The Difference between GL-4 and GL-5 Gear Oils
by Richard Widman

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The original target audience for this paper was my group of friends in the Corvair world, but it applies to all cars and is particularly important for all classic cars.

There is a lot of confusion about gear oils and the API classifications. In this paper I will try to differentiate the two oils and clear up the mysteries that are flying all over the internet. It is extremely common, or normal, for all GL-5 oils to claim they cover the API GL-4 requirements for gear oils. ***This is a true statement.*** Does that make them satisfactory for synchromesh or synchronized transmissions? **NO!** They meet the GEAR OIL specifications, not transmission oil specifications. The API GL-4 and GL-5 categories do not mention or have anything to do with transmission synchronizers.

History:
The gear oils of a few decades ago had lead additives that were effective at wear reduction, but not very good for the environment. A long time ago they began to be replaced by gear oils with a phosphorous additive (in itself a decent anti-wear additive) with active sulfur to grip hold of the gears and create a very solid sacrificial layer of material that could be worn off, thereby protecting the gear surface. Eventually it was discovered that the active sulfur was causing corrosion of brass and other soft metals used in differentials and transmissions.

Somewhere around 25 years ago a deactivated or buffered sulfur was developed that would react with the phosphorous to create the protective/sacrificial layer in the conditions created in the gear boxes (temperature and pressure) without being corrosive to the brass, copper, etc. **This additive system is used in most gear oils today.**

The problems arise when we try or need to use the same product in the transmission that we use in the differential. Many people have called oil companies and been told by the "Techs" that answer their questions that their oils have buffered sulfur and therefore are not corrosive to yellow metals, so their GL-5 oils can be used with brass components. While that answer is totally correct, it does not address the question asked: *Can I use your GL-5 in my synchromesh transmission?*

Let's take a look at the API GL-5 rating. It is a rating for EP (Extreme Pressure) protection. The higher the EP protection, the higher the GL category. In the mid 60's, Ford needed better protection in their pickup trucks and GM developed the front wheel drive Oldsmobile Toronado that had a differential with a very high angle of contact for power transmission to the wheels so a higher category was developed (later to be called GL-6) to offer the protection needed. This level of protection can still be claimed, but can no longer be tested since the Toronado rig used to test it is no longer available. (Note: The 1966 and 1967 Toronados had sun gears between the axle shafts instead of spyder gears and a very high offset, while suffering from the high temperatures of the engine compartment and very high pressures.) This is why you will frequently see GL-6 listed as "obsolete". The test is obsolete, not the car or its needs. Many other high performance cars continue to spec this level of EP performance.

In normal operation, the sulfur/phosphorous additive forms a black sacrificial coating on the gears and anything it touches with a little pressure and temperature. As the gears turn, instead of wearing, the sacrificial coating of additives is peeled off or worn off. This is normal and acceptable in all steel gears. But when one or more of the surfaces is brass or another soft metal, the sacrificial coating is stronger than the base metal, and instead of just peeling off, it takes with it a few microns of brass that it is bound to.

A traditional GL-4 gear oil of any given viscosity has about ½ of the level of sulfur/phosphorous additive that would be in the GL-5 product, so the bond is not as strong, and therefore can be peeled off without peeling a layer of brass (or less brass). This means that the GL-4 product provides a little less extreme pressure protection, so in the differential of a high-powered car, it would not be the ideal product in the differential. To understand this need we should be aware of the fact that the differential is where the final torque is applied to the wheels (in most applications).

But in the transmission, we should consider two factors:

- Due to the fact that the differential applies the final torque, normally we do not need the full EP protection in the transmission where less torque (about 30%) is applied.
- We need to be able to break the EP protection to stop the spinning of the gears long enough to mesh them or synchronize them.

When we use a GL-5 product in a transmission that requires GL-4, we normally find 2 to 4 times as much copper in the used oil as we would with a GL-4 product (with used oil analysis). Eventually the synchronizers wear to the point that they no longer make contact with the other half of the cone, bottoming out before stopping the opposing gear. (*Refer to the picture below*.)

GL-3

It should be noted that while GL-3 is frequently considered obsolete since it has less protection than the GL-4, some transmission manufacturers today specify GL-3 (Chrysler and Mitsubishi among them). There are many formulations of GL-3 oils in the market, some with sulfur/phosphorous additive and some with zinc/phosphorous. Almost any diesel motor oil classifies as a GL-3 or GL-4 in gear protection.

Synchromesh transmission oils

General Motors, Honda and others have developed oils that combine the best shift characteristics with their transmission components for reduced wear. These products in general could classify as GL-4 oils if they wanted to, but actually when we analyze their components they are very similar to 5W-30 diesel motor oils, with a few friction modifiers added. The viscosity is closer to an ATF. They are way too thin for a Corvair transmission or any other where a SAE 80W-90 or 75W-90 is recommended.

Modern transmission oils

I am getting questions about the application of traditional GL-4 or GL-5 oils in modern cars or the use of modern transmission oils in classic cars, so let's look into them.

