540 RAT – Tech Facts, NOT Myths

MOTOR OIL ENGINEERING TEST DATA

by 540 RAT

The date June 20, 2013 just above, is the date this Blog was first started, **NOT** the date of the information included. It is regularly updated with the latest information, as indicated by the date several paragraphs below.

NOTE: The motor oil wear protection test data included in this Blog, is from Engineering performance testing of many different motor oils, which shows how they compare relative to each other. The focus is on the motor oils themselves. Therefore, the resulting comparison data applies to ANY engine that uses the oils included here, no matter if the engine is used for racing, daily driving, grocery getting, watercraft, or any other activity

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I have no agenda here. I do not sell anything. I do not charge for viewing the Engineering Test Data found here in my Blog. I do not charge people for the oil tests I perform for them. I do not make even one penny off my Blog. I do not answer to a Board of Directors. I do not answer to Investors/Shareholders. I do not work for any Oil Company. I do not work for any aftermarket Additive Company. I do not accept sponsors. I do not accept Advertising (any Ads you come across on this Blog have nothing to do with me. They are put there by the Blog Service Provider, and I have no control over them). This allows me to be 100% UNBIASED and INDEPENDENT with no outside influence.

I operate this Blog in my spare time when I get the chance. I simply share my Engineering Test Data as a courtesy to other Gear Heads. I do not express an "opinion" about motor oil like most everyone else on the Internet does. I do not express a "theory" about motor oil like most everyone else on the Internet does. I merely post the FACTS that the Science of Physics and Chemistry proves to me. And my test data EXACTLY MATCHES real world experience. A number of examples are provided below in this Blog.

It does not matter to me how many minds I change. I do not have to convince anyone of anything. People are free to embrace my Engineering Test Data and make use of it for their own benefit, or they can ignore it and continue to only guess how motor oils truly perform. But, countless intelligent people all over the world have no trouble understanding the value of my breakthrough Test Data, that simply cannot be found anywhere else. So, I invite you to read through my entire Blog and decide for yourself, what you think of the Engineering Test Data included here.

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Before we get into motor oil tech, let's briefly touch on a little background info. That way people will better understand who I am and where I'm coming from. Here are my credentials:

Mechanical Engineer

U.S. Patent Holder (Mechanical device designed for Military Jet Aircraft)

Member SAE (Society of Automotive Engineers)

Member ASME (American Society of Mechanical Engineers)

Lifelong Gear Head, Mechanic, Hotrodder, Drag Racer, and Engine Builder

I'm a working Professional Degreed Mechanical Engineer, and Mechanical Design Engineering is what I do for a living. A Mechanical Engineer is clearly the most qualified Engineer to test motor oil that was formulated by Chemical Engineers, for wear protection capability between mechanical components under load. But, as you will see below, the following write-up is not intended to be a chapter out of an Engineering textbook. And the intended audience is not other Engineers. There are no formulas, equations, charts or graphs. The intended audience includes Mechanics, Automotive Enthusiasts, Gear Heads, Hotrodders, Racers and Engine builders. So, it is written in normal everyday spoken language, rather than overly technical jargon. That way, it will be the easiest to follow and understand by the widest possible audience. And some key points will be "intentionally" reiterated from time to time as the information presented here progresses, to emphasize those points.

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** This Blog now has over **485,000** total "views" worldwide!! Heading toward the amazing half a million views milestone, clearly shows how popular this Blog is all over the world.

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Its view count increases by more than 10,000 views per month. And the highest number of views on a single day took place on March 29, 2018 when 1,092 views were recorded. That replaced the earlier record from January 18, 2018 when 1,061 views were recorded. Of course simply listing the number of views by itself, is not intended to indicate validation of the test data (validation is shown throughout the Blog). But, indicating the number of views does show that an enormous number of people worldwide recognize the value, understand the importance, and make use of the motor oil test data FACTS included here, that cannot be found anywhere else. And as a result, they are posting and sharing links to this Blog, all over the world.

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!! THE INFO ON THIS BLOG BLOG WAS LAST UPDATED ON August 19, 2018 !!

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• Tech Article, "36. Is Motor Oil Viscosity Index (VI) Useful Information?", was added.

• The view count above, was updated.

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NOTE: All oils used in the testing here, were purchased in the U.S.A., unless otherwise specified.

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HOW TO SEARCH ON THIS BLOG:
Press the **F3** key, or press "**ctrl F**". Type in what you are looking for, in the FIND window at the top, and it will show the number of matches found, at the top. It will highlight those matches in yellow, and will take you right to the first match.

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A COMMENT ABOUT THE "Q & A" SECTION ABOVE:

In this Blog's Q & A Section, people can contact me directly with their questions, and I will answer them as soon as I can. I have received and answered hundreds of questions.

I can see a view count of how many people read this Q & A section each day, which is often around one hundred people (however, the daily view count of the main body of this Blog itself, is many times higher than that). However, none of the daily view counts on this Blog, are visible to the general public.

And be aware that this Blog automatically blocks and deletes all nasty messages that contain certain key words. So, I cannot see what has been said in any nasty message. I can only see "how many" nasty messages were blocked and deleted.

So, if people want to contact me in the Q & A Section, they have to send normal decent questions or messages so that I can see them.

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SOCIAL MEDIA AND BOUNDARY LUBRICATION:

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I should probably take a moment here to address an issue that some of you may have come across, and wondered about. A Social Media critic of this Blog, like all critics of this Blog that I'm aware of, is totally unqualified to be commenting about my Blog's factual Engineering test data, which is determined by the Physics and Chemistry involved in the testing. However, this critic claims that "boundary lubrication" is all that matters, rather than my test data. For those not familiar with that, here is a definition:

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"The regime known as "boundary lubrication" occurs when conventional hydrodynamic fluid film formulation due to fluid entrainment is insufficient to fully separate lubricated, rubbing surfaces. In such circumstances it is found that the surfaces often continue to be separated by a very thin protective film produced by adsorption or reaction of components of the lubricant on the solid surfaces. The precise nature and properties of boundary lubricating films have long been a subject of debate and research."

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This is the condition that is in effect just before the parts would seize, if that was not maintained. And this is where zinc or other extreme pressure anti-wear motor oil components would be in play. But, this critic is so laughably unaware, that he doesn't even understand that my Engineering tests have absolutely, and automatically, always involved every oil's boundary lubrication capability. Because boundary lubrication "IS" part of the motor oil testing I perform.

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My testing determines each oil's ultimate failure point, also called its maximum "film strength/load carrying capability/shear resistance value", which takes place at the same time

as the boundary lubrication reaches its limit. So, to put all this in simple terms, if you refer to my test results of each oil's ultimate failure point, as the film strength limit, the load carrying capability limit, the shear resistance limit, or the boundary lubrication limit, they all effectively mean the same thing and represent the same psi value that I post in my Wear Protection Ranking List. And a debate about any practical difference between them, is just unnecessary silly semantics. But, this critic is so clueless, that he completely misses the point, that he is arguing "FOR" what my testing has been doing all along. He completely endorses my testing, while thinking he is arguing against it.

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For the reasons just mentioned, I don't bother talking about boundary lubrication itself, in this Blog. As I said above, this Blog is not intended to be a chapter out of an Engineering textbook. It is meant to provide useful information to the reader. So, what is truly important to us, is finding each oil's actual ultimate failure point/maximum wear protection capability limit, which is precisely the information that my Engineering test data provides. That way, we know just how capable each oil is, which is what we compare. With that information, my Blog readers can make an informed buying decision, the next time they buy motor oil for their engine. Ask that critic what specific data he thinks he can provide, for you to take to the Auto Parts Store, and he won't have an answer for you.

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Another example of that critic having no idea what he is talking about, is his bogus claim that my test data could only apply to old school engines, such as traditional flat tappet engines, but not to new modern engines. He does not know that there are brand new, major brand name, modern state of the art engines, coming off the assembly line with dual overhead camshafts (DOHC), with lobes that push directly down on buckets which compress the valve springs. Not all brand new modern engines are fully roller type engines. So, those brand new engines, and old-school flat tappet engines, have the same exact type of cam lobe friction interface.

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On top of that, he has no grasp of the statement, "Most engine wear takes place during cold start-up before oil flow reaches all the critical internal components". This is an absolutely FACTUAL statement that I make from time to time. It definitely pertains to most all Hotrods and Race cars, that can often sit for weeks at a time, or even longer, no matter if the engine is OLD-SCHOOL or MODERN. Under that condition, most of the oil has drained off of critical internal engine components, and seeped out of oil passages.

That leaves those parts with only a questionable amount of an oil film remaining, to prevent wear during cold startup, while waiting for oil to start flowing again. And of course having an oil film from a highly ranked, excellent performing, low cold viscosity rated motor oil such as 0WXX or 5WXX, from my Wear Protection Ranking List, greatly helps to reduce wear during critical cold start-up conditions. And priming the engine with oil before firing it up, provides even better insurance against wear. Hotrodders and Racers are who this Blog was originally started for, and they still make up a huge portion of this Blogs readers. So, this is certainly worth repeating from time to time.

But, for daily drivers, there is little concern about cold start-up wear, because there is sufficient residual oil on critical components and in oil passages, from running the engine every day. And in addition to that, this critic doesn't even know that once any engine is fired up and running with full oil flow, no matter if it is OLD-SCHOOL or MODERN, as long as it is run easy while being allowed to fully warm-up, which allows sufficient lubrication even with the reduced oil flow rate from the oil being cold and thick, there will be little to no wear taking place during that time. See my Tech Article, "23. Multi-viscosity motor oils are not exactly what some people think", and "31. The Truth about Motor Oil Temperature and Wear Protection Capability", for more details.

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These are just a couple of examples showing that my test data does "in fact", apply to both old-school and modern engines, no matter what that critic says. I invite you to compare my complete Blog to any nonsense he has spewed on Social Media. And then decide for yourself who is providing FACTUAL information, that you can actually make use of yourself, in any engine from mild to wild.

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BOTTOM LINE:

My advice is, ignore any critics of my Blog, because they have always been wrong, and cannot be trusted. They are not Engineers, they don't have Credentials, they don't have in-depth real world experience with engines, and they have never done any testing themselves. So, they draw all kinds of incorrect conclusions and assumptions about motor oil, since they have no idea what they are doing. They read a few lame Internet articles, and they think they are experts. But, they are completely clueless that some technical information they read about motor oil, is so highly theoretical, that it isn't even a factor in the real world. So, they don't even know, what they don't know.

If normal decent Blog readers have a legitimate question, they can ask me in the Q&A Section at the top of this Blog. And I'll answer their question as soon as possible.

But, it is not my job to train critics how to be an arm-chair Engineer in a couple of paragraphs, when all they really want to do, is argue about everything. I don't have time for that kind of nonsense. If critics cannot accept the information I share here, they are free to go back to just "guessing" how motor oils perform, and to drawing "incorrect" conclusions and assumptions about other technical aspects of motor oil. That will be their loss, not mine.

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This Blog will provide you with the best, most complete, FACTUAL motor oil test data you will ever find anywhere. I challenge anyone, anywhere, to PROVE that my Engineering test data is wrong. Enough said. Now on with the Tech FACTS you came here for.

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BRIEF TECH INTRO:

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The absolute MOST important capability of any motor oil, is to PREVENT WEAR!!! And that capability is determined by its proprietary additive package formulation which includes the extreme pressure anti-wear components. Everything else a motor oil does, comes AFTER that. And everything else a motor oil does, is in "back-up support" of preventing wear. For example, preventing acid formation, ultimately prevents wear. Preventing deposit build-up, maintains oil flow and lubrication, preventing wear. Preventing sludge build-up, maintains oil flow and lubrication, preventing wear. Minimizing air bubbles/foam, keeps the oil mostly liquid oil which is required for proper lubrication, preventing wear, etc, etc. You get the idea.

Here are the two primary decisions you need to make regarding the motor oil you use in your engine, in their order of importance:

1. The NUMBER ONE most important decision is to select an oil from my Wear Protection Ranking List found below in the Blog, that provides the level of wear protection that you feel comfortable with for your particular engine. The higher the psi value, the better the wear protection. Racing engines and High Performance street engines that load their oil near its limit, especially traditional American flat tappet pushrod V-8 engines, are best protected with highly ranked oils. Ordinary low performance daily drivers that only lightly load their oil, can get by well enough with low ranked oils, if absolute maximum life out of the engine is not critical.

Regarding traditional American flat tappet pushrod V-8 engines specifically:

Stock or lightly modified versions of those engines are best protected by oils that provide 90,000 psi or higher film strength/load carrying capability/shear resistance.

Racing and High Performance street versions of those engines are best protected by oils that provide 100,000 psi or higher film strength/load carrying capability/shear resistance.

NOTE: There are synthetic oils on the market that perform very well, while other synthetics do not. There are conventional oils on the market that perform very well, while other conventional oils do not. My Wear Protection Ranking List shows you which oil is which.

2. The NUMBER TWO most important decision is to decide when to change the oil you are using, no matter what that oil may be. See Tech Article "25. Recommended Oil Change Interval – For Automobiles "AND" Motorcycles", below in this Blog for all the details on that.

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Motor oil exists in "TWO" forms inside an engine, under which it needs to protect against wear. They are as follows:

1. "Liquid oil" which can be defined as oil thick enough to drip, run, pour or flow.

2. An "oil film" can be defined as a coating of oil too thin to drip, run, pour or flow.

An example of oil in "liquid" form, is in the rod and main bearing clearance, where the incompressible hydrodynamic liquid oil wedge is formed between the crankshaft journals and its bearing shells, as the oil is pulled in by the rotating crankshaft. Oil pressure does not keep the parts separated. Oil pressure serves only to supply oil to be pulled in between the parts.

The fact is, liquids cannot be compressed to allow metal to metal contact, so parts are kept separated and no wear or damage can take place. In liquid form, it does not matter what the oil's viscosity is, what brand it is, how hot it is, nor how much it costs. Because in the incompressible liquid form, all motor oils provide the same unsurpassed wear protection.

A mere "film of oil", is the last line of defense against metal to metal contact, and the subsequent wear and/or damage that can follow. An example of an oil film is between non-roller flat tappet lifters and cam lobes of traditional pushrod American V-8 engines, or in DOHC engines between the cam lobes and non-roller type followers they may use. But, it is most critical in pushrod engines which typically use large single intake and single exhaust valves with stiff valve springs, compared to DOHC engines which often use two smaller intake and two smaller exhaust valves with lighter and smaller valve springs. In these locations, no incompressible hydrodynamic liquid oil wedge can be formed because of the wide open parts configuration. And the oil present is simply pushed aside, leaving only a film of oil between the parts with a very thin, highly loaded "line contact" between the parts.

Since "all liquid oils" are incompressible and thus provide unsurpassed wear protection, there is nothing to test for comparisons between different oils in liquid form. My Engineering Tests evaluate the much more critical oil film strength/load carrying capability/shear resistance, which as mentioned above, is the last line of defense before metal to metal contact takes place.

No reliable comprehensive information had been available for this capability comparison, until I began my dynamic motor oil testing, under load, at a representative operating temperature. I perform those Engineering Wear Protection Tests to find out where the motor oil film strength, load carrying capability, shear resistance "limits" are for each individual motor oil. That's what we compare. The higher the limit, given in PSI, the better the wear protection.

"Film strength, load carrying capability, shear resistance" performance is where motor oil wear protection capability VARIES WIDELY depending on a given oil's proprietary formulation. And it is at the film strength level, where oils can be evaluated and compared, for those different wear protection capabilities. This is where good oils are separated from not so good oils.

Only dynamic wear testing under load, at a normal operating temperature, can reveal how the various motor oils truly compare regarding wear protection. So, that is precisely what I do to discover the facts. And that is why merely looking at an oil's spec sheet is worthless. A spec sheet cannot show you an oil's wear protection capability, because Engineering tests and real world experience have proven over and over again, that the zinc level does NOT matter. That is only a MYTH that has been repeated a million times until people just assume is true, which it is not. Only the psi value from my test data will actually show us how motor oils truly perform regarding wear protection.

My test data EXACTLY matches real world severe over-heating experience, real world Track experience, real world flat tappet break-in experience, and real world High Performance Street experience. Test data validation doesn't get any better than this.

BOTTOM LINE:

THIS BLOG CONTAINS THE MOST COMPLETE, INDEPENDENT, UNBIASED, ACCURATE AND FACTUAL, BREAKTHROUGH MOTOR OIL WEAR PROTECTION CAPABILITY TEST DATA, THAT YOU WILL EVER FIND ANYWHERE. THE INFORMATION HERE IS PROVEN, AND TRUSTED WORLDWIDE. Many people have called it the "be-all, end-all" of motor oil information, which is absolutely true, because it is the real deal.

For all the motor oil comparison data, see my Wear Protection Ranking List below in this Blog.

But, there could be some confusion for people who do not actually read my entire Blog. My test data on wear protection is generally aimed at High Performance and Racing engines that are capable of pushing motor oils near their limits. So, knowing how capable various oils truly are, can be critical. It is of course also for people who simply want to know what oils will provide the best possible wear protection for their engines, even if they don't technically push their motor oil near its limit.

However, for ordinary daily driver vehicles, the oil used is nowhere near as critical as it is for High Performance and Racing engines. So, a normal daily driver vehicle may operate just fine for the life of the engine on say a low performing 60,000 psi motor oil. But, a High Performance or Racing engine may require a high performing 90,000 psi or higher motor oil, to avoid wear and/or damage. It just depends on how much loading the engine puts on its motor oil.

NOTE: Read my Wear Protection Ranking List carefully regarding an oil you may be considering for your application. Because some Oil Companies make changes to their oil, making them worse than they were previously, apparently to maintain or increase profit margins. So, always look for the most recent test data on oils that have both older and newer data posted. In those cases, I always indicate which oils are older and no longer available. It may be that you can no longer safely use an oil that was just fine for your needs in the past.

And the better performing the oil, the higher the reserve wear protection capability, also called margin of safety, which means capability beyond what is actually required. If you have a problem at some point, say an engine component starts to fail, or the oil level gets low, or there is an overheating condition, or you increase the power level dramatically, etc, etc, then extra reserve wear protection capability could save your engine. So, people have to decide for themselves how much wear protection capability they feel comfortable with for any given engine build. And since you have to buy oil anyway, why not select a better performing motor oil while you are at it?

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Additional motor oil technical info:

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Oil is not the same temperature throughout a running engine, the highest oil temps will typically be found in the incompressible "liquid" oil wedge formed as the oil is pulled into the clearance of the rod and main bearings. That is because, the oil at those locations is being heavily loaded on the power stroke, while at the same time, being sheared. Oil at these locations can be 50* to 90* hotter than sump temperatures.

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During the very brief time interval that oil is flowing through the rod and main bearings, most oils will momentarily reach and exceed their thermal breakdown points. And the cooler the oil starts out, the lower the max temp it reaches there. This is where oils with a higher onset of thermal breakdown point, offer some benefit. Because the less often an oil reaches its breakdown point, and the lower the max temp reached above that point, the longer its capability will remain near new oil level. This means that oils with higher onset of thermal breakdown points, can go longer between oil changes, with regard to thermal deterioration. However, oils with more modest thermal breakdown points can also be used without issue, as long as reasonable oil change intervals are followed, to stay ahead of any significant thermal deterioration.

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The oil on the cylinder walls is not subjected to the burning combustion temperatures as some might think, because very nearly all oil has been scrapped off the cylinder walls by the oil rings, and is not present during combustion. If any significant amount of oil was still on the cylinder walls during combustion, the exhaust pipes would be blowing blue smoke.

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When the piston is at TDC, the cylinder walls are coated with oil from all the oil spraying and flying around inside the crankcase. But, as the piston moves downward, the piston skirt scrapes off excess bulk oil, and the lower oil ring of a multi-piece oil ring, scrapes additional oil off the cylinder wall like a squeegee scraping water off a windshield. So, there is a layer of liquid oil between the piston skirt and the cylinder wall (its thickness depends on the piston to cylinder clearance), not just merely an oil film like you would see between a non-roller flat tappet lifter and its cam lobe. And any oil the lower oil ring doesn't scrape off, the top oil ring of the multi-piece oil ring, will scrape off, directing it through the oil ring expander/spreader and through the oil holes in the piston.

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Piston ring spring tension against the cylinder walls is NOT what seals the rings against combustion, like most people think. There is no possible way that a mere few pounds of ring spring tension alone, could keep the rings in proper contact with the cylinder walls during the high pressure of combustion. The fact is, rings are kept in contact with the cylinder walls during combustion primarily by the tremendous combustion pressure itself, which is typically well over 1,000 psi, depending on the particular engine. The rings' spring tension does keep the rings in contact with the cylinder walls enough to direct the high combustion pressure through the ring side clearance above, and then on behind the rings', to their inside diameter back clearance. And it is this force "behind the rings" that presses the rings out against the cylinder wall with enough force to seal the combustion pressure during the power stroke (some racing pistons have gas ports behind the rings just for this purpose). That is why proper ring side clearance and back clearance are very important, as is free ring movement in the pistons' ring grooves. To ensure free ring movement and make sure that they don't get gummed up and stuck in the piston ring groves, it is important to use quality fuel and to change the oil at reasonable intervals.

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And remember, cylinder walls are in direct contact with the coolant on their outer surface. So, the cylinders are the most directly cooled parts of an engine, meaning the oil side of the cylinder walls are not anywhere near as hot as many people might think.

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IDEAL OIL TEMPERATURE RANGE

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An ideal oil sump temperature range is between 215*F and 250*F. If your sump temperature runs hotter than this range, you should add an oil cooler, or upgrade your oil cooler, if you already have one. This range is hot enough to quickly boil off the normal condensation that always forms during cold engine start-up, before that water dilutes the oil. And it is also hot enough to NOT promote the formation of sludge, like colder temperatures below the boiling point of water, can.

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And that range is cool enough to do three things:

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1. It is cool enough to keep the oil's wear protection capability at the highest level achievable by that oil.

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2. It is cool enough to provide critical cooling for engine components, which of course are directly oil cooled. Remember, engine components are only indirectly water cooled.

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3. It is cool enough to keep most oils below their onset of thermal breakdown point.

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But, motor oils do NOT stop working the instant they reach their onset of thermal breakdown point. However, it is not a good idea to run oil above its thermal breakdown point for extended periods of time. Because that will degrade its capability more and more as time/mileage goes on.

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In recent years there have been entirely too many wiped cam lobes and ruined lifter failures in traditional American flat tappet engines, even though a variety of well respected brand name parts were typically used. These failures involved people using various high zinc oils, various high zinc Break-In oils, various Diesel oils, and various oils with aftermarket zinc additives added to the oil. They believed that any high zinc oil concoction is all they needed for wear protection during flat tappet engine break-in and after break-in. But, all of those failures have proven over and over again, that their belief in high zinc was nothing more than a MYTH, just as my test data has shown.

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A high level of zinc/phos is simply no guarantee of providing sufficient wear protection. And to make matters even worse, excessively high levels of zinc/phos can actually "cause" DAMAGE your engine, rather than "prevent" it. Motor Oil Industry testing has found that motor oils with more than 1,400 ppm ZDDP, INCREASED long-term wear. And it was also found that motor oils with more than 2,000 ppm ZDDP started attacking the grain

boundaries in the iron, resulting in camshaft spalling (pitting and flaking). The ZDDP value is simply the average of the zinc and the phosphorus values, then rounded down to the nearest 100 ppm (parts per million).

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From those failures where I was able to find out what specific oils were used, it turned out that those were oils I had already performed my Engineering Wear Protection Capability tests on. And all those oils had only provided poor wear protection capability, meaning that if they had looked at my test data before using those oils, they would have known in advance that their engines would be at significant risk of failure with those oils. And that is just what happened.

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A number of people who have had those failures, and some had repeated failures, have contacted me, asking what they can do to prevent that failure in the future. I tell them to forget all that high zinc nonsense and look at my Wear Protection Ranking List. And to select any high ranking oil there, no matter how much zinc it has, because zinc quantity simply does NOT matter. The only thing that matters regarding wear protection, is the psi value each oil can produce in my testing. The higher the psi value, the better the wear protection. I recommend they use the SAME highly ranked oil for break-in and after break-in. It's that simple.

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WHEN PEOPLE HAVE TAKEN THAT ADVICE, NOT ONE PERSON HAS EVER COME BACK TO ME TO REPORT THAT MY RANKING LIST DID NOT WORK FOR THEM. Since my ranking list has worked in every case to prevent wiped flat tappet lobes and lifters, it can also work for you to provide the best possible wear protection for your engine. My test data is the real deal, it exactly matches real world experience, and it is the best and most complete motor oil comparison data you will ever find anywhere.

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And for those people who have been able to use various high zinc oils without having trouble with their flat tappet engines, that only means that the oil they used had enough wear protection capability for the loads their engines saw at that time. It does not mean they were necessarily using a great oil. And it does not provide any information about how much reserve wear protection capability their oil provided, nor how their oil compares to other oils on the market.

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But, there are some high zinc oils that do provide excellent wear protection. And you can see which ones they are, by looking at my ranking list below.

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LOOKING AT PETROLEUM QUALITY INSTITUTE OF AMERICA (PQIA) INFORMATION, OR SENDING OIL SAMPLES TO TYPICAL MOTOR OIL LABS LIKE "ALS TRIBOLOGY" OR "BLACKSTONE LABS" IS NOT SUFFICIENT

What many people don't understand is, that looking at PQIA information, or sending oil samples in to a typical motor oil lab, does NOT tell us everything we need to know about how well a motor oil performs. Some people think that if they look at PQIA on-line, or get a lab printout of their motor oil, that they know everything they need to know. But, that is simply NOT true. Here's why.

PQIA information might be interesting to look at, but it doesn't really provide any truly significant or meaningful information beyond what the API certifications of "reputable brands", already tells us. The wind-up is that API has already done all that for you by granting the appropriate certification to various oils. If an oil's performance was far enough off to be a problem, it would not meet the requirements for the specific API certification it was being considered for. So, all the end user has to do is look at the bottle of a "reputable brand" for the certification the oil has, and to change the oil at reasonable intervals, which for most street driven vehicles is ideally 5,000 miles. Doing that will provide an engine with the protection it needs in terms of acid neutralization and deposit and/or sludge build-up prevention. But, looking at PQIA, will NOT give you any information at all, about how well a given motor oil can provide wear protection, which is THE most important thing any motor oil does.

Motor oil lab printouts will only provide information such as the amount of metals, the amount of contaminants, the amount of additive package components in the oil, and its viscosity rating in centistokes (cSt) at 100*C (212*F). And the cost for this test is usually around $30.00 US per sample sent in.

According to a Royal Purple Motor Oil Engineer I spoke with a few years ago, he said only people outside of the Motor Oil Industry, use the unprofessional terminology of calling new oil lab tests, virgin oil analysis (VOA), and used oil lab tests, used oil analysis (UOA). The VOA and UOA references are commonly used on Internet Forum discussions about motor oil, even though they are not legitimate names. Even so, in order for the most people to follow along, I'll continue to use that wrong terminology for a moment here.

For a VOA, you will NOT get any information on absolutely THE most important thing any motor oil does for your engine, and that is PREVENT WEAR. Everything else a motor oil does for your engine, comes AFTER that. There is not one thing in that lab printout that will tell you how good that oil is at preventing wear. And looking at the zinc and phosphorus levels is completely worthless, because as you will see below, those levels DO NOT predict an oil's wear protection capability, even though countless people have been brainwashed to believe it does. Therefore, you still have no idea if that oil is any good at performing job number one for your engine. So, you are left with guessing, believing Advertising hype, or Internet chatter, as to which oil you should choose for your engine. In other words, you wasted $30.00 for the lab test, plus the cost of shipping, and your time, all for nothing.

If you have a lab printout from when an oil was brand new, and then you get a UOA of that exact same oil, you can compare those two printouts to see how the oil has changed during that particular change interval. There is definitely some value to that, for indications of engine health, how much of the factory additive package has been depleted, etc. But, it still doesn't provide any meaningful direct information about how that motor oil compares to other motor oils in terms of wear protection. And if you do see extra metal quantity in the used oil that might be of concern, it is too late, because you are looking at results after the fact. Wear and/or damage has already begun. That is like closing the barn door after the horse already got out. And you still wouldn't know if the extra metal is because of a poor choice of motor oils or because of a mechanical problem.

So, you need something FAR BETTER than looking at PQIA info or motor oil lab printouts for selecting the best motor oil for your engine, if you are interested in the best possible wear protection for it.

That something FAR BETTER, is the independent and unbiased Engineering testing I perform at a representative OPERATING OIL TEMPERATURE to establish motor oil wear protection capability.

Motor oils are derived from base oil stocks, which is a generic oil base that is modified with an additive package to produce a lubricant with the desired properties. A base stock oil with no additive package would perform quite poorly. Base oil stocks are classified by the API (American Petroleum Institute) and fall into one of the categories below:

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• Group I and II – are conventional mineral oils derived from crude oil.

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• Group III – is a highly refined conventional mineral oil made through a process called hydrocracking. This group of oil is allowed to be called a synthetic oil in North America.

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• Group IV – are true synthetic oils, known as PAO (Polyalphaolefin).

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• Group V – are synthetic base stocks other than PAO's, which include esters and other compounds.

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People on Internet discussions argue endlessly over the merits or lack thereof, of these oil Groups, to try and determine which oil type is best to use. But, with my Engineering tests, you can bypass all that debate, and go directly to the results of how oils you find on Auto Parts Store shelves, actually perform when put to the test. My testing is a dynamic friction test under load, similar to how an engine dyno test is a dynamic HP/Torque test under load. Both tests show how their subjects truly perform in the real world, no matter what Brand names are involved, no matter what outrageous claims may have been made, and no matter what their spec sheets say.

The resulting breakthrough data used in the Wear Protection Ranking List is NOT my opinion, and it is NOT my theory. The data is the result of the Physics and Chemistry involved in the testing. I am only the messenger. The Science is what tells us how these oils perform. And no one can argue with Physics and Chemistry.

You can see my entire 224 motor oil "Wear Protection Ranking List", which EXACTLY matches real world severe over-heating experience, real world Track experience, real world flat tappet break-in experience, and real world High Performance Street experience (test data validation doesn't get any better than this), along with additional motor oil tech FACTS, that CANNOT be found anywhere else, by reading below.

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Section 4 – Motor Oil component quantity Lab Test results – includes the amount of zinc, phosphorus, detergent, acid neutralizer and more

Section 5 – Reserved for future Motor Oil Test Data

Section 6 – Detailed Motor Oil and Mechanical Tech Articles
NOTE: Some of the motor oil Articles were written before the most recently tested motor oils were added to the Wear Protection Ranking List in Section 1. The articles included are:

1. I-Beam vs H-Beam – which Connecting Rod is Best?

2. Rod Bolt Strength – what do we Really need?

3. Solid Roller Lifters – Bushings vs Needles, which is Best?

4. Camshaft Overlap vs LSA (Lobe Separation Angle)

5. Leak Down Test vs Compression Test, which is Best?

6. Can you really suck the Oil Pan dry?

7. Dynamic Compression Ratio (DCR) vs Static Compression Ratio (SCR)

8. 0W40 vs 5W30 vs 0W30

9. Aftermarket Zinc Additives – Do they Work?

10. Break-In Oils – Do we Really need them?

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13. Do comparable zinc levels provide comparable wear protection?

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35. PISTON TO CYLINDER CLEARANCE IS "NOT" WHAT MANY PEOPLE THINK IT IS

36. Is Motor Oil Viscosity Index (VI) Useful Information?

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TYPICAL GEAR HEAD MINDSET vs ENGINEER MINDSET

A typical Gear Head's mindset regarding new flat tappet engine Break-In is, "What I've been doing works, so I don't want to change anything". An Engineer's mindset is, "No matter what you've been doing, let's see if we can move forward and improve things, making them "better" than they were before".

An example of this regarding motor oil is, a typical Gear Head has been using some high zinc oil, or some oil with an aftermarket zinc additive also poured in. And with that, he "thinks" he has made a good oil selection. But, using oil like that, knowing nothing more than the zinc level, requires a careful and elaborate break-in procedure, if there is any hope of not wiping any lobes in a flat tappet engine. He's managed to get by with this, so he thinks he has it all figured out.

But, when his motor oil concoction is put through Engineering Wear Protection Testing, the results often show it to be a low performer regarding film strength load carrying capability, no matter how much zinc is present. As a result, that oil ranks rather low on my Wear Protection Ranking List, and means that it provided only a very low Margin of Safety. With this being the case, the engine was at significant risk of failure. So, he has essentially been playing Russian Roulette with his engine, without even knowing it.

For those not familiar with the term, Margin of Safety refers to how much capability your motor oil provides, vs how much capability you actually need to prevent wear and/or damage/failure. The higher the Margin of Safety, the more reserve wear protection capability you have available, and the safer your engine is.

The careful and elaborate flat tappet break-in procedures that Gear Heads typically use, is nothing more than a crutch to try and prevent wiped lobes with low performing motor oils. A fair number of people have been lucky enough to get away with this, while some others have been wiping lobes. And wiped flat tappet lobes have been all too common over the past few years, even though name brand, highly respected parts are being used. It can be a hit or miss situation, regarding wiping lobes or not wiping lobes. But, it doesn't have to be this way, if better performing oils are chosen.

And keep in mind that so-called Break-Oils with their typical low wear protection capability are absolutely NOT required for proper break-in and ring sealing. That has been proven over the past couple of decades by numerous Factories using highly ranked 5W30 Mobil 1 synthetic oil in their brand new performance vehicles. They break-in and seal their rings just fine, and of course come with a warranty.

Being an Engineer with clear improvement in mind to solve the iffy situation of wiping lobes or not wiping lobes, I recommend switching to different motor oils that rank far higher on my Wear Protection Ranking List, no matter how much zinc they have. The only thing that truly matters is an oil's film strength load carrying capability, NOT merely how much zinc it has.

Using much higher ranking motor oils with their much higher wear protection capability, means that special break-in procedures ARE NOT REQUIRED. And an engine will be far safer due to the better motor oils providing a much higher Margin of Safety.

The Engineering mindset that resulted in the Wear Protection Ranking List, is the whole point of this Blog. So now, we no longer have to guess which oil is best. We have the data available at our finger tips to show us how various motor oils compare head to head, regarding wear protection capability.

And since you have to buy motor oil anyway, why not use this Engineering Wear Protection Test Data to help you select a high performing motor oil with excellent wear protection? The engine you save may be your own.

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SECTION 1- MOTOR OIL "WEAR PROTECTION" RANKING LIST.

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THE SINGLE MOST IMPORTANT thing a motor oil does for your engine, is prevent wear. Everything else it does for your engine, comes AFTER that. But, I have found that there is a tremendous amount of misinformation and misunderstanding about motor oil. The worst of all is that a lot of people, even those at Cam Companies, blindly accept the MYTH about needing high levels of zinc in motor oil in order to have sufficient wear protection. But, that line of thinking is NOT based on technical fact, and is simply FALSE. So, at the beginning of 2012, I began Tribology Research using motor oil "Wear Testing" equipment, to explore the facts regarding the wear prevention capabilities of motor oil. For those not familiar with the terminology, Tribology means the study of friction, lubrication, and wear between moving surfaces.

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I'm a total perfectionist when it comes to technical issues. And those who know me personally, know that I would never jeopardize my reputation or my integrity, by posting test data that would turn the Hobby/Industry on its ear, unless I was absolutely sure about the data I put out there. Of course I've always known my carefully generated data is completely accurate. And to make that clear to the world, you will see below that my test data EXACTLY matches real world severe over-heating experience, real world race track experience, real world flat tappet break-in experience, and real world High Performance street experience.

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OIL TEST DATA AND SEVERE OVER-HEATING EXPERIENCE ARE IDENTICAL

I received the following feedback from one of my Oil Test Data Blog readers:

Hi RAT, I want to share a real world experience about one of the oils you have tested.

About a year ago, my son was driving our old 1999 Toyota Camry, with 230,000 miles on it at the time, in heat of summer. And you know how young kids are today, they don't know very much about how to look after cars. So, he drives about 45 miles to his destination, and parks it.

By this time, because of a leak from the water pump, most of the coolant is gone. But, because he shuts the engine off and walks away without noticing the leak, the engine cools off. The next day when he wants to drive home, there is no coolant left in engine. But, he doesn't know that, so he starts it up and drives away. After driving about 30 miles on the freeway, it overheats so much that the engine stalls. That's when I get the call!

After I towed the car home, I filled radiator and noticed the leak from water pump, and the head gasket was leaking into the combustion chamber. So, I knew it had over-heated really bad, TWICE. I expected that the pistons and valves must have been damaged due to the extreme heat. But, after I took the head off, the valves and cylinder walls looked in surprisingly good shape. After I put it back together, it ran as good as before. And it now has 244,000 miles on it.

I then knew, the oil that was in it at the time, played very important role, and had prevented the pistons from being damaged. BUT, that oil wasn't in your ranking list at the time. So, I always wondered where that oil would it rank if ever tested?

Guess what? Now that you have tested that oil, it ranked near the very top of the Ranking List. It is 5W30 Valvoline MaxLife High Mileage (red bottle).

So if anyone doesn't want to believe in your oil test ranking, I have to tell them they better believe it. I am positive that it was the high wear protection capability of that motor oil that kept the engine from further damage!!

His experience shows precisely what I've talked about, when I have said that having extra reserve wear protection capability from highly ranked oils, may well save your engine when bad things happen.

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OIL TEST DATA AND RACE TRACK EXPERIENCE ARE IDENTICAL

A June 2018 Testimonial regarding Amsoil 5W30 Signature Series, was sent by a Blog reader from Greece, which proved ONCE AGAIN that my motor oil Engineering Test Data "EXACTLY MATCHES" real world racing experience, as I have always said. It also proves

ONCE AGAIN, that all my critics are DEAD WRONG, and have no idea what they are talking about, regarding motor oil and its performance capabilities. If you want the FACTS about motor oil, you need to read this Blog.

For reference, at the time of this writing Amsoil 5W30 Signature Series, produced 134,352 psi, and is ranked 2nd for oils "just as they come, right out of the bottle" (only Amsoil 0W20 Signature Series, was able to slightly beat it), out of 223 oils tested so far. And Amsoil 10W30 Dominator Racing oil, produced a far lower 97,118psi, is ranked 62nd. The higher the psi value an oil can produce, the better the wear protection. Here is what he said in his Testimonial:

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Hi (again) 540 Rat,
I 've seen several times, as a Rally spectator 'n' fan, a Skoda Fabia S2000 participating in Greek Rally Championship, sponsored by Amsoil, and after reading your blog, the question "which specific Amsoil do they use, in a N/A 1,996 cc = 121c.in. racing motor running up to 9500r.p.m. and approx. 300hp…" emerged. So, I took myself to the service park with the intention to ask team engineers about that. In fact, I didn't need to do so, because I saw them in an oil change using Amsoil 5W30 Signature Series oil, instead of Amsoil Dominator Racing oil. I found that this was kind-a-weird, so I decided to ask them "why so".

Chief engineer told me that every time they need to rebuild the engine, they measure accurately, all geometric parameters such as clearances, ring's width, cams heights etc. in order to replace if something was out of specs, and after 3800 racing kms (2000+miles), they decided to use Amsoil 5W30 Signature Series oil, because all mentioned components' wear was close to non-measurable from one to the next rebuild procedure.

In fact, that's -in my opinion- another proof that your data are "online" with real world's facts. Of course, a high pressure oil pump and FIA approved oil cooler are provided. But apart from these, it's still a highly stressed engine, revving most of its lifespan between 6,000 and 9,500 rpm, "feeding" via gearbox all 4 wheels.

The question remains: why not use Amsoil Dominator Racing oil…
(To mention rally team's name, in order to avoid "suspicious minds" from "bad thoughts": "Cabilis Performance")

Keep doing great things,
E.C.
Greece

My final comment about this Testimonial: Amsoil Signature Series oil has performed far better than Amsoil Dominator Racing oil, in my Engineering tests. So, the obvious choice is their Signature Series oil, if you want the absolute best wear protection. Perhaps this Race Team has been reading my Blog.

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Here's another example of my Engineering Test Data and Racing experience being identical

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An oval track dirt racer (his class is extremely competitive, so he asked that his name be left out) on the SpeedTalk Forum runs a 7200 rpm, solid flat tappet, 358ci Small Block Chevy motor, with valve spring pressures of about 160 on the seat and 400 open, that are shimmed to .060" from coil bind. The rules and the combination of parts, were causing him to experience repeated cam failures while using high zinc, semi-synthetic 10W30 Brad Penn, Penn Grade 1 motor oil. Lab Report Data from testing performed by Professional Lab, "ALS Tribology" in Sparks, Nevada, showed that this oil contains 1557 ppm zinc, 1651 ppm phosphorus, and 3 ppm moly. In spite of this being a high zinc oil, that most folks would "assume" provides excellent wear protection, he experienced wiped lobe cam failure about every 22 to 25 races.

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A race consists of one 8 lap (a lap is typically 3/8 mile) heat race and one 20 lap feature race, plus any caution laps. If you add it all up, 25 races only total about 281 miles at the point of cam failure. So, that is a perfect example of what I've been saying all along about high zinc levels being absolutely NO GUARANTEE of adequate wear protection. And my test data on this 10W30 Brad Penn, Penn Grade 1 motor oil, shows that it produces a wear protection capability of only 71,206 psi, which puts it in the MODEST wear protection category, and it ranks a very disappointing 174th out of 223 oils tested so far. That means of course that there are 173 different oils I've tested that provide better wear protection.

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So, my test data ACCURATELY PREDICTED EXACTLY what he experienced during racing. And that is, that this oil does not provide high enough wear protection capability to provide a sufficient margin of safety for this engine's operating conditions. Looking at my "Wear Protection Ranking List" and choosing a much higher ranked oil, would have prevented all those cam failures. Repeatedly suffering cam failures in motors with so little time on them, may have been considered by some folks to be a normal consumption of parts back in the '60's or '70's. But, in the 21st Century that we live in now, by any measure, that is for sure premature failure. We no longer have to accept that as the cost of doing business, because we can do far better now.

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So, he switched to the super micro polished billet lifters from PPPC and the cam life went up to 40 races, which was an improvement since he could now go 450 miles between failures. But, that was still clearly unacceptable. Then later on, he started using "Oil Extreme Concentrate" as an additive to the 10W30 Brad Penn, and he's never lost a lobe on a cam since. Adding the "Oil Extreme Concentrate" completely eliminated his premature wiped lobe cam failures. At the time of this writing, the motor had gone 70+ Races without issue, and was still doing fine. This "Oil Extreme Concentrate" is one additive that actually works as advertised, and makes low ranked oils far better than they were to begin with. And that is PRECISELY WHAT MY MOTOR OIL TEST DATA PREDICTED as well.

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Here's how. I also added "Oil Extreme Concentrate" to 10W30 Brad Penn, Penn Grade 1 semi-synthetic, as part of my motor oil "Dynamic Wear Testing Under Load" research. And with 2.0 OZ of "Oil Extreme Concentrate" added per qt, which is the amount intended for racing, its wear protection capability shot up by a BREATH TAKING 56%, to an amazing 111,061psi, which puts it in the INCREDIBLE wear protection category, and now ranks it a jaw dropping 24th out of 223 oils tested so far. So, it moved up a whopping 150 ranking positions, just by adding the "Oil Extreme Concentrate". This totally accounts for the reason all his cam lobe failures were eliminated.

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In addition to this, a NASCAR team sent me three high zinc synthetic Mobil 1 Racing Oils for testing, because they were having wear problems when using these oils (more on that below). Lab Report Data from testing performed on these oils by Professional Lab, "ALS Tribology" in Sparks, Nevada, showed that on average, these oils contained 1774 ppm zinc, 1658 ppm phosphorus, and 1444 ppm moly. And because these were all high zinc oils, most folks would "assume" that they'd provide sufficient wear protection. However, the results of my testing showed that these oils only provided POOR WEAR PROTECTION CAPABILITY. So, they were NOT a good choice for their racing application, which confirmed why they had wear problems. This is yet another perfect example of what I've been saying about high zinc levels being NO GUARENTEE of adequate wear protection. And this example clearly showed once again that my test data EXACTLY MATCHED what this race team had experienced on the track.

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So, these examples PROVE once and for all, that my test data EXACTLY MATCHES REAL WORLD RACE TRACK EXPERIENCE, and that my test data is the spot on REAL DEAL, just as I've said all along. This completely confirms that my test results WILL ACCURATELY PREDICT what we can expect from motor oils in running engines on the track or on the street, EVEN if those oils are high zinc oils. So, that should be more than enough proof to satisfy anyone who was skeptical of how well my test data compares to the real world. And if anyone thinks my data comes from flawed methodology, they are not paying attention, and need to reread everything again more carefully.

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OIL TEST DATA AND WIPED LOBE AT BREAK-IN EXPERIENCE ARE IDENTICAL

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A guy on the Corvette Forum, whose name I will leave out, built a replica 454, flat tappet LS6 BBC engine for a 1970 Corvette, using a Crane Cams blueprint LS6 cam and Crane solid lifters. He used Brad Penn Break-In oil, then after initial break-in, he changed the oil to Brad Penn 10W40. Then after about 100 miles he heard a tapping noise. After looking into it, he found a wiped cam lobe and ruined lifter. There were metal particles throughout the entire engine, causing devastation which had damaged the rod and main bearings, the oil pump, and the crankshaft, thus requiring another very costly and time consuming total rebuild.

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He has built many engines over the years, always using Crane Cams solid or hydraulic cams and never had a failure. So, he's an experienced engine builder, used parts from Crane Cams, a reputable Industry Leader, and used oil with plenty of zinc. Problem is, he is among those who think any oil is fine, as long as it has plenty of zinc in it. However, my Engineering tests of the Brad Penn, Penn Grade 1, Break-In oil, shows that it produces a film strength load carrying capacity of only 56,020 psi, which ranks it 215th out of 223 oils tested so far, and puts it in the UNDESIRABLE wear protection category, even though it's high in zinc. And my Engineering tests of the 10W40 Brad Penn, Penn Grade 1, shows that it produces a film strength load carrying capacity of only 57,864 psi, which ranks it 211th out of 223 oils tested so far, and also puts it in the UNDESIRABLE wear protection category, even though it has a high zinc level. That of course means that 214 other oils provide better wear protection than his Break-In oil, and 210 other oils provide better wear protection than his after break-in oil.

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So, this is another example where my test data accurately predicted that using these particular high zinc oils, that provided such low wear protection capability, would put a flat tappet engine at extreme risk of failure during and after break-in. And of course very expensive engine failure is exactly what happened. Selecting a highly ranked oil from my Wear Protection Ranking List, no matter how much zinc is in it, would have provided the engine with far better wear protection. With so many other excellent performing motor oils on the market, it makes no sense to choose oils that are ranked so low on my list, even if they do have a lot of zinc in them. Because high zinc levels are absolutely no guarantee of sufficient wear protection. The line of thinking that you always need a high zinc level, is nothing more than a total MYTH.

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OIL TEST DATA AND HIGH PERFORMANCE STREET EXPERIENCE ARE IDENTICAL

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And here is one example of a flat tappet High Performance Street Hotrod engine operating just fine with low zinc oils, just as my Test Data predicts. A buddy built a 500 HP, flat tappet, solid lifter, 383ci small block Chevy for his '69 Corvette several years ago. He asked me what oil he should use to break it in and to use later on as well. He wanted to use a conventional oil at that time, that was affordable, and readily available. So, I suggested he use conventional low zinc 5W30 Castrol GTX, API SN, that provided 95,392 psi in my testing (this was an earlier version which has since been replaced), which put it in the OUTSTANDING wear protection category.

He used that oil from day one with no elaborate break-in procedure at all. He just drove the car. It is his only car, so it is his daily driver, which he always drives like he stole it. And he has never had any issue with his cam or lifters. Then maybe a year or so ago he decided he wanted to switch to a synthetic oil that was affordable and readily available, so I suggested he go with low zinc synthetic 5W30 Mobil 1, API SN, that provided 105,875 psi in my testing, which put it in the INCREDIBLE wear protection category.

He has used that oil ever since and still has not had any issue at all with his cam or lifters. He has tens of thousands of hard Hotrod miles on that cam and lifter combo, which is far more miles than most weekend only Hotrods will ever see, and he has never suffered one bit from not using a high zinc oil. So, this is yet another example of the fact that high zinc oils are NOT needed for sufficient wear protection, even in flat tappet engines, and not even for break-in. The only thing that matters, is an oil's film strength load carrying capacity. And that is precisely the data my Motor Oil Testing ranks.

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Not only does my oil testing methodology and the resulting data match up EXACTLY with real world severe over-heating experience, real world race track experience, real world flat tappet break-in experience, and real world High Performance street experience, but it has also been endorsed by the following well respected Industry sources:

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1. An Engineering Ph.D. who is the most highly respected Engineer, Car builder and Tech Guru on a popular Automotive Forum, asked me if he could include my Oil Testing Info in a list of Tech Papers written by well respected Industry authors, that he makes available to enthusiasts. And he told me, "I'm 100% on board with backing you with my endorsement on your testing: I run a Propulsion Testing Laboratory for a major Aerospace Company, so I'm in the testing

business. Your methods and approach are in accordance with sound engineering testing methods, and are not arguable by intelligent people”. He also said this about my Oil Testing info, “This is excellent stuff, and I’ve already sent copies of this to my engineering colleagues”.

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Then later, even though he had no direct connection to my oil testing, he received hate mail and threats for backing me. This behavior came from disrespectful people who are on the wrong side of the facts. They are high zinc level “believers”, even though the facts have proven over and over again that the whole idea of depending on high zinc levels for wear protection, is only an outdated myth. Sadly, discussing motor oil can become emotionally charged just like Religion and Politics. But, Engineering test data is NOT determined by emotion, it is determined by the facts that come out of the Physics and Chemistry involved. After this ordeal, he’d had enough, and asked that I no longer use his name in connection with my oil testing. Of course I respect his wishes and will no longer mention his name here. I feel bad that he was subjected to this totally uncalled for behavior. However, these shameful events will have no affect on my ongoing oil testing. For me, there is no emotion involved with the oil testing I perform. I simply report the results exactly the way they came out, good or bad.

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2. A NASCAR engine supplier out of North Carolina (they did not want their name associated with any Internet motor oil arguments that may come up, so they asked that their name be left out, which I honored) was so impressed with the motor oil “Wear Protection Capability Testing” I perform, that they sent me 3 NASCAR Racing Oils they use, for testing. They valued my testing efforts enough to include me in what they do, which is quite an endorsement, considering the Professional level of Racing they are involved in. They had been seeing some wear issues with those oils, and wanted to see if I could shed any light on that by testing them. I did test those oils for them, and the test results showed that those oils did not provide acceptable wear protection capability, which accounted for the wear problems they were having. So, they have selected other oils to use, and their wear problems have gone away. If I had tested those oils before they started using them, I could have saved them time, money and grief.

