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ENGINEERING

Oil

What motor oil is best for my aircooled Porsche?
(or any high performance engine)
by Charles Navarro
Last Updated 11/11/08

The purpose of proper lubrication is to provide a physical barrier (oil film) that separates moving parts reducing wear and friction, but there are many surfaces within an engine that operate with metal-to-metal contact, again popular belief, that are very highly dependant on a strong and robust anti-wear film. The top piston ring operating in sliding contact with the bore operates in a mixed lubrication regime consisting of both boundary (metal-to-metal direct contact) as well as hydrodynamic (oil film between moving surfaces) lubrication. The majority of non-corrosive wear occurs where boundary lubrication exists, especially at cam lobes, tappets, cam follower/buckets, and rockers. Oils contain dispersants, friction modifiers, viscosity modifiers, anti-foam, anti-corrosion, antioxidant and anti-wear additives, all of which can affect the strength and durability of anti-wear films. The focus of this study is on the levels of zinc and phosphorus found in motor oils and their interactions with other additives, more exactly, the zinc (Zn) and phosphorus (P) that makes up the anti-wear additive ZDDP, zinc dialkyl dithiosphosphate, as the ZDDP level is causing concern for all older engines, including aircooled Porsches, with modern oils.

What general characteristics make motor oils specifically well suited to an aircooled or other high performance engine? Aside from recommendations issued by Porsche, what makes a good oil? These oils must be thermally stable, having a very high flashpoint, low noack volatility, and must “maintain proper lubrication and protect vital engine components under the extreme pressure and the high temperature conditions” found in aircooled Porsches. Porsche recommends and uses Mobil 1 0w40 as a factory fill in new vehicles and their 15w50 has been a popular choice used by many in the aftermarket in aircooled models. What was once considered a 'safe' oil is no longer as many of these lubricants have been reformulated for many reasons, not limited to allow for protection of emissions controls and for longer drain intervals.

Even prior to the introduction of the API's SM standard, there was concern that current API SL standards from back in 2003 may inhibit the backwards compatibility of motor oils, specifically referring to the limitation of ZDDP, which is "the most effective combined anti-wear and anti-oxidant additives currently available." *SAE 2003-01-1957, **Effect of Oil Drain Interval on Crankcase Lubricant Quality**, Shell Global Solutions.* The authors continue to state that oils are required to provide longer protection in severe operation but that an oils performance is "limited by environmental considerations." Furthermore, they state that it is hard to predict the effects of these reformulated oils in just a single oil change and may only be evident over an engine's lifetime. It is hard to know the full extent of the potential damage these new SM oils will have on our performance engines so chose your lubricants carefully.

Porsche’s recommendation in hand, our initial analysis from 2005 and 2006 and from virgin oil analyses going back to the 1990s, we found that then recent SH/SJ formulations of Mobil lubricants tested, including Mobil 1, have had higher Zn and P content than SL or current SM formulations. Even current "re-introduced"

formulations are not the original formulations many shops and owners were used to. Aside from reduced Zn and P levels (now restored in certain products), many products with "adequate" Zn and P still use high levels of Ca detergents, well documented in various SAE publications as known for causing more wear than Ca/Mg or Ca/Mg/Na detergents, as previously used in oils like Mobil 1 15w50, back when it was API SH/SJ rated and prior to reformulation. This confirms the industry wide trend of the reduction of Zn and P from motor oils and switch to Ca-based detergents, with the eventual reduction to 0.06-0.08% or even worse, the elimination of these additives, which are essential to an aircooled Porsche engine's longevity.

Many Porsche repair shops have acknowledged that these newest SM and CJ-4 motor oils are not sufficient for protecting any Porsche engine. With longevity and the protection of vital engine components in mind, many shops are recommending non-approved motorcycle or racing oils, or the addition of oil supplements at every oil change, for their higher levels of protection.

Oil companies have been cutting back on the use of Zn and P as anti-wear additives and switching to alternative zinc-free (ZF) additives and ash-less dispersants in their new low SAPS oils since Zn, P, and sulfated ash have been found to be bad for catalytic converters. One such ZF dispersant/anti-wear additive is boron, which does not foul the catalysts in the particulate emissions filters or catalytic converters. For most owners, the reduction in longevity of a catalytic converter is a small price to pay considering the many thousands of dollars it costs to properly rebuild a Porsche engine. It is worth noting that most Porsches have lived the majority of their lives with high Zn and P oils as found in API SG-SJ oils as late as 2004, and we never hear of problems with their catalytic converters.

In addition to protecting emissions controls, there are many other design considerations in formulating engine lubricants, which include improving fuel economy and longer drain intervals. Many believe that the EPA has banned zinc and phosphorus in motor oils. This is not true. In response to modern engine design and longer emission control warranties which are required by the EPA, manufacturers have turned to reformulation of oils to do this, as well as to improve fuel economy by reducing fiction. High friction can result in areas with boundary lubrication or where high viscous friction forces and drag may occur with hydrodynamic lubrication in bearings. The use of friction modifiers, such as moly (there are many different species of Mo-based friction modifiers, help to reduce friction in metal-to-metal contact with the formation of tribofilms characterized with their glassy, slippery surfaces. Lower viscosity motor oils are key to increasing fuel economy by their reduction in drag where high viscous friction occurs in hydrodynamic lubrication. While lower viscosities improve fuel economy greatly, they also reduce the hydrodynamic film strength and high temperature high shear viscosity of the motor oil, factors both of which are key to protecting high performance engines, especially aircooled ones.

However, it is worth noting that these new API guidelines do not need apply to “racing,” “severe duty,” or any motor oils that do not carry an API “starburst” seal or clearly state for off-road-use only. Motor oils meeting “Energy Conserving I or II” standards should be avoided as well as those with an API SM or ILSAC GF-4 classifications. The European ACEA A3/B3 "mid-SAPS" classifications, which place a cap on P levels at 0.10-0.12% but allow for higher Zn levels, to be better in taking into consideration wear and engine longevity, setting much lower wear limits, while still limiting emissions and protecting emissions control devices. It is common to find API SJ rated oils, particularly those meeting Volkswagen's stringent 505.01 standard for PD TDI engines, to also meet ACEA A3/B3 requirements. The current ACEA A3/B3 classifications require higher high-temperature high-shear (HTHS) viscosities, stay in grade sheer stability, and tighter limits on evaporative loss (noack volatility), high temperature oxidation, and piston varnish. This makes oils meeting these ACEA standards that much better for your Porsche, especially since wear limits are much more stringent for valve train wear, 1/6th to 1/4th the wear allowed in the sequences for API's newest SM or CJ-4 standards. Of particular interest is the upcoming ACEA E9 standard to supersede the API CJ-4 standard in Europe, creating a classification for low ash oils that are low detergent and are very effective in controlling wear in legacy engines.

Failure to use the right oil, use proper filtration, or observe proper changing intervals can affect the performance of even the best motor oil. This also includes changing the oil too often (needlessly bad for the environment and your wallet) or not often enough. Against conventional wisdom, engine wear decreases as oil ages to a certain extent, which means that changing your oil more frequently actually causes engine wear;

these findings were substantiated by studies conducted by the auto manufacturers and petroleum companies, leading to drain intervals increased from 3,000mi/3 months to 5,000-7,500mi/6 months in most domestic vehicles, using mostly non-synthetic oils. Based off of extremely long drain intervals recommended by most European manufacturers, some in excess of two years and 20,000 mi, some users have found it best to reduce those intervals by half or even a quarter. Porsche for the 2008MY has reduced their extended drain intervals significantly to one year/12,000 mi, which is actually less miles than Porsche recommended back in the 1990s with 964 and 993 based aircooled 911s. Based on UOAs provided to us by our customers, new Porsche owners should consider reducing their drain intervals further to no more than 9,000 mi or one year and some shops recommend changes every 5,000-6,000 mi or six months.

Vehicles with track time or sustained high oil temperatures or RPMs should have their oil changed after every event (or every other event). This translates to a total of about 10 hours max, with vehicles with 12 qt or higher oil capacities- engines with smaller capacities must be changed more often. Vehicles subjected to very short drives or sustained operation in heavy traffic should indeed be serviced more often. Likewise, vehicles not driven often but driven hard a few times a year can probably go a year between oil changes, but that doesn't mean you shouldn't use a good oil! Regular used oil analysis is the best way to determine ideal drain intervals for your driving habits - one good rule of thumb I have seen quoted is to change the oil with the TBN (total base number) is reduced by 50% of the original total (requiring you to also know your oil's virgin TBN). Another common recommendation is to change the oil once it's TAN (total acid number) equals the TBN. Other factors to consider are fuel dilution and shearing out of grade when determining your drain interval. With this knowledge in hand, using a quality motor oil with proper filtration and regular service is the best thing to do for your engine and to protect your investment.