A lot of study has gone into the development of oils that are more slippery, more protective, and more efficient. The current emphasis on fuel economy has driven many new transmission designs and oils to match them. The economy gains have come with gear and machining design (smaller synchronizers with double sided contact surfaces fused onto the ring) in an assembly that not only permits, but requires, thinner oils. They also cannot tolerate sulfur/phosphorous additives in the oil, depending on friction modifiers and new compounds to achieve GL-4 or better performance. This can become confusing, as few lubricant manufacturers state their ingredients. All you see are claims for performance or recommendations for their own brand. In most cases these new formulations are much better for the transmission and its efficiency.

For the most part these are SAE 75W-80 and 75W-85 oils. Way too thin for most classic cars, but necessary for modern cars. The additive package uses magnesium or calcium sulfonate compounds and often synthetic base oil, and will give you better EP protection than a GL-4 sulfur/phosphorous oil.

Many of these claim GL-4+ performance and pass most of the old GL-5 and SAE J2360 extreme pressure tests, but additionally pass manufacturers tests for synchronization. The problems of where to apply them lie with the auto manufacturers, where, for example, Toyota specifies in their owner's manual, their SAE 75W without defining the rest of it. Oil sales people will sell you 75W-90, but what Toyota is really asking for is 75W-85 without sulfur/phosphorous. From the comments I receive, a standard SAE 75W-90 GL-4 does cause hard shifting and grinding in these Toyotas in 70ºF weather.

Nissan has the same problem with 75W-90 oil, but their manual clearly states 75W-80 for 6 speed transmissions and 75W-85 for 5 speed transmissions. It does not specify "non sulfur/phosphorous" oil, instead referring to "Genuine Nissan Oil" (which does not contain those additives).

VW calls for 75W oil that meets their spec. They are looking for a viscosity on the low end (or slightly below) of a 75W-80 and no sulfur/phosphorous additives.

With these new non-sulfur/phosphorous oils giving a minimum of GL-4 extreme pressure protection, I believe manufacturers will stop specifying GL-3 when they revise their manuals. Recommendations are also coming out from the additive makers to use these new formulations in place of the older Synchromesh Fluids.

Transaxles

So, what do we put in transaxles where the transmission and differential are combined in one unit? This is a good question, and the answer lies in the design and surface area of the gears. If the contact surfaces of the gears are big enough to carry the weight and torque necessary, we depend less on the oil and its additives. If the surface area is compact, we need to depend more on the additive's ability to handle the boundary lubrication. When we have transaxles, we have to depend on the manufacturer to tell us what product is correct.

When we have transaxles, we also need to be aware of whether the differential portion uses *Limited Slip* "LSD" technology of some kind that limits the slipping of the wheels in mud and snow. This requires an additive that lets a clutch bind the wheel movement together at a certain speed differential of the wheels. This additive can be in any oil. Many GL-5 oils have a small amount. This is often enough for some differentials as long as they were not rinsed out. Some systems need more additive than others. You can usually tell if you need more additive by making a U-Turn. If the inner wheels click or try to lock up on the turn, you need more additive. Often an oil that has a little of this additive will say it is satisfactory for "service fill" or "top-off".

How can you tell whether or not you have a limited slip differential? That is the easy part: Jack up both driven wheels and spin one of them with your hand (transmission in neutral) if the other wheel spins the same way, you have a limited slip differential. If it spins in the reverse direction, you do not. You can also just jack up one wheel and try to spin it. If it refuses to turn, or turns with a lot of resistance, and the car is in neutral, with no brake on, you have limited slip

You will find numerous wrong comments on forums and other sites where users claim that GL-4 means LSD. That is totally false. A check of the API site could have set them straight.

Engine/Transaxle combinations

While not used in any Corvairs, there are cars where the same oil sump is used for lubrication of the engine, transmission, and differential. With this design, the parts of the transmission and differential are dimensioned for use of a GL-4 (or perhaps at one time even a GL-3). My 1975 Morris Mini is an

example of these cars. As far as I know, most have been fairly low HP engines, and where the higher HP (turbo versions) were offered, synthetic oil was recommended. One caution that is not often mentioned in those manuals: The multigrade oils used should be group II or stronger, or you should avoid extending the interval beyond what is mentioned. The lesser quality multigrade oils tend to get their polymers ground or sheered in the gears, just like some of the sludge prone OHV engines of today where gears are used for synchronization of the cam and crank. Note: Corvair engines do not suffer from this sheer due to the large diameter of the cam/crankshaft synchronization gears in the engine.

We can also note that the Chevrolet Luv pickups, as well as the Isuzu Rodeo and Trooper and many others have recommended motor oil in the transmission for many years, even though they have separate compartments. They only use gear oil in the differential.

The concept of using motor oil in these situations goes back to what I said towards the beginning. Most motor oils can qualify for GL-4 (or at least GL-3) EP protection. As long as the torque on the gears in low speed sliding action does not exceed what is covered by the GL-4, there is no benefit to sulfur/phosphorous additives, but there is one for the synchronizers.