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3. The “Oil Extreme” Oil Company was so impressed with the detail and accuracy of my oil testing, that they wanted to hire me to perform product development research testing for them. That was clearly a major endorsement of the testing I perform. But, I declined taking any money from them, because I won’t be tied to any Oil Company by money. That way I can maintain my independent and unbiased status. I report the test results just how they come out, good or bad. And there is no way I’d allow any Oil Company to influence anything I report. I did however, agree to perform testing for them for free, along with other testing I perform. And those results will be posted along with other test results.

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In addition to that, my oil test data has also been validated and backed-up by a total of FOUR other independent Industry sources. They are as follows:

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1. Well known and respected Engineer and Tech Author David Vizard, whose own test data, largely based on real world engine dyno testing, has concluded that more zinc in motor oil can be damaging, more zinc does NOT provide today's best wear protection, and that using zinc as the primary anti-wear component, is outdated technology.

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2. The GM Oil Report titled, "Oil Myths from GM Techlink", concluded that high levels of zinc are damaging and that more zinc does NOT provide more wear protection.

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3. A motor oil research article written by Ed Hackett titled, "More than you ever wanted to know about Motor Oil", concluded that more zinc does NOT provide more wear protection, it only provides longer wear protection.

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4. This from the Brad Penn Oil Company:
There is such a thing as too much ZDDP. ZDDP is surface aggressive, and too much can be a detriment. ZDDP fights for the surface, blocking other additive performance. Acids generated due to excessive ZDDP contact will "tie-up" detergents thus encouraging corrosive wear. ZDDP effectiveness plateaus, more does NOT translate into more protection. Only so much is utilized. We don't need to saturate our oil with ZDDP.

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Those who are familiar with my test data, know that my test results came up with the exact same results stated by all four of those independent sources. So, this is an example where motor oil "Dynamic Wear Testing Under Load" using oil testing equipment, engine dyno testing, Motor Oil Industry testing, and proper motor oil research using only the facts, from a total of five (including my own) independent sources, all converged to agree and come to the same exact conclusion. Back-up validation proof, doesn't get any better than this.

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So, with all those sources in total agreement, that should provide more than enough proof to anyone, that my data is absolutely correct, and that it DOES NOT come from flawed methodology, as some have said simply because they didn't like or didn't understand the results. The fact is, scientific test data is not determined by emotion, it is determined by the facts that are a result of the Physics and Chemistry involved. And anyone questioning any one of those sources, questions them all, as well as the Physics and Chemistry that determined all those identical results. And no sensible person would try to argue against Physics and Chemistry. Because that is a battle no man can win.

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Of course, many folks, including Enthusiasts, Hotrodders, Racers, Builders, Cam Companies, etc, have always been conditioned to believe that high zinc levels in motor oil are a must for sufficient wear protection in High Performance engines. And of course there are a number of oils available that say something along the lines of "Extra Zinc for Extra Protection". So, a lot of those folks just cannot bring themselves to accept the fact that high zinc levels are NOT what they are cracked up to be. They feel compelled to believe the claims on those bottles of oil and the Marketing/Advertising claims made by the Oil Companies that provide those high zinc oils.

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But, people need to consider the following. Those Oil Companies are in business to make money. That's it. So, they put a product on the market that they feel there is a demand for, and will make them money. As a result, they will say "ABSOLUTELY ANYTHING", to move that product, which will help their bottom line. So, high zinc loving people need to stop and consider that for a moment. The Oil Companies have a vested interest in telling people what they want to hear, so they will buy their oil. Therefore, they don't hesitate to make misleading claims and false advertising. When it comes to motor oil, there is no such thing as truth in advertising.

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Oil Company claims about the benefit of high zinc levels in motor oil is NOT based on actual fact. Extra zinc cannot physically provide extra wear protection, because zinc simply DOES NOT work that way. Zinc is used up a little at a time as it is sacrificed to help protect against wear. More zinc will take longer to become depleted, simply because there is more there to use up. It's the same idea as more gas in your tank will take longer to run out, but more gas in your tank cannot physically make more HP.

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These high zinc motor oil producing Oil Companies NEVER provide any test data to prove that their high zinc oils always provide better wear protection than ordinary modern low zinc street oils. They can't do it, because it's NOT TRUE. So, high zinc believers are only embracing smoke and mirrors, nothing else. And actual dynamic motor oil friction tests under load, PROVE that the need for high zinc levels is simply NOT TRUE. That is why I started testing motor oil, so that I could separate the facts from the fiction.

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Motor Oil Company Advertising claims are only hype and hot air, but actual test data is the real thing. If I test a modern low zinc API certified oil against a high zinc oil, and the modern API certified low zinc oil clearly outperforms the high zinc oil in terms of wear protection, how can the high zinc lovers honestly believe that the high zinc oil is better? How could that high zinc oil magically perform better in an engine, when it was worse in testing? And if I test two high zinc oils, and one does well and one does not, how can the high zinc lovers believe that all high zinc oils are always good?

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So, high zinc lovers need to do a little soul searching and ask themselves why they want to believe something that does NOT stand-up to real world testing? Keep in mind that testing is so important and valuable, that multi-million dollar corporate decisions are made, based on test data. Not only that, but Racers test engine and chassis setups at the track all the time. And they believe what the test results tell them, because that's the only way they have to know what really works and what doesn't. So, it makes no sense to disregard oil testing, when virtually all other types of testing are taken as Gospel.

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My Motor Oil Engineering Test Data is breakthrough information that can't be found anywhere else, which finally allows us to directly compare the wear protection capability of various motor oils. Engineering Test Data drives the world, yet there are some high zinc loving critics who just can't understand the value of this Engineering Test Data. So, they try to tear it down with the emotion that is often found in discussions of Religion or Politics. But, by them rejecting meaningful motor oil information, they are only hurting themselves.

In fact, it is quite clear that most of the time, they don't even bother to read the information I provide. They just make negative comments right off the top, completely unaware of the information provided. Unfortunately for them, that is their loss, because they will have to continue selecting their oil based on the incorrect thinking that zinc level is all they need to know. And in doing so, they will more often than not, end up with far less wear protection than they think they have, which often results in wiped flat tappet lobes. Some people are their own worst enemies. However, for technically savvy folks who do grasp the value of my motor oil film strength/load carrying capability test data, FACTUAL information is included in the Blog below.

It is not a matter of agreeing with my data or not agreeing with it, because the data used to create my Wear Protection Ranking List is NOT my opinion, and it is NOT my theory. The data, as mentioned above, is the result of the Physics and Chemistry involved in the testing. I am only the messenger. The Science is what tells us how these oils perform. And no sensible person would try to argue against Physics and Chemistry. Science is absolute whether people like it or not, and emotion cannot change it.

So, think long and hard before believing anything critics say when they try to discredit my Motor Oil Engineering Test Data. There are always some who try, but fail in their attempt. They are not actually arguing with me, even if they think they are. They are actually arguing against the Science of Physics and Chemistry. Who do you think will win that battle? And ask them how they figure they know more than what the Science of Physics and Chemistry proves. Ask them what their qualifications are. Ask them what testing they have ever done.

They are typically high zinc lovers who just can't accept the fact that what they've always believed about the need for high zinc oils, is only an Old Wives Tale MYTH. So, they get upset and go out of their way trying to undermine anything that goes against what they have been brainwashed to believe about high zinc oils. But, emotion does not determine the Engineering results of how good any particular oil is.

These naysayers cannot factually back-up anything they say. They think they are motor oil experts simply because they have done a bunch of Internet reading. They will sometimes make a big deal about what is in the base oil. They will sometimes provide links to lame Internet articles, which are often just a lab test of a single individual zinc component, showing what it did in that particular lab test. But, that is not any actual motor oil that you buy and pour into your engine. It may be somewhat interesting to read, but that type of test does not does not take into account the countless formula variations and synergistic effects found in the actual motor oils that are available on the market. Therefore, you are only looking at a single data point of a test that is not even what will end up in your engine. Or in other words, worthless information that many zinc lovers falsely believe, is the last word on motor oil. That is NOT how Engineering works. And lot of their lame Internet articles are nothing more than one author copying from the same worthless source material as other authors.

And if that isn't bad enough, some information they throw out there as Gospel is only advertising hype from a motor oil's bottle or website. As mentioned above, it is no secret that Motor Oil Companies are among the worst for false advertising. The absolute worst motor oils on the market, and the absolute best motor oils on the market, make the same claims about how wonderful they are. So, the claims made on motor oil bottles and websites would only be taken as truthful, by gullible people who are not Technically savvy.

Then these naysayers will also sometimes use the oil recommendations from Cam Companies as support for their position on what oil to use. Problem is, just because Cam Companies sell cams, does not mean they know the first thing about motor oil. They are simply staffed by people who are also brainwashed to believe that any high zinc oil will provide all the wear protection necessary for flat tappet cams. But, the proof that they are clueless about motor oil, is the fact that even the leading Cam Companies still have flat tappet lobes getting wiped, when people use the oils they recommend. And those oils are typically the oils that have tested very poorly in my Motor Oil Engineering Wear Protection Testing. On top of that, Cam Companies often do not even employ Degreed Mechanical Engineers. So, it comes as no surprise that they supply bad information as to what oils to use. Wiped flat tappet lobes continue to happen over and over again, when people use high zinc oils that produce poor results in my testing. It's time to take notice of that.

The people who recommend poor performing motor oils, believe if they haven't lost a lobe while using a certain oil, that it must be great oil. But, they just don't know, what they don't know. That only means the oil they used provided "enough" protection for the particular application that didn't fail. But, that does not tell them anything about how much extra protection they had beyond that. So, their "opinion" of that oil is not a good technical evaluation of its capability. That would be like them telling you that an engine making 750 HP, is good as long as it has rods in it that can withstand 751 HP. Yeah, it might not throw a rod, or maybe it will. But, no technically savvy person would want to run a margin of safety that close.

It's the same idea with the oil you choose to run. Don't run an oil with a margin of safety that close. My Motor Oil Engineering Test Data, allows us see how different oils truly compare to each other, so we can run a substantial margin of safety to provide the best possible wear protection for our engines. So, before you consider following the bad advice others give about the oil they only "think" is good, read the real world facts about motor oil in this Oil Test Data Blog, then decide for yourself who is providing factual motor oil information that you can actually use to your advantage.

People who want the facts about which motor oils are good and which are not so good, want to see unbiased and independent test data. And that is exactly what my motor oil film strength/load carrying capability data provides. I back-up everything I say with that hard Engineering test data that exactly matches real world experience. It matches real world experience because my test data is the real deal, which accurately predicts what we can expect from the oils we buy. I test the actual motor oils that we buy and pour into our engines. So, my test data comes entirely from real "on-the-market" motor oils, which is what truly matters.

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It's been said that I'm the motor oil Police, because I discover and expose false motor oil claims and misleading motor oil advertising, with my test results that show the FACTS. I don't sell motor oil, so it doesn't make any difference to me, what oil people choose to run. But, people need to understand that some high zinc oils do provide very good wear protection, while many other high zinc oils do not. And without looking at the test data, you cannot tell which is which, until perhaps it's too late. In fact, MANY WIPED FLAT TAPPET LOBES COULD HAVE BEEN AVOIDED, INCLUDING DURING BREAK-IN, if people had not blindly believed the MYTH that all high zinc oils provide all the wear protection they need. Because nothing could be further from the truth.

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So, the folks who choose to use only high zinc oils NO MATTER WHAT the test result FACTS show us, are only fooling themselves. Of course everyone is entitled to their own opinion. But, ignoring the FACTS is their loss, and depending on the particular oil they choose, they are likely NOT getting the wear protection they THINK they are. If you value your engine, wouldn't you prefer to choose the motor oil that can REALLY provide the best wear protection, based on test data FACTS, rather than the old incorrect high zinc MYTH? Don't believe what the high zinc lovers say, because they are only trying to justify what they "believe", even though they have NO PROOF what so ever, to backup what they say. On the other hand, I backup everything I say. So, read the FACTS, then make your own decision.

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I was very dissatisfied with the ASTM test procedures I reviewed. Some called for testing at 100*F (NOT 100*C), which is way too COLD and is therefore NOT representative of real world temperatures experienced by a running engine, where it spends 99% of its life. Other ASTM tests called for testing at 150*C (302*F), which is way too HOT, and is also NOT representative of real world oil temperatures experienced by a running engine, where it spends 99% of its life. In addition to that, every oil I've ever tested for the onset of thermal breakdown, would already be at or beyond the threshold of thermal breakdown at 302*F.

An ideal oil sump temperature range in a running engine is between 215*F and 250*F, though oil temps are not entirely uniform throughout the engine (more on that below). This range is hot enough to quickly boil off normal condensation rather than letting it evaporate over time, which can allow it to dilute the oil. And this range is also low enough to provide sufficient cooling for internal components, all of which are directly oil cooled, while at the same time staying below the onset of thermal breakdown in nearly all motor oils.

So, the Official ASTM test procedures I reviewed for my application, were COMPLETELY WORTHLESS for finding out the truth when it comes to wear protection capability of motor oil at representative oil temperatures where an engine spends 99% of its life. Being a perfectionist, I was not willing to accept sub-par test procedures. So, I developed my own test procedure using the real world temperature of 230*F, which "IS" representative of where engines typically spend 99% of their life.

And that temperature also works extremely well with my test equipment, and produces accurate and repeatable results which are essential for meaningful comparisons between different motor oils. My test procedure produces the most realistic and useful data you will ever find anywhere. And that is why I have numerous endorsements of my Engineering test procedure, as well as validation back-ups, including race track data, flat tappet break-in data, and High Performance street data, that exactly match my Engineering test data. BOTTOM LINE: My test data WILL ACCURATELY PREDICT what we can expect from a motor oil in a running engine.

However, I do occasionally come across someone criticizing my test data because my Engineering testing does not use an Industry Standard test temperature. So, let me be perfectly clear to those critics who don't grasp what I said above. Industry Standard test temperatures of 100*F or 302*F are COMPELTELY WORTHLESS, because they do not represent real world temperatures where engines spend 99% of their life. My Engineering test temperature DOES represent real world temperatures where engines spend 99% of their life. And I challenge anyone, anywhere, no matter who they are, to PROVE that my Engineering test temperature of 230*F, is not a better representation of the temperatures inside a normal running engine, than those worthless Industry test temperatures.

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Motor oil is not the same temperature everywhere inside a running engine. Typical main bearing oil temps can be 55*-90*F higher than sump temps. However, main bearing oil under running conditions is not just a film of oil, it is a liquid wedge of flowing oil (that is why the cooling benefits of better flowing thinner oil are important here to avoid driving up bearing temps. See the section on viscosity selection immediately following my "Wear Protection Ranking List" below). Liquid oil is not compressible, therefore it completely prevents metal to metal contact (more on that below). My testing focuses on oil film strength, which is what is critical, and is the last defense against metal to metal contact. Even so, I also tested a dozen different oils at 275*F to see how their wear protection capability at that higher temp, compared to the 230*F that I normally test at.

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The oils tested at 275*F consisted of different brands, different viscosities, some low zinc modern API certified oils, some high zinc Racing/Performance oils, some synthetic, some conventional, some semi-synthetic, some with low levels of detergent and some with high levels of detergent. As expected, the wear protection capability psi values dropped as the oils got hotter and thinner. But for most of the oils, the drop was not enormous. And the average psi drop for the whole group of oils, was only about 12% from their 230* values. What was also of interest here, was how the ranking of these dozen oils might change relative to each other, as they got hotter. The result was that there was some shuffling of the ranking order within the top 10 oils, but all of the top ten oils were still in the top 10.

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It was also quite clear by looking at these results, that high zinc levels, high detergent levels, and heavy viscosities did NOT play any particular roll in how well a motor oil does or does not provide wear protection. The only thing that matters is the base oil and its additive package "as a whole", with the primary emphasis being on the additive package, since the additive package is what contains the extreme pressure anti-wear components.

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In addition to the testing at 275*F, I also tested a couple of those oils at a much higher 325*F to see how their wear protection capability might change at that temp. It turned out that their load carrying capacity leveled off and stayed approximately the same between 275* and 325*, and their ranking relative to each other did not change. So, it is comforting to know that you don't run into dangerously low wear protection if and when you end up with overheated oil at some point. But of course the oil will have already run into thermal breakdown and should be changed as soon as possible.

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So, all this testing showed that the oil ranking positions did not change significantly even at higher temps. And that means that my "Wear Protection Ranking List" below, which was generated with oil temps at 230*F, is still representative of how the various oils compare to each other, even at the higher operating temperatures seen in certain locations of the engine.

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METHODOLOGY

The details of the specific test equipment set-up I developed, as well as the details of the specific test procedure I developed, that provide the accuracy and repeatability that I demand, are Proprietary Intellectual Property. But, I can share the following:

The test methodology or test procedure I use at a representative operating oil temperature of 230*F, is a dynamic rubbing friction test under load, which generates a wear scar on a test specimen that is bathed in the oil being tested. This procedure, which is performed exactly the same for every motor oil tested, provides excellent repeatability, which is critical to validate the methodology. And as shown above, my test data EXACTLY matches real world severe over-heating experience, real world race track experience, real world flat tappet break-in experience, and real world High Performance street experience. No matter what any critics may say, with my test data exactly matching real world experience, that absolutely PROVES and VALIDATES that my data is the real deal. You cannot get any better than that, so you will not find better motor oil comparison data anywhere. The test result is "pounds" of force being applied over the wear scar "area", which is in square inches (the size of that "area" is of course is determined by the oil's film strength/load carrying capability/shear resistance capability). So, the result is pounds per square inch, which of course is just shortened to "psi". The better an oil's wear protection capability, the smaller the wear scar will be on the test specimen, and the higher the resulting psi value will be. Multiple tests are performed on each oil, and the resulting values are averaged to arrive at the most accurate possible value for comparison. And the motor oils are ranked, based on the average psi value they generated.

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The motor oil "Dynamic Wear Testing Under Load" I performed to generate my "Wear Protection Ranking List", is worst case torture testing, using oil testing equipment that is for the record, NOT a "One Armed Bandit" tester and NOT a "4-Ball Wear Tester". My testing subjects the oil to far more severe loading than even the most wicked flat tappet race engine ever could. So, since my oil testing compares various oils under worst case conditions, absolutely no further testing is required in a running engine. If oils rank higher in my "Wear Protection Ranking List" than the oil you currently use, those higher ranked oils will provide a HIGHER LEVEL OF WEAR PROTECTION than your current oil. It's really that simple.

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My test equipment is NOT intended to duplicate an engine's internal components. On the contrary, the test equipment is specifically designed to cause an oil to reach its failure point, in order to determine what its capability limit it is. And every oil I test is brought to its failure point, that's how it works. The difference in the failure points, is what we compare. And in addition to that, my equipment's calibration is checked and adjusted if required, each time the testing switches to a different oil. That keeps the final results accurate at all times.

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You will NOT find this many oils tested on the exact same equipment, using the exact same procedure, using the exact same real world representative operating oil temperature, by the exact same operator, anywhere else. Therefore, this is the best apples to apples motor oil comparison you will ever find.

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But, a running engine is designed to last indefinitely, and of course, they do not generally cause an oil to reach its failure point. So, due to the complete difference in design, the pressures in my test are completely different, and cannot be compared directly to an engine's lobe/lifter interface pressure. That would be comparing apples to oranges, which makes no sense. My testing is so severe, that the oil fails at an earlier point. And that is why my test data psi values may appear lower than you might expect to see in some running engines. Keep in mind, I'm comparing OIL AGAINST OIL, and the procedure used is exactly the same for each oil tested. For better or worse, each oil stands on its own merit. And if oil A produces twice the psi value of oil B in my testing, then oil A will also offer twice the wear protection capability of oil B, in a running engine.

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The "dynamic wear testing under load" I use, is intentionally designed to find the SPECIFIC LIMIT of each individual oil's "Load carrying capability/film strength/shear resistance", at a representative operational temperature of 230*F. Or in other words, to determine each oil's "wear protection capability" psi value, which can be compared to any other oil tested on the same equipment. As mentioned above, the results that come out of my testing are NOT my opinion, and they are NOT my theory. They are the FACTS that come out of the Physics and Chemistry involved in the tests.

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Performing "dynamic wear testing under load", is the ONLY TYPE OF TESTING that will provide accurate data regarding an oil's film strength. Dynamically testing motor oil under load, is the same concept as dynamically testing an engine under load on a dyno. That is the only way to truly find accurate performance data of a motor oil, or of an engine.

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And obtaining accurate oil film strength data is ABSOLUTELY THE ONLY WAY to determine an oil's wear protection capability, because an oil's film strength is the last line of defense against metal to metal contact. In order to reach metal to metal contact, and subsequent wear or damage, you MUST penetrate the film strength of the oil. And oil thicker than a mere film becomes liquid oil. Of course liquids are NOT compressible, which is how hydraulics work. Since liquids cannot be compressed, ALL oils provide THE SAME wear protection when they are in liquid form, no matter if they cost $3.00 per quart or $30.00 per quart. So, oil film strength testing is the GOLD STANDARD for determining how capable an oil is at preventing wear, and how different oils directly compare to each other. In other words, the ONLY THING that separates one oil's ability to prevent wear from another oil's ability to prevent wear, is the difference in their individual film strength capabilities.

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But, testing motor oil in a running engine CANNOT determine the EXACT SPECIFIC wear protection LIMIT of an oil, which is necessary, in order to make an accurate comparison between various oils. So, attempting to test various motor oils for comparison in a running engine, provides no meaningful data, other than perhaps that a given oil did not cause a failure in that particular engine combo. If you were to test say a half a dozen different oils in your engine combo, and you had no problems with any of them, how can you tell how they rank against each other? It's a proven fact that all oils do not provide the same wear protection capability. That means you have no way of knowing which of those 6 oils provides you with the highest level of protection. Therefore, motor oil testing in a running engine, is a waste of time, effort and money, when it comes to gathering accurate data for comparison between various oils. And that is precisely why I perform all my testing with motor oil test equipment, rather than in an engine.

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And simply looking at an oil's zinc level on its Lab Report is of no value at all, because some high zinc oils provide excellent wear protection, while other high zinc oils only provide poor wear protection. And you have no way to tell which is which by looking at the zinc level alone. An oil's wear protection capability is determined by its base oil and its additive package "as a whole", and NOT just by how much zinc is present.

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The old claim that you must have a high level of zinc for a high level of protection, is only a MYTH that has been BUSTED. And no one anywhere, can provide any real world test data proving that high zinc levels will always protect your engine. Because zinc simply does NOT work that way, no matter what you've read and heard a million times. More zinc simply takes longer to be depleted as it is sacrificed and used up while helping protect heavily loaded parts. Therefore, more zinc provides "longer" wear protection, NOT "more" wear protection. So, if someone tells you that you must have a high level of zinc for sufficient wear protection, no matter who they are, or no matter what Company they may represent, DO NOT believe it. Because they are proving that they DO NOT understand how zinc really works, and are only repeating the same old wives' tale with absolutely NOTHING to back it up.

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And ZDDP DOES NOT build up on parts like some sort of plating process. ZDDP simply DOES NOT work that way. ZDDP that is present in the oil, is activated by heat and pressure, which is precisely what the oil is subjected to during my oil testing procedure. My testing DOES NOT discount ZDDP levels either. ZDDP is part of the additive package, and the additive package is what contains the extreme pressure anti-wear components. You cannot test oil film strength without also automatically testing the ZDDP included in that oil at the same time. Since ZDDP is an integral part of an oil's additive package, and the additive package is primarily what creates an oil's film strength, the ZDDP that is present, will be working as well as its chemical composition allows, during any film strength testing.

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I've also "wear tested" a number of oils, both synthetic and conventional, when they were used with 5,000 miles on them. And in every case, even though those oils had been subjected to heat and stress over a significant length of time, there was NO REDUCTION what so ever, in wear protection capability, even though the zinc levels had dropped by around 25% on average. So, this is even further proof that the zinc level is not tied to a motor oil's wear protection capability, as well as absolute proof and validation that testing new oils is representative of what we can expect from those oils as they accumulate time and miles on them.

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Most major oil companies say to NEVER EVER add anything to their oils, because doing so will upset the oil's carefully balanced additive package that was designed by their Chemical Engineers. I tested doing that very thing in several different oils, and found that adding zinc additives in every case, ruined the oils by SIGNIFICANTLY REDUCING their wear protection capability. That of course, is just the opposite of what people "think" they will be getting. So, those major oil Companies were absolutely correct about not adding anything to their oil. And people who insist on choosing an oil based on zinc level alone, are very likely shooting themselves in the foot, and ending up with far LESS wear protection than they THINK they have. It just depends on which particular oil they select. A number of popular traditional high zinc oils have proven to provide poor wear protection when actually put to the test.

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In order for people to choose an oil that truly provides the best possible wear protection for their engine, they need to select an oil based on its "wear protection capability", NOT its "zinc level". Modern API certified oils have reduced zinc/phosphorus levels, and that now absent quantity of zinc/phosphorus has been replaced with alternate anti-wear components that are equal to, or better than zinc/phosphorus. In fact, many of the modern low zinc oils provide BETTER WEAR PROTECTION than many of the traditional high zinc oils, which you will see in the ranking list below.

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Oil "wear protection" capability that was tested here, and an oil's "friction reduction" capability, are two entirely different things. While the test data here provides excellent information about an oil's ability to prevent wear, it says nothing about an oil's ability to reduce friction. So, the data here will not provide any information regarding potential differences in HP or miles per gallon.

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It should also be noted that I do NOT get paid by any Oil Company, nor by any Motor Oil Retailer, nor do I sell anything myself. So, I have no vested interest in what oil people choose to run. Therefore, all the data here is totally independent, unbiased, and is reported exactly how the test results came out. I have no agenda here, other than simply sharing the FACTS with like-minded gear heads.

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The ppm (parts per million) quantities of zinc, phosphorus, moly and in some cases titanium, shown in the ranking list below, are taken directly from the Lab Reports that came back from the Professional Lab "ALS Tribology" in Sparks, Nevada. Some oils have MORE ZINC than phosphorus, while other oils have MORE PHOSPHORUS than zinc. It just depends on the particular oil's formulation. Either way, the numbers below are correct and are NOT typos.

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The "Load Carrying Capability/Film Strength/Shear Resistance" ranking list is from all the real world motor oil "Wear Testing" I've performed so far on new oils. The list includes modern API certified low zinc oils, traditional high zinc High Performance/Racing oils, Diesel oils, low zinc oils with zinc additives added in, low zinc and high zinc oils with other aftermarket additives added in, and Break-In oils.

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All oil bottles involved in the testing were thoroughly shaken before the samples were taken. This ensured that all the additive package components were distributed uniformly throughout all the oil in the bottle, and not settled to the bottom.

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Lower ranked oils are not necessarily "bad", they simply don't provide as much wear protection capability as higher ranked oils. If you have been running a low ranked oil in your engine without issue, that does not mean you have switch to a different oil, and it also does not mean you were using a great oil. It only means that your engine's wear protection needs have not exceeded that oil's capability. And as long as your engine's needs don't exceed that oil's capability, you will never have a problem. But, if unexpected circumstances come up that make your engine's needs exceed that oil's capability, such as an overheating condition, an oiling condition, a loading condition, some parts heading south, or whatever, your engine can end up junk. But, if you'd been using an oil with a much higher capability, it could still provide enough extra protection to save your engine. So, each person has to decide for themselves, which motor oil provides the wear protection capability they are comfortable with, for any given engine build.

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For the test results in the Wear Protection Ranking List, the HIGHER the psi value, the BETTER the wear protection. And this applies to ALL engines, including ANY High Performance flat tappet engine. An easy way to use this ranking list, is to find an oil you are familiar with, then look at the oils ranked higher, which provide better wear protection, and look at oils ranked lower, which provide less wear protection.

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Until I started performing Tribology Research, and setup my motor oil "Wear Protection Capability Ranking List", there was no good way to know which oils provided good wear protection, and which oils didn't. Because it's been proven over and over by a number of sources that zinc levels alone, cannot indicate which oils are good and which oils are not. The whole high zinc mindset is only Folklore that CANNOT BE PROVEN, and it DOES NOT stand up to any form of testing. So previously, all we could do was guess, or use trial and error to determine which oil was good enough, and which oil was not. And even then, we had no way of knowing how various "good enough" oils compared among themselves.

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You cannot advance your knowledge into the future by clinging to the incorrect thinking of the past. This is the 21st Century, and we no longer have to guess or use trial and error to decide on which oil to use. Now, we have documented wear test data available. So the future is here, and all we have to do is look at the Ranking List, to choose an oil that provides a wear protection capability level we are comfortable with for any given build.

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The "Wear Protection" test data here DIRECTLY APPLIES to flat tappet lobe/lifter interfaces (no matter how wicked the engine), pushrod tip/rocker arm interfaces, non-roller tip rocker arm/valve stem tip interfaces, distributor gear/cam gear interfaces, mechanical fuel pump pushrod tip/cam eccentric interfaces, and all highly loaded engine interfaces.

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Here are some key points that you will see in the following test results:

* Synthetic oils rank between number 1 and number 221.

* Conventional oils (with no aftermarket additives) rank between number 4 and number 223.

* Since the ranking of synthetic oils and conventional oils completely overlap, there is no clear distinction between their wear protection capabilities, which means that conventional oils are still far better than most people think.

* I've also tested a number of synthetic, semi-synthetic and conventional gasoline engine oils for the onset of thermal breakdown. Individually, the synthetic oils that were tested, varied between 300* F and 210* F. But, on average, the onset of thermal breakdown for those synthetic oils was 276*F. Individually, the conventional oils varied between 280* F and 255* F, and the average for those conventional oils was 268*F. So, as you can see looking at the averages for each type of oil, there was only an 8* difference, meaning that overall, there is little to no difference in their abilities to withstand high temps. So, while some individual synthetic oils do well when subjected to high heat, overall they do not live up to the outrageous claims of some Internet articles. At the end of the day, the conventional oils tested here, were about the same regarding their ability to withstand heat, making them a lot better than many people think.

And the average value for the onset of thermal breakdown for all these gasoline engine oils combined = 273* F. For more specific test data on motor oil thermal breakdown, see SECTION 3 – MOTOR OIL THERMAL BREAKDOWN TEST DATA.

* Also when comparing same viscosity synthetic oils vs conventional oils in a running engine, using synthetic oils will sometimes result in mechanically noisier engines. This is NOT a problem and has nothing to do with their wear protection capabilities, nor how much zinc is present in each oil. It is simply a characteristic difference that will sometimes show up between the two oil types.

* High zinc oils rank between number 10 and number 223 which VERY CLEARLY shows that simply having a high level of zinc is no guarantee of superior wear protection. If a high level of zinc was a guarantee of superior wear protection, then all high zinc oils would rank at the top of the list. But, that simply is NOT the case. And many wiped flat tappet lobes COULD HAVE BEEN AVOIDED, including during break-in, if people had not blindly believed that all high zinc oils provide all the wear protection they need. Because nothing could be further from the truth.

* Low zinc oils rank between number 1 and number 195.

* Since the low zinc oils and the high zinc oils completely overlap, you can see that zinc does not play the primary role in determining an oil's wear protection capability. An oil's wear protection capability is determined by its base oil and its additive package "as a whole", with the primary emphasis on the additive package, which contains the extreme pressure anti-wear components. And modern alternate extreme pressure components are equal to, or better than zinc. Tech Author David Vizard calls the use of zinc as the primary anti-wear component, outdated technology. And that is precisely what my motor oil "Dynamic Wear Testing Under Load" found as well.

* I've also tested ZDDPlus zinc additive in 3 low zinc oils, and I've tested Edelbrock Zinc additive in 3 different low zinc oils. In each case, the recommended amount of additive was used. And in all 6 cases, these high zinc additives ruined the oils and made them WORSE than they were before the extra zinc was added, by SIGNIFICANTLY reducing their wear protection capabilities. These additives did the opposite of what was promised. That is not surprising, because most major Oil Companies say to never add anything to their oils, because doing that will ruin the oil by upsetting the carefully balanced additive package that their Chemical Engineers designed into them. And that is precisely what was seen when using these high zinc additives.

* However, I have come across an exception to the warning about not adding anything to motor oil. I tested adding "Oil Extreme Concentrate" to ordinary 5W30 Pennzoil, API SN, conventional oil in the yellow bottle. This additive is calcium petroleum sulfontate based,

rather than high zinc based. And after adding the recommended amount (for street applications) of that additive, it IMPROVED the wear protection capability of that oil by a whopping 30%.

I also added the recommended amount of “Oil Extreme Concentrate” (for racing applications) to 10W30 Lucas Hot Rod & Classic Hi-Performance Oil, conventional oil. And it IMPROVED the wear protection capability of that oil by a mind blowing 69%.

I also added the recommended amount of “Oil Extreme Concentrate” (for racing applications) to 10W30 Brad Penn, Penn Grade 1, semi-synthetic oil. And it IMPROVED the wear protection capability of that oil by a breath taking 56%.

I also added the recommended amount of “Oil Extreme Concentrate” (for racing applications) to 10W30 Comp Cams Muscle Car & Street Rod Oil, synthetic blend oil. And it IMPROVED the wear protection capability of that oil by a significant 24%.

I also added the recommended amount of “Oil Extreme Concentrate” (for racing applications) to 5W30 Royal Purple XPR (extreme performance racing oil) synthetic oil. And it IMPROVED the wear protection capability of that oil by 9%.

This Oil Extreme Concentrate ACTUALLY MAKES THE OIL BETTER in terms of wear protection, and works as advertised in that regard. Obviously, this additive being calcium petroleum sulfontate based, does not ruin the oil like high zinc based additives do.

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There were however, limits to its improvement potential. When the testing was complete, the conclusion was that oils with “around” 80,000 psi capability or less, should experience a SIGNIFICANT BENEFIT from using the “Oil Extreme Concentrate Additive”, in terms of improved wear protection capability. But, oils with a higher capability psi, did not see a benefit.

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Prolong Engine Treatment is another motor oil additive that testing showed significantly improves an oil’s wear protection capability. I tested it in a full synthetic oil, and two conventional oils, which as a group, had a wide range for their original ranking positions. The additive improved the wear protection capability of all 3 oils, on average by about 46%. But, keep in mind that the data here only provides information on wear protection capability, and does NOT provide any information as to how compatible this product’s chlorine may be with a given oil’s additive package. Chlorine and additive package incompatibility has a possible risk of creating damaging bearing corrosion problems. There have been legal issues with this product that you can Google for yourself. Contact Prolong’s maker for more information on compatibility, to find out if it is safe to use in your application. The test data on Prolong is included in my Ranking List for informational purposes only, because of requests I have received about testing this product. But, I do not endorse nor recommend its use. It is always best to simply choose a highly ranked oil in the first place, and avoid using any aftermarket additives.

* Traditional Heavy Duty Diesel oils formulated for big trucks and heavy equipment, rank overall between number 43 and 193. But, if you omit the two highest ranked Heavy Duty Diesel oils which are SIGNIFICANTLY MORE CAPABLE than most of the other Heavy Duty Diesel oils, the rest only rank between 95 and 193. Other than those two particular highest ranked Heavy Duty Diesel oils, the poor wear protection performance of most Heavy Duty Diesel oils, makes it very clear that in general, they are a poor choice for use in High Performance gas engines. Heavy Duty Diesel oils should be used only in Heavy Duty Diesel engines, where they are intended to be used. Heavy Duty Diesel engines are designed MUCH differently than gasoline engines, so both types of oils are formulated for different requirements.

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* I've also tested synthetic and conventional Diesel oils for the onset of thermal breakdown. Individually, the synthetic oils that were tested, varied between 285* F and 255* F. But, on average, the onset of thermal breakdown for those synthetic Diesel oils was 269*F. Individually, the conventional Diesel oils varied between 265* F and 250* F, and the average for those conventional oils was 254*F. The average value for the onset of thermal breakdown for all the tested Diesel oils combined = 261* F. Comparing the overall averages, you can see that these Diesel oils fell victim to heat about 12* F earlier than the gasoline engine oils that were tested. So, that is another reason why using Diesel oils in High Performance gas engines, is a poor choice. For more specific test data on motor oil thermal breakdown, see SECTION 3 – MOTOR OIL THERMAL BREAKDOWN TEST DATA.

* Break-In oils rank between number 138 and number 223. But, if you omit the highest ranked Break-In oil which is far more capable than the other Break-In oils, the rest only rank between 183 and 223. So, if you are looking for outstanding wear protection during break-in, you will be extremely disappointed with most of these oils. Because they are not formulated to prevent wear, they are formulated to allow the parts to quickly "wear in", which is totally unnecessary. This is because newly manufactured parts will have a surface that "microscopically" looks like peaks and valleys. The loading on those tiny little peaks, will be EXTREMELY high, because the load is not spread out across enough surface area to support the load. And no motor oil made by man can stop those peaks from being very quickly worn down, thus leaving a smoother surface that will distribute the load across a surface area large enough to support that load.

That makes it is physically IMPOSSIBLE to stop parts from wearing-in on their own, no matter what oil you run. And we've seen that for many years with factory filled synthetic 5W30 Mobil 1 (which is one of the top ranked oils regarding wear protection capability) in countless thousands of brand new vehicles, that always break-in their components and seal their rings just fine. That means so-called break-in oils are completely unnecessary. And the poor wear protection provided by most break-in oils, can put a flat tappet engine in serious danger of wiping lobes. No matter what anyone tells you, for roller lifter engines or for flat tappet engines (no matter how wicked they may be), it is best to use a highly ranked oil, no matter how much zinc is in it, for BOTH break-in and after break-in. In fact, the SAME highly ranked oil can be used for both purposes, meaning you can choose a single highly ranked oil and stay with it from first fire, on.

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VISCOSITY vs WEAR PROTECTION CAPABILITY COMPARISON:

20 wt oils rank between number 2 and 212.

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30 wt oils rank between number 1 and 223.

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40 wt oils rank between number 5 and 211.

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50 wt oils rank between number 37 and 220.

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60 wt oil, the only one tested, ranked number 97.

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70 wt oil, the only one tested, ranked number 169.

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So, as you can see, this is absolute PROOF that viscosity does NOT determine an oil's wear protection capability, even though many people mistakenly believe it does. As mentioned above, an oil's wear protection capability is determined by its base oil and its additive package "as a whole", with the primary emphasis on the additive package, which contains the critical extreme pressure anti-wear components. And the additive package has nothing to do with viscosity.

NOTE: HTHS (High-Temperature/High-Shear) test data only provides information on how capable various motor oils are at maintaining their viscosity under high heat and high stress conditions. But, HTHS viscosity data DOES NOT provide any useful information at all about an oil's wear protection capability. Because a motor oil's viscosity DOES NOT determine its wear protection capability. See article 17 titled, "Do HTHS (High-Temperature/High-Shear) values provide any useful information about wear protection capability?", for more details.

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I generally recommend that people choose a highly ranked motor oil to begin with, since highly ranked oils don't need any additional help. And to use that oil just as it comes, right out of the bottle, with NO aftermarket additives at all. However, there is also data included below from testing a several different aftermarket motor oil additives, for informational purposes only, just to show how these additives actually work compared to their claims. But, I do NOT endorse them nor recommend their use.

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* FOR THE RECORD, I am NOT connected in any way to the Motor Oil or Aftermarket Additive Industry. I have absolutely no interest in what products people choose to use. So, I DO NOT promote any particular brand. I only share the results that come out of my Engineering tests, good or bad.

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The Wear Protection reference categories are:

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* Over 120,000 psi = FANTASTIC wear protection

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* 105,000 to 120,000 psi = INCREDIBLE wear protection

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* 90,000 to 105,000 psi = OUTSTANDING wear protection

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* 75,000 to 90,000 psi = GOOD wear protection

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* 60,000 to 75,000 psi = MODEST wear protection

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* Below 60,000 psi = UNDESIRABLE wear protection

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The HIGHER the psi value, the BETTER the Wear Protection.

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Test result differences between oils of less than 10% are not significant, and oils within that range can be considered approximately equivalent.

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IT'S WORTH REPEATING THAT SOME KEY POINTS TO KEEP IN MIND ABOUT THIS TESTING ARE:

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The psi reference values above, ONLY APPLY TO MY TEST DATA, not to actual engine component loading. Here's why:

The motor oil "Dynamic Wear Testing Under Load" I perform is WORST CASE torture testing. My test equipment is NOT intended to duplicate an engine's internal components. On the contrary, the test equipment is specifically designed to generate severe loading, that will quickly cause an oil to reach its failure point, in order to determine what its capability limit it is. The test loading is severe enough, that the wear scar size that forms, based on an oil's load carrying capability (the wear scar is what is measured), has stabilized at its final size by the conclusion of a 30 second load test. Procedure development testing showed that more time than that did not change the wear scar size. Every oil I test is brought to its failure point, that's how it works. The difference in the failure points, is what we compare. My testing subjects the oil to far more severe loading than even the most wicked flat tappet race engine could ever generate.

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But, a running engine is designed to last indefinitely, and of course, they do not generally cause an oil to reach its failure point. So, due to the COMPLETE DIFFERENCE in design, the pressures in my test are completely different, and therefore CANNOT be compared directly to an engine's lobe/lifter interface pressure. That would be comparing apples to oranges, which makes absolutely no sense at all. My testing is so severe, that the oil fails at a much earlier point than it would in an engine. And that is why my test data psi values appear lower than you might expect to see in some running engines.

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In addition to that, my equipment's calibration is checked and adjusted if required, each time the testing switches to a different oil. That keeps the final results accurate at all times. And keep in mind, I'm comparing OIL AGAINST OIL, and the procedure used is exactly the same for each oil tested. For better or worse, each oil stands on its own merit, and produces the best wear protection capability that its chemical composition allows. If oil A produces twice the psi value of oil B in my testing, then oil A will also provide twice the wear protection capability of oil B, in a running engine.

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All the oils were tested at a representative operational temperature of 230*F. A colder test temperature of less than 212*F would have been too cold, and would have been below desirable normal operating temperature, as well as being too low to even quickly boil off natural condensation, which if not quickly eliminated can dilute the oil. A hotter test temperature of above 250*F, would have been hotter than desirable normal operating temperature, and would have been so high, that many motor oils would already have reached the threshold of thermal breakdown. Remember that critical internal engine components are directly "OIL COOLED", and only indirectly water cooled. So, the oil needs to stay cool enough to actually help cool those components. Therefore, 230*F is an ideal test temperature to arrive at the most meaningful values for comparison. I've also tested oils at 275*F, as well as 325*F, and found that there was no significant change in the ranking order, which further confirms that the test temperature of 230*F is absolutely valid, even though operating temperatures vary in certain locations of an engine.

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All the oils tested here were brand new oils. But, I've also "wear tested" a number of those oils, both synthetic and conventional, when they were used with 5,000 miles on them. And in every case, even though those oils had been subjected to heat and stress over a significant length of time, there was NO REDUCTION what so ever, in wear protection capability, even though the zinc levels had dropped by around 25% on average. So, this is even further proof that the zinc level is not tied to a motor oil's wear protection capability, as well as absolute proof and validation that testing new oils is representative of what we can expect from those oils as they accumulate time and miles on them.

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I'm a Mechanical Engineer. Mechanical Design Engineering is what I do for a living. And a Mechanical Engineer is clearly the most qualified Engineer to test motor oil that was formulated by Chemical Engineers, for wear protection capability between mechanical components under load.

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And again, most important of all, is at the end of the day, my test data EXACTLY MATCHES real world race track experience, real world flat tappet break-in experience, and real world High Performance street experience, which PROVES once and for all, that my test data is the spot on REAL DEAL. This completely confirms that my test results WILL ACCURATELY PREDICT what we can expect from motor oils in running engines on the track, during flat tappet or roller break-in, or on the street, EVEN if those oils are high zinc oil. It also bears repeating, that all the data here was determined by the Physics and Chemistry involved. It is NOT my opinion, and it is NOT my theory. It is the Science that tells us what is going on with motor oils. And no one can argue with Physics and Chemistry. So, that should be more than enough proof to satisfy anyone who was skeptical of how well my test data compares to the real world.

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The "WEAR PROTECTION RANKING LIST" itself, begins here:

1. Prolong Engine Treatment added to 5W30 Pennzoil Ultra, API SN synthetic = 136,658 psi
This oil on its own WITHOUT the Prolong Engine Treatment added to it, has a wear protection capability of 92,569 psi. With the recommended amount of Prolong added per qt, its wear protection capability "WENT UP 48%".
The data here provides information on wear protection capability, but does NOT provide any information as to how compatible this product's chlorine may be with a given oil's additive package. Chlorine and additive package incompatibility has a possible risk of creating damaging bearing corrosion problems. There have been legal issues with this product that you can Google for yourself. Contact Prolong's maker for more information on compatibility, to find out if it is safe to use in your application. The test data on Prolong is included in my Ranking List for informational purposes only, because of requests I have received about testing this product. But, I do not endorse nor recommend its use. It is always best to simply choose a highly ranked oil in the first place, and avoid using any aftermarket additives at all.
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2. 0W20 Amsoil Signature Series, synthetic = 134,840 psi
The bottle does not have an API symbol, but it claims the oil can be used in applications that require API SN, GM dexos 1, ACEA A1/B1. It also claims to provide 75% better wear protection than required by the API SN specification. And it claims 50% more cleaning power than Amsoil OE motor oil.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2017. And it produced the highest psi value ever seen in my testing,

from “ANY” motor oil just as it comes right out of the bottle, with no aftermarket additives. Very impressive. My test results confirm that Amsoil’s claim of this oil providing exceptional wear protection, is true. And this is further proof that you do NOT need heavy thick viscosity to provide such impressive wear protection.

As it stands in Fall 2017, Amsoil Signature Series synthetic motor oils, hold the top two positions in my Wear Protection Ranking List for oils just as they come, right out of the bottle, with no aftermarket additives. Motor oils have to be EXTREMELY GOOD to perform that well in my Engineering torture test on motor oil. Amsoil knows what they are doing, and they have set the bar to a new very high level.

3. 5W30 Amsoil Signature Series, synthetic = 134,352 psi
The bottle does not have an API symbol, but it claims the oil can be used in applications that require API SN, GM dexos 1, ACEA A5/B5, A1/B1. It also claims to provide 75% better wear protection than required by the API SN specification (though it does say that claim is in reference to their 0W20 Amsoil Signature Series synthetic). And it claims 50% more cleaning power than Amsoil OE motor oil.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2017.
The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the FANTASTIC Wear Protection Category. And it produced the highest psi value ever seen in my testing, from any 5W30 motor oil just as it comes right out of the bottle, with no aftermarket additives. Very impressive. My test results confirm that Amsoil’s claim of this oil providing exceptional wear protection, is true. This oil could well be “THE MOTOR OIL OF CHOICE” for most High HP engines, including Bad Boy traditional American flat tappet pushrod engines, or for virtually any engine where 5W30 is used.

And I also went on to test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil had only a modest 7% drop in capability. But, even at that elevated temperature, it produced an impressive 124,573 psi, which still kept this much hotter and thinner oil in the FANTASTIC Wear Protection Category.

In addition, I also tested this oil at 130*F, which is an oil temperature in the middle of the range of the Sequence IVA Wear Test (ASTM D6891) = 123,882 psi, which still had it in the FANTASTIC Wear Protection Category, even though this value is about an 8% drop from the normal 230*F test temperature’s psi value. NOTE: An engine warming up, will transition right past this temperature as it heats up to its normal operating temperature.

So, here are the three temperatures I tested this oil at, put together for easy comparison:
130*F = 123,882 psi
230*F = 134,352 psi
275*F = 124,573 psi
As you can see, there is no meaningful difference between these three psi values, and as mentioned above, all three psi values are in the FANTASTIC Wear Protection Category. So, none of these temperatures had any negative affect on the oil's wear protection capability.

I also tested this oil to find out its onset of thermal breakdown, which was 295*F.

As it stands in Fall 2017, Amsoil Signature Series synthetic motor oils, hold the top two positions in my Wear Protection Ranking List for oils just as they come, right out of the bottle, with no aftermarket additives. Motor oils have to be EXTREMELY GOOD to perform that well in my Engineering torture test on motor oil. Amsoil knows what they are doing, and they have set the bar to a new very high level.

Here's a June 2018 Testimonial regarding Amsoil 5W30 Signature Series oil, sent by a Blog reader from Greece, which proved ONCE AGAIN that my motor oil Engineering Test Data "EXACTLY MATCHES" real world racing experience, as I have always said. It also proves ONCE AGAIN, that all my critics are DEAD WRONG, and have no idea what they are talking about, regarding motor oil and its performance capabilities. If you want the FACTS about motor oil, you need to read this Blog.

For reference below, Amsoil 10W30 Dominator Racing oil, produced a far lower 97,118psi, in my testing. The higher the psi value an oil can produce, the better the wear protection. Here is what he said in his Testimonial:

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Hi (again) 540 Rat,

I've seen several times, as a Rally spectator 'n' fan, a Skoda Fabia S2000 participating in Greek Rally Championship, sponsored by Amsoil, and after reading your blog, the question "which specific Amsoil do they use, in a N/A 1,996 cc = 121c.in. racing motor running up to 9500r.p.m. and approx. 300hp…" emerged. So, I took myself to the service park with the intention to ask team engineers about that. In fact, I didn't need to do so, because I saw them in an oil change using Amsoil 5W30 Signature Series oil, instead of Amsoil Dominator Racing oil. I found that this was kind-a-weird, so I decided to ask them "why so".

Chief engineer told me that every time they need to rebuild the engine, they measure accurately, all geometric parameters such as clearances, ring's width, cams heights etc. in order to replace if something was out of specs, and after 3800 racing kms (2000+miles), they decided to use Amsoil 5W30 Signature Series oil, because all mentioned components' wear was close to non-measurable from one to the next rebuild procedure.

In fact, that's -in my opinion- another proof that your data are "online" with real world's facts. Of course, a high pressure oil pump and FIA approved oil cooler are provided. But apart from these, it's still a highly stressed engine, revving most of its lifespan between 6,000 and 9,500 rpm, "feeding" via gearbox all 4 wheels.

The question remains: why not use Amsoil Dominator Racing oil…
(To mention rally team's name, in order to avoid "suspicious minds" from "bad thoughts": "Cabilis Performance")

Keep doing great things,
E.C.
Greece

My final comment about this Testimonial: Amsoil Signature Series oil has performed far better than Amsoil Dominator Racing oil, in my Engineering tests. So, the obvious choice is their Signature Series oil, if you want the absolute best wear protection. Perhaps this Race Team has been reading my Blog.