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Biography for Charles Navarro

Charles Navarro is one of the founders of LN Engineering, which was started in 2002 as a manufacturer of high performance Porsche and VW components, including their Nickies line of billet aluminum nickel silicon carbide (NSC) cylinders. LN Engineering also offers custom ARP hardware, JE Pistons, and R&R Pro Connecting Rods and is partnered with Jake Raby of Aircooled Technology for their efforts in research and development. This also includes years of joint testing in the field of lubricants as well as flat tappet cams and lifters in an effort to resolve years of unexplained cam and lifter failures that coincidently started around the time the API SL standard was introduced. Rather than considering that it was a lubricant related issue, we focused on the lifters themselves and in partnership with Schubeck Racing, developed ceramic composite lifters which were excellent in eliminated cam and lifter failures and wear entirely. Not until Schubeck Racing went out of business and the supply of lifters disappeared, did we return to evaluating conventional lifters and cams. To learn more about the ceramic composite lifters we one sold, click here. Through careful evaluation of material, surface finish, and cam and lifter radius and taper was Aircooled Technology able to find an adequate solution. Not outright failure, but high wear was still a big problem using a popular 20w50. Not until we started evaluating lubricants, did we find that the oil used was just as important as all the other considerations made. For Aircooled Technology, Brad Penn was the wear solution and is required for all their engine kits and turnkey engines, right from the start. LN Engineering and Aircooled Technology have since tested many lubricants for their real-world as well as on-the-dyno performance for both wear and horsepower. Brad Penn still remains Aircooled Technology's #1 choice in lubricant for their customers.

WE RECOMMEND BRAD PENN - PENN GRADE 1 RACING AND BREAK-IN MOTOR OILS - THE GREEN OIL

WE RECOMMEND SWEPCO LUBRICANTS INCLUDING SWEPCO 306 SUPREME ENGINE OIL

WE RECOMMEND MOTUL SPECIFIC & 300V LUBRICANTS

LN Engineering proudly offers Swepco, Brad Penn Racing, Mobil 1 motorcycle, and Motul 300V lubricants!

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Frequently Asked Questions about Motor Oils

Do some oils make more horsepower?

NEW! Aircooled Technology and LN Engineering together just recently completed in January 2008 comparative oil testing of various non-synthetic, semi-synthetic, and full-synthetic oils with some very interesting results, which can be reviewed in our white paper titled "**Evaluation of motor oils and their effects on engine output and efficiency**."

ZDDP forms AW films only when there is metal to metal contact, so why do I hear that it is so important when there shouldn't be metal to metal contact in the first place?

This isn't 100% true. Yes, there has to be metal to metal contact (friction) to form anti-wear films. What most naysayers don't explain is that there are different kinds of lubrication - boundary and hydrodynamic are just two. Boundary layer lubrication exists where there is always metal to metal contact, like with the top piston ring, cam lobe, tappets, and rockers which makes up most of the non-corrosive wear. Hydrodynamic lubrication exists in areas like bearings, where in the best case scenario, there should never be any metal to bearing contact. The thickness and speed of formation of AW wear films on metal to metal surfaces has to do greatly with ZDDP levels, which detergents are used, and amount of pressure and friction between the surfaces in contact.

What oil should I be using to break in a new engine?

Ideally you want an oil with low or no detergency, no friction modifiers, be non-synthetic, and high levels of Zn and P, to make it as easy as possible for AW wear films to form on engine parts during this critical process.

Brad-Penn offers a SAE 30 break in oil with .14% Zn and P already in the motor oil which requires no additional additives to protect your vital engine parts during the break-in procedure, especially the cam and valve-train. We recommend running a break-in specific oil for the first 100-200 miles, with a change of oil immediately after initial cam break-in, and again at the 100-200 mile mark. If using this oil while breaking in your engine on a dyno, make sure to observe your oil temperatures and try not to exceed 210F to maintain optimal film strength with the viscosity of oil being used.

Alternatively, Joe Gibbs Racing and CMW Oil both offer specialty break-in oils similar to Brad Penn's Racing 1 Break-in oil. In the UK, Millers Oils offers a line of Classic motor oils including "running-in" oil and classic multi-grade oils for older engines needing additional protection. There are countless other oils that should be satisfactory as long as you follow the above criteria for choosing a break-in oil.

Can I use a diesel oil like Rotella to break in my engine?

Many cam manufacturers have recommended Rotella T in the past for cam break in. Remember, this was the CI-4 Rotella T some manufacturers were recommending, not the new CJ-4 Rotella. Be advised that we do not recommend the continued use of the new CJ-4 Rotella T for cam break-in or any other CJ-4 oil for this purpose. Additionally in support of this position, magazines such as Fleet Equipment, in one such article "Focusing on Oil," stated that CJ-4 oils should only be used in 2007 and later diesel engines and that earlier diesel or mixed fleet engines should remain on CI-4 oils.

How should I break in my engine if I don't have access to a dyno to properly break in my rebuilt engine?

Although not directly related to oils, I get asked this question very often. If you have questions on how you should break in an engine and proper break in procedure, we recommend reading the following articles about the subject:

http://www.mototuneusa.com/break_in_secrets.htm
http://www.aircooled.net/gnrlsite/resource/articles/engnbrkn.htm

Which motor oil do I (Charles Navarro) use in my aircooled Porsche?

Although there are many excellent motor oils out there, considering the wide array of oils I have access to, I currently am using Brad Penn 20w50 API SJ for the summer and winter months in my aircooled Porsche since it never sees sub-freezing starts. The Brad Penn Penn Grade 1 Racing oil is the same "green" oil everyone was familiar with back when Kendall GT was the best motor oil money can buy, as both the original and this newer product both come from the same facility using genuine Pennsylvania crude. These oils are proven to protect cams, rockers, lifters, and all valve train components as well as provide superior rod bearing life

because of their very high HTHS viscosities AND low levels of individual detergents to net a high level of detergency with the use of Ca, Mg, and Na synergistically. Just ask anyone about the "green" Kendall oil from decades past and you'll know why we like it so much.

If I were to have sub-freezing starts, I would probably use the Swepco 306 15w40 API CI-4. Swepco comes highly recommended by Jerry Woods, a very well-respected and experienced Porsche engine builder. Both these oils are highly refined paraffin base stocks, and I feel they are excellent choices for my aircooled 911 with oil changes both in the fall and spring, as my 911 is not a daily driver, but does see year round service. It is worth noting that Brad Penn now offers a 10w40 motorcycle version with a higher synthetic content which is also excellent for year round use. I have also run a 50%/50% blend of Brad Penn Racing 0w30 and 20w50 to yield a 10w40 viscosity for winter use, prior to their release of the aforementioned 10w40.

In my two newer vehicles, both of which are Volkswagens, they require a VW 505.01 specification motor oil, and I use Motul 5w40 505.01 specific, which is an API SJ rated semi-synthetic. I also favor Mobil 1's 10w40 MX4T (now 4T Racing) and 20w50 V-Twin formulations, as they are very robust oils born from Mobil's M1R Nascar oil from years past. Motul's 300V also falls under this category, essentially a group 5 full-synthetic ester oil formulated like Brad Penn's line of non and semi-synthetic oils.

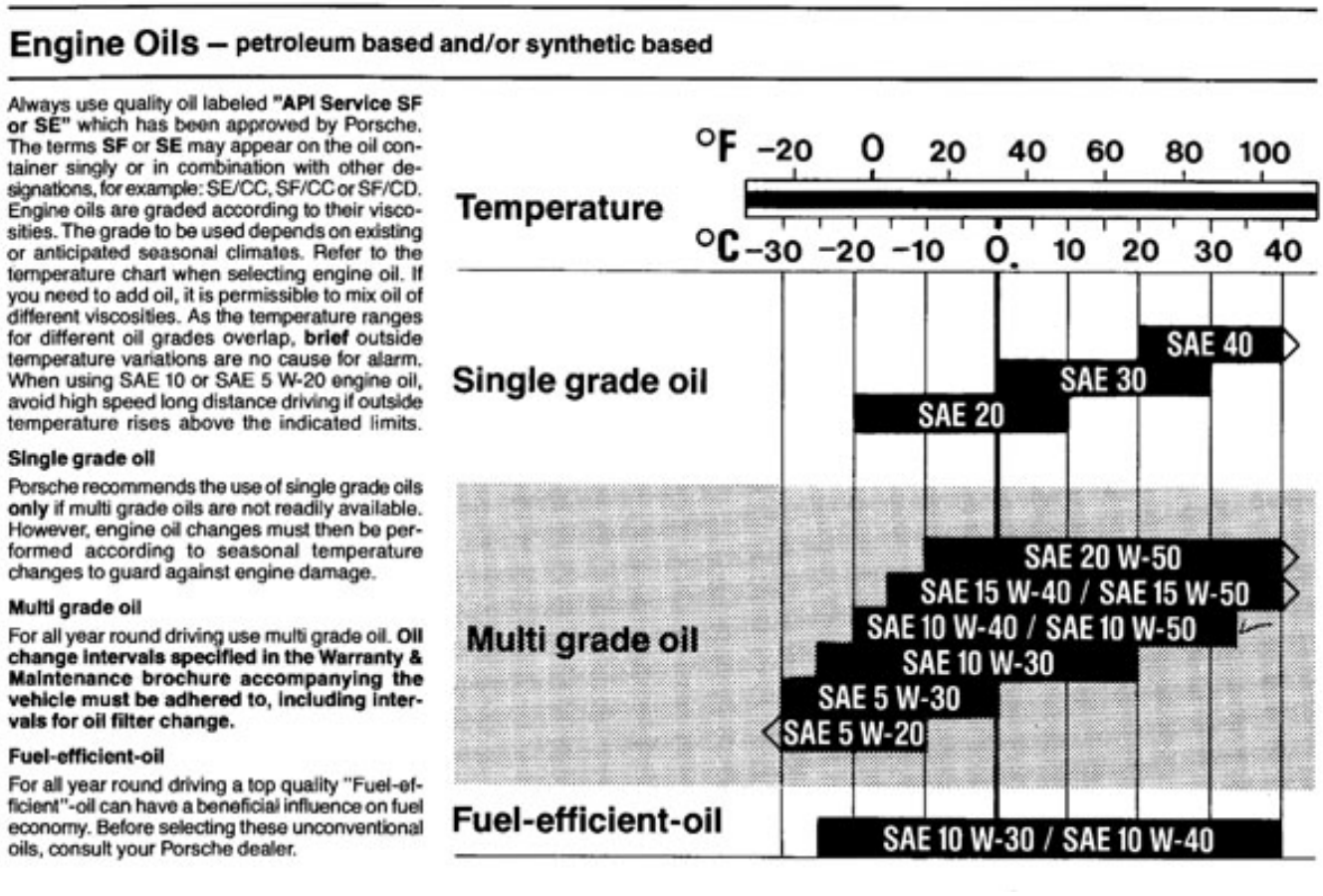
Very important in my consideration of any of these oils are that they have the proper balance of Zn and P as well as level of detergency. Oils with high detergency need equally high levels of anti-wear additives as well as those oils using Ca-based detergents also need more Zn and P that those oils that use Mg and/or Na detergents. Brad Penn, Motul 300V, and even Mobil 1's motorcycle oils all use lower levels of Ca detergents and the less aggressive (lower wear) Mg and Na-based detergents.