In the case of those single compartment motor/transaxle, there is an additional benefit of constantly filtering the oil. The risk is that if you get gasoline in your oil you will thin out hydrodynamic film protection in the gears. If you are running a mixture too rich, the additional soot (carbon particles) will wear the gear surfaces as well as your camshaft.

Viscosity:
First it should be noted that the SAE motor oil viscosity chart (J300) is different from the SAE gear oil chart (J306). A SAE 40 motor oil has approximately the same viscosity as one of the thinner SAE 90 gear oils, while the SAE 50 Motor oil is similar in viscosity to the thicker SAE 90 gear oils.

Viscosity has nothing to do with API Gear Oil classification (GL-4, GL-5, etc.). Some manual transmissions specify an ATF (Automatic Transmission Fluid), others a SAE 75W-80 (almost the same viscosity as the ATF), others a 75W-85, 75W-90 or 80W-90. Some specify a SAE 50 motor oil or SAE 50 CAT TO-4 transmission oil. The oil viscosity should be chosen according to the manufacturer's recommendations for the temperatures where you will drive.

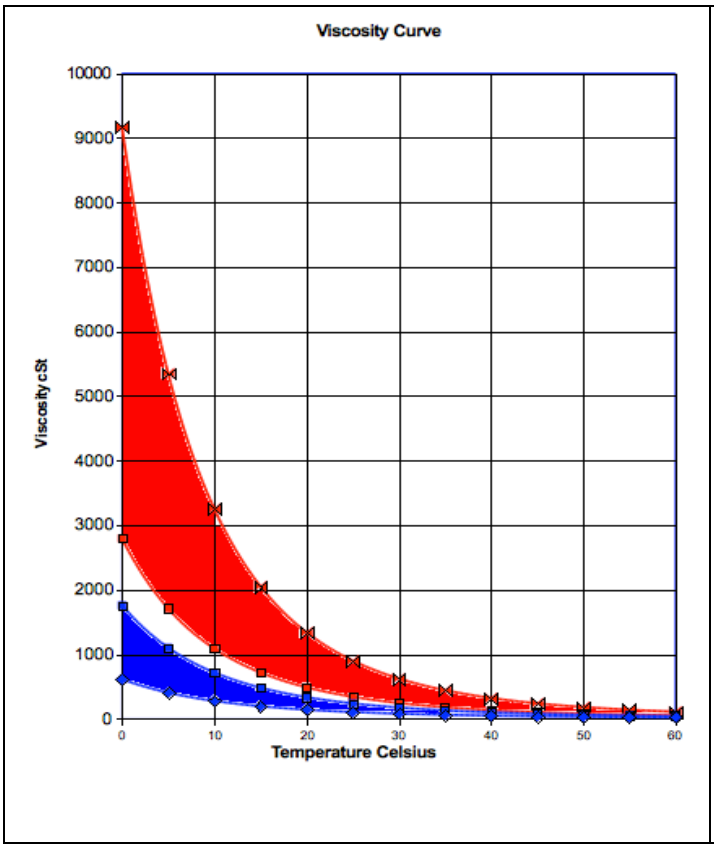
- If it is too thick (viscous) it will not displace fast enough from the synchronizers and will heat up your transmission and cause hard shifts. It will also fail to flow properly in the needle bearings or other tight spaces.
- If it is too thin it will not provide the hydrodynamic lubrication that is required between gears and in the bearings or bushings.

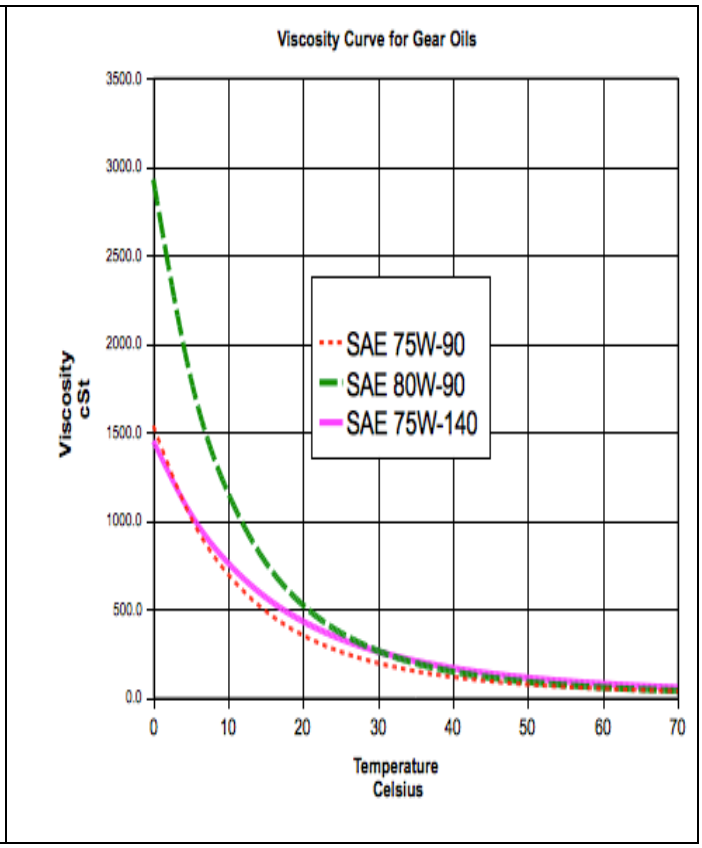
If we look at the service manual for the Corvair, the one I have from 1960 recommends SAE 80 Gear oil. While I do not have a SAE J306 viscosity chart earlier than the 1996 update, in the graph below we can see what those viscosity limits were in 1996, with the blue being the range for SAE 80 and red being the range for SAE 90. What this means is that any given brand had to stay within that range for that weight of oil.