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4. 5W30 Renewable Lubricants, Bio-SynXtra, Super High Performance motor oil = 130,436 psi
This patented biobased motor oil uses agricultural vegetable oil base stock, and is biodegradable. It claims to have been formulated with the latest additive package components added to that base stock. It has no Motor Oil Industry certifications, but claims the formula passed the tests required for API SN. It claims superior wear protection and high temperature stability, both of which proved to be true in my Engineering tests. It also claims to have a very high Viscosity Index value, which helps against fuel dilution concerns. The higher the Viscosity Index value, the less the oil's viscosity is reduced as it heats up.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Summer 2018.

The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the FANTASTIC Wear Protection Category.

I also went on to test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil had only an extremely small 0.7% drop in capability. Even at that elevated temperature, it produced 129,486 psi, which still kept this much hotter oil in the FANTASTIC Wear Protection Category.

I also tested this oil for its onset of thermal breakdown point, which was 275*F.

This was the first biobased motor oil I ever tested. And its performance was EXTREMELY IMPRESSIVE. These results probably surprise a lot of people, since this oil wasn't even made from petroleum base stock. So it appears, there could be a very bright future for biobased motor oil, if they are formulated well.

And the test data produced by this biobased oil, further backs up what I have said about a motor oil's "base stock" NOT being all that critical, it is the "additive package" that IS critical.

5. Prolong Engine Treatment added to 5W30 Castrol GTX, API SN conventional = 130,366 psi
This oil on its own WITHOUT the Prolong Engine Treatment added to it, has a wear protection capability of 95,392 psi. With the recommended amount of Prolong added per qt, its wear protection capability "WENT UP 37%".

The data here provides information on wear protection capability, but does NOT provide any information as to how compatible this product's chlorine may be with a given oil's additive package. Chlorine and additive package incompatibility has a possible risk of creating damaging bearing corrosion problems. There have been legal issues with this product that you can Google for yourself. Contact Prolong's maker for more information on compatibility, to find out if it is safe to use in your application. The test data on Prolong is included in my Ranking List for informational purposes only, because of requests I have received about testing this product. But, I do not endorse nor recommend its use. It is always best to simply choose a highly ranked oil in the first place, and avoid using any aftermarket additives at all.

6. 0W40 Mobil 1 "FS" European Car Formula, ACEA A3/B3, A3/B4, API SN, synthetic = 127,221 psi
This new oil replaces the older version called, 0W40 Mobil 1, European Formula, API SN, synthetic. See below for the older version's ranking position.
zinc = TBD
phos = TBD
moly = TBD
This new "FS" version was tested in Summer 2016.
However, a 40wt hot viscosity rated motor oil is too thick to be ideal for most engines. It is best to select the thinnest motor oil viscosity that will still provide acceptable "hot" oil pressure. And you do NOT need to select the "highest rated" motor oil, just as it comes right out of the bottle, from this Wear Protection Ranking List. There are many highly ranked oils here, that will provide your engine with excellent wear protection. So, you have many oils to choose from.

I also went on to test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil did have a 16% drop in capability. But, even at that elevated temperature, it produced an impressive 106,876 psi, which put this much hotter and thinner oil in the INCREDIBLE Wear Protection Category.

I also tested this oil to find out its onset of thermal breakdown, which was 280F.

7. 0W20 Quaker State Ultimate Durability, API SN, synthetic (originally gold, now green bottle) = 124,393 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested in Spring 2016. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, which put it in the FANTASTIC Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil did have a 14.7% drop in capability. But, even at that elevated temperature, it produced an impressive 106,163 psi, put this much hotter and thinner oil in the INCREDIBLE Wear Protection Category.

8. 5W30 Valvoline Full Synthetic High Mileage with MaxLife Technology, API SN, GM dexos 1 approved (silver bottle) = 123,470 psi
Valvoline had a chart on their Website showing that this is their best oil for fuel economy and Horsepower. They also said this oil provided more anti-wear film strength than 5W30 Mobil 1, which is what I also found in my testing.
High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include “Seal Swell” chemicals to help reduce oil leakage in those older engines.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested in Spring 2017.
The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the FANTASTIC Wear Protection Category.

However, I also went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. And this oil did have a significant 27% drop in capability. At that reduced value down to 89,862 psi, this much hotter and thinner oil dropped down to the top of

the GOOD Wear Protection Category range. You can avoid such a drop in capability by keeping the oil at a more reasonable cooler temperature.
I also tested this oil to find out its onset of thermal breakdown, which was 285*F.

9. 5W30 Pentosin Pento Super Performance III, for gas and diesel engines, API S"M", ACEA C3, synthetic, made in Germany = 122,711 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested late 2016. For more information on this oil, see Tech Article 30.

10. 5W20 Quaker State Ultimate Durability, API SN, GM dexos 1 approved, synthetic (originally gold, now green bottle) = 121,396 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2015. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the FANTASTIC Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. And this oil did have a significant 23% drop in capability. However, even at that reduced value down to 92,893 psi, this much hotter and thinner oil was in the OUTSTANDING Wear Protection Category.

11. 5W30 MPT THIRTY-K synthetic oil = 120,562 psi
This oil has no API symbol, but claims the following:
* Is recommended for API S"M", CF, ACEA A3/B3/B4.
* Provides the best protection available for gasoline and Diesel engines.
* Provides the lowest coefficient of friction available.
* Provides 30,000 mile (THIRTY-K) oil change intervals with well maintained vehicles, or 15,000 mile oil change intervals with vehicles subjected to severe operating conditions.
* Sticker on the bottle says to "SHAKE WELL", which I always do with every oil I test. But, that begs the question, if there is so much concern about this oil's additive package components settling out in the bottle, that they actually put a separate sticker on the bottle about it, how can you be sure that settled out additive components in an engine that has been sitting for a length of time, with those components stuck on the bottom of the oil pan, will be sufficiently picked up again to work as intended? The maker also claims the following component quantities:
zinc = 1150 ppm
phos = 1605 ppm
moly = 1106 ppm
calcium = 2650 ppm

If those component levels are correct, this oil should not be used in late model vehicles equipped with cats, because levels that high can damage the cats. But, with the impressive psi value produced by this oil, it would be an excellent choice for Classic vehicles, older Hotrod vehicles, off-road vehicles, and racing vehicles.

This oil was tested Spring 2018. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the FANTASTIC Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil experienced a drop of only about 3% in wear protection capability. And at that elevated temperature, it produced 117,234 psi, which put this much hotter and thinner oil in the INCREDIBLE Wear Protection Category.

I also tested this oil for the onset of thermal breakdown, which was 270*F.

It was interesting to see that a little known Oil Company was capable of formulating such impressive motor oil performance. This oil actually performs head to head with the Big Boy Oil Companies. I seldom see that from little known Oil Companies.

12. 5W20 Valvoline Modern Engine Oil, for engines 2012 and newer, API SN, synthetic = 120,531 psi
This new line of motor oil came out at the beginning of 2018, and claims to fight carbon build-up on piston crowns, combustion chambers, valves and Turbochargers, in GDI (Gas Direct Injection) and other newer engines. This oil's impressive wear protection psi value, certainly makes it an excellent choice, in that regard. But, in spite of their claims, do not expect it to keep those engine components any cleaner than other quality motor oils. Here's why: Even if this oil has more or better cleaning agents as it implies, those cleaning agents cannot do any cleaning if those engine components are not exposed to the oil.

Any engine in good condition that does not blow blue smoke out the exhaust pipe, and does not consume oil between oil changes, does not have any significant amount of oil on those engine components, for any cleaning to take place. So, some might say that those claims of cleaner engine components are misleading at best, or outright false at worst, as it relates to most newer engines.

The only way this oil has any chance of providing any additional cleaning on those engine components, is if it is used in an engine that goes through enough oil to blow blue smoke out the exhaust pipe and consumes measurable amounts of oil between oil changes, which would

expose those components to the oil. But, nearly all cleaning of those components in engines in good condition, normally has to come from the cleaning agents in the "fuel" being used, NOT the oil being used. But, that is a problem for Direct Injection engines, since fuel vapor does not wash over the intake valves, like it does with Port Injection engines.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Spring 2018. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the FANTASTIC Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. And this oil experienced about a 12% drop in capability. But, even at that elevated temperature, it produced 105,567 psi, which put this much hotter and thinner oil in the INCREDIBLE Wear Protection Category.

I also tested this oil for the onset of thermal breakdown, which was 260*F.

13. 0W30 Gulf Competition, High Performance Racing Engine Oil, ester-based synthetic = 119,789 psi
zinc = TBD
phos = TBD
moly = TBD
This oil claims reduced frictional properties. There were no ACEA nor API certifications on the bottle's label, but the Gulf paperwork literature that was sent to me along with the oil, said the following: "No formal specifications can be claimed, but this oil contains performance additives designed to achieve ACEA A3/B4 and API SL/CF. While this oil is excellent for motorsport use, it is not recommended for use in road cars if the car or its engine is still under the original manufacturer's warranty".

This oil was purchased in "Sweden" in December 2016.

This oil was tested January 2017. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the INCREDIBLE Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. But, this oil had only a small 6% drop in capability. And even at that elevated temperature, it produced an impressive 112,618 psi, which still kept this much hotter and thinner oil in the INCREDIBLE Wear Protection Category.

This oil's onset of thermal breakdown = 265*F.

14. 5W30 Mobil 1, Advanced Full Synthetic, API SN, GM dexos 1 approved = 117,799 psi
zinc = TBD
phos = TBD
moly = TBD
This was the latest current version of this oil when tested at the end of 2015. This oil is used by a number of Auto Makers worldwide as factory fill oil in their High Performance cars. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the INCREDIBLE Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. And this oil did have a disappointing 36% drop in capability. At that reduced value down to 75,861 psi, this much hotter and thinner oil dropped down to the GOOD Wear Protection Category. You can avoid such a drop in capability by keeping the oil at a more reasonable cooler temperature.

15. Prolong Engine Treatment added to 5W30 Pennzoil, API SN conventional (yellow bottle) = 117,028 psi
This oil on its own WITHOUT the Prolong Engine Treatment added to it, has a wear protection capability of 76,989 psi. With the recommended amount of Prolong added per qt, its wear protection capability "WENT UP 52%".

The data here provides information on wear protection capability, but does NOT provide any information as to how compatible this product's chlorine may be with a given oil's additive package. Chlorine and additive package incompatibility has a possible risk of creating damaging bearing corrosion problems. There have been legal issues with this product that you can Google for yourself. Contact Prolong's maker for more information on compatibility, to find out if it is safe to use in your application. The test data on Prolong is included in my Ranking List for informational purposes only, because of requests I have received about testing this product. But, I do not endorse nor recommend its use. It is always best to simply choose a highly ranked oil in the first place, and avoid using any aftermarket additives at all.

16. 10W30 Mobil 1, Advanced Full Synthetic, API SN = 115,635 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested at the end of 2015.

17. 5W30 Pennzoil Ultra, API SM synthetic = 115,612 psi
zinc = 806 ppm
phosphorus = 812 ppm
moly = 66 ppm
calcium = 3,011 ppm
TBN = 10.3
This oil is no longer available and has been replaced by newer API "SN" versions a couple of times. See below for the current "SN" version's ranking position.

18. 5W20 Valvoline MaxLife High Mileage, API SN, dexos 1 approved, synthetic blend (red bottle) = 114,125 psi
High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include "Seal Swell" chemicals to help reduce oil leakage in those older engines.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Spring 2016.

19. 5W30 Mobil 1 ESP Formula (Emission System Protection), for diesel and gas engines, ACEA C2, C3, API SN, synthetic = 113,836 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested late 2016. For more information on this oil, see Tech Article 30.

20. 5W30 Quaker State Ultimate Durability, API SN, GM dexos 1 approved, synthetic (originally gold, now green bottle) = 113,377 psi
zinc = TBD
phos = TBD
moly = TBD
This was the latest current version of this oil when tested at the end of 2015. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the INCREDIBLE Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. But, this oil only had a very small 3.7% drop in capability. And even at that elevated temperature, it produced an extremely impressive 109,211 psi, which still kept this much hotter and thinner oil in the INCREDIBLE Wear Protection Category.

21. 5W30 Pennzoil Euro "AV" European Formula, for diesel and gas engines, ACEA C3, API SN, synthetic = 112,664 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested late 2016. For more information on this oil, see Tech Article 30.

22. 5W30 Motul 300V Ester Core 4T Racing Oil, synthetic = 112,464 psi
This Motorcycle Road Racing oil is from France and comes in liter bottles (slightly more than a quart). At the time this oil was tested in spring 2014, it cost $24.25 per bottle. And with the shipping cost added to that, the final cost was about $33.00 per bottle (shipping was all inside the U.S.), making it THE most expensive motor oil I've ever tested.
zinc = 1724 ppm
phosphorus = 1547 ppm
moly = 481 ppm
calcium = 3141 ppm
TBN = 7.4
This oil contains sufficient amounts of the components required (detergent, acid neutralizer, etc) for normal change intervals in street driven vehicles. But, it has way too much zinc/phos for use in cat equipped vehicles. However, it is well suited for Race Cars, Street Hotrods and Classic cars.

23. 5W30 Mag 1, FMX, European Formula, API S"M", ACEA C3-08, synthetic, for gas and diesel cars and light trucks = 111,622 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Spring 2016.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. And this oil did experience a 17.1% drop in capability. But, even at that elevated temperature, it produced 92,508 psi, which still put this much hotter and thinner oil in the OUTSTANDING Wear Protection Category.

I also tested this oil to find out its onset of thermal breakdown, which was at 280*F.

24. "Oil Extreme concentrate" added to 5W30 Pennzoil Ultra, API SM synthetic = 111,570 psi
This oil on its own WITHOUT the "Oil Extreme concentrate" added to it, has a wear protection capability of 115,612 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability "WENT DOWN 3.5%".
zinc = TBD

phosphorus = TBD.
moly = TBD
calcium = TBD
TBN = TBD

25. “Oil Extreme concentrate” added to 10W30 Brad Penn, Penn Grade 1 semi-synthetic = 111,061psi
This oil on its own WITHOUT the “Oil Extreme concentrate” added to it, has a wear protection capability of only 71,206 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability “WENT UP A BREATH TAKING 56%”.
zinc = TBD
phosphorus = TBD.
moly = TBD
calcium = TBD
TBN = TBD

26. 5W30 LE (Lubrication Engineers) Monolec Tetra-Syn, API SN, GF-5, dexos 1, synthetic = 110,883 psi
zinc =
phos =
moly =
This oil was tested Spring 2018.

27. 5W30 Oil Extreme Motor Oil, API SM synthetic (per the Oil Company, even though synthetic wording is not shown on the label) = 110,286 psi
The Company claims this oil contains their proprietary formula of calcium petroleum sulfontate EP (Extreme Pressure) technology that is NOT found in any other motor oil. They also claim that it will provide 5 to 7 more HP, 7 to 10% better fuel mileage, cut engine wear in half, and will extend drain intervals two or three times safely. This oil is endorsed and promoted by Tech Author David Vizard. And he was so impressed by this oil’s performance that he also became a share holder in the Company. The results from the “Dynamic Wear Testing Under Load” performed here, fully supports their claim regarding wear protection. So, their hype about that, turned out to be absolutely true. And since this oil beat nearly every high zinc oil I’ve ever tested, it also proved another one of their claims, that using zinc as the primary anti-wear component, is outdated technology.
zinc = 765 ppm
phosphorus = 624 ppm
moly = 52 ppm
calcium = 7,652 ppm
TBN = 23.2

28. 5W40 Mag 1, FMX, European Formula, API SN, ACEA A3/B4, synthetic, for gas and diesel

cars and light trucks = 109,147 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Spring 2016.

29. 5W30 Valvoline MaxLife High Mileage, API SN, synthetic blend (red bottle) = 108,045 psi
High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include "Seal Swell" chemicals to help reduce oil leakage in those older engines.
zinc = TBD
phosphorus =TBD
moly = TBD
This is an earlier version that is no longer available. It has been replaced by a new formula version that now has GM dexos 1 approval. See below for the new version's ranking position.

30. 5W30 Castrol Edge Professional "LL03", for diesel engines, ACEA C3, gold bottle, synthetic = 107,067 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested late 2016. For more information on this oil, see Tech Article 30.

31. 10W30 Lucas Racing Only synthetic = 106,505 psi
zinc = 2642 ppm
phosphorus = 3489 ppm
moly = 1764 ppm
calcium = 2,929 ppm
TBN = 9.0
NOTE: This oil is suitable for short term racing use only, and is not suitable for street use.

32. CFS 0W30 NT Millers Nanodrive Racing Oil, API SM synthetic = 105,907 psi
This oil is from England, comes in liter bottles (slightly more than a quart), and it uses a nanotechnology formulation. At the time this oil was tested in fall 2013, it cost $22.45 per bottle. And with the shipping cost added to that, the final cost was about $28.00 per bottle (shipping was all inside the U.S.), making it one of the most expensive oils I've ever tested.
zinc = TBD, but the maker claims it has approximately 1100 ppm ZDDP.
phos = TBD
moly = TBD
calcium = TBD
TBN = TBD

33. 5W30 Mobil 1, Advanced Full Synthetic, API SN = 105,875 psi
zinc = 801 ppm
phosphorus = 842 ppm
moly = 112 ppm
calcium = 799 ppm
TBN = 7.5
This is an earlier version that is no longer available. It has been replaced by a new formula version that now has GM dexos 1 approval. See above for the new version's ranking position.

34. "Oil Extreme concentrate" added to 10W30 Lucas Hot Rod & Classic Hi-Performance Oil conventional = 105,758 psi
This oil on its own WITHOUT the "Oil Extreme concentrate" added to it, has a wear protection capability of only 62,538 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability "WENT UP A MIND BLOWING 69%".
zinc = TBD
phosphorus = TBD
moly = TBD
calcium = TBD
TBN = TBD

35. 5W30 NAPA Full Synthetic, API SN, dexos 1 approved, silver bottle = 105,319 psi
The bottle says this oil was developed by Valvoline.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Summer 2017.

36. 0W30 Amsoil Signature Series 25,000 miles, API SN synthetic = 105,008 psi
zinc = 824 ppm
phosphorus = 960 ppm
moly = 161 ppm
calcium = 3,354 ppm
TBN = 11.4
This is an older version of this oil that was replaced by a newer formula in 2017. The newer formula claims 75% better wear protection.

37. 5W30 Joe Gibbs Driven LS30 Performance Motor Oil, synthetic = 104,487 psi
The bottle says it is formulated specifically for high output GM LS engines, and that no ZDDP or additives required. This is by far, the best performing Joe Gibbs oil I've ever tested. It is at the very top of the OUTSTANDING wear protection category, and fell just short of the INCREDIBLE wear protection category.
zinc = 1610 ppm

phosphorus = 1496 ppm
moly = 0 ppm
calcium = 3515 ppm
TBN = 8.8
This oil contains sufficient amounts of the components required (detergent, acid neutralizer, etc) for normal change intervals in street driven vehicles. But, it has way too much zinc/phos for use in cat equipped vehicles. However, it is well suited for Race Cars, Street Hotrods and Classic cars.

38. 15W50 Aeroshell W, Piston Aircraft engine oil, semi-synthetic = 104,332 psi
zinc = 2 ppm
phos = 1286 ppm
moly = < 1 ppm
See more Lab Test data at the beginning of "Section 4 – Motor Oil component quantity Lab Test results".
This oil was tested at the end of 2017.
The psi value shown just above, is from the normal test temperature of 230*F, which put this oil near the upper end of the OUTSTANDING wear protection category. However, I went on to also test this oil at the much higher temperature of 275*F. And this is the first oil I have tested that actually had an "increase" in capability at 275*F = 106,300 psi, which put it in the INCREDIBLE Wear Protection Category at this much higher temperature. This is also the "first" aircraft engine oil I have tested. And this viscosity would generally be used in "air cooled" aircraft engines.
I also tested this oil for the onset of thermal breakdown, which was 285*F.

39. 10W30 Valvoline NSL (Not Street Legal) Conventional Racing Oil = 103,846 psi
zinc = 1669 ppm
phosphorus = 1518 ppm
moly = 784 ppm
calcium = 1,607 ppm
TBN = 4.4
NOTE: This oil is suitable for short term racing use only, and is not suitable for street use. Since this testing was performed, Valvoline has discontinued this oil.

40. 10W40 Valvoline MaxLife High Mileage, API SN, synthetic blend (red bottle) = 103,840 psi
High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include "Seal Swell" chemicals to help reduce oil leakage in those older engines.
zinc = TBD
phos = TBD
moly = TBD

This oil was tested at the end of 2015. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the OUTSTANDING Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. And this oil did have a significant 25% drop in capability. At that reduced value down to 77,817 psi, this much hotter and thinner oil dropped to the GOOD Wear Protection Category.

41. A 50/50 mix of 0W40 Mobil 1 European Car Formula (but this bottle did NOT have the latest "FS" designation on the label), API SN, ACEA A3/B3, A3/B4 synthetic and 5W30 Pennzoil Platinum pure plus technology made from natural gas, API SN, dexos 1, ACEA A1/B1, A5/B5 synthetic = 103,735 psi
zinc = TBD
phos = TBD
moly = TBD
These oils were sent to me by a Blog reader who requested this Witches Brew test, which you could call a 2.5W35 when combined. This concoction was tested Spring 2017.
My previous combination testing involved aftermarket additives being added to a single motor oil. But, this is the first time I tested two "oils" mixed together. And this is an example which shows that API SN certified oils are compatible, and that mixing them together, does NOT harm their wear protection capability.

42. 5W50 Motorcraft, API SN synthetic = 103,517 psi
zinc = 606 ppm
phosphorus = 742 ppm
moly = 28 ppm
calcium = 1,710 ppm
TBN = 6.7

43. 10W30 Valvoline VR1 Conventional Racing Oil (silver bottle) = 103,505 psi
zinc = 1472 ppm
phosphorus = 1544 ppm
moly = 3 ppm
calcium = 2,707 ppm
TBN = 7.6

44. 5W30 Amsoil Series 3000 Heavy Duty Diesel Oil synthetic, API CI-4 PLUS, CF, SL, ACEA A3/B3, E2, E3, E5, E7 = 102,642 psi.
This oil is Engineered for Diesel engines not equipped with Diesel particulate filters (DPF). Amsoil says this oil delivers better wear protection than other popular Diesel oils. And in this

case, their hype is absolutely true. They also say it effectively reduces fuel consumption, with its advanced fuel efficient formula. This oil costs $11.15 per quart in the 2013 Amsoil Factory Direct Retail Catalog, which is 10% more than Amsoil's 5W40 Premium Synthetic Diesel Oil. So, in this case, you pay only 10% more for the Amsoil Series 3000 Heavy Duty Diesel Oil, but you get a whopping 33% more wear protection than you get with the Amsoil's 5W40 Premium Synthetic Diesel Oil. Money very well spent, if you run a Diesel oil intended for engines not equipped with Diesel particulate filters. This 5W30 Amsoil Series 3000 Heavy Duty Diesel Oil is one of the very best Diesel oils I have tested.
zinc = TBD
phos = TBD
moly = TBD

45. 5W30 Pennzoil High Mileage Vehicle, API SN, conventional = 102,402 psi
High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include "Seal Swell" chemicals to help reduce oil leakage in those older engines.
zinc = TBD
phos =TBD
moly = TBD

46. "Oil Extreme concentrate" added to 5W30 Mobil 1, API SN synthetic = 102,059 psi
This oil on its own WITHOUT the "Oil Extreme concentrate" added to it, has a wear protection capability of 105,875 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability "WENT DOWN 3.6%".
zinc = TBD
phosphorus = TBD.
moly = TBD
calcium = TBD
TBN = TBD

47. 0W20 Toyota Motor Oil, API SN, synthetic = 101,460 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Spring 2016.

48. 0W20 Mazda GF-5 with Moly, API SN, GF-5, synthetic = 101,285 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2017. It is made by Idemitsu Lubricants.

49. 5W40 Joe Gibbs DT40, synthetic = 101,265 psi
This oil claims to be formulated specifically for modern Sports Car engines, yet it has no API certifications at all, and claims to have a ZDDP anti-wear package, which would indicate that it does not have low enough zinc/phos levels to be safely used in modern cat equipped vehicles.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested at the end of 2015.

50. 10W30 Valvoline VR1 Synthetic Racing Oil, API SL (black bottle) = 101,139 psi
zinc = 1180 ppm
phosphorus = 1112 ppm
moly = 162 ppm
calcium = 2,664 ppm
TBN = 7.4

51. 5W30 Valvoline Modern Engine Oil, for engines 2012 and newer, API SN, synthetic = 101,069 psi
This new line of motor oil came out at the beginning of 2018, and claims to fight carbon build-up on piston crowns, combustion chambers, valves and Turbochargers, in GDI (Gas Direct Injection) and other newer engines. This oil's impressive wear protection psi value, certainly makes it an excellent choice, in that regard. But, in spite of their claims, do not expect it to keep those engine components any cleaner than other quality motor oils. Here's why: Even if this oil has more or better cleaning agents as it implies, those cleaning agents cannot do any cleaning if those engine components are not exposed to the oil.

Any engine in good condition that does not blow blue smoke out the exhaust pipe, and does not consume oil between oil changes, does not have any significant amount of oil on those engine components, for any cleaning to take place. So, some might say that those claims of cleaner engine components are misleading at best, or outright false at worst, as it relates to most newer engines.

The only way this oil has any chance of providing any additional cleaning on those engine components, is if it is used in an engine that goes through enough oil to blow blue smoke out the exhaust pipe and consumes measurable amounts of oil between oil changes, which would expose those components to the oil. But, nearly all cleaning of those components in engines in good condition, normally has to come from the cleaning agents in the "fuel" being used, NOT the oil being used. But, that is a problem for Direct Injection engines, since fuel vapor does not wash over the intake valves, like it does with Port Injection engines.
zinc = TBD
phos = TBD
moly = TBD

This oil was tested Spring 2018. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the OUTSTANDING Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil experienced only about a 3.5% drop in capability. At that elevated temperature, it produced 97,445 psi, which kept this much hotter and thinner oil in the OUTSTANDING Wear Protection Category.

I also tested this oil for the onset of thermal breakdown, which was 260*F.

52. "Oil Extreme concentrate" added to 5W30 Pennzoil, API SN conventional (yellow bottle) = 100,252 psi
This oil on its own WITHOUT the "Oil Extreme concentrate" added to it, has a wear protection capability of only 76,989 psi. But, with 1.5 OZ of concentrate added per qt, which is the bottle's instruction for street driven vehicles, its wear protection capability "WENT UP A WHOPPING 30%".
zinc = 970 ppm
phosphorus = 749 ppm, this value is 91 ppm lower than the basic oil because the concentrate has less phosphorus in it, which diluted the overall ppm count of the mixture.
moly = 285 ppm
calcium = 4,443 ppm
TBN = 18.8

53. 0W20 Mobil 1 Extended Performance, API SN, dexos 1 approved, synthetic = 100,229 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested in Spring 2016.

54. 5W30 Chevron Supreme, API SN conventional (blue bottle) = 100,011 psi
This oil only cost $4.29 per quart at an Auto Parts Store when I bought it.
zinc = 1018 ppm
phos = 728 ppm
moly = 161 ppm

55. 5W20 Castrol Edge with Titanium, API SN synthetic (gold bottle) = 99,983 psi
zinc = 1042 ppm
phos = 857 ppm
moly = 100 ppm

titanium = 49 ppm
This is an earlier version that is no longer available. It has been replaced by 5W20 Castrol Edge Extended Performance (gold bottle). See below for its ranking position.

56. 5W30 Pennzoil Platinum, API SN synthetic = 99,949 psi
This was the original API SN version, that was NOT made from natural gas.
zinc = TBD
phos = TBD
moly = TBD

57. "Oil Extreme concentrate" added to 5W30 Pennzoil, API SN conventional (yellow bottle) = 99,529 psi
This oil on its own WITHOUT the "Oil Extreme concentrate" added to it, has a wear protection capability of only 76,989 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability "WENT UP 29%".
zinc = TBD
phos = TBD
moly = TBD

58. 5W30 Pennzoil "Ultra" Platinum, Pure Plus Technology, made from pure natural gas, API SN, GM dexos 1 approved = 99,039 psi
This oil was introduced in 2014, and comes in a dark gray bottle with a blue vertical stripe on the label.
zinc = TBD
phos = TBD
moly = TBD
The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the OUTSTANDING Wear Protection Category.

However, I went on to also test this oil late in 2015, at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. But, this oil had only an extremely small 2.7% drop in capability, the smallest drop I have seen. And at that reduced value down to 96,363 psi, this much hotter and thinner oil was still in the OUTSTANDING Wear Protection Category.

59. "Oil Extreme concentrate" added to 5W30 Oil Extreme Motor Oil, API SM synthetic = 98,396 psi
This oil on its own WITHOUT the "Oil Extreme concentrate" added to it, has a wear protection capability of 110,286 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability "WENT DOWN 11%".

zinc = TBD
phos = TBD
moly = TBD

60. 10W30 LE (Lubrication Engineers) Monolec Ultra Diesel oil, API CK-4, CJ-4, CI-4, CH-4, CI-4Plus, conventional = 97,878 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Spring 2018. And this is the best performing CK-4 Diesel oil I have tested to date.

61. “Oil Extreme concentrate” added to 5W30 Pennzoil, API SN conventional, yellow bottle = 97,651 psi
This oil on its own WITHOUT the “Oil Extreme concentrate” added to it, has a wear protection capability of only 76,989 psi. But, with 3.0 OZ of concentrate added per qt, its wear protection capability “WENT UP 27%”.
zinc = TBD
phos = TBD
moly = TBD

62. 10W40 Pennzoil High Mileage Vehicle, API SN, conventional = 97,419 psi
High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include “Seal Swell” chemicals to help reduce oil leakage in those older engines.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested at the end of 2015.

63. 10W30 Amsoil Dominator Racing Oil synthetic = 97,118 psi
zinc = 1613 ppm
phos = 1394 ppm
moly = 0 ppm

64. 5W30 Pennzoil Platinum Euro “L”, made from natural gas, for diesel and gas engines, ACEA C3, GM dexos “2” approved, API SN, synthetic = 97,051 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested late 2016. For more information on this oil, see Tech Article 30.

65. “Oil Extreme concentrate” added to 5W30 Pennzoil, API SN conventional, yellow bottle = 96,739 psi
This oil on its own WITHOUT the “Oil Extreme concentrate” added to it, has a wear protection capability of only 76,989 psi. But, with 4.0 OZ of concentrate added per qt, its wear protection capability “WENT UP 26%”.
zinc = TBD
phos = TBD
moly = TBD

66. 20W50 Castrol GTX, API SN conventional = 96,514 psi
zinc = 610 ppm
phos = 754 ppm
moly = 94 ppm

67. 30 wt Red Line Race Oil synthetic = 96,470 psi
zinc = 2207 ppm
phos = 2052 ppm
moly = 1235 ppm
NOTE: This oil is suitable for short term racing use only, and is not suitable for street use.

68. 0W20 Mobil 1 Advanced Fuel Economy, API SN synthetic = 96,364 psi
zinc = 742 ppm
phos = 677 ppm
moly = 81 ppm
This is an earlier version of this oil that did not have dexos 1 approval. See below for the later version of this oil that does have dexos 1 approval.

69. 5W30 Quaker State Ultimate Durability, API SN synthetic = 95,920 psi
zinc = 877 ppm
phos = 921 ppm
moly = 72 ppm
This is an earlier version that is no longer available. It has been replaced by a new formula version that now has GM dexos 1 approval. See above for the new version’s ranking position.

70. 5W30 Castrol Edge with Titanium, API SN synthetic (gold bottle) = 95,717 psi
zinc = 818 ppm
phos = 883 ppm
moly = 90 ppm
titanium = 44 ppm
This is an earlier version that is no longer available. It has been replaced by 5W30 Castrol Edge Extended Performance (gold bottle). See below for its ranking position.

71. 10W30 Joe Gibbs XP3 NASCAR Racing Oil synthetic = 95,543 psi
zinc = 743 ppm
phos = 802 ppm
moly = 1125 ppm
NOTE: This oil is suitable for short term racing use only, and is not suitable for street use.

72. 5W20 Castrol GTX, API SN conventional = 95,543 psi
zinc = TBD
phos = TBD
moly = TBD
NOTE: The two oils above were tested weeks apart, but due to the similarities in their wear scar sizes, their averages ended up the same.

73. 5W30 Castrol GTX, API SN conventional = 95,392 psi
zinc = 830 ppm
phos = 791 ppm
moly = 1 ppm
This is an older version of this oil that is no longer available. See 5W30 Castrol GTX "ULTRACLEAN" below, for current capability.

74. 10W30 Amsoil Z-Rod Oil synthetic = 95,360 psi
zinc = 1431 ppm
phos = 1441 ppm
moly = 52 ppm

75. 5W30 Havoline, API SN conventional = 95,098 psi
zinc = TBD
phos = TBD
moly = TBD

76. 5W30 Valvoline SynPower, API SN synthetic = 94,942 psi
zinc = 969 ppm
phos = 761 ppm
moly = 0 ppm

77. "Oil Extreme concentrate" added to 5W30 Chevron Supreme, API SN conventional = 94,864 psi
This oil on its own WITHOUT the "Oil Extreme concentrate" added to it, has a wear protection capability of 100,011 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability "WENT DOWN 5.1%".

zinc = TBD
phosphorus = TBD.
moly = TBD

78. 5W30 Valvoline Premium Conventional, API SN = 94,744 psi
zinc = TBD
phos = TBD
moly = TBD

79. 5W20 Mobil 1, Advanced Full Synthetic , API SN synthetic = 94,663 psi
zinc = 764 ppm
phos = 698 ppm
moly = 76 ppm
This is an earlier version that is no longer available. It has been replaced by 5W20 Mobil 1 that includes GM dexos 1 approval. See below for its ranking position.

80. 5W20 Valvoline SynPower, API SN synthetic = 94,460 psi
zinc = 1045 ppm
phos = 742 ppm
moly = 0 ppm
This is an earlier version that is no longer available. It has been replaced by 5W20 Valvoline SynPower that includes GM dexos 1 approval. See below for its ranking position.

81. 10W40 Bel-Ray, Friction Modified, Thumper Racing 4T, 4-Sroke Motorcycle engine oil, NOT for wet clutch applications, meets API SN and JASO MB requirements, conventional = 93,958 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2017.

82. 10W40 Mobil 1 Racing 4T, four stroke Motorcycle oil, synthetic = 93,661 psi
This oil claims to meet or exceed API SN.
zinc = TBD
phos = TBD
moly = TBD

83. 5W30 Eneos, API SN, synthetic = 93,135 psi
zinc = TBD
phos = TBD
moly = TBD

84. 5W40 High Performance Lubricants Racing Oil, synthetic = 92,693 psi
The bottle calls this oil, “Bad Ass”.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Summer 2016.

85. 5W30 Valvoline MaxLife High Mileage, API SN, GM dexos 1 approved, synthetic blend (red bottle) = 92,639 psi
High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include “Seal Swell” chemicals to help reduce oil leakage in those older engines.
zinc = TBD
phos =TBD
moly = TBD
This was the latest current version of this oil when tested at the end of 2015. The psi value of this oil, which came from testing it at the normal operating test temperature of 230*F, put it in the OUTSTANDING Wear Protection Category.

However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. And this oil did have an 8.3% drop in capability. At that reduced value down to 84,928 psi, this much hotter and thinner oil dropped to the GOOD Wear Protection Category.

86. 5W30 Pennzoil Ultra, API SN synthetic = 92,569 psi
This was the original API SN version, that was NOT made from natural gas.
zinc = TBD
phos = TBD
moly = TBD
The older API “SM” version of this oil, produced a wear protection capability value of 115,612 psi.

87. 0W20 Pennzoil Platinum, Pure Plus Technology, made from Natural Gas, API SN, synthetic (silver bottle with blue vertical stripe on the label) = 92,504 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested in Spring 2016.

88. 5W30 Lucas, API SN conventional = 92,073 psi
zinc = 992 ppm
phos = 760 ppm
moly = 0 ppm

89. 5W30 O'Reilly (house brand), API SN conventional = 91,433 psi
This oil only cost $3.99 per quart at an Auto Parts Store when I bought it.
zinc = 863 ppm
phos = 816 ppm
moly = 0 ppm

90. 5W30 Castrol GTX High Mileage, API SN, synthetic blend = 91,404 psi
High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include "Seal Swell" chemicals to help reduce oil leakage in those older engines.
zinc = TBD
phos =TBD
moly = TBD

91. 10W30 Bel-Ray, Friction Modified, Thumper Racing 4T, 4-Sroke Motorcycle engine oil, NOT for wet clutch applications, meets API SM and JASO MB requirements, conventional = 91,358 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2017.

92. 5W30 Maxima RS530 Synthetic Racing Oil = 91,162 psi
zinc = 2162 ppm
phos = 2294 ppm
moly = 181 ppm

93. 5W30 Red Line, API SN synthetic = 91,028 psi
zinc = TBD
phos = TBD
moly = TBD

94. 0W20 Castrol Edge, Fluid Titanium Technology, API SN, dexos 1 approved, synthetic (black bottle) = 90,745 psi
zinc = TBD
phos =TBD
moly = TBD
This oil was tested in Spring 2016.

95. 5W20 Royal Purple API SN synthetic = 90,434 psi
zinc = 964 ppm
phos = 892 ppm
moly = 0 ppm

96. 0W40 Amsoil Max-Duty Signature Series Diesel oil, API CK-4/SN, CJ-4, CI-4+, CF, ACEA E9, E7, synthetic = 90,307 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested late 2017.
Comparing the three Amsoil Max-Duty Signature Series Diesel Oils tested late 2017/early 2018:
0W40 = 90,307 psi
5W40 = 87,154 psi
15W40 = 87,881 psi
Oil psi value differences of less than 10% are not significant, and oils within that range can be considered approximately equivalent. These three oils are all within a range of about 3.5%, which is very consistent for oils in the same product line. Therefore, any of these three oils would provide essentially the same level of wear protection. But, the 0W40 will flow the best when cold, making it the top choice of the three.

97. 10W30 Quaker State Defy High Mileage, API SL semi-synthetic = 90,226 psi
Defy has always been a High Mileage oil since it was first introduced. But, "High Mileage" hasn't always been prominently displayed on the front label. Newer bottles do now prominently display "High Mileage" on the front label. High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include "Seal Swell" chemicals to help reduce oil leakage in those older engines.
zinc = 1221 ppm
phos = 955 ppm
moly = 99 ppm

98. 10W60 Castrol TWS Motorsport, API SJ conventional = 90,163 psi
This oil is manufactured in Europe and is sold in the US for BMW models M3, M5, M6, Z4M, and Z8.
zinc = TBD
phos = TBD
moly = TBD

99. 5W20 Valvoline Premium Conventional, API SN = 90,144 psi
zinc = TBD
phos = TBD
moly = TBD

100. 10W30 Motorcraft Super Duty Diesel oil, conventional = 89,829 psi
This oil claims it has over 1,000 ppm phosphorus for better wear protection.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested at the end of 2017.

101. “Oil Extreme concentrate” added to 5W30 Castrol GTX, API SN conventional = 89,659 psi
This oil on its own WITHOUT the “Oil Extreme concentrate” added to it, has a wear protection capability of 95,392 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability “WENT DOWN 6%”.
zinc = TBD
phosphorus = TBD.
moly = TBD

102. 5W20 Mobil 1, Extended Performance, dexos 1 approved, API SN, synthetic = 89,599 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2017.

103. 0W20 Valvoline SynPower, API SN, synthetic = 89,556 psi
zinc = TBD
phos =TBD
moly = TBD
This oil was tested in Spring 2016.

104. 5W30 Havoline, API SN synthetic = 89,406 psi
zinc = TBD
phos = TBD
moly = TBD

105. 5W30 Penrite 10 Tenths Racing 5, synthetic = 88,992 psi
This oil comes from Australia in 1 liter bottles (slightly more than a quart), and can be ordered in the U.S. from Summit Racing Equipment. It claims low friction for max power, and says it is not suitable for motorcycles with wet clutches. It also claims to have a full zinc formula.
zinc = TBD
phos = TBD
moly = TBD

106. 0W20 Amsoil XL (Extended Life), API SN, ACEA A1/B1, GM dexos1 gen2, synthetic = 88,860 psi
This oil claims 25% more cleaning power than Amsoil OE.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Spring 2018. At the time of this test, 0W20 Amsoil XL cost about 27% “LESS” than Amsoil’s top of the line 0W20 Signature Series motor oil.

107. 30 wt Castrol Heavy Duty, API SM conventional = 88,089 psi
zinc = 907 ppm
phos = 829 ppm
moly = 56 ppm

108. 5W30 Mobil 1 High Mileage, API SL, synthetic = 88,081 psi
High Mileage oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include “Seal Swell” chemicals to help reduce oil leakage in those older engines.
zinc = TBD
phos =TBD
moly = TBD

109. 20W50 LAT Synthetic Racing Oil, API SM = 87,930 psi
zinc = TBD
phos = TBD
moly = TBD

110. 15W40 Amsoil Max-Duty Signature Series Diesel Oil, API CK-4/SN, CJ-4, CI-4+, CF, ACEA E9, E7 synthetic = 87,881 psi
It claims 6X more wear protection than required by Detroit Diesel DD13 Scuffing Test.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested early 2018.
Comparing the three Amsoil Max-Duty Signature Series Diesel Oils tested late 2017/early 2018:
0W40 = 90,307 psi
5W40 = 87,154 psi
15W40 = 87,881 psi
Oil psi value differences of less than 10% are not significant, and oils within that range can be considered approximately equivalent. These three oils are all within a range of about 3.5%, which is very consistent for oils in the same product line. Therefore, any of these three oils would provide essentially the same level of wear protection. But, the 0W40 will flow the best when cold, making it the top choice of the three.

111. 5W30 Valvoline Nextgen 50% Recycled Oil, API SN conventional = 87,563 psi
zinc = 947 ppm
phos = 778 ppm
moly = 0 ppm

112. 5W30 Pennzoil Platinum, Pure Plus Technology, made from pure natural gas, API SN = 87,241 psi
This oil was introduced in 2014, and comes in a silver bottle with a blue vertical stripe on the label.
zinc = TBD
phos = TBD
moly = TBD
This is an earlier version that is no longer available. It has been replaced by a new formula version that now has GM dexos 1 approval.

113. 5W40 Amsoil Max-Duty Signature Series Diesel Oil, API CK-4/SN, CJ-4, CI-4+, CF, ACEA E9, E7 synthetic = 87,154 psi
It claims 6X more wear protection than required by Detroit Diesel DD13 Scuffing Test.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested early 2018.
Comparing the three Amsoil Max-Duty Signature Series Diesel Oils tested late 2017/early 2018:
0W40 = 90,307 psi
5W40 = 87,154 psi
15W40 = 87,881 psi
Oil psi value differences of less than 10% are not significant, and oils within that range can be considered approximately equivalent. These three oils are all within a range of about 3.5%, which is very consistent for oils in the same product line. Therefore, any of these three oils would provide essentially the same level of wear protection. But, the 0W40 will flow the best when cold, making it the top choice of the three.

114. 0W20 Amsoil OE (Original Equipment), API SN, ACEA A1/B1, GM dexos1 gen2, synthetic = 86,622 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Spring 2018. At the time of this test, 0W20 Amsoil OE cost about 40% “LESS” than Amsoil’s top of the line 0W20 Signature Series motor oil.

115. 5W50 Mobil 1, API SN, synthetic = 86,456 psi
zinc = TBD
phos = TBD
moly = TBD

116. 10W30 Joe Gibbs HR4 Hotrod Oil synthetic = 86,270 psi
zinc = 1247 ppm
phos = 1137 ppm
moly = 24 ppm

117. 5W20 Pennzoil Ultra, API SM synthetic = 86,034 psi
zinc = TBD
phos = TBD
moly = TBD

118. 5W20 Mobil 1, API SN, GM dexos 1 approved, synthetic = 85,893 psi
zinc = TBD
phos = TBD
moly = TBD
This was the latest current version of this oil when tested Fall 2015

119. 15W40 RED LINE Diesel Oil synthetic, API CJ-4/CI-4 PLUS/CI-4/CF/CH-4/CF-4/SM/SL/SH/EO-O = 85,663 psi
zinc = 1615 ppm
phos = 1551 ppm
moly = 173 ppm

120. 5W20 NAPA Synthetic, API SN, silver bottle = 85,550 psi
The bottle claims this oil exceeds the dexos 1 spec, but it does NOT have the dexos 1 logo. The bottle also says this oil was made by Ashland Inc.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Summer 2017.

121. 5W30 Castrol Edge w/Syntec, API SN synthetic (formerly Castrol Syntec), (black bottle) = 85,179 psi
zinc = TBD
phos = TBD
moly = TBD

122. 20W50 Millers Classic Performance Oil, API SJ, conventional = 84,764 psi
zinc = TBD
phos = TBD
moly = TBD
Claims high ZDDP level. It comes from England in 1 Liter bottles, which is slightly more than a quart, and is available in the U.S.

123. 5W30 Walmart Supertech, API SN, dexos 1 gen 2 approved, synthetic, silver gray bottle = 84,570 psi
This oil cost $4.97 per quart in December 2017.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested late 2017.

124. 5W30 Schaeffer's Supreme 9000, API SN, synthetic = 84,118 psi
zinc = TBD
phos = TBD
moly = TBD

125. 5W30 Royal Purple API SN synthetic = 84,009 psi
zinc = 942 ppm
phos = 817 ppm
moly = 0 ppm

126. 20W50 Royal Purple API SN synthetic = 83,487 psi
zinc = 588 ppm
phos = 697 ppm
moly = 0 ppm

127. 20W50 Kendall GT-1 High Performance with liquid titanium, API SN conventional = 83,365 psi
zinc = 991 ppm
phos = 1253 ppm
moly = 57 ppm
titanium = 84 ppm

128. 5W30 Mobil 1 Extended Performance 15,000 mile, API SN synthetic = 83,263 psi
zinc = 890 ppm
phos = 819 ppm
moly = 104 ppm

129. 0W20 Castrol Edge with Titanium, API SN synthetic (gold bottle) = 82,867 psi
zinc = TBD
phos = TBD
moly = TBD

130. 0W40 Mobil 1, European Formula, API SN, made in the U.S., synthetic = 82,644 psi
This is an earlier version that has been replaced by 0W40 Mobil 1 "FS" European Car Formula. See above for the newer version's ranking position.
zinc = TBD
phos = TBD
moly = TBD

131. 0W40 Pennzoil Ultra, API SN, synthetic = 81,863 psi
zinc = TBD
phos = TBD
moly = TBD

132. 5W30 LAT Synthetic Racing Oil, API SM = 81,800 psi
zinc = 1784 ppm
phos = 1539 ppm
moly = 598 ppm

133. "Oil Extreme concentrate" added to 5W30 Royal Purple XPR (extreme performance racing oil) synthetic = 81,723 psi
This oil on its own WITHOUT the "Oil Extreme concentrate" added to it, has a wear protection capability of only 74,860 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability "WENT UP 9%".
zinc = TBD
phos = TBD
moly = TBD

134. 0W30 Mobil 1, API SN, Advanced Fuel Economy, synthetic = 81,240 psi
zinc = TBD
phos = TBD.
moly = TBD

135. 5W30 Peak, API SN synthetic = 80,716 psi
zinc = TBD
phos = TBD
moly = TBD

136. 0W20 Mobil 1 Advanced Fuel Economy, API SN, dexos 1 approved, synthetic = 79,612 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested in Spring 2016. At that time, this was the latest current version of this oil.

137. 5W30 Castrol GTX "ULTRACLEAN, API SN conventional = 78,664 psi
This oil claims 50% better sludge protection than Industry standards.
zinc = TBD
phos = TBD
moly = TBD
This was the latest current version of this oil when tested Summer 2017. For reference, this oil's wear protection capability dropped 16,728 psi, and it dropped over 50 Ranking positions, compared to the previous 5W30 Castrol GTX that was NOT called ULTRACLEAN.

138. 5W30 Edelbrock "Cat-Safe", API SM synthetic = 78,609 psi
This oil is made for Edelbrock by Torco
zinc = 924 ppm
phos = 659 ppm
moly = 28 ppm

139. 30wt Amsoil Break-In Oil conventional = 78,192 psi
zinc = 2051 ppm
phos = 1917 ppm
moly = 0 ppm

140. 20W50 Resolute Racing Oil, API SN conventional = 77,554 psi
zinc = TBD
phos = TBD
moly = TBD
This oil cost only $2.49 per quart when bought for this test. It is a Regional Oil from the Mid-Western U.S. farm country.

141. 5W40 Amsoil Premium Diesel Oil synthetic, API CJ-4, CI-4 PLUS, CF, SN, SM, ACEA E7, E9 = 77,207 psi
zinc = TBD
phos = TBD
moly = TBD

142. 10W30 Renegade Pro Series Racing Oil, synthetic blend = 77,136 psi
zinc = TBD, but bottle claims over 3000 ppm
phos = TBD
moly = TBD

143. 15W40 ROYAL PURPLE Diesel Oil synthetic, API CJ-4 /SM, CI-4 PLUS, CH-4, CI-4 = 76,997 psi
zinc = TBD
phos = TBD
moly = TBD

144. 5W30 Pennzoil, API SN conventional (yellow bottle) = 76,989 psi
zinc = 839 ppm
phos = 840 ppm
moly = 267 ppm

145. 10W40 Chevron Supreme, API SN conventional (blue bottle) = 76,806 psi
zinc = TBD
phos = TBD
moly = TBD

146. 5W30 Lucas API SM synthetic = 76,584 psi
zinc = 1134 ppm
phos = 666 ppm
moly = 0 ppm

147. 5W30 GM's AC Delco dexos 1 API SN semi-synthetic = 76,501 psi
zinc = 878 ppm
phos = 758 ppm
moly = 72 ppm

148. 10W30 Mobil Super 5000, API SN, conventional = 76,461 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested at the end of 2015.

