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

By Richard Widman

This is the twelfth draft of this paper. 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 *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 SM and CJ-4) and the desire to add commercial additives to increase those levels. Here we will investigate the advantages and disadvantages of these products.

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" for gasoline engines and the "DG" oils were similar to what is known today as "API CA" for diesel engines. At some point in time some 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.

The base oils used in those oils were fractionally distilled petroleum products using solvents to extract what they could of impurities and wax. Today these base oils would be 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 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.

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 additives for optimum performance. It is the combination of additives and base oil that gives performance and protection. The API Service MS (known as "SB" today) oils had little or no detergent and approximately 250 ppm (parts per million) of zinc combined with 200 ppm of phosphorous. A good CI-4 oil in the market today has 1200 to 1400 ppm of zinc and 1000 to1200 ppm of phosphorous.

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 and build pressure (the cushion) in the bearings and creates additional wear. If the oil shears excessively 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 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.

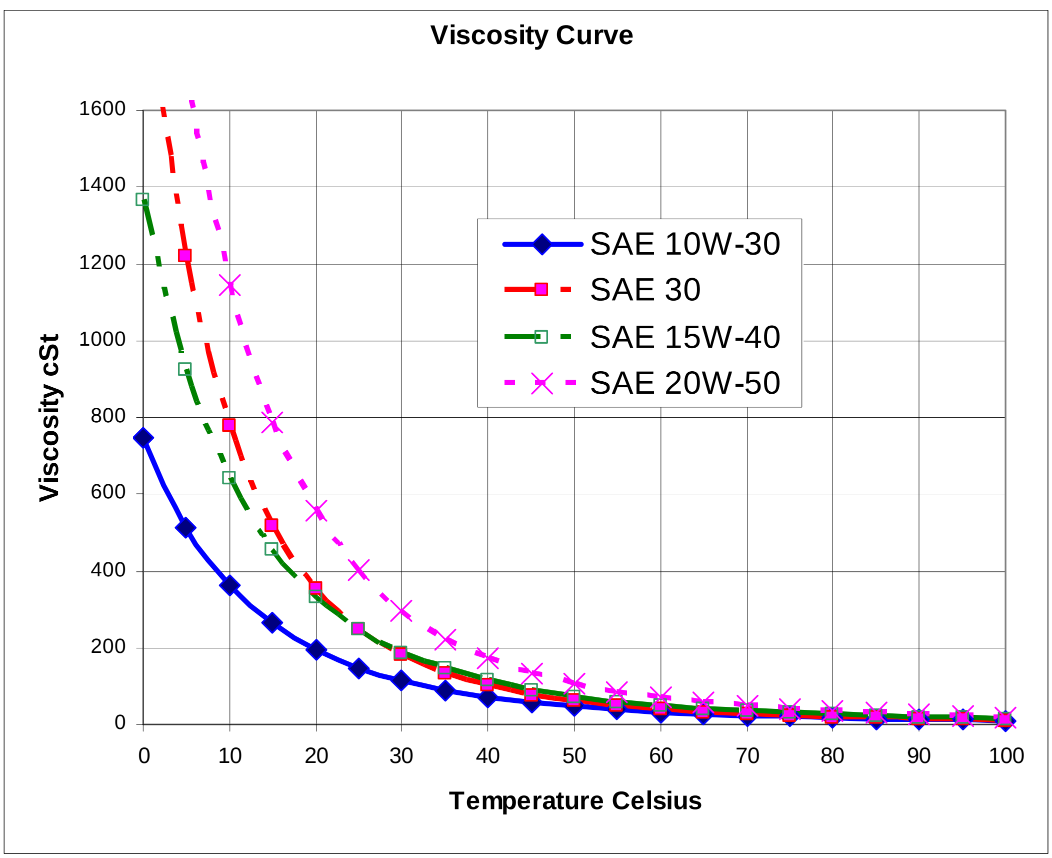
Viscosity

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 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

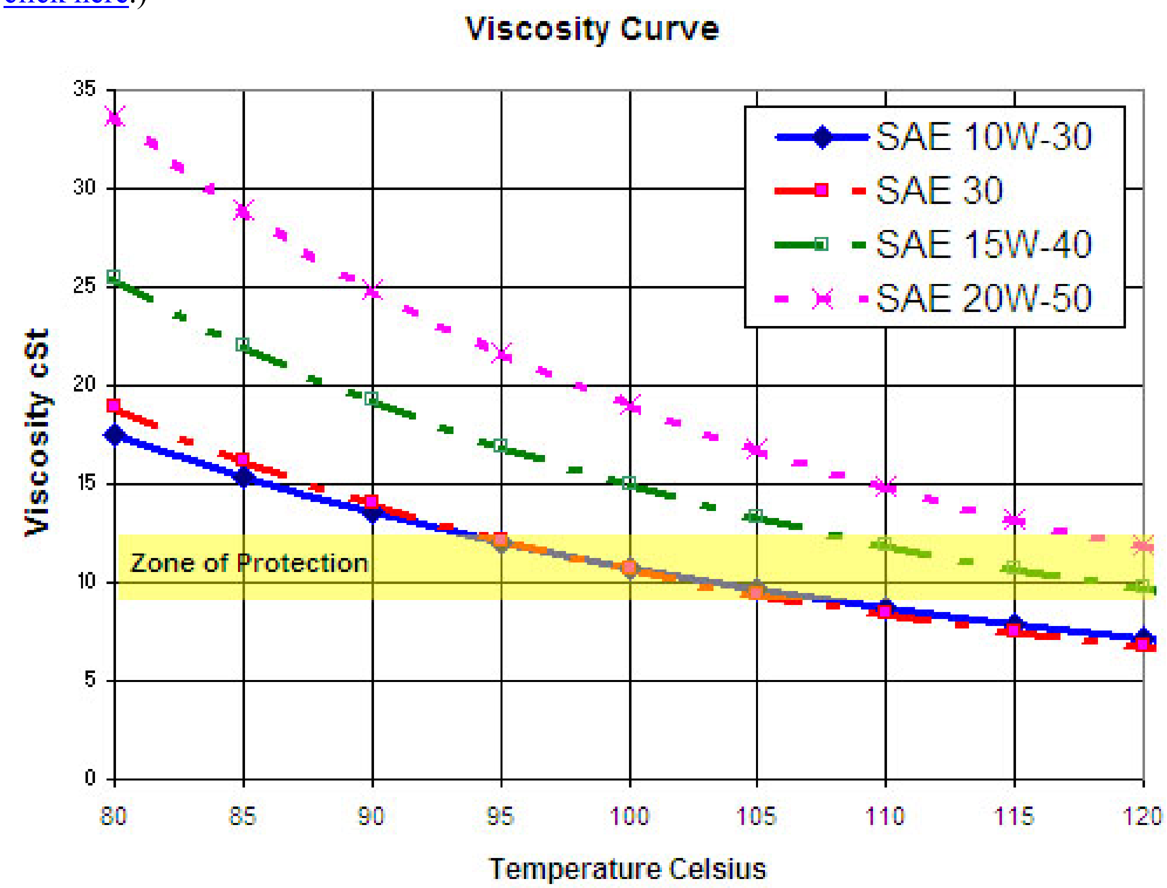
As an example, the 1960 Corvair Service Manual recommends SAE 10W-30 or SAE 30 for most operating conditions anticipated. There were no 5W-30 or 0W-30 oils to recommend in those days, but Chevrolet *apparently* designed this engine to run on oil that is between 9.3 cSt and 12.5 cSt in the bearings. This 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.)



