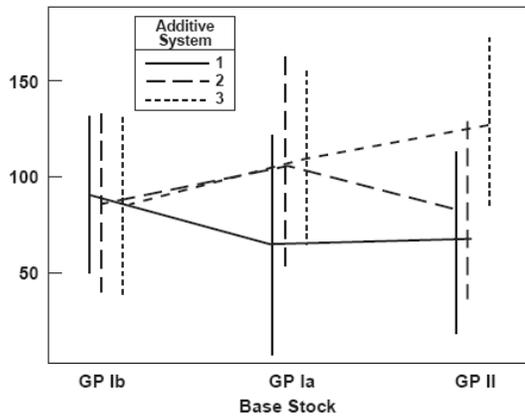
Average Cylinder Liner Wear,  $\mu\text{m}$



### Top Ring Wear

System 1 shows the least wear in top ring weight loss in the group II base oil and the better group I base oil, but slightly worse than 2 and 3 in the high aromatic/high sulfur group I base oil. Additive system 3 produced the least wear in the worst oil and the most wear in the best oil (group II).

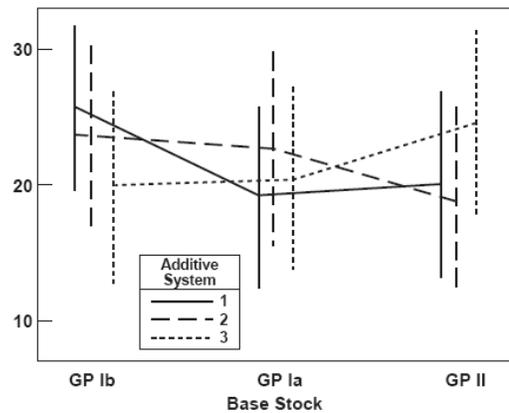
Top Ring Weight Loss, mg



### Second Ring Wear

When we look at the weight loss from wear in the second ring we find that system 1 is the worst in the high aromatic/high sulfur group I base oil but the best in the low aromatic/low sulfur group I base oil. System 3 again produced the best results in the worst oil, but tied for worst in the best oil.

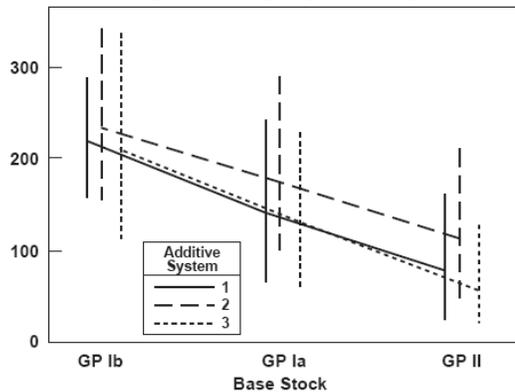
Second Ring Weight Loss, mg



### Piston Pin Bearing Wear

The wear of the piston pin bearing was more dependent on the base oil than the additive system, with the low-quality high aromatic/high sulfur base oil allowing double the wear of the group II oil. System 2 showed the highest wear in all three oils.

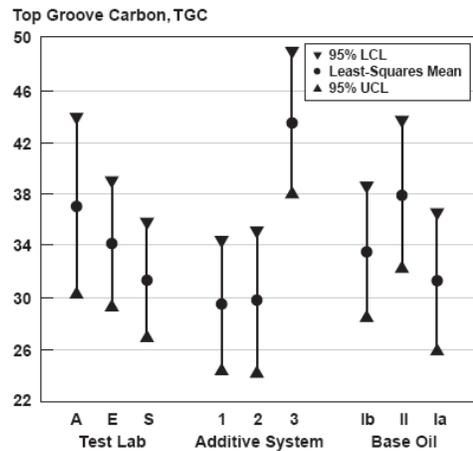
Upper-Connecting Rod Bearing Weight Loss, mg



### Carbon Deposits in the Top Ring Groove

This test, in a single cylinder Caterpillar engine showed very high carbon deposits on in the top ring groove with additive system 3, while systems 1 and 2 left the grooves very clean.

The group II base oil showed the least deposits.



The CI-4 tests go on to demonstrate further these interactions between additives and base oils.

### Summary

We tend to think of “additives” as simple products like salt or pepper. In reality they are extremely complex. Some of the additive packages used contain moly, boron, or other substances and non-polar compounds. Both moly and boron, for example are good anti-oxidants. High loads of moly can be good for anti-wear, but also add to total ash content, fouling valves, and forming deposits. Total sulfated ash content needs to be restricted by limiting the amount organic-metallic additives to limit deposits.

It should also be noted that ZDDP is activated by heat and pressure. Until an engine warms up the layer left from the day before is wiped off and not replaced. This is another reason not to race an engine until it is hot and to maintain a working thermostat in your cooling system.

The formulation of motor oils is like the formulation of a soup, a cake, or anything else that uses a lot of ingredients that interact with each other. The premise going into the API studies was that all of those additive packages would perform well in which base oil.

Since the additives are polar, they fight for surface area. The addition of extra ZDDP usually results in reduced cleanliness, higher engine temperatures and more deposits. Some studies have shown that going past 1400 ppm of phosphorus will increase wear over the long term, and going above 2000 ppm will begin to break down iron and result in camshaft spalling. There is certainly good reason to stay under 1800 ppm of phosphorus and safer with less than 1600 ppm.

Here is the oil analysis for an engine where a retail additive was added to the oil for the latest three oil changes. This additive increased the zinc and detergent, but not the phosphorus. The most recent one increased the viscosity out of range for the oil. *It also increased the wear metals.*

| SPECTROCHEMICAL ANALYSIS (ppm) |                        |                        |                     |          |             |        |     |          |        |        |         |         |                  |           |         |        |            |      |            |          |          |           |   |
|--------------------------------|------------------------|------------------------|---------------------|----------|-------------|--------|-----|----------|--------|--------|---------|---------|------------------|-----------|---------|--------|------------|------|------------|----------|----------|-----------|---|
| Lab No<br>Condition            | Date Taken<br>Tested   | Time on Oil<br>on Unit | IRON                | CHROMIUM | LEAD        | COPPER | TIN | ALUMINUM | NICKEL | SILVER | SILICON | BOHRIUM | SODIUM           | MAGNESIUM | CALCIUM | BARIUM | PHOSPHORUS | ZINC | MOLYBDENUM | TITANIUM | VANADIUM | POTASSIUM |   |
| 258853<br>Normal               | 25-NOV-05<br>21-DEC-05 | 322<br>8008            | 31                  | 2        | 0           | 7      | 10  | 6        | 0      | 0      | 11      | 1       | 0                | 9         | 3051    | 0      | 1167       | 1601 | 1          | 0        | 0        | 0         | 0 |
| 242661<br>Normal               | 21-OCT-05<br>28-NOV-05 | 349<br>7686            | 81                  | 4        | 0           | 12     | 11  | 8        | 0      | 0      | 24      | 8       | 2                | 13        | 3784    | 0      | 1371       | 1446 | 2          | 0        | 0        | 0         | 0 |
| 155043<br>Normal               | 18-MAY-05<br>20-JUL-05 | 361<br>6962            | 23                  | 1        | 2           | 3      | 0   | 4        | 0      | 0      | 5       | 2       | 6                | 17        | 3541    | 0      | 1084       | 1263 | 0          | 0        | 0        | 0         | 0 |
| 64492<br>Normal                | 27-MAR-05<br>11-APR-05 | 387<br>6901            | 17                  | 1        | 3           | 11     | 0   | 5        | 0      | 0      | 7       | 10      | 6                | 27        | 2460    | 0      | 1007       | 1144 | 5          | 0        | 0        | 0         | 0 |
|                                |                        |                        | Physical Properties |          |             |        |     |          |        |        |         |         | Additional Tests |           |         |        |            |      |            |          |          |           |   |
| Lab No                         | Fuel                   | Visc40                 | Visc100             | Water    | Soot/Solids | Glycol | SAE | TBN      |        |        |         |         |                  |           |         |        |            |      |            |          |          |           |   |
| 258853                         | <1                     | NA                     | 16.63               | 0        | 0.8         | NEG    | 50  | 7.3      |        |        |         |         |                  |           |         |        |            |      |            |          |          |           |   |
| 242661                         | <1                     | NA                     | 15.10               | 0        | 0.9         | NEG    | 40  | 8.6      |        |        |         |         |                  |           |         |        |            |      |            |          |          |           |   |
| 155043                         | <1                     | NA                     | 15.54               | 0        | 0.5         | NEG    | 40  | 5.2      |        |        |         |         |                  |           |         |        |            |      |            |          |          |           |   |
| 64492                          | <1                     | NA                     | 18.40               | 0        | 0.6         | NEG    | 50  | 5.3      |        |        |         |         |                  |           |         |        |            |      |            |          |          |           |   |

Be careful in following incomplete recommendations or brands. Just because a company produces a good product does not mean that all they produce is high quality. Just because a discount store oil is made by a major oil company it is not necessarily high quality. Those companies make what the customer (discount store) asks for.