149. 5W30 Motul 8100 X-clean, API SM, synthetic = 76,166 psi
This oil is made in France, and comes in a 1 liter bottle, which = 1.05 qts
zinc = TBD
phos = TBD

moly = TBD
For reference, 5W30 Motul 300V Ester Core 4T Racing Oil, synthetic, produced a wear protection capability of 112,464 psi

150. 20W50 Mobil 1 V-Twin 4 Cycle Motorcycle Oil, API SJ, synthetic = 75,855 psi
zinc = TBD
phos = TBD
moly = TBD

151. 5W50 Castrol Edge with Syntec, API SN synthetic (formerly Castrol Syntec), (black bottle) = 75,409 psi
zinc = 1252 ppm
phos = 1197 ppm
moly = 71 ppm

152. 5W30 Castrol Edge Extended Performance, API SN, GM dexos 1 approved, synthetic (gold bottle) = 74,899 psi
zinc = TBD
phos = TBD
moly = TBD
This was the latest current version of this oil when tested Fall 2015. For reference, this oil's wear protection capability dropped 20,818 psi, and it dropped over 70 Ranking positions, compared to the original 5W30 Castrol Edge with Titanium.

153. "Oil Extreme concentrate" added to 10W30 Comp Cams Muscle Car & Street Rod Oil semi-synthetic = 74,874 psi
This oil on its own WITHOUT the "Oil Extreme concentrate" added to it, has a wear protection capability of only 60,413 psi. But, with 2.0 OZ of concentrate added per qt, which is the amount intended for racing, its wear protection capability "WENT UP AN IMPRESSIVE 24%".
zinc = TBD
phosphorus = TBD.
moly = TBD

154. 5W30 Royal Purple XPR (Extreme Performance Racing) synthetic = 74,860 psi
zinc = 1421 ppm
phos = 1338 ppm
moly = 204 ppm

155. 15W40 Cenpeco (Central Petroleum Company) S-3 Diesel Oil, conventional, API CI-4, CH-4, CG-4, CF, CE, CD, SL, SJ, SH = 74,593 psi
zinc = TBD

phos = TBD
moly = TBD

156. 5W40 MOBIL 1 TURBO DIESEL TRUCK synthetic, API CJ-4, CI-4 Plus, CI-4, CH-4 and ACEA E7 = 74,312 psi
zinc = 1211 ppm
phos = 1168 ppm
moly = 2 ppm

157. 0W50 Mobil 1 Racing Oil = 73,811 psi
zinc = 1676 ppm
phos = 1637 ppm
moly = 1263 ppm

158. 5W30 Peak, API SN conventional = 73,690 psi
zinc = TBD
phos = TBD
moly = TBD

159. 5W30 Precision Turbo & Engine HPL with Boosted Technology, synthetic = 73,637 psi
The bottle says this oil is manufactured by High Performance Lubricants.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Spring 2017. And its onset of thermal breakdown = 260*F.

160. 5W30 Mobil Super Synthetic, API SN, GM dexos 1 approved = 73,601 psi
zinc = TBD
phos = TBD
moly = TBD

161. 5W30 Castrol GTX Magnatec, API SN, GM dexos 1 approved, synthetic blend = 73,566 psi
This oil claims to have molecules that cling to parts, forming an extra layer of protection during warm-up, reducing engine wear.
zinc = TBD
phos = TBD
moly = TBD

162. 15W40 CHEVRON DELO 400LE Diesel Oil, conventional, API CJ-4, CI-4 Plus, CH-4, CF-4,CF/SM, = 73,520 psi
zinc = 1519 ppm

phos = 1139 ppm
moly = 80 ppm

163. 15W40 MOBIL DELVAC 1300 SUPER Diesel Oil conventional, API CJ-4, CI-4 Plus, CI-4, CH-4/SM, SL = 73,300 psi
zinc = 1297 ppm
phos = 1944 ppm
moly = 46 ppm

164. 15W40 Farm Rated Heavy Duty Performance Diesel Oil conventional CI-4, CH-4, CG-4, CF/SL, SJ = 73,176 psi
zinc = 1325ppm
phos = 1234 ppm
moly = 2 ppm

165. 5W30 Amalie Elixir Oil, API SN, synthetic = 72,825 psi
zinc = TBD
phos = TBD
moly = TBD

166. 5W20 Valvoline SynPower, API SN, GM dexos 1 approved = 72,581 psi
zinc = TBD
phos = TBD
moly = TBD
This was the latest current version of this oil when tested Fall 2015.

167. 5W30 Walmart Supertech, API SN, conventional, blue bottle = 72,521 psi
This oil cost $2.44 per quart in December 2017.
zinc = TBD
phos = TBD
moly = TBD
This oil was tested late 2017.

168. 5W20 Motorcraft, Friction Fighting Formula, API SN, synthetic blend = 72,144 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Summer 2017.

169. 15W40 “NEW” SHELL ROTELLA T Diesel Oil conventional, API CJ-4, CI-4 Plus, CH-4, CF-4,CF/SM = 72,022 psi
zinc = 1454 ppm

phos = 1062 ppm
moly = 0 ppm

170. Brad Penn, Penn Grade 1 Nitro 70 Racing Oil semi-synthetic = 72,003 psi
zinc = TBD
phos = TBD
moly = TBD

171. 0W30 Mobil 1 Racing Oil = 71,923 psi
zinc = 1693 ppm
phos = 1667 ppm
moly = 1326 ppm

172. 0W20 Kendall GT-1, with liquid Titanium, API SN, synthetic = 71,385 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested in Spring 2016.

173. 0W30 Brad Penn, Penn Grade 1, partial synthetic = 71,377 psi
zinc = 1621 ppm
phos = 1437 ppm
moly = 0 ppm

174. 15W40 "OLD" SHELL ROTELLA T Diesel Oil conventional, API CI-4 PLUS, CI-4, CH-4,CG-4,CF-4,CF,SL, SJ, SH = 71,214 psi
zinc = 1171 ppm
phos = 1186 ppm
moly = 0 ppm
Yes it's true, the old Rotella actually has LESS zinc than the new Rotella.

175. 10W30 Brad Penn, Penn Grade 1, partial synthetic = 71,206 psi
zinc = 1557 ppm
phos = 1651 ppm
moly = 3 ppm

176. 15W40 VALVOLINE PREMIUM BLUE HEAVY DUTY DIESEL Oil conventional, API CJ-4, CI-4 Plus, CI-4, CH-4, CG-4, CF-4, CF/SM = 70,869 psi
zinc = TBD
phos = TBD
moly = TBD

177. 5W20 Castrol Edge Extended Performance, API SN, GM dexos 1 approved, synthetic (gold bottle) = 70,417 psi
zinc = TBD
phos = TBD
moly = TBD
This was the latest current version of this oil when tested Fall 2015. For reference, this oil's wear protection capability dropped 29,566 psi, and it dropped over 100 Ranking positions, compared to the original 5W20 Castrol Edge with Titanium.

178. 15W50 Mobil 1, API SN synthetic = 70,235 psi
zinc = 1,133 ppm
phos = 1,168 ppm
moly = 83 ppm

179. 10W40 Resolute All Season Motor Oil, API SN conventional = 69,709 psi
zinc = TBD
phos = TBD
moly = TBD
This oil cost $2.49 per quart when bought for this test. It is a Regional Oil from the Mid-Western U.S. farm country.

180. 5W40 CHEVRON DELO 400LE Diesel Oil synthetic, API CJ-4, CI-4 Plus, CI-4, SL, SM = 69,631 psi
zinc = TBD
phos = TBD
moly = TBD

181. 5W40 Liqui Moly Leichtlauf High Tech Oil, synthetic = 69,580 psi
zinc = TBD
phos = TBD
moly = TBD
This oil is made in Germany and is available in the U. S. It comes in 1 Liter bottles which is slightly more than a quart.

182. 0W40 Castrol Edge with Syntec, API SN, European Formula, made in Belgium and sold in the U.S., synthetic (black bottle) = 69,307 psi
zinc = TBD
phos = TBD
moly = TBD

183. 0W30 Castrol Edge with Syntec, API SL, European Formula, made in Germany and sold in the U.S., synthetic (black bottle) = 69,302 psi
zinc = TBD
phos = TBD
moly = TBD

184. 30wt Edelbrock Break-In Oil conventional = 69,160 psi
zinc = 1545 ppm
phos = 1465 ppm
moly = 4 ppm

185. 5W30 High Performance Lubricants Break-In Oil, synthetic = 69,097 psi
zinc = the bottle claims high zinc
phos = the bottle claims high phos
moly = TBD
This oil was tested Summer 2016.

186. 5W30 Motorcraft, API SN synthetic = 68,782 psi
zinc = 796 ppm
phos = 830 ppm
moly = 75 ppm

187. 10W40 Edelbrock synthetic = 68,603 psi
zinc = 1193 ppm
phos = 1146 ppm
moly = 121 ppm
This oil is manufactured for Edelbrock by Torco.

188. 5W30 Quaker State Advanced Durability, API SN, conventional = 68,581 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2015

189. 5W30 Toyota Motor Oil, API SN conventional = 68,069 psi
zinc = TBD
phos = TBD
moly = TBD

190. 5W40 SHELL ROTELLA T6 Diesel Oil, synthetic, API CJ-4, CI-4 Plus, CI-4, CH-4, SM, SL = 67,804 psi
zinc = TBD

phos = TBD
moly = TBD

191. 10W30 Champion Racing Oil, synthetic blend = 67,239 psi
zinc = TBD
phos = TBD
moly = TBD

192. 10W30 ProHonda HP4S, 4 Stroke Motorcycle Oil, API SJ, synthetic = 66,852 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2015

193. 15W40 LUCAS MAGNUM Diesel Oil, conventional, API CI-4,CH-4, CG-4, CF-4, CF/SL = 66,476 psi
zinc = 1441 ppm
phos = 1234 ppm
moly = 76 ppm

194. 15W40 CASTROL GTX DIESEL Oil, conventional, API CJ-4, CI-4 Plus, CI-4, CH-4, CG-4, CF-4/SN = 66,323 psi
zinc = TBD
phos = TBD
moly = TBD

195. 10W30 Royal Purple HPS (High Performance Street), synthetic = 66,211 psi
zinc = 1774 ppm
phos = 1347 ppm
moly = 189 ppm

196. 5W30 Schaeffer Supreme 7000 Synthetic Plus, API SN = 66,099 psi
zinc = TBD
phos = TBD
moly = TBD
This oil was tested Fall 2015

197. 10W40 Valvoline 4 Stroke Motorcycle Oil, API SJ, conventional = 65,553 psi
zinc = 1154 ppm
phos = 1075 ppm
moly = 0 ppm

198. 15W40 Swepco 306 Supreme Formula Engine Oil, with Dimonyl, conventional, API CI-4/SL, CF-2 = 65,185 psi
This oil is from Southwestern Petroleum Corporation.
zinc = TBD
phos = TBD
moly = TBD

199. 5W30 Klotz Estorlin Racing Oil, API SL, synthetic = 64,175 psi
zinc = 1765 ppm
phos = 2468 ppm
moly = 339 ppm

200. “ZDDPlus” added to Royal Purple 20W50, API SN, synthetic = 63,595 psi
zinc = 2436 ppm (up 1848 ppm)
phos = 2053 ppm (up 1356 ppm)
moly = 2 ppm (up 2 ppm)
The amount of ZDDPlus added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 24% LOWER than this oil had BEFORE the ZDDPlus was added to it. Most major Oil Companies say to NEVER add anything to their oils, because adding anything will upset the carefully balanced additive package, and ruin the oil’s chemical composition. And that is precisely what we see here. Adding ZDDPlus SIGNIFICANTLY REDUCED this oil’s wear prevention capability. Just the opposite of what was promised.

201. 5W30 PurOl Elite Series, synthetic = 63,282 psi
zinc = TBD
phos = TBD
moly = TBD

202. Royal Purple 10W30 Break-In Oil, conventional = 62,931 psi
zinc = 1170 ppm
phos = 1039 ppm
moly = 0 ppm

203. 10W40 Crane Cams Break-In Oil, conventional = 62,603 psi
zinc = TBD, but claims high zinc formula
phos = TBD
moly = TBD

204. 10W30 Lucas Hot Rod & Classic Hi-Performance Oil, conventional = 62,538 psi
zinc = 2116 ppm
phos = 1855 ppm

moly = 871 ppm

205. 5W30 Motul 8100 ECO-nergy, API SL, synthetic = 61,880 psi
This oil is made in France, and comes in a 1 liter bottle, which = 1.05 qts
zinc = TBD
phos = TBD
moly = TBD
For reference, 5W30 Motul 300V Ester Core 4T Racing Oil, synthetic, produced a wear protection capability of 112,464 psi

206. 0W20 Klotz Estorlin Racing Oil, API SL, synthetic = 60,941 psi
zinc = TBD
phos = TBD
moly = TBD

207. 10W30 Comp Cams Muscle Car & Street Rod Oil, synthetic blend = 60,413 psi
zinc = 1673 ppm
phos = 1114 ppm
moly = 67 ppm
This oil is manufactured for Comp Cams by Endure.

208. 10W40 Torco TR-1 Racing Oil with MPZ, conventional = 59,905 psi
zinc = 1456 ppm
phos = 1150 ppm
moly = 227 ppm

209. 10W40 Summit Racing Premium Racing Oil, API SL = 59,483 psi
This oil is made for Summit by I.L.C.
zinc = 1764 ppm
phos = 1974 ppm
moly = 41 ppm
NOTE: This oil line was discontinued in Spring 2013.

210. 10W40 Edelbrock, conventional = 59,120 psi
zinc = TBD
phos = TBD
moly = TBD
This oil is manufactured for Edelbrock by Torco.

211. 10W40 Spectro Motor-Guard High Performance Motorcycle Oil, API SL, conventional = 57,977 psi
zinc = 1800 ppm (claimed on bottle)

phos = 1800 ppm (claimed on bottle)
moly = TBD

212. 10W40 Brad Penn, Penn Grade 1, partial synthetic = 57,864 psi
zinc = TBD, but the bottle claims high zinc
phos = TBD
moly = TBD

213. 0W20 LAT Synthetic Racing Oil, API SM = 57,228 psi
zinc = TBD
phos = TBD
moly = TBD

214. "ZDDPlus" added to O'Reilly (house brand) 5W30, API SN, conventional = 56,728 psi
zinc = 2711 ppm (up 1848 ppm)
phos = 2172 ppm (up 1356 ppm)
moly = 2 ppm (up 2 ppm)
The amount of ZDDPlus added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 38% LOWER than this oil had BEFORE the ZDDPlus was added to it. Adding ZDDPlus SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.
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215. "ZDDPlus" added to Motorcraft 5W30, API SN, synthetic = 56,243 psi
zinc = 2955 ppm (up 1848 ppm)
phos = 2114 ppm (up 1356 ppm)
moly = 76 ppm (up 2 ppm)

The amount of ZDDPlus added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 12% LOWER than this oil had BEFORE the ZDDPlus was added to it. Adding ZDDPlus SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

216. 30wt Brad Penn, Penn Grade 1, Break-In Oil, conventional = 56,020 psi
zinc = TBD, but the bottle claims high zinc
phos = TBD
moly = TBD

217. 0W Mobil 1 Racing Oil = 55,080 psi
zinc = 1952 ppm
phos = 1671 ppm
moly = 1743 ppm

218. “Edelbrock Zinc Additive” added to Royal Purple 5W30, API SN, synthetic = 54,044 psi
zinc = 1515 ppm (up 573 ppm)
phos = 1334 ppm (up 517 ppm)
moly = 15 ppm (up 15 ppm)
The amount of Edelbrock Zinc Additive added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was a whopping 36% LOWER than this oil had BEFORE the Edelbrock Zinc Additive was added to it. Adding Edelbrock Zinc Additive SIGNIFICANTLY REDUCED this oil’s wear prevention capability. Just the opposite of what was promised.

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219. 10W30 Comp Cams Break-In Oil, conventional = 51,749 psi
zinc = 3004 ppm
phos = 2613 ppm
moly = 180 ppm

220. “Edelbrock Zinc Additive” added to Lucas 5W30, API SN, conventional = 51,545 psi
zinc = 1565 ppm (up 573 ppm)
phos = 1277 ppm (up 517 ppm)
moly = 15 ppm (up 15 ppm)
The amount of Edelbrock Zinc Additive added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was a “breath taking” 44% LOWER than this oil had BEFORE the Edelbrock Zinc Additive was added to it. Adding Edelbrock Zinc Additive SIGNIFICANTLY REDUCED this oil’s wear prevention capability. Just the opposite of what was promised.

221. 15W50 Joe Gibbs Driven BR Break-In oil, conventional = 51,299 psi
NOTE: Total Seal also sells this Break-In Oil with their label on it.
zinc = TBD, but high levels are claimed on the bottle.
phos = TBD
moly = TBD

222. “Edelbrock Zinc Additive” added to Motorcraft 5W30, API SN, synthetic = 50,202 psi
zinc = 1680 ppm (up 573 ppm)
phos = 1275 ppm (up 517 ppm)
moly = 89 ppm (up 15 ppm)
The amount of Edelbrock Zinc Additive added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 22% LOWER than this oil had BEFORE the Edelbrock Zinc Additive was added to it. Adding Edelbrock Zinc Additive SIGNIFICANTLY REDUCED this oil’s wear prevention capability. Just the opposite of what was promised.

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223. 30wt Lucas Break-In Oil, conventional = 49,455 psi
zinc = 4483 ppm
phos = 3660 ppm
moly = 3 ppm

224. 5W30 Joe Gibbs Driven BR30 Break-In Oil, conventional = 47,483 psi
NOTE: Total Seal also sells this Break-In Oil with their label on it.
zinc = TBD, but high levels are claimed on the bottle.
phos = TBD
moly = TBD

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SECTION 2 – MOTOR OIL VISCOSITY SELECTION

THE BENEFITS OF USING THINNER OIL:

• Thinner oil flows quicker at cold start-up to begin lubricating critical engine components much more quickly than thicker oil can. Most engine wear takes place during cold start-up before oil flow can reach all the components. So, quicker flowing thinner oil will help reduce start-up engine wear, which is actually reducing wear overall.

• The more free flowing thinner oil at cold start-up, is also much less likely to cause the oil filter bypass to open up, compared to thicker oil. Of course if the bypass opened up, that would allow unfiltered oil to be pumped through the engine. The colder the ambient temperature, and the more rpm used when the engine is cold, the more important this becomes.

• Thinner oil also flows more at normal operating temperatures. And oil FLOW is lubrication, but oil pressure is NOT lubrication. Oil pressure is only a measurement of resistance to flow. Running thicker oil just to up the oil pressure is the wrong thing to do, because that only reduces oil flow/lubrication. Oil pressure in and of itself, is NOT what we are after.

• The more free flowing thinner oil will also drain back to the oil pan quicker than thicker oil. So, thinner oil can help maintain a higher oil level in the oil pan during operation, which keeps the oil pump pickup from possibly sucking air during braking and cornering.

•The old rule of thumb for desired oil pressure, that we should have at least 10 psi for every 1,000 rpm, pertains to, and is highly recommended for High Performance and Racing engines. Engine bearing clearances are primarily what determines the oil viscosity required for any given engine. (NOTE: Viscosity does NOT determine an oil's wear protection capability, like many people think. Wear protection capability is determined by an oil's additive package, which contains the extreme pressure anti-wear components. That is why 5W30 oils can perform so much better than thicker oils in my wear protection capability testing). But, whatever the bearing clearance, for High Performance and Racing engines, it is best to run the thinnest oil we can, that will still maintain at least the old rule of thumb oil pressure, even if that means using a high volume oil pump to achieve that. A high volume oil pump/thinner oil combo is much preferred over running a standard volume oil pump/thicker oil combo. Because oil "flow" is our goal for ideal oiling, NOT simply high oil pressure. So, one of the benefits of running a high volume oil pump, is that it will allow us to enjoy all the benefits of running thinner oil, while still maintaining desirable oil pressure.

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But, for normal daily driver street engines, it is acceptable to use the old rule of thumb only as an "approximate" general guideline, not an "absolute requirement". And for those engines, no matter what their bearing clearance is, it is best to run the thinnest oil we can, that will still maintain at least "reasonable" oil pressure, that is not too far below the old rule of thumb oil pressure.

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Using thicker oil just to achieve higher oil pressure, will simply reduce oil flow for no good reason. The oil pump relief valve determines the max oil pressure an engine can make, no matter what the oil viscosity is. And in some engines, the relief valve limits oil pressure to a max of 65 psi. But, that does not mean the engine's redline has to be limited to exactly 6,500 rpm because of that. Oil pressure does NOT determine the engine's redline, the mechanical design of the engine does.

Plain bearings, such as rod and main bearings, are lubricated by oil flow, not by oil pressure. Oil pressure is NOT what keeps these parts separated. Oil pressure serves only to supply the oil to the clearance between the bearings and the crankshaft journals. Those parts are kept apart by the incompressible hydrodynamic liquid oil wedge that is formed as the liquid oil is pulled in by the spinning crankshaft. As long as sufficient oil is supplied by the necessary oil pressure mentioned above, no wear can occur. And the higher flow rate of thinner oil, supplies more oil volume to the main and rod bearings, which also helps ensure that the critical incompressible hydrodynamic liquid oil wedge is always maintained.

Thinner oil will of course flow out from the bearing clearances quicker than thicker oil will. But, by making sure there is sufficient oil pressure as mentioned above, the oil supply will always stay ahead of the oil flowing out, which will maintain that critical incompressible hydrodynamic liquid oil wedge.

• Oil flow is what carries heat away from internal engine components. Those engine components are DIRECTLY oil cooled, but only INdirectly water cooled. And better flowing thinner oil will keep critical engine components cooler because it carries heat away faster than slower flowing thicker oil can. This is especially important with plain main and rod bearings, since the flow of oil through the bearings is what cools them. If you run thicker oil than needed, you will drive up engine component temps.

Here are some comparison numbers from an 830 HP road race engine on the track:

15W50 oil = 80 psi = 265* oil sump temperature

5W20 oil = 65 psi = 240* oil sump temperature

Here you can see how the thicker oil flowed more slowly through the bearings, thus getting hotter, driving up bearing temperatures and increasing sump temperatures. And the thinner oil flowed more freely and quickly through the bearings, thus cooling and lubricating them better than thicker oil, while also reducing sump temperatures.

Here's some additional background on all this – You might be surprised by how much heat can be generated just from an oil's internal friction, though friction may not the best term to use here. It is probably better to think of this as the heat generated due to the shearing action taking place within the oil.

It is the shearing action of the oil between the crankshaft and bearings, while the engine is under a heavy loading condition, that generates the bearing heat that we are concerned with. The oil wedge formed as the crankshaft pulls oil in and around the clearance as it spins, is liquid oil. And since liquids cannot be compressed, the oil wedge itself is what carries that heavy engine loading (oil pressure serves only to deliver oil to the crank/bearing interface) and prevents the crankshaft and bearings from coming in contact with each other, once the engine is running. Cold start up after sitting, is when the bearings and cranksaft start out in contact with each other.

The difference in flow rate, and the difference in shearing generated heat, is why the viscosity used, makes a difference in bearing and sump temperatures. Thicker oil which flows more slowly and generates more heat from shearing, it is not carrying heat away and cooling the bearings as well or as quickly as it could, so that drives up bearing temps. This in turn, causes hotter oil to be coming out of the bearings and into the sump, which is why we see higher temps on a gauge. That is the opposite of what we want.

On the other hand, quicker flowing thinner oil, not only generates less heat from shearing, but it also carries heat away much quicker, keeping bearing temps down. And this means the oil coming out from the bearings, and going into the sump, is also cooler. And that is why we see the cooler sump temps. This is precisely what we saw with the road race engine example above.

If an engine is running hot, use a thinner oil to increase flow, increase internal component cooling, and help keep sump temperatures down. Keeping oil temps down is important to help keep oil below the threshold of thermal breakdown.

• Thinner oil will typically increase HP because of less viscous drag and reduced pumping losses, compared to thicker oils. That is why very serious Race efforts will generally use watery thin oils in their engines. But, an exception to this increase in HP would be in high rpm hydraulic lifter pushrod engines, where thinner oil can allow the lifters to malfunction at very high rpm. In everyday street vehicles, where fuel consumption is a consideration, thinner oils will also typically increase fuel economy. The majority of new cars sold in the U.S. now call for 5W20 specifically for increased fuel economy. And now Diesel trucks are increasingly calling for 5W30, also for fuel economy improvement.

• Relatively few engines are built with loose enough bearing clearances, to ever need to run oil thicker than a multi-viscosity 30 weight (though some may need a high volume oil pump). The lower the first number cold viscosity rating, the better the cold flow. For example, 0W30 flows WAY better cold than 20W50. And 0W30 flows WAY better cold than straight 30wt, which is horrible for cold start-up flow and should be avoided at all cost. And the lower the second number hot viscosity rating, the better the hot flow. For example, hot 0W30 flows WAY better hot than 20W50.

* The churning action of rotating and reciprocating internal engine components, along with oil spraying out from between pressurized components, traditional oil pumps with their old-tech spur gear design, old tech oil pressure relief valves, and overall windage, all contribute in varying degrees, to causing the engine oil to become aerated, which is exhibited by air bubbles/foam in the oil. Air bubble-filled foamy oil, is what typically causes engines running on a dyno to experience oil pressure drops, assuming they have acceptable oil drain-back from the top end, and are keeping the oil pump pickup submerged. Also, air bubble-filled foamy oil, is what typically causes engines being run hard in cars, to experience drops in oil pressure,

assuming the oil pump pickup is still submerged in oil. And if that isn't bad enough, air bubble-filled, foamy oil cannot lubricate critical internal components properly. For proper lubrication of critical components, you need incompressible "liquid" oil, NOT compressible air bubble-filled foamy oil.

This is an issue to take very seriously, if you want to provide your engine with the best possible lubrication protection. If this aerated oil issue is bad enough, it can cause wear, damage or outright engine failure. And it can be extremely difficult to diagnose, in the event of an outright engine failure. Because when you take the engine apart for examination, you typically can't find anything wrong at all, other than say the rod and/or main bearings that failed. That's because the air bubbles/foam are long gone by then.

You can't do much about the churning action of rotating and reciprocating internal engine components, nor can you do much about the oil spraying out from between pressurized components. Though you can try to reduce windage problems by selecting the best oil pan designs. You can also select a superior smoother flowing gerotor oil pump design with its internal bypass relief valve. But, the one thing that is the easiest to change to reduce engine oil aeration concerns, is to choose the proper engine oil viscosity.

Heavy thick oils such as 5W50 and 20W50, that are of course 50 weight oils at normal operating temperature, are slower to release and eliminate air bubbles/foam, than thinner oils such as 5W30 and 10W30 that are 30 weight oils at normal operating temperature. Motor oils do of course contain anti-foaming agents to help control (though not altogether eliminate) air bubbles/foam. But, the air bubbles that will still be present in the oil anyway, have to travel through the oil to be released. And thicker heavier oils slow down that process, leaving compromised lubrication. Adding aftermarket oil treatments that thicken the oil more, makes aeration issues even worse, by causing further slowing of air bubble release. Data on this is not widely published, so I have future testing planned that will provide much needed test data on this subject. But in the meantime, keep in mind that thinner oils such as 5W30 and 10W30, allow air bubbles to travel through the oil and be released quicker, making them a better viscosity choice to fight motor oil aeration issues, and provide the best possible lubrication protection for your engine.

• Thicker oils DO NOT automatically provide better wear protection than thinner oils, as some people mistakenly believe. Extensive "dynamic wear testing under load" of approximately 200 motor oils, has shown that the base oil and its additive package "as a whole", with the primary emphasis on the additive package, which is what contains the extreme pressure anti-wear components, is what determines an oil's wear protection capability, NOT its viscosity. In fact, the test data has shown that 5W20 oils can provide INCREDIBLE wear protection with over 120,000 psi load carrying capability/film strength/shear resistance, while 15W50 oils can sometimes only provide UNDESIRABLE wear protection with less than 60,000 psi. So, DO

NOT use thicker oil under the assumption that it can provide better wear protection for our engines, because that is simply NOT TRUE.

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BOTTOM LINE: Thinner oils are better for most engine lubrication needs.

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• But, the "specific" viscosity selected for any given engine, is very important. Engine build differences and engine wear differences, result in different clearances. And depending on how robust an oiling system is, different clearances can require different motor oil viscosities for engines to generate acceptable oil pressure. The looser the clearances, the faster a given motor oil viscosity will bleed off through those clearances. Or the thinner the viscosity, the faster the oil will bleed off through given clearances. So, we need sufficient oil pressure to ensure that an adequate oil supply is always present at critical components, to protect an engine from wear and/or damage.

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And having various motor oil viscosities available, allows us to select the correct oil for any given engine, no matter what its clearances may be. To automatically take into account all the possible variations, I recommend using the thinnest oil that will still maintain acceptable "HOT" oil pressure. And that viscosity requirement can vary from engine to engine, because of differences in clearances.

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In addition to that, the viscosity chosen may also make a difference in mechanical engine noise. Sometimes, an engine might have a little mechanical tick or rattle that isn't really a problem, other than bothering the owner, which can be eliminated by choosing the next thicker viscosity, than oil pressure requirements alone, may have required. So, viscosity choices can give us options to meet the needs of any given engine.

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SUMMARY – MOTOR OIL VISCOSITY SELECTION RECOMMENDATION

To provide an engine with the best "oil film strength/load carrying capability/shear resistance" wear protection during cold startup and normal operating temperatures – Select a HIGHLY RANKED motor oil from my Wear Protection Ranking List, that has the lowest cold viscosity rating, AND that also has the lowest hot viscosity rating, that will still maintain acceptable "HOT" oil pressure. For properly built engines, a highly ranked 5W30, will usually fulfill those requirements.

NOTE: When I talk about using thinner oil in engines as long as the oil pressure is still acceptable, I am generally referring to gas engines in Hotrods and Race cars, where any thoughts of referring a factory stock engine and its Owner's Manual, has gone out the window, and where people tend to want to use 20W50 because they MISTAKENLY think it might be better. For those engines, there can be a significant improvement in oiling by using thinner oil than 20W50, as long as the oil pressure is still good. I say that, because a lot of those engines weren't built with a high volume oil pump, and thin oil with a standard volume oil pump, can be asking for trouble. Thus, my comment about still needing acceptable oil pressure, in order to safely run thin oil in those engines.

Virtually all newer gas engine vehicles now call for thin oils from the factory. So, they are already in good shape regarding motor oil viscosity.

But, traditional Diesel trucks are a different animal. So, for traditional Diesel trucks, I suggest following the manufacturer's motor oil viscosity recommendation. However, few people bother to make sure the Diesel oil they use, has every last certification called for in the Owner's Manual. And I have never seen, nor heard of that ever being a problem. Because engines are just not that sensitive to the oil being used.

Also, if your Diesel truck calls for 15W40 for example, you could use 0W40 or 5W40 Diesel oil instead of 15W40 Diesel oil. Because the 0W40, 5W40 and 15W40 are all rated as 40wt oils at normal operating temperature. And the 0W40 or the 5W40 would flow significantly better when cold, than the 15W40.

It is also advisable to select from oils I have recently tested, when possible. Such as those that were tested within the past year or year and a half (more recent tests now include when the testing was performed), to help ensure that what you buy, is the same exact oil I tested. Because the big oil companies change their formulations fairly often. And it is not uncommon for "some" oils to perform worse in their newer formulations, as a result of apparent oil company internal cost reductions, to maintain profits.

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SECTION 3 – MOTOR OIL THERMAL BREAKDOWN TEST DATA

Thermal breakdown is the point at which the composition of the oil begins to change due to the temperature it's exposed to.

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The “Official” test for this is called the NOACK Volatility Test. In this test, per the ASTM spec, the oil is heated to 250*C (482*F) for one hour. The lighter oil fractions will vaporize, leaving thicker and heavier oil, contributing to poor circulation, reduced fuel economy, increased oil consumption, **increased wear** and increased emissions.

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The test reports results in the percentage, by weight, lost due to “volatilization.” Before July 1, 2001, 5W-30 motor oil in the United States could lose up to 22 percent of its weight and still be regarded as “passable.” Now, with GF-4, the maximum NOACK volatility for API licensing is 15 percent. European standards limit high quality oils to a maximum of 13 percent loss.

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This of course means that any motor oil that has been heated above its onset of thermal breakdown point, has started to deteriorate. So, reasonable oil change intervals should be followed. See Tech Article, “25. Recommended Oil Change Interval”, for more details.

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To find out how an assortment of oils actually perform in the real world, I heated the following oils, and below are the approximate temperatures (rounded to the nearest 5* increment) at which each oil started to “vaporize” (which looks like smoke to the casual observer, even though the oil is NOT actually burning), which indicated the onset of thermal breakdown:

SYNTHETIC GASOLINE ENGINE OILS:

10W30 Amsoil Dominator Racing Oil, synthetic = 300* F

10W30 Amsoil Z-Rod Oil, synthetic = 300* F

5W30 Pennzoil Ultra Platinum, API SN, GM dexos 1 approved, synthetic = 290*F (high temp tested late 2015)

5W30 Joe Gibbs Driven LS30 Performance Motor Oil, synthetic = 290* F

0W30 Mobil 1, API SN, Advanced Fuel Economy, synthetic = 290* F

0W30 Castrol Edge with Syntec (black bottle), API SL, European Formula, synthetic, made in Germany and sold in the U.S. = 290* F

0W40 Castrol Edge with Syntec (black bottle), API SN, European Formula, synthetic, made in Belgium and sold in the U.S. = 290* F

10W30 Lucas Racing Only, synthetic = 290* F

5W50 Mobil 1, API SN, synthetic = 290*F

5W30 Motul 300V, Ester Core 4T Racing Oil, synthetic = 285* F

0W40 Mobil 1, API SN, European Formula, synthetic, made in the U.S. = 285* F

5W30 Royal Purple XPR, synthetic = 285* F

5W30 Mobil Super Synthetic, API SN = 285*F

10W30 Joe Gibbs XP3 NASCAR Racing Oil, synthetic = 280* F

5W30 Pennzoil Ultra, API SM, synthetic = 280* F

5W20 Castrol Edge w/Titanium, API SN, synthetic = 280* F

0W30 Mobil 1 Racing Oil, synthetic = 280* F

5W50 Motorcraft, API SN, synthetic = 275* F

5W20 Quaker State Ultimate Durability, API SN, GM dexos 1 approved, synthetic = 270*F (tested late 2015)

0W50 Mobil 1 Racing Oil, synthetic = 270* F

5W30 Mobil 1 Advanced Full Synthetic, API SN = 265* F (this is an earlier version without GM dexos 1 approval)

5W30 Quaker State Ultimate Durability, API SN, GM dexos 1 approved, synthetic = 260*F (tested late 2015)

0W40 Pennzoil Ultra, API SN, synthetic = 260* F

5W30 Mobil 1, Advanced Full Synthetic, API SN, GM dexos 1 approved = 255*F (this was the latest current version when tested late 2015)

5W30 Oil Extreme Motor Oil, API SM, synthetic = 255* F

5W30 PurOl Elite Series, synthetic = 255*F

0W Mobil 1 Racing Oil, synthetic = 210* F, and this is NOT a typo

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SEMI-SYNTHETIC GASOLINE ENGINE OILS:

0W30 Brad Penn, Penn Grade 1, semi-synthetic = 280* F

5W30 Castrol GTX Magnatec, synthetic blend = 260*F

5W30 Valvoline MaxLife High Mileage, API SN, GM dexos 1 approved, synthetic blend = 250*F (tested late 2015)

10W30 Renegade Pro Series Racing Oil, synthetic blend = 250* F

10W40 Valvoline MaxLife High Mileage, API SN, synthetic blend = 240*F (tested late 2015)

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CONVENTIONAL GASOLINE ENGINE OILS:

5W30 Castrol GTX, API SN conventional= 280* F

20W50 Castrol GTX, API SN, conventional = 275* F

10W30 Valvoline VR1 Conventional Racing Oil, silver bottle = 260* F

5W30 Chevron Supreme, API SN, conventional, blue bottle = 255*F

Here are the "averages" for the onset of thermal breakdown of these GASOLINE ENGINE oils:

The 27 Full synthetic oils = 276* F

The 5 Semi-synthetic oils = 256* F

The 4 Conventional dino oils = 268* F

The average value for the onset of thermal breakdown for all 33 gasoline engine oils combined = 273* F.

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As you can see by looking at the average value for each oil type above, there was only a 10* difference between the average of the conventional oils and the average of the full synthetic oils. So, the real world observation here does NOT support common internet motor oil info claims about synthetic oils in general, having an unbelievable outrageously high temperature capability compared to other less expensive conventional oils. The fact is, the test data here shows that, while there are some significant individual differences, synthetic and conventional oils overall, are rather close in thermal capability. This means that conventional oils are still far better than most people think.

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SYNTHETIC DIESEL OILS:

RED LINE, 15W40 Diesel Oil, synthetic, API CJ-4/CI-4 PLUS/CI-4/CF/CH-4/CF-4/SM/SL/SH/EO-O = 285* F

5W30 Amsoil Series 3000 Heavy Duty Diesel Oil synthetic = 280* F

MOBIL 1 TURBO DIESEL TRUCK, 5W40 synthetic, API CJ-4, CI-4 Plus, CI-4, CH-4 and ACEA E7 = 270* F

5W40 Amsoil Premium Diesel Oil synthetic, API CJ-4, CI-4 PLUS, CF, SN, SM, ACEA E7, E9 = 265* F

ROYAL PURPLE, 15W40 Diesel Oil, synthetic, API CJ-4 /SM, CI-4 PLUS, CH-4, CI-4
= 265* F

SHELL ROTELLA T6, 5W40 synthetic, API CJ-4, CI-4 Plus, CI-4, CH-4, CG-4/SM = 260* F

CHEVRON DELO 400LE, 5W40 synthetic, API CJ-4, CI-4 Plus, CI-4, SL, SM = 255* F

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CONVENTIONAL DIESEL OILS:

CASTROL GTX DIESEL, 15W40 conventional, API CJ-4, CI-4 Plus, CI-4, CH-4, CG-4, CF-4/SN = 265* F

CHEVRON DELO 400LE, 15W40 conventional, API CJ-4, CI-4 Plus, CI-4, CH-4, SM, SL = 265* F

FARM RATED 15W40 Heavy Duty Performance Diesel, conventional, API CI-4, CH-4, CG-4, CF/SL, SJ = 255* F

VALVOLINE PREMIUM BLUE HEAVY DUTY DIESEL, 15W40 conventional, API CJ-4, CI-4 Plus, CI-4, CH-4, CG-4, CF-4, CF/SM = 255* F

MOBIL DELVAC 1300 SUPER, 15W40 conventional, API CJ-4, CI-4 Plus, CI-4, CH-4/SM, SL = 250* F

LUCAS 15W40 MAGNUM Diesel Oil, conventional, API CI-4,CH-4, CG-4, CF-4, CF/SL = 250* F

“NEW” SHELL ROTELLA T, 15W40 conventional, API CJ-4, CI-4 Plus, CH-4, CG-4, CF-4,CF/SM = 250* F

“OLD” SHELL ROTELLA T, 15W40 conventional, API CI-4 PLUS, CI-4, CH-4,CG-4,CF-4,CF,SL, SJ, SH = 250* F

Swepco 306 Supreme Forumula Engine Oil, 15W40 conventional, API CI-4/SL, CF-2 = 250*F
Here are the “averages” for the onset of thermal breakdown of these DIESEL oils:

The 7 full synthetic oils = 269* F

The 9 conventional oils = 254* F

The average value for the onset of thermal breakdown for all 16 Diesel oils combined = 261* F, which is 13* “LOWER” than the average of all 33 gasoline engine oils combined. That makes Diesel oils a poor choice for high performance gasoline engines, in terms of thermal breakdown capability.

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NOTE: Motor oils do NOT stop working the instant they reach their onset of thermal breakdown point. However, it is not a good idea to run oil above its thermal breakdown point for extended periods of time. Because that will degrade its capability more and more as time/mileage goes on.

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SECTION 4 – COMPONENT QUANTITY LAB TEST RESULTS

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All the component quantity Lab test results shown below, were taken from brand new, thoroughly shaken bottles of oil. And all tests were performed at ALS Tribology, in Sparks, Nevada. Having all the oils tested by the same Lab, makes this the most consistent and reliable information you will ever find, for this many oil to oil comparisons.

Most motor oils contain more zinc than phosphorus, but that is not always the case. A good percentage of motor oils are formulated to contain more phosphorus than zinc. It just depends on what the Chemical Engineers decided they needed for any particular oil. So, you will find some oils below that show more phosphorus than zinc. And those values are correct, they are NOT typos.

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If you've read Section 1 – Motor Oil "Wear Protection" Ranking List, of this Blog, you know that the amount of zinc/phos, does NOT determine an oil's wear protection capability. Because it is physically impossible for more zinc/phos to provide more wear protection. Zinc/phos does NOT work that way. More zinc/phos simply takes longer to become depleted, since there was more to begin with. It is much like the way more gas in your tank will take longer to run out, but more gas in your tank will NOT make more power.

But, many people incorrectly believe you need high levels of zinc/phos for adequate wear protection in High Performance engines, simply because they have always been told that, read that or heard that. Amazingly, they've blindly accepted that notion with NO PROOF what so ever. And unfortunately for them, that line of thinking is nothing more than an old wives' tale MYTH that took on a life of its own, because it kept being repeated over and over for years and years. But, repeating wrong folklore over and over, does NOT make it magically become true.

Engineering tests have BUSTED that old high zinc/phos myth. And that test data has PROVEN beyond any doubt, that the idea of all high zinc/phos oils providing adequate wear protection, is simply NOT TRUE. The fact is, some high zinc/phos oils provide excellent wear protection, while other high zinc/phos oils provide poor wear protection. And you simply CANNOT tell from an oil's Lab print out, which one is which, just by looking at the amount of zinc/phos.

However, some people just can't accept that they have been off-track all these years about zinc/phos, and choose to ignore the Engineering test data FACTS. Sadly, they insist on clinging to their old false beliefs about needing high levels of zinc/phos, and in so doing, they are putting their engine, and by extension, the engines of others, at risk for no good reason.

Also, some high zinc/phos believers even get emotional and nasty about all this. But, they can never back-up anything they say with actual facts. And no amount of hostility or verbal attacks, will change the Engineering FACTS. Engineering does NOT work that way. My

Engineering testing does not involve pre-conceived notions or emotion. It is all performed Professionally, and I report the results just as they are determined by the Physics and Chemistry involved, good or bad. In other words, I back-up everything I say with hard FACTUAL test data.

This is the 21st Century, and we now have correct Engineering test data FACTS available, so that we can finally make informed decisions about motor oil selection, that was not available before. Technology marches on. People can embrace it, and make use of it to their advantage, or they can be left behind to continue making poor motor oil choices.

In fact, incorrect choices of poor performing high zinc/phos motor oils, is the primary reason why flat tappet wiped lobes are still a problem, whether during break-in or after. But, choosing a high performing motor oil from my Motor Oil Wear Protection "Ranking List", which is based on oil film strength load carrying capability, rather than on the amount of zinc/phos, can make wiped lobes and complicated break-in procedures a thing of the past.

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In addition to that, not only are high levels of zinc/phos no guarantee of providing sufficient wear protection, but too much zinc/phos can actually DAMAGE your engine. Oil industry testing has found that motor oils with more than 1,400 ppm ZDDP, INCREASED long-term wear. And it was also found that motor oils with more than 2,000 ppm ZDDP started attacking the grain boundaries in the iron, resulting in camshaft spalling. The ZDDP value is the average of the zinc and phosphorus values, rounded to the next lowest 100 ppm increment.

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This by Brad Penn:

"There is such a thing as too much ZDDP. ZDDP is surface aggressive, and too much can be a detriment. ZDDP fights for the surface, blocking other additive performance. Acids generated due to excessive ZDDP contact will "tie-up" detergents thus encouraging corrosive wear. ZDDP effectiveness plateaus, more does NOT translate into more protection. Only so much is utilized. We don't need to saturate our oil with ZDDP. "

The use of zinc/phosphorus as the "primary" extreme pressure anti-wear components is outdated technology. Still, even the best modern low zinc/phos oils still use a some zinc/phos, but they are used only as a "portion" of the extreme pressure anti-wear components, that make up the overall additive package. And other modern "proprietary" extreme pressure anti-wear components, which are superior to zinc/phos, and can vary from Company to Company, are used as the "primary" extreme pressure anti-wear components. But, we don't see those components in a normal Lab test print out, because they are proprietary, so the Lab is not specifically looking for them.

So, what all this means is that the amount of zinc/phos on an oil's Lab print out will NOT help you choose an oil that will provide the excellent wear protection you desire. As mentioned above, the only way to find out how well an oil truly provides wear protection, is to look at an oil's film strength load carrying capability. And you can find that information in this Blog, in Section 1 – Motor Oil "Wear Protection" Ranking List.

However, you can make use of an oil's Lab print out on zinc/phos levels to see which oils have too much zinc/phos and can actually "damage" an engine. As indicated above, for "long-term higher mileage" usage, it is best to avoid oils that have more than 1,400 ppm ZDDP. For limited use Hotrods and Race Cars, it is best to avoid oils that have more than 2,000 ppm ZDDP.

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Also, looking at an oil's Lab print out values for "detergent/dispersant, anti-deposit buildup/anti-sludge" and TBN, can be very useful. It these values are comparable to the values of typical normal street oils, that means you can use normal oil change intervals. But, if those values are significantly lower than for typical normal street oils, then shorter change intervals are required because those components will become depleted sooner.

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Over time, as mileage accumulates on any motor oil, the additive package components become more and more depleted as they are used up. That, along with the oil becoming dark, dirty and contaminated, is why changing oil at reasonable intervals is important.

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So, to find out just how much the component quantities are reduced as mileage accumulates, I also sent the Lab about a dozen used oils, both synthetic and conventional, that had 5,000 miles on them. The most noteworthy component quantity depletions among those used oils were:

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• The zinc levels dropped by around 25% on average, over 5,000 miles. But, even with significantly reduced zinc levels, there was no reduction in the original oil film strength load carrying capability. So, that is further PROOF that the zinc level is not tied to the wear protection level.

• The TBN values dropped by about 4 points on average, over 5,000 miles.

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Only "brand new oil" component quantities are shown below, and they are listed in the following order:

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1. Gasoline Engine Oil

2. Break-In Oil

3. Diesel Oil

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GASOLINE ENGINE OIL

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15W50 Aeroshell W, Piston Aircraft engine oil, semi-synthetic (lab tested late 2017)
Silicon = 7 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = < 5 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = < 1 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 5 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = < 1 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 2 ppm (anti-wear)
Phosphorus = 1286 ppm (anti-wear)
Moly = < 1 ppm (anti-wear)
Potassium = < 1 ppm (anti-freeze corrosion inhibitor)
Sodium = < 1 ppm (anti-freeze corrosion inhibitor)
TBN = 2.6 (Total Base Number is an acid neutralizer to prevent corrosion. Most automotive gasoline engine oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 18.8 (cSt range for SAE 50 is 16.3 to 21.8)
Viscosity (cSt at 40*C) = 143.1, and cSt (centistokes) represents an oil's thickness.

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Amsoil 0W30 Signature Series (25,000 miles) synthetic (lab tested 2011)
This one does NOT have the API symbol, but its text says it's recommended for API SN applications
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 191 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 18 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 3354 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 1 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 824 ppm (anti-wear)
Phos = 960 ppm (anti-wear)
Moly = 161 ppm (anti-wear)

Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 1 ppm (anti-freeze corrosion inhibitor)
TBN = 11.4 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.5 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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Even though extended drain intervals are not really in the best interest of any engine, because motor oil is typically dark, dirty, contaminated and in need of changing by 5,000 miles, for those who absolutely insist on extended drain intervals, this may be one of the best oils for that. Because it has a lot of extra detergent and acid neutralizer (TBN), so that there is a lot of reserve to draw from as these become depleted over time.

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As a comparison, Mobil 1 Extended Performance (15,000 miles), looks rather poor for extended drain intervals when compared to this Amsoil product. This Amsoil motor oil has over twice as much detergent, and 44% more TBN than Mobil 1 Extended Performance (15,000).

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Amsoil 10W30 Dominator Racing Oil synthetic (lab tested 2013)
Silicon = 3 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 15 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 10 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1661 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1613 ppm (anti-wear)
Phos = 1394 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 6.5 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.6 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Amsoil 10W30 Z- Rod Oil synthetic (lab tested 2011)
This one does NOT have the API symbol, but its text says it's recommended for API SL and earlier applications.
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 11 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2908 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1431 ppm (anti-wear)
Phos = 1441 ppm (anti-wear)
Moly = 52 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 8.3 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.6 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Brad Penn 0W30 Penn Grade 1 High Performance Oil partial synthetic (lab tested 2011)
This oil is from Bradford, Pennsylvania, thus the name Brad Penn.
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 13 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2922 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1621 ppm (anti-wear)
Phos = 1437 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 2 ppm (anti-freeze corrosion inhibitor)
TBN = 8.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.5 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Brad Penn 10W30 Penn Grade 1 High Performance Oil partial synthetic (lab tested 2011)
This oil is from Bradford, Pennsylvania, thus the name Brad Penn.
Silicon = 9 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 646 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2518 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 5 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1557 ppm (anti-wear)
Phos = 1651 ppm (anti-wear)
Moly = 3 ppm (anti-wear)
Potassium = 5 ppm (anti-freeze corrosion inhibitor)
Sodium = 450 ppm (anti-freeze corrosion inhibitor)
TBN = 8.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.3 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Castrol 5W20 Edge with Titanium API SN synthetic (lab tested 2011)
Silicon = 7 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 54 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 1236 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 662 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1042 ppm (anti-wear)
Phos = 857 ppm (anti-wear)
Moly = 100 ppm (anti-wear)
Titanium = 49 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 2 ppm (anti-freeze corrosion inhibitor)
TBN = 9.5 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 9.1 (cSt range for SAE 20 is 5.6 to 9.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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Castrol 5W30 Edge with Titanium API SN synthetic (lab tested 2011)
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)

Boron = 55 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 1176 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 577 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 2 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 818 ppm (anti-wear)
Phos = 883 ppm (anti-wear)
Moly = 90 ppm (anti-wear)
Titanium = 44 ppm (anti-wear)
Potassium = 4 (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 10.1 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.6 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Castrol 5W30 Edge API SM synthetic (lab tested 2011)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 57 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 14 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 3206 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 955 ppm (anti-wear)
Phos = 799 ppm (anti-wear)
Moly = 149 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 10.1 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 9.7 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Castrol 5W30 GTX, API SN conventional (lab tested 2012)
Silicon = 11 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 6 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 8 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2634 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)

Zinc = 830 ppm (anti-wear)
Phos = 791 ppm (anti-wear)
Moly = 1 ppm (anti-wear)
Potassium = 6 ppm (anti-freeze corrosion inhibitor)
Sodium = 139 ppm (anti-freeze corrosion inhibitor)
TBN = 6.2 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.7 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Castrol 5W30 GTX API SM conventional (lab tested 2011)
Silicon = 8 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2969 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 888 ppm (anti-wear)
Phos = 873 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 8 ppm (anti-freeze corrosion inhibitor)
Sodium = 114 ppm (anti-freeze corrosion inhibitor)
TBN = 7.5 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.4 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Castrol 30wt Heavy Duty, API SM conventional (lab tested 2012)
Silicon = 7 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 112 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2682 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 907 ppm (anti-wear)
Phos = 829 ppm (anti-wear)
Moly = 56 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 8 ppm (anti-freeze corrosion inhibitor)

TBN = 7.3 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 12.1 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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5W50 Castrol Edge w/Syntec API SN synthetic (lab tested 2012)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 47 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 1037 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 459 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1252 ppm (anti-wear)
Phos = 1197 ppm (anti-wear)
Moly = 71 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 9.5 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 17.7 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Castrol 20W50 GTX API SN conventional oil (lab tested 2012)
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 125 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 11 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2463 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 610 ppm (anti-wear)
Phos = 754 ppm (anti-wear)
Moly = 64 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 14 ppm (anti-freeze corrosion inhibitor)
TBN = 7.1 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 17.5 (cSt range for SAE 50 is 16.3 to 21.8) And cSt (centistokes) in general terms, represents an oil's thickness.
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Chevron Supreme 5W30 API SN conventional (lab tested 2012)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 82 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 8 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2715 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1018 ppm (anti-wear)
Phos = 728 ppm (anti-wear)
Moly = 161 ppm (anti-wear)
Potassium = 8 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 7.5 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.3 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Comp Cams 10W30 Muscle Car & Street Rod Oil synthetic blend (lab tested 2012)
Silicon = 1 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 12 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2803 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1673 ppm (anti-wear)
Phos = 1114 ppm (anti-wear)
Moly = 67 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 8.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.8 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Edelbrock 5W30 Cat Safe API SM synthetic (lab tested 2012)
Silicon = 1 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 57 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 13 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)

Calcium = 2565 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 924 ppm (anti-wear)
Phos = 659 ppm (anti-wear)
Moly = 28 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 5 ppm (anti-freeze corrosion inhibitor)
TBN = 7.4 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.4 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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Edelbrock 10W40 synthetic (lab tested 2012)
Silicon = 0 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 854 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 27 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1193 ppm (anti-wear)
Phos = 1146 ppm (anti-wear)
Moly = 121 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 5 ppm (anti-freeze corrosion inhibitor)
TBN = 6.0 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 14.5 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.