We see here that a typical:

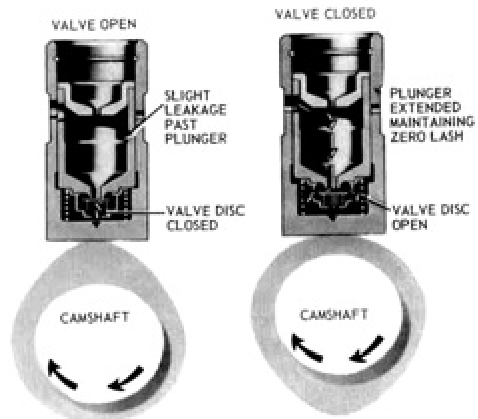
- SAE10W-30 engine oil is in the design viscosity between 92° C and 107° C
- SAE 30 is in the design viscosity between 94° C and 106° C
- SAE 15W-40 is in the design viscosity between 108° C and 121° C
- SAE 20W-50 oil is in the designed viscosity range between 118° C and 130° C.

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.

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.

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.
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 low oil levels, 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

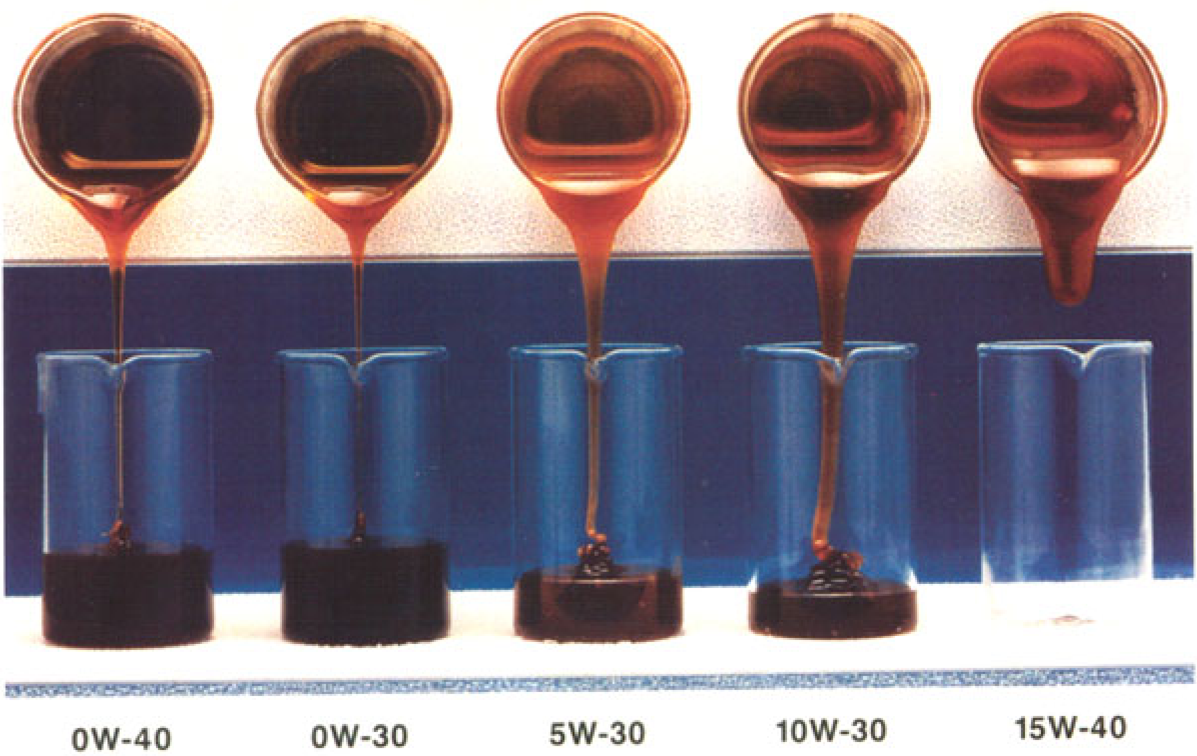
heat after shut-down of the engine or overheating. Turbo equipped cars are more prone to carbon buildup since the drivers frequently shut off the engine without letting the turbo cool off first. The excessive heat then carbonizes the oil in the turbo bearing, sometimes causing it to seize if the engine 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, 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.

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.



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 damages 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 are 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 (legally considered "synthetic" after Mobil lost a law suit 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 that you cannot change to synthetics after using mineral oils.

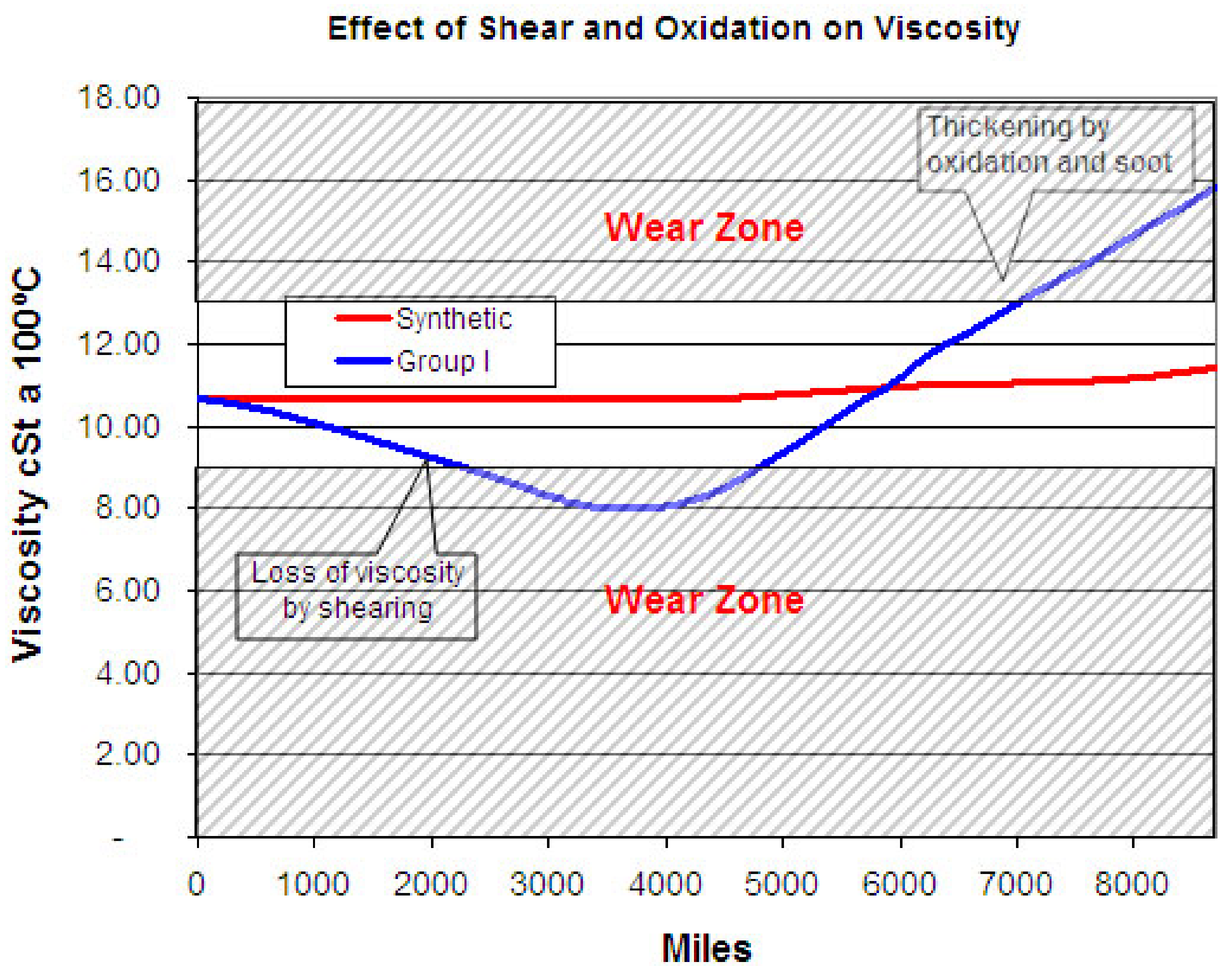
- Group I oils are solvent refined and normally low in natural viscosity index, although some oil fields produce better grades than others. They have 20 to 30% aromatics, high nitrogen and sulfur.
- Group II oils are hydroprocessed oils (or solvent refined and then hydrotreated). Normally 92% to 99% 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 then the necessary solvency and help them maintain a clean engine, softening the seals to avoid leakage.