Not long ago I received the following email:

*"Most of the world's high performance cars have one thing in common. They have Mobil oil in the sump. That's good enough for me"*

Attached was the SDS sheet with the title of ExxonMobil Super Tech 5W-30. While the msds sheet is normally not the place to see detailed motor oil specs, it does tell us two very important things. ***"Solvent dewaxed heavy paraffinic distillate"*** and ***"Solvent refined heavy paraffinic distillate"***. This tells us that it is a Group I product. Old technology with left over base oil and plant capacity.

| Chemical Name   | CAS Number |
|---|------------|
| SOLVENT DEWAXED HEAVY PARAFFINIC DISTILLATE             | 64742-65-0 |
| SOLVENT REFINED HEAVY PARAFFINIC DISTILLATE (PETROLEUM) | 64741-88-4 |
| ZINC DITHIOPHOSPHATE                                    | 68649-42-3 |

A search of the Internet shows that this is actually a Wal-Mart brand made by ExxonMobil, apparently to Wal-Mart (price) specs. The actual additive values, as analyzed by an independent laboratory, are in this table. The traces of aluminum, iron, and sodium are contaminations from pipes and packaging. This oil has about half the additives of a CH-4 or CI-4. While this is more than a 1960's oil, it is less than the 1960's oil with GM's additive.

| ELEMENTS IN PARTS PER MILLION |          |
|-------------------------------|----------|
| MI/HR on Oil                  |          |
| MI/HR on Unit                 |          |
| Sample Date                   | 10/14/07 |
| Make Up Oil Added             |          |
| ALUMINUM                      | 1        |
| CHROMIUM                      | 0        |
| IRON                          | 1        |
| COPPER                        | 0        |
| LEAD                          | 0        |
| TIN                           | 0        |
| MOLYBDENUM                    | 0        |
| NICKEL                        | 0        |
| MANGANESE                     | 0        |
| SILVER                        | 0        |
| TITANIUM                      | 0        |
| POTASSIUM                     | 0        |
| BORON                         | 0        |
| SILICON                       | 2        |
| SODIUM                        | 1        |
| CALCIUM                       | 1648     |
| MAGNESIUM                     | 2        |
| PHOSPHORUS                    | 651      |
| ZINC                          | 740      |
| BARIUM                        | 0        |

The bottom line on this oil, from the SDS and oil analysis, is that it appears to be cheap base oil with a very low level of additives. I can't find an API license for this product, nor can I find the actual ads or labels on line, so I don't know what they claim for this product.

The anecdotal comments and reviews of this product on various websites where consumers rate products show the famous "I've used it and have no problems" and similar comments. Without an oil analysis to see the wear metals, you can use any oil on the market, including an SA or hydraulic oil and "not have any problems" for a couple of years – as long as you change it every 3000 miles or so. But at 30,000 miles or so you will be repairing your engine, blaming whatever you want. I've seen *dozens* of engines rebuilt between 30,000 and 50,000 miles where this level of protection is used.

Why are there cheap, old technology, group I products in the market? *Because people buy them* and these oil companies have equipment they would otherwise have to write off.

This is not meant as a criticism of Mobil. They make some good products, but the engine does not care who makes it, only that it lubricates, cools, cleans, and seals.

Here is an example of the wear caused by group I oils that have sheared. In this example, the engine required 15W-40, and the sample on the right shows the wear metals of the Group I oil with its temporary and permanent shear. The column on the left is the Group II product in the next oil change. It shows a 37% reduction in iron wear, 50% reduction in chrome wear, 100% reduction in lead wear (bearings), and a 67% reduction in copper wear.

| Metales (ppm)         |      |        |
|-----------------------|------|--------|
| Hierro (Fe)           | 47   | ← 74   |
| Crómo (Cr)            | 4    | ← 8    |
| Plomo (Pb)            | <1   | ← 3    |
| Cobre (Cu)            | 1    | ← 3    |
| Estaño (Sn)           | <1   | 1      |
| Aluminio (Al)         | 3    | 4      |
| Niquel (Ni)           | <1   | <1     |
| Plata (Ag)            | <1   | <1     |
| Titanio (Ti)          | <1   | <1     |
| Vanadio (V)           | <1   | <1     |
| Pruebas Fisicas       |      |        |
| Viscosidad (cSt 100C) | 13.3 | ← 12.2 |

Be careful of marketing statements made to sell obsolete products. Here are comments from an interview that was printed a few years ago:

*Technical Support for Shell Marketing ..... says the less-expensive Shell “Rimula Premium fleet oil is adequate for a temporary machine.*

*When choosing engine oil, it also is important to consider an engine's planned life. Companies keeping machines for life should consider investing in the highest-grade oil. But, oil that only meets the minimum standards is fine for engines that are going to be resold before they are rebuilt, at least for the original owner.”*

### Additive levels

So if we go back and compare the 517 ppm of zinc and 482 ppm of phosphorous of the late 1960’s with the 1200 ppm to 1400 ppm of a fully formulated CH-4 or CI-4 we will find that we are way beyond the 800 ppm that the GM additive was apparently designed to do for their higher horsepower flat tappet engines.

Understanding the label on the oil is not easy. Oils can be rated SN or SM and must have between 600 ppm and 800 ppm of phosphorous. They could be rated SL and have up to 1000 ppm of phosphorous.

But if there is a CI-4 in front of the SL (CI-4/SL) there is no limit on the amount of phosphorous, and a fully formulated CI-4 oil made with synthetic or group II+ base stock will typically only have about 1350 ppm of zinc and 1200 ppm or so of phosphorous. With a better the base stock, less additives are required for the same performance, and, as I mentioned above, the API classification is based on performance, not additive content.

If there is a CJ-4 or CK-4 in front of the SN, SM, or SL, it is limited to 1200 ppm of phosphorous, not the 800 ppm of a gasoline engine oil. This means that the phosphorous limits for the following products, copied from the API site (<http://eolcs.api.org/>) are:

Motorcraft 10W-30 CJ-4: 1200 ppm

Supreme 5W-20 SN: 800 ppm

Supreme 5W-30 CI-4/SL: Unlimited

Supreme 10W-30 CI-4/SL: Unlimited

Mobil 1 5W-30 SN: 800 ppm

Mobil 1 Extended Performance 10W-30 SN: 800 ppm

| Company                           | Brand Name                   | Viscosity | API Certification   |
|-----------------------------------|------------------------------|-----------|---------------------|
| FORD MOTOR COMPANY                | MOTORCRAFT SUPER DUTY        | 10W-30    | CH-4,CI-4,CJ-4/SM   |
| AMERICAN PETROLEUM COMPANY, INC   | SUPREME SN                   | 5W-20     | SN*                 |
| AMERICAN PETROLEUM COMPANY, INC   | SUPREME                      | 5W-30     | CI-4/SL*            |
| AMERICAN PETROLEUM COMPANY, INC   | SUPREME                      | 10W-30    | CH-4,CI-4/SL        |
| SHELL LUBRICANTS - SOPUS PRODUCTS | ROTELLA T                    | 15W-40    | CH-4,CI-4,CJ-4/SM** |
| EXXONMOBIL OIL CORPORATION        | Mobil 1                      | 5W-30     | SN/CF*              |
| EXXONMOBIL OIL CORPORATION        | MOBIL 1 EXTENDED PERFORMANCE | 10W-30    | SN/CF*              |

## Other Additives

There are many chemicals and synthetic oil formulations used as additives that are multipurpose. The specific combination of these in any formulations will react differently to produce the results wanted. Mixing the wrong proportions will change the results.

**Friction Modifiers:** Every oil is designed for a specific purpose. In general, motor oils are designed to be as slick as possible and to reduce friction as much as possible. These are generally esters (group V synthetic) and fatty acids whose molecules also attach to the metallic surfaces to reduce friction during sliding action. If the contact is heavy, they are pulled off, allowing friction and wear unless there are enough anti-wear additives to take over.

- The friction modifiers in motor oils are designed to reduce the friction between the point where hydrodynamic lubrication is lost and boundary lubrication starts, reducing the friction in the mixed lubrication range.
- If you use motor oil in a wet-clutch or wet-brake application (motorcycle, automatic transmission, tractor, transmission or differential of heavy equipment, etc.) the clutches and brakes will slip due to the effect of these esters or fatty acids, creating heat and poor performance.
- Automatic transmission oils have different friction modifiers that are slippery as long as there is a high-speed differential between the discs, but change as the discs come together to grab quickly and not slip. Each type of friction material in the discs, and each angle and depth of groove in the surface is compatible with a specific friction modifier/oil combination. Using the wrong oil for a given material will make brusque or mushy shifts, depending on the combination.
- CVT fluids depend on the correct combination of sophisticated friction modifiers to make most things slippery but maintain the correct friction on the belts.

**Corrosion inhibitors:** These are additives used to reduce the effects of moisture and the acids formed during the combustion process. Motor oil provides this protection through a combination of the anti-acid capability of the Calcium or Magnesium in the detergent and the coating of ZDDP, similar to the galvanization of steel, but to a very minimal level. The ability of an oil to inhibit corrosion is shown on the spec sheets as BN or TBN (Base Number or Total Base Number). When an oil reaches the point where this reserve meets the Acid Number (TAN), an oil should be changed. (Some say change oil when the TBN is 50% of the

original value, but that might be 6 in some oils and 3 in others – not a very good parameter.) Gasoline leaking past the rings from leaks or poor combustion seriously reduces the TBN.

**Oxidation inhibitors:** Oxygen and heat work to break down the petroleum molecules to acids and gums, turning the oil into sludge and varnish. Oxidation inhibitors used in oils are typically products like amino phosphates and other organic compounds. These are depleted with time, making it necessary to change the oil (although there are some high-end oil filters that replace these).

**Foam inhibitors:** These additives reduce the surface tension and also act like alka-seltzer in the oil, joining and breaking up the bubbles that are formed by the turbulence of returning oil into the oil pan. If bubbles are allowed to circulate, they will cause cavitation of any parts under pressure and failure of the lifters. *Foam is particularly prevalent when engines are overfilled or underfilled.* High levels of oil are beaten into foam by the crankshaft. Low levels of oil circulate faster than they can release the air.

**Pour point inhibitors:** All mineral oils need pour point depressants to allow them to flow at low temperatures by keeping any wax or other molecules from joining together blocking the flow. *Synthetics do not thicken like mineral oils and generally do not use pour point depressants.*

**Seal swell control:** Esters and other group V synthetics are used in small quantities to control the drying or swelling of the seals and gaskets in the engine. Each one causes specific effects in specific seals. The goal is to *slightly soften and swell the seals over the life of the engine* to compensate for their natural drying, contraction and wear. Engine deposits that block the flow of oil to the seals can cause shaft wear from dried seals and dirt grinding on them. Cars that are not driven much may suffer from a lack of fresh oil being circulated over the seals.

## Reading the label

Unfortunately, it is not easy to read the label and make a decision. Marketing people make the big decisions and determine what the label will say in most cases. As an example of the power of marketing, I know of one brand that packaged oils in black bottles. They switched to red bottles and multiplied their bottled oil sales 5 times! The engine won't run any better when the oil has been stored in a red bottle, but the engine does not make the purchase decision. Now the trend seems to be going to silver and gold to imply quality.

Many brands use racing to showcase their brands. I believe this is good for the sport and helps develop better oils, but we have to be careful when using racing oils; since they don't need cleanliness because the engines will be disassembled in relatively few miles; we don't run our engines at 10,000 to 18,000 rpm; and because they put the race cars on labels of some of their poor quality oils to raise the price and sales.