I do not recommend using ZDDP boosters.

What viscosity motor oil should I use in my Porsche?

Porsche nicely answered this one for us (from '84 911 owners manual). You can use a 20w50 year round, even with cold starts to 20F, which covers the majority of Porsche owners. I might add, if your Porsche is also your daily driver and you see repeated sub freezing (32F) starts, it wouldn't hurt to use a 15w40 instead. The other recommendation frequently given by engine builders is that a 15w40 can be run up to 90F ambient air temperature and at higher temperatures, a 20w50 should be used.

We have also tested the Brad Penn 20w50 versus a 50/50 blend of the Brad Penn 0w30 and 20w50, which yields a 10w40 viscosity, with near identical low wear levels, regardless of viscosity. The used oil analysis for the 10w40 can be viewed in PDF here as well as for the 20w50 by clicking here. Both sets of tests were conducted on a 1991 c4 cab with a 3.6 liter normally aspirated 964 engine with approximately 60,000 original miles.



Although the chart shows fuel-efficient oils, modern fuel efficient oils should not be used in your aircooled or watercooled Porsche.

How did you determine the recommended 0.12% Zn and P level (ZDP, a.k.a. ZDDP)?

There are many excellent SAE technical papers on the subject, but the one I found most interested was from 1977 titled "Cam and Lifter Wear as Affected by Engine Oil ZDP Concentration and Type." There is some background that is needed to shed light on their results. First of all, there are different types of ZDPs. There is an Aryl ZDP which is the most stable form. There is also an Alkyl ZDP which although is not as stable, exhibits the best wear protection.

In various fleet tests, it was determined that the best performance was from oils containting all Alkyl ZDPs or predominantly Alkyl ZDP blends. They also looked at the performance of "ashless" oils (0.03-0.05% Sulfated Ash) vs oils with normal levels (0.11% or higher) and it would appear that oils with lower ash levels needed more ZDP to provide the same level of protection. I bring this up since the newest CJ-4 and SM oils require significantly lower ash levels, less than 0.10%. Across the Indianapolis, Phoenix, and Los Angeles taxi fleets observed, oils with 0.11-0.13% Alkyl ZDP resulted in the lowest combined and average cam wear measured. Levels of wear remained low with oils with Alkyl ZDPs as high as 0.19%. Excessive Zn and P levels cam result in additional wear.

The oils that had at least 0.07% Alkyl combined with 0.05% Aryl performed just as well as oils with higher Alkyl only ZDP levels, suggesting some sort of synergistic properties of the decomposition products of the Alkyl/Aryl blend. Combined ZDP levels of the Aryl and Alkyl blend were min. 0.12%.

Our assumption with choosing a minimum Zn and P levels of 0.12% is on the assumption that the best combo of ZDPs are being used for wear performance, not longer drain intervals, with a motor oil that uses low levels of Ca-based detergents supplemented with Na or Mg detergents. Oils for long-drain intervals almost entirely use Ca-based detergents! Oils with Ca-based detergents in high concentrations need significantly more Zn

and P, at least 0.145%. Both Redline and Swepco use Ca-based detergents and run additional levels of Zn and P of 0.145% or roughly 1450 ppm, as would be expected.

The more detergent an oil is, the more anti-wear additives are needed. That means the correct amount of Zn and P in any given oil is a moving target.

More recently, in the development of the IIIG sequence, developers went so far as to say that there was no need for the VD and VE sequences for testing of OHV (overhead valve) engines because these engines are not commercially available as new anymore and do not reflect the needs of more modern engines. In a SAE paper titled "How Much ZDP is Enough?" from 2004, the resulting trend of decreasing phosphorus is as a direct result of observations that modern engines, with lower spring pressures and lighter vavletrain, including multiple intake and exhaust valves, seems to require only .03% Ph to prevent wear. It was further documented that by increasing to 180 lbs of spring pressure with a .03% ZDP resulted in 267 mil of wear where with .05% ZDP concentration tests resulted in 26 mil of wear. That same .05% oil with just 205 lbs of pressure resulted in 153 mil of wear, requiring .095% ZDP to reduce wear, resulting in just 16 mil. The ZDP requirements of a motor oil are directly proportional to valvetrain spring pressure. Most older SOHC and pushrod aircooled Porsche engines have significantly more pressure, as a stock street pushrod Porsche 356 or 912 engine exceeds these levels of spring pressure compared to the levels of pressure on modern engines, for which oils are tested for.

Newer oils will continue this trend, leaving older engines with fewer and fewer choices for motor oils compliant with the requirements of these older valvetrain, hence our recommendations for using oils with higher levels of ZDDPs as substantiated by earlier testing sequences and the results on engines similar to our older aircooled Porsches.

What motor oils had the 0.12% levels of zinc and phosphorus recommended?

The current API standard is SM, and calls for 0.06-0.08% Zn and P.

Here are the running averages for all the oils tested thus far, listed by their API rating:

API	P (ppm)	Zn (ppm)	B (ppm)	Mo (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	Total Detergents
SE-SJ	1301	1280	151	357	1936	293	214	2443
CI-4	1150	1374	83	80	2642	199		2840
SL	994	1182	133	273	2347	109	22	2479
CJ-4	819	1014	26		2075	7		2082
SM	770	939	127	122	2135	13	139	2287

I do not recommend the use of any SM or CJ-4 motor oils in any aircooled Porsche, or any vehicle that can benefit from the added anti-wear additives such as pre-ODBII vehicles. If your vehicle is designed to use these newer oils or if your vehicle requires a manufacturer approved oil and is still under warranty, always follow your manufacturer's recommendations!

What oil should I use in my newer Porsche requiring a "Porsche approved" oil, like the M96 engine?

We do not recommend use of most of the Porsche "approved" oils in any aircooled engine, including the 84 and later engines up to and including the 993 that are recommended to run these approved oils.

In the search for a "**Porsche approved**" oil, a quick glance at various Porsche owners manuals for a Turbo and GT2 as late as 2004 showed a recommendation for an API SH or SJ motor oil, so my recommendation is to find an approved oil with at least an API SL rating - an API SH or SJ would be even better. Additionally, try

to use a 5w40 rather than a 0w40, as the viscosity with the narrower spread will have a higher high temperature high shear viscosity and should protect critical engine parts better at the upper limits. You do not need a 0w over a 5w until cold start temperatures are under -25C. Do not run any 30wt oil in your Porsche, aircooled engines included!

Coupled with Google and armed with the "overview of engine oils approved by Porsche "Porsche approval list", including some oils that no longer have Porsche approval but were approved at some point, here are some suggestions for oils. Remember, we're looking for an API, SH, SJ, or at worse case, SL rating AND meeting the ACEA A3/B3 specification. Remember, the earlier the API specification, the more likely the oil will be to have higher anti-wear additives.

Possible choices for Porsche-approved lubricants readily available in the US that are still API SL rated as of July 2008 are Kendall GT-1 5w40 Full Synthetic and Castrol Syntec 5w40; both oils have similar flashpoints to Mobil 1 and have higher HTHS viscosities than M1 0w40 because of their being 5w40 oils. There are other approved oils made by other European lubricant manufacturers that are of excellent quality, but can't be found at your FLAPS like the two listed above.

Shown below are some alternative suggestions for 5w40 viscosity oils that are not necessarily Porsche Approved, but are of excellent quality nonetheless. I have noted some of these oils meet Volkswagen's 505.01 specification for PD TDI engines, which is very rigorous and in my opinion, is a standard requiring additional protection so much so that Mobil formulated a special version of 5w40 in an API SJ that is specific to the 505.01 standard. If cost was no object and I was out of the warranty period, Motul 300V, Redline, or even Amsoil would be two obvious choices.