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GM's 5W30 AC Delco dexos 1, API SN semi-synthetic (lab tested 2012)
This oil is made by ExxonMobil.
Silicon = 0 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 218 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2260 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 878 ppm (anti-wear)

Phos = 758 ppm (anti-wear)
Moly = 72 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 6.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.2 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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5W30 Joe Gibbs Driven LS30 Performance Motor Oil, synthetic (lab tested 2014)

The bottle says it is formulated specifically for high output GM LS engines, and that no ZDDP or additives are required.
Silicon = 7 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 257 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 3515 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1610 ppm (anti-wear)
Phos = 1496 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 12 ppm (anti-freeze corrosion inhibitor)
TBN = 8.8 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.1 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

.
This oil contains sufficient amounts of the components required (detergent, acid neutralizer, etc) for normal change intervals in street driven vehicles. But, it has way too much zinc/phos for use in cat equipped vehicles. However, it is well suited for Race Cars, Street Hotrods and Classic cars.

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Joe Gibbs 10W30 HR- 4 Hot Rod Oil synthetic (lab tested 2011)
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)

Boron = 6 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 164 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2964 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1247 ppm (anti-wear)
Phos = 1137 ppm (anti-wear)
Moly = 24 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 2 ppm (anti-freeze corrosion inhibitor)
TBN = 9.4 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.6 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Joe Gibbs 10W30 XP3 NASCAR Racing Oil synthetic (lab tested 2011)
NOTE: Some of the numbers here were so unusual and unexpected, that I had the lab re-test the oil sample on another day, after other oil tests showed normal results, just to ensure that the original test was valid. And the re –test came back with the exact same numbers. So, the numbers are what they are. We know this line of oil works very well, because it was developed for, and is used by, winning NASCAR Cup teams.

.
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 259 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 1 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 356 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 743 ppm (anti-wear)
Phos = 802 ppm (anti-wear)
Moly = 1125 ppm (anti-wear)
Potassium = 5 ppm (anti-freeze corrosion inhibitor)
Sodium = 5 ppm (anti-freeze corrosion inhibitor)
TBN = 1.8 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 12.2 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

.
The detergent and TBN levels are so very low here, that this oil should most likely be changed after every outing, before those components are totally exhausted.
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Kendall 20W50 GT-1 High Performance with liquid Titanium, API SN conventional (lab tested 2012)
This oil is made by ConocoPhillips.
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 188 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2606 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 991 ppm (anti-wear)
Phos = 1253 ppm (anti-wear)
Moly = 57 ppm (anti-wear)
Titanium = 84 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 8.2 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 18.2 (cSt range for SAE 50 is 16.3 to 21.8) And cSt (centistokes) in general terms, represents an oil's thickness.
****

5W30 Klotz Estorlin Racing Oil API SL synthetic (lab tested 2012)
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 667 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 735 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1765 ppm (anti-wear)
Phos = 2468 ppm (anti-wear)
Moly = 339 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 341 ppm (anti-freeze corrosion inhibitor)
TBN = 8.0 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)

Viscosity (cSt at 100*C) = 9.3 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
****

5W30 LAT Synethic Racing Oil API SM (lab tested 2012)
Silicon = 3 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 143 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1516 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1784 ppm (anti-wear)
Phos = 1539 ppm (anti-wear)
Moly = 598 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 7.3 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.0 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Lucas 5W30 API SN conventional (lab tested 2012)
Silicon = 11 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 8 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2607 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 992 ppm (anti-wear)
Phos = 760 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 14 ppm (anti-freeze corrosion inhibitor)
Sodium = 423 ppm (anti-freeze corrosion inhibitor)
TBN = 6.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.9 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
****

Lucas 5W30 API SM synthetic (lab tested 2012)
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2711 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1134 ppm (anti-wear)
Phos = 666 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 406 ppm (anti-freeze corrosion inhibitor)
TBN = 6.3 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.4 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Lucas 10W30 Racing Only synthetic (lab tested 2011)
Silicon = 18 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 1 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2929 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 2642 ppm (anti-wear)
Phos = 3489 ppm (anti-wear)
Moly = 1764 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 9 ppm (anti-freeze corrosion inhibitor)
TBN = 9.0 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.5 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

.
The ZDDP values are so extremely high here, that this oil really is only suited for short life dedicated racing engines, as the name implies. Using zinc/phos levels this high in other engines could be cause for concern, since excessively high levels can "cause" engine damage rather than "prevent" it.

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Lucas 10W30 Hot Rod & Classic Hi-Performance Oil conventional (lab tested 2012)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 7 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2891 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 2116 ppm (anti-wear)
Phos = 1855 ppm (anti-wear)
Moly = 871 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 9.2 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.8 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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5W30 Maxima RS530 Synthetic Racing Oil synthetic (lab tested 2012)
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 735 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 820 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 2162 ppm (anti-wear)
Phos = 2294 ppm (anti-wear)
Moly = 181 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 366 ppm (anti-freeze corrosion inhibitor)
TBN = 8.4 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 9.3 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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0W Mobil 1 Racing Oil (lab tested 2013)
Silicon = 7 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)

Boron = 74 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 14 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1938 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1952 ppm (anti-wear)
Phos = 1671 ppm (anti-wear)
Moly = 1743 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 1 ppm (anti-freeze corrosion inhibitor)
TBN = 8.2 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 6.1 And cSt (centistokes) in general terms, represents an oil's thickness.

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0W30 Mobil 1 Racing Oil (lab tested 2013)
Silicon = 17 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 67 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 13 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1823 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 10 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1693 ppm (anti-wear)
Phos = 1667 ppm (anti-wear)
Moly = 1326 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 1 ppm (anti-freeze corrosion inhibitor)
TBN = 8.0 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.3 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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0W50 Mobil 1 Racing Oil (lab tested 2013)
Silicon = 8 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 74 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 212 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1694 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1676 ppm (anti-wear)

Phos = 1637 ppm (anti-wear)
Moly = 1263 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 8.4 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 17.6 (cSt range for SAE 50 is 16.3 to 21.8) And cSt (centistokes) in general terms, represents an oil's thickness.

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Mobil 1 0W20 Advanced Fuel Economy API SN synthetic (lab tested 2012)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 81 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 631 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 820 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 742 ppm (anti-wear)
Phos = 677 ppm (anti-wear)
Moly = 81 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 7.6 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 8.9 (cSt range for SAE 20 is 5.6 to 9.2) And cSt (centistokes) in general terms, represents an oil's thickness.

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Mobil 1 5W20 API SN synthetic (lab tested 2012)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 79 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 554 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 781 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 764 ppm (anti-wear)
Phos = 698 ppm (anti-wear)
Moly = 76 ppm (anti-wear)
Potassium = 7 ppm (anti-freeze corrosion inhibitor)

Sodium = 1 ppm (anti-freeze corrosion inhibitor)
TBN = 7.6 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 9.2 (cSt range for SAE 20 is 5.6 to 9.2) And cSt (centistokes) in general terms, represents an oil's thickness.

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Mobil 1 5W30 Extended Performance (15,000 miles) API SN synthetic (lab tested 2011)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 89 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 666 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 942 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 890 ppm (anti-wear)
Phos = 819 ppm (anti-wear)
Moly = 104 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 7.9 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.5 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

.
The detergent, anti-wear and TBN components of this Extended Performance oil are either about average or below average for typical API SN oils (even though some of the components are a little higher than in its standard Mobil 1 counterpart). TBN eventually becomes depleted as miles accumulate on oil in service. That's "one" of the primary reasons for changing oil in the first place, to replenish the exhausted additive package. And it is not unusual for a TBN value to drop by about 4 points per 5,000 miles. So, with this oil starting out with a fairly low TBN value to begin with, it would seem very unlikely it could ever go a whopping 15,000 miles without having the TBN totally depleted well before reaching that 15,000 mile mark. So, this extended mileage claim appears to be only an unsupported marketing gimmick.

.
But, for those interested in long drain intervals, I'd suggest sending in a sample of this oil and having it lab tested at about the half way mark of 7,500 miles to see how much, if any, TBN remains. But, of course motor oil is typically already dark, dirty, contaminated and in need of changing by 5,000 miles anyway.

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Mobil 1 5W30 API SN synthetic (lab tested 2011)
Silicon = 8 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 87 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 603 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 799 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 801 ppm (anti-wear)
Phos = 842 ppm (anti-wear)
Moly = 112 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 6 ppm (anti-freeze corrosion inhibitor)
TBN = 7.5 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.5 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Mobil 1 15W50 API SN full synthetic oil (lab tested 2012)
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 84 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 556 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 791 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1133 ppm (anti-wear)
Phos = 1168 ppm (anti-wear)
Moly = 83 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 2 ppm (anti-freeze corrosion inhibitor)
TBN = 8.1 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 18.3 (cSt range for SAE 50 is 16.3 to 21.8) And cSt (centistokes) in general terms, represents an oil's thickness.
****

Motorcraft 5W30 API SN full synthetic oil (lab tested 2012)
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 188 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)

Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2030 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 796 ppm (anti-wear)
Phos = 830 ppm (anti-wear)
Moly = 75 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 2 ppm (anti-freeze corrosion inhibitor)
TBN = 7.0 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.1 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Motorcraft 5W50 API SN full synthetic oil (lab tested 2012)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 282 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 8 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1710 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 606 ppm (anti-wear)
Phos = 742 ppm (anti-wear)
Moly = 28 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 2 ppm (anti-freeze corrosion inhibitor)
TBN = 6.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 19.4 (cSt range for SAE 50 is 16.3 to 21.8) And cSt (centistokes) in general terms, represents an oil's thickness.
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5W30 Motul 300V Ester Core 4T Racing Oil, synthetic (lab tested 2014)

This Motorcycle Road Racing oil is from France and comes in liter bottles (slightly more than a quart). At the time this oil was tested in spring 2014, it cost $24.25 per bottle. And with the shipping cost added to that, the final cost was about $33.00 per bottle (shipping was all inside the U.S.), making it THE most expensive motor oil I've ever tested.
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)

Magnesium = 17 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 3141 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1724 ppm (anti-wear)
Phos = 1547 ppm (anti-wear)
Moly = 481 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 3 ppm (anti-freeze corrosion inhibitor)
TBN = 7.4 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.2 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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This oil contains sufficient amounts of the components required (detergent, acid neutralizer, etc) for normal change intervals in street driven vehicles. But, it has way too much zinc/phos for use in cat equipped vehicles. However, it is well suited for Race Cars, Street Hotrods and Classic cars.
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5W30 Oil Extreme API SM synthetic (lab tested 2013)
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 87 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 52 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 7652 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 765 ppm (anti-wear)
Phos = 624 ppm (anti-wear)
Moly = 52 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 505 ppm (anti-freeze corrosion inhibitor)
TBN = 23.2 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.1 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness
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O'Reilly 5W30 (house brand) API SN conventional (lab tested 2012)
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)

Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 7 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2556 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 853 ppm (anti-wear)
Phos = 816 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 9 ppm (anti-freeze corrosion inhibitor)
Sodium = 422 ppm (anti-freeze corrosion inhibitor)
TBN = 5.5 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.4 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil’s thickness.

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Pennzoil 5W30 Ultra API SM synthetic (lab tested 2011)
Silicon = 3 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 363 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 13 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 3011 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 806 ppm (anti-wear)
Phos = 812 ppm (anti-wear)
Moly = 66 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 10.3 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.8 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil’s thickness.

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Pennzoil 5W30, API SN conventional, yellow bottle (lab tested 2013)
Silicon = 3 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 102 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 8 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1881 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)

Zinc = 839 ppm (anti-wear)
Phos = 840 ppm (anti-wear)
Moly = 267 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 7.9 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.7 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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Quaker State 5W30 Ultimate Durability API SN synthetic (lab tested 2011)
Silicon = 3 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 10 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2831 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 877 ppm (anti-wear)
Phos = 921 ppm (anti-wear)
Moly = 72 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 7.9 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.5 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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NOTE: This bottle's plastic was so paper thin and flimsy, that just gripping the bottle with the cap off, squeezed oil up, out and all over the place. So, use extra care with this one.

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Quaker State 10W30 Defy, API SL synthetic blend (lab tested 2012)
Silicon = 3 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 170 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 8 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2652 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)

Zinc = 1221 ppm (anti-wear)
Phos = 955 ppm (anti-wear)
Moly = 99 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 6.5 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.7 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness
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Redline 30wt Race Oil synthetic (lab tested 2011)
Silicon = 23 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 70 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1982 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 3 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 2207 ppm (anti-wear)
Phos = 2052 ppm (anti-wear)
Moly = 1235 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 20 ppm (anti-freeze corrosion inhibitor)
TBN = 5.0 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 9.9 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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These ZDDP values are high enough here, that this oil really is only suited for short life dedicated racing engines, as the name implies. Using zinc/phos levels this high in other engines could be cause for concern, since excessively high levels, can "cause" engine damage rather than "prevent" it.

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The very low TBN value in this Redline oil is also consistent with short term use only.

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Royal Purple 5W20 API SN synthetic (lab tested 2011)
Silicon = 2 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)

Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2862 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 964 ppm (anti-wear)
Phos = 892 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 267 ppm (anti-freeze corrosion inhibitor)
TBN = 7.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 8.7 (cSt range for SAE 20 is 5.6 to 9.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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Royal Purple 5W30 API SN synthetic (lab tested 2011)
Silicon = 3 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 8 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2822 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 942 ppm (anti-wear)
Phos = 817 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 6 ppm (anti-freeze corrosion inhibitor)
Sodium = 424 ppm (anti-freeze corrosion inhibitor)
TBN = 7.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.3 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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Royal Purple 5W30 XPR (Extreme Performance Racing) synthetic (lab tested 2008)
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 1 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 10 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 3039 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1421 ppm (anti-wear)

Phos = 1338 ppm (anti-wear)
Moly = 204 ppm (anti-wear)
Potassium = 0 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 10.9 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.6 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Royal Purple 5W30 API SL synthetic (lab tested 2011)
Silicon = 9 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 15 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 1192 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2745 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1179 ppm (anti-wear)
Phos = 985 ppm (anti-wear)
Moly = 211 ppm (anti-wear)
Potassium = Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 11.0 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.7 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Royal Purple 10W30 HPS (High Performance Street) synthetic (lab tested 2011)
Silicon = 7 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 46 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 3626 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1774 ppm (anti-wear)
Phos = 1347 ppm (anti-wear)
Moly = 189 ppm (anti-wear)
Potassium = 11 ppm (anti-freeze corrosion inhibitor)
Sodium = 2 ppm (anti-freeze corrosion inhibitor)
TBN = 10.2 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)

Viscosity (cSt at 100*C) = 11.3 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Royal Purple 20W50 API SN full synthetic oil (lab tested 2012)
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 10 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2530 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 588 ppm (anti-wear)
Phos = 697 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 12 ppm (anti-freeze corrosion inhibitor)
Sodium = 120 ppm (anti-freeze corrosion inhibitor)
TBN = 7.8 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 19.5 (cSt range for SAE 50 is 16.3 to 21.8) And cSt (centistokes) in general terms, represents an oil's thickness.
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Summit 10W40 Premium Racing Oil, API SL (lab tested 2013)
Silicon = 1 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 77 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 6 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1338 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1764 ppm (anti-wear)
Phos = 1974 ppm (anti-wear)
Moly = 41 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 6.8 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 14.2 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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Torco 10W40 TR-1 Racing Oil conventional (lab tested 2012)
Silicon = 2 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 10 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 917 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 44 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1456 ppm (anti-wear)
Phos = 1150 ppm (anti-wear)
Moly = 227 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 6.3 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 15.4 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.

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Valvoline 5W20 SynPower API SN synthetic (lab tested 2012)
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2781 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1045 ppm (anti-wear)
Phos = 742 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 8 ppm (anti-freeze corrosion inhibitor)
Sodium = 386 ppm (anti-freeze corrosion inhibitor)
TBN = 6.9 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 8.5 (cSt range for SAE 20 is 5.6 to 9.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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Valvoline 5W30 SYNPower API SN synthetic (lab tested 2011)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)

Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 19 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2605 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 969 ppm (anti-wear)
Phos = 761 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 11 ppm (anti-freeze corrosion inhibitor)
Sodium = 205 ppm (anti-freeze corrosion inhibitor)
TBN = 7.1 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.5 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Valvoline 5W30 NextGen 50% Recycled Oil, API SN conventional (lab tested 2013)
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 7 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1861 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 947 ppm (anti-wear)
Phos = 778 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 398 ppm (anti-freeze corrosion inhibitor)
TBN = 5.8 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.5 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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The TBN value in this new oil, is as low as some used oils have at 5,000 miles. So, this oil might barely make it to 5,000 miles, without the TBN being depleted.
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Valvoline NSL (Not Street Legal) 10W30 Conventional Racing Oil (lab tested 2011)
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)

Magnesium = 5 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1607 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 2 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1669 ppm (anti-wear)
Phos = 1518 ppm (anti-wear)
Moly = 784 ppm (anti-wear)
Potassium = 7 ppm (anti-freeze corrosion inhibitor)
Sodium = 190 ppm (anti-freeze corrosion inhibitor)
TBN = 4.4 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 9.8 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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The very low TBN value in this NSL oil would require increased oil change frequency, to avoid acid build-up. And Valvoline has said that their NSL oils should be changed at least every 500 miles.

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Valvoline VR1 10W30 Racing Oil conventional (Silver Bottle, lab tested 2011)
This one does NOT have the API symbol, but its text says it exceeds API SM
Silicon = 10 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 73 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2707 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 3 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1472 ppm (anti-wear)
Phos = 1544 ppm (anti-wear)
Moly = 3 ppm (anti-wear)
Potassium = 6 ppm (anti-freeze corrosion inhibitor)
Sodium = 380 ppm (anti-freeze corrosion inhibitor)
TBN = 7.6 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.0 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Valvoline VR1 10W30 "SYNTHETIC" Racing Oil API SL (Black Bottle, lab tested 2011)
Silicon = 8 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt

can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 15 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2664 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1180 ppm (anti-wear)
Phos = 1112 ppm (anti-wear)
Moly = 162 ppm (anti-wear)
Potassium = 5 ppm (anti-freeze corrosion inhibitor)
Sodium = 195 ppm (anti-freeze corrosion inhibitor)
TBN = 7.4 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.4 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Valvoline 10W40 4 Stroke Motorcycle Oil API SJ conventional (lab tested 2008)
Silicon = 20 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 137 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 13 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1849 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1154 ppm (anti-wear)
Phos = 1075 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 0 ppm (anti-freeze corrosion inhibitor)
Sodium = 126 ppm (anti-freeze corrosion inhibitor)
TBN = 7.1 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 14.6 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.

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BREAK-IN OIL

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Amsoil 30wt Break-In Oil conventional (lab tested 2013)

Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 15 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1587 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 2051 ppm (anti-wear)
Phos = 1917 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 6.5 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.4 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Comp Cams 10W30 Break-in Oil conventional (lab tested 2012)
Silicon = 4 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 22 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 4208 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 3004 ppm (anti-wear)
Phos = 2613 ppm (anti-wear)
Moly = 180 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 2 ppm (anti-freeze corrosion inhibitor)
TBN = 14.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.7 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Edelbrock 30wt Break-in Oil conventional (lab tested 2012)
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 46 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 3402 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)

Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1545 ppm (anti-wear)
Phos = 1465 ppm (anti-wear)
Moly = 4 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 8 ppm (anti-freeze corrosion inhibitor)
TBN = 10.6 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 10.8 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Lucas 30wt Break-in Oil conventional (lab tested 2012)
Silicon = 15 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 1 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1099 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 4483 ppm (anti-wear)
Phos = 3660 ppm (anti-wear)
Moly = 3 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 4 ppm (anti-freeze corrosion inhibitor)
TBN = 5.9 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 11.9 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.
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Royal Purple 10W30 Break-In oil conventional (lab tested 2012)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 411 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2769 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1170 ppm (anti-wear)
Phos = 1039 ppm (anti-wear)
Moly = 0 ppm (anti-wear)

Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 5 ppm (anti-freeze corrosion inhibitor)
TBN = 9.8 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 12.1 (cSt range for SAE 30 is 9.3 to 12.4) And cSt (centistokes) in general terms, represents an oil's thickness.

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DIESEL OIL

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Chevron 15W40 Delo 400 LE Diesel Oil API CJ-4, CI-4 Plus, CH-4, CF-4,CF/SM, conventional (lab tested 2012)
Silicon = 5 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 393 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 346 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1466 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1519 ppm (anti-wear)
Phos = 1139 ppm (anti-wear)
Moly = 80 ppm (anti-wear)
Potassium = 6 ppm (anti-freeze corrosion inhibitor)
Sodium = 5 ppm (anti-freeze corrosion inhibitor)
TBN = 8.0 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 15.4 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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Farm Rated 15W40 Heavy Duty Performance Diesel Oil, CI-4, CH-4, CG-4, CF/SL, SJ conventional (lab tested 2012)
This oil is made by CITGO Petroleum Corp.
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 677 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 912 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)

Zinc = 1325 ppm (anti-wear)
Phos = 1234 ppm (anti-wear)
Moly = 2 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 3 ppm (anti-freeze corrosion inhibitor)
TBN = 9.3 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 15.1 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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Lucas 15W40 Magnum Diesel Oil API CI-4, CH-4, CG-4, CF-4, CF/SL, conventional (lab tested 2012)
Silicon = 9 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 10 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 3374 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1441 ppm (anti-wear)
Phos = 1234 ppm (anti-wear)
Moly = 76 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 11.7 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 14.4 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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Mobil 1 5W40 Turbo Diesel Truck Oil API CJ-4, CI-4 Plus, CI-4, CH-4 and ACEA, synthetic (lab tested 2012)
Silicon = 2 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 77 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 654 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 865 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1211 ppm (anti-wear)
Phos = 1168 ppm (anti-wear)
Moly = 2 ppm (anti-wear)

Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 2 ppm (anti-freeze corrosion inhibitor)
TBN = 9.3 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 14.3 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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Mobil 15W40 Delvac 1300 Super Diesel Oil conventional (lab tested 2012)
Silicon = 6 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 47 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 756 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 1040 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1297 ppm (anti-wear)
Phos = 944 ppm (anti-wear)
Moly = 46 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 15 ppm (anti-freeze corrosion inhibitor)
TBN = 9.8 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 14.5 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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Redline 15W40 Diesel Oil API CJ-4/CI-4 PLUS/CI-4/CF/CH-4/CF-4/SM/SL/SH/EO-O, synthetic (lab tested 2012)
Silicon = 20 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 4 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2986 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1615 ppm (anti-wear)
Phos = 1551 ppm (anti-wear)
Moly = 173 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 4 ppm (anti-freeze corrosion inhibitor)
TBN = 8.3 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)

Viscosity (cSt at 100*C) = 13.4 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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"NEW" 15W40 Shell Rotella T Diesel Oil API CJ-4, CI-4 Plus, CH-4, CF-4, CF/SM, conventional (lab tested 2012)
Silicon = 3 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 29 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 9 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2848 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1454 ppm (anti-wear)
Phos = 1062 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 14 ppm (anti-freeze corrosion inhibitor)
Sodium = 6 ppm (anti-freeze corrosion inhibitor)
TBN = 9.1 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 15.0 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.
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"OLD" 15W40 Shell Rotella T Diesel Oil API CI-4 PLUS, CI-4, CH-4,CG-4,CF-4,CF,SL, SJ, SH conventional (lab tested 2012)
Silicon = 3 ppm (anti-foaming agent in new oil, but in used oil, certain gasket materials and dirt can also add to this number)
Boron = 29 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge, anti-wear)
Magnesium = 6 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Calcium = 2680 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Barium = 0 ppm (detergent/dispersant, anti-deposit buildup/anti-sludge)
Zinc = 1171 ppm (anti-wear) Yes it's true, the old Rotella actually has LESS zinc than the new Rotella.
Phos = 1186 ppm (anti-wear)
Moly = 0 ppm (anti-wear)
Potassium = 4 ppm (anti-freeze corrosion inhibitor)
Sodium = 0 ppm (anti-freeze corrosion inhibitor)
TBN = 10.1 (Total Base Number is an acid neutralizer to prevent corrosion. Most gasoline engine motor oils start with TBN around 8 or 9)
Viscosity (cSt at 100*C) = 15.3 (cSt range for SAE 40 is 12.5 to 16.2) And cSt (centistokes) in general terms, represents an oil's thickness.

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Section 5 – Reserved for future Motor Oil Test Data

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Section 6 – DETAILED MOTOR OIL AND MECHANICAL TECH ARTICLES

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NOTE: Some of the motor oil Articles were written before the most recently tested motor oils were added to the Wear Protection Ranking List in Section 1.

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1. I-BEAM VS H-BEAM – WHICH CONNECTING ROD IS BEST?

I do NOT sell connecting rods, so I have no vested interest in what rods people choose to use. But, there is so much misinformation, misunderstanding and confusion about connecting rod design, that I've put together a brief overview for those who are interested in knowing the Engineering FACTS, rather than relying on the incorrect info that is so common on the Internet and elsewhere.

It is best to avoid H-Beam rods in general, no matter who makes them, and no matter who else uses them. Because as you will see below, an H-Beam rod is never the best choice. They were originally made by someone who "thought" they might be better and/or cheaper to make, without benefit of any Engineering analysis. So, the maker didn't even know what the H-Beam shortcomings were. Then other makers copied them, and eventually people started to think they must be good because they kept showing up. And because they looked different than stock rods, some figured they must be trick parts that are better.

But, you will only find the H-Beam style being used in the aftermarket Automotive Industry where it is common for companies to create parts without having them designed by actual Degreed Engineers. A lot of the aftermarket companies "just make stuff" without even knowing what they are doing. No competent Degreed Mechanical Engineer would ever design an H-Beam rod, because an H-Beam rod is a textbook case of how NOT to design a connecting rod. So, buyer beware.

A rod's max compression loads are determined by the amount of HP being made. It's a simple matter of the higher the HP, the higher compression loading on the rod. And an Engineering "FACT" (NOT opinion or theory) determined by proper buckling and crippling analysis, is that the I-Beam rod design has about twice the strength in compression, compared to a comparable H-Beam rod. So, that makes an I-Beam rod a far better choice for any application, and particularly for those at higher performance levels, such as those making over 1000 HP.

But, a rod's max tension loads are determined by the mass of the parts involved, the rod length, the stroke length, and the max rpm. That's it. The max tension loads will never change, no matter if you throw Nitrous, a Turbo, or Blower at it, as long as the short block and redline don't change. That max tension loading occurs at TDC on the exhaust stroke. And that has absolutely nothing what so ever to do with the amount of HP being made. In order to change the max tension loading, you'd have to change the short block configuration and/or the redline. Both types of rods have similar tension capability, since that is only a product of the beams cross-sectional area.

In High Performance engines, connecting rod "compression loading" is ALWAYS considerably higher than the "tension loading". Here's an example using an 800HP, 540ci BBC with a 7,000 rpm redline:

Max compression loading on the rod is about 21,000 lbs or 10.5 tons.

Max tension loading is only around 11,000 lbs or 5.5 tons.

So, as you can see in this particular example, the compression loading is about twice as high as the tension loading. But, if the HP increases, the compression loading will also increase. And "THAT IS WHY" a rod's compression loading capability is important to consider when you are in the market for a new set of rods for a High Performance engine.

An I-Beam rod made from high quality material such as 4340 forged steel will provide plenty of "Margin of Safety" with regard to compression strength. But, a comparable H-Beam rod's margin of safety can be iffy, and it only gets worse as the HP levels go up. For an H-Beam to catch up to the compression strength of an otherwise comparable I-Beam, the H-Beam would need to be FAR heavier than the lighter, stronger and more efficient I-Beam design. So, by using I-Beam rods, your engine can rev quicker, and you will have the capability to increase the HP later on, without worrying about the rods being strong enough to handle the extra HP.

The superiority of the I-Beam is why it is the structural beam design of choice for countless Professional Engineering applications such as:

• OEM automobile engines, including the Supercharged Corvette
• Aluminum rods (that aren't a solid rectangular cross section)
• Piston aircraft engines
• High performance high rpm motorcycle engines, which put out way more HP per cubic inch and spin to much higher rpm than most of our stuff ever will.
• Heavy equipment that uses Diesel engines, such as big rigs, bulldozers, earth movers, cranes, ships, trains and other industrial engines.
• Big rig trailer frames
• Aircraft, spacecraft, and ship structural frames
• Large in-building overhead crane main support beams
• Bridge construction
• Large building construction
• Etc., etc.

The fact that I-Beams are used in these applications, to name just a few, should serve as a sanity check for those who "think" H-Beams are better. H-Beam fans need to ask themselves one question, "If the H-Beam is better, then why haven't they been used by Degreed Engineers in these applications over these many, many decades?"

So, the next time you need a set of rods, you might want to do yourself a favor, and only consider I-Beam rods which are a significant UPGRADE over H-Beams.

BOTTOM LINE: For comparably made I-Beam and H-Beam rods which weigh the same, the I-Beam will be FAR STRONGER IN COMPRESSION, than the H-Beam. For comparably made I-Beam and H-Beam rods that have the same strength in compression, the I-Beam will be FAR LIGHTER. The Engineering facts (NOT theory and NOT opinion) are that the I-Beam rod is simply a far stronger, lighter and more efficient design than the H-Beam. So, no matter what anyone tells you, there is simply NO good reason to ever use an H-Beam rod. It makes no sense to buy H-Beams when the clearly superior I-Beams are readily available.

H-Beam users sometimes get emotional and nasty about the fact that H-Beams are inferior in every way, and that they could have made a better choice. But, emotional outbursts will NOT change the Physics involved that prove the superiority of the I-Beam rod design. Of course people can use whatever they want, and for those still having a hard time accepting all this, consider the following:

Lunati's recommendation for their rods:

• H-Beam Rods – ideal for High Performance street & mild race engines.

• Pro Series I-Beam Rods – perfect for Street Rods, Street-Strip Engines and all-out Race Engines

• Pro Mod I-Beam Rods – perfect for any racer needing an ultra-strong I-beam design

They also say that every Lunati connecting rod is forged from premium quality 4340 alloy steel for strength.

So, as you can see, Lunati knows what they are doing, mirrored what I said above, and got it right about H-Beams, I-Beams and forgings.

And speaking of that topic, no one "needs" a billet rod either. Forged rods have desirable grain structure and desirable residual compressive stresses, but billet rods DO NOT. Forged parts are always better than billet parts. For example, all fracture critical jet aircraft parts are forged, NOT billet. Billet parts are simply cheaper to manufacture in small quantities, even though machining time will be higher. Because billet parts do not require the horribly expensive forging presses and dies. But, when parts are produced in high enough mass quantities to spread out the cost of the forging presses and dies, then forged parts can end up being both superior and more affordable, because forgings don't need as much final machining time.

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2. ROD BOLT STRENGTH – WHAT DO WE REALLY NEED?

This write-up is not intended to be a chapter out of an Engineering Design Book. That would be way too long, way too involved, and way too boring for most folks here to have any interest in. Instead, this is just a general overview of how connecting rod bolts compare, and what we REALLY NEED in our motors.

Yield Strength = the stress at which a material begins to deform plastically. Prior to the yield point the material will deform elastically and will return to its original shape and size when the applied stress is removed. Once the yield point is passed, the deformation will be permanent, which is considered a "failed" condition for a bolt. So, the bolt must be discarded.

Tensile Strength = the maximum stress that a material can withstand while being stretched or pulled, without starting to neck down and ultimately breaking.

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First let's look at some typical strength values of various bolts, to get a general feel for how they compare.

Grade 2 hardware store general purpose bolt:
Yield strength = 55,000 psi
Tensile strength = 74,000 psi
Cost = a few cents each

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Grade 5 hardware store general purpose bolt:
Yield strength = 85,000 psi
Tensile strength = 120,000 psi
Cost = a few cents each

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Grade 8 hardware store general purpose bolt:
Yield strength = 120,000 psi
Tensile strength = 150,000 psi
Cost = a few cents each

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ARP 8740 chrome moly "connecting rod" bolt:
Yield strength = 180,000 psi
Tensile strength = 200,000 psi
Cost = $120.00 per set of 16 at Summit Racing Equipment, or about $8.00 each.

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ARP 2000 “connecting rod” bolt:
Yield strength = 180,000 psi
Tensile strength = 220,000 psi
ARP 2000 rod bolt material has twice the fatigue life of 8740 chrome moly rod bolt material.
Cost = $200.00 per set of 16 at Summit Racing Equipment, or about $13.00 each.

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ARP L19 “connecting rod” bolt:
Yield strength = 200,000 psi
Tensile strength = 260,000 psi
ARP L19 rod bolt material is subject to hydrogen embrittlement, and stress corrosion. It also cannot be exposed to any moisture, including sweat and/or condensation.
Cost = $200.00 per set of 16 at Summit Racing Equipment, or about $13.00 each.

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ARP Custom Age 625+ “connecting rod” bolt:
Yield strength = 235,000 psi
Tensile strength = 260,000 psi
ARP Custom Age 625+ rod bolt material has nearly 3 ½ times the fatigue life of the ARP 3.5 rod bolt material.
Cost = $600.00 per set of 16 at Summit Racing Equipment, or about $38.00 “EACH”.

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ARP 3.5 “connecting rod” bolt:
Yield strength = 220,000 psi
Tensile strength = 260,000 psi
Cost = $855.00 per set of 16 at Summit Racing Equipment, or about $53.00 “EACH”!!!

So, as you can see above, hardware store general purpose bolts are considerably weaker than “purpose built” connecting rod bolts. And we won’t even bother getting into the differences in fatigue life. Suffice it to say, we CANNOT use general purpose hardware store bolts in our connecting rods.

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A connecting rod bolt’s maximum tension loads are determined by the mass of the parts involved, the rod length, the stroke length, and the max rpm. That’s it. It has absolutely nothing what so ever to do with the amount of HP being made. The max tension loads on the rod bolts will never change, no matter if you add Nitrous, a Turbo, or a Blower to an engine, as long as the short block and redline don’t change. That max tension loading occurs at TDC on the exhaust stroke as the mass involved is brought to a dead stop, and has its direction reversed. In order to change the max tension loading on the rod bolts, you'd have to change the short block configuration and/or the redline. And vacuum pulling on the rod bolts when chopping the throttle at high rpm, is not a concern. Because those affects don't even begin to build until well past TDC, which of course is "AFTER" the mass of the parts involved has already been brought to a stop, and their direction reversed.

The rod's big end "clamp-up preload" provided by stretching/torquing the rod bolts, must always be HIGHER than the "cyclic tension load" applied to the bolts at TDC exhaust, in order to prevent rod bolt failure. And the larger the difference between the preload and the cyclic load, the better. Precision detailed "Strength Analysis" calculations can be performed using sound Engineering principles, to determine the "Margin of Safety" (MOS) between the "cyclic tension loading" and the "clamp-up preload", to make sure you have a sufficient MOS for the engine to be reliable. I'll spare you all the involved and complicated math, and just show you the results.

Before we go on, first a comment on "cap screw" rod bolt sizes. Your rod bolts are NOT the size you think they are. If you run 3/8" rod bolts, only the threads are 3/8". But, the part of the bolt that matters regarding the stretch, is the shank. And the main length of the shank is only 5/16", not the 3/8" you might have thought. And if you run 7/16" rod bolts, the threads are 7/16", but main length of the shank is only 3/8". So, where you are most concerned, the bolts are one size SMALLER than you thought.

And if that isn't enough detail, you must also consider, in addition to the main section of the shank, the other diameters involved which come from the radius transition between the threads and the shank, the radius transition between the shank and the shoulder right under the bolt head flange, and that shoulder itself right under the bolt head flange. The bolts stretch the whole length between the threads and the bolt head flange. And all those individual sections contribute to the total stretch by different amounts.

So, the rod bolt "Strength Analysis" must take into account all those various diameters, as well as the length of each of those diameters. Because the stretch has to be calculated for each individual section of the shank between the threads and the bolt head flange. If this is not done correctly, the "Strength Analysis" results will simply end up being wrong and worthless. But, for the results shown below, all those details were carefully worked out for those portions of the "Strength Analysis". So, the answers below are all accurate.

Rod bolt "Strength Analysis" performed on known real world Street Hotrods, Street/Strip cars and Sportsman Drag cars, being operated at their typical maximum rpm, indicates the following:

• An engine with a max rpm rod bolt MOS of around 125% or higher, results in the engine being as safe and reliable as a stock grocery getter, or in other words essentially bullet proof. This is our design target when planning a new build. Having a MOS higher than this can't hurt of course, but in terms of strength requirements, there is really no added value for doing that. However, a higher MOS can help with rod bolt fatigue life, if that is critical for a particular application. More on fatigue life later.

• If you are a little more aggressive, and run a maximum rpm rod bolt MOS between 100% and 125% only "on occasion", which limits the number of cycles at this higher stress level, you will still generally be able to keep the engine together.

• But, if you were to run a typical maximum rpm rod bolt MOS under 100%, your rod bolts will be expected to fail prematurely.

As mentioned above in the definition of Yield Strength, we CANNOT stretch our rod bolts beyond the yield point. Because once the yield point is passed, it is considered a "failed" condition for a bolt, and the bolt must be discarded. So, a typical conservative Engineering approach in most general applications is to use a preload clamp-up of about 75% of yield. That way you have a good range between the installed preload and the yield point, in case the bolts get stressed even more during operational use. However, typical engine connecting rod bolt preload clamp-up in most reliable engines, can vary from a low of about 60% of yield to a high of about 90% of yield, with 75% of yield, the sweet spot you might say, right in the middle.

Since rod bolt stretch specs have generally become the standard in High Performance engine builds, the stretch called for is more often around 90% of the yield point. Stretching to this higher percentage of yield, is used to maximize preload clamp-up, in an effort to try and help minimize rod big end distortion at high rpm, which can cause additional undesirable rod bolt bending that would add to the bolt stress.

So, this high level of stretch is a good idea from that standpoint, but at the same time, you are left with a smaller range between the installed preload clamp-up and the yield point. But, this common 90% of yield has worked out quite well in the real world for Hotrods, Street/Strip cars, and Sportsman Drag cars. Even though there is less range between the installed preload clamp-up and the yield point, the yield point in properly selected rod bolts is not typically reached in actual operation, so all is good.

You may also have noticed that through all this discussion of rod bolt strength, there has been no mention at all of rod bolt tensile strength. That's because we CANNOT go beyond the yield strength which is reached well "BELOW" the tensile strength. So, what good is tensile strength then? For a large number of steels, there is a direct correlation between tensile strength and fatigue life. Normally, as tensile strength increases, the fatigue life increases. So, while tensile strength does not come into play during rod bolt "Strength Analysis", it is a factor in rod bolt fatigue life.

Rod bolt fatigue life is important to Road Racers because of the number of cycles they see. And rod bolt fatigue life is absolutely critical for Endurance Racers like NASCAR. And NASCAR teams do an incredible job managing the fatigue life of their rod bolts. But, for our Hotrods, Street/Strip cars and Sportsman Drag cars, rod bolt fatigue life isn't typically a big concern, if the motors are built with the correct rod bolts in the first place. That is because these bolts won't typically see enough cycles in their lifetime to cause a failure due to fatigue. But, with that said, it is still a good idea to keep fatigue life in the back of your mind, when it comes to choosing your rod bolts. It can be a tie breaker, in the event that multiple rod bolts are being considered for a certain build. More on that below.

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Even though there are various companies that offer rod bolts, below we will compare 5 different rod bolts offered by Industry leader ARP.

So, let's take a look at a typical 540ci BBC motor, running steel rods with 7/16 "cap screw" rod bolts, and uses 7,500 rpm as its typical maximum, which results in a cyclic tension load on each rod bolt that = 7,280 lbs or about 3.6 tons:

• For general reference, let's first take a look at rods installed the old school traditional way, here using ARP 2000 rod bolts that are torqued to about 75 ft lbs with original ARP moly lube.
Bolt stretch is about .005", which = 76% of yield strength
Clamp-up preload on each rod bolt = 16,531 lbs or about 8.3 tons
Margin of Safety (MOS) for this setup = 127%, which meets our MOS design target for being safe, reliable and essentially bullet proof.

Now, for the rest of the rod bolts we'll be looking at, we'll preload them to the more common higher percentage of yield strength, which is typical of the stretch called for these days.

• Using ARP 8740 chrome moly rod bolts (this has the same yield strength as ARP 2000)
Bolt stretch = .006" which = 90% of yield strength
Clamp-up preload on each rod bolt = 19,686 lbs or about 9.8 tons
Margin of Safety (MOS) = 170%

• Using ARP 2000 rod bolts (this has the same yield strength as 8740 chrome moly)
Bolt stretch = .006" which = 90% of yield strength
Clamp-up preload on each rod bolt = 19,686 lbs or about 9.8 tons
Margin of Safety (MOS) = 170%

• Using ARP L19 rod bolts
Bolt stretch = .0066" which = 90% of yield strength
Clamp-up preload on each rod bolt = 21,655 lbs or about 10.8 tons
Margin of Safety (MOS) = 197%

• Using ARP Custom Age 625+ rod bolts
Bolt stretch = .0078" which = 90% of yield strength
Clamp-up preload on each rod bolt = 25,445 lbs or about 12.7 tons
Margin of Safety (MOS) = 250%

• Using ARP 3.5 rod bolts
Bolt stretch = .0073" which = 90% of yield strength
Clamp-up preload on each rod bolt = 23,821 lbs or about 11.9 tons
Margin of Safety (MOS) = 227%

As you can see above in all 6 examples, whether torqued the traditional way to a lower stretch value, or stretched to the more recently called for higher percentage of yield value, all these rod bolts are above the minimum 125% MOS target for safety and reliability. Therefore, all these configurations would operate without issue, just like a stock grocery getter. So, if a builder chooses any of these bolts or stretch values between the 127% and the 250% "Margins of Safety" above, he could NOT go wrong, no matter how much HP the motor makes. Remember that HP has NOTHING to do with the max tension loads on rod bolts.

Since most Hotrods, Street/Strip cars, and Sportsman Drag cars, with their lower number of cycles, can live almost indefinitely with some of the more affordable mainstream rod bolts above, it's rather hard to make a case for using the much more expensive and higher strength 625+ or 3.5 bolts, even if they do have higher fatigue life values.

BOTTOM LINE

So then, all we REALLY NEED, from a conservative Engineering standpoint, is to at least reach the 125% MOS target for safety and reliability, no matter how much HP is being made. And anything above that 125% is fine, but not necessary.

But, things aren't always wine and roses, because some engines will NOT stay together and live like the well built configurations above. I've done "failed" rod bolt "Strength Analysis" on two smaller very high revving engines, after the fact, to take a look at why they failed. One blew-up catastrophically when a rod bolt broke, costing its owner 20 grand. And the other engine was found to have rod bolts stretched beyond the yield point, during a teardown for other reasons. So, its fuse had been lit, but fortunately it was caught just in the nick of time before they let go, saving its owner a ton of money and agony.

In both cases, the rod bolt "Strength Analysis" revealed that they had been built wrong, and that they were well BELOW 100% MOS, which predicts premature rod bolt failure. One had only a 67% MOS and the other had only an 86% MOS. If rod bolt "Strength Analysis" had been performed before these engines were built, during the planning stages, then all that grief and cost could have been avoided. They have since been rebuilt much stronger, with MOS values now well ABOVE that 125% safe target. And they have now been raced for some time without issue.

SUMMARY

• ARP 8740 chrome moly rod bolt – a strong affordable rod bolt, but it has only a moderate fatigue life, which makes the ARP 2000 rod bolt which is in the same general price range, a much better choice since it has twice the fatigue life.

• ARP 2000 rod bolt – considering how good its strength and fatigue life are, this rod bolt is an excellent choice for most Hotrods, Street/Strip cars, and Sportsman Drag cars.

• ARP L19 rod bolt – the strength and fatigue life increases this bolt provides over the ARP 2000 are not significant enough to overcome the concerns the L19 has with hydrogen embrittlement, stress corrosion, and the fact that it CANNOT be exposed to any moisture, including sweat and/or condensation. Don't forget that every engine forms condensation inside, at every cold start-up. Plus, oil rises to the top of, and floats on water because of density differences, which can leave portions of the rod bolts exposed to water even after the engine is built. Therefore, it is best to avoid the L19 rod bolt altogether, especially since the ARP 2000 rod bolt already provides way more than enough strength and fatigue life than is typically required by most Hotrods, Street/Strip cars, and Sportsman Drag cars. So, there simply is no good reason to select the ARP L19 rod bolt. If you are currently running L19 bolts, I'd suggest you consider replacing them with different bolts the next time you have the motor apart.

• ARP Custom Age 625+ rod bolt – a very pricey bolt, but with its excellent strength and its impressive fatigue life, this bolt is one of the very best rod bolts on the market.

• ARP 3.5 rod bolt – this bolt has excellent strength, but its staggering cost is 43% HIGHER than the 625+ bolt, yet the 625+ bolt is superior to the 3.5 bolt in virtually every way. So, there is no good reason to select the 3.5 bolt either.

CONCLUSION and RECOMMENDATION

Of the 5 rod bolts above:

• The ARP 2000 rod bolt is an excellent value, considering how good its strength and fatigue life are. And it should be considered the rod bolt of choice for most Hotrods, Street/Strip cars, and Sportsman Drag cars, no matter how much HP they make. And this is why you most often see quality aftermarket rods come with these bolts.

• ARP Custom Age 625+ rod bolt has a price that is not for the faint of wallet, but it should be considered the rod bolt of choice for very high revving engines, road race engines, and endurance engines, which require the utmost in rod bolt strength and/or fatigue life.
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3. SOLID ROLLER LIFTERS – BUSHINGS VS NEEDLES, WHICH IS BEST?

Discussions about running solid roller lifters in BBC's, can be a hotly debated topic. The debate breaks down into two sides. On one side is the traditional needle type solid roller lifter and on the other side is the newer and much higher load rated bushing type solid roller lifter.

Let me say right up front, that I have no agenda here at all. The purpose of the following write-up is only to share the findings that came out of my "root cause failure analysis" investigation into needle bearing failures in solid roller lifters. By sharing the results of my investigation, I thought it could help fellow Hotrodders and Racers to make a better informed buying decision. I have only good intentions about sharing this data, because I feel that everyone deserves to know the truth about what's been going on, and how the two types of lifters compare.

Personally, I do not sell lifters, nor do I work for a company that does. So I have no stake in what particular brands or models of lifters are good, bad or questionable. Therefore, I have no stake in what lifters are purchased either. I also don't care what parts other people run in their motors. That's up to them. The info I provide here is not based on emotion or personal preference. It is simply based on the Engineering facts, and followed up with my thoughts based on those facts. That's it, nothing more.

It is not exactly clear how high the failure percentage is with the needle type solid roller lifters. But these failures have been a significant issue for BBC's, for some years now, and are still happening. Over the last several years, most of my BBC friends, buddies and acquaintances, as well as numerous participants from various Hotrod and Racing Forums, have experienced premature needle type solid roller lifter failures, associated with the needles, axles and/or roller wheels.

The engine damage has ranged from just the lifters themselves, all the way to major engine destruction, requiring a total rebuild. This is not something new. Among the people I know who've experienced premature failures, it spreads from California to Nova Scotia, and from mild to wild engines. There is certainly more of a potential for these needle type lifters to fail, than there is with any other component inside a BBC. Whatever the true failure percentage is, it is way too high to simply ignore altogether. So, it would be wise to at least take that into consideration when it comes time to purchase a set of solid roller lifters.

Comp Cams has said that the life expectancy of their ENDURE-X "needle type" solid roller lifter in street driven BBC's is ONLY 2,000 MILES!!! And those lifters are pressure fed, come with precision sorted needles, and have wear resistant tool steel axles. And in Isky's ads for their "bushing type" EZ-Roll solid roller lifters, they say that with these lifters, you'll never worry about needle bearing overload or premature roller bearing failure again, because they provide 350% higher load rating than comparable needle type solid roller lifters. And now many other Companies are following Isky into the bushing type solid roller lifter market. So, all of these lifter manufacturers certainly recognize the fact that needle type solid roller lifters have some serious durability/longevity short comings.