The determination of the base oil used is difficult. Some brands will proudly display a registered name for their high-quality base oil, so that is a start. Chevron's "ISOSYN®", American Petroleum's "MAX-SYN®", Pennzoil's "Purebase®" (even if the ad campaign was flawed), ConocoPhillips' "Pure Performance®", Shell Oil's "Star®" are all examples of what you should see mentioned somewhere on their labels. Another thing to look for is the term "Severely refined", although I'm sure someone will stretch that one out too. In theory "highly refined" gives you group II, but since it has no legal definition, it really has no meaning anymore.

One of the best tools we have to figure out what is behind the hype is the Internet. Chevron's site is one of the easiest to use: [Chevron Products](#), from there I can see the Delo Synthetic 5W-40 I used in my BMW. It is only a group III product (or was when I bought it according to an email

reply from their Lubetek center and the sds), but it has shown excellent results in several engines when I've analyzed it. This product was then updated to a CJ-4 with zinc reduced to 0.127 (1270 ppm) and phosphorous reduced to 0.115 (1150 ppm).] Today I use a PAO/Ester Synthetic oil in this BMW.

## Energy conserving oils

The energy conserving classification in API approved oils checks oils against a known oil to see whether it is more slippery (less friction). This reduction of friction is through reduced viscosity and increased friction modifying additives. Since the friction modifiers or better base oils reduce the dependence on ZDDP, sometimes it can be reduced as well, **but it does not have to be.** So

*just because it says "Energy Conserving" does not mean it has reduced levels of ZDDP.*

### Bottom line recommendations:

1. Remember that the correct viscosity is your primary consideration. **Increasing** it beyond what it should be will cause **more wear and heat**. Reducing it below what is needed will cause additional bearing wear. *Read your manual* and use the "preferred" viscosity or the lowest viscosity that covers your temperature range.
2. We should recognize that the 10W-30 in the Corvair manual is probably a general recommendation for the weather ranges in the US. That is a huge range. If you are constantly driving in high temperature areas, your oil temperature is probably higher than "normal" so an oil such as a 10W-40 would give you the same start-up protection, and would be in its proper viscosity range between 105° C and 120° C instead of 95° C to 105° C. Making that a 5W-40 would give you better startup protection at the same time. *But don't use 5W-40 or 10W-40 oils that are not 100% synthetic or good semi-synthetic* (note the shear of polymers above).
3. ZDDP, when burned, leaves deposits on pistons, heads, ring grooves, valves, etc. Tests show that oils with 1% sulfated ash leave 58% less deposits in the engine than oils with 1.45% sulfated ash. Every ounce of additive that you add increases the ash content.
4. The same study showed that oils with 1% sulfated ash gave 36% lower oil consumption than oils with 1.45% sulfated ash.
5. Shear strength of the base oil is more important than a few parts per million of ZDDP. Synthetics will give the best protection, with Group II oils next. Try not to fall for the group I oils. This is not always easy to identify, although in the USA group II is now more of a norm than an exception.

### APPLICATIONS

Chevron Delo 400 Synthetic heavy duty motor oils are recommended for use in diesel and four-stroke cycle gasoline engines, torque converters, gear cases, and hydraulic systems operating year-round in arctic-type climates. They utilize the latest technology to provide excellent performance with either high or low sulfur diesel fuels.

Chevron Delo 400 Synthetic heavy duty motor oils meet:

- **API Service Categories**
  - CG-4, CF-4, CF, CD<sup>1</sup>, SH<sup>1</sup>, SJ
  - Energy Conserving for API SH<sup>1</sup> (SAE 0W-30)
  - CI-4 PLUS, CI-4, CH-4, SL (SAE 5W-40)
- **major diesel engine manufacturers' requirements**
  - Mack EO-N Premium Plus 03, EO-N Premium Plus, EO-M PLUS, EO-M (SAE 5W-40)
  - Cummins CES 20078, 20076, 20071 (SAE 5W-40)
- **performance requirements of**
  - Allison C4 (SAE 0W-30)

### TYPICAL TEST DATA

| SAE Grade   | 0W-30                  | 5W-40             |
|---|------------------------|-------------------|
| Product Number  | 235195                 | 235194            |
| MSDS Number   | 17066                  | 7351              |
| API Gravity   | 33.1                   | 31.5              |
| Viscosity, Kinematic<br>cSt at -40°C<br>cSt at 40°C<br>cSt at 100°C | 11,000<br>52.2<br>10.3 | —<br>96.6<br>15.6 |
| Viscosity, Cold Crank,<br>°C/Poise                                  | -35/47.5               | -30/60.0          |
| Viscosity Index   | 190                    | 172               |
| Flash Point, °C(°F)   | 215(419)               | 232(449)          |
| Pour Point, °C(°F)  | -51(-60)               | -43(-45)          |
| Sulfated Ash, wt %  | 1.1                    | 1.5               |
| Base Number, ASTM D 2896  | 10                     | 12.5              |
| Phosphorus, wt %  | 0.114                  | 0.136             |
| Zinc, wt %  | 0.130                  | 0.151             |

Typical test data are average values only. Minor variations which do not affect product performance are to be expected in normal manufacturing.

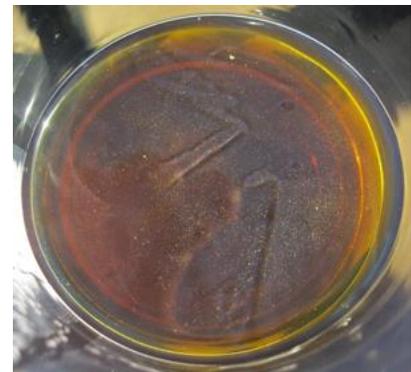
6. If you want the maximum valve train protection, look for an oil that is certified CI-4/SL without CJ-4 or CK-4. If the CI-4 comes before the SL, that is fine. Oils that are only SL certified have much less anti-wear additives.
7. You do not want the API starburst for flat-tappet engines. That is what tells you that it meets all the reduced phosphorous levels for catalytic converters.
8. The SN or SN Plus oils are not the end of the world. They are better than 50 years ago, but not as good for our engines as a CI-4 or even a CK-4. They use ashless antioxidants and better base oils than a lot of other oils. Wholesale price of an SN is about 12% higher than an SL because of this difference. The no-ash antioxidants make up for the phosphorous reduction in oxidation and the blend of better base oils improve the hydrodynamic cushion, reducing the time the engine is in mixed or boundary lubrication. This “better base oil” comment is only valid on the non-synthetic oils. *A good synthetic already had that advantage.*
9. If you have been using a low-quality oil and move up to a CI-4/SL or CK-4 with 3000 ppm to 3200 ppm of detergent, don't be surprised if it smokes a little for the first 3000 miles or so. It will clean up *some* of the deposits in the ring grooves and pistons, improving the cooling and ring movement. Once that has burned up the smoking will stop. It will not completely clean your engine, but it will help.
10. **Forget the myth** that you can't put high detergent oils in older engines or engines that have been using poor quality oil. *I do it every day!* 50% of my market is API SF or lower, frequently without thermostats. They are full of sludge. Some drain plugs come out looking like a cork, with an inch or so of thick sludge on the end. No matter what the engine, I put in a 10W-30 high detergent CI-4 oil and instruct the customer to come back when it thickens up, or the following week if he doesn't want to check it himself. Once it no longer thickens up quickly, we move on to 15W-40 (if that was originally required) and add a 1200-mile engine cleaner. At the end of that cycle we move to whatever oil the engine should have. Yes, it is scary to see the smoke during those 1200 miles or so, but in the end it helps.
11. Do not use home-brew rinse procedures. I know people who swear by a diesel rinse during the oil change, others use gasoline or kerosene, and some actually swear by a five-minute cleaning cycle with laundry detergent in the engine before rinsing with diesel. This destroys the engine. These products do more damage than good.
  - a. During this cleaning cycle, you are running 22% left over oil and 78 % diesel or whatever.
  - b. Once you have put in the new oil, you are running 78% new oil and 22% cleaning solution, reducing the quality and viscosity of the new oil.
12. If you have an engine that needs internal cleaning of the lifters, valve train, ring grooves, etc. Use a product designed to clean it in 1000 or more miles. These products use group V synthetics to deep clean slowly. Don't use the 20-minute flush junk. It can loosen too much at once and clog passages yet not get to the ring lands to clean them. Sometimes it is nothing more than kerosene. Ideally these products should be run in a Group I or Group II oil that is CI-4 rated, and the following oil change should be the same for a short (3000 mile) rinse cycle. Follow the instructions on the product.



13. When moving up to a high-quality synthetic oil that actually uses group V (high in solvency) oils in the blend, you may also notice some smoking as when increasing detergency. This will go away in a few thousand miles, and your rings will seat better.
14. Forget the myth that you can't switch over to synthetics in an older engine. Any formulation on the market today is totally compatible, and the better formulations will not only give you better shear protection and cold weather protection, but will clean up the sludge around the seals, allowing them to be softened and expanded to their normal size by the oil.
15. Forget the myth that synthetics cause leaks. The formulations of decades ago were pure PAO (group IV) that had poor solvency and tended to shrink seals. All of today's formulations have esters or other ingredients that make them totally compatible with the seals, and *the better ones will actually reduce leaking after a couple thousand miles.*
16. Forget the myth about the wax and sludge formations from paraffinic oils, or from a specific brand. Those are old wives' tales. Today the filtration systems for the group I oils remove enough paraffin to eliminate that, and the hydrocracking of the group II oils convert the paraffin to good oil. I still wouldn't buy a group I oil, but that is because of the 20 to 30% impurities and rapid decomposition.
17. Forget the myth that multigrade oils have higher consumption or "oil burning". The reverse is true. Tests show multigrade oils have up to 30% less consumption than single grades in the same engine.
18. There is nothing wrong with changing brands or viscosities. They are all compatible. But I recommend finding a brand that you are confident with and sticking with it to receive the full benefits of that formulation.
19. When changing brands, remember that some of the previous brand remains in the engine. While this is true of all engines, it is especially true of Corvairs, where approximately 1 quart remains. You will not get the full benefits of the new formulation until the 3<sup>rd</sup> oil change. If every oil change is a different brand, you will never get the full protection.
20. Be careful of the term "Semi-Synthetic". There is no standard on its use. It is legal everywhere I know to put 1% of a synthetic oil in the cheapest mineral oil and call it semi-synthetic. I know of one brand that calls their products semi-synthetic because of the synthetic polymers used for viscosity control. Some brands use base oils so poor that they need a percentage of synthetic just to get up to the minimum performance standards.
21. **Never change oil when it is cold.** The oil should be as hot as you want to risk your hand. Change it at the end of a decent drive, when it is hot, thin, and the contaminants are in suspension.
22. Never leave the cap off, or oil pan off for longer than absolutely necessary, as dirt and dust will stick onto all of the available parts. This dirt will contaminate your new oil. You can only see particles over 40 microns, but the ones between 5 and 15 microns are the most damaging, since most of those over 15 microns will eventually get stuck in the filter. (The average filter retains 50% of the particles that are 20 microns and over on each pass.)
23. If you are not going to use the car for 2 months or more, *change the oil first.* Change it, run the engine a minute to circulate the oil, and turn it off. Engines stored with used oil will suffer from corrosion of the bearings from the reduced anti-corrosion additives and

small contaminants trapped in the bearings. The new oil will clean and protect until you are ready to use the car.