Brand	**Viscosity**	**API**	**HTHS (cSt)**	**Flash Point (degC)**
Mobil 1 Synt S Special V 505.01	5w40	SJ	4.67	239
Motul 300V	5w40	SH	5.05	?
Motul Specific 505.01	5w40	SJ	4.81-5.11	?
Pennzoil Platinum Synthetic European Formula	5w40	SL	4.5	226
Redline	5w40	SL	5.3	250

Although Motul Specific 5w40 API SJ has been discontinued, I have it on the above table for reference. I have run it in my newer VWs with excellent results and have enough oil stockpiled to last a few more years before I have to worry about choosing another oil meeting the 505.01 specification. It was replaced by another Motul Specific VW oil, which now carries a 502.00 approval as well as the 505.01 specification. Interesting point it is the ONLY oil on the market that is a 502.00 oil that meets 505.01 requirements. We have plans to test the VW specific Motul oils in both aircooled and watercooled Porsche engines as we believe it's robust formulation should provide superior performance to any Porsche approved oils.

Another popular oil highly recommended on the Rennlist forums has been the Mobil 1 Truck and Diesel 5w40 that was an excellent choice up until May 2008, when it was "reformulated" to meet the standards of new diesel engines and hence, is not an API SM/CJ-4 rated oil. As I have stated previously, I don't have the same faith in backwards compatibility of these reformulated products because there just is not the evidence that they will do the same job over the long haul. To this effect, many fleet service related publications still recommend using SL/CI-4 oils in vehicles without particulate emissions filters, leaving the new reformulated oils only for those engines absolutely requiring these low Zn/P oils.

Of additional interest is a German Porsche AG Technical Bulletin "2000 Motoroelfreigaben", showing 10w40 and thicker oils are also an acceptable viscosity, which was previously considered as being too thick for these newer, non-variocam equipped engines. If that is the case, Mobil 1 High-Mileage 10w40 or even Mobil 1 MX4T 10w40 may be excellent non-approved candidates, the latter motorcycle oil for track use mostly and not recommended for use with catalytic converter equipped vehicles. The only exception to this are the 2001 and later engines with Variocam, since this system is sensitive to oil viscosity and will throw a CEL if the wrong viscosity is used. Another suggestion is to mix 50/50 Mobil 1 0w40 and Mobil 1 MX4T 10w40, to yield a

product in the proper viscosity that is recommended with levels of anti-wear additives as originally recommended by Porsche, with an API SH or SJ rating.

If you have run the Mobil 1 4T Racing / MX4T motorcycle 10w40 oil, or any other non-approved oils in your M96 engine, we'd like to hear from you. We may provide oil testing at no charge to you for your assistance.

Although not a new Boxster or 911 with an M96 engine, I am also using my wife's 2004 W8 VW Passat for oil testing, as it's valve-train and overall engine performance is similar to that of the M96 engine, with oil changes every 5,000 mi with a similar 12 qt oil capacity. Currently, we have base-line results (additional results here) for the Motul VW approved 505.01 spec motor oil required by VW. Currently, Motul 300V 5w40 is being run to determine its performance compared to the cheaper, semi-synthetic Motul 505.01 oil and for 2009 we have planned to try running Motul's newest VW specific 502.00 5w40 motor oil to then be followed by Mobil 1 0w40 (also VW 502.00 approved) and possible other oils including Redline, Amsoil, and many others so as to compare their performance to hopefully find an oil that will provide the best performance for the M96 engine.

How can I find what API specification the oil I use meets or how do I find an oil with Zn and P levels higher than an API SL or SM oil?

Here are some quick links to the API's find brand by viscosity search engine for popular viscosities:

0w40 | 5w40 | 15w40 | 5w50 | 15w50 | 20w50

This is an easy way to find oils with API SF, SG, SH, or SJ ratings. Side by side with a "Porsche" approved oil list, you can easily find which oils probably have higher levels of Zn and P. You also want to make sure the oil meets the ACEA A3/B3 requirements as well, as the ACEA is much more stringent in allowable tolerances for wear required for the much more severe driving conditions European cars sustain.

Is there any potential problems with boosting the Zn and P in my API SM or CJ-4 oil or such a thing as too much ZDDP?

Beware of ZDDP boosters and concentrates being sold under various names. These products should truly only be used at time of break-in or not at all if a fully-formulated break-in oil is used. I haven't tested every one of these products, but one thing is very obvious to me. Every product previously sold to boost ZDDP, be it STP or EOS, always had roughly an equal amount of detergents to offset the affect of ZDDP in reducing the TBN of motor oil. Most of these ZDDP concentrates omit detergents altogether or use over-based Ca detergents known to reduce the efficiency of the anti-wear properties of the oil! Just like you need more Zn and P in an oil that has more detergents, you also have to have additional detergency because of the breakdown of ZDDP in peroxides and its interaction with combustion byproducts to form sulfuric acid. Knowing the right balance is something best left to the oil manufacturers and their chemical engineers. More acid, will increase the oils TAN, and will lead to corrosive wear of bearings. For once, I will have to say that more is not better, especially in this case. EOS and STP are decades old, and proven products that work synergistically with your existing motor oil and were never designed to boost the Zn and P more than 100-200ppm - unlike some recommendations to run double the ZDDP, in excess of 2000 ppm, which can lead to increased wear! It is not only the level of Zn and P that is important, but also starting with an oil that meets the ACEA A3/B3 standard would assure a starting TBN of 10 or higher and with similarly higher HTHS viscosities will also give you greater protection too. If you do choose to use these products, you must do used oil analysis to determine drain intervals and monitor overall TBN retention and ensure that the TAN increase does not lead to increased bearing wear! Too much ZDDP can also foul spark plugs and oxygen sensors, not to mention plug EGR valves and the catalytic converter. Additionally, lack of testing of these ZDDP boosters compared to fully formulated oils intended for racing or for older engines or even against SM-rated oils side by side do not instill confidence in their performance, or at least at the time this was written.

How can I boost the level of Zn and P safely?

IF YOU MUST, PLEASE REMEMBER MORE IS NOT ALWAYS BETTER AND THAT USING THE RIGHT OIL IS ALWAYS

BETTER THAN ADDING OIL SUPPLEMENTS TO INFERIOR OILS!

We're shooting for 1200-1400ppm Zn and P! Some may say that it is out of date to be recommending EOS (new part number for EOS is **88862586**) or STP. Well, I am concerned about the various highly concentrated products being marketed, aiming at boosting Zn and P to 2000+ ppm. There is no published evidence to show that you need those levels of Zn and P and more importantly, you are drastically altering the chemistry of the lubricant by doing so. Remember, STP and EOS have been around for decades and are proven!

One way would be to use GM's Engine Oil Supplemental additive. By our calculations, between .5 and .66 oz of GM EOS has to be added to each quart of oil to raise the Zn and P by 100 ppm each. For a Porsche 911, I recommend using 1 bottle (pint) of GM EOS with every oil change if the oil you are using has less than the recommended 1200-1400 ppm (0.12-0.14%) Zn and P. If the oil you want to use has less than 1000 ppm (0.10%) Zn and P, choose a different oil, since you will need to add too much of the GM EOS to boost this. One pint of GM EOS is sufficient to boost the levels in the very popular SM rated Mobil 1 0w40 and Mobil 1 15w50 products in a 911. For a four cylinder Porsche, 1 bottle of STP 4-cyl treatment (red bottle) is the perfect amount for boosting the Zn and P in a ~4 quart fill. Alternatively, about 1/3 of the bottle of EOS will be more than enough.

If adding oil additives isn't for you, alternatively you can use Mobil 1 MX4T or V-Twin, as these oils have significantly more additives. If you were to blend 50/50 regular Mobil 1 and the Mobil 1 V-Twin, you will end up with Zn and P in the 1400-1500ppm range, which is basically like a SJ or CI-4. Similarly, you can blend 50/50 Mobil 1 0w40 and Mobil 1 10w40 MX4T (4T Racing) giving you a good level of Zn and P, balanced detergency, and the proper viscosity for required by your 986 or 996 (and later) water-cooled Porsche. This way you are mixing two similarly formulated oils made by the same manufacturer and you are most likely to have predictable results, like we have seen previously when we tested 50/50 blends of Brad Penn 0w30 and 20w50 and then compared back to back with test results of running the 20w50 Brad Penn oils.

EOS should be used as a last resort now that we know what oils are best for our engines (which was not the case back in 2004/2005 when these problems began to pop up and were identified as lubricant related) OR as an assembly lubricant as originally intended.

Why use a motorcycle oil?

Motorcycle oils have higher levels of phosphorus/zinc for enhanced wear protection and the same high-temperature detergent technology for superior wear protection and engine cleanliness, even at elevated oil temperatures. Specifically motorcycle oils for aircooled engines are designed for very high localized oil temperatures and high overall oil temperatures, and typically have high flash points coupled with higher HTHS viscosities and lower noack% losses. As a whole, it would appear that all most motorcycle oils we tested have excellent anti-wear additive levels and most are not SM oils, but rather earlier SG, SH, or SJ rated. In a pinch, it should be fairly easy to find a motorcycle oil with any of these SG, SH, or SJ ratings at your local auto parts store when it may be more difficult to get Brad Penn or Swepco, without having it shipped to you. Please do remember that motorcycle oils typically have levels of Zn and P that will kill catalytic converters, so if you have one, either remove it first or use another oil, like Brad Penn or Swepco. Also, motorcycle oils are not as detergent as the aforementioned Brad Penn or Swepco, so you must change the oil much more often, even though the perception of being able to go longer because the oil costs more is a false one.