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.

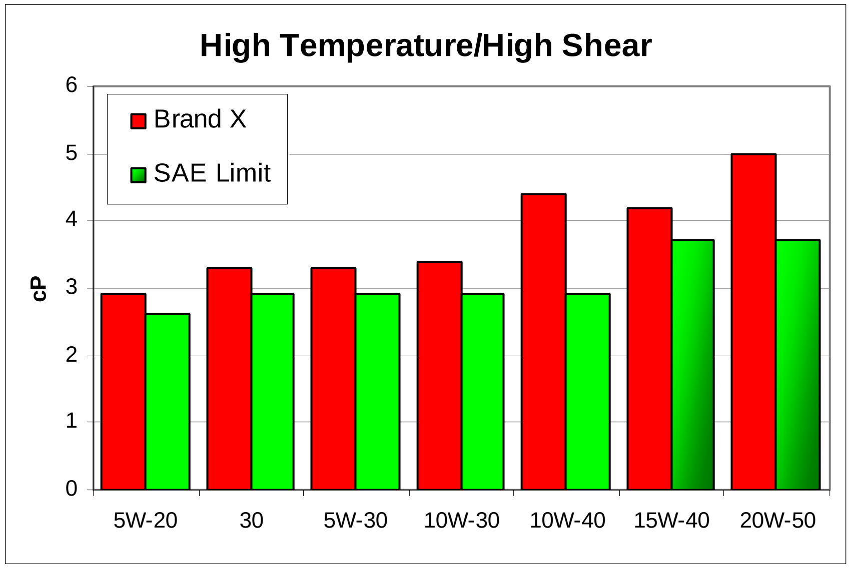
In addition to its use as an anti-wear agent, ZDDP is used in the oils to reduce oxidation. Reduced levels will lead to excess thickening and the formation of acids.

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 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

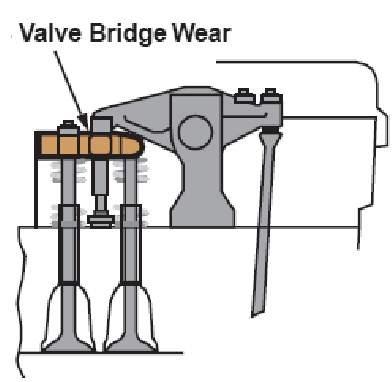
All oils are tested for evaporation for 1 hour in an oven at 250° C in a test called NOAK. An SJ oil is allowed to have 20% evaporation, An SL oil is allowed only 15%, and a CI-4 oil is only allowed 13%. Many synthetic oils are around 5% to 8%. The higher the number, the thicker the oil gets in service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

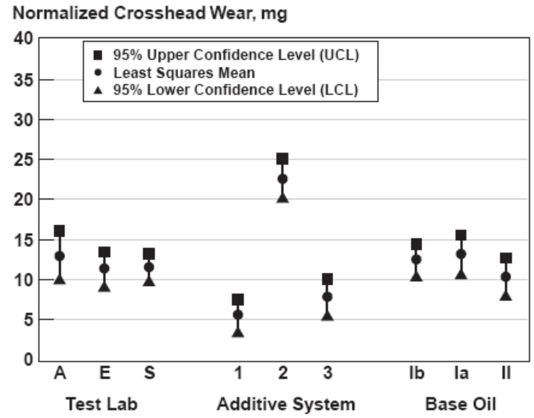
Before we get into detail on additives it is important to understand that the quality of the base oil affects the performance of the oil so much that in general *a Group II oil will have better performance with 10% less additives than a Group I oil*. This means that looking at an oil analysis report 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.

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. 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.

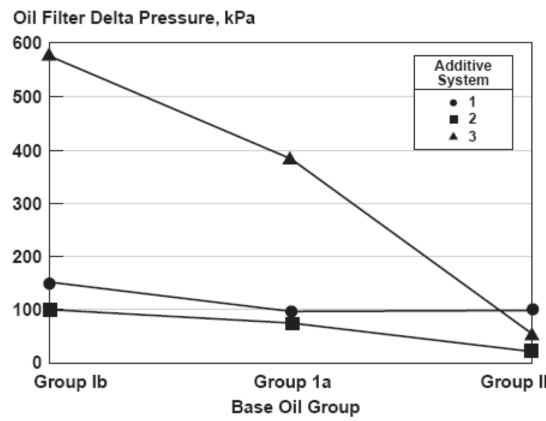


Crosshead Wear

In this test, additive system #2 showed

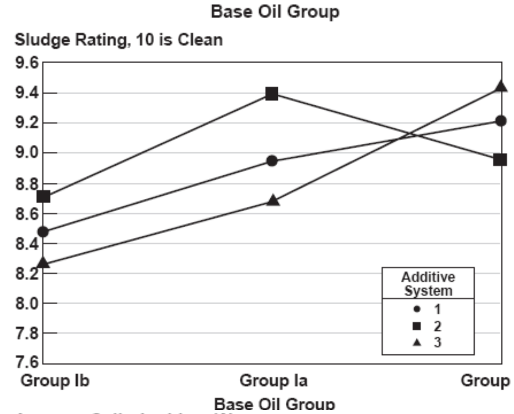
- The highest crosshead wear in the valve train (23 mg vs 6 mg and 8 mg).
- The lowest oil filter restriction (48 psi vs 100 psi and 175 psi).
- The least amount of sludge in the oil pan and rocker covers (a rating of 9 vs 8.85 and 8.8 on a scale of 10).

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



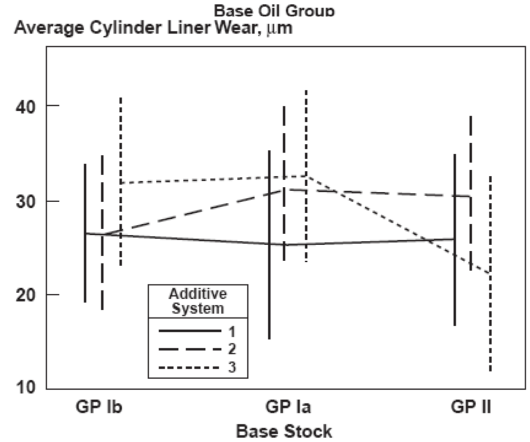
Increase in Oil Pressure from soot

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(▲).

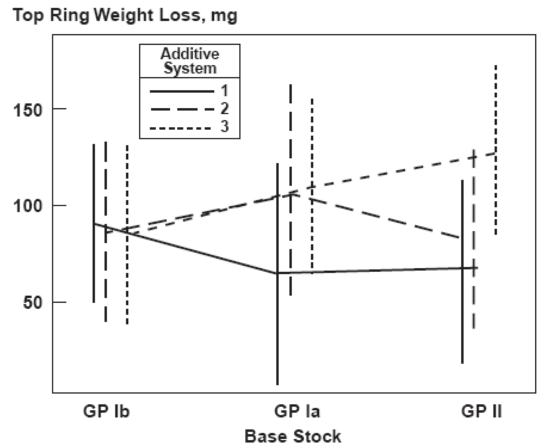


Average Cylinder Liner Wear

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.