You will note a huge range is possible between different brands within each range. In the chart on the right-hand side you can see that the 80W-90 gear oils on the market today are thinner than the thinnest SAE 90. You could actually use a synthetic 75W-140 if you could find it in a GL-4.

SAE 80W-90 or 85W-90 oils are often referred to as multigrade oils. This is not true. They have no polymers to modify their viscosity. They are simply SAE 90 oils with a normal (95 to 105) viscosity index where the low temperature properties either meet the 80W or 85W specification. So, an 80W-90 is at the low end of the SAE 90, while the 85W-90 is at the high end of the range for a SAE 90.

From personal experience and that of several friends who have tried them, I recommend staying away from the 85W-90 in Corvairs and most other cars, since that puts it at the high end of the 90 scale. You will notice a harder shift for the first few shifts of the day.





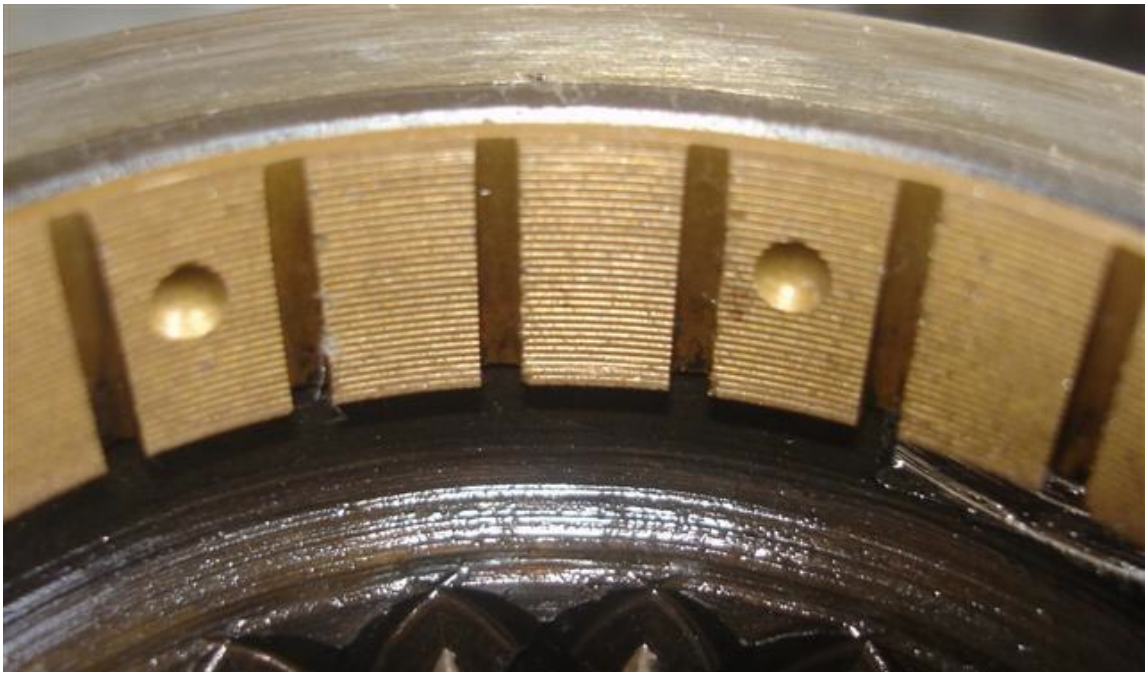
Recommendations

In general, you should use your manual. Nobody knows the vehicle more than the people who put it together. The exceptions are cars like the Corvair where oils have changed dramatically since the manuals were printed. There are other exceptions where those who write manuals have no idea how a transmission works and are guided by wrong information from oil salespeople.