Can I use a diesel motor oil in a car?

The newest CJ-4 formulations are now limited in the amounts of Zn and P allowed, compared to the CI-4 formations most users are familiar with. If the oil says CJ-4 or LE or "Low Emissions", even if it also lists CI-4 or CI-4+, more than likely it conforms to the new, lower levels, and should be avoided unless you have a 2007 and later diesel which requires these oils. The verdict is still out in my opinion on the performance of a CJ-4 oil in our application. If you choose to use a diesel or mixed fleet oil, stick to an a CI-4 rated oil. Nowhere should the oil say for emission system protection or for use in engines equipped with particulate

emissions filters. Swepco 306 15w40 is one such example of an extraordinary diesel oil we use in our performance engines. Swepco 306 has a healthy dose of boron and moly also for additional ant-wear response. Although difficult to find, earlier CF-4 or CH-4 rated diesel oils have similarly high levels of Zn and P but are less detergent.

Worth noting, CI-4 diesel motor oils tend to have more detergents, and it has been determined in the SAE paper "Oil Development for Nascar" that overly detergent motor oils can block or "clean" the anti-wear films off of engine parts, that is one reason that these oils usually have high levels of anti-wear additives. SAE Technical Paper Series 2007-01-3999, Modern Heavy Duty Engine Oils with Lower TBN Showing Excellent Performance, also show that low detergent packages increase the effectiveness of film formation, just as in racing oils tend to have less aggressive detergent packages, which is another reason many be to consider a racing oil versus a diesel oil for your engine. The new ACEA E9 specification will be for a low Zn and P (ash) oil with low TBN, building upon this relationship to ensure that wear protection is not sacrificed for improved detergency or longer drain intervals.

What makes Swepco 306 15w40 different from any other diesel oils?

Harley's SYN3 didn't reduce the Zn or P, just supplemented it with the added boron. Similarly, Swepco's 306 has high levels of boron in addition to high levels of Zn and P, but in a non-synthetic product using highly refined paraffinic base stock similar to Brad Penn. Since we are discussing aircooled engines specifically, the highest levels of boron we had previously found, which is matched by the Swepco 306 15w40, was in Harley Davidson’s SYN3 motor oil. Boron, which is a supplemental zinc-free anti-wear additive, was present in these oils at levels six to ten times that of what is present in any reformulated SM or CJ-4 motor oil. It has been shown that boron works synergistically with the ZDDP and it's performance is tied to levels of the ZDDP. Additionally, Swepco is among the minority of lubricant manufacturers choosing to manufacture and market the newer CJ-4 rated oils along since previous CI-4 and earlier lubricants to address the requirements of older engines rather than forcing backwards compatibility in fleet service.

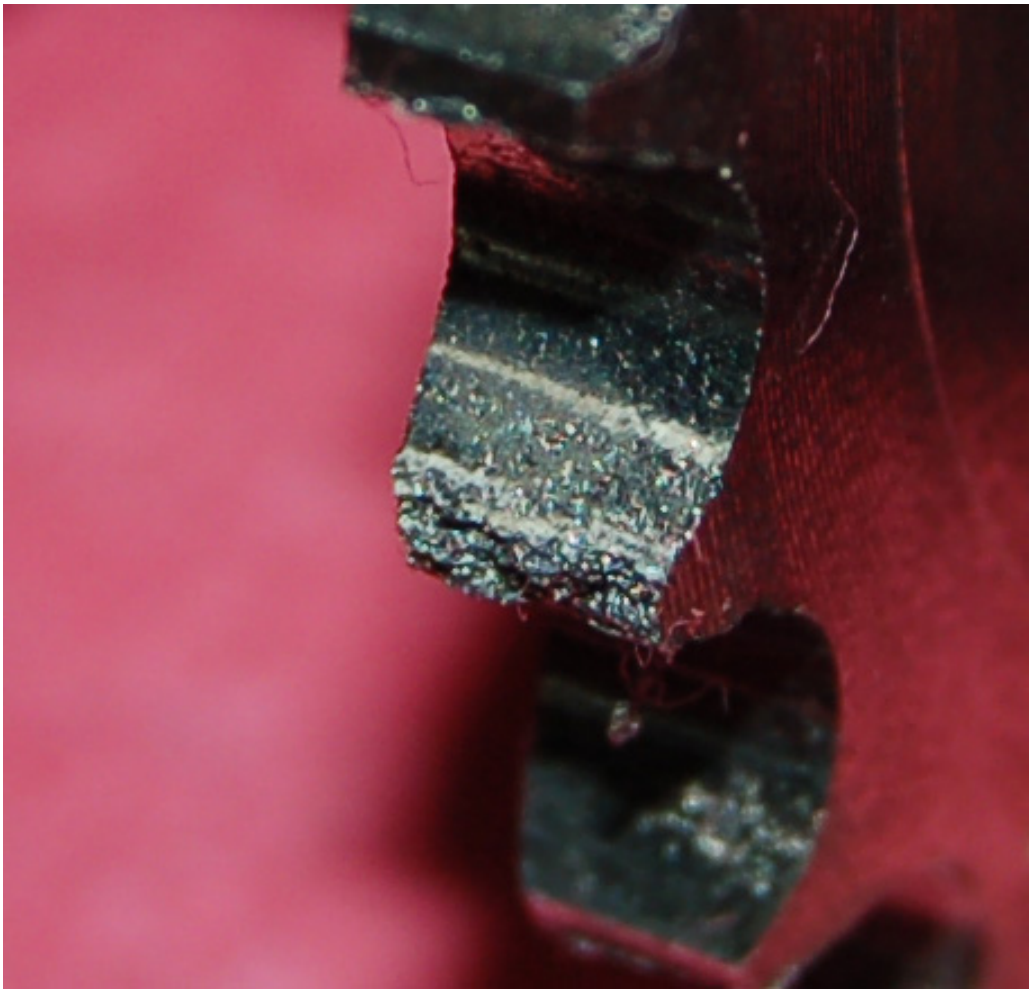
If new oils, with reduced zinc etc., are lacking in lubrication quality, why is it that engines are not being destroyed at a high rate?

Wear falls into two categories - catastrophic and non-catastrophic. Ever since the creation of the API SL standard, there have been more catastrophic cam and lifter failures from poor boundary (metal-to-metal contact) lubrication as well as corrosive bearing wear in areas with hydrodynamic lubrication. One industry wide solution was the supplemental use of EOS or switching to a racing oil, CI-4 diesel oil, or the use of oils specifically designed for older engines, like Brad Penn. Some companies, ours included, looked towards coatings for bearings and friction surfaces to remediate the problem, or even cutting edge materials like sintered silicon nitride composite followers to remove the wear component all together.

The other failure mode of engines with these poor performing lubricants was in non-catastrophic, measured in increased wear, as in bearings, cams, lifters, rockers, etc. all showing wear indicative of very high mileage or severe use in very few hours. The problem here is that most of the problems fall under the non-catastrophic, and may take years to surface. On a newer engine, like the M96, this wear may not cause any problems until the vehicle is out of the warranty period. Only when a catastrophic failure occurs, does an owner or shop take proactive measures to prevent this from happening again. All it takes is one catastrophic failure on a very high dollar engine to get a shop to make such a change, and until then, most shops continue to play Russian roulette whether they know it or not. The best preventative measure that can be taken with any engine is to change the oil often and use the best oil available, best meaning not expensive or full-synthetic, but rather an oil that is designed with high levels of anti-wear additives and the right balance of detergents.

To see additional photos of both catastrophic and non-catastrophic cam and lifter damage, click here to see how prior to our discovery that the reformulation of motor oils was the primary cause of many of our problems how we were able to minimize these failures with our ceramic composite lifters, manufactured from sintered silicon nitride.

Shown below are two examples of non-catastrophic wear, discovered in two M96 engines at time of disassembly, caused by long drain intervals and use of motor oils not necessarily formulated with the best wear performance in mind. Like mentioned earlier, the factory recommended drain intervals may be too long and recommended "approved" oils may be best for your engine:



cam sprocket wear, 2.5 Boxster M96 engine, using Mobil 1 0w40 at factory recommended drain intervals, ~35,000 mi.

cam chain tensioner pad, 2.5 Boxster M96 engine, using Mobil 1 0w40 at factory recommended drain intervals, ~75,000 mi.

My car calls for a 5w20 motor oil. Should I be using a 5w20?

Although a manufacturer may specify a particular grade, like 5w20, the owner's manual sometimes says that a 5w30 or other alternative oil is acceptable. In fact, I have spoken to many owners who use a 0w30, 0w40, or 5w40 in their engines, even though a 5w20 is specified, with the real downside only being reduced fuel economy. The use of a 5w20 is more than likely one to meet CAFE fuel economy requirements but nonetheless, you should never go away from manufacturer recommendations, especially under warranty. Machinery Lubrication has an excellent article on motor oils - fuel economy versus wear that is worth reading. But for most users, using the factory recommended viscosities and oils meeting manufacturer specifications as well as sticking to fully-synthetic oils will be satisfactory for these engines, as they were designed for oils with lower viscosities and reduced anti-wear additives. Also, some engines, like Porsche engines equipped with Variocam, are sensitive to viscosity changes and will cause a CEL if the wrong viscosity is used, so be aware of this when choosing to deviate from manufacturer recommended viscosities. So great care needs to be used when using thicker viscosities of motor oils to determine if higher operating temperatures or increased ambient air temperatures justify these changes.