24. When changing oil, always change the oil filter. If you pre-fill your filter, do it with extreme caution. Any oil that goes into the center will reach the engine unfiltered (and there is no cleanliness requirement for new oils).
25. Never use a funnel to pour the oil in unless it is absolutely clean of all possible dust and dirt. Most shop rags will leave a lot of dirt.
26. If the oil was particularly dirty, thick, contaminated with gasoline, or suspect in any way, change it a second time within 100 miles or so to eliminate the contaminants that were in the 22% that was not drained out.
27. After rebuilding an engine, *always return to the original viscosity recommended by the factory*. If done right you will have the original clearances. The use of a high viscosity oil, especially during break-in, may cause engine seizure on startup and will cause a high wear rate. This is the moment when the clearances are the tightest they will ever be.
28. **Don't believe** the myth that you can break in a rebuilt engine with synthetic oils. *The argument that new cars come with synthetics so you can break in a rebuilt engine is totally false*. None of us has the same work conditions, torque wrench calibrations or parts that the factory has. Use high quality mineral oil until the consumption stops; then switch to synthetic if you want maximum protection. *Note: The use of Chrome or Moly rings in your rebuild will extend the break-in period. Don't switch over to synthetics until oil consumption has (basically) stopped*.
29. After rebuilding an engine, your first oil and filter change should be after a few hours and again be before 1000 miles, preferably by 500 or less. During this time, you are creating a more-round bearing chamber to avoid aeration, seating the rings, and cleaning out the dust and other products you added while rebuilding (unless you have a "clean room" to assemble your engine).
30. After rebuilding an engine, **break it in slowly**, without a lot of stress and use of the power it has. You will have contaminants in the oil. You will have more foaming (and therefore less hydrodynamic film strength) from imperfect bearing fit to crank (the amount depending on fabrication of parts and calibration of the torque wrench). You will have more metal particles in suspension in the oil from the break-in (the filter only takes out particles over about 20 to 25 microns.) Once you are on your second oil change you can occasionally push the power, and once it stops oil consumption it is ready for anything. The oil in this picture is from a new car, with 2000 miles on it. There are thousands of shiny particles floating in it, even though it had an EOM oil filter.
31. In most cases, an oil change every 6 months or 5,000 miles is plenty of security, especially for group II oils. Synthetics last longer. The only reasons to change more often are:
  - a. The poor quality of Jiffy Lube (and Fram) filters
  - b. Driving in high dust/dirt conditions



- c. Short trips that do not allow the engine to warm up
- d. Towing trailers the entire time
- e. Very cold operations where the choke is frequently closed and any leaking fuel does not get a chance to burn off (cuts viscosity and TBN).
- f. Pure city driving mostly in 1<sup>st</sup> and 2<sup>nd</sup> gear.

I use group II/IV semi-synthetic SN oils in my older (>400,000 miles) 4x4's and change them every 5000 miles, mostly dirt roads or city driving (except my Grand Cherokee where I use a 5W-30 SN PAO/Ester synthetic). I use synthetic CI-4/SL oil in my 1988 BMW and change it once a year, whether I've accumulated much mileage or not. Now that my Corvair rebuild is broken-in I use a group II CI-4 10W-30 and change it once a year. I have determined that these are safe limits based on used oil analysis (more than 5000 samples).

32. The optimum oil change interval should be determined by analysis of the used oil, but this is really not practical for the average driver, particularly because a single sample shows very little. Regular sampling gives you excellent information, but you have to know how to use it. The results given by the labs are too generic to be of much use unless something is really wrong. For the average driver the cost is more than the benefit. The lab results that compare your sample to the average, or "norm" are only a starting point. You need to compare them against the best, check your driving conditions against those of the "best", and set your goals.

Used oil analysis is extremely useful to companies with a large number of vehicles or equipment and many drivers and mechanics. When I have a hundred or so samples of oils from the same engines, I'm able to see the protection or wear from different base oils, oil formulations, additives, contaminants, mileage, driving habits, and tuning. It really is amazing to see the differences in wear metals. My 2.7 L Toyota 4 cylinder shows 1 ppm of iron wear in 5000 miles while another 2.7 L Toyota shows 991 ppm of iron in 2000 miles. These differences are used to manage maintenance procedures, oils, filters and other things to optimize maintenance costs and reduce repairs

For those interested in knowing more about oil analysis there is plenty written on the web. I have more than 50 pages about it on my site, but it is in Spanish.

33. If you have your oil analyzed, don't draw too many conclusions until the 3<sup>rd</sup> oil change. An oil with little detergency will have left sludge and wear particles embedded in various crevices of the engine that will take 10,000 miles or more to clean up with a good oil.
34. **Take care of your air filter**, do not undersize it to put chrome ones on or anything else that causes the vacuum created by the engine to draw dirt in from other areas of the engine compartment unfiltered. No oil can compensate for dirt ingestion (although the better the HTHS, the higher protection in critical parts). And do not use high pressure air to clean your filter.

35. **Forget motorcycle oils:** Motorcycle oils typically have *different friction modifiers* to make them compatible with the belts and clutches in the transmissions (see friction modifiers above). This makes them less energy efficient (*more friction*) and in theory will increase your gasoline consumption slightly. Similar wet-clutch products are normally used in transmissions of farm tractors where some are considered “optional” for engine use, although not the primary recommendation. The lack of this friction modifier that would otherwise reduce the surface contact and dependence on the ZDDP *increases the chance that the ZDDP will be stripped from the sliding surface and cause more wear.*

| Meets or Exceeds API SF/SG/SJ | §           |
|-------------------------------|-------------|
| Meets or Exceeds JASO MA      | §           |
| Test                          | SAE 10W-40  |
| Vis @ 100°C (cSt)             | 15.2        |
| Vis @ 40°C (cSt)              | 104.1       |
| Viscosity Index               | 155         |
| Spec Gravity @ 60°F           | 0.8794      |
| Density (lbs/gal)             | 7.32        |
| Total Base No.                | 8           |
| Flash COC (°C)                | 216         |
| Pour Point (°C) max           | -33         |
| CCS cP (°C)                   | 6200(-25°C) |
| MRV TP-1 cP (°C)              | 38000(-30C) |
| Noack % off @ 250°C           | <15.0       |
| Sulfated Ash, wt. %           | 0.70        |
| Zinc/Phosphorus, wt. %        | 0.120/0.109 |
| Calcium, wt. %                | 0.230       |

Reading the spec sheets for several of these oils shows reduced detergency and not necessarily high ZDDP. Often, they are also only available in higher viscosities. Here we see an example of one such oil (Valvoline) that only meets API SJ, only has 1200 ppm of zinc, 1090 ppm of phosphorous and only 2300 ppm of detergent. Reviewing the SDS we can see that 70 to 80% of it is, however a group II product, so it should have less shear than a group I, but more shear than a synthetic. I have never analyzed the wear permitted by these products. This comment is based on what is printed on various spec sheets and design specs.

| Components   | CAS-No.            | Concentration |
|--|--------------------|---------------|
| DISTILLATES (PETROLEUM),<br>HYDROTREATED HEAVY<br>PARAFFINIC<br>PETROLEUM DISTILLATE | 64742-54-7         | >=70-<80%     |
|  | NJTS# 800986-5245P | >=10-<15%     |

My recent (2012) involvement in the study and marketing of the newest motorcycle oils has reinforced my recommendation against motorcycle oils in our cars. Oils for modern car engines (API SN) and high-performance motorcycles where the clutch and transmission are separate have low friction coefficients, generally between 0.80 and 1.00 (some below and some above). The main motorcycle oil category (MA) was recently split into MA1 (old standards) and MA2 (new standards). The three friction tests show the MA1 with friction coefficients between 1.25 and 1.85, while the newer oils (MA2) have friction coefficients between 1.70 and 2.50. We are not looking for higher friction in our valve trains or anywhere else in the engines. These oils are designed to protect the engine while avoiding slippage of wet-clutches. For more information, refer to [http://www.jalos.or.jp/onfile/pdf/4T\\_EV1105.pdf](http://www.jalos.or.jp/onfile/pdf/4T_EV1105.pdf)

**36. Forget single grade oils:** Single grade oils, with the exception of some specialty products, are obsolete. Since no major manufacturer recommends them, they, at best are CF or SF in additive levels, and more often made with Group I oils.