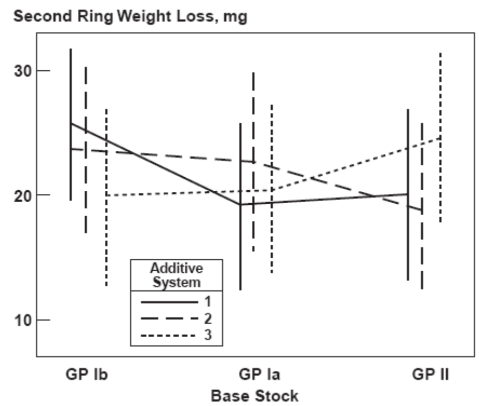
Top Ring Wear

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).



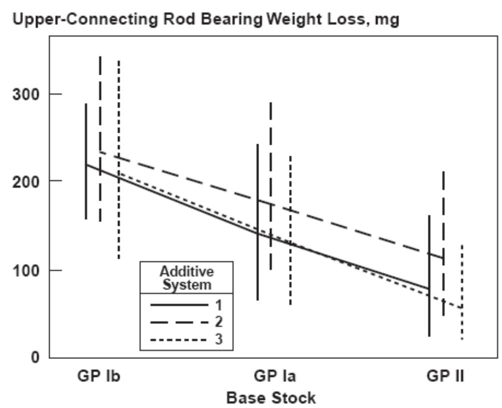
Second Ring Wear

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.



Piston Pin Bearing Wear

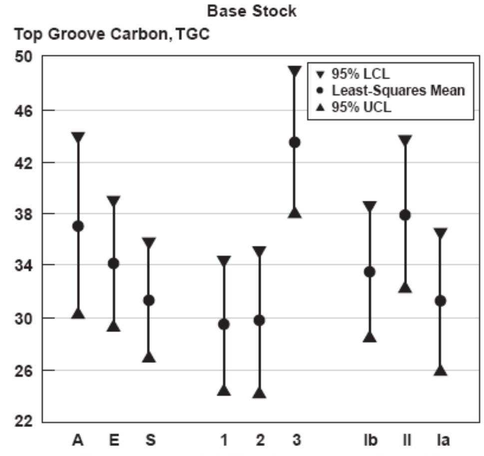
The wear of the piston pin bearing was more dependent on the base oil than the additive system, with the low quality high aromatic/high sulfur base oil allowing double the wear of the group II oil. System 2 showed the highest wear in all three oils.



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 (to limit deposits) by limiting the amount organic-metallic additives.

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 maintain a working thermostat.

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.

Since the additives are polar, they fight for surface area. The addition of 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.

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

SPECTROCHEMICAL ANALYSIS (ppm)

Lab No Condition	Date Taken Tested	Time on Oil on Unit	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
258853 Normal	25-NOV-05 21-DEC-05	322 8008	31	2	0	7	10	6	0	0	11	1	0	9	3051	0	1167	1601	1	0	0	0
242661 Normal	21-OCT-05 28-NOV-05	349 7686	81	4	0	12	11	8	0	0	24	8	2	13	3784	0	1371	1446	2	0	0	0
155043 Normal	18-MAY-05 20-JUL-05	361 6962	23	1	2	3	0	4	0	0	5	2	6	17	3541	0	1084	1263	0	0	0	0
64492 Normal	27-MAR-05 11-APR-05	387 6601	17	1	3	11	0	5	0	0	7	10	6	27	2460	0	1007	1144	5	0	0	0

	Physical Properties						Additional Tests	
Lab No	Fuel	Visc40	Visc100	Water	Soot/Solids	Glycol	SAE	TBN
258853	<1	N/A	16.63	0	0.8	NEG	50	7.3
242661	<1	N/A	15.10	0	0.9	NEG	40	8.6
155043	<1	N/A	15.54	0	0.5	NEG	40	5.2
64492	<1	N/A	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 MSDS 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.

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

"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.

A search of the internet shows that this is actually a Wal-Mart brand made by ExxonMobil, apparently to Wal-Mart 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.

	MI/HR on Oil	
	MI/HR on Unit	
	Sample Date	10/14/07
	Make Up Oil Added	
ELEMENTS IN PARTS PER MILLION	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 MSDS 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.

Be careful of marketing statements made to sell obsolete products. Here are comments from an interview that was printed a couple of 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 250 ppm of zinc and 200 ppm of phosphorous of the 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 that are xW-30 and thinner can be rated SM and must have between 600 ppm and 800 ppm of phosphorous. They can also 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 the API classification is based on performance, not additive content.

If there is a CJ-4 in front of the SL or SM, it is limited to 1200 ppm of phosphorous. This means that the phosphorous limits for the following products, copied from the API site (http://eolcs.api.org/) are:

Motorcraft 10W-30: 1200 ppm

Monolec Ultra 15W-40: Unlimited

Supreme 5W-20 SM: 800 ppm

Supreme 5W-30 SL: 1000 ppm

Supreme 10W-30: Unlimited

Mobil 1 5W-30: 800 ppm

Mobil 1 Extended Performance 10W-30: 800 ppm

Company	Brand Name	Viscosity	API Certification
FORD MOTOR COMPANY	MOTORCRAFT SUPER DUTY	10W-30	CF-4,CG-4,CH-4,CI-4,CJ-4/SM
LUBRICATION ENGINEERS INC	8801 MONOLEC ULTRA	15W-40	CF,CF-2,CH-4/SM
AMERICAN PETROLEUM COMPANY, INC	SUPREME	5W-20	SM*
AMERICAN PETROLEUM COMPANY, INC	SUPREME	5W-30	SL*
AMERICAN PETROLEUM COMPANY, INC	SUPREME	10W-30	CF-4,CG-4,CH-4,CI-4/SL
SHELL LUBRICANTS - SOPUS PRODUCTS	ROTELLA T	15W-40	CF-4,CG-4,CH-4,CI-4,CJ-4/SM**
EXXONMOBIL OIL CORPORATION	Mobil 1	5W-30	SM/CF*
EXXONMOBIL OIL CORPORATION	MOBIL 1 EXTENDED PERFORMANCE	10W-30	SM/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.

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% or the original value, but that might be 6 in some oils and 3 in others.) 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. 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 under filled.*

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.

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.

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: Cbest Products, from there I can see the 5W-40 I have 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 msds), but it has shown excellent results in several engines when I've analyzed it.

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[1], SH[1], SJ
  - — Energy Conserving for API SH[1] (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 cSt at -40°C cSt at 40°C cSt at 100°C	 11,000 52.2 10.3	 — 96.6 15.6
Viscosity, Cold Crank, °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.

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 that 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* (note 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.

6. If you want the maximum valve train protection, look for an oil that is certified CH-4/SL or CI-4/SL without CJ-4. If the CH-4 or CI-4 comes before the SL, that is fine. Oils that are only SL certified have less anti-wear additives.

7. You do not want the API starburst. That is what tells you that it meets all the reduced phosphorous levels for catalytic converters.

8. The SM oils are not the end of the world. They use no-ash antioxidants and better base oils than a lot of other oils. Wholesale price of an SM is about 6% 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 CH-4/SL or CI-4/SL 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.

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 this 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 and add a 1200 mile engine cleaner. At the end of that cycle we move to whatever oil the engine should have.

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. 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 oils in the blend, you may also notice some smoking as when increasing detergency. This will go away in a few thousand miles.

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 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 it to good oil. I still wouldn't buy a group I oil, but 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 3rd 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. 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.

23. When changing oil, always change the oil filter. You should not pre-fill the filter unless you do it from the outer ring holes. Any oil that goes into the center will reach the engine unfiltered (and there is no cleanliness standard for new oils).