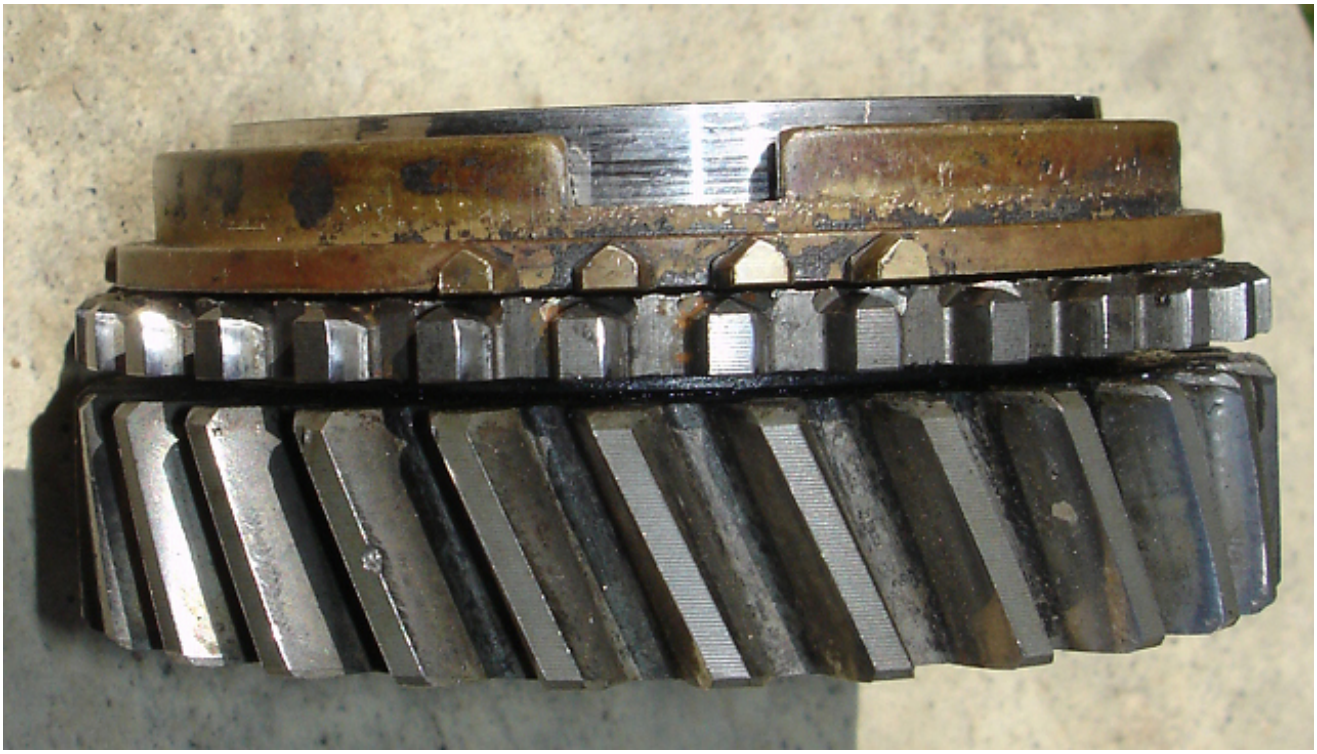
You need to realize that an oil with GL-4/GL-5 on the label is a GL-5. It is not appropriate for synchronized transmissions.

For the Corvair:

- Considering that most Corvairs have seen a lot of miles, there is probably some wear in the transmission, so we could look at the higher viscosities within the recommendations unless it has been rebuilt.
- This is a car that was produced long before any of the oils that are on the market today. My car was a perfect example of what happens if you do not have any EP additives. The teeth on the synchronizers were in excellent condition. But the rest of the transmission had severe signs of wear. (*See picture below*)



- Too much additive may reduce the wear on gears, needle bearings, and shafts in certain conditions, but will wear out your synchronizers. You need to look for a GL-4 oil that does not include GL-5 in its label, even though it looks good, even though it claims GL-4/GL-5 on the label. The Corvair differential is well built with parts much bigger than those of many cars today. Those gears can carry the power of the car. You can see in the following picture of a Toyota synchronizer how the brass synchronizer has worn so much that the entire ring bottoms out and no longer grabs.



- For many climates, the SAE 80W-90 is the best viscosity for the Corvair. But there are synthetic products available that cover that full range with a SAE 75W-90 rating. This would be even better especially in cooler climates. The trick in this formulation is a very high viscosity index in the synthetic base oil. See the chart at the end of this article to see how a few typical oils react to different temperatures. You should note that you might need to shift below the -20ºC shown as a starting point in these graphs. In this case, the synthetic oil is your best bet. Most manual automotive transmissions will run between 30ºC and 50ºC in normal operation. I have been using 75W-90 GL-4 for at least a year and have much better shifts. Morning temperatures here are normally in the 65ºF to 75ºF range.
- Corvairs with automatic transmissions: This is much simpler. Just use a good Dexron III in the transmission and a good GL-5 in the differential, adding the LSD additive if the oil manufacturer does not include it and if you have "*positraction*". They may or may not include it. You have to read the label or spec sheet. As an example, I have

    - 75W-80 GL-3 without LSD
    - 75W-80 GL-4+ without LSD
    - 75W-85 GL-4+ without LSD
    - 75W-90 GL-4 with LSD and without
    - 75W-90 GL-5 with LSD and without
    - 80W-90 GL-4 with LSD and without
    - 80W-90 GL-5 with LSD and without
    - 75W-140 GL-5 Synthetic with and without LSD
    - 85W-140 with and without LSD

To confuse things a little more, we have to read the literature and sometimes consult with the manufacturers. In looking for a few GL-4 products that would meet our needs, I identified Redline MT-90 as a candidate, but then saw this on their website. I questioned them and received this response.