Here is the data sheet for current *Chevron Ursa Super Plus SAE 30 and SAE 40* single grade oils. You can see that the levels of zinc and phosphorous are even lower than the current SN oils. Their Ursa Super Plus 10W-30 is 6% more viscous at 100°C and 16% less viscous at 40°C, with 9% more phosphorous.

| SAE Grade   | 30         | 40          |
|---|------------|-------------|
| Product Number                                      | 271203     | 271204      |
| SDS Number  | 23578      | 23578       |
| API Gravity   | 29.4       | 28.7        |
| Viscosity, Kinematic<br>cSt at 40°C<br>cSt at 100°C | 96<br>11.5 | 141<br>14.7 |
| Viscosity Index                                     | 107        | 104         |
| Flash Point, °C(°F)                                 | 232(450)   | 254(489)    |
| Pour Point, °C(°F)                                  | -27(-17)   | -24(-11)    |
| Sulfated Ash, wt %                                  | 0.95       | 0.98        |
| Base Number,<br>ASTM D2896                          | 6.3        | 6.3         |
| Phosphorus, wt %                                    | 0.069      | 0.069       |
| Zinc, wt %  | 0.072      | 0.072       |

**37. Be careful with specialty oils:** Often recommended on some classic oil sites is Halfords Classic Oil. That, and similar oils, are the last thing you want to consider.

This is what their web page says:

API SE CC  
Protects and preserves old engines  
High viscosity helps to reduce oil loss & leakage  
Multi-grade Oil for use in Summer and Winter  
Oil adapts to outside temperature

**38. Forget aftermarket additives:** As demonstrated earlier in this paper, when you buy a good oil, it has the proper compromise between cleanliness and anti-wear. With the right test equipment and conditions, you *might* find a combination of ingredients that *might* reduce wear, but it will be at the expense of sludge and carbon. It will do you little good to reduce wear and rebuild the engine because it is fouled with carbon or the oil stops circulating because of the sludge.

The exception to this rule is an occasional cleaning additive, for one cycle. I do not recommend the “maintenance dose” of one or two ounces of cleaning additive per oil change that some additive manufacturers recommend. They are displacing anti-wear additives on the surface area.

Additives that claim to stick to the metal areas and therefore continue lubricating when there is no oil probably end up burning onto the surfaces, resulting in polished cylinders and lack of seal and oil control, with excess carbon build-up. They do not tell you what happens to them in the combustion process; and the upper cylinder and rings are exposed to very high temperatures.

Good rings clean off the remaining lubricant from the cylinder walls to avoid its burning and filling the hashes of the walls or getting burned in the combustion chamber.

We know that according to SAE studies and others, 1400 ppm of phosphorous is sufficient, 1600 to 1800 ppm is possibly dangerous to cams, lifters, and other parts, and 2000 ppm is considered dangerous and probable damage.

According to the ZDDPlus web site, you add their product to a modern SM or later oil that has 600 ppm of phosphorous. Actually, 600 is the lower limit, 800 is the higher limit, with most oils around 760 ppm.

And they go on to say that one 4 ounce bottle, added to 4 quarts of these oils will give you 2100 ppm of phosphorous. It would actually be 2100 to 2300, which we know is dangerous.

If you add that bottle to a CK-4, that ranges between 1000 and 1200, you would end up with 2500 to 2700 ppm of phosphorous. If you add it to a CI-4, that normally ranges between 1200 and 1400, you would end up with 2700 to 2900 ppm of phosphorous.

If we look back at history, considering about 200 ppm of phosphorous in the oils of the late 50's, moving almost to 500 by the late 60's, we can see that it would have been a benefit in those years, but not the whole bottle. As one bottle, with 4 ounces of this additive would give you 1700 ppm of phosphorous the the earlier oil and about 2000 ppm for the oils of the late 60's.

Certainly, there are other factors, such as temperature and pressure, that will accelerate the problems, but based on this, I see no reason to risk overdosing on phosphorous.

39. **Don't fall for the "Meets recommendations for 19xx and older cars."** That means it satisfied the minimum requirements of cars made in those days to get them through the 20,000-mile warrantee, or whatever it was. The next generation oils were developed because those oils did not do what the manufacturers needed them to do. The oils marketed that way are usually cheap base oils with minimum additive packages. They shear down under stress; they have high foaming and oxidation, high evaporation, high sludge formation, high carbon build-up in piston grooves and heads.
40. **Watch out for the claims like:** *"Mobil 1 15W-50 is also recommended for older valve train designs that may benefit from a higher level of anti-wear normally not required for newer generation vehicles. Mobil 1 15W-50 will also provide better anti-wear protection for higher valve spring tensions in certain racing engines."* You have to go beyond that statement to see that this is a SN oil that shears down to 4.5 CP in the HTHS test. There are several synthetic xW-40 oils that maintain that viscosity or close to it. I have no idea what they are comparing to when they recommend it for *"older valve train designs that may benefit from a higher level of anti-wear normally not required for newer generation vehicles."* As an SN oil, it may have a higher level than an SF, but it is nowhere near what would be a **"benefit"**.
41. **CJ-4 or CK-4 Oils:** The listing of oils as CK-4/CJ-4/CI-4/CH-4 means they have the reduced additive levels for low sulfur diesel fuel. The makers are allowed to say they replace CI-4 in diesel engines in the United States where the sulfur level has been reduced to 15 ppm. That does not mean they can replace CI-4 oils in countries where the sulfur level remains high (15,000 ppm in Venezuela, 500 ppm in Canada for on road and no limit for off-road). It is my understanding that Europe is now at 10 ppm.

The question of why CK-4 can replace CI-4 when the sulfur is below 15 ppm is frequently raised, and it is due to the reduced need to combat the formation of acids and the way the sulfur breaks down the additives in the oil. The development of the CK-4 oils was not performance driven, but emissions driven. The CK-4 oils protect the catalytic converters on the latest designs of diesel engines, but the high level of ZDDP in CI-4 oils can, over a period of 300,000 miles or so, damage the catalytic converter, especially if the engine is burning oil or either base oil or the additives used are the cheaper more volatile ones. CK-4 oils also have to be changed more frequently if the sulfur level of the diesel fuel is high.

CK-4 does not replace CI-4 in *Boundary Lubrication* (see page 2). The base oils used are normally stronger and provide more *Hydrodynamic Lubrication* than the cheaper base oils, but in flat tappet engines they lose when that oil film is scraped off. Most modern diesel engines have roller tappets to eliminate this problem.

Will a CK-4 oil ruin your Corvair or other flat-tappet engine? No. But it **may** allow more wear of the drive train than a CI-4 if you are comparing two with the same base oils and have high valve spring pressure in your engine. And it will allow **less wear** than the oils produced in the 1960's. In general, I would be very happy with today's CK-4 oils.

42. Brand recommendations: I am hesitant to recommend brand names to look for because
- a. *Formulas change frequently*
  - b. Because people tend to read or remember only part of what they should look for.
  - c. Due to inventories in different stores and distribution centers, different regions of the various countries where this will be read have different products with the same label at any given time.
  - d. Some companies also produce totally different products under the same label in different countries. Looking at the API licenses for ExxonMobil (when I first wrote this) I found that Mobil Delvac 1300 Super was formulated as a:
    - i. CF, CF-2, CF-4, CG-4, CH-4, CI-4, **CJ-4/SL\*\*** in the US
    - ii. CF, CF-4, CG-4, CH-4, **CI-4/SL**, SJ in Canada (actually no separate license, but the web site says it is formulated as such). I do not know if Mobil has a separate plant in Canada, exports a different product, or hadn't updated their web site.
    - iii. CF, CF-4, CG-4, CH-4, **CI-4/SL** in Mexico
    - iv. CF, CF-4, **CG-4** in Colombia
  - e. Whatever I list today will probably be outdated tomorrow.
  - f. Product spec sheets should rule: I have never used or analyzed Amsoil products, but I like the fact that their web site gives every possible product aspect (full disclosure). There are other brands that also show the complete or almost complete data. I *dislike* the business practice of Shell because it is almost impossible to find any real product data on their web site. It is 99.9% advertising.
  - g. If I say Shell or Mobil makes a satisfactory product, some will take that as a negative comment and others will go out and buy anything with the Shell or Mobil label, no matter the rating. *You should get and read the spec sheet*, but at the very least *you must read the label*.

### **Brand comments**

Due to overwhelming feedback I will review a few brands. *This is only as an example of what to look for when reading the specs and labels.* None of these comments should be taken as derogatory or recommendations of any particular brand mentioned. Through one retirement fund or another I probably have shares in every one that is publicly traded. I'm including some links, but do not know how long they will be valid. These comments are valid at this moment according to the API and these companies' web sites, and for products produced in the U.S.A. unless otherwise noted. In the interest of "*Full Disclosure*" I will say that I was once a distributor for Chevron. In spite of their lousy business practices, they have excellent products.

**First, we need to remember that to identify the actual rating of this oil, we have to look only at the highest rating to the left of the slash. Then ignore everything to the right of the slash (“/”).**

There are currently (November 2019) 833 companies with API licenses to make motor oil. Many of them have 20 or more different oils registered. Today there are more than 10,000 licensed oils to choose from, of which many are 10W-30. There may be some excellent choices that have not registered their products. Frequently this is because they don't want their products checked, but sometimes it is because they use their own chemistry and testing, where it would be very costly to get approvals for the license, considering their market and volume of sales.

It is important to realize that new products are ADDED to existing licenses. The licenses expire every year. So, between the time a new product is added and the old license expires, there will be duplicate API ratings.

Many of these products may have changed since I reviewed them the last time. Many more will have changed again before you read this. Sometimes the API changes their site structure, so any old links may be invalid.

These products and companies are not listed in any particular order.

*Diesel oils rated FA-4 with a 10W-30 viscosity have a much lower HTHS shear viscosity, and should not be used in Corvairs.*

As an example, here are a few of the 10W-30 products registered with the API. (This is not an endorsement of these products in particular.) I have reduced the list to the 10W-30 products since that is what should be in our Corvairs. If the link does not work, it means that the company does not have a current license registered. This may be permanent or may just be a bureaucratic delay. Check back in a week or two. The API is quick to remove expired licenses, but the renewal process and coordination with companies is slow. You can search by name, country, viscosity, or classification from this link: <https://engineoil.api.org/Directory/EolcsSearch> . From there you can filter by viscosity, classification, etc.