24. 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.

25. 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.

26. **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.*

27. After rebuilding an engine, your first oil and filter change should 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).

28. 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 15 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.

29. 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 1st and 2nd gear.

    I use group II CI-4/SL oils in my 4x4's and change them every 4000 miles, mostly dirt roads or city driving. 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. After break-in I will do the same with my Corvair. I have determined that these are safe limits based on used oil analysis (more than 4000 samples).

30. 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 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 4000 miles while another 2.7 L Toyota shows 991 ppm of iron in 2000 miles. These differences are used to change 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.

31. If you have your oil analyzed, don't draw too many conclusions until the 3rd oil change. An oil with little detergency will have left sludge and wear particles embedded in various crevices of the engine that will take a 10,000 miles or more to clean up with a good oil.

32. **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 it.

33. **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. 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^{0}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 show reduced detergency and not

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

necessarily high ZDDP. Typically 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 MSDS 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.

34. 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.

35. 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.

36. 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 SM 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 SM oil, it may have a higher level than an SF, but it is no where near what would be a ***benefit***.

37. 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 we find that Mobil Delvac 1300 Super is 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 hasn'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. If I say Shell makes a satisfactory product, some will take that as a negative comment and others will go out and buy anything with the Shell label. *You should get and read the spec sheet*, but at the very least *you must read the label*. As an example, here are *a few* of the products Shell has registered with the API for the US. (This is not en endorsement of Shell products.) Here you can see that:

   i. Rotella T would be limited to 1200 ppm of phosphorous

   ii. Rotella T CI-4 would not be limited.

   iii. Rotella T CI-4 Plus **probably** has about 200 ppm more than their CI-4.

Brand Name	SAE Viscosity Grade	Service Category
FORMULASHELL	10W-30	SM*
FORMULASHELL HMF (HIGH MILEAGE FORMULA)	10W-30	SM
SHELL RIMULA PREMIUM	10W-30	CF,CF-4,CG-4,CH-4,CI-4/SL
SHELL RIMULA SUPER	10W-30	CF-4,CG-4,CH-4,CI-4,CJ-4/SM**
SHELL ROTELLA T	10W-30	CF-4,CG-4,CH-4,CI-4,CJ-4/SM**
SHELL ROTELLA T CI-4	10W-30	CF,CF-4,CG-4,CH-4,CI-4/SL
SHELL ROTELLA T CI-4 PLUS	15W-40	CF,CF-4,CG-4,CH-4,CI-4/SL**
SHELL ROTELLA T SB	10W-30	CF,CF-4,CG-4,CH-4,CI-4/SL
SHELL ROTELLA T SB	10W-40	CF,CG-4,CH-4,CI-4**
SHELL ROTELLA T SYNTHETIC	5W-40	CF,CF-4,CG-4,CH-4,CI-4/SL**
SHELLFLEET	15W-40	CF,CF-4,CG-4,CH-4,CI-4/SL

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.

There are currently 438 companies in the USA with API licenses to make motor oil. Many of them have 20 to 40 different oils registered. That is more than 10,000 oils to choose from. Here are a few choices. 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.

The fact that I am listing some 15W-40 oils does not mean I would use them in a Corvair engine. It is to show some differences and because I know that some people will continue to use thicker oils.

ExxonMobil http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=0020

- **Mobil 1:** I'm sure Mobil 1 is an excellent oil for the average car. They have a lot of technology and blend for the high end masses. Unfortunately all of the normal **Mobil 1** products have been reduced to SM/CF or SL/CF. This severely limits the sliding protection we are looking for in an oil for flat tappet engines.
- **Mobil 1 High Mileage** is the same. It might have a little more seal swell or other additives, but it is still registered as an SL.
- **Mobil 1 Diesel Truck & SUV** is the same. SM/CF in its offering as a 5W-30
- **Mobil 1 Turbo Diesel Truck**, however looks very recommendable with a registration of CI-4/SL. It is only offered as a SAE 5W-40, but that covers a wide enough range of temperatures that it should not be a problem in most areas. *This appears to be a traditional synthetic formulation, so it would be on my list for* ***synthetic****s, but note its thickening at low temperatures in the graph below.*
- **Mobil Delvac 1 5W-40** appears to be the same or very similar to Mobil 1 Turbo Diesel Truck, so would also make *a on the list for* ***synthetic,*** *but note its thickening at low temperatures in the graph below.*
- **Exxon XD-3 Extra Range Oil** appears to be the only ExxonMobil 10W-30 product that meets the CI-4/SL criteria. The MSDS shows that the base oil is "severely refined" *implying* a group II oil. *I would therefore classify this oil as one of the top choices for a* ***Non-Synthetic.***

Shell Lubricants: http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=1064 The following API registrations are listed. I cannot find any source on line that gives product specs, although some MSDS are listed by third parties.

- **Shell Rimula Premium** 10W-30 and 15W-40 are registered as CI-4/SL products. I cannot find more information on this product.
- **Shell Rotella T CI-4** 10W-30 is registered as CI-4/SL. This appears to be a group II oil, *so I could add it to the list for* ***Non-Synthetic*** *oils.*
- **Shell Rotella T CI-4 Plus** 15W-40 is registered as CI-4/SL. This also appears to be a group II oil. *Perhaps a good choice in* ***non-synthetics*** *if you want a high viscosity oil.*

- **Shell Rotella T SB** 10W-30 is registered as a CI-4/SL. This is a synthetic blend, apparently made from group I, group IV, and group V base oils. *A decent choice between the synthetics and others.*

- **Shell Rotella T Synthetic** 5W-40 is registered as a CI-4/SL. This appears to be a group III product. This could qualify on the *low end of the **synthetics** (since it is only group III).*

Pennzoil Product Company: http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=0012 The following registrations are listed. Probably due to the fact that most of their sales are Jiffy Lube sales, most of their offerings are SM/CF.

- **Long Life Heavy Duty** 10W-30 and 15W-40 are registered as CI-4/SL. (Long Life Gold is a CJ-4). This product is made with Purebase, which is supposed to be group II.

- **Synthetic Blend (SUV, Truck and Minivan)** 15W-40 is registered as a CI-4/SL. Their site only shows a SM version of this product. It apparently has between 10 and 30% synthetic according to its MSDS.

Chevron Products Company: http://eolcs.api.org/DisplayCompanyInfo.asp?CompanyID=226581 Between the Chevron and Texaco brands, there are a lot of offerings. Here are those that might interest us.

- **Caltex Delo Sports Synthetic Blend** 5W-40 is registered as a CI-4/SL. This is listed in the API registration but not the Chevron site. It may be export only.

- **Chevron Delo 400** 10W-30 is registered as a CI-4/SL. This a group II (ISOSYN) product. *This would be an excellent choice in a **non-synthetic***

- **Chevron Delo 400 Multigrade** 15W-40 is registered as a CI-4/SL (note that Chevron Delo 400 **LE** is a CJ-4) This a group II (ISOSYN) product.

- **Chevron Delo 400 Synthetic** 5W-40 is registered as a CI-4/SL. *This is an excellent **synthetic***, however it uses a group III base oil. It is currently in my BMW.

- **Chevron RPM Heavy Duty** 10W-30 and 15W-40 are registered as CI-4/SL. This appears to be a group I base oil. *I'd put it on the list, but toward the bottom.*

- **Texaco Ursa Premium TDX** 10W-30 and 15W-40 are registered as CI-4/SL. This product is licensed, but no longer shown on the Chevron product list or their MSDS list. (note that Their TDX **EC** is a CJ-4.