- MTL & MT-90 are not for use in differentials with hypoid gears

> *"In your Corvair manual transaxle I would recommend the 75W90NS as a GL-5 type gear oil was originally called for. A GL-4 gear oil is suitable for use in a zero or low offset hypoid gear application, where extreme pressures of a high offset hypoid are present a GL-5 gear oil is required. In your transaxle where high offset gears are not present, a GL-4 gear oil could be used though we would recommend a GL-5 as called for."*

While he confirms that the Corvair does not have high offset hypoid gears (*"In your transaxle where high offset gears are not present")*, he says he recommends his GL-5 product because the Corvair originally recommended GL-5 (*"a GL-5 type gear oil was originally called for"*). There is a problem with that statement: The GL categories are based on the ASTM STP 512 standards which were originally developed in 1972, three years after the end of the production of the Corvair.

Here is a clarification from Lubrizol (one of the premier additive companies)

- API Category GL-4 designates the type of service characteristic of spiral-bevel and hypoid gears in automotive axles operated under moderate speeds and loads. These oils may be used in selected manual transmission and transaxle applications.
- API Category GL-5 designates the type of service characteristic of gears, particularly hypoids in automotive axles under high-speed and/or low-speed, high-torque conditions. Lubricants qualified under U.S. Military specification MIL-L-2105D (formerly MIL-L-2015C), MIL-PRF-2105E and SAE J2360 satisfy the requirements of the API GL-5 service designation.

Summary

Just remember that GL-4 and GL-5 are gear oil ratings, **not transmission oil ratings**. Transmissions have gears ***and*** synchronizers. These seemingly conflicting requirements must be met differently.

When someone tells you that their GL-5 covers GL-4, remember they are correct as far as EP protection, but that is only half the answer. When they say their Sulfur/Phosphorous additive will not corrode the yellow metals, they are also correct, but if there are enough to meet GL-5 protection, they will slowly peel away your brass synchronizers.

What should you do if you cannot find a GL-4 that does not include GL-5 on its label? My next choice, and one I almost did even though I have plenty of GL-4 80W-90, would be a SAE 50 oil that meets CAT TO-4 specifications. My third choice would be a SAE 50 diesel motor oil of the highest API classification I could find, preferably group II. As you will see on the graph below, the temperature curve for a SAE 50 motor oil (or CAT transmission oil) and a SAE 80W-90 are very similar.

But we should not get carried away thinking we cannot find a GL-4 oil. There is plenty available in 75W-90. I get emails from all over the world, and we almost always come up with an answer.

What should you do if you've put a bigger engine in the Corvair or dramatically increased the HP? I would use a synthetic GL-4 oil. If I felt it was not enough (gut feeling, stubbornness, etc.), I would send it away for analysis, then use a GL-5 for the same period of time and analyze it. If the GL-4 is not sufficient protection, it will show up in iron particles in the sample. The GL-5 might reduce the iron

wear, but you can see for yourself how much copper increases. The only problem with this is the sample base is not statistically valid. But it will give you more than a guess unless you have magnetic plugs or magnets on your filter.

I have received comments from people who have used VW transaxles with 150 to 200 hp engines in racing situations, where they say the synchronizers are expendable, but the gears are expensive and hard to come by, so GL-5 is better. It will make for harder shifts, but if you are going to quadruple the torque, you may be better off that way. It is a personal decision.

Here is a simple explanation of the problem from Nissan:

> **Warning:**
> **If Nissan service manual asks for API GL-4 rated oil than you have to use API GL-4 oil. GL-5 is NOT made to replace GL-4. DO NOT USE GL-5, it will destroy your transmission.**