While solid roller setups do make the most power, they can also decrease the valve train's life expectancy, compared to what you would generally expect from other types of lifters. Failures of needle type pressure fed solid roller lifters as early as 3,000 to 5,000 miles, or even earlier with street driven BBC Hotrods is not that uncommon. Even the highly regarded Morel needle type solid rollers that they supply to Lunati, have failed at about 5,000 miles in an 850 HP BBC Street/Strip Hotrod. So, there is nothing magical about those particular lifters either.

However, one of the earliest and nastiest failures that I am aware of, was from a set of Isky Redzone needle type lifters that suffered needle/axle failure at only 1,500 miles in another Street/Strip BBC Hotrod, and wiped out the whole engine. But the single "earliest" failure that I'm aware of was from a set of Isky Redzones needle type lifters that suffered needle/axle failure at only 1,200 miles in a mild BBC Street Hotrod.

But some folks think that if they choose the right oil, they can keep their pressure fed solid roller lifters in good shape. But the fact is, that no matter what oil you run, even all the way up to high zinc/phos Racing Oils that cost around $20 per quart, your pressure fed solid roller lifters can still fail at a time/mileage that most of us would consider premature. So, even if you use the best oil money can buy, it cannot save you. That's because these lifters typically do NOT suffer from oil related failures (more on that below).

Of course there are some who maintain that pressure fed solid roller lifters don't experience premature failure, with their owners wondering what all the fuss is about. But reasonable longevity, as a good number of people have found out the hard way, is not guaranteed. Having these lifters reach an acceptable life span, can be just the luck of the draw and not something that you can bet your engine on.

And no matter how well built your engine is. No matter how much valve spring pressure you have. No matter how good your rocker geometry is. No matter what brand of lifter you have. No matter how often you change your oil. No matter what lifter to bore clearance you run (more on that below). At the end of the day, there are only two kinds of pressure fed needle type solid roller lifter users. Those who have had premature failures and those who are vulnerable to premature failures. These lifters are absolutely NOT bullet proof. In fact they are essentially a ticking time bomb waiting to go off, as you will see below.

When I first looked into this issue, the needle type solid roller lifter failures were a very often discussed problem, and no one ever made any attempt to determine what the root cause of the failure was. So, I decided to look into it myself for my own reason. And that reason was that I was building a Street/Strip 540 BBC for myself, and I did not want the engine destroyed by failed needle lifters.

So, I decided to perform a root cause failure analysis, in order to get to the bottom of this all too common premature failure issue. While it is difficult to accurately say just what the failure percentages are, I at least wanted to inspect failed examples and determine why those that had failed, did fail. To that end, I collected a few sets (I would have liked a much larger sampling, but these were the only examples I could get my hands on at the time) of FAILED standard diameter .842″ BBC pressure fed, needle type solid roller lifters. These failed lifters were different name brands, and had used different name brands and viscosities of high zinc/phos oils. And they were from different performance level engines, ranging from relatively MILD to relatively WILD.
FACTS FROM THE INVESTIGATION:

The engines' specs are:

*** 408ci BBC, 243*/249* duration at .050, .663″/.655″ valve lift, .024/.026 hot lash, 210 lbs on the seat valve spring pressure, 567 lbs on the nose valve spring pressure, 15W40 Chevron Delo motor oil, Isky Redzone lifters, 6300 max rpm. These failed at about 3,000 nearly all street miles. This is a relatively mild BBC Hotrod, so failures are certainly NOT limited to only super High Performance motors.

*** 540ci BBC, 266*/272* duration at .050, .678″/.688″ valve lift, .016 hot lash, 260 lbs on the seat valve spring pressure, 650 lbs on the nose valve spring pressure, 20W50 Redline motor oil, Crower HIPPO lifters. These started to fail at about 5,000 nearly all street miles. This is a stout Street/Strip BBC Hotrod.

*** 632ci BBC, 277*/292* duration at .050, .848″/.824″ valve lift, .026/.028 hot lash, 325 lbs on the seat valve spring pressure, 875 lbs on the nose valve spring pressure, 20W50 Mobil 1, Redline, and Royal Purple XPR Racing Oil, Crower HIPPO lifters, 7200 max rpm. These failed after 1 1/2 years. Mileage and driving style not documented. This is an example of a BBC Race motor.

Careful root cause failure analysis revealed that oiling had played no part what so ever in these failures, but they all had suffered needle/axle failure due to the EXACT SAME root cause – METAL SURFACE FATIGUE FAILURE. This is exhibited by extensive flaking and pitting of the metal's surface, which is called Spalling. With loose flakes floating around, and the surface no longer smooth and round, the needles can stop rolling and start sliding, thus forming flat spots, which just speeds up the failure process all the more.

This metal fatigue failure comes from excessive loading in general, and from excessive shock loading/hammering in particular. These lifters are way too small for the loads they typically see. And as such, they are a poor design for this application, when it comes to any certainty of a long life. So, it really is not surprising that they are susceptible to failure. After all, jack hammering is designed to destroy things.

And if that isn't bad enough, I also found that only the 3 bottom needles are in "load-bearing" contact when the lifter is loaded down. On top of that, the needles only make a "line contact", which means extremely high localized pressure on the needles themselves, as well as on the axle and on the roller ID. And not only had the needles/axles failed, as is normally the case, but the roller OD's, which are also subject to metal surface fatigue failure, had also failed or were starting to fail, depending on the particular set in question. And the larger the lash had been, the worse the lifters had failed.

As for lifter to bore clearance: The smaller the clearance, the less the lifters can tilt to the side, and the more the load is evenly applied across the whole length of the needles, axle and roller wheel, which can help postpone lifter failure a little. And the larger the clearance, the more the lifter can be severely loaded on only one end of the needles, axle and roller wheel, due to lifter sideways tipping. And that just makes this whole problem go from bad to worse, thus accelerating the failure. So, for that reason, I'd recommend not exceeding .0015" lifter to bore clearance with .842" lifters.

Keep in mind that for iron and steel, the coefficient of thermal expansion is essentially identical. What that means is that the lifter to lifter bore clearance will stay virtually the same from cold to hot engine temps. Therefore, that max recommended clearance of .0015" is more than enough. Remember the rule of thumb for iron/steel parts is, .001" clearance for every 1.0" of diameter. So, by that rule, .842" lifters really only need .000842" inches of clearance, which means that .0015" clearance is nearly twice what they actually NEED. Any more clearance than that, and you are only making things worse for the lifters.

Spintron testing has shown that the lifters can bounce up and down on the cam's base circle, within their lash slop. So, the larger the lash, the more severe the shock loading/hammering can be, even with proper spring pressures. Because the lifter isn't always going to be in a position to follow the lobe's clearance ramp as intended, but instead it will hit hard somewhere on that ramp. So all the effort the cam designer put into designing that clearance ramp, will have no effect at all on how hard the lifter hits, at the point of actual contact.

And of course if an engine isn't built right, and the spring pressures aren't high enough, Spintron testing has also shown that in this case, the lifters can even bounce the valves up and down off their seats as well. This obviously just makes things go from bad to worse.

So, no matter what Super Duper brand or model of lifter you run, due to this repeated shock loading/hammering, you can still end up with prematurely failed pressure fed needle type solid roller lifters.

After I determined the root cause of these failed lifters, I pulled a brand new set of Crower Severe Duty needle type HIPPO lifters out of my 540ci BBC and put in a set of Isky bushing type EZX's (a particular version of the EZ-Roll design).

The EZX's bushings spread the load way out across the axle's surface, thus greatly reducing the localized pressure between them. As Isky has stated, they have a 350% higher load rating than needle type solid roller lifters. However, even this bushing type of lifter is still subject to roller OD surface fatigue failure, but at least the highly vulnerable needles are gone.
SUMMARY/SUGGESTIONS:

1. The overall big picture failure percentage is still unclear, but to be on the safe side, I recommend NOT running needle type solid roller lifters, no matter what brand, no matter how expensive they might be, and no matter what their marketing hype says. Because the needles and their axles are by far the most vulnerable to premature metal surface fatigue failure, even if they have high pressure pin oiling.

Failures with these needle type lifters can include the lifters themselves, the cam, and the block's lifter bores. And in the worst case, which is not that unusual, they can wipe out the whole engine, requiring a total rebuild. If you do choose to run needle type solid roller lifters anyway, rather than upgrading to the much higher load rated bushing type, you may well be playing Russian Roulette with your engine. And you'd need to ask yourself, is it REALLY worth risking potential engine destruction, when a far superior, much more durable alternative is readily available?

Clearly the best plan to try and avoid the potential for failure, is to upgrade to the "non-needle" bushing type pressure fed solid roller lifters, which have a much, much higher load rating. Although there are now a number of different bushing lifters on the market, one of the most popular lifter of this kind, is the Isky EZX bushing type solid roller lifter. While there is no such thing as a bulletproof solid roller lifter, these lifters are about as close as you will get.

2. Try not to exceed .0015” lifter to bore clearance with .842” lifters. The smaller the clearance, the more the load is spread out and evenly applied across the whole axle, bushing/needles and roller wheel, which can help postpone lifter failure a little. And the larger the clearance, the more the load can be applied to only one end of the axle, bushing/needles and roller wheel, due to lifter sideways tipping, which can drive up localized loading and increase the likelihood of failure.

3. Run the smallest amount of lash that you can live with. Because reduced lash will allow less clearance slop for the lifter to bounce around in. And not being so far out of position on the lobe’s ramp, can help to somewhat reduce the shock loading/bouncing/hammering that the lifters will see, no matter how well that cam lobe ramp is designed.

4. Since you cannot escape metal fatigue failure, it is best to try and replace/rebuild the lifters at frequent enough intervals to head off failure before it catches up with you. But failure intervals are unpredictable and can vary widely, which makes it very difficult to decide on a maximum interval to follow. The most common failure interval that I’m aware of, not limited just to those I personally inspected, seems to be between 3,000 and 5,000 miles, though it’s not that unusual for them to fail much sooner than that, as mentioned above. With that being the case, personally I’d never exceed 5,000 miles, as a rebuild/replace max limit.

All you can really do is use your best judgement here. I recommend being on the conservative side, because the engine you might save will be your own. But at least with bushing type solid roller lifters, all we have to be on the lookout for is roller wheel OD surface fatigue failure, since they don’t use the “vulnerable to failure” needles.

5. You could also “consider” running a rev kit, if that is reasonable for your application. It “may” help a little by keeping the lifter in contact with the lobe. But engines equipped with rev kits, that were still running the normally “called for” loose lash, have still suffered premature pressure fed needle type solid roller lifter failures. Even though a rev kit will keep the solid roller lifter in contact with the lobe, base circle and ramps, you still most likely are running the recommended sloppy loose lash. All that slop didn’t just magically go away because the lifter stays in contact with the cam. It still has to be taken up somewhere, and that somewhere is taken up with hammer blows to the pushrod/rocker arm, when the lifter smacks into pushrod, and/or when the pushrod smacks into the rocker. And all that shock loading gets reacted at the roller/axle/needle interface with the lobe. So, rev kits don’t really seem to help all that much.

6. Don’t lose any sleep over what oil brand or viscosity to run, how often to change it, or whether or not it has high or low levels of zinc/phos, because it won’t make any difference when it comes to metal fatigue failure. Just use your favorite oil and change it at your normal

interval. Though running a high quality oil with excellent film strength is always a good choice in general.

7. Beyond what is mentioned above, all you can really do is just keep a close eye out for any unusual changes in lash, to try and catch a failure in its early stages, before too much damage is done.

Only "hydraulic" roller setups, that don't have such radical lobes, don't have such high spring pressures, don't see such high rpm, and have no lash, thus no bouncing/hammering/shock loading, seem to have an acceptable record of a good life expectancy on the street, in most cases. So, these are the lifters that really "should" be used in street driven Hotrods.

But of course a lot of us choose to run solid roller lifters on the street anyway, for the performance capability they provide. But truth be told, this type of lifter is really only intended for race engines. So, we have to deal with their shortcomings when they are used in street driven Hotrods, which is not really the correct application. Because of course, street driven Hotrods see way more time/mileage/jack hammer pounding cycles than race engines ever will.

BOTTOM LINE: Solid roller lifters are very high maintenance parts when run on the street. And to be on the safe side, they will need to be rebuilt/replaced at frequent intervals, when used in that manner. They are probably the weakest link in most street driven BBC engines. And just installing them and forgetting them, can be very risky.

We have generally pushed this nearly 60 year old basic pushrod engine design about as far as we can. And to totally eliminate the potential for lifter failure, we'd need to upgrade to a more modern overhead cam design. But for those of us who still choose to run our beloved traditional BBC's, we'll just have to deal with this potential problem as best we can. That's the price we pay for power.

Everyone will have to make their own decision about what lifter type they choose to run. But you'll find the much higher load rated, bushing type Isky EZX solid roller lifters, with a much higher margin of safety, in my 540 BBC.

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4. CAMSHAFT OVERLAP VS LSA (LOBE SEPARATION ANGLE)

Let’s take a look at which method makes the most sense for selecting a cam, LSA (lobe separation angle) or Overlap and Duration. Many cam designers and engine builders will tell racers, hot rodders and gear heads to start with some particular LSA for choosing a cam. And of course you hear guys say, that they are going to be picking a new cam, and that they will be using “such and such LSA”, but that they haven’t yet decided on the lift and duration. And they don’t even consider the specific overlap value at all.

The whole idea of starting with some given LSA as a starting point, simply makes no sense at all. Here’s why: LSA has no value at all, in and of itself, because of the fact that it is “overlap” that defines an engine’s operational characteristics. And LSA is merely a “by-product” of that overlap. In fact, Comp Cams guru Billy Godbold and I share the same philosophy about that. And he said this:

“LSA doesn’t mean anything except for how it affects the camshaft centerlines. You determine the centerlines, which determines OVERLAP, and THAT has performance effects.”

Here’s an example of what we are talking about.
Let’s say some old time cam designer or engine builder tells a young kid that he should use a 110* LSA for an old 327 ci flat tappet SBC that he wants to do his first modification on. So, the kid pulls out a Comp Cams catalog and looks up solid flat tappet cams for it. And since he was told to go with a 110* LSA as a starting point, he comes across these two cams that have the 110* LSA as was recommended, as well as the following “advertised duration” and “.050 duration”:

CAM..…………ADV DUR…………….. .050 DUR
#1……………….256*/262*……………….218*/224*
#2……………….306*/306*……………….260*/260*

Now, anyone at all familiar with cams would see a very significant difference between these two cams. Old Pro’s know what they are seeing, but the kid can’t tell much about them. And yet they both have the SAME EXACT recommended 110* LSA. So, targeting that particular LSA didn’t tell the kid anything at all in terms of how the cams will operate/perform in his engine. But if he’d calculated “advertised overlap”, using the procedure below, he’d get advertised overlap values of:

Cam #1 = 39*
Cam #2 = 86*

There is obviously a HUGE difference between these advertised overlap values, but again, these two cams have the SAME EXACT 110* LSA. Now if he looks at the adv overlap reference chart below, he'd see that cam #1 falls between the "ordinary street" and "street performance" categories. So, that cam isn't much more than Granny's grocery getter cam. But, cam #2 falls fully into the "race" category, making it a wicked cam by any measure. Now the kid can see that they are radically different cams, even though they have the SAME EXACT 110* LSA. So, it took the "overlap" to finally show him that he is dealing with two entirely different cams that have COMPLETELY DIFFERENT operational characteristics.

This clearly shows how LSA, all by itself, does NOT make a distinction between operational characteristics, and is virtually useless in defining a cam. But on the other hand, ADVERTISED OVERLAP absolutely DOES define a cam's operational characteristics, every time. So, it makes much more sense to go in knowing how much overlap you want, then select a cam based on that, which will best meet your needs. Now the kid can make a much more informed buying decision.

As shown above, cams can be wildly different with the SAME EXACT LSA, but ADVERTISED OVERLAP will always show you what's going on. and here are some reference examples of how various overlaps compare :

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"APPROXIMATE" SOLID LIFTER ADVERTISED OVERLAP PERFORMANCE REFERENCE CHART

300ci…………………400ci…………………500+ci……….Typical usage
10*……………………25*………………. ….40*…………. towing
30*……………………45*……………….. ….60*…………..ordinary street
50*……………………62.5*…………….. ….75*……………street performance
70*……………………80*……………………90*…………..street/strip
85*……………………92.5*…………………100*…………..race
95*……………………105*…………………115*…………..Pro race

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Here's the CORRECT way to calculate your cam's ADVERTISED OVERLAP which is needed for the chart above:

• Add your intake and exhaust advertised duration (typically shown as duration at .015 tappet lift. NOTE: duration at .050 tappet lift will NOT give you the correct advertised duration value)

• Divide that answer by 4

• Subtract the lobe separation angle (LSA) from that answer

• Multiply that answer by 2, and you have the CORRECT advertised overlap to use in the chart above

NOTE: Because of the differences resulting from not having any lash, and the way hydraulic cam advertised duration is rated, if you want to figure the “advertised overlap” for a HYDRAULIC LIFTER cam, so that you can use the chart above, REDUCE the Hydraulic cam’s listed ADVERTISED DURATION (typically shown as duration at .006 tappet lift) by 8*, for both intake and exhaust, then follow the calculation procedure as shown above.

If you consider OVERLAP rather than LSA, you can make a much better decision about the cam you select for your next build.

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5. LEAK DOWN TEST vs COMPRESSION TEST – WHICH IS BEST?

Using a compression tester to check the basic condition of an engine is better than nothing, but it is NOT the best choice. Compression test results can be inaccurate and inconsistent. This is because the condition of the battery, variations in ambient temperature, and the effects of the presence or lack of oil around the rings which helps seal them, as you go from the first cylinder to the last cylinder, and/or if the engine has been sitting, can all affect the results. This makes a compression test only a mediocre unreliable test at best.

Leakdown testing is by far the BEST METHOD for checking an engine’s basic condition. It is done by checking each cylinder at TDC of the compression stroke. And any leakage heard, helps to pinpoint where any problems are located. Air leaking out of the carb indicates a leaking intake valve. Air leaking out of the exhaust system indicates a leaking exhaust valve. Air leaking out of a breather indicates ring leakage. And air leaking out of the radiator cap opening indicates a leaking head gasket.

I’ve tested the 3 different types of leakdown testers.

One is a single gauge tester that reads leakdown percentage directly. This one is NOT recommended because its accuracy is typically not the best.

Another one is a dual gauge “low input pressure (typically around 35 psi or less, depending on the particular unit)” type that has one psi gauge and one gauge face that shows leakdown percentage directly. These are usually fairly inexpensive, and are also NOT recommended because of their typical inaccuracy.

And the last type is a matching dual psi gauge “high input pressure (usually can go up to 100 psi)” type. This type is convenient to use, and has good accuracy, making it clearly the best of the 3 leakdown tester types. So, if you decide to get a leakdown tester, do yourself a favor and get this type.

Note: Input pressure can be referred to in two ways, static and dynamic. Static means you set the regulator to the desired input pressure, say 80 psi (more on that below) with the tester NOT connected to the engine yet.

Then once you do connect the tester to the engine, the pressure will drop somewhat, becoming dynamic input pressure. You can then readjust the regulator to bring that dynamic input pressure back up to the original 80 psi, if you want. But I’ve found no difference at all in the final leakdown percentage results between doing that, or just letting the pressure drop somewhat and leaving it there. So, the most convenient method is to simply set the static input pressure to 80 psi and simply leave it.

The way to get to the final answer for a given test is:

For example, after you connect the 80 psi static pressurized tester to the engine, the left side regulator controlled gauge may say something like 70 psi after it drops, while the right side engine leakage gauge may say something like 65 psi.

You just plug a few numbers into your calculator, in the following manner:
You ask yourself, 65 psi on the leakage gauge is what % of the 70 psi on the dynamic input pressure gauge? And you punch into the calculator 65/.70 (don’t forget that its “point” 70 here) and the answer comes up 92.8, which means that the right side leakage gauge is showing or holding 92.8% as much as the left side input gauge. And because the original 70 psi dynamic input pressure was 100% of the dynamic input pressure, you simply punch into your calculator 100 – 92.8 = 7.2% leakage in that cylinder, which is your final accurate answer for that cylinder. That’s all there is to it.

For those who don’t use much math, that may seem like too much trouble. But if you read through what was done a couple of times, and then actually do it a couple of times, you’ll see that it’s no big deal at all. And you’ll be crunching the numbers freely after the first couple of cylinders.

There is no universally accepted input pressure for automotive leakdown testing. But the FAA (Federal Aviation Administration) has established 80 psi input pressure as their standard for leakdown testing on piston aircraft engines. And they allow up to 25% leakdown in those aircraft engines.

That 80 psi input pressure works perfectly fine for car engines too, so I use that as my input pressure as well.

And the reference chart I use for COLD leakdown testing on High Performance Engines is:

0-10 % = good condition

10-15% = though not ideal, still acceptable

over 15% = tear down and repair recommended for optimum performance

(for non-performance daily driver/grocery getter type vehicles, over 30% = tear down and repair recommended)

As a point of reference, my 540ci BBC Street/Strip engine shows a COLD leakdown of about 3%, using conventional Speed Pro rings, with a top ring end gap of .021" and a second ring end gap of .027". And keep in mind that anytime you do a leakdown test, at least with conventional rings, you will hear some air leakage. Even for the small amount of leakdown that my engine shows, I can still hear some air leakage hissing out of the breathers, from the ring end gaps.

Here's the excellent leakdown tester that I use and like real well. It's from "Goodson Tools and Supplies for Engine Builders"

Dual-Gauge Leak-Down Tester & Replacement Parts (http://www.goodson.com/Dual-Gauge_Leak-Down_Tester/)

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6. CAN YOU REALLY SUCK THE OIL PAN DRY?

From time to time, you will hear someone claim they had an issue with sucking the oil pan dry because of running a high volume oil pump. But, sucking the pan dry because of the oil pump size is only an OLD WIVES' TALE with no truth to it at all. An oil pump can only pump as much oil out of the pan, as the motor will bleed off through all its clearances. Beyond that, the oil pump reaches bypass pressure and simply returns any excess oil to the pump's intake side, or else the relief valve releases the excess oil directly back into the pan. Either way, it's not sucking that extra amount of oil out of the pan. Therefore, it's leaving a larger volume of oil "in" the pan. And if for some reason the bypass isn't large enough, then the pressure would HAVE TO GO UP.

Once an oil pump reaches bypass pressure, it makes no difference whether the pump is std volume or high volume, it won't drain oil from the pan any quicker. Pressure is pressure, no matter how it is generated. So, if a std volume pump can't pump the pan dry, then neither can a high volume pump at the same pressure.

In order to suck the pan dry, you'd have to have "insufficient drain-back". Blaming the pump, would be misidentifying the problem. Sure the pump gets the oil up to the top, but its drain-back that gets it back to the pan. So, just be sure that you have plenty of drain-back capacity and it would be impossible to pump the pan dry.

While dyno testing my 540ci BBC with .003" clearance on the rods and mains, using 5W30 synthetic oil, and using a Titan "high volume" gerotor oil pump, it maintained a rock steady 80 psi (the preset relief valve setting) from about 5,000 rpm on up, with no pressure drop AT ALL. So, there was no sign of aerated oil. Now, with a pump that big, generating that much oil pressure, and using oil that thin, if an engine was ever going to pump the pan dry, that should have been it, right?

But it never happened, and it maintained oil pressure better than most I've seen. The thinner oil will also drain back better, but it will have also passed more oil through the engine, providing better flow/lubrication and cooling. One thing I did during the engine build, was to enlarge the drain-back holes in the AFR heads, to twice their original area. And if that's all it took for sufficient drain-back to keep from pumping the pan dry, then keeping the pan full of oil is NOT Rocket Science.

NOTE: The information here about oil pumps and oil drain-back, as it relates to concerns about an engine sucking its own oil pan dry, absolutely applies to statically mounted engines on a dyno as well as to engines being operated dynamically in a vehicle. The only difference is that engines being operated dynamically in a vehicle also have the additional requirement for an oil pan design that will keep the oil pump pickup submerged in oil during dynamic operation, rather than letting the oil be sloshed away from the pickup, which would starve the engine of oil. But, starving the engine of oil because of oil being sloshed away from the pickup, and concerns about the engine sucking its own pan dry, are NOT the same thing.

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7. DYNAMIC COMPRESSION RATIO (DCR) VS STATIC COMPRESSION RATIO (SCR)

Most every gearhead believes that he understands compression ratio numbers, and simply takes them at face value. The normal compression ratio that everyone talks about and see's on spec sheets is technically called "STATIC" compression ratio (SCR). That is always "THE" compression ratio being discussed unless otherwise specified.

And it of course comes from:

The total cylinder/head gasket/combustion chamber volume at BDC (bottom dead center), which we will call "V large".

Then divide that total volume at BDC by the combustion chamber volume at TDC (top dead center), call that "V small". So, you have (V large / V small) = Static compression ratio. As the name implies, it is a ratio of the max total volume divided by the small volume.

The 4 strokes are of course:

1. Intake
2. Compression
3. Power
4. Exhaust

And that's all well and good for textbook learning, but in a real running engine, things aren't so cut and dried. The "problem" is that an engine never "see's or feels" the static compression ratio number. So, that makes the static compression ratio more or less a theoretical reference tool.

The difference in a running engine is that the cylinder volume needed to determine a running or Dynamic compression ratio (DCR), is not calculated with the piston at BDC. It is calculated with the piston at the position where the intake valve just closes. It is only at this point, that true compression can actually begin.

Here are the Intake and Exhaust valve timing events at .050" tappet lift (meaning lobe lift or lifter lift, NOT valve lift), per my 540ci BBC engine's cam card:

In. opens at 25* BTDC (before top dead center)
In. closes at 61* ABDC (after bottom dead center) = 266* duration at .050 tappet lift

Ex. opens at 64* BBDC (before bottom dead center)
Ex. closes at 28* ATDC (after top dead center) = 272* duration at .050 tappet lift

As you can see, there is overlapping everywhere. This is done to optimize engine performance by making use of dynamic intake charge ramming effects and dynamic exhaust gas scavenging effects. So, actual running engine specs don't fit neatly into the basic idea of the simple and separate 4 strokes. In order to calculate DCR from a useful intake valve closing point, rather than the .050" tappet lift timing shown above from the cam card, you need to use the Cam maker's advertised tappet lift value.

For my Comp Cams steel billet solid roller cam, the advertised duration specs are given at .015" tappet lift. But my cam card does not provide the actual intake and exhaust timing events at that .015" tappet lift spec. So, I manually measured and calculated the piston/crankshaft position at the intake valve closing point based on .015" tappet lift of my actual engine. I did this during engine assembly mock up, where I could also take into account valve lash, rocker arm geometry, and rocker arm ratio. By doing it this way, I ended up with very precise numbers, which were used to get the most accurate final results. But, to get numbers this precise, it required that I determine the actual DCR after the fact, rather than determining it before buying any parts. So, I had to make some careful calculations earlier, in order to end up as close to my target as possible.

I ended up with my intake valves closing at 80.5* ABDC (or only 99.5* from TDC, rather than the theoretically ideal of BDC or 180* BTDC). This position had the piston 2.805" from TDC. And considering that my stroke is 4.250", this means that my piston had traveled 34% up the cylinder before the intake valve had closed, and compression could finally begin. I have a fairly large bad boy street/strip cam, and the larger the cam's duration, the later the intake valve will close.

Then to do the calculations for DCR, it's from the total cylinder/head gasket/combustion chamber volume at the point of intake valve closing. Call that value "DV large". Then divide all that by the combustion chamber volume at TDC, the same value that was used above to calculate the SCR, which was called simply "V small". So, you have (DV large / V small) = Dynamic compression ratio. As the name implies, it is a ratio of the large volume divided by the small volume. It is of course the same process that is used to determine SCR, except for the

DCR, the large volume (DV large) is a much smaller value. And since the TDC volume (V small) was used for both SCR and DCR calculations, you can see how changing that TDC volume will change both types of compression ratio's. They are linked by that "V small" value.

After crunching all the numbers, I ended up with an actual running engine compression ratio, or dynamic compression ratio (DCR) of 7.43 to 1. So, my two compression ratio numbers are:

Static Compression Ratio (SCR) = 10.75:1, which is the one seen on spec sheets
Dynamic Compression Ratio (DCR) = 7.43:1, which is the one the engine actually see's/feel's

You can see that the dynamic compression ratio is a far cry from the more commonly referenced static compression ratio of 10.75 to 1. This 7.43 DCR is what the engine actually see's/feel's and is what primarily determines its octane requirement. And as you have seen by now, the cam and its intake valve closing point, is the primary factor for determining an engine's DCR. Change your cam, change you DCR.

If your Hotrod is on the ragged edge of detonating/pinging, you could switch to a cam with more duration, which will reduce your DCR and make the engine less sensitive to the octane it requires, because of a later intake closing point. That is just the opposite of what some folks might think. Because they'd likely think if their Hotrod was on the ragged edge of detonating/pinging, they'd need a milder cam. But, that would be going the "wrong" direction. Because a milder cam with less duration, would close the intake valve sooner, increasing the DCR. And that would make the engine even "more sensitive" to the octane it requires.

As an example, my cam has a 108* LSA (lobe separation angle), and the narrower this is, the sooner the intake valve closes, thus upping the DCR. And my cold cranking compression checked out to be 175 psi. But another very similar BBC engine with the same displacement and the same SCR, but with a wider 112* LSA, checked out to have only 165 psi cold cranking compression, due to its later intake valve closing, and thus lower DCR.

General approximate guidelines for DCR, though not absolute, are that a DCR of 7.5 to 8.5 will make best power for a street engine running 91 octane or higher. And the lower the DCR is in that range the better, for avoiding detonation problems.

Note: Race engines using race gas, can tolerate higher DCR's up to about as high as 9:1.

As you can see, my 7.43 DCR came in quite close to the conservative 7.5 DCR number I had been targeting. I wanted to stay at the lower end of the recommended range so that my engine could tolerate California's winter blend of pump premium, which has been known to fall below the octane number that we see with the summer blend. Call it adding a bit more margin of safety. Because detonation can cause ugly failures that you must avoid at all cost.

On top of that, I wanted to run a lot of ignition timing advance at low rpm, for crisp and quick throttle response. And staying at the lower end of the DCR range, allows me to do that without issue. It's also no secret that larger engines, say upper 400 cubic inches and above, are big enough that they can absorb a low DCR and/or big cams with ease, so that you won't even notice it.

BOTTOM LINE: The critical compression ratio that really counts, is the Dynamic Compression Ratio (DCR). OEM's of course design their engines based on DCR. That's why a lot of high performance, high rpm, factory stock engines with more cam duration and/or wider LSA's (which results in a later intake valve closing), are running higher SCR's, because that brings the DCR back into the desired range.

This lowering of the DCR, due to the late closing of the intake valve, is the reason why aftermarket Hotrod and Racing cam manufacturers spec a higher static compression ratio for their larger cams, because that gets the DCR into the proper range.

NOTE: HP = (Torque x rpm)/5252.

Little engines can make big HP, if you spin them to a high rpm. And in order to spin them to a high rpm, you need a large duration cam for the engine to breathe. But of course a large duration cam means a later closing intake valve, thus a lower DCR. So, you adjust the static compression ratio (SCR) to set the DCR to right where you want it. That allows you to have a very high performance engine that runs on ordinary pump gas. Here's an example of just that:

The 2011 Yamaha YZF-R6 (600cc in-line 4 cylinder Sport Bike)

Its short 1.673" stroke allows it to rev to a 16,000 rpm redline, with only a 74.4 ft/sec average piston speed, while still being under the OEM limit of 80 ft/sec.

And it's large duration cam that allows it to breathe enough to rev to 16,000 rpm, would have lowered the DCR unacceptably, except for the amazingly high 13.1 to 1 SCR which brings the DCR back up to an acceptable level. And the DCR is still set low enough so that even with the 13.1 SCR, it can still operate safely on ordinary pump premium gas.

After reading this, you may never look at the commonly referenced static compression ratio (SCR) the same way again. What is REALLY the most important compression ratio, is the Dynamic Compression Ratio (DCR). Because that is one of the primary factors determining how well your engine will run, and what its octane requirement will be.

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8. 0W40 vs 5W30 vs 0W30

On the Corvette C6, Z06 Forum, perhaps the most popular oil the U.S. guys like to use is what they call, the 0W40 Euro blend Mobil 1. This oil is what GM calls for in the Owner's Manual and also on the oil filler cap on C6 Z06's sold in Canada and Europe, whereas 5W30 Mobil 1 is called for in the U.S. The rationale the U.S. Corvette owners typically use for choosing this 0W40 Euro blend Mobil 1 instead of following GM's recommendation, is the thinking that this oil may have more zinc than U.S. oil, and their mistaken belief that more zinc and a higher viscosity can provide better wear protection, as well as their mistaken belief that 5W30 Mobil 1 is not very good.

Also, on "Bob is the Oil Guy" Forum, 0W30 Castrol Edge with Syntec (black bottle), API SL, European Formula, made in Germany and sold in the U.S., is very popular. This is apparently because they favor the better cold flowing 0W cold viscosity rating (which is a good idea), and because of the thinking that this oil may have more zinc than U.S. oil, and their mistaken belief that more zinc can provide better wear protection.

The Z06 guys as well as the Bob Forum guys, obviously feel this way based on emotion and guessing/speculation, because they clearly never had any test data to evaluate……………… until now.

All this calls for performing Engineering Wear Protection testing those 0W40 and 5W30 Corvette Z06 oils, as well as testing 0W30 oils, to see how they all compare. Then Z06 owners and the Bob Forum guys can take a look at actual hard test data numbers that will show the facts. With that information in hand, they can make an informed decision when it comes to selecting an oil that will truly provide them with the best wear protection.

So, I tested the following motor oils:

0W40 and 5W30 Pennzoil Ultra

0W40, 5W30 and 0W30 Mobil 1

0W40, 5W30 and 0W30 Castrol Edge with Syntec (in the black bottle)

NOTE: Castrol's top of the line 100% Edge motor oil, comes in the gold bottle.

The Wear Protection reference categories are:

- Over 105,000 psi = INCREDIBLE wear protection
- 90,000 to 105,000 psi = OUTSTANDING wear protection
- 75,000 to 90,000 psi = GOOD wear protection
- 60,000 to 75,000 psi = MODEST wear protection
- Below 60,000 psi = UNDESIRABLE wear protection

Here is how these oils ranked just among themselves, according to their Wear Protection Capability. All wear protection capability testing was performed at 230* F, and the higher the psi value, the better the wear protection. I also included values for the onset of thermal breakdown for comparison (the thermal breakdown values were rounded to the nearest 5* increment):

1. 5W30 Pennzoil Ultra, API SM synthetic = 115,612 psi, which puts it in the INCREDIBLE wear protection category.
The onset of thermal breakdown = 280* F

2. 5W30 Mobil 1, API SN synthetic = 105,875 psi, which puts it in the INCREDIBLE wear protection category.
The onset of thermal breakdown = 265* F

3. 5W30 Castrol Edge w/Syntec, API SN (black bottle, formerly Castrol Syntec) synthetic = 85,179 psi, which puts it in the GOOD wear protection category.
The onset of thermal breakdown = TBD (I did not test this particular oil for this when I had it on hand)

4. 0W40 Mobil 1, API SN, European Formula, made in the U.S., synthetic = 82,644 psi, which puts it in the GOOD wear protection category.
The onset of thermal breakdown = 285* F

5. 0W40 Pennzoil Ultra, API SN, synthetic = 81,863 psi, which puts it in the GOOD wear protection category.
The onset of thermal breakdown = 260* F

6. 0W30 Mobil 1, API SN, Advanced Fuel Economy, synthetic = 81,240 psi, which puts it in the GOOD wear protection category.
The onset of thermal breakdown = 290* F

7. 0W40 Castrol Edge with Syntec (black bottle), API SN, European Formula, made in Belgium and sold in the U.S., synthetic = 69,307 psi, which puts it in the MODEST wear protection category.
The onset of thermal breakdown = 290* F

8. 0W30 Castrol Edge with Syntec (black bottle), API SL, European Formula, made in Germany and sold in the U.S., synthetic = 69,302 psi, which puts it in the MODEST wear protection category.
The onset of thermal breakdown = 290* F

As you can see from these actual Engineering test values, all the 5W30 oils provide better wear protection than any of the 0W oils. But even so, any of these oils would be acceptable for normal daily driver use. However, for highly loaded High Performance applications where the best possible wear protection is desired, the obvious choice would be 5W30 Pennzoil Ultra, API SM or 5W30 Mobil 1, API SN, which are the only oils in this test that provide INCREDIBLE wear protection.

So, GM got it right about which oil to recommend in their U.S. Z06 Corvette's. One can only speculate that perhaps they expect the U.S. cars to be run harder, so they call for the best protection in those engines. Although, general availability in Canada and Europe may also play a part in what oil they recommend. Whatever the case, both oil viscosities had to meet GM's endurance testing requirements.

Folks can of course decide for themselves which oil they want to run in their own cars. But now, they have the accurate test data to make an informed decision.

NOTE: After this piece was originally written, 5W30 Pennzoil Ultra, API "SM" has been phased out and replaced TWICE by a newer API "SN" version. See the Wear Protection Ranking List in Section 1, for the current psi value and ranking position.

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9. AFTERMARKET ZINC ADDITIVES – DO THEY WORK?

Do aftermarket zinc additives actually work? To find out, I tested ZDDPlus zinc additive in 3 low zinc oils, and I also tested Edelbrock Zinc additive in 3 different low zinc oils. In each case, the recommended amount of additive was used. And in all 6 cases, these high zinc additives ruined the oils and made them WORSE than they were before the extra zinc was added, by SIGNIFICANTLY reducing their wear protection capabilities. These additives did the opposite of what was promised. That is not surprising, because most major Oil Companies say to never add anything to their oils, because doing that will ruin the oil by upsetting the carefully balanced additive package that their Chemical Engineers designed into them. And that is precisely what was seen when using these high zinc additives.

So, do yourself a favor and don't add any aftermarket zinc additives to your motor oil, because you will only make your oil's wear protection capability WORSE than it was to begin with, no matter what anyone tells you.

Here are the results of that testing:

* This combination ranked 113 out of 129 oils tested: "ZDDPlus" added to Royal Purple 20W50, API SN, synthetic = 63,595 psi
zinc = 2436 ppm (up 1848 ppm)
phos = 2053 ppm (up 1356 ppm)
moly = 2 ppm (up 2 ppm)
The amount of ZDDPlus added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 24% LOWER than this oil had BEFORE the ZDDPlus was added to it. Adding ZDDPlus SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

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* This combination ranked 122 out of 129 oils tested: "ZDDPlus" added to O'Reilly (house brand) 5W30, API SN, conventional = 56,728 psi
zinc = 2711 ppm (up 1848 ppm)
phos = 2172 ppm (up 1356 ppm)
moly = 2 ppm (up 2 ppm)
The amount of ZDDPlus added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 38% LOWER than this oil had BEFORE the ZDDPlus was added to it. Adding ZDDPlus SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

* This combination ranked 123 out of 129 oils tested: "ZDDPlus" added to Motorcraft 5W30, API SN, synthetic = 56,243 psi
zinc = 2955 ppm (up 1848 ppm)
phos = 2114 ppm (up 1356 ppm)
moly = 76 ppm (up 2 ppm)

The amount of ZDDPlus added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 12% LOWER than this oil had BEFORE the ZDDPlus was added to it. Adding ZDDPlus SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

* This combination ranked 125 out of 129 oils tested: "Edelbrock Zinc Additive" added to Royal Purple 5W30, API SN, synthetic = 54,044 psi
zinc = 1515 ppm (up 573 ppm)
phos = 1334 ppm (up 517 ppm)
moly = 15 ppm (up 15 ppm)
The amount of Edelbrock Zinc Additive added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was a whopping 36% LOWER than this oil had BEFORE the Edelbrock Zinc Additive was added to it. Adding Edelbrock Zinc Additive SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

* This combination ranked 127 out of 129 oils tested: "Edelbrock Zinc Additive" added to Lucas 5W30, API SN, conventional = 51,545 psi
zinc = 1565 ppm (up 573 ppm)
phos = 1277 ppm (up 517 ppm)
moly = 15 ppm (up 15 ppm)
The amount of Edelbrock Zinc Additive added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was a "breath taking" 44% LOWER than this oil had BEFORE the Edelbrock Zinc Additive was added to it. Adding Edelbrock Zinc Additive SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

* This combination ranked 128 out of 129 oils tested: "Edelbrock Zinc Additive" added to Motorcraft 5W30, API SN, synthetic = 50,202 psi
zinc = 1680 ppm (up 573 ppm)
phos = 1275 ppm (up 517 ppm)
moly = 89 ppm (up 15 ppm)
The amount of Edelbrock Zinc Additive added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 22% LOWER than this oil had BEFORE the Edelbrock Zinc Additive was added to it. Adding Edelbrock Zinc Additive SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

A motor oil's wear protection capability is determined by its base oil and its additive package (where the extreme pressure anti-wear components are added to the base oil) "as a whole", not just by the amount of zinc present. You will be best served by choosing a motor oil based on its wear protection capability, because zinc levels alone don't mean a thing. In fact, MANY WIPED

FLAT TAPPET LOBES COULD HAVE BEEN AVOIDED, INCLUDING DURING BREAK-IN, if people had not blindly believed that all high zinc oils provide all the wear protection they need. Because nothing could be further from the truth. Engineering testing has proven over and over again, that some high zinc oils provide excellent wear protection, while other high zinc oils only provide poor wear protection. And without wear protection test data, you have no way of knowing which ones are good and which ones are not.

The outdated thinking that high zinc levels are needed, is simply Folklore not based on the facts. No one can prove that more zinc provides more wear protection, because it is simply not true. Plenty of people will swear that you need high levels of zinc, but ask them to provide "proof" instead of mere opinion. They cannot do it because Physics and Chemistry proves otherwise.

Even though aftermarket zinc additives failed in every test, there were a couple of other aftermarket additives that did in fact improve motor oil wear protection capability. Prolong significantly improved every motor oil it was tested in, and Oil Extreme Concentrate significantly improved lower ranked oils.

Bottom line: If you really want to provide your engine with the best possible wear protection, read my entire Oil Test Data Blog, then make your own decision. The engine you save, may be your own.

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10. BREAK-IN OILS – DO WE REALLY NEED THEM?

First, a little background info so that we are all on the same page. The independent and unbiased Engineering testing I perform at a REPRESENTATIVE OPERATIONAL TEMPERATURE, to establish motor oil wear protection capability, is a dynamic friction test under load, similar to how an engine dyno test is a dynamic HP/Torque test under load. Both tests show how their subjects truly perform in the real world, no matter what brand names are involved, no matter what outrageous claims may have been made, and no matter what their spec sheets may say.

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My Motor Oil Wear Protection Ranking List of over 150 different oils, is “proven” by the Physics and Chemistry involved, and it EXACTLY matches real world Track experience, real world flat tappet break-in experience, and real world High Performance Street experience (test data validation doesn’t get any better than this). You can see the details on this, by going to the Oil Test Data Blog link below.

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And the data used to create my Wear Protection Ranking List is NOT my opinion, and it is NOT my theory. The data, as mentioned above, is the result of the Physics and Chemistry involved in the testing. I am only the messenger. The Science is what tells us how these oils perform. And no reasonable person would try to argue with Physics and Chemistry. The fact is, motor oil wear protection capability is determined by the base oil and its additive package “as a whole”, with the emphasis on the additive package, which is what contains the extreme pressure anti-wear components, and NOT merely by how much zinc is present. The use of zinc as the primary extreme pressure anti-wear component is outdated technology. Modern extreme pressure anti-wear components are equal to or better than zinc, which is why many modern low zinc oils outperform many traditional high zinc oils.

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So, think twice before believing anything the naysayers say when they try to discredit my Motor Oil Engineering Test Data. There are always some who try. They are not actually arguing with me, even if they think they are. They are actually arguing against Physics and Chemistry. Who do you think will win that battle? And ask them how they figure they know more than what the Science of Physics and Chemistry proves. Ask them what their qualifications are. Ask them what testing they have ever done.

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They are typically high zinc lovers who just can’t accept the fact that what they’ve always believed about the need for high zinc oils, is only an Old Wives Tale MYTH. So, they get upset and go out of their way trying to undermine anything that goes against what they have been brainwashed to believe about high zinc oils. But, emotion does not determine how good any particular oil is. Factual Engineering tests have proven over and over again that zinc levels alone DO NOT determine an oil’s wear protection capability. The naysayers cannot back-up anything they say, but I back-up everything I say with hard Engineering test data that exactly matches real world experience.

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My Test Data Blog now has over 95,000 views worldwide (at the time this was written). Of course simply listing the number of views by itself, is not intended to indicate validation of the test data (validation is shown throughout the Blog). But, indicating the number of views does show that an enormous number of people worldwide recognize the value, understand the importance, and make use of the motor oil test data FACTS included there, that cannot be found anywhere else. And as a result, they are posting and sharing links to my Blog, all over the world. See for yourself. A link is provided at the end of this posting.

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Now, on with Break-In Oil information.

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So-called Break-In oils are typically hyped by claiming they provide for quick ring seating while providing extra wear protection for other parts. Of course no oil can be formulated to "allow" the wear of only certain parts, AND to "prevent" the wear of other parts, at the same time. It has to be formulated for one or the other, which we will see below.

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When impossible Marketing claims like that are made, it is only to sell product, no matter what the truth really is. Many would call that blatant false advertising, which motor oils are famous for. The absolute best oils and the absolute worst oils all make the same claim about how great they are. Until my wear protection capability test data became available, buyers had no way of knowing which oils actually live up to those claims and which ones don't. Because we now know that looking at the zinc level alone, is absolutely worthless, and tells you nothing about an oil's wear protection capability.
Let's take a look at component quantities of several Break-In Oils, from the Lab Tests performed by ALS Tribology in Sparks, Nevada.

Lucas 30 wt Break-In Oil, conventional
zinc = 4483 ppm
phos = 3660 ppm
moly = 3 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 1104 ppm
TBN = 5.9
This oil has by far, the highest level of zinc/phos I have ever come across. It has way more than twice the amount of zinc that begins to CAUSE wear/damage. Because of that, the extremely low level of TBN, and the extremely low level of detergent, this oil should be used for only a very short time, as a Break-In oil would suggest.

Comp Cams 10W30 Break-In Oil, conventional
zinc = 3004 ppm
phos = 2613 ppm
moly = 180 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 4234 ppm
TBN = 14.7

This oil also has by far, way too much zinc/phos. It has way more than enough zinc to begin causing wear/damage, rather than prevent it. Because of that, this oil also should be used for only a very short time, as a Break-In oil would suggest.

Edelbrock 30 wt Break-In Oil, conventional
zinc = 1545 ppm
phos = 1465 ppm
moly = 4 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 3452 ppm
TBN = 10.6
This oil is manufactured for Edelbrock by Torco.

.
Royal Purple 10W30 Break-In Oil, conventional
zinc = 1170 ppm
phos = 1039 ppm
moly = 0 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 3184 ppm
TBN = 9.8

As you can see above, there is absolutely no consistency at all, between the Break-In oils that were fomulated by these various Oil Companies. These oils are all over the place and bouncing off the walls. We see zinc from 1170 ppm to 4483 ppm. We see phos from 1039 ppm to 3660 ppm. We see detergent levels from 1104 ppm to 4234 ppm. And we see TBN values from 5.9 to 14.7. WOW!!! These oils couldn't be much more different, and yet they are all aimed at the EXACT SAME Break-In oil market. It makes you wonder if these Oil Companies have any idea what they are doing, and if they even test these oils to see what they can really do.

So, let's take a look at the wear protection these oils and several other Break-In oils, actually provide, and see how they rank just among themselves, according to their "Load Carrying Capacity/Film Strength" psi value. This data will tell us once and for all, what the Oil Companies would not, and that is, whether the oils are formulated to "allow" wear or "prevent" wear.

.
The Wear Protection reference categories are:

• Over 105,000 psi = INCREDIBLE wear protection

• 90,000 to 105,000 psi = OUTSTANDING wear protection

• 75,000 to 90,000 psi = GOOD wear protection

• 60,000 to 75,000 psi = MODEST wear protection

• Below 60,000 psi = UNDESIRABLE wear protection

The higher the psi , the better the Wear Protection

1. 30wt Amsoil Break-In Oil conventional = 78,192 psi
zinc = 2051 ppm
phos = 1917 ppm
moly = 0 ppm

.
2. 30wt Edelbrock Break-In Oil conventional = 69,160 psi
zinc = 1545 ppm
phos = 1465 ppm
moly = 4 ppm

.
3. Royal Purple 10W30 Break-In Oil, conventional = 62,931 psi
zinc = 1170 ppm
phos = 1039 ppm
moly = 0 ppm

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4. Crane Cams 10W40 Break-In Oil, conventional = 62,603 psi
zinc = TBD, but bottle claims high zinc formula
phos = TBD
moly = TBD

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5. 30wt Brad Penn, Penn Grade 1, Break-In Oil, conventional = 56,020 psi
zinc = TBD, but the bottle claims high zinc
phos = TBD
moly = TBD

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6. 10W30 Comp Cams Break-In Oil, conventional = 51,749 psi
zinc = 3004 ppm
phos = 2613 ppm
moly = 180 ppm

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7. 15W50 Joe Gibbs Driven BR Break-In oil, conventional = 51,299 psi

NOTE: Total Seal also sells this Break-In Oil with their label on it.
zinc = TBD
phos = TBD
moly = TBD

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8. 30wt Lucas Break-In Oil, conventional = 49,455 psi
zinc = 4483 ppm
phos = 3660 ppm
moly = 3 ppm

.
9. 5W30 Joe Gibbs Driven BR30 Break-In Oil, conventional = 47,483 psi
NOTE: Total Seal also sells this Break-In Oil with their label on it.
zinc = TBD
phos = TBD
moly = TBD

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Anyone who has followed my previous oil tests, knows that the wear protection capability psi values provided by most of these Break-In oils is quite low overall. Only the Amsoil made it into the GOOD WEAR PROTECTION category (75,000 to 90,000 psi). Edelbrock, Royal Purple and Crane Cams oils made it into the MODEST WEAR PROTECTION category (60,000 to 75,000 psi), while the Brad Penn, Comp Cams, Lucas and both Joe Gibbs Break-In oils managed only the UNDESIRABLE PROTECTION category (below 60,000 psi).