**Shell USA:** <https://engineoil.api.org/Directory/EolcsResultsDetail?accountId=-1&companyId=10139>

Note: Many people report on forums that they are happy using products from Shell's Rotella line

|                                    |        |            |                                    |
|------------------------------------|--------|------------|------------------------------------|
| Rimula R4 Multi                    | 10W-30 | CI-4       |                                    |
| Rimula R5 LE                       | 10W-30 | CJ-4/SM    | limited to 1200 ppm of phosphorous |
| Shell T2 HD                        | 10W-30 | CK-4       | limited to 1200 ppm of phosphorous |
| Shell Rotella T5                   | 10W-30 | CK-4, CJ-4 | limited to 1200 ppm of phosphorous |
| Shell Rotella T4 Triple Protection | 10W-30 | CK-4, CJ-4 | limited to 1200 ppm of phosphorous |
| Shell Rimula R5LE                  | 10W-30 | CK-4, CJ-4 | limited to 1200 ppm of phosphorous |
| Shell T2 HD                        | 10W-30 | CK-4, CJ-4 | limited to 1200 ppm of phosphorous |
| Shell Rotella T5 Ultra             | 10W-30 | FA-4       | Low HTHS. <b>Not recommended</b>   |

**ExxonMobil:** <https://engineoil.api.org/Directory/EolcsResultsDetail?accountId=-1&companyId=10345>

|                         |        |                     |                                    |
|-------------------------|--------|---------------------|------------------------------------|
| MOBIL DELVAC ELITE      | 10W-30 | CJ-4, CI-4, CH-4    | limited to 1200 ppm of phosphorous |
| MOBIL DELVAC 1300 SUPER | 10W-30 | CJ-4, CI-4, CH-4/SM | limited to 1200 ppm of phosphorous |
| Mobil Delvac Extreme    | 10W-30 | CK-4, CJ-4, CI-4    | limited to 1200 ppm of phosphorous |
| Mobil HDEO              | 10W-30 | CK-4, CJ-4, CI-4    | limited to 1200 ppm of phosphorous |
| House Brand HDEO        | 10W-30 | CK-4, CJ-4, CI-4    | limited to 1200 ppm of phosphorous |
| Mobil Delvac HDEO       | 10W-30 | CK-4, CJ-4, CI-4    | limited to 1200 ppm of phosphorous |

|                         |        |                     |                                    |
|-------------------------|--------|---------------------|------------------------------------|
| Mobil Delvac 1300 Super | 10W-30 | CK-4, CJ-4, CI-4/SN | limited to 1200 ppm of phosphorous |
| Mobil Delvac Extreme FE | 10W-30 | FA-4                | Low HTHS. <b>Not recommended</b>   |
| Mobil Delvac Super FE   | 10W-30 | FA-4/SN             | Low HTHS. <b>Not recommended</b>   |

**Pennzoil Product Company:**

<https://engineoil.api.org/Directory/EolcsResultsDetail?accountId=-1&companyId=10217>

|                |        |                     |                                    |
|----------------|--------|---------------------|------------------------------------|
| LONG-LIFE GOLD | 10W-30 | CJ-4, CI-4, CH-4/SM | limited to 1200 ppm of phosphorous |
| LONG LIFE      | 10W-30 | CI-4, CH-4/SL       |                                    |

**Chevron Products Company:**

<https://engineoil.api.org/Directory/EolcsResultsDetail?accountId=-1&companyId=10110>

|  |        |                           |                                    |
|--|--------|---------------------------|------------------------------------|
| CALTEX DELO GOLD MULTIGRADE            | 10W-30 | CH-4                      | not recommended                    |
| CALTEX DELO GOLD ULTRA SYNTHETIC BLEND | 10W-30 | CI-4                      |                                    |
| DELO SPORTS SYNTHETIC BLEND            | 10W-30 | CI-4                      |                                    |
| CALTEX DELO SPORTS CYNTHETIC BLEND     | 10W-30 | CI-4/SL                   |                                    |
| Ursa Super Plus EC                     | 10W-30 | CJ-4                      | limited to 1200 ppm of phosphorous |
| CHEVRON DELO 400 LE                    | 10W-30 | CJ-4, CI-4, CH-4/SM       | limited to 1200 ppm of phosphorous |
| DELO 400 SDE                           | 10W-30 | CK-4, CJ-4, CI-4, CH-4    | limited to 1200 ppm of phosphorous |
| Delo ULA                               | 10W-30 | CK-4, CJ-4, CI-4, CH-4    | limited to 1200 ppm of phosphorous |
| Delo 600 ADF                           | 10W-30 | CK-4, CJ-4, CI-4, CH-4    | limited to 1200 ppm of phosphorous |
| Ursa Super Plus EC                     | 10W-30 | CK-4, CJ-4, CI-4, CH-4/SN | limited to 1200 ppm of phosphorous |
| Delo 400 XLE                           | 10W-30 | CK-4, CJ-4, CI-4, CH-4/SN | limited to 1200 ppm of phosphorous |
| Delo 400 ZFA                           | 10W-30 | FA-4/SN                   | Low HTHS. <b>Not recommended</b>   |

**BP Products** (I will only list the Castrol US motor oils that the parent company BP) has listed):

<https://engineoil.api.org/Directory/EolcsResultsDetail?accountId=-1&companyId=10104>

|                          |        |               |                                    |
|--------------------------|--------|---------------|------------------------------------|
| CASTROL HYPURON          | 10W-30 | CJ-4, CI-4    | limited to 1200 ppm of phosphorous |
| Hypuron Advanced Formula | 10W-30 | CJ-4, CI-4/SN | limited to 1200 ppm of phosphorous |
| Vecton Long Drain        | 10W-30 | CK-4          | limited to 1200 ppm of phosphorous |
| CRB Multi                | 10W-30 | CK-4          | limited to 1200 ppm of phosphorous |
| Vecton                   | 10W-30 | FA-4          | Low HTHS. <b>Not recommended</b>   |

Since none of these oils is a CI-4, none would make my primary list of choices.

**Valvoline:** <https://engineoil.api.org/Directory/EolcsResultsDetail?accountId=-1&companyId=10267>

|                              |        |                   |                                    |
|------------------------------|--------|-------------------|------------------------------------|
| Premium Blue 7800 Plus       | 10W-30 | CI-4/SL           |                                    |
| ALL FLEET PLUS               | 10W-30 | CJ-4 CI-4 CH-4/SL | limited to 1200 ppm of phosphorous |
| ALL FLEET PLUS               | 10W-30 | CJ-4 CI-4 CH-4/SM | limited to 1200 ppm of phosphorous |
| ALL FLEET PLUS               | 10W-30 | CJ-4 CI-4 CH-4/SM | limited to 1200 ppm of phosphorous |
| PREMIUM BLUE SYNTHETIC BLEND | 10W-30 | CJ-4 CI-4 CH-4/SN | limited to 1200 ppm of phosphorous |
| Premium Blue 8600            | 10W-30 | CK-4              | limited to 1200 ppm of phosphorous |

|                                |        |                   |                                    |
|--------------------------------|--------|-------------------|------------------------------------|
| ALL-FLEET PLUS E900            | 10W-30 | CK-4 CJ-4 CI-4    | limited to 1200 ppm of phosphorous |
| ALL-FLEET PLUS                 | 10W-30 | CK-4 CJ-4 CI-4    | limited to 1200 ppm of phosphorous |
| Premium Blue 8600ES            | 10W-30 | CK-4 CJ-4 CI-4,   | limited to 1200 ppm of phosphorous |
| Premium Blue 9200 One Solution | 10W-30 | CK-4 CJ-4 CI-4/SN | limited to 1200 ppm of phosphorous |
| Premium Blue 8700FE            | 10W-30 | FA-4              | Low HTHS. <b>Not recommended</b>   |
| VR1 SYNTHETIC RACING           | 10W-30 | SL                |                                    |

Valvoline VR1 Racing Formula SAE 10W-30 is still a good non-diesel choice at this moment. (11/2019). The chemical formulations look decent for our use. It has 1100 ppm of zinc and 1000 of phosphorous, so it is similar to a CK-4 (note that they reduced it from 1400 zinc and 1100 phosphorous since my previous draft). Maybe a tad low on detergency, but the sodium sulfonate is very effective at sludge control, so on balance I'd go for it. They have cleared up my concern that they previously said it could be used as an SN, stating that it should not be used with catalytic converters.

### Here are a few of the “specialty” brands

**Royal Purple:** <https://engineoil.api.org/Directory/EolcsResultsDetail?accountId=-1&companyId=10239>

|                              |        |               |                                    |
|------------------------------|--------|---------------|------------------------------------|
| ROYAL PURPLE LONG RIDER PLUS | 10W-30 | CI-4/SL       |                                    |
| ROYAL PURPLE                 | 10W-30 | CI-4, CH-4/SL |                                    |
| ROYAL PURPLE LONG RIDER      | 10W-30 | CI-4, CH-4/SL |                                    |
| Duralec                      | 10W-30 | CJ-4/SN       |                                    |
| Royal Purple Duralec Super   | 10W-30 | CK-4          | limited to 1200 ppm of phosphorous |

**Amsoil:** <https://engineoil.api.org/Directory/EolcsResultsDetail?accountId=-1&companyId=10079>

|     |        |         |                                    |
|-----|--------|---------|------------------------------------|
| OEC | 10W-30 | CJ-4/SN | limited to 1200 ppm of phosphorous |
|-----|--------|---------|------------------------------------|

There are also several apparently good Amsoil products on their site, and may be using proprietary chemistry that would be expensive to run through API tests for their relatively small volume.

*From their spec sheets, this could be fairly high on my list:*

- Z-ROD® 10W-30 Synthetic Motor Oil

**Schaeffer Manufacturing:** <https://engineoil.api.org/Directory/EolcsResultsDetail?accountId=-1&companyId=10248>

|                                 |        |      |                                    |
|---------------------------------|--------|------|------------------------------------|
| 711 Synshield OTR Plus          | 10W-30 | CK-4 | limited to 1200 ppm of phosphorous |
| 722 SynShield Ultra Performance | 10W-30 | CK-4 | limited to 1200 ppm of phosphorous |
| 6000 Synshield Max MPG          | 10W-30 | FA-4 | Low HTHS. Not recommended          |

**Brad Penn:** BRAD PENN® *PENN-GRADE I*® Partial Synthetic SAE 10W-30 Racing Oil is not registered with the API, but it appears to be a blend of 5 to 10% Group IV with group I oils. The 1500 ppm of zinc and 1400 ppm of phosphorous, 10.6 TBN and 1.2 Sulfated ash content indicates it is in the neighborhood we are looking for, and the HTHS values are very good.