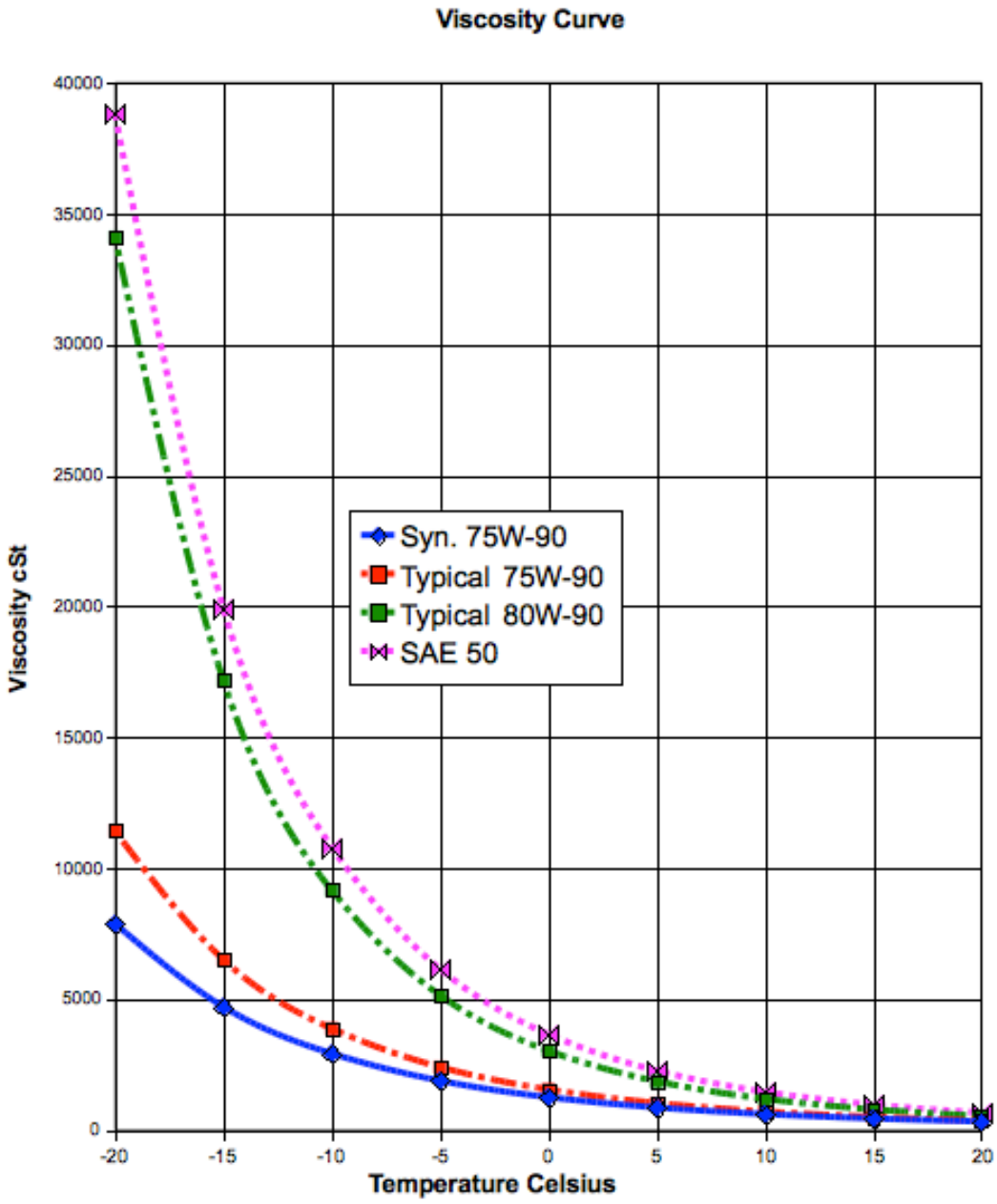
It is interesting to note in this explanation by Lubrizol how the new SAE J2360 (replaces the GL-5 rating) is explained:

> "SAE J2360 is a global quality standard specified by many North American OEMs and by growing numbers elsewhere in the world. The rigorous approval requirements, including controlled field testing and independent committee review, ensure that products approved under the SAE J2360 Standard meet the very highest demands of axles **and non-synchronized manual transmissions**." (*emphasis added*).

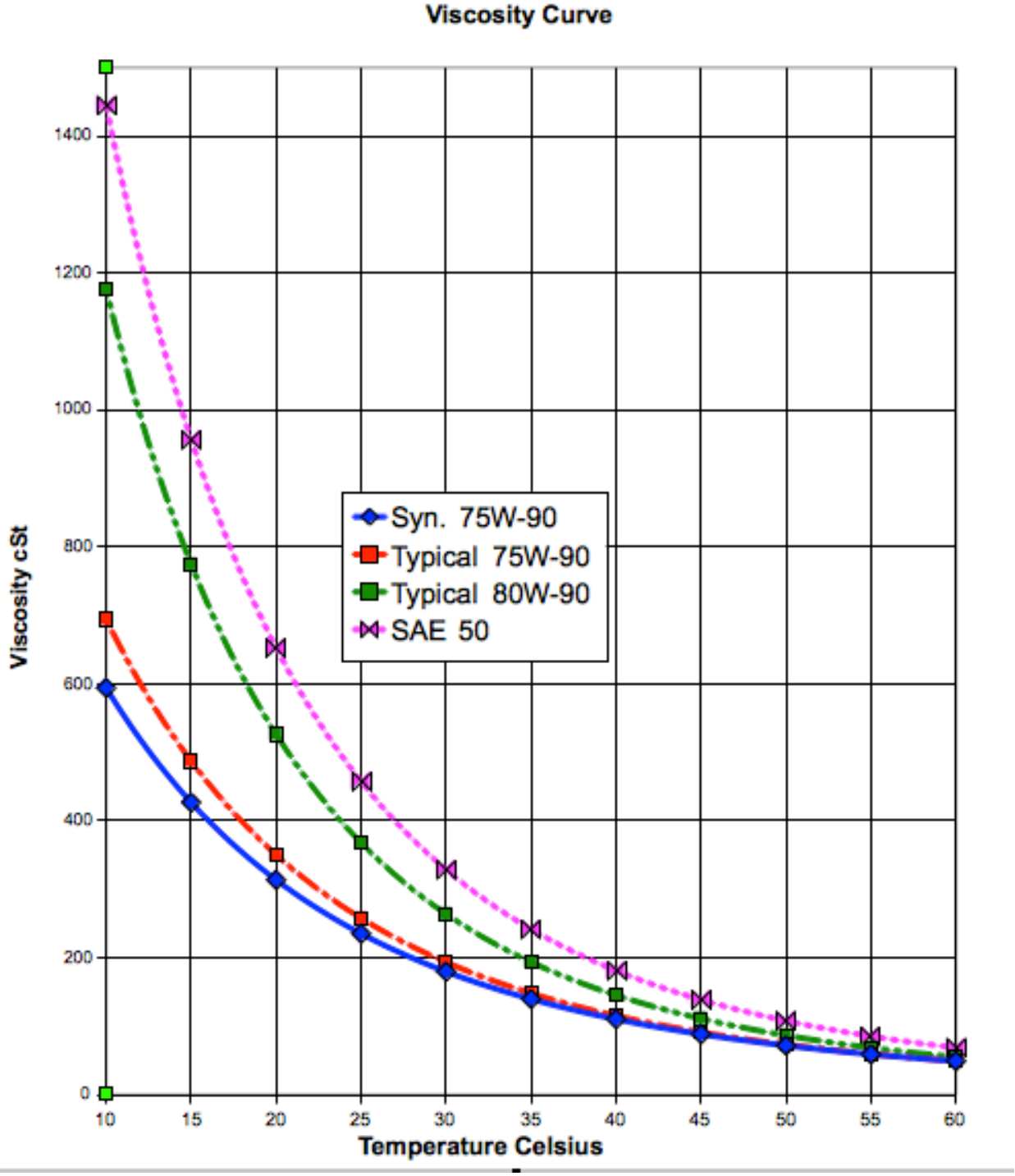
The important part of that statement for us is the last part: "**and non-synchronized transmissions**", since our transaxles are synchronized.