In comparison, the highest ranking oil (with no aftermarket additives) on my Wear Protection Ranking List, is 5W30 Motul 300V Ester Core 4T Racing Oil, synthetic = 112,464 psi, with a zinc level of 1724 ppm. That oil provides FAR GREATER wear protection capability than even the top ranked Amsoil Break-In oil here. And it provides nearly 2 1/2 times as much wear protection as the lowest ranked Joe Gibbs Break-In oil here.

So, now we finally know that because of their low wear protection capabilities, these Break-In oils are formulated only to allow wear, and are NOT formulated to provide a high level of wear protection. Of course it was impossible for them to be capable of both things at the same time, in spite of their advertising claims. And without the type of dynamic wear testing performed here, we would have never known what these Break-In oils were truly formulated for.

Every oil test I've performed, showed that the level of zinc has nothing to do with an oil's wear protection capability, nor its ranking against other oils. And we've seen it yet again here, that high zinc levels do NOT always provide better wear protection. In fact, the ULTRA HIGH zinc

Lucas Break-In oil, ended up in next to last place in wear protection capability for this group of Break-In oils.

And no one can complain that my test equipment and test procedure do not allow high zinc oils to perform at their highest level. Because here are some high zinc (over 1100 ppm) conventional, semi-synthetic, and full synthetic oils that I've tested previously. And they all produced test results of at least 90,000 psi, which put them all in the "INCREDIBLE or OUTSTANDING WEAR PROTECTION" categories.

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5W30 Motul 300V Ester Core 4T Racing Oil, synthetic = 112,464 psi
zinc = 1724 ppm
phosphorus = 1547 ppm
moly = 481 ppm

.
10W30 Lucas Racing Only, full synthetic = 106,505 psi
zinc = 2642 ppm
phos = 3489 ppm
moly = 1764 ppm

.
5W30 Joe Gibbs Driven LS30 Performance Motor Oil, synthetic = 104,487 psi
zinc = 1610 ppm
phosphorus = 1496 ppm
moly = 0 ppm

.
10W30 Valvoline NSL (Not Street Legal) Conventional Racing Oil = 103,846 psi
zinc = 1669 ppm
phos = 1518 ppm
moly = 784 ppm

.
10W30 Valvoline VR1 Conventional Racing Oil (silver bottle) = 103,505 psi
zinc = 1472 ppm
phos = 1544 ppm
moly = 3 ppm

.
10W30 Valvoline VR1 Synthetic Racing Oil, API SL (black bottle) = 101,139 psi
zinc = 1180 ppm

phos = 1112 ppm
moly = 162 ppm

.
30 wt Red Line Race Oil, full synthetic = 96,470 psi
zinc = 2207 ppm
phos = 2052 ppm
moly = 1235 ppm

.
10W30 Amsoil Z-Rod Oil, full synthetic = 95,360 psi
zinc = 1431 ppm
phos = 1441 ppm
moly = 52 ppm

.
10W30 Quaker State Defy, API SL (semi-synthetic) = 90,226 psi
zinc = 1221 ppm
phos = 955 ppm
moly = 99 ppm

As you've seen above in the poor performing high zinc break-in oils and immediately above in the excellent performing high zinc non-break-in oils, the zinc levels completely overlap among all those poor performing and excellent performing oils. So, that is absolute proof once and for all, that you simply CANNOT predict an oil's wear protection capability based on its zinc level alone.

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Now the brainwashed high zinc believers have ironclad data to show them that everything they have always believed about only needing to look at zinc levels, is total nonsense. Zinc levels alone are completely worthless. Only film strength/load carrying capability from dynamic wear testing under load, can tell us which oils provide good wear protection and which oils don't. If the high zinc believers don't grasp the value of this information, then they will never be able to select the best possible oil for their needs.

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A fair number of people have been able to get away with using these poor performing Break-In oils in high performance flat tappet engines without a problem. But, they typically were only able to do that with these oils by following elaborate and worrisome break-in procedures. Those break-in procedures typically include removal of the inner valve springs, to reduce the pressure between the lobes and lifters. They also typically follow the routine of keeping the engine at around 2,500 rpm for 20 minutes, etc, etc. Everything they do as part of their

elaborate and nerve wracking break-in procedure, is only a crutch to prevent wiping lobes because these break-in oils provide such poor wear protection. But, if high ranking oils were selected instead, and used for Break-In, people wouldn't have to go through all that, because NO elaborate break-in procedures would be required with those far superior high ranking oils.

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People think they have to go through all this break-in agony, because they assume parts quality isn't that high, even when using parts from reputable Industry leading companies. They never even consider for a moment that their beloved high zinc oils are to blame. But, as you can see above, these break-in oils show that they put flat tappet engines at serious risk of failure, because of their poor wear protection capability, even though they have high zinc levels. People typically believe they are getting sufficient wear protection because of all that zinc, from what the bottles and/or websites claim. But, now we know that the hype about great wear protection was nothing more than false advertising snake oil. These oils are formulated only to allow wear, by having low wear protection capability, in spite of their high zinc levels.

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And that is precisely why there are still so many flat tappet wiped lobe engine failures at break-in and shortly thereafter. When people use these poor performing break-in oils, in flat tappet engines, they are simply playing Russian Roulette with their engines. They may be OK, or they may suffer engine failure. It's extremely iffy, because the margin of safety is about zero with these oils. But, it does NOT have to be that way if a highly ranked oil is chosen instead.

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It's a similar situation where a fair number of people have managed to get away with using low zinc oils with aftermarket zinc additives added into those oils, for breaking-in high performance flat tappet engines. Some people were able to squeak by with this type of oil concoction that also provides only minimal wear protection capability. But, quite a few people have experienced wiped lobe engine failure doing this. These people also "thought" they were getting outstanding wear protection, from what those zinc additive bottles and/or websites claimed. But, Engineering test data has proven over and over again, that simply having high zinc levels, is no guarantee of having sufficient wear protection.

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I tested the zinc additives "ZDDPlus" which added a whopping 1848 ppm zinc when added at the recommended quantity, and "Edelbrock Zinc Additive" which added 573 ppm zinc when added at the recommended quantity. Each zinc additive was tested in two full synthetic oils and one conventional oil. And in EVERYONE of the six test oils, the wear protection capability DROPPED SIGNIFICANTLY.

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The “ZDDPlus” caused a drop of about 25% on average, and the “Edelbrock Zinc Additive” caused a drop of about 34% on average. The oils with the “ZDDPlus” ended up having a “Load carrying capacity/Film strength” of only 58,855 psi on average. And the oils with the “Edelbrock Zinc Additive” ended up having a “Load carrying capacity/Film strength” of only 51,930 psi on average. That puts them into the UNDESIRABLE PROTECTION category (below 60,000 psi). So, the wear protection capability of these oil concoctions, was right in the exact same range as most of the Break-In oils tested here. Oil Companies have typically said to NEVER add anything to motor oil, because doing that will ruin an oil’s carefully balanced additive package and its resulting chemical properties. And they were absolutely correct, because that is precisely what the test data showed.

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It’s also a similar situation where a fair number of people have managed to get away with using Diesel oils for breaking-in high performance flat tappet engines. They were able to squeak by with Diesel oil even though these oils also provide only minimal wear protection capability, which puts their engines at a substantial risk of failure. These folks “thought” they were getting outstanding wear protection. But, I tested 13 different popular conventional and synthetic Diesel oils, including the “OLD” Rotella, and they had a “Load carrying capacity/Film strength” of only 72,408 psi on average, putting them in the MODEST PROTECTION category (60,000 to 75,000 psi). This wear protection capability puts them right at the upper range of the Break-In oils tested here.

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To summarize, most of the Break-In oils, the low zinc oils with aftermarket zinc added to them, and the Diesel oils, provided about the same level of modest to undesirable wear protection in gasoline engines. And that makes most of them a risky proposition for use as Break-In oils.

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This points out that all the effort, including elaborate break-in procedures, that people go through with these motor oils, in order to prevent wiped lobes in High Performance flat tappet engines, is misguided because these oils DO NOT provide the best wear protection in the first place. There are far better motor oil choices readily available.

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Many people probably have a gut feeling that whatever Break-In oil they use, should not be overly protective against wear, so that components can break-in quickly. That’s why you often hear people say to break-in an engine with conventional oil, then later switch to synthetic, even though they aren’t aware that an oil being conventional or synthetic does not determine its wear protection capability.

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But, then the flat tappet guys often want to have max protection against wear to avoid wiped lobes. So, they will then often choose conventional oil with high levels of zinc, “falsely believing” that will help increase the oil’s wear protection. But, as mentioned many times before, “wear testing” and “lab testing” have ALWAYS shown that the level of zinc does NOT determine an oil’s wear protection capability. No more than the level of gas in your tank determines how much HP your engine makes.

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We’ve only looked at the “lower end” of the spectrum of Break-In oils, which are formulated to allow break-in wear. But, since things just aren’t that simple, let’s also take a look at the “upper” end of the spectrum of Break-In oils. Consider the following facts.

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Countless thousands of brand new Performance cars have come off the production line, factory filled with full synthetic motor oil. We’ve seen this for years in both domestic and import Performance Cars. Perhaps the most commonly known is the full synthetic 5W30 Mobil 1 that comes in High Performance GM vehicles. Also the Ford GT Sports Car of a few years back, as well as Ford’s Supercharged Shelby GT500 Mustangs, came factory filled with full synthetic 5W50 Motorcraft oil.

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That full synthetic 5W30 Mobil 1, API SN oil ranks in the top 10% of all the oils I’ve tested, with a “Load carrying capacity/Film strength” value of 105,875 psi. And the full synthetic 5W50 Motorcraft, API SN oil also ranks in the top 10% of all the oils I’ve tested, with a “Load carrying capacity/Film strength” value of 103,517 psi. With the extremely impressive wear protection capability provided by these oils, if any oils would interfere with ring seal and proper break-in wear overall, these oils would be the ones to do it. But, that is simply not a problem, and of course these vehicles all come with a normal factory warranty.

CONCLUSION:

We know that countless High Performance factory engines, both 2 valve and 4 valve, have nicely broken-in for many, many years with NO ring sealing problems what so ever, using various oils with high wear protection capability. In addition to that, using oils with excellent wear protection capability, has worked perfectly fine for breaking-in in traditional High Performance flat tappet engines, and have proven that NO elaborate break-in procedures are required at all. You can simply fire the engine and drive the car with no drama and no worries. Try doing that with the poor performing high zinc Break-In oils.

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So, why would anyone ever believe that you need so-called Break-In Oils with poor their wear protection capability, when these oils are simply NOT needed for ring seal (properly built engines will seal/seat their rings almost immediately no matter what oil is used), and they put High Performance flat tappet engines at serious risk of wiped lobe engine failure? Plus, they require elaborate break-in procedures if there is any hope at all of getting away with using these poor performing oils. Bottom Line: So-called Break-In oils are simply not necessary and can also put flat tappet engines at serious risk.

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If you wondered how those factory full synthetic oils with "high wear protection capability" and how any other synthetic or conventional oil with "high wear protection capability", can still allow proper break-in, here's the answer. Newly manufactured parts will have a surface that "microscopically" looks like peaks and valleys. The loading on those tiny little peaks, will be EXTREMELY high, because the load is not spread out across enough surface area to support the load. And no motor oil ever made by man can stop those peaks from being very quickly worn down, thus leaving a smoother surface that will distribute the load across a surface area large enough to support that load. And that is precisely what happens during actual break-in wear. So, it is PHYSICALLY IMPOSSIBLE to stop break-in wear, no matter how hard we try. And that is a good thing, because we want that initial break-in wear, so that our part interfaces are nicely mated to each other in order to support the loads involved.

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Engine break-in is NOT Rocket Science. You just need to make a wise choice when selecting the motor oil to use. At the end of the day, here's what I recommend:

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* For traditional flat tappet engines, no matter how wicked they may be – use a highly ranked oil from my Wear Protection Ranking list, no matter how much zinc is in it, for break-in to protect against wiped lobes, and a side benefit is that no elaborate break-in procedures will be necessary. Then continue to use the same oil after break-in. NOTE: This recommendation also applies to any other non-roller type engine.

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* For traditional roller lifter engines – since they don't have flat tappet lifter/lobe interfaces, their break-in is not as critical as it is for flat tappet engines. So, you can pretty much use any oil you have sitting around, and it won't make any particular difference for break-in. However, with that said, I would still recommend using a highly ranked oil from my Wear Protection Ranking list, no matter how much zinc is in it, for break-in. Because roller engines still have various component interfaces that can benefit from using oils that provide excellent wear protection. Then continue to use the same oil after break-in. NOTE: This recommendation also applies to any other roller type engine.

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No matter what anyone tells you, the same oil can be used just fine for both break-in and after break-in. These above recommendations have proven to work very well in the real world, while providing excellent protection for your engine.

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Other points I'd suggest are:

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• Always prime an engine, making sure that oil is coming out of all rockers, right before first fire.

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• Use a thinner oil such as 5W30 or 10W30, rather than something thicker. Because thinner oil will flow quicker/better. And flow is lubrication. Also quicker/better flow will get oil to all components sooner which is very important to prevent unnecessary wear during cold start-up. And the quicker/better flow of thinner oil, will also carry away heat quicker/better than what thicker oils can. Remember that engine internal parts are DIRECTLY oil cooled, but only INDIRECTLY water cooled.

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• And the last thing is to change the oil soon after initial break-in, to get rid of all the contaminants that will be present right after first firing a brand new engine.

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11. CAN YOU ALWAYS COUNT ON HIGH ZINC MOTOR OIL?

Can you always count on high zinc motor oil to provide the most desirable wear protection? To find out, I performed Engineering "Wear Protection Capability" testing on a group 40 different high zinc oils to see how high zinc oils compare among themselves. And the fact is, not all high zinc oils provide the same wear protection. See below for details:

Wear protection reference categories are:

• Over 105,000 psi = INCREDIBLE wear protection

• 90,000 to 105,000 psi = OUTSTANDING wear protection

• 75,000 to 90,000 psi = GOOD wear protection

• 60,000 to 75,000 psi = MODEST wear protection

• Below 60,000 psi = UNDESIRABLE wear protection

The higher the psi number, the better the wear protection.

1. 10W30 Lucas Racing Only synthetic = 106,505 psi
zinc = 2642 ppm
phos = 3489 ppm
ZDDP= 3000 ppm
NOTE: This oil is suitable for short term racing use only, and is not suitable for street use.

2. 10W30 Valvoline NSL (Not Street Legal) Conventional Racing Oil = 103,846 psi
zinc = 1669 ppm
phos = 1518 ppm
ZDDP = 1500 ppm
NOTE: Due to its very low TBN value, this oil is only suitable for short term racing use, and is not suitable for street use.

3. 10W30 Valvoline VR1 Conventional Racing Oil (silver bottle) = 103,505 psi
zinc = 1472 ppm
phos = 1544 ppm
ZDDP = 1500 ppm

4. 10W30 Valvoline VR1 Synthetic Racing Oil, API SL (black bottle) = 101,139 psi
zinc = 1180 ppm
phos = 1112 ppm
ZDDP = 1100 ppm

5. 30 wt Red Line Race Oil synthetic = 96,470 psi
zinc = 2207 ppm
phos = 2052 ppm
ZDDP = 2100 ppm
NOTE: This oil is suitable for short term racing use only, and is not suitable for street use.

6. 10W30 Amsoil Z-Rod Oil synthetic = 95,360 psi
zinc = 1431 ppm
phos = 1441 ppm
ZDDP = 1400 ppm

7. 10W30 Quaker State Defy, API SL semi-synthetic = 90,226 psi
zinc = 1221 ppm
phos = 955 ppm
ZDDP = 1000 ppm

8. 10W30 Joe Gibbs HR4 Hotrod Oil synthetic = 86,270 psi
zinc = 1247 ppm
phos = 1137 ppm
ZDDP = 1100 ppm

9. 15W40 RED LINE Diesel Oil synthetic, API CJ-4/CI-4 PLUS/CI-4/CF/CH-4/CF-4/SM/SL/SH/EO-O = 85,663 psi
zinc = 1615 ppm
phos = 1551 ppm
ZDDP = 1500 ppm

10. 5W30 Lucas API SM synthetic = 76,584 psi
zinc = 1134 ppm
phos = 666 ppm
ZDDP = 900 ppm

11. 5W50 Castrol Edge with Syntec API SN, synthetic, formerly Castrol Syntec, black bottle = 75,409 psi
zinc = 1252 ppm
phos = 1197 ppm
ZDDP = 1200 ppm

12. 5W30 Royal Purple XPR (Extreme Performance Racing) synthetic = 74,860 psi
zinc = 1421 ppm
phos = 1338 ppm
ZDDP = 1300 ppm

13. 5W40 MOBIL 1 TURBO DIESEL TRUCK synthetic, API CJ-4, CI-4 Plus, CI-4, CH-4 and ACEA E7 = 74,312 psi
zinc = 1211 ppm
phos = 1168 ppm
ZDDP = 1100 ppm

14. 15W40 CHEVRON DELO 400LE Diesel Oil, conventional, API CJ-4, CI-4 Plus, CH-4, CF-4,CF/SM, = 73,520 psi
zinc = 1519 ppm
phos = 1139 ppm
ZDDP = 1300 ppm

15. 15W40 MOBIL DELVAC 1300 SUPER Diesel Oil conventional, API CJ-4, CI-4 Plus, CI-4, CH-4/SM, SL = 73,300 psi
zinc = 1297 ppm
phos = 1944 ppm
ZDDP = 1600 ppm

16. 15W40 Farm Rated Heavy Duty Performance Diesel, CI-4, CH-4, CG-4, CF/SL, SJ (conventional) = 73,176 psi
zinc = 1325ppm
phos = 1234 ppm
ZDDP = 1200 ppm

17. 15W40 “NEW” SHELL ROTELLA T Diesel Oil conventional, API CJ-4, CI-4 Plus, CH-4, CF-4,CF/SM = 72,022 psi
zinc = 1454 ppm
phos = 1062 ppm
ZDDP = 1200 ppm

18. 0W30 Brad Penn, Penn Grade 1 (semi-synthetic) = 71,377 psi
zinc = 1621 ppm
phos = 1437 ppm
ZDDP = 1500 ppm

19. 15W40 “OLD” SHELL ROTELLA T Diesel Oil conventional, API CI-4 PLUS, CI-4, CH-4,CG-4,CF-4,CF,SL, SJ, SH = 71,214 psi
zinc = 1171 ppm
phos = 1186 ppm
ZDDP = 1100 ppm

20. 10W30 Brad Penn, Penn Grade 1 (semi-synthetic) = 71,206 psi
zinc = 1557 ppm
phos = 1651 ppm
ZDDP = 1600 ppm

21. 15W50 Mobil 1, API SN synthetic = 70,235 psi
zinc = 1133 ppm
phos = 1,168 ppm
ZDDP = 1100 ppm

22. 30wt Edelbrock Break-In Oil conventional = 69,160 psi
zinc = 1545 ppm
phos = 1465 ppm
ZDDP = 1500 ppm

23. 10W40 Edelbrock synthetic = 68,603 psi
zinc = 1193 ppm
phos = 1146 ppm
ZDDP = 1100 ppm

24. 15W40 LUCAS MAGNUM Diesel Oil, conventional, API CI-4,CH-4, CG-4, CF-4, CF/SL = 66,476 psi
zinc = 1441 ppm
phos = 1234 ppm
ZDDP = 1300 ppm

25. 10W30 Royal Purple HPS (High Performance Street) synthetic = 66,211 psi
zinc = 1774 ppm
phos = 1347 ppm
ZDDP = 1500 ppm

26. 10W40 Valvoline 4 Stroke Motorcycle Oil conventional, API SJ = 65,553 psi
zinc = 1154 ppm
phos = 1075 ppm
ZDDP = 1100 ppm

27. 5W30 Klotz Estorlin Racing Oil, API SL synthetic = 64,175 psi
zinc = 1765 ppm
phos = 2468 ppm
ZDDP = 2100 ppm

28. "ZDDPlus" added to Royal Purple 20W50, API SN, synthetic = 63,595 psi
zinc = 2436 ppm (up 1848 ppm)
phos = 2053 ppm (up 1356 ppm)
ZDDP = 2200 ppm
The amount of ZDDPlus added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 24% LOWER than this oil had BEFORE the

ZDDPlus was added to it. Most major Oil Companies say to NEVER add anything to their oils, because adding anything will upset the carefully balanced additive package, and ruin the oil's chemical composition. And that is precisely what we see here. Adding ZDDPlus SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

29. Royal Purple 10W30 Break-In Oil conventional = 62,931 psi
zinc = 1170 ppm
phos = 1039 ppm
ZDDP = 1100 ppm

30. 10W30 Lucas Hot Rod & Classic Hi-Performance Oil, conventional = 62,538 psi
zinc = 2116 ppm
phos = 1855 ppm
ZDDP = 1900 ppm

31. 10W30 Comp Cams Muscle Car & Street Rod Oil, synthetic blend = 60,413 psi
zinc = 1673 ppm
phos = 1114 ppm
ZDDP = 1300 ppm

32. 10W40 Torco TR-1 Racing Oil with MPZ conventional = 59,905 psi
zinc = 1456 ppm
phos = 1150 ppm
ZDDP = 1300 ppm

33. "ZDDPlus" added to O'Reilly (house brand) 5W30, API SN, conventional = 56,728 psi
zinc = 2711 ppm (up 1848 ppm)
phos = 2172 ppm (up 1356 ppm)
ZDDP = 2400 ppm
The amount of ZDDPlus added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 38% LOWER than this oil had BEFORE the ZDDPlus was added to it. Adding ZDDPlus SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

34. 10W40 Summit Racing Premium Racing Oil, API SL conventional = 59,483 psi
zinc = 1764 ppm
phos = 1974 ppm
Claimed ZDDP level on the bottle = 1800 ppm
NOTE: Summit discontinued this line of oil, as of spring of 2013.

35. “ZDDPlus” added to Motorcraft 5W30, API SN, synthetic = 56,243 psi
zinc = 2955 ppm (up 1848 ppm)
phos = 2114 ppm (up 1356 ppm)
ZDDP = 2500 ppm
The amount of ZDDPlus added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 12% LOWER than this oil had BEFORE the ZDDPlus was added to it. Adding ZDDPlus SIGNIFICANTLY REDUCED this oil’s wear prevention capability. Just the opposite of what was promised.

36. “Edelbrock Zinc Additive” added to Royal Purple 5W30, API SN, synthetic = 54,044 psi
zinc = 1515 ppm (up 573 ppm)
phos = 1334 ppm (up 517 ppm)
ZDDP = 1400 ppm
The amount of Edelbrock Zinc Additive added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was a whopping 36% LOWER than this oil had BEFORE the Edelbrock Zinc Additive was added to it. Adding Edelbrock Zinc Additive SIGNIFICANTLY REDUCED this oil’s wear prevention capability. Just the opposite of what was promised.

37. 10W30 Comp Cams Break-In Oil conventional = 51,749 psi
zinc = 3004 ppm
phos = 2613 ppm
ZDDP = 2800 ppm

38. “Edelbrock Zinc Additive” added to Lucas 5W30, API SN, conventional = 51,545 psi
zinc = 1565 ppm (up 573 ppm)
phos = 1277 ppm (up 517 ppm)
ZDDP = 1400 ppm
The amount of Edelbrock Zinc Additive added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was a “breath taking” 44% LOWER than this oil had BEFORE the Edelbrock Zinc Additive was added to it. Adding Edelbrock Zinc Additive SIGNIFICANTLY REDUCED this oil’s wear prevention capability. Just the opposite of what was promised.

39. “Edelbrock Zinc Additive” added to Motorcraft 5W30, API SN, synthetic = 50,202 psi
zinc = 1680 ppm (up 573 ppm)
phos = 1275 ppm (up 517 ppm)
ZDDP = 1400 ppm
The amount of Edelbrock Zinc Additive added to the oil, was the exact amount the manufacturer called for on the bottle. And the resulting psi value here was 22% LOWER than

this oil had BEFORE the Edelbrock Zinc Additive was added to it. Adding Edelbrock Zinc Additive SIGNIFICANTLY REDUCED this oil's wear prevention capability. Just the opposite of what was promised.

40. 30wt Lucas Break-In Oil conventional = 49,455 psi
zinc = 4483 ppm
phos = 3660 ppm
ZDDP = 4000 ppm

So, as you saw above, the highest ranking high zinc oil that provided the BEST WEAR PROTECTION of this group of 40 high zinc oils, had 3000 ppm ZDDP. But, the lowest ranking high zinc oil had one third MORE ZDDP at 4000 ppm. Even though this lowest ranked oil had far more zinc in it, it provided LESS THAN HALF AS MUCH WEAR PROTECTION, making it by far the worst of all 40 oils tested. Then the 4th place oil had only 1100 ppm ZDDP, and the 7th place oil had only 1000 ppm ZDDP.

So, the results above show:

1. My tester and test procedure have no problem at all showing excellent performing high zinc oils. The fact is, my oil testing performs worst case torture testing on motor oil. So, an oil HAS TO BE GOOD to produce good results. And we saw that many high zinc oils produced excellent results here.

2. This is ABSOLUTE PROOF that not all high zinc oils have equal wear protection capabilities. And why would anyone think that all high zinc oils are good? Not all tires are good. Not all cylinder heads are good. Not all camshafts are good. The world just doesn't work that way. Some high zinc oils are quite good and provide excellent wear protection, while other high zinc oils are not good at all, and provide rather poor wear protection. It just depends on the particular oil in question. And that makes it totally clear here, that you simply CANNOT predict an oil's wear protection capability by looking only at its zinc level. Life is just NOT that simple. If you only look at zinc levels, that is no better than guessing. So, if anyone tells you that you need high levels of zinc for more wear protection, even if it comes from a Cam Company, don't believe a word of it. Because as you can see above, they have no idea what they are talking about. Would you really want to use the 40th ranked last place oil simply because it has more zinc than the number one ranked oil here? That is just what you'd be doing if you believed the incorrect advice about only looking at zinc levels. In fact, MANY WIPED FLAT TAPPET LOBES COULD HAVE BEEN AVOIDED, INCLUDING DURING BREAK-IN, if people had not blindly believed that all high zinc oils provide all the wear protection they need. Because nothing could be further from the truth.

3. A motor oil's wear protection capability is determined by its base oil and its additive package "as a whole", with the emphasis on its additive package which is what contains the extreme pressure anti-wear components, and NOT simply by how much zinc is present. The ONLY way to know for sure how much wear protection any given oil can provide, is to look at "dynamic wear testing under load" results, such as I have provided above.

My motor oil testing, is very similar in concept to dyno testing an engine. An engine dyno test is also dynamic testing under load. For the guys who just want to look at a motor oil zinc level reference chart, that is like looking at an engine's build sheet instead of its dyno print out. Which do you think has more value?

For actual motor oil facts, go to the link at the bottom, and read my entire motor oil testing write-up, then decide for yourself what you want to believe. Actual test data facts, or the common high zinc MYTH? The engine you save, may be your own.

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12. DIESEL OIL – IS IT THE RIGHT CHOICE FOR HIGH PERFORMANCE GASOLINE ENGINES?

Before we get into the eye-opening Diesel oil test data, let's take a look at some fundamental aspects of motor oil wear protection, so that we are all on the same page. The amount of misinformation and misunderstanding about motor oil is absolutely mind boggling, even though the basic technology of motor oil is NOT Rocket Science. It is simply unbelievable how much COMPLETELY WRONG information is out there on the Internet and on the various Forums.

And of course once wrong information has been repeated countless times, it becomes fact as far as most people know, even though it is completely worthless. But, you really can't blame folks for not knowing any better. Because in addition to a ton of bad information being out there, motor oil advertising hype is often misleading or downright false, almost no one ever tests anything to know for sure what is true and what is not, aftermarket companies sell bogus oil additive products, including zinc additives, that only wreck an oil's chemical properties, and any test data outside of the oil companies themselves, is virtually impossible to find ANYWHERE……………until now.

If you are interested in seeing the FACTS from real world independent and unbiased Engineering Test Data on motor oil, then the information below is for you.

"THE" single most common misunderstanding about motor oil is that higher zinc levels provide better wear protection. That has been repeated over and over again so many times over the years, that people just assume it is correct. But the fact is, that thinking is COMPLETELY FALSE.

Here are the FACTS:

Zinc is used/sacrificed in very small quantities at time, so the total amount present in your oil does not change how much wear protection the oil provides, as long as you don't run out of zinc. "Lab Testing" and "Wear Testing" analysis proves/confirms that more zinc provides LONGER wear protection, NOT MORE wear protection. This is not a new discovery. In fact, Ed Hackett wrote an article some years ago, titled "More than you ever wanted to know about Motor Oil". And in that article he says the exact same thing, so it's been well known for a long time. You can Google his article if you like, and see for yourself.

An analogy for the zinc level in motor oil would be the amount of gas in your tank. Gas is also used in very small quantities at a time. So, if you have a quarter of a tank or a full tank, it does NOT change how much power your engine makes, as long as you don't run out of gas. More gas provides LONGER running time, NOT more power. It's the same type of idea regarding the amount of zinc in motor oil.

Zinc is used as an extreme pressure, anti-wear additive. But, zinc "DOES NOT" build-up over time like some type of plating process. For those who have actually taken an engine apart that has been running high zinc oil, you know that you don't find a build-up of zinc that looks like some sort of coating or sludge build-up. Zinc does NOT work that way. And zinc is not even a lubricant until heat and load are applied. Zinc is only used when there is actual metal to metal contact in the engine. At that point zinc must react with the heat and load to create the sacrificial film that allows it to protect flat-tappet camshafts and other highly loaded engine parts.

So, with zinc being sacrificial, it will become depleted over time as it is used up. This has been proven/confirmed by analysis of new and used oil lab test results. And the literature from the "ZDDPlus" zinc additive folks says the exact same thing, if you'd also like to see it there. On top of that, excessively HIGH zinc levels can lead to INCREASED wear/damage and cast iron erosion. There is such a thing as "too much of a good thing".

So, you really don't want or need a ton of zinc. You simply need "enough" so that you don't run out of it with your particular application, that's all. And this is precisely the reason why the motor oil "wear testing" I've been performing, has ALWAYS shown that the level of zinc does NOT affect how well an oil can provide wear protection. I've had many HIGH zinc oils, as well as many modern LOW zinc oils, produce outstanding results in the wear testing. I've also had HIGH zinc oils as well as LOW zinc oils that produced only modest results in the wear testing.

And this brings us to the second most common misunderstanding about motor oil, which is that modern API certified motor oils cannot provide adequate wear protection for flat tappet cam lobe/lifter interfaces. This has also been repeated over and over again so many times over the years, that people just assume it is correct. But the fact is, that thinking is also COMPLETELY FALSE.

Wear protection is determined only by the base oil and its additive package "as a whole", and NOT just by how much zinc is present. There is nothing magical or sacred about zinc. It is just one of a number of motor oil additive package components that can be used for extreme pressure anti-wear purposes. The other components that are typically Oil Company proprietary secrets, can be added to, or used in place of zinc. And most modern API SM and SN certified oils have shown in my wear testing to be quite good when it comes to providing wear protection, and have even EXCEEDED the protection provided by many high zinc oils.

So, modern low zinc oils CAN BE USED SAFELY with flat tappet cam setups, even in engines with radical cams and high spring pressures. Simply choose from the higher ranked oils on the list at the end of this write-up, and you'll be good to go. I know people who've been using modern low zinc oils in High Performance flat tappet set-ups for a long time, and they've had no issue at all.

On a side note:
Whatever you do, DO NOT add aftermarket zinc additives to low zinc oils. Because I did testing on this exact situation and found that adding zinc to low zinc oils, ruins an oil's chemical properties and SIGNIFICANTLY reduces its wear protection capability. The Oil Companies always say to "never add anything" to their oil. Believe them, because they know what they are talking about. After all, they are the experts on their own products.

So, back to the topic at hand:
Just looking at an oil's spec sheet to see how much zinc is present, tells you ABOLUTLELY NOTHING about how well that oil can provide wear protection. To only look at the zinc level to try and predict an oil's wear protection capability would be much like looking at your gas gauge to predict how much power your engine will make. That kind of thinking simply makes no sense at all. So, throw away that useless motor oil zinc quantity reference list. In other

words, forget about zinc. The ONLY THING that matters, and the ONLY WAY to tell how well an oil can prevent wear, is to perform some type of dynamic WEAR TESTING that is done at representative temperatures. And that is exactly what I've done here.

The test equipment used here to perform this kind of testing, focuses on an oil's "load carrying capacity or film strength", and for good reason. THE single most CRITICAL capability of any motor oil is its film strength. Everything else it does for your engine comes AFTER that. Here's why. When oil is down to a very thin film, it is the last line of defense against metal to metal contact and subsequent wear or damage. And oil film strength capability DIRECTLY APPLIES to flat tappet lobe/lifter interfaces, cam gear/distributor gear interfaces, mechanical fuel pump pushrod tip/cam eccentric interfaces and other highly loaded engine component interfaces. The higher an oil's film strength, the better your engine is protected in these areas.

Oil film strength capability also DIRECTLY APPLIES to cold start-up conditions. In this case, only an oil film remains on most internal engine components, because most of the oil drained off after hot shut down. And it's no secret that nearly all wear occurs during start-up when there can be a couple of seconds or even more, depending on the oil viscosity being used and the ambient air temperature, before a flow of oil reaches all the components. Before oil flow reaches the components, all you have saving your engine from wear or damage, is the remaining oil's film strength. That makes it another very important reason why an excellent film strength is highly desirable.

When Amsoil refers to wear scar size comparisons on their website, they are referencing oil film strength test data. A few years or so ago, when Castrol Edge and Valvoline SynPower ads talked about their oils providing better wear protection than Mobil 1, they were referencing oil film strength test data. Pennzoil Ultra, API SM advertised that no leading synthetic oil provides better wear protection, and they also reference oil film strength test data. The bottom line is that oil film strength testing and the resulting data, is the "Gold Standard" in the motor oil industry, regarding wear protection.

There is no additional value to performing more "comprehensive" oil testing related to wear prevention. Because when an oil is thicker than a mere film, it becomes LIQUID oil. And LIQUIDS are INCOMPRESSIBLE, which of course is how hydraulics work. But, that refers to 100% PURE LIQUID with no air bubbles what so ever. And the nature of liquids being "incompressible", is a basic FACT of Physics.

So, since liquid oil CANNOT be compressed, there can be NO metal to metal contact, THUS NO WEAR OR DAMAGE. This means that ALL oils when in "incompressible liquid form", provide the SAME level of wear protection. And it does not matter if they cost one dollar per quart, or twenty dollars per quart. Nor does it matter how much zinc/phos is present.

For example, the normal flow of oil between the crank journals and rod or main bearings, is "liquid" oil. And the "liquid" oil in that hydrodynamic wedge is incompressible, just like any liquid is. For a crank journal to ever touch the bearings, the oil has to be reduced to only a film, and that film has to be PENETRATED. Because of course, to achieve metal to metal contact, and thus wear/damage, you have to go THROUGH the oil's film strength to get there.

If conditions cause a flow of liquid oil to be squeezed out of the way, you are right back to being left with only an oil film, and the need for good film strength. And this is PRECISELY why we perform OIL FILM STRENGTH testing. The ONLY thing that separates one oil from another oil, in terms of wear prevention, is the DIFFERENCE between their film strength capabilities. So, if an oil has sufficient film strength capability, then you are good to go when it comes to wear protection, no matter how much zinc is present.

The tester used here, was never intended to reflect exactly what goes on inside a running engine. It was designed to test "oil against oil", nothing else. So, the whole point of my "wear testing" was to test oils directly against each other, head to head, back to back, at a representative operating temperature. Then see how they stacked up against each other.

For example, if oil "A" has a 110,000 psi "load carrying capacity/film strength" (no matter how much zinc is present) in this test, and oil "B" has only a 65,000 psi "load carrying capacity/film strength" (no matter how much zinc is present) in this test, it's not hard to understand the fact that oil "A" with its WHOPPING 70% HIGHER CAPABILITY, will provide a MUCH HIGHER level of reserve wear protection in a running engine as well (no matter how much zinc is present).

My testing performs severe torture testing on motor oil, which is much harder on the oil, than what the oil will ever experience inside any running engine. This is a dynamic friction test under load, and the test results are determined by the size of the wear scar. And how good an oil is at preventing wear, high zinc or low zinc, is determined in a fair and straight forward manner. The numbers come out how they come out, depending on the capability of the oil.

All of the oils are tested at a representative normal operating oil temperature of 230*F, to make the comparison meaningful. By testing in this manner, it absolutely shows which oils are better at preventing wear than others. This real world test comparison allows you to test a large number of oils EXACTLY THE SAME, under controlled and repeatable conditions, which you simply cannot do in a running engine. And you can see how they compare right away, without having to wait for 100,000 miles to find out what happened. With this testing methodology, you can quickly and easily distinguish between outstanding oils and merely ordinary oils.

The whole thing simply comes down to what is called "margin of safety" or extra reserve protection capability. Let's say the lowest ranked oil has a 20% margin of safety relative to your engine's needs, which means that the oil's capability "exceeds" your engine's needs by 20%.

So, you are in good shape and you will never see a problem. But, if something bad happens like an overheating condition, or an oiling condition, or a loading condition, or some parts heading south, or whatever, and your oil protection requirements increase to say 50% above your engine's typical needs. Now you've just exceeded the oil's capability by a whopping 30%, and your engine is junk. But, what if you'd been running an oil that had a whopping 70% margin of safety to begin with? In this case, when your engine's needs went up 50%, but you still have another 20% capability above that. So, your engine would still live to fight another day.

So, in the end, it just depends on how much margin of safety an individual is comfortable with for his particular engine combo. The whole point of all my oil testing, is having the data to make an informed choice when it comes to choosing the best motor oil.

I did this testing only for my own knowledge, because there is so much misinformation and misunderstanding about motor oil. But, I do NOT sell oil, and I do NOT get paid by any oil company. So, it doesn't matter to me what oil people buy, or why they buy, the oil they buy. That being the case, I have absolutely no reason to try to make one oil seem better than another. On the contrary, I'm only interested in seeing how they TRULY differ.

So, there is no Snake Oil pitch going on here. And I'm not trying to convince anyone of anything, I'm only sharing my test data results. People can embrace my data or ignore it. That of course is totally up to them. So, run whatever oil you like, but now you'll have the data to see how oils rank, relative to each other.

NOTE: A motor oil's "load carrying capacity/film strength" capability is NOT the same thing as slipperiness or friction reduction. Therefore, this type of test data says nothing at all about the amount of Horsepower one oil will make vs another.

DIESEL OIL TESTING

I always found it a bit curious that some folks would use Diesel oil in High Performance gasoline engines, rather than the more obvious high quality gas engine oils. I assumed they figured that Diesel oils had higher zinc levels which most folks "mistakenly thought" was needed. Or maybe they figured if that oil works well for hard working Diesel engines, then it should work for their gas engines as well. But, other than some lab test reports showing zinc quantities, I haven't seen much real data on any of that.

Is it possible that the Diesel oil fans somehow know more than the Oil Companies' Chemical Engineers and Chemists? But, based on only a casual overview, the value of using Diesel oil in gas engines seemed to be mostly just folklore that had been repeated over and over, without any real data to support that. So, since I've been performing a lot of motor oil testing this year, I thought is was time to do some extensive testing on Diesel oil, to see once and for all, just what the Diesel oil hype is all about.

So, finally, on with the Diesel Oil test data:
*** The higher the psi result, the higher the "Load carrying capacity/Film strength", and the better the oil is at preventing wear.

*** All oils were tested at 230* F (representative of actual running temperature).

*** Multiple tests were performed on each oil, and those results were averaged to arrive at each oil's final value shown below.

*** Test Result differences between oils of less than 10%, are not significant, and oils within that range can be considered approximately equivalent.

*** All oil bottles were thoroughly shaken before the samples were taken. This ensured that all the additive package components were distributed uniformly throughout all the oil in the bottle, and not settled to the bottom.

*** All the oils here are current new oils, recently purchased, except for the unopened OLD Rotella T mentioned above.

*** The onset of "Thermal Breakdown" is determined by the temperature at which the oil begins to smoke/vaporize. This indicates that the lighter components in the oil are beginning to boil off, which changes the oil's chemical composition for the worse. Always keep your oil below the point of thermal breakdown. If your oil does get too hot, then change it at your earliest convenience.

*** Lab Testing for component quantities shown below, was performed by ALS Tribology (formerly Staveley Labs) in Sparks, Nevada.

*** Diesel engine oils have C-type API certification rating designations. The "C" is in reference to "C"ompression ignition engines.
Gas engine oils have S-type API certification rating designations. The "S" is in reference to "S"park ignition engines.

Here are the 13 Diesel Oils that were tested. And they are ranked in the order of their "Load Carrying Capacity/Film Strength" values:

1. RED LINE, 15W40 Diesel Oil, synthetic, API CJ-4/CI-4 PLUS/CI-4/CF/CH-4/CF-4/SM/SL/SH/EO-O
"Load Carrying Capacity/Film Strength" = 85,663 psi

zinc = 1615 ppm
phos = 1551 ppm
moly = 173 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 2999 ppm
TBN = 8.3
The onset of thermal breakdown is approximately 285*

2. ROYAL PURPLE, 15W40 Diesel Oil, synthetic, API CJ-4 /SM, CI-4 PLUS, CH-4, CI-4
"Load Carrying Capacity/Film Strength" = 76,997 psi
zinc = TBD
phos = TBD
moly = TBD
total detergent/dispersant/anti-deposit build-up/anti-sludge = TBD
TBN = TBD
The onset of thermal breakdown is approximately 265*

3. MOBIL 1 TURBO DIESEL TRUCK, 5W40 synthetic, API CJ-4, CI-4 Plus, CI-4, CH-4 and ACEA E7
"Load Carrying Capacity/Film Strength" = 74,312 psi
zinc = 1211 ppm
phos = 1168 ppm
moly = 2 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 1596 ppm
TBN = 9.3
The onset of thermal breakdown is approximately 270*

4. CHEVRON DELO 400LE, 15W40 conventional, API CJ-4, CI-4 Plus, CI-4, CH-4, SM, SL,
"Load Carrying Capacity/Film Strength" = 73,520 psi
zinc = 1519 ppm
phos = 1139 ppm
moly = 80 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 2205 ppm
TBN = 8.0
The onset of thermal breakdown is approximately 265*

5. MOBIL DELVAC 1300 SUPER, 15W40 conventional, API CJ-4, CI-4 Plus, CI-4, CH-4/SM, SL ,
"Load Carrying Capacity/Film Strength" = 73,300 psi
zinc = 1297 ppm
phos = 944 ppm
moly = 46 ppm

total detergent/dispersant/anti-deposit build-up/anti-sludge = 1843 ppm
TBN = 9.8
The onset of thermal breakdown is approximately 250*

6. Farm Rated 15W40 Heavy Duty Performance Diesel, conventional, API CI-4, CH-4, CG-4, CF/SL, SJ
"Load Carrying Capacity/Film Strength" = 73,176 psi
zinc = 1325 ppm
phos = 1234 ppm
moly = 2 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 1593 ppm
TBN = 9.3
The onset of thermal breakdown is approximately 255*

7. SHELL ROTELLA T, 15W40 conventional, API CJ-4, CI-4 Plus, CH-4, CG-4, CF-4,CF/SM
"Load Carrying Capacity/Film Strength" = 72,022 psi
zinc = 1454 ppm
phos = 1062 ppm
moly = 0 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 2886 ppm
TBN = 9.1
The onset of thermal breakdown is approximately 250*
NOTE: This new Rotella T has SIGNIFICANTLY MORE zinc than the OLD Rotella T, NOT LESS as is often claimed. And these two Rotella oils were Lab tested more than a month apart. So, their component quantities had no chance of being mixed up. This new Rotella's wear protection capability is just slightly BETTER than the OLD Rotella. Therefore, the new Rotella is NOT the junk some have claimed.

8. "OLD" SHELL ROTELLA T, 15W40 conventional, API CI-4 PLUS, CI-4, CH-4,CG-4,CF-4,CF,SL, SJ, SH
"Load Carrying Capacity/Film Strength" = 71,214 psi
zinc = 1171 ppm
phos = 1186 ppm
moly = 0 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 2715 ppm
TBN = 10.1
The onset of thermal breakdown is approximately 250*
NOTE: There is ABSOLUTELY NOTHING special about this OLD Rotella, as so many have always claimed. That was only folklore. It is simply ordinary Diesel oil.

9. VALVOLINE PREMIUM BLUE HEAVY DUTY DIESEL, 15W40 conventional, API CJ-4, CI-4 Plus, CI-4, CH-4, CG-4, CF-4, CF/SM

“Load Carrying Capacity/Film Strength” = 70,869 psi
zinc = TBD
phos = TBD
moly = TBD
total detergent/dispersant/anti-deposit build-up/anti-sludge = TBD
TBN = TBD
The onset of thermal breakdown is approximately 255*

10. CHEVRON DELO 400LE, 5W40 synthetic, API CJ-4, CI-4 Plus, CI-4, SL, SM,
“Load Carrying Capacity/Film Strength” = 69,631 psi
zinc = TBD
phos = TBD
moly = TBD
total detergent/dispersant/anti-deposit build-up/anti-sludge = TBD
TBN = TBD
The onset of thermal breakdown is approximately 255*

11. SHELL ROTELLA T6, 5W40 synthetic, API CJ-4, CI-4 Plus, CI-4, CH-4, CG-4/SM
“Load Carrying Capacity/Film Strength” = 67,804 psi
zinc = TBD
phos = TBD
moly = TBD
total detergent/dispersant/anti-deposit build-up/anti-sludge = TBD
TBN = TBD
The onset of thermal breakdown is approximately 260*

12. LUCAS 15W40 MAGNUM Diesel Oil, conventional, API CI-4,CH-4, CG-4, CF-4, CF/SL
“Load Carrying Capacity/Film Strength” = 66,476 psi
zinc = 1441 ppm
phos = 1234 ppm
moly = 76 ppm
total detergent/dispersant/anti-deposit build-up/anti-sludge = 3393 ppm
TBN = 11.7
The onset of thermal breakdown is approximately 250*

13. CASTROL GTX DIESEL, 15W40 conventional, API CJ-4, CI-4 Plus, CI-4, CH-4, CG-4, CF-4/SN
“Load Carrying Capacity/Film Strength” = 66,323 psi
zinc = TBD
phos = TBD
moly = TBD

total detergent/dispersant/anti-deposit build-up/anti-sludge TBD
TBN = TBD
The onset of thermal breakdown is approximately 265*

The average value for Thermal Breakdown among the conventional Diesel oils here, was 255*, which is 17* LOWER than among the conventional gas engine oils I've tested.

The average value for Thermal Breakdown among the synthetic Diesel oils here, was 267*, which is 15* LOWER than among the synthetic gas engine oils I've tested.

And as you can see with these Diesel oils above, zinc levels alone do NOT establish their wear prevention ranking. The zinc levels are randomly up and down, relative to the ranking order. So, zinc levels clearly have NOTHING to do with an oil's protection capability or ranking order. Also, anyone who has followed my motor oil testing, probably noticed that these Diesel oil "Load Carrying Capacity/Film Strength" psi values are rather low, with an average value for the whole group of only 72,408 psi. This number would put an oil for gasoline engines, only in the MODEST PROTECTION category (60,000 to 75,000 psi).

And considering that these oils are intended for use in heavy duty working Diesel engines as used in big rigs, bulldozers, locomotives, etc, etc, you probably expected to see some rather impressive psi numbers. But, if you were expecting that, you were obviously disappointed and maybe even shocked. So, what's going on here?

Obviously since all these diesel oil numbers are so closely clustered together with only about a 20,000 psi range (compared to the gas engine oil numbers which have a much larger range of almost 60,000 psi), it is clear that the oil companies intentionally formulated them to be in this general range. Why would they do that? How can that be good enough for these hard working diesel engines?

Diesel engines of this type are made very rugged and very durable for the long haul. And in order to accomplish that, the engine's components are designed and sized to keep the part loading at a modest level. And of course, these engines are known primarily for their impressive low end torque under boost, but NOT for their high rpm HP. All that being the case, these oils don't need to have a higher capability. And this type of Diesel engine typically takes a LOT OF OIL. So, cost becomes a real factor when changing oil. This means that no oil company is going to make their products way better than needed, because that would make their products too expensive to be competitive in the marketplace.

And no one can complain that my test equipment and test procedure do not allow high zinc oils to perform at their highest level. Because here are some high zinc (over 1100 ppm) conventional, semi-synthetic, and full synthetic gasoline engine oils that I've tested previously.

And they all had test results over 90,000 psi, which put them in the “OUTSTANDING PROTECTION” category for gasoline engines.

10W30 Lucas Racing Only, full synthetic = 106,505 psi
zinc = 2642 ppm
phos = 3489 ppm
moly = 1764 ppm

10W30 Valvoline NSL (Not Street Legal) Conventional Racing Oil = 103,846 psi
zinc = 1669 ppm
phos = 1518 ppm
moly = 784 ppm

10W30 Valvoline VR1 Conventional Racing Oil (silver bottle) = 103,505 psi
zinc = 1472 ppm
phos = 1544 ppm
moly = 3 ppm

10W30 Valvoline VR1 Synthetic Racing Oil, API SL (black bottle) = 101,139 psi
zinc = 1180 ppm
phos = 1112 ppm
moly = 162 ppm

30 wt Red Line Race Oil, full synthetic = 96,470 psi
zinc = 2207 ppm
phos = 2052 ppm
moly = 1235 ppm

10W30 Amsoil Z-Rod Oil, full synthetic = 95,360 psi
zinc = 1431 ppm
phos = 1441 ppm
moly = 52 ppm

10W30 Quaker State Defy, API SL (semi-synthetic) = 90,226 psi
zinc = 1221 ppm
phos = 955 ppm
moly = 99 ppm

SUMMARY
Thermal Breakdown BEGINS SOONER with Diesel oil, than with gas engine oils, which is not desirable for High Performance gas engine usage. And as you can see by looking at this short list of “high zinc” gas engine oils, or by looking at my complete Wear Protection Ranking List,

there are many, many gas engine oils available that are FAR SUPERIOR to the best Diesel oils in terms of wear protection. Therefore, using Diesel oils in high performance gas engines is NOT the best choice, if you want superior wear protection with plenty of margin of safety (extra reserve wear protection above what the engine typically needs).

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For those who have used Diesel oil in High Performance gas engines for years without issue, you were able to do that only because the wear protection required by the engines, never happened to exceed the oil's capability. But, you were clearly running a MUCH LOWER margin of safety than you would have been, if you'd used a much more capable gas engine oil instead. So, if you've been using Diesel oil in High Performance gas engines, you may want to rethink what you've been doing and consider upgrading to one of the far better gas engine oils.