- **Texaco Ursa Premium TDX Synthetic** 5W-40 is registered as a CI-4/SL. This is also a group III product, probably the same or very similar to the Delo. *A good choice in synthetics.*

BP Products (includes Castrol): http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=0021

- **Castrol GTX Diesel** 15W-40 is registered as a CI-4/SL. This appears to be a group I base oil.

- **Castrol Syntec Blend Truck & SUV** 15W-40 is registered as a CI-4/SL. It appears to be a blend of group II and group III base oils. The other viscosities are registered as SM.

- **Castrol Tection Extra** 10W-30 is registered as a CI-4/SL, while the 15W-40 version is registered as a CJ-4/SM. I can only find the 15W-40 on their web site.

- **Castrol Tection HD** 10W-30 and 15W-40 are registered as CI-4/SL. This appears to be a blend of group I and group II base oils. *This would be near the bottom of my list.*

Citgo Petroleum Corporation: http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=0080

- **Citgard 600** 10W-30 is registered as a CI-4/SL, while Citgard 15W-40 is registered as a CJ-4/SL. This is a blend of group I and group II base oils. *I'd add it near the bottom of the list.*
- **Mystik JT-8 Synthetic Blend Super Heavy Duty** 10W-30 and 15W-40 are registered as CI-4/SL. It has 20% to 40% group III base oil blended with group I base oil. This one might be near the middle of the list somewhere.

ConocoPhillips (76 Lubricants): http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=0055 Their MSDS are very generic, not specifying what base oils they are using. One spec sheet is specific about the use of group II, so I assume the rest is group I.

- **76 Guardol QLT** 10W-30 and 15W-40 are registered as CI-4/SL. It appears to be a group I oil. *This would put it near the bottom of the list.*
- **76 Royal Triton QLT** 15W-40 is registered as a CI-4. It is a blend of group II and group IV base oils.
- **76 T5X Heavy Duty** 10W-30 and 15W-40 are registered as CI-4/SL. It appears to be a group I oil. *This also goes near the bottom of the list.*

Petro Canada: http://eolcs.api.org/DisplayCompanyInfo.asp?CompanyID=227023

- Duron 10W-30 and 15W-40 are registered as CI-4/SL oils. This appears to be a mixture of group II and group I base oils.

  "Mixture of severely hydrotreated and hydrocracked and/or solvent-refined base oil (petroleum) and other proprietary, non-hazardous additives."
- Duron Synthetic 5W-40 is registered as a CI-4/SL oil. This appears to be either group III synthetic or a mixture of group II and group III.

  "Mixture of severely hydrotreated and hydrocracked base oil (petroleum)."

Royal Purple: http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=0777 All three of these products appear to be mixtures of traditional synthetic oils and group II oils. *Any of the three would be on the list*, with the exception of that much group II in a 10W-40.

"Base Oil (synthetic) . Synthetic additives with iso-paraffinic diluents."

- Royal Purple 10W-30 and 10W-40 are registered as CI-4/SL oils, while the 15W-40 is a CJ-4.
- Royal Purple Long Rider 10W-30 and 15W-40 are both registered as CI-4/SL oils.
- Royal Purple Long Rider Plus 10W-30 and 15W-40 are also both registered as CI-4/SL oils.

Valvoline: http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=0028

- **All Fleet Plus** 10W-30 has two registrations, one as a CI-4/SL and the other as a CJ-4/SL as a separate product. I can only say: Read the label. It is a brand new license, so it should be accurate. This is a group II product. It would not be on my list unless I saw on the label that it was not a CJ-4 product.
- **Premium Blue Classic** 15W-40 is registered as a CI-4/SL, but "Premium Blue Conventional" is only an SM. This also appears to be group II.

Amsoil: http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=0995 It surprises me that the API web site shows Amsoil has only registered 15W-40 viscosities in the CI-4 category. There are several apparently good Amsoil products on their site, but I don't know why they aren't registered. *Any of these three could be fairly high on my list*, especially the AMO and the ACD.

- **PCO 15W-40** 15W-40 is registered as a CI-4/SL. Their spec sheet and MSDS show it as a synthetic blend of group II and traditional synthetic oil, but does not identify the percentage.
- **AMO Synthetic Premium Protection Motor Oil** 10W-40 is not listed in the API site, but the Amsoil site shows it is CI-4/SL, with excellent NOAK and HTHS (4.3 cP). *Note below that in low temperatures it has a lower viscosity than several 5W-40 synthetic oils.*
- **ACD Synthetic 10W-30/SAE 30 Heavy Duty Diesel Oil**: This oil is not listed on the API site, but shows very good numbers. It appears to be a pure synthetic, although I cannot see whether it is group III or a group IV/group V combination.

Schaeffer Manufacturing: http://eolcs.api.org/DisplayLicenseInfo.asp?LicenseNo=0032

- **Supreme 7000 Synthetic Plus 15W-40** is registered as a CI-4 but on the Schaeffer web site it is a CJ-4 made from a blend of "parasynthetic base oil with paraffinic base oil". It appears to be a combination of group I, group II, and group III base stock blended with 10 to 20% group IV.
  - Complex Mixture of Distillates,(petroleum), hydrotreated heavy paraffinic and distillates, (petroleum) of solvent dewaxed heavy paraffinic and hydrotreated and severely hydrocracked base oils.
  - Polyalphaolefin Synthetic Base Fluids

Brad Penn: These oils are not registered with the API, but I was asked to look at them. (This doesn't mean I'll look at all 10,000+ oils in the US market).

- BRAD PENN® *PENN-GRADE 1®* 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. I do not see specific values for zinc and phosphorus although the 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, even though all their 10W-30 and 15W-40 oils are CI-4/SL group II+, and their 10W-40 is a CI-4/SL 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.

As you can see, with the exception of a couple of products, I've had to go to the 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 or 15W-40) 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.