Is there moly in my motor oil? Is moly bad for my engine?

From our testing, most SM oils have some level of boron and moly to make up for the lower level of Zn and P and is now more commonly found in SM oils and the new CJ-4 oils. In the development of long-life motor oils with reduced Zn and P, organic soluble moly has been added to help neutralize oxides formed in the motor oil from byproducts of combustion in addition to its use as a friction modifier to improve fuel economy and reduce engine wear in GF-4 and energy conserving oils. Some brands of oils have more moly than others, with Redline and Royal Purple using significantly high levels of moly in their lubricants. Some oil manufacturers claim that the addition of moly can reduce friction up to 38%, reduce bearing wear up to 60%

and reduce overall operating temperatures.

On the flip side, some advertise their product does not have moly intentionally, claiming moly is an abrasive and deposit forming, which are both true in as much as ZDDP, although forming good anti-wear films, it increases friction and the oil's traction coefficient. CMW Oil is one of the most vocal proponents of the elimination of moly all together from motor oils and does not use any moly friction modifiers in its street, race, or fleet lubricants. CMW is not alone in their recommendation against the use of moly in oils, with Cummins Engine Oil Recommendations, Bulletin No. 3810340-02, stating that "there is firm evidence that certain friction modifiers, molybdenum dithiophosphate for example, can in certain formulations result in cam follower pin failure at relatively low mileage." Also, molybdenum compounds in motor oils can degrade and cause bearing corrosion and is particularly aggressive towards copper. In almost all cases, any engine oil formula having "moly" will also contain a copper deactivator which will protect bearings from the moly compounds. The only problem, the copper deactivator decomposes at relatively low temperatures and looses it's potency after a few thousand miles, which can be seen in used oil analyses of moly rich oils having higher than normal copper levels. Link Additionally, there is documentation in various SAE publications showing a vast number of different species of moly friction modifiers, some providing better wear than fuel savings and vice-versa, and unfortunately, there is no easy way to determine how a friction modified oil is formulated other than to assume that a GF-4 or energy conserving oil is most likely to bias fuel savings for lower wear protection in thinner oils, like the aforementioned 5w20 viscosity so many import and domestic engines now require to meet CAFE requirements.

What kind of real-world field-testing have you done?

With some select oils, on top of our standard additive package and total base number (TBN) analysis on all the motor oils we have tested, we also chosen several motor oils for field testing done by Jake Raby @ Aircooled Technology on a vw type 4 platform with a 2270cc engine producing 185 HP, complete with data acquisition. Testing consisted of approximately 800 mi on each oil, with a complete oil system purge (including external oil lines and oil cooler) and a new Mobil 1 oil filter to ensure the best level of filtration possible, followed by used oil analysis. We tested oils as inexpensive as Castrol GTX to as expensive as Mobil 1 V-Twin and Amsoil's Harley V-Twin, including Brad Penn and a few others. The results of this testing has helped us in making some of the recommendations we now make and proof that these oils all work very well in aircooled engines. Aircooled Technology has also done side by side dyno comparisons for each motor oil tested, with particular interest in HP differences and wear metals in UOAs. Unfortunately, we lost the samples of the V-Twin and Amsoil Harley in shipping, but we have the results of the Brad Penn vs. Castrol GTX vs. Royal Purple Max Cycle available here. The Brad Penn was the clear winner in field testing, with the lowest wear metal counts between GTX, RP, and the Brad Penn. Comparing the best and worst , the Brad Penn used up ~6% of it's ZDDP versus ~23% for the GTX. The Brad Penn and RP came through in range for its viscosity grade whereas the GTX came in out of specification.

Aircooled Technology also has a spintron for testing of camshafts and lifters, allowing them to test many different oils and their performance for break-in protection. This has led them to mandate the use of Brad Penn Break-In 30WT oil on all their engines. LN Engineering is has its own spintron to conduct additional product testing in house. See video of how a spintron works and video of testing in progress. Aircooled Technology also assisted LN Engineering with its development of a ceramic composite lifter prior to discovery of oils as the primary contributor to cam lifter wear and failures. Additionally, Aircooled Technology and LN Engineering together just recently completed in January 2008 comparative oil testing of various non-synthetic, semi-synthetic, and full-synthetic oils with some very interesting results, which can be reviewed in our white paper titled "**Evaluation of motor oils and their effects on engine output and efficiency**."

Although very drawn out and time consuming (it takes a long time to rack up enough miles to do the testing), I have been running various oils in my '91 Porsche C4 Cabriolet with a stock 3.6 964 engine with ~54,000 miles on the engine (now over 61,000 as of Nov. 2008). UOA (used oil analysis) also has verified exceptional performance of Brad Penn in this application in UOA with the current fill having 2400 mi on it, which can be viewed here. We have left the Brad Penn in as the current fill and hope to be able to get a few more thousand miles on this fill to our target of 6,000-7,500 mi with this oil. The previous fill was Valvoline Racing non-street-

legal 20w50, which also had an excellent UOA, but because of it's low detergency, cannot be used for drain intervals longer than the 1400 mi I had on the oil; the UOA can be viewed here. It is worth noting that Valvoline recommends significantly less miles with their Racing oils because more conventional inline and V-engines have smaller sump capacities of 4-5 quarts compared to the normal fill of a 911 of 12 quarts. I would guess that the Valvoline Racing NSL would probably be ok up to about 2000 mi in a 911. Also, all above miles are highway, put on the car in days. The rest of the time the car sits in our garage. Most recently, we completed a run of a 50/50 blend of Brad Penn 0w30 and 20w50 which yields a 10w40 viscosity, which similar wear results to the previously tested Brad Penn 20w50 which can be viewed here. We are currently as of November 2008 testing the no longer available API SL rated 15w50 Mobil 1 which will be tested against the various other versions of Mobil 1 including the new 15w50 SM-rated and various M1 motorcycle oils through 2009.

Although not a new Boxster or 911 with an M96 engine, I am also using my wife's 2004 W8 VW Passat for oil testing, as it's valve-train and overall engine performance is similar to that of the M96 engine, with oil changes every 5,000 mi with a similar 12 qt oil capacity. Currently, we have base-line results (additional results here) for the Motul VW approved 505.01 spec motor oil required by VW. Currently, Motul 300V 5w40 is being run to determine its performance compared to the cheaper, semi-synthetic Motul 505.01 oil and for 2009 we have planned to try running Motul's newest VW specific 502.00 5w40 motor oil to then be followed by Mobil 1 0w40 (also VW 502.00 approved) and possible other oils including Redline, Amsoil, and many others so as to compare their performance to hopefully find an oil that will provide the best performance for the M96 engine.

We have also run in various race engines over a complete season the Brad Penn 20w50 and 50 wt oils and have been very impressed with their high temperature performance upon teardown of engines for inspection. Used oil analysis and physical inspection upon teardown has shown Brad Penn Racing oil to have some of the lowest wear metals in UOA as well as inspecting finding highly stressed components coming out like new. Compared to oils twice their price, even more impressive is considering Brad Penn is not a synthetic oil and the oils we are comparing them against are Group IV and V full-synthetics and the Brad Penn similarly has exceptional high temperature performance expected of and seen when using full-synthetics.

Last but not least, we have the feedback of dozens of engine builders and their collective knowledge and experiences with how reformulation has affected their customers and the engines they have built or rebuilt.

What oil should I do if I have an older, higher mileage engine? Can I use a synthetic?

We do not recommend high-mileage oils or high-mileage/stop leak/stop smoke additives because of the questionable formulation of some of these lubricants. Although not always the case, some high-mileage oils share the same improved HTHS viscosities and higher levels of anti-wear additives, such as with Mobil 1 10w40 High Mileage formulation. Regarding the whole synthetic versus non-synthetic debate, Brad Penn and Swepco oils are ideal for older engines, as they do not contain any of the Group IV or Group V synthetics-both the Brad Penn and Swepco products are highly refined parrafinic based petroleum oils. The only exception to this is the Brad Penn 0w30, which has 30-40% Group IV PAO base stock mixed in for additional low temperature and high temperature performance, exceeding some popular 0w40 fully-synthetic oils. Brad Penn's Motorcycle Oils are overwhelmingly synthetic, using hydro-cracking to get their exclusive Pennsylvania crude to classify as a Group III synthetic, which is then blended with other synthetic stocks, to compete directly with Mobil 1's motorcycle 10w40 and 20w50 oils. Most synthetic oils are formulated with seal swelling and conditioning agents to minimize the worsening of existing or formation of new leaks. That said, I have had mixed results. In my 911, which had been serviced with Castrol GTX 20w50 its entire life, I switched to Mobil 1. What was once a leak free engine now had substantial leaks, requiring attention. Once the leaks were addressed, the engine returned to being leak free and suffered from no new leaks. Also, since I have been asked, there is no problem switching back to a non-synthetic oil after having used a fully-synthetic, and in all my testing, I have switched back and forth between synthetic and non-synthetic oils many times without any problems.

Should I use a semi or partial -synthetic or full-synthetic motor oil?