Although I prefer API licensed products, this is probably worth considering, particularly because

Pennsylvania crude is some of the best, so the group I would have a low aromatic content. *I would put this somewhere in the middle of the list.*

I have intentionally left out the brand that I sell, although it includes a Group II CI-4 10W-30 and a CI-4 group IV/group V blend of traditional synthetics. I only sell it in Bolivia, so it would not help with your decision, and this is not a sales pitch.

With the exception of a couple of products, I've had to go to the sds (previously called msds) information to figure out the base oil. As long as you get a CI-4 and keep the viscosity range to 20 or 25 points (10W-30) and don't stretch your oil change intervals, a group I won't kill the engine. If you are racing or driving hard, want to extend intervals between oil changes, or plan on keeping the car for many years, it is better to look for the better base oil.

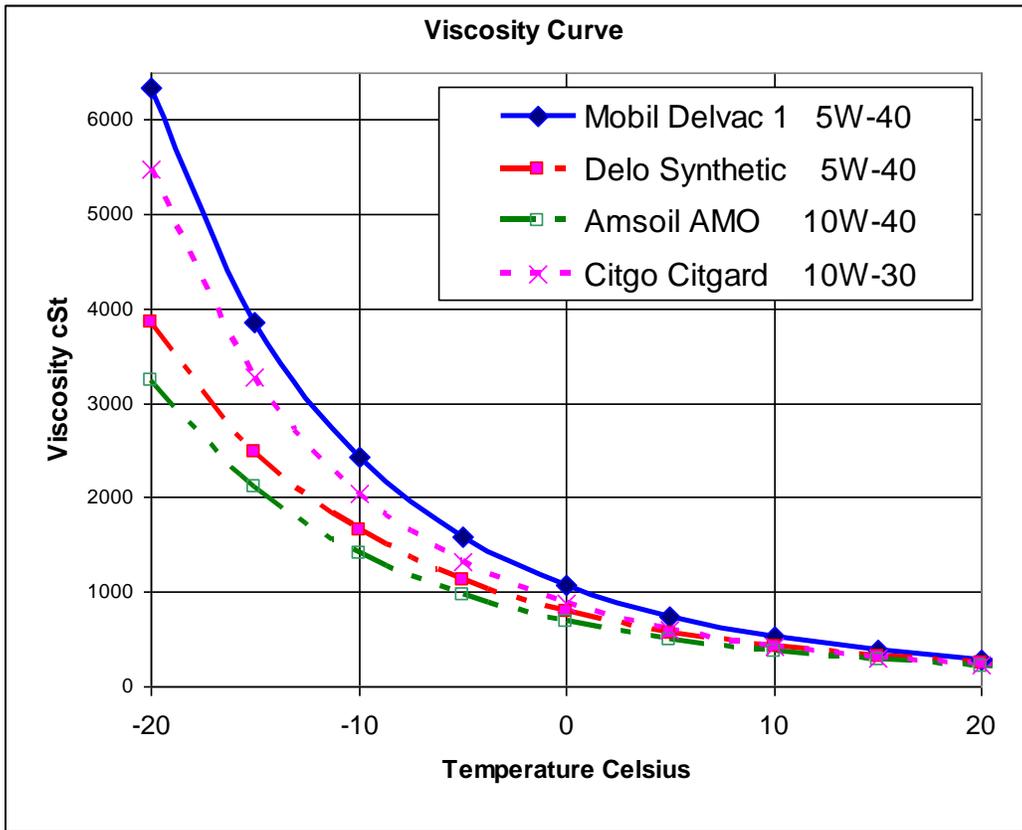
Obviously, price and availability are considerations. Look through the oils on the shelf, read the labels and look up the specs and SDS information if you want the details. Then stick with that brand to get the best results over the long run.

I read a website recently that said it was extremely easy to choose a motor oil. "*Just read the label.*" I think you can see from this information that this is far from reality if you really want to take care of your engine beyond what the manufacturer guarantees or if you have an engine with flat tappet valve trains.

If your goal is to find an oil that will take you to the end of your warranty period without problems, you can read the label and choose something that meets the minimum the manufacturer recommends. But chances are that *if you own a classic car or are reading this far, your goal is maximum protection.*

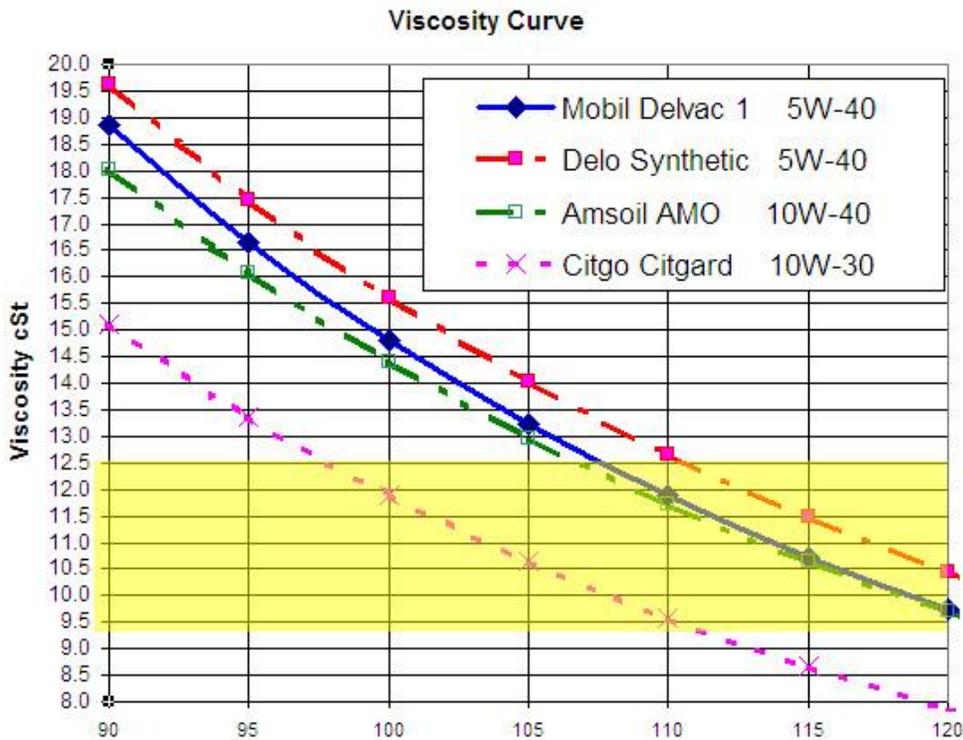
Also, in the viscosity section we talked about the difference in behavior between a *mineral oil with its polymers* to give it viscosity (a typical 10W-30 being a 10 with polymers to create resistance and flow like a 40 at 100° C) and a synthetic oil. The synthetic oil is a *full-bodied* oil that behaves like a thinner oil in the cold (typical 10W-30 synthetic being a 30 wt that acts like a 10 in the cold). Here are some real-life examples of how this works. I am using a mineral oil CI-4/SL SAE 10W-30 as a comparison with 3 synthetics, two being labeled as 5W-40 and one being labeled as a 10W-40. These graphs are based on normal curves for products with these characteristics. At very low temperatures the addition of pour point depressants (normally not present in synthetics) could affect the curve.

Of these, the Amsoil 10W-40 is by far the best oil in cold weather. It is 30% thinner than the 10W-30 mineral oil at -4° F. This Amsoil 10W-40 is ½ the viscosity of the Delvac 1 5W-40 (which is the same as the Mobil 1 Turbo Diesel Truck 5W-40) at this temperature. The viscosities don't get close until they are around 70° F. (21° C)



When you get up around operating temperatures the following graph shows:

- The 10W-30 mineral oil in the ideal viscosity range between 98° C and 111° C.
- The Amsoil 10W-40 in the ideal viscosity range between 106° C and 121° C.
- The Delo 5W-40 in the ideal viscosity range between 112° C and 126° C.
- The Mobil 5W-40 in the ideal viscosity range between 108° C and 122° C.



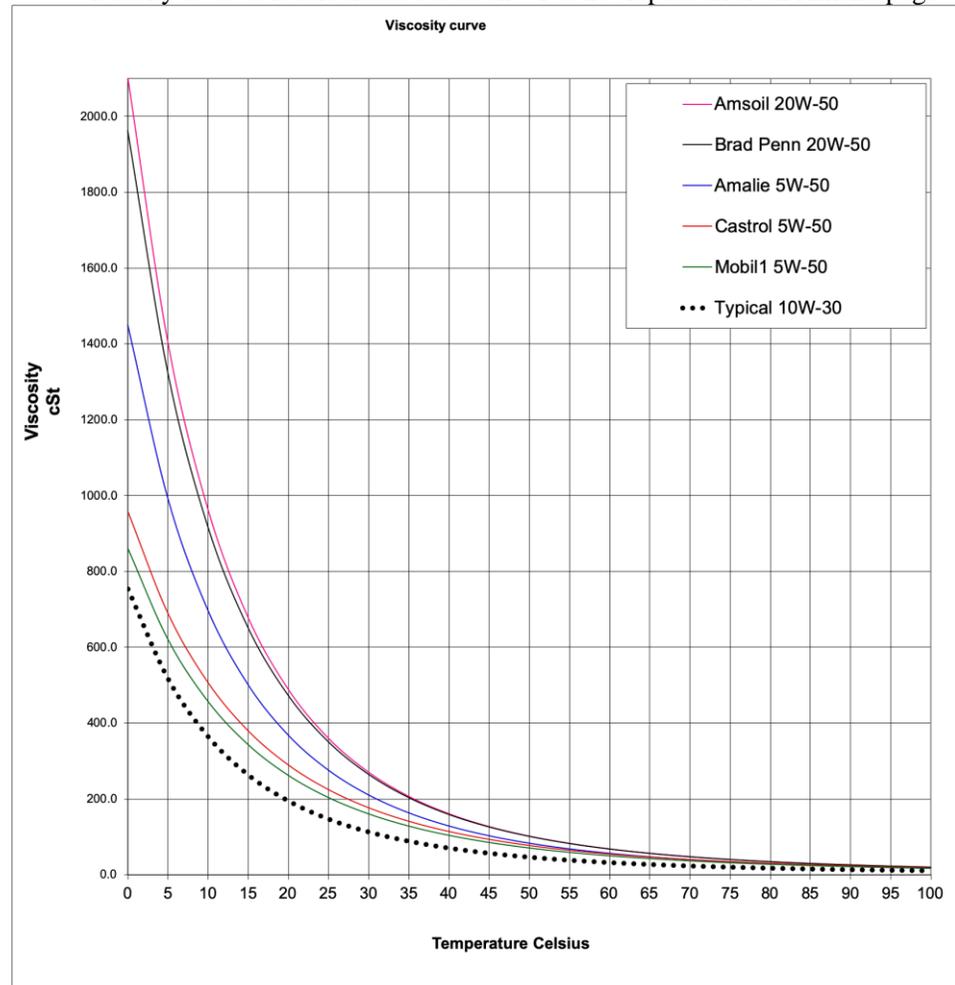
## SAE xW-50 oils

Although I don't believe they are appropriate for Corvairs, I have been asked to comment on xW-50 oils. In general, 20W-50 oils in a Corvair would require a very worn engine and extremely hot climate to avoid premature wear and damage to the valve train (*note an exception below*). I would not recommend any *mineral oil* that covers a spread any bigger than that since they will shear down under stress.