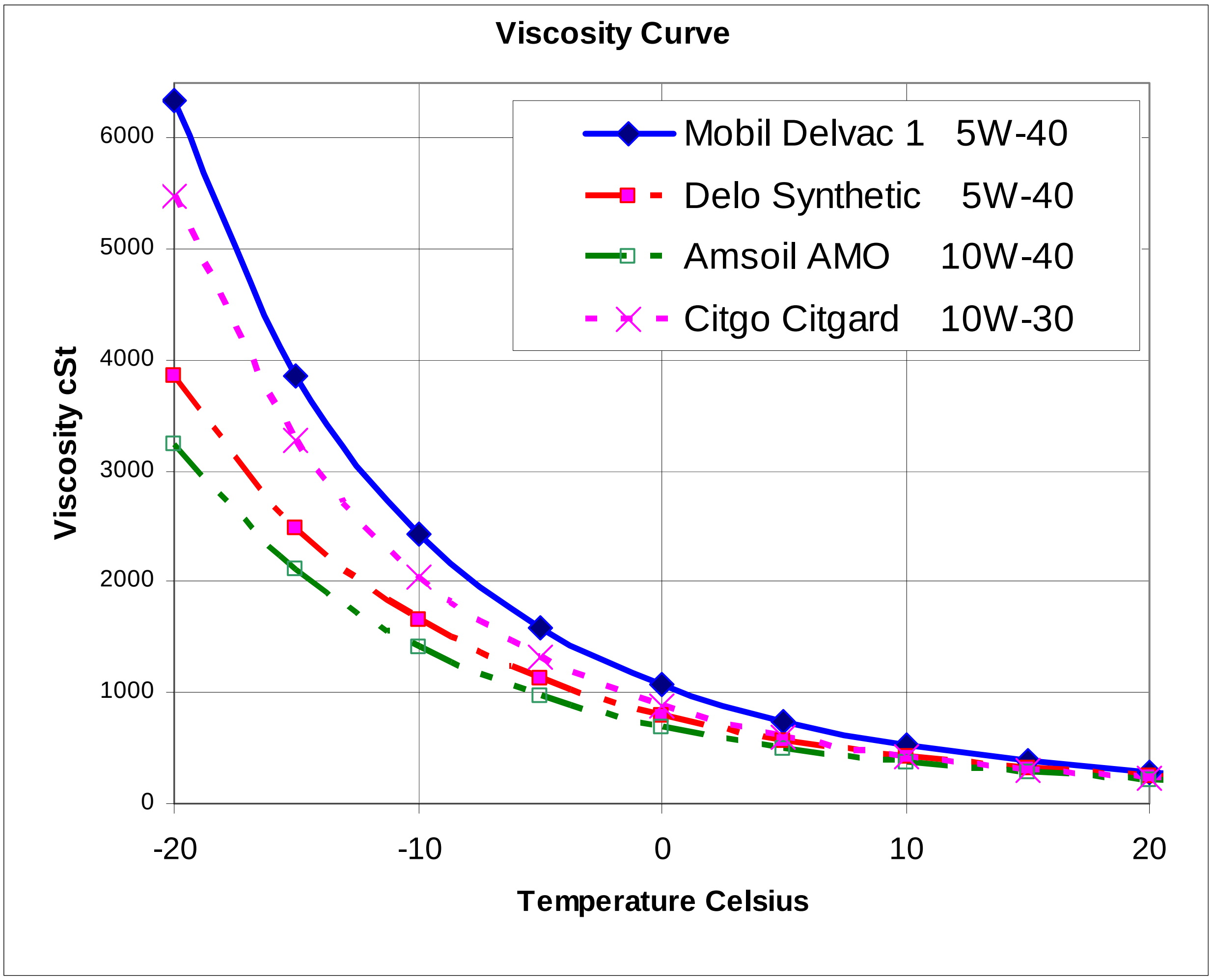
Obviously price and availability are considerations. Look through the oils on the shelf, read the labels and look up the specs and MSDS information if you want the details. Then stick with that brand to get the best results over the long run.

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 warrantee period without problems, you can read the label and chose 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.*

Finally, in the viscosity section we talked about the difference in behavior between a *mineral oil with it's 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 4 oils from *the list;* the Citgard 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.

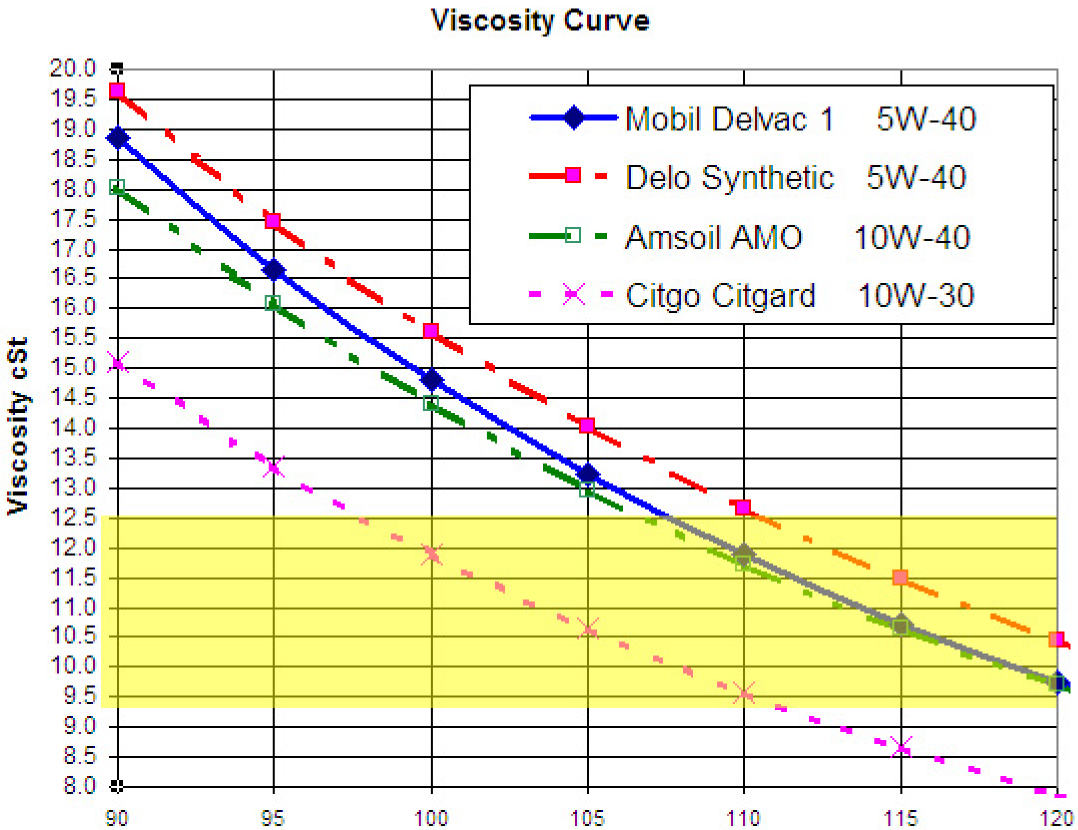
The Amsoil 10W-40 is by far the best oil in cold weather. It is 30% thinner than the 10W-30 mineral oil at -4° F. This Amsoil 10W-40 is ½ the viscosity of the Delvac 1 5W-40 (which is the same as the Mobil 1 Turbo Diesel Truck 5W-40) at this temperature. The viscosities don't get close until they are 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/or extremely hot climate to avoid premature wear and damage to the valve train *(note an exception below).* I would not recommend any *mineral oi*l that covers a spread any bigger than that since they will shear down under stress.

Here is a brief look at four 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. Note that the Castrol Syntec, while being legally called a synthetic, is a group III product. That probably explains why it shears down to 3.7 under pressure, making it thinner than the average 40 weight when you really need it. They do not show their viscosity at 40° C or the viscosity index (from which we could calculate the low temperature properties). Brad Penn lists a 10W-50 with the API, but not on their site.

Oil	Viscosity	API	100° C	40° C	HTHS	Base Oil
Amalie Elixir Full Synthetic	5W-50	SM, SL, CF	17.5	110		????
Castrol Syntec Full Synthetic	5W-50	SL/CF	17.3		3.7	"Base oil – highly refined"
Mobil 1: Canada, Australia	5W-50	SM, SL/CF	17.3	105	4.22	Traditional Synthetic
Top 1 8000 Full Synthetic	5W-50	SL/CF	19.9	132		?????
AMSOIL High Performance Synthetic 20W-50 Motor Oil	20W-50	CI-4+/SL	18.4	115.7	5	Traditional Synthetic
Brad Penn Partial Synthetic	20W-50	SJ/CF	20	159	6.2	Part Synthetic group III