Here is a synchronizer that has been worn by GL-5 oil. You will note that there are no longer any teeth on the brass, completely worn or "peeled" away

Here is a chart that shows the behavior of several transmission oils at start-up temperatures.



Here are those same oils in normal operating temperatures once everything has warmed up.



Product possibilities

I hate to call these recommendations, but will list what I can of products that I know of and that are available in the US. As always, this is as of this writing, and all information is gathered from the Internet. Local availability will vary.

First lets remember that the details are in the spec sheets. Some brands make it hard to find the information.

I can applaud Mystic Oil's clarification when they start their spec sheet this way (although later in the sheet they only mention the various GL classifications. Note how they say *"**and non-synchronized manual transmissions.**"*

For API Gear Lubricant Service: GL-2*, GL-3*, GL-4, GL-5, GL-6*, MT-1
For Service Fill Limited Slip Axle Lubrication

Mystik JT-7 Multi-Purpose Gear Lubricants are multi-purpose, thermally stable, sulfur-phosphorus extreme pressure (EP) gear lubricants that exceed the performance requirements of the latest axle and non-synchronized manual transmission specs, MIL-PRF-2105E, and Mack GO-J. A specially

Texaco, on the other hand, does not mention this limitation, although it is the same. They just don't mention transmissions at all in their 80W-90 gear oil. They leave it up to the consumer to realize that transmissions don't use normal gear oils (as such).

Havoline Gear Oils:

- meet the performance requirements of **API Service Categories** MT-1, GL-4, and GL-5
- are qualified for **SAE J 2360** (formerly known as MIL-PRF-2105E)

The list:
My list is a short one. If you want me to add something I can look at it if you send me a link. I've been looking and don't see much. These are listed in alphabetical order.

- Amsoil Synthetic manual Transmission and Transaxle Gear Lube 75W-90 GL-4
- Citgo Citgear Standard XD 75W-90 GL-4
- Pennzoil Gearplus 80W-90 GL-4
- Pennzoil Synthetic 75W-90 GL-4 (from the spec sheet, the best overall viscosity curve)
- Quaker State Multi-purpose Gear Lubricant 80W-90 GL-4
- Redline MT90 is a good possibility, although their web page has this disclaimer. Note my observations on page 6.

  - MTL & MT-90 are not for use in differentials with hypoid gears
- Shell Spirax G SAE 90 GL-4 (I do not recommend this due to it's extremely high low temperature viscosity.)
- Shell Spirax GX 80W-90 GL-4 (I do not recommend this due to it's low high temperature viscosity)
- Chevron had a product called Chevron Manual Transaxle oil that was excellent, but I cannot find it except in clearance sites. I don't know if it has been replaced.

In general I would not use a 75W-90 in a Corvair transmission unless it was synthetic, but there are some very good GL-4 Synthetic 75W-90 oils in the market for Mercedes, Volvo and Mack truck and bus transmissions that would be acceptable, especially in colder climates. Look for one where the viscosity at 100ºC is 15 cSt or above.

I hope this clears up some of the confusion and avoids transmission damage.

If you have additional questions, feel free to send them to me at oil@asboman.com

If you have not read the report on motor oils, you can find it here:
Selection of the right motor oil for flat tappet engines.