Here is a brief look at three 5W-50 oils, one synthetic 20W-50, one part-synthetic 20W-50 and one mineral 20W-50. It is hard to find information on xW-50 oils. I found some oils licensed with the API that were not on the manufacturer's web sites. The old Castrol Syntec group III synthetic is no longer listed. It sheared down to 3.7 under pressure, making it thinner than the average 40 weight when you really need it.

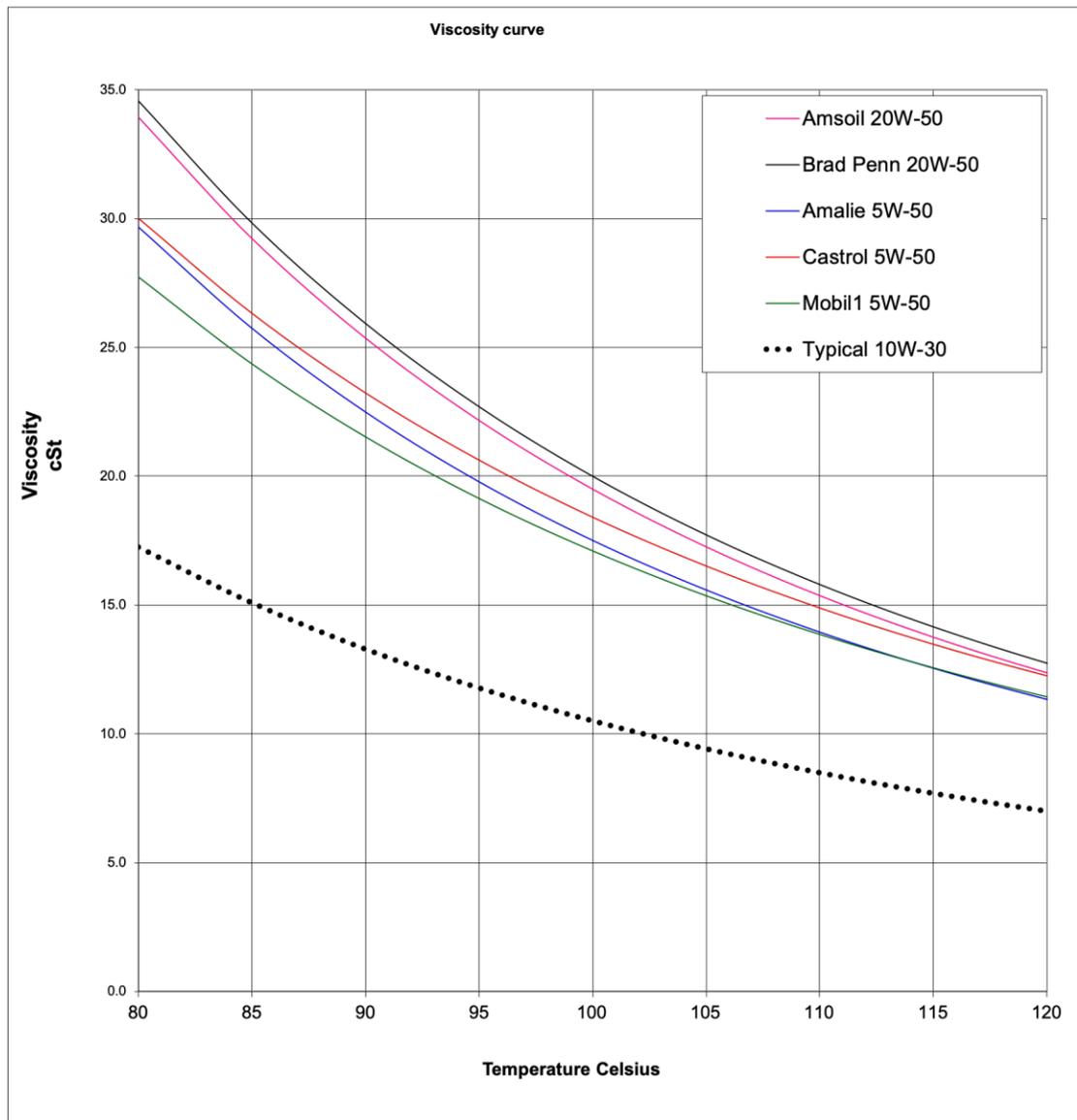
| Oil  | Viscosity | API       | 100° C | 40° C | HTHS    | Base Oil                    |
|--|-----------|-----------|--------|-------|---------|-----------------------------|
| Amalie Elixir Full Synthetic                         | 5W-50     | SM        | 17.5   | 129*  | ?       | ????                        |
| Castrol Edge Full Synthetic                          | 5W-50     | SN        | 18.4   | 114   | 4.1     | "Base oil – highly refined" |
| Mobil 1:   | 5W-50     | SN        | 17.1   | 104   | 4.4     | Traditional Synthetic       |
| AMSOIL Premium Protection Synthetic 20W-50 Motor Oil | 20W-50    | CI-4+     | 19.5   | 160.3 | 5.5     | Traditional Synthetic       |
| Brad Penn Partial Synthetic                          | 20W-50    | 1400 Phos | 20     | 159   | 6.2 (?) | Part Synthetic group III    |
| Havoline   | 20W-50    | SN        | 18.2   | 154   | ?       | Mineral                     |
| Typical 10W-30                                       |           |           | 10.5   | 70    | 3.0     |                             |

- \*Viscosity at 40°C recalculated based on VI to not repeat error on Amalie page



Note that in these graphs, I have added a dotted black line for the viscosity curve recommended by Chevrolet for the Corvair. Anything thicker is not fully flowing and protecting.

The second graph shows the viscosities of the same oils at operating temperatures.



Before considering a 5W-50 oil, you should look for its HTHS value. There is no point in a higher viscosity that shears down below the 5W-40 oils on the market, and we should remember that our Corvairs should be lubricated with 10W-30 under most circumstances.

So, what is my bottom-line recommendation in xW-50 oils? *Only if you are racing* since the oils do not circulate properly until they get up to full operating temperatures. The viscosity should get down to 12.5 cSt or below for full protection. Mobil 1 and Amalie 5W-50 oils reach that point at 115°C, but we normally do not operate at that temperature.

*In the interest of full disclosure*, I also sell a 5W-50 oil. It has a curve very close to the Amalie 5W-50, but it is rated CI-4/SL. Most of my sales of this product are to the Mercedes dealer. I also use it in my race cars.

The current format of the API website does not allow me to sort the CI-4 oils without first choosing a brand. Here you can find the 548 oils that are registered with the API as CI-4 at this

moment on their website: <https://engineoil.api.org/Directory/EolcsResults?accountId=-1&serviceCategories=CI-4>

If you are looking for other viscosities you can find them on the API site listed above.

And remember: when reading the label, you are looking at the highest classification to the left of the slash.

**One more conclusion:** Now that I have actual analysis of an oil of the late 60's, and see that the level of anti-wear protection was about half of today's gasoline oils and less than a third of the protection offered by a CI-4, CJ-4, or CK-4 oil. With these levels of protection in a CI-4, I see no reason to make a home brew with aftermarket additives. The risks of imbalance are too high.

**Finally**, remember we are talking about protecting engines without catalytic converters, primarily those with flat tappet or sliding valve trains. This is where we want the highest boundary lubrication.

In newer cars, especially those with catalytic converters, look for the SN Plus (soon to be SP) to the **left** of the slash. When it comes to eliminating sludge and protecting the exhaust systems, the new detergents in the SN Plus oils are far above anything in the SM category.

So, what does it boil down to? That is normally the question I get.

1. My first choice for the average Corvair is CI-4, 10W-30, Group II.
2. For low annual mileage or more protection, CI-4, 10W-30 (or 5W-30), Synthetic, even going to 5W-40 for high temperature operation or compensating for some consumption.
3. If no CI-4 is available, I'd look for a CJ-4 or CK-4 Synthetic in the above viscosities.
4. If no CI-4 is available, and no budget for Synthetic, I'd then look for the CK-4 10W-30.

When would I use a 15W-40?

A well-worn engine where the temperatures never drop below 70°F

When would I use a 20W-50?

For an autocross in hot weather or really worn oil burner that you will be repairing soon.

Can I use a 5W-30?

Yes: Particularly in colder climates, and especially with synthetics. For the reasons I mentioned on page 29, a good synthetic SAE 30 can be labeled 5W-30 and 10W-30 (That does not mean all SAE 30's are 5W-30, but a 5W-30 is a 30 with better cold weather protection). With mineral oils, I'd say only if they are the best. The cheap stuff might shear down.

Where should I look for a CI-4?

- Farm and tractor supply stores
- Truck stops and stores that cater to the diesel pickup crowd

I hope this has helped with your understanding of engine lubrication and oil selection to protect your Corvair or other engine. This is not an endorsement of any brand of oil. The brand is not as important as the certifications.

If you are interested in more information on viscosity determinations, please check out my paper on [Oil Selection for Classic Minis](#).

You will find more on oils and analysis at:

<https://www.widman.biz/English/>