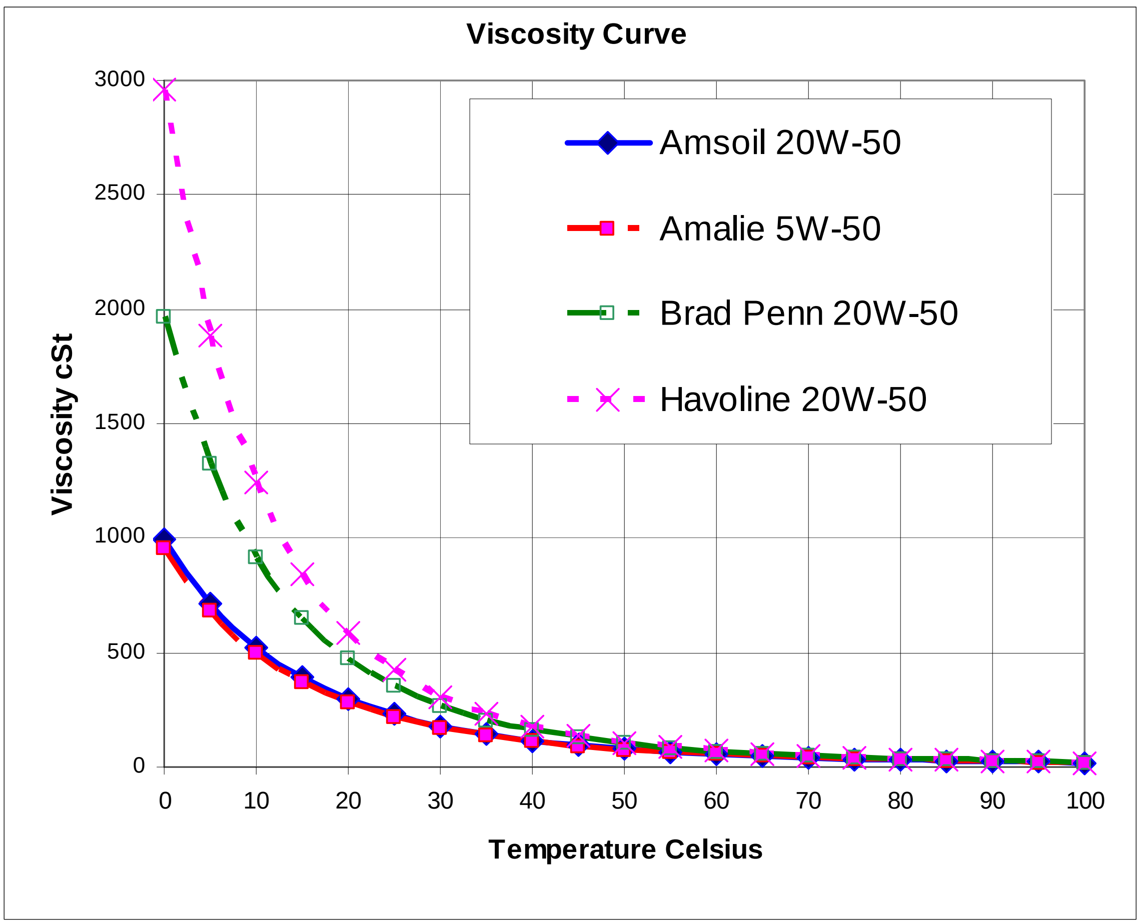
Havoline	20W-50	SM	18.5	175		Mineral

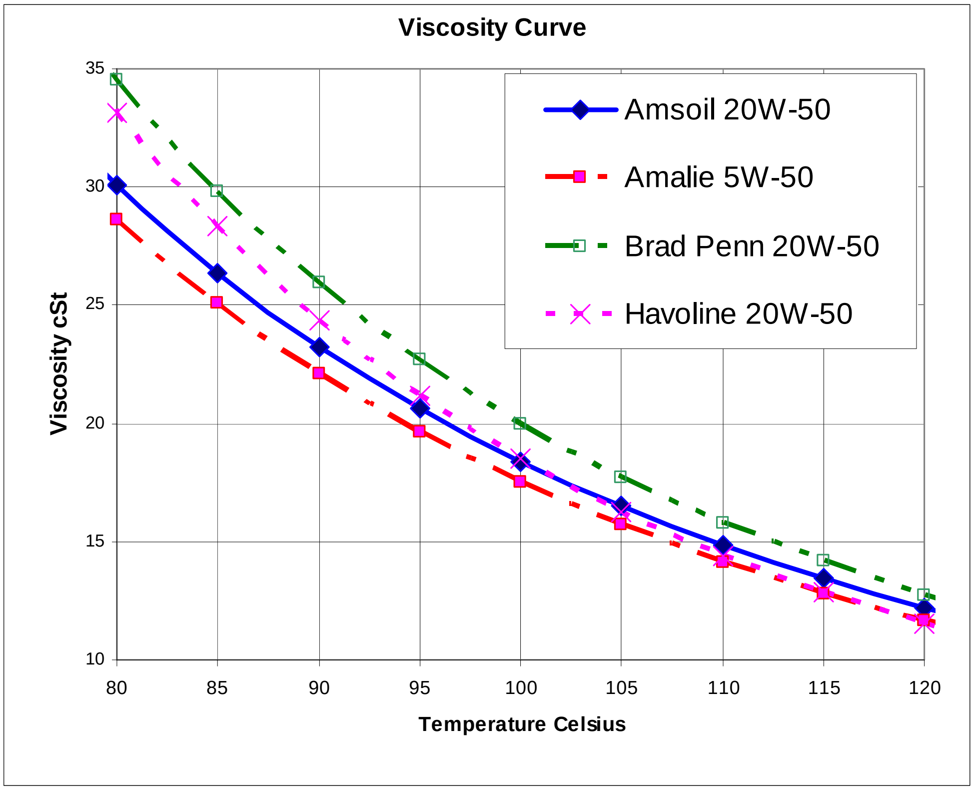
Note that in of the 5W-50 oils, even the Mobil 1 (that I could only find in Australia and Canada) shears down to less than the better 10W-40 oils (Amsoil AMO is 4.33 cP). The "Top 1 Full Synthetic" is considerably thicker than the rest at both low and high temperatures, but they do not show their base oil, an msds, or HTHS.

I have included two more traditional 20W-50 oils: Brad Penn and Havoline. You can see how viscous the Havoline in cold temperatures and how thin it is at operating temperatures. The Brad Penn product's formulation reduces its thickening in the cold and its thinning at operating temperatures. Since a number of people have mentioned their preference for Castrol GTX 20W-50, I tried to include them here, but their spec sheets are too incomplete to be meaningful.

But note also that viscosity of the Amsoil 20W-50 is close to the 5W-50 oils at 40° C. It appears from their spec sheets that with a 3600 Cold Crank Test at -15° C, their 20W-50 oil could be labeled as 10W-50 or 5W-50. According to the SAE J300 table, it is allowed to be as thick as 9500 cP at -15° C, but it only thickens to 3600 cP. The xW rating is based on maximum viscosity at a given temperature, with no minimum.

Here you can see what happens with these oils at low temperatures. The Havoline 20W-50 is very viscous and slow to pump. The Brad Penn, while labeled the same, is 1/3 thinner, and the Amsoil is 2/3 thinner, tied with the 5W-50 of Amalie.





Between 100° C and 105° C the Havoline (and other similar mineral oils) goes from the thickest to the thinnest. Brad Penn maintains the most viscosity, while Amsoil becomes the second most viscous. At about 165° C (temperatures found in turbos) the Amsoil product becomes the thickest.

I think in general the 5W-50 oils should generally be considered special application oils, and it will take careful analysis of the products available for any application to determine their usefulness for a specific purpose. There is too much shear and too much variation to go take a stab in the dark based on a brand.

So what is my bottom line recommendation in xW-50 oils? *Of all the specs I could find* (in a reasonable amount of time), there are only two oils in this group with excellent pumpability, and excellent high temperature protection. Amsoil's 20W-50 is the only one of these that also shows excellent shear strength, and tops it off as a CI-4/SL. It might not be the best option for catalytic converters because of the phosphorous content, but based on available data from this selection, it would be at the top of my list. I would use this in any engine where 5W-50, 10W-50 or 20W-50 is recommended

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 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.

The following is a list of the SAE 5W-30 and 10W-30 oils listed as CI-4 at this moment on their website: http://eolcs.api.org/FindBrandByServiceCategory.asp?ServiceCategory=CI-4

Please remember that this printed list subject to change. There are actually some licenses listed on the API site that have expired.

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