In the SAE paper titled "Oil Development for Nascar Racing," published in 2000, it was determined that a 50 weight non-synthetic motor oil provided the same level of protection as a fully-synthetic 30 weight, as long as the additive package is correct, so once again, it goes to prove that dino oils can perform as well as their fully synthetic counterparts and that to some extent, it is the additives that matter most. That's why we recommend Brad Penn Racing oils and Swepco 306, both of which aren't fully synthetic. They get the job done and have been proven to perform better than most fully synthetic oils in overstressed Porsche engines. Also realize that if an oil says partial synthetic, it probably is like the Brad Penn, only 10% synthetic, so the remainder of the Group I or II base stock used to formulate the oil is just as important, if not more so, than the small percentage of synthetic product used.

I have been running a non-detergent oil in my engine? Should I switch to a detergent oil? Should I add STP or EOS?

First, if your engine has been run with a non-detergent oil for the majority of its life, you should stick to the non-detergent oil you have been using. You should not use STP or EOS products either, as both add detergents back to the oil. Switching to a detergent oil will un-lodge sludge and put into suspension everything that the non-detergent oil had left behind. Wait until you rebuild the engine or at the very least, although not recommended, if you really want to switch to a detergent oil, drop the oil pan, clean it thoroughly, and add an oil filter to the engine, if one doesn't already exist. From what I have been told, you will want to change the oil countless times until the oil, after running for an hour or two, stays clean. Again, it has been suggested this might be five or six times, or even as long as 1000 mi with changes ever 100 or so miles. Using an engine flush product as well is a good idea, but make sure to follow the instructions provided, and you will need a few oil changes to ensure the the flush product itself has been completely purged from the crankcase and engine.

I have been running detergent monograde oils, like Castrol HD30, in my classic car. Can I use a multi-grade?

Yes, there is no reason why you cannot switch to a 15w40 or 20w50. Just remember to choose a viscosity appropriate for your climate and engine (see chart above). Most 10w40 and lighter oils do not have sufficient levels of Zn and P, unless a motorcycle or racing oil with API ratings of SG, SH, or SJ. If you are running a straight weight oil in a race car that doesn't need cold start protection, most monograde racing oils (like Brad Penn Racing 50wt) have lower detergency coupled with higher Zn and P, and are the obvious solution because of their higher flash points and sheer stability for cars run on the track hard, hot, and for extended periods of time under these conditions. These true straight weight racing oils do not have the needed detergency for extended use and should be changed after every race session and are not best for the street. Also, many race engines that use monograde 40, 50 or heavier weight oils also use sump or tank heaters to ensure the oil is already to temperature before the engine is started up, eliminating concern for wear caused at start-up by the reduced cold-flow characteristics typical of a thicker mono-grade oil.

What viscosity motor oil should I use?

You should always refer to your owner's manual for the recommended grade and viscosity of oil to be used in any engine (see chart above for aircooled Porsche engines). A good rule of thumb is your should always have 10psi for every 1000 rpm minimum with the engine and oil hot BUT do not run an oil too thin, as you also have to consider than a lighter oil has lower film strength when hot! It's ok to have the pressure relief bypass some of your oil with the trade-off of a higher HTHS viscosity. If you scroll back up to the top of the frequently asked questions, you'll find a chart showing viscosity recommendations for an aircooled engine which are pretty much the same as you would want to run in any vintage or performance engine unless your engine builder or the engine manufacturer states otherwise.

We are aware of the group of people who believe thinner oils are better for their engines. This is only the case if the engine is of a design requiring thinner oils or can support use of these thinner oils. Where choosing the thinnest oil to maintain the required pressure might seem logical, you have to also consider that you have

a thinner oil film and lower HTHS viscosity for that thinner viscosity oil, which provides less protection in areas where metal to metal contact occurs where pressure itself only insures bearing protection, which has not been a problem we've ever experienced using higher viscosity oils like 15w40 and 20w50 viscosities.

Motor oils are superior today than what was available even a decade ago. Why does it matter what oil I use in my aircooled engine since they are "better" than what was offered when my engine was new?

Yes, most do agree that motor oils and the additives used today are more advanced than what was available in the 50s, 60s, and 70s for sure. That said, modern motor oils are governed by requirements dictated by auto manufacturers and API standards (among other standard bodies).

Most modern engines have dual overhead cams with four or more valves per cylinder, allowing for lower valvetrain mass and significantly lighter spring pressures, than what are used in older SOHC or OHV pushrod engines. One reason we need oils with more Zn and P is as follows: a good comparison is a stock Porsche 912 had about 200 lbs spring pressure; a Ford Crown Victoria, like those used in the Taxi motor oil study years ago by Consumer Reports and even earlier by GM in the 70s had up to 180 lbs, usually more like 160 lbs. A modern Porsche Boxster engine has only about 135 lbs over the nose. The amount of Zn and P that has to be used to protect valvetrain components is directly proportional to spring pressure and valve train mass. A high performance street pushrod or single overhead cam engine can easily have 300 or more lbs. of spring pressure or more if a race engine.

Most modern engines are water cooled, not aircooled, allowing for better control of localized engine temperatures. There obviously are exceptions to this- turbos are one exception that comes to mind. The oil used to cool (and lubricate) the turbos sees tremendous oil temperatures. Newer turbos are also water cooled to address the coking issue of localized very high oil temperatures typically found in turbos. Diesel engines also run higher oil temperatures than their gasoline fueled bretheren. These engines need higher HTHS (high temperature high shear) viscosities. Usually ACEA A3/B3 compliant oils are tested for this and must meet a minimum specification of 3.5 cSt. Most modern oils are not tested to see if it meets the ACEA A3/B3 requirements, as they are much more demanding than those imposed by the API.

Other examples are small displacement/high horsepower/high rpm engines, like BMWs M3 and M5, just to name two. They vary by manufacturer, but many have specific requirements when it comes to motor oils. Many of the manufacturer specific oils encompass the need for a very high TBN or total base number for long drain intervals while maintaining very strict limits on wear rates, again usually higher than what is specified by the API standards. One good example of this is the Volkswagen Group Oil Specifications, including but not limited to 500.00, 501.01, 502.00, 503.00, 503.01, 505.00, 506.00, and 506.01, all of which pertain to oil requirements. VW also has a 504.00 and 507.00 specification to top things off. Who knew oil could be so confusing?

Porsche used to recommend in excess of two year/20,000 mi drain intervals on their newest cars, as does most every European auto manufacturer, which is too long in the opinion of many veteran Porsche mechanics and engine builders. In fact, Porsche reduced the interval to one year/12,000 mi just recently with the 2008MY, retroactive back to 1984, which if you didn't know, is less than what Porsche recommended on the later aircooled engines in the 90s, using API SF-SH rated oils.

BMW and Mercedes even have oils and vehicles in which they call for 30,000 mi drain intervals. The demands of formulating a long life motor oil can directly impact the anti-wear properties, as Zn and P must be substituted out for other anti-wear additives, to improve the TBN retention of the motor oil and its detergents for the longer intervals. This is fine with newer, lighter valvetrains, but not the case with older engines that need those higher levels of Zn and P to provide the minimum levels to ensure adequate protection. We don't need long drain intervals on our older cars.

Another consideration is that modern oils are for the most part designed with increasing the longevity of emissions control devices, not making your engine last longer. One good example of this is the new CJ-4

specification for diesel oils, for 2007 and later diesel engines with particulate emission filters or other emissions controls. One thing to remember is that most of our older Porsches and even some of the newer ones were designed to run Zn and P levels as found in API SE-SJ oils, even up to 2004, not these newer SL or SM rated oils!

What is sludge?

Another rampant problem is sludge formation. Many manufacturers have turned to synthetic oils to fight the formation of sludge, requiring owners to use synthetics meeting manufacturers stringent specifications due to the contamination, high oil temperatures, extended drain intervals, small filter capacities, and reduced sump capacities. Visit http://en.wikipedia.org/wiki/Oil_sludge for a list of cars suffering sludge formation and you can see this is a big deal. Another excellent link on sludge formation is http://www.schleeter.com/oil-sludge.htm.

Sludge formation in our older aircooled engines can easily be solved by getting the engine (and oil) sufficiently hot (>212F) and doing so for at least 20 or 30 minutes at a time. Try to avoid starting up the engine and just letting it idle, as this just increases the fuel contamination in the oil. You do more harm not getting the oil up to temperature and putting serious miles on it than not starting it at all. Changing your oil after the car as been sufficiently driven and the oil is nice and hot also helps to get the moisture out of the engine and should be done before the car is put into storage for the winter, for those who don't use their cars during the winter months.

I want to learn more about how motor oils are evaluated. How is valve train wear tested for and measured? What other key factors go into evaluating a motor oils performance that pertains to my Porsche?

The most stringent test used in evaluating ACEA A1, A3, and A5 as well as B and C series sequence is the Peugeot TU3M Valve Train Scuffing Wear Evaluation test (CEC L-38-A-94). At its peak, the engine is operated at 3,000 rpm at oil temperatures of 212F (100C) for 60 hours (100 hours combined). The camshaft and rocker lobes, similar to the setup in an aircooled Porsche 911, are limited to an average wear of 10 micrometers and max wear of 15 micrometers.

Another test is the Mitsubishi 4D34T4 (JASO M345:1999) valvetrain test for JASO DH-1, with a max 95 micrometers cam wear. Total wear is similar to limits permitted in current CI-4 and CJ-4 oils, but this particular test is done at 105C for 160 hours at a steady full load at max power for the full 160 hours. Above specifications as reported by the Southwest Research Institute for the Peugeot and Mitsubishi test sequences.

Again it is worth noting that modern engines have ligher valvetrains running lower spring pressures than most aircooled Porsche engines, so just because an oil meets one of the above ACEA requirements on their testbed, it doesn't necessarily imply an equal level of protection or performance in your engine.

The European ACEA A1, A2, A3, B2, B3, and B4 classifications plate a cap on P levels at 0.10-0.12%. Additionally, ACEA A2 and A3 sequences require higher high-temperature high-shear (HTHS) viscosities, stay in grade sheer stability, and tighter limits on evaporative loss, high temperature oxidation, and piston varnish. This makes oils meeting these ACEA standards that much better for your Porsche, especially since wear limits are much more stringent for valve train wear, 1/6th to 1/4th the wear allowed in the sequences for API's SM standard. **Porsche requires a minimum 3.5 cSt @ 150C HTHS viscosity**, which is a good measure of the protection any given motor oil provides. For the JASO JPI-5S-36 test procedure, a high temperature high shear viscosity of 2.9 mPa s min is required with shear stability performance less than that required of the ACEA sequences, so it's best to look for an ACEA A2 or A3 in addition to any other classifications for a motor oil. It's worth mentioning that the JASO test also has friction tests for addressing wet clutch requirements with a JASO-MA and MB, each testing its friction characteristic with respect to performance with wet clutches and the effect of friction modifiers on these clutches, but since we're not worried with this for Porsche engines, I won't elaborate. There is a new ACEA A5 classification for extended drain intervals using low viscosity low friction motor oils also requiring a HTHS viscosity of 2.9 to 3.5 mPa s. The A5 classification may not be suitable for an engine calling for an A3 or earlier and may not offer the same

performance, where the A3 calls for a min 3.5 mPa s HTHS vis. Most test sequences and limits remain the same between A1 and A5 ACEA classifications except where the A3 and A5 add a sequence for DI (direct injection) piston & cleanliness & ring sticking and A3 and A5 oils have lower evaporative loss limit and all grades must stay in grade at 100C for 30 cycles, where an A1 does not.

There are no current test sequences that guarantee the performance of modern oils in our aircooled engines or for that matter in any vintage or performance engine, even as late as 2004. Our best recommendations come from used oil analysis in real world testing as well as feedback from engine builders around the world who are clients of LN Engineering.

Who can test my engine oil? (used oil analysis)

Used oil analysis is a valuable part of determining proper drain intervals and keeping an eye on the overall health of your engine. I now exclusively use Staveley Services North America for my VOA (virgin oil analysis) and UOA (used oil analysis) testing. Once you have a VOA for a baseline of the oil you are using, a good rule of thumb for determining your drain interval is to change the oil when the TBN has been reduced to 50% of the original amount, unless testing deems an oil change is required earlier. This is more conservative than other recommendations to change the oil when the TBN is as low as 1 or 2. This means you should do a VOA (virgin oil analysis) of the oil you are using and you should order your oil tests with the optional TBN analysis to make that determination. If also testing for the TAN (Total Acid Number), when the TBN equals the TAN, then that is also an indicator that your oil needs to be changed.

In most cases, changing the oil at about half the recommended drain interval is a safe recommendation of how often you oil should be changed. In some cases, a manufacturers severe drain interval is exactly this, half the normal drain interval.

If switching labs, it is always good to have a control sample with results from each lab, from the same bottle, as not always can you compare results from different labs.

What should I be looking for in an oil filter?

It is very common to see the factory oil filter be the most recommended, and in our case it's usually a Mahle or Mann oil filter. For sure, it does meet the manufacturer's specifications, but we can do better. My filter of choice is the Mobil 1 branded filter. It has a synthetic filter media, anti-drainback valve, high burst strength, and is one of the best constructed filters I have seen. Just as good is the K&N Gold filter or Amsoil branded oil filters. In a pinch, I would not hesitate to use a Napa Gold or Wix filter, or even an original equipment factory replacement filter, which in the case of Porsche or VW is usually a Mahle or Mann filter made in Germany.

I do not recommend anything that has a "washable" filters, like an o-berg, as your only filtration, as these filters are only meant to catch large debris. If you need more flow, consider a dual oil filter setup or use of a bypass filter.

Use of magnetic filtration devices are also a good idea - Pareto Point's MagDog magnetic bypass oil filter and to a lesser extend, the FilterMag, trap magnetic debris, effectively reducing oil Fe (iron) contaminants completely from your motor oil. To learn more about the MagDog, click here or here.

For further reading on the subject of oil filters, visit these sites:

- http://minimopar.knizefamily.net/oilfilterstudy.html
- http://www.ntpog.org/reviews/filters/filters.shtml
- http://motorcycleinfo.calsci.com/FilterStudy.html
- http://www.mr2.com/TEXT/oil_filter_test.html

What if my engine does not have filtration?

Without filtration, regardless of how much money you spend on your oil, you will end up having to change your oil often. Remember, that doesn't mean you should use a cheap oil!

Most stock engines have a spin on or cartridge style oil filter. In the majority of those cases, it's a bypass filter, where only a small portion of the oil actually goes through the filter. It's the idea that the oil is constantly filtering, so eventually all the oil will get filtered.

With full flow filtration, 100% of the oil goes through the filter. This does however require very high quality filters with HIGH burst strengths and durable construction, especially of the internal filtration media, because what's the point of full filtration if the media just bursts and lets the contaminants out and doesn't filter the oil?

What gear oil is best for my Porsche transaxle (manual gearbox)?

There are many excellent choices for gear lubes, both synthetic and non-synthetic that are appropriate for use in our transaxles. I have had excellent success with the tried and true Swepco 201 80W-90 gear oil everyone has been using for years, but many do seek the benefits of a synthetic hypoid or gear lube.

For transaxles that call for a GL-4 spec gear oil, I have had excellent results with Amsoil's fully synthetic GL-4 gear lube, not to be mistaken with a GL-5, which is "backwards compatible." Another excellent GL-4 is manufactured by Redline, MT-90, which is a true GL-4 75w90 gear oil.

For transaxles that are compatible with GL-5 spec gear lube, you have many choices. Swepco for starters, being the most popular choice for gear lube among most Porsche owners. Royal Purple makes an excellent Max Gear lubricant, which I have found to work well in worn transmissions that need extra cushion or have notchy shifting. I have also run Redline's 75w90NS in a 901-transaxle- this formulation does not have friction modifiers for limited slip differentials, which can be picky in some transmissions.

Another favorite of mine is Mobilube SHC 75w90 (now known as Delvac 1 75w90), not to be mistaken with the Mobil 1 gear lube found at your local flaps. This stuff is the factory GL-5 fill from Porsche in all their race cars and is an industry standard in semi / mixed fleets. You cannot go wrong with Mobilube SHC or its Delvac 1 branded replacement.

Does it matter what fuel I use?

Yes. Only use "Top Tier" fuels, like Shell V Power. Cheaper fuels may not have the detergency or lubricity required of high performance engines. It is worth noting that auto manufacturers, such as BMW, helped to establish the requirements for these top tier fuels to meet the needs of their engines. Fuels with lower levels of sulphur also typically result in less engine wear as well.

What fuel system cleaner, lead additive, or octane booster should I use?

Fuel system cleaners are widely available from dozens of companies, all promising everything from helping you to pass emissions testing to increasing octane. Many do little more than put a drain on your wallet. In most cases, using a quality pump premium formulation is the best thing you can do for your engine, regardless of octane requirements. Most modern engines and fuel management systems can adjust for the increased octane and provide improved fuel economy and horsepower, so even though the octane requirement may be 87 or 91 octane, it can benefit from 93 or even 94 octane.

If you want to use a fuel system cleaner, use one that meets OEM requirements and is actually used by OEMs. Redline makes a fuel system cleaner that is good for both fuel injected and carbureted engines, called

SI-1. They also make a lead substitute, called just that, Lead Substitute, that also cleans your fuel system and is safe for injectors and catalytic converters. Both are excellent products ok for continuous use or occasional cleanings.

Another product endorsed by many Porsche owners is Chevron's Techron Fuel System cleaner. There are many versions of this cleaner, but it is the most expensive one (with the highest % of Techron) that does the trick. The only caveat is that many owners recommend this cleaner should be used just before you change your oil, as the fuel system cleaner can contaminate your motor oil.

Additionally, Swepco's 503 gasoline and diesel fuel improver is an excellent fuel system cleaner, but can be expensive to ship because of hazardous material charges.

Regardless of which you choose, I recommending using these products at least every time you change your oil (preferably before you change it!).

If you need to boost your octane, again, if you have access to race gas, that's your best bet for a guaranteed octane boost. That said, Torco makes two race gas concentrates. One is unleaded and safe for use with catalytic converters and for street use and the other is leaded (with real lead) for OFF-ROAD USE ONLY. For example, 10 gallons of pump premium blended with 1/3rd of a bottle of either concentrate yields roughly 98 octane. In my own personal testing, the engine ran smoother and the plugs were cleaner when running their race gas concentrate, as it helps the fuel burn more completely and cleaner, regardless of the fact that it did make my carbureted engine run richer. But keep in mind that lead gets into the oil and will cause accelerated wear, so try to keep lead additives or leaded fuel limited to race engines that get oil changes frequently, if not after every race.

I want to learn more about motor oils. Is there any recommended reading?

I have created a Google notebook containing links to many of the SAE Journals I've referenced, which can be viewed by clicking here.

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