CONCLUSION

The bottom line is that the end user does NOT know more about motor oil than the Oil Companies' Chemical Engineers and Chemists. So, the BEST choice is to use only quality gas engine oil in High Performance gas engines. These oils offer MUCH HIGHER wear protection capability and can withstand somewhat higher temperatures before the onset of Thermal Breakdown. Leave the less capable Diesel oils for use only in Diesel engines, where they are meant to be used.

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13. DO COMPARABLE ZINC LEVELS PROVIDE COMPARABLE WEAR PROTECTION?

Some folks have a hard time accepting certain data that has come out of the motor oil "wear testing" that I've been performing. The result that is the hardest for them to accept is the outcome showing that an oil with a high level of zinc, will not automatically provide excellent wear protection. That runs counter to everything they've always been told over the years.

The data I've provided up to now has always included low zinc modern API certified oils along with traditional high zinc High Performance and Racing oils. But having so many oils of different types of oil in the same test, might be a bit overwhelming or confusing. So, here I've selected only 13 oils that all have between 1100 and 1800 ppm zinc. That way the comparison is just apples to apples. Now zinc levels vs wear protection can easily be compared straight across.

The excellent performance of many of these high zinc oils, shows that my testing equipment and test procedure do in fact, allow high zinc oils to perform as well as they are capable of performing.

Wear protection categories are:

- Over 105,000 psi = INCREDIBLE wear protection

- 90,000 to 105,000 psi = OUTSTANDING wear protection

- 75,000 to 90,000 psi = GOOD wear protection

- 60,000 to 75,000 psi = MODEST wear protection

- Below 60,000 psi = UNDESIRABLE wear protection

I've also included detergent levels for reference as well.

All the oils below are full synthetic unless otherwise specified.

The following group of 13 oils are ranked according to their "load carrying capacity/film strength", or in other words, their "wear protection" performance, at 230*F. The higher the psi number, the better the wear protection. The tests were repeated multiple times for each oil, and then those results were averaged to arrive at the final psi numbers shown below. And every single oil was tested EXACTLY THE SAME.

1. 10W30 Valvoline NSL (Not Street Legal) Conventional Racing Oil = 103,846 psi
zinc = 1669 ppm
total detergent = 1618 ppm
detergent ppm/zinc ppm ratio = 1.0
NOTE: Due to its very low TBN value, this oil is only suitable for short term racing use, and is not suitable for street use.

2. 10W30 Valvoline VR1 Conventional Racing Oil (silver bottle) = 103,505 psi
(.3% below no.1)
zinc = 1472 ppm
total detergent = 2787 ppm
detergent ppm/zinc ppm ratio = 1.9

3. 10W30 Valvoline VR1 Synthetic Racing Oil, API SL (black bottle) = 101,139 psi
(2.6% below no.1)
zinc = 1180 ppm
total detergent = 2683 ppm
detergent ppm/zinc ppm ratio = 1.9

4. 10W30 Amsoil Z-Rod Oil = 95,360 psi
(8.2% below no.1)
zinc = 1431 ppm
total detergent = 2927 ppm
detergent ppm/zinc ppm ratio =2.0

5. 10W30 Joe Gibbs HR4 Hotrod Oil = 86,270 psi
(16.9% below no.1)
zinc = 1247 ppm
total detergent = 3134 ppm
detergent ppm/zinc ppm ratio = 2.5

6. 5W30 Royal Purple XPR (Extreme Performance Racing) = 74,860 psi
(27.9% below no.1)
zinc = 1421 ppm
total detergent = 3050 ppm
detergent ppm/zinc ppm ratio = 2.1

7. 15W40 Farm Rated Heavy Duty Performance Diesel, CI-4, CH-4, CG-4, CF/SL, SJ (conventional) = 73,176 psi
(29.5% below no.1)
zinc = 1325ppm
total detergent = 1593 ppm
detergent ppm/zinc ppm ratio = 1.2

8. 0W30 Brad Penn, Penn Grade 1 (semi-synthetic) = 71,377 psi
(31.3% below no.1)
zinc = 1621 ppm
total detergent = 2939 ppm
detergent ppm/zinc ppm ratio = 1.8

9. 10W30 Brad Penn, Penn Grade 1 (semi-synthetic) = 71,206 psi
(31.4% below no.1)
zinc = 1557 ppm
total detergent = 3173 ppm
detergent ppm/zinc ppm ratio = 2.0

10. 15W50 Mobil 1, API SN = 70,235 psi
(32.4% below no.1)
zinc = 1133 ppm
total detergent = 1437 ppm
detergent ppm/zinc ppm ratio = 1.3

11. 10W30 Royal Purple HPS (High Performance Street) = 66,211 psi
(36.2% below no.1)
zinc = 1774 ppm
total detergent = 3676 ppm
detergent ppm/zinc ppm ratio = 2.1

12. 10W40 Valvoline 4 Stroke Motorcycle Oil conventional, API SJ = 65,553 psi
(36.9% below no.1)
zinc = 1154 ppm
total detergent = 1999 ppm
detergent ppm/zinc ppm ratio =1.1

13. Royal Purple 10W30 Break-In Oil conventional = 62,931 psi
(39.4% below no.1)
zinc = 1170 ppm
total detergent = 3184 ppm
detergent ppm/zinc ppm ratio = 2.7

SUMMARY:
As you can see, the number one oil above, the 10W30 Valvoline NSL Conventional Racing Oil, has 1669 ppm zinc and 103,846 psi "load carrying capacity/film strength". But, the number 11 oil, the 10W30 Royal Purple HPS (High Performance Street), has 1774 ppm zinc, but ONLY 66,211 psi "load carrying capacity/film strength", which is a WHOPPING 36.2% below the number one Valvoline.

On top of that, the number one Valvoline is conventional dino oil, while the Royal Purple is synthetic. So, many people might not expect conventional oil to perform so well, since synthetic oil gets all the hype. Conventional oil is still quite good and does not get the respect it deserves. It's sort of like the fact that Chevy's late model high performance push rod engines are still quite good, even though most all other modern vehicles use overhead cam designs and get most of the hype.

If you had only looked at the spec sheet for each of these two oils, you'd assume they were equal in wear protection because their zinc levels were essentially the same. But nothing could be further from the truth. This is real world test data (not just some theory), which compared motor oils against each other under the EXACT SAME test conditions. So, this is a perfect example of the fact, that you cannot simply look at the zinc value on an oil's spec sheet, and assume that you can predict how well it will provide wear protection. Things are just NOT that simple in the real world.

And for those folks who want to avoid high levels of detergent in their oils, for fear that an oil with a lot of detergent will not be able to provide adequate wear protection, let's look at that above as well. The oils ranked 1st and 12th both had low levels of detergent. And the oils ranked 2nd and 13th both had high or relatively high levels of detergent. The rest of the oils were a mixed bag of high and low detergent oils. So, that is proof that detergent levels are a non-issue, and that there are better things to worry about.

You simply cannot believe all the misinformation you come across about motor oil, on the Internet, on Forums, and elsewhere. The bottom line is that, the only way to really KNOW how well an oil can provide wear protection, is to perform real world "wear testing" at a representative temperature, and see how it performs dynamically, under load. It's the same kind of reason that we dyno test engines, rather than simply looking at their build sheets. "Wear testing" motor oil is the gold standard, just like "dyno testing" an engine is the gold standard. Anything else is simply guessing.

As I've said before, there are no BAD oils here. They all will generally work well enough in most applications. But, some do clearly provide a higher level of reserve "extra protection capability" than others. Of course you can decide for yourself, how much reserve "extra protection capability" is good enough for your needs.

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14. DOES PROLONG ENGINE TREATMENT ACTUALLY WORK?

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I was asked to test Prolong Engine Treatment motor oil additive, which claims to increase wear protection and decrease heat and friction, to see if it actually works the way the makers claim.

Their website says, “Unlike other engine treatments on the market, Prolong Engine Treatment does not contain any solid particles such as PTFE resins, ‘molys’, zinc, copper or graphite. There is simply no other product that works as well as Prolong to reduce friction and heat in your vehicle’s engine”.
A few things the packaging says:

• No Equal In The World

• Prolong works in an effective partnership with your motor oil, to give your engine the ultimate protection against destructive metal to metal contact.

• Prolong Engine Treatment works immediately.

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They call for using their 12 ounce bottle for the initial treatment, and then to use their 8 ounce bottle at the following oil changes. The 12 ounce bottle costs about $20.00 and the 8 ounce bottle costs around $17.00. Those bottles are intended to treat 4 to 5 quarts of oil.

So, I tested Prolong Engine Treatment, and here are the results:

• 5W30 Pennzoil Ultra, API “SN”, full synthetic, by itself produces a wear protection capability of 92,569 psi. But, with the addition of the recommended amount of Prolong, its wear protection capability increased to 136,658 psi, or up 48%. Comparing this increased value to the earlier API “SM” version of 5W30 Pennzoil Ultra, which by itself had a wear protection capability of 115,612 psi, the addition of Prolong increased its capability by 18%. The Prolong added capability of 136,658 psi, is the highest value I’ve ever seen. It is so high that it is completely off my wear protection category chart. This combination will become my latest number one ranked oil. No one could ever ask for any oil to provide a higher level of wear protection than this combination provides.

• 5W30 Castrol GTX conventional, by itself produces a wear protection capability of 95,392 psi. But, with the addition of the recommended amount of Prolong, its wear protection capability increased to 130,366 psi, or up 37%. This combination will become my latest number two ranked oil.

• 5W30 Pennzoil conventional yellow bottle, by itself produces a wear protection capability of 76,989 psi. But, with the addition of the recommended amount of Prolong, its wear protection capability increased to 117,028 psi, or up 52%. This combination will become my latest number three ranked oil.

• This Prolong Engine Treatment motor oil additive works amazingly well in all types of oils, at all ranking levels. It is the REAL DEAL in terms of improving wear protection. You just have to decide for yourself if it is worth the extra money for your own particular needs. For most people, it would be more cost effective to simply choose a highly ranked oil in the first place, and avoid using any additives at all. But, for heavily loaded race engines, flat tappet engines, and for flat tappet break-in, where the ultimate in wear protection is desired, it could be worth considering.

• But, keep in mind that I only test an oil's "Wear Protection Capability". That provides the information that people usually care about most. However, that data is limited to ONLY wear protection capability, and does NOT provide any information as to how compatible overall this product's chlorine may be with a given oil's additive package. Chlorine and additive package incompatibility has a possible risk of creating damaging bearing corrosion problems. Contact Prolong's maker for more information on compatibility to find out if it is safe to use in your application. The test data on Prolong is included here for informational purposes only. I do not endorse nor recommend its use.

And for the record, I have no affiliation what so ever, with any Oil Company or any Oil Additive Company. I simply post the results that come out of my independent and unbiased testing.

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15. TEST DATA ON THE NEWEST PENNZOILS MADE FROM NATURAL GAS

Pennzoil has introduced a new line of motor oil made from natural gas. I thought it would be interesting to see how they perform in terms of wear protection capability, which is by far the most important job a motor oil performs, as well as how they compare to previous Pennzoil's. I purchased the new 5W30 Pennzoil "Ultra" Platinum and the new 5W30 Pennzoil Platinum for testing.

Wear protection reference categories are:

• Over 105,000 psi = INCREDIBLE wear protection

• 90,000 to 105,000 psi = OUTSTANDING wear protection

• 75,000 to 90,000 psi = GOOD wear protection

• 60,000 to 75,000 psi = MODEST wear protection

• Below 60,000 psi = UNDESIRABLE wear protection

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The HIGHER the psi value, the BETTER the Wear Protection.

• 5W30 Pennzoil "Ultra" Platinum, Pure Plus Technology, made from pure natural gas, API SN = 99,039 psi
This oil was introduced in 2014, and comes in a dark gray bottle with a blue vertical stripe on the label. This oil now combines the names Ultra and Platinum, where these names previously identified different oil's. As you can see, this oil is well into the OUTSTANDING wear protection category.
zinc = TBD
phos = TBD
moly = TBD

• 5W3 Pennzoil Platinum, Pure Plus Technology, made from pure natural gas, API SN = 87,241 psi
This oil was introduced in 2014, and comes in a silver bottle with a blue vertical stripe on the label. As you can see, this oil is near the top of the GOOD wear protection category.
zinc = TBD
phos = TBD
moly = TBD

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Here's how they compare to the previous version of these API SN oil's that were NOT made from natural gas.
• 5W30 Pennzoil Ultra, API SN synthetic = 92,569 psi
This was the original API SN version, that was NOT made from natural gas. This older oil's psi value is about 6.5% lower than the new natural gas version.
zinc = TBD
phos = TBD
moly = TBD
The older API "SM" version of this oil, produced a wear protection capability value of 115,612 psi.

• 5W30 Pennzoil Platinum, API SN synthetic = 99,949 psi
This was the original API SN version, that was NOT made from natural gas. This older oil's psi value is about 14.5% higher than the new natural gas version.
zinc = TBD
phos = TBD
moly = TBD

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16. HIGH TEMP MOTOR OIL WEAR TESTING – MYTH VS REALITY

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I've re-tested a dozen of those oils at a higher temperature to get a better idea of how various oil types perform over a wider range of temperatures. The oils chosen this time consist of:

*** 10 different brands
*** 6 low zinc (below 1,000 ppm) oils
*** 6 high zinc (above 1,000 ppm) oils
*** Viscosities ranging from 5W20 to 20W50
*** 8 full synthetic oils
*** 3 conventional dino oils
*** 1 semi-synthetic oil
*** 6 Racing/High Performance oils
*** 6 Modern API certified oils
*** 6 Low detergent (less than 2.0 "detergent/zinc" ratio) oils
*** 6 High detergent (2.0 or higher "detergent/zinc" ratio) oils

Here are those 12 oils, ranked by their test result capabilities at 230*F:
1. 5W30 Pennzoil Ultra, API SM (synthetic)
115,612 psi "load carrying capacity"

2. 10W30 Lucas Racing Only (synthetic)
106,505 psi "load carrying capacity" (8% below no. 1)

3. 5W30 Mobil 1, API SN (synthetic)
105,875 psi "load carrying capacity" (8% below no. 1)

4. 5W50 Motorcraft, API SN (synthetic)
103,517 psi "load carrying capacity" (10% below no. 1)

5. 10W30 Valvoline VR1 Racing Oil silver bottle (conventional)
103,505 psi "load carrying capacity" (10% below no. 1)

6. 5W20 Castrol Edge w/Titanium, API SN (synthetic)
99,983 psi "load carrying capacity" (14% below no. 1)

7. 20W50 Castrol GTX, API SN (conventional)
96,514 psi "load carrying capacity" (17% below no. 1)

8. 10W30 Joe Gibbs XP3 NASCAR Racing Oil (synthetic)
95,543 psi "load carrying capacity" (17% below no. 1)

9. 5W30 Castrol GTX, API SN (conventional)
95,392 psi "load carrying capacity" (17% below no. 1)

10. 10W30 Amsoil Z-Rod Oil (synthetic)
95,360 psi "load carrying capacity" (18% below no. 1)

11. 5W30 Royal Purple XPR (synthetic)
74,860 psi "load carrying capacity" (35% below no. 1)

12. 0W30 Brad Penn, Penn Grade 1 (semi-synthetic)
71,377 psi "load carrying capacity" (38% below no. 1)
Of these 12 oils, the top 10 were in the over 90,000 psi "OUTSTANDING PROTECTION CATEGORY". And the last 2 were in the 60,000 to 75,000 psi "MODEST PROTECTION CATEGORY". Now let's take a look at how things changed at a higher temperature.

Capability ranking at 275*F:

1. 5W30 Pennzoil Ultra, API SM = 97,955 psi (dropped 15% from its 230* value)

2. 5W30 Mobil 1, API SN = 96,323 psi (dropped 9% from its 230* value)
(2% below no. 1 here at 275*)

3. 10W30 Lucas Racing Only = 95,996 psi (dropped 10% from its 230* value)
(2% below no. 1 here at 275*)

4. 5W50 Motorcraft, API SN = 92,545 psi (dropped 11% from its 230* value)

(6% below no. 1 here at 275*)

5. 10W30 Amsoil Z-Rod Oil = 91,351 psi (dropped ONLY 4% from its 230* value)
(7% below no. 1 here at 275*)

6. 20W50 Castrol GTX, API SN = 85,815 psi (dropped 11% from its 230* value)
(12% below no. 1 here at 275*)

7. 5W20 Castrol Edge w/Titanium, API SN = 84,584 psi (dropped 15% from its 230* value)
(14% below no. 1 here at 275*)

8. 10W30 Joe Gibbs XP3 NASCAR Racing Oil = 80,957 psi (dropped 15% from its 230* value)
(17% below no. 1 here at 275*)

9. 5W30 Castrol GTX, API SN = 80,957 psi (dropped 15% from its 230* value)
(17% below no. 1 here at 275*)
NOTE: This is not a typo here, number 8 and 9 here just happened to have the same size wear scar, thus the same psi value.

10. 10W30 Valvoline VR1 Racing Oil, silver bottle = 75,116 psi (dropped 27% from its 230* value)
(23% below no. 1 here at 275*)

11. 0W30 Brad Penn, Penn Grade 1 = 68,768 psi (dropped ONLY 4% from its 230* value)
(30% below no. 1 here at 275*)

12. 5W30 Royal Purple XPR = 66,664 psi (dropped 11% from its 230* value)
(32% below no. 1 here at 275*)

As expected, the capability psi values dropped as the oils got hotter and thinner. But for most of the oils, the drop was not enormous. And the average psi drop for the whole group of 12 oils, was only about 12% from their 230* values.

You can see, there was some shuffling of the ranking order, but the original top 10, are still in the top 10. And there was no indication of the presence of slow burn zinc (requires more heat and load to become effective) that may have helped the low performing high zinc oils, do better at higher temps.

But, since engines oil won't typically be running at just 230*F or at just 275*F, it makes the most sense to average the values from the relatively cool low temp and the relatively hot high temp, to arrive at values in the middle. This will provide a more real world reference overall.

The "average" capability ranking from 230*F and 275*F combined:

1. 5W30 Pennzoil Ultra, API SM (synthetic)
106,784 psi "load carrying capacity"
zinc = 806 ppm
total detergent = 3387 ppm
detergent ppm/zinc ppm ratio = 4.2, the higher this number, the higher the proportion of detergent, which can have the potential to try and clean away zinc

2. 10W30 Lucas Racing Only (synthetic)
NOT SUITABLE FOR STREET USE
101,251 psi "load carrying capacity" (5% below no. 1)
zinc = 2642 ppm
total detergent = 2943 ppm
detergent ppm/zinc ppm ratio = 1.1

3. 5W30 Mobil 1, API SN (synthetic)
101,099 psi "load carrying capacity" (5% below no. 1)
zinc = 801 ppm
total detergent = 1489 ppm
detergent ppm/zinc ppm ratio = 1.9

4. 5W50 Motorcraft, API SN (synthetic)
98,031 psi "load carrying capacity" (8% below no. 1)
zinc = 606 ppm
total detergent = 2005 ppm
detergent ppm/zinc ppm ratio = 3.3

5. 10W30 Amsoil Z-Rod Oil (synthetic)
93,356 psi "load carrying capacity" (13% below no. 1)
zinc = 1431 ppm
total detergent = 2927 ppm
detergent ppm/zinc ppm ratio =2.0

6. 5W20 Castrol Edge w/Titanium, API SN (synthetic)
92,284 psi "load carrying capacity" (14% below no. 1)
zinc = 1042 ppm
total detergent = 1952 ppm
detergent ppm/zinc ppm ratio = 1.9

7. 20W50 Castrol GTX, API SN (conventional)
91,165 psi "load carrying capacity" (15% below no. 1)
zinc = 610 ppm

total detergent = 2599 ppm
detergent ppm/zinc ppm ratio = 4.3

8. 10W30 Valvoline VR1 Racing Oil silver bottle (conventional)
89,311 psi "load carrying capacity" (16% below no. 1)
zinc = 1472 ppm
total detergent = 2787 ppm
detergent ppm/zinc ppm ratio = 1.9

9. 10W30 Joe Gibbs XP3 NASCAR Racing Oil (synthetic)
NOT SUITABLE FOR STREET USE
88,250 psi "load carrying capacity" (17% below no. 1)
zinc = 743 ppm
total detergent = 620 ppm
detergent ppm/zinc ppm ratio = .8

10. 5W30 Castrol GTX, API SN (conventional)
88,175 psi "load carrying capacity" (17% below no. 1)
zinc = 830 ppm
total detergent = 2648 ppm
detergent ppm/zinc ppm ratio = 3.2

11. 5W30 Royal Purple XPR (synthetic)
70,762 psi "load carrying capacity" (34% below no. 1)
zinc = 1421 ppm
total detergent = 3050 ppm
detergent ppm/zinc ppm ratio = 2.1

12. 0W30 Brad Penn, Penn Grade 1 (semi-synthetic)
70,073 psi "load carrying capacity" (34% below no. 1)
zinc = 1621 ppm
total detergent = 2939 ppm
detergent ppm/zinc ppm ratio = 1.8 (only 43% of the detergent concentration of no. 1)

Looking at these 230*F and 275*F combined "average values", you can see the following:

*** Modern API certified oils ranked from number 1 to number 10
*** Racing/High Performance oils ranked from number 2 to number 12
*** High detergent oils ranked from number 1 to number 11
*** Low detergent oils ranked from number 2 to number 12
*** Synthetic oils ranked from number 1 to number 11
*** Conventional dino oils ranked from number 7 to number 10

*** Semi-synthetic oil ranked number 12
*** 20 wt type oil ranked number 6
*** 30 wt type oils ranked from number 1 to number 12
*** 50 wt type oils ranked from number 4 to number 7

So, it's quite clear by looking at these results, that high zinc levels, high detergent levels, and heavy viscosities do NOT play any particular roll in how well a motor oil does or does not provide wear protection. The only thing that matters is the base oil and its additive package "as a whole". Looking at zinc levels, detergent levels, and viscosities on an oil's spec sheet, will NOT help you choose a motor oil that provides the best wear protection. If that is all you go by, you will be kidding yourself about how good any particular oil is.

And keep in mind that the oil industry is fully aware that there is alternate chemistry available besides zinc/phos, which can be used for extreme pressure wear protection, that is equal to or better than zinc/phos. And that alternate chemistry is just what they use to reduce the zinc/phos levels in modern API certified oils. So, you do NOT need to have high levels of zinc/phos in order to have outstanding wear protection, no matter how loud someone screams that you do. Because they simply DO NOT know what they are talking about, and are only repeating that same old incorrect wives tale. That high zinc thinking is only a MYTH repeated a million times until everyone just "thinks" it's true. But, that MYTH has been BUSTED by real world "dynamic wear testing under load".

In spite of what many Racers, Hotrodders and Gearheads have been lead to believe about zinc levels, only "dynamic wear testing under load" can provide the necessary data to help you choose a motor oil that will truly provide the best wear protection. It's the same type of idea where we dyno test engines to see how they truly perform, rather than just looking at their spec sheets.
SYNTHETIC VS CONVENTIONAL OILS

Some of the most commonly claimed benefits of synthetics are:

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1. Synthetics provide a higher level of wear protection.

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2. Synthetics can withstand higher temperatures before thermal breakdown begins.

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3. Synthetics provide superior flow under extremely cold conditions.

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So, let's see how the real world testing above, supports those claims. The synthetics above did show some advantage regarding wear protection, but NOT by a large amount. The highest ranked conventional oil ranked 7th out of 12, but was only 15% below the highest ranked synthetic oil. And this conventional oil ranked higher than other synthetic and semi-synthetic oils.

This shows that you cannot automatically assume that a synthetic oil will provide the best wear protection just because it is synthetic. Wear protection depends on the oil and its additive package "as a whole". And it's the additive package that contains the extreme pressure protection components, not the oil itself. And again, only "dynamic wear testing under load" can provide the data to help you choose an oil that provides the best wear protection.

THERMAL BREAKDOWN

Thermal breakdown is the point at which the composition of the oil begins to change due to the temperature it's exposed to.

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The "Official" test for this is called the NOACK Volatility Test. In this test, per the ASTM spec, the oil is heated to 250*C (482*F) for one hour. The lighter oil fractions will vaporize, leaving thicker and heavier oil, contributing to poor circulation, reduced fuel economy, increased oil consumption, **increased wear** and increased emissions.

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The test reports results in the percentage, by weight, lost due to "volatilization." Before July 1, 2001, 5W-30 motor oil in the United States could lose up to 22 percent of its weight and still be regarded as "passable." Now, with GF-4, the maximum NOACK volatility for API licensing is 15 percent. European standards limit high quality oils to a maximum of 13 percent loss.

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This of course means that any motor oil that has been heated above its onset of thermal breakdown point, has started to deteriorate. So, reasonable oil change intervals should be followed. See Tech Article, "25. Recommended Oil Change Interval", for more details.

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So, I also heated the oils and observed the temperature at which they started to vaporize (which looks like smoke to the casual observer, even though the oil is NOT actually burning), which indicates the onset of thermal breakdown:

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5W30 Pennzoil Ultra, API SM = 280*

5W30 Mobil 1, API SN = 265*

10W30 Lucas Racing Only = 290*

5W50 Motorcraft, API SN = 275*

10W30 Amsoil Z-Rod Oil = 300*, the BEST in this test

20W50 Castrol GTX, API SN = 275*

5W20 Castrol Edge w/Titanium, API SN = 280*

10W30 Joe Gibbs XP3 NASCAR Racing Oil = 280*

5W30 Castrol GTX, API SN = 280*

10W30 Valvoline VR1 Racing Oil, silver bottle = 260*, the WORST in this test

0W30 Brad Penn, Penn Grade 1 = 280*

5W30 Royal Purple XPR = 285*

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Here are the "averages" for the onset of thermal breakdown with these 12 oils:

Full synthetic oils = 282*

Semi-synthetic oil = 280*

Conventional dino oils = 272*

For the oils tested above, certain specific oils did show a significant difference, such as the synthetic Amsoil Z-Rod oil which had a 40* advantage over the conventional Valvoline VR1 Racing Oil.

But, as for overall averages, there was only a 10* difference between synthetic and conventional oils. So, the real world observation here does NOT support common internet oil info claims about synthetic oils having an unbelievably high temperature capability compared to conventional oil.

Don't believe everything you read on the internet about motor oil. Because there is a lot of misinformation floating around, that has often been repeated over and over without any proof to back it up. Most sources never ever do any independent testing at all, they just repeat what others have already written. And it doesn't matter how many times, different sources repeat the same wrong information, it will never magically become true.

As mentioned above, performing real world "dynamic wear testing under load" is the only way to determine the true story about which oils actually do provide the best wear protection. And this is precisely why I decided to perform my own testing. That way I could see for myself what is real and what is not.

The above info also makes a good case for running an effective oil cooler setup, if one is needed to keep the oil safely below the threshold of thermal breakdown. But you may also need an oil cooler thermostat as part of that type of setup as well, so that the oil doesn't end up too cool. You should keep oil temps above 212*F to keep the normal engine condensation quickly boiled off, rather than just slowly evaporated off. You don't want to allow slowly evaporating water to have the chance to mix in with the oil and dilute it. Oil can only be thinned out by becoming diluted with coolant/water or fuel. And oil can only get thicker by getting overheated and vaporizing its lighter components. So, an ideal sump temperature range for most motor oils in general, would be between 215*F and 250*F. You get the idea, not too cold, not too hot, just right.

I did not test the cold flow capability of synthetic oils here. So, that claim's validity remains to be seen. But I did perform one last test here, and that was testing at 325*F, to see what wear protection capability still exists during extreme heating conditions. I selected the highest ranked low zinc oil, 5W30 Pennzoil Ultra, API SM and the highest ranked high zinc oil, 10W30 Lucas Racing Only. Even though they were both vaporizing a lot at this temperature, here are the results at 325*F:

1. 5W30 Pennzoil Ultra, API SM
98,329 psi "load carrying capacity" (essentially no change from its 275* value)

2. 10W30 Lucas Racing Only
97,561 psi "load carrying capacity" (essentially no change from its 275* value)

As you can see, their load carrying capacity leveled off and stayed approximately the same between 275* and 325*. So, it is comforting to know that you don't run into dangerously low wear protection if and when you end up with overheated oil at some point. But of course the oil will have already run into thermal breakdown and should be changed as soon as possible.

At the end of the day, there are many outstanding motor oils available. And now you have even more oil performance data to consider. So, making an educated choice to suit your needs should not be too difficult.

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17. DO "HTHS" (High-Temperature/High-Shear) VALUES PROVIDE ANY USEFUL INFORMATION ABOUT WEAR PROTECTION CAPABILITY?
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The Motor Oil Wear Protection testing I perform, provides valuable information on how capable various motor oils are at providing wear protection.

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But, HTHS (High-Temperature/High-Shear) test data only provides information on how capable various motor oils are at maintaining their viscosity under high heat and high stress conditions. But, that HTHS viscosity data DOES NOT provide any information at all about an oil's wear protection capability. Because a motor oil's viscosity DOES NOT determine its wear protection capability. A lot of people are completely mistaken when they believe viscosity determines an oil's wear protection capability. On some Forums, people discuss HTHS values and how they indicate an oil's wear protection capability. But, that whole line of thinking is completely FALSE.

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Here are some FACTS that came directly out of the Engineering tests I perform on motor oil.
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20 wt oils rank between number 2 and 212 out of 223.
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30 wt oils rank between number 1 and 223 out of 223.
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40 wt oils rank between number 5 and 211 out of 223.
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50 wt oils rank between number 37 and 220 out of 223.
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60 wt oil, the only one tested, ranks number 97 out of 223.
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70 wt oil, the only one tested, ranks number 169 out of 223.
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So, as you can see, oil viscosity itself plays no particular role in an oil's wear protection

capability. An oil's wear protection capability is determined by its base oil and its additive package "as a whole", with the primary emphasis on the additive package, which contains the extreme pressure anti-wear components, which has nothing to do with viscosity.

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Any HTHS values used as a comparison for wear protection, DO NOT reliably tell you anything. The extreme pressure anti-wear components from the additive package are what really determine wear protection, NOT those HTHS values. People often do not understand this, which is why they sometimes get the wrong idea about HTHS values.

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The oils I have ranked, were all tested at a representative 230*F operating temperature.

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But, I have also tested various motor oils at 275*F as well as 325*F. What I found was that going from 230*F to 275*F, the wear protection capability of the oils tested, dropped by only about 12% on average. I also found that going from 275*F to 325*F, their wear protection capability leveled off and stayed about the same. I also found that even at these elevated temperatures, there was no significant change in ranking order. And this proves that my normal test data which comes from 230*F, is valid even at much higher temperatures.

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Keep in mind that my test data pertains to motor oil film strength/load carrying capability/ shear resistance, which is of critical importance where that is the form of lubrication involved in many locations in an engine. But, regarding rod and main plain bearings, an oil's film strength/load carrying capability/shear resistance is not what prevents wear in that location of an engine. Remember that all liquids are incompressible, even water. An engine's plain bearings are lubricated by oil flow. Oil viscosity is NOT what keeps these parts separated. The parts are kept separated by the incompressible hydrodynamic liquid oil wedge that is formed as the liquid oil is pulled in between the spinning parts. As long as sufficient oil is supplied to the crankshaft/bearing interface, no wear can occur. Because as long as sufficient oil pressure is maintained to provide the needed oil supply, that critical incompressible hydrodynamic liquid oil wedge will be maintained. The only way high oil temps could compromise this type of lubrication, is if the oil pressure fell so dangerously low, that it could no longer supply sufficient oil flow to maintain that all-important incompressible hydrodynamic liquid oil wedge. Again, ALL liquids are incompressible, no matter what their temperature is. If your oil sump temp gets higher than recommended, keep a close eye on your oil pressure gauge to make sure it is at an acceptable level.

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I also tested a number of used oils with 5,000 miles on them. And found that there was no loss of wear protection capability.

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At the end of the day, the most important thing a motor oil does, is protect an engine against wear. Everything else it does, comes AFTER that. I don't place a lot of importance on HTHS data, because my film strength/load carrying capability values are really the only data that provides useful information regarding wear protection capability.

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18. ENGINEERING TEST DATA ON HIGH MILEAGE MOTOR OILS

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Before we get into motor oil tech, let's briefly touch on a little background info. In addition to being a lifelong Gear Head, Mechanic, Hotrodder, Drag Racer, and Engine Builder, I'm also a working Professional Degreed Mechanical Engineer, as well as a U.S. Patent holder. Mechanical Design Engineering is what I do for a living. A Mechanical Engineer is clearly the most qualified Engineer to test motor oil that was formulated by Chemical Engineers, for wear protection capability between mechanical components under load.

It should also be noted, that I do not sell motor oil, nor do I work for any Motor Oil Company. I have no vested interest in what motor oil people choose to buy. I only share my Motor Oil Engineering Test Data for free, as a courtesy for other interested parties, so they too can benefit from the knowledge that was never available until now. People can embrace my data and make good use of it, or they can ignore it and continue to make uninformed motor oil choices, which will result in them not always having the wear protection they think they have. And having less wear protection than they think they have, has often resulted in wiped lobes in flat tappet engines.

The independent and unbiased Engineering testing I perform at a REPRESENTATIVE OPERATIONAL TEMPERATURE, to establish motor oil wear protection capability, is a dynamic friction test under load, similar to how an engine dyno test is a dynamic HP/Torque test under load. Both tests show how their subjects truly perform in the real world, no matter what brand names are involved, no matter what outrageous claims may have been made, and no matter what their spec sheets may say.

I always check and adjust if needed, the calibration of my test equipment each time I test a different oil, to keep the results accurate. I also perform multiple tests on each oil, then average those values to arrive at the most accurate and representative value that I post for comparison. The results, good or bad, simply are what they are, and are determined by the complete chemical makeup of each oil tested, which is just what your engine sees after you pour it in.

My Motor Oil Wear Protection Ranking List of over 150 different oils, is "proven" by the Physics and Chemistry involved, and it EXACTLY matches real world Track experience, real world flat tappet break-in experience, and real world High Performance Street experience (test data validation doesn't get any better than this). You can see the details on all that, by going to the Oil Test Data Blog link below.

It is not a matter of agreeing with my data or not agreeing with it, because the data used to create my Wear Protection Ranking List is NOT my opinion, and it is NOT my theory. The data, as mentioned above, is the result of the Physics and Chemistry involved in the testing. I am only the messenger. The Science is what tells us how these oils perform. And no sensible person would try to argue against Physics and Chemistry. Science is absolute whether people like it or not, and emotion cannot change it.

The fact is, motor oil wear protection capability is determined by the base oil and its additive package "as a whole", with the emphasis on the synergistic effects of the base oil and entire additive package, which is what contains the extreme pressure anti-wear components, and NOT merely by how much zinc is present. The use of zinc as the primary extreme pressure anti-wear component is outdated technology. Modern extreme pressure anti-wear components are equal to or better than zinc, which is why many modern low zinc oils outperform many traditional high zinc oils. Engineering tests have proven over and over again, that it is completely worthless to simply look at the zinc level of a particular motor oil to try to determine how well it provides wear protection.

So, think long and hard before believing anything the naysayers say when they try to discredit my Motor Oil Engineering Test Data. There are always some who try, but fail in their attempt. They are not actually arguing with me, even if they think they are. They are actually arguing against the Science of Physics and Chemistry. Who do you think will win that battle? And ask them how they figure they know more than what the Science of Physics and Chemistry proves. Ask them what their qualifications are. Ask them what testing they have ever done.

They are typically high zinc lovers who just can't accept the fact that what they've always believed about the need for high zinc oils, is only an Old Wives Tale MYTH. So, they get upset and go out of their way trying to undermine anything that goes against what they have been brainwashed to believe about high zinc oils. But, emotion does not determine the Engineering results of how good any particular oil is. As mentioned above, and it bears repeating, factual Engineering tests have proven over and over again that zinc levels alone DO NOT determine an oil's wear protection capability.

The naysayers cannot factually back-up anything they say. They think they are motor oil experts simply because they have done a bunch of Internet reading. They will sometimes make a big deal about what is in the base oil. They will sometimes provide links to lame Internet articles, which are often just a lab test of a single individual zinc component, showing what it did in that particular lab test. But, that is not any actual motor oil that you buy and pour into your engine. It may be somewhat interesting to read, but that type of test does not does not take into account the countless formula variations and synergistic effects found in the actual motor oils that are available on the market. Therefore, you are only looking at a single data point of a test that is not even what will end up in your engine. Or in other words, worthless information that many zinc lovers falsely believe, is that last word on motor oil. That is NOT how Engineering works. And lot of their lame Internet articles are nothing more than one author copying from the same worthless source material as other authors.

And if that isn't bad enough, some information they throw out there as Gospel is only advertising hype from a motor oil's bottle or website. Of course it is no secret that Motor Oil Companies are among the worst for false advertising. The absolute worst motor oils on the market, and the absolute best motor oils on the market, make the same claims about how wonderful they are. So, the claims made on motor oil bottles and websites would only be taken as truthful, by gullible people who are not Technically savvy.
These zinc lover critics may mean well, but they really DO NOT know what they are talking about. Motor Oil Companies will say absolutely anything to sell their products. When it comes to motor oil, there is no such thing as truth in advertising. And that is why you never see any advertising data from a given Motor Oil Company about how its modern low zinc oils compare to its traditional high zinc oils. That is because it is simply not true that all high zinc oils are better than all low zinc oils. The truth is, some high zinc oils are quite good, while other high zinc oils are quite poor. And you cannot tell the difference by looking only their zinc quantities.

Then these naysayers will also sometimes use the oil recommendations from Cam Companies as support for their position on what oil to use. Problem is, just because Cam Companies sell cams, does not mean they know the first thing about motor oil. They are simply staffed by people who are brainwashed to believe that any high zinc oil will provide all the wear protection necessary for flat tappet cams. But, the proof that they are clueless about motor oil, is the fact that even the leading Cam Companies still have flat tappet lobes get wiped, when people use the oils they recommend. And those oils are typically the oils that have tested very poorly in my Motor Oil Engineering Wear Protection Testing. On top of that, Cam Companies typically do not employ Degreed Mechanical Engineers. So, it comes as no surprise that they supply bad information as to what oils to use.

The people who recommend poor performing motor oils, believe if they haven't lost a lobe while using a certain oil, that it must be great oil. But, they just don't know, what they don't know. That only means the oil they used provided "enough" protection for the particular application that didn't fail. But, that does not tell them anything about how much extra protection they had beyond that. So, their "opinion" of that oil is not a good technical evaluation of its capability. That would be like them telling you that an engine making 750 HP, is good as long as it has rods in it that can withstand 751 HP. Yeah, it might not throw a rod, or maybe it will. But, no technically savvy person would want to run a margin of safety that close.

It's the same idea with the oil you choose to run. Don't run an oil with a margin of safety that close. My Motor Oil Engineering Test Data, allows us see how different oils truly compare to each other, so we can run a substantial margin of safety to provide the best possible wear protection for our engines. You have to spend money buying oil anyway, so why not buy excellent oil while you are at it? So, before you consider following the bad advice others give about the oil they only "think" is good, read the real world facts about motor oil, at the link provided at the end of this posting, then decide for yourself who is providing factual motor oil information that you can actually use to your advantage.

The whole idea of simply needing a high zinc level for sufficient wear protection, is only an old wives tale myth that has been busted. Modern extreme pressure anti-wear additives are equal to or better than zinc. Relying only on zinc as the primary anti-wear component, is outdated technology. Wiped flat tappet lobes continue to happen over and over again, when people use high zinc oils that produce poor results in my testing. It's time to take notice of that.

People who want the facts about which motor oils are good and which are not so good, want to see unbiased and independent test data. And that is exactly what my motor oil film strength/load carrying capability data provides. I back-up everything I say with that hard Engineering test data that exactly matches real world experience. It matches real world experience because my test data is the real deal, which accurately predicts what we can expect from the oils we buy. I test the actual motor oils that we buy and pour into our engines. So, my test data comes entirely from real "on-the-market" motor oils, which is what truly matters.

To provide your engine with the best possible wear protection, as well as to prevent wiped flat tappet wiped lobes, I recommend that you select a highly ranked oil (I'd suggest an oil with over 90,000 psi capability for High Performance Street/Strip flat tappet engines) from my Wear

Protection Ranking List, no matter how much zinc it has. That same oil, assuming it is not a short term only Racing Oil, can be used for both break-in and after break-in. Also, do NOT use any aftermarket additives at all, use the oil just as it comes right out of the bottle.

Using special break-in procedures is only a crutch for poor performing high zinc oils. And if you select a highly ranked oil from my wear protection ranking list, no matter how much zinc it has, with no aftermarket additives, you won't even have to perform any special break-in procedures. Using an oil with a highly ranked film strength/load carrying capability is that good. I have not had one person who has followed that recommendation, ever report a wiped lobe again. If you make a wise motor oil choice based on my test data, rather than the old myth of any high zinc oil is good enough, the engine you save may be your own.

My Test Data Blog now has over 95,000 views worldwide. Of course simply listing the number of views by itself, is not intended to indicate validation of the test data (validation is shown throughout the Blog). But, indicating the number of views does show that an enormous number of people worldwide recognize the value, understand the importance, and make use of the motor oil test data FACTS included there, that cannot be found anywhere else. And as a result, they are posting and sharing links to my Blog, all over the world. See for yourself. A link is provided at the end of this posting.

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Now, on with Test Data on High Mileage Motor Oils.

High Mileage motor oils are formulated for older engines with over 75,000 miles on them. And High Mileage oils include "Seal Swell" chemicals to help reduce oil leakage in those older engines.

Below is how 5 different High Mileage oils ranked just among themselves, regarding wear protection capability, after they were tested.

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The Wear protection reference categories are:

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• Over 105,000 psi = INCREDIBLE wear protection

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• 90,000 to 105,000 psi = OUTSTANDING wear protection

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• 75,000 to 90,000 psi = GOOD wear protection

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• 60,000 to 75,000 psi = MODEST wear protection

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• Below 60,000 psi = UNDESIRABLE wear protection

1. 5W30 Valvoline MaxLife High Mileage, API SN, synthetic blend = 108,045 psi

2. 5W30 Pennzoil High Mileage Vehicle, API SN, conventional = 102,402 psi

3. 5W30 Castrol GTX High Mileage, API SN, synthetic blend = 91,404 psi

4. 10W30 Quaker State Defy High Mileage, API SL semi-synthetic = 90,226 psi

5. 5W30 Mobil 1 High Mileage, API SL, synthetic = 88,081 psi

As you can see, these oils all performed very well, even though the top 3 are modern low zinc API SN oils. And that is even more proof that oils DO NOT need high zinc levels to provide excellent wear protection.

To see how these oils rank in my overall Wear Protection Ranking List of over 150 different oils, go to:

Section 1 – Motor Oil "Wear Protection" Ranking List, in this Blog.

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19. ENGINE DYNO HP vs CHASSIS DYNO HP

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Don't put too much stock in Chassis Dyno data. Here's why:

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From time to time, folks try to determine what their engine HP is by back calculating from the Rear Wheel HP data they obtained from a Chassis Dyno. Let's take a look at what it takes to make sense of that.

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First we need to look at the 3, count 'em 3, different correction factors in use.

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1. SAE J607 also called SAE STD, which is the classic Hotrod and Racing Engine correction factor used by most folks on an engine dyno. So, if you plan to compare Hotrod or Racing Engine dyno figures between various engines across the nation, you must use this correction factor in order to be on the same page with most everyone else. It is corrected to 60*F, zero % humidity, and 29.92" hg. This one gives GROSS HP, and excludes the use of accessories, full exhaust system, full air cleaner, or any emissions equipment. Since this correction factor has the most favorable correction conditions, it will of course provide the highest numbers of all the correction factors shown here.

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2. SAE J1995 also called SAE GROSS, was used by the OEM's through '71. It is corrected to 77*F, zero % humidity, and 29.234" hg. This one gives GROSS HP, and excludes the use of accessories, full exhaust system, full air cleaner or any emissions equipment. The results using this one, are usually somewhere around 20% higher than SAE NET HP figures.

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3. SAE J1349 also called SAE NET, has been used by the OEM's since '72. It is also corrected to 77*F, zero % humidity, and 29.234" hg. But this one gives NET HP, and DOES include the use of accessories, full exhaust system, full air cleaner, and any emissions equipment.

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Since each correction factor will provide different HP results, when it comes to trying to compare and/or calculate one way or the other, between engine dyno numbers and chassis dyno numbers, you MUST use the SAME correction factor for both the engine dyno and the chassis dyno. This will keep things an apples to apples comparison and/or calculation.

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If you don't use the same correction factors, you end up with, at best, an apples to oranges comparison, or at worst, an apples to elephants comparison. Neither one of these is much good for back calculating engine HP from rear wheel HP.

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When Engine and Chassis Dyno numbers are compared properly, by using the same correction factor, the most widely accepted drive train loss figures for non-IRS cars have typically been around 12 to 15% for stick cars, and around 25 to 30% for automatics.

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So, let's look at some real world Engine Dyno vs Chassis Dyno tests, to see how things typically shake out:

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From June 2011 Popular Hotrodding Magazine

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'70 Chevy Nova
555ci BBC
675 HP from Engine Dyno using SAE J607/SAE STD correction factor
9" rearend (not IRS)
Powerglide automatic

1. On a Dyno Dynamics Eddy Current chassis dyno with 2 smallish 12" diameter rollers, using SAE J1995/SAE GROSS correction factor. This is an apples to oranges comparison because of incompatible correction factors, and Rear wheel HP = 487, for a 28% drive train loss. The loss was so high here, not only because of the incompatible correction factors, but also because under load, the 2 smallish dyno rollers caused MAJOR out of shape, HP robbing, tire distortion.

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2. On a Dynojet Inertia chassis dyno with 1 large 24" diameter roller, using SAE J1349/SAE NET correction factor. This is an apples to elephants comparison because of REALLY incompatible correction factors, and Rear wheel HP = 564, for a 16% drive train loss. The larger dyno roller did not cause any HP robbing tire distortion here.

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The results between these two chassis dyno's varied by a whopping 77 Rear wheel HP, or 12%. This leaves you with absolutely no chance of back calculating engine HP with any degree of accuracy. Even if you threw out number 1 with all the tire distortion, and looked only at number 2, you still couldn't accurately back calculate engine HP. Because that 16% loss is considered to be more in line with stick drive train losses, when compatible correction factors are used, and NOT automatic drive train losses when significantly incompatible correction factors are used.

The results here just leave you scratching your head. So, you can't accurately back calculate engine HP and you can't even feel confident about how much HP you are actually putting to the ground either. This certainly questions the value of using a Chassis dyno at all.

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From February 2011 Super Chevy Magazine

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'72 Corvette
383ci SBC

426 HP from Engine Dyno using SAE J1995/SAE GROSS correction factor
IRS rear end
4 speed stick

On Super Chevy Magazine's brand new Dynojet inertia chassis dyno, and using the SAE J1349/SAE NET correction factor. This is an apples to oranges comparison because of incompatible correction factors, and Rear wheel HP = 283, for a whopping 34% drive train loss.

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'70 Chevelle LS6
454ci BBC
450 HP from factory Engine Dyno using SAE J1995/SAE GROSS correction factor
Solid rear end (no IRS)
TH400 automatic

On Super Chevy Magazine's brand new Dynojet inertia chassis dyno, and using the SAE J1349/SAE NET correction factor. This is an apples to oranges comparison because of incompatible correction factors, and Rear wheel HP = 285, for a whopping 37% drive train loss.

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'69 L72 Yenko Camaro
427ci BBC
425 HP from factory Engine Dyno using SAE J1995/SAE GROSS correction factor
Solid rear end (no IRS)
Stick tranny

On Super Chevy Magazine's brand new Dynojet inertia chassis dyno, and using the SAE J1349/SAE NET correction factor. This is an apples to oranges comparison because of incompatible correction factors, and Rear wheel HP = 288, for a whopping 32% drive train loss.

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'57 Chevy BelAir
283ci SBC
245 HP dual quad, from factory Engine Dyno using SAE J1995/SAE GROSS correction factor
Solid rear end (no IRS)
Powerglide automatic

On Super Chevy Magazine's brand new Dynojet inertia chassis dyno, and using the SAE J1349/SAE NET correction factor. This is an apples to oranges comparison because of incompatible correction factors, and Rear wheel HP = 158, for a whopping 36% drive train loss.

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The drive train losses for this group of 4 cars ranged from 32% to 37%, and were high due to incompatible correction factors. On top of that, there was no clear distinction at all between stick cars, automatic cars, and IRS cars, even though stick cars typically only have about half as much drive train loss as automatic cars. So, none of these figures are worth much either, in terms of accuracy or usefulness.

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From March 2011 Hotrod Magazine

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2011 Shelby GT500 Super Snake Mustang
5.4L Supercharged V-8
750 HP from Engine Dyno using SAE J607/SAE STD correction factor
solid rearend (not IRS)
6 speed stick

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1. On a Dynojet Inertia chassis dyno using SAE J607/SAE STD correction factor. Rear wheel HP = 654, for a 13% drive train loss. Being that this is an apples to apples comparison because of the same correction factors being used, it makes sense to see a 13% drive train loss, which is in the range of what would be expected for a non-IRS stick car.

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2. On a SECOND Dynojet Inertia chassis dyno at another shop, which also used the SAE J607/SAE STD correction factor. Rear wheel HP = 652, for a 13% drive train loss. Being that this is an apples to apples comparison because of the same correction factors being used, again it makes sense to see a 13% drive train loss, which is in the range of what would be expected for a non-IRS stick car.

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3. On a Superflow Auto Dyn eddy current chassis dyno using SAE J607/SAE STD correction factor. Rear wheel HP = 630, for a 16% drive train loss. Being that this is an apples to apples comparison because of the same correction factors being used, it still makes sense to see a 16% drive train loss, which is just on the outer edge of the range of what would be expected for a non-IRS stick car.

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4. On a Mustang brand eddy current chassis dyno using SAE J1349/SAE NET correction factor. This is an apples to oranges comparison because of incompatible correction factors, and Rear wheel HP = 568, for a 24% drive train loss. These numbers are too far off to be of any use for comparison or for even determining how much HP is put to the ground.

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5. On a Dyna Pack hydraulic type chassis dyno that bolts directly to the hubs, and using SAE J1349/SAE NET correction factor. This is an apples to oranges comparison because of incompatible correction factors, and Rear wheel HP = 585, for a 22% drive train loss. These numbers are too far off to be of any use for comparison or for even determining how much HP is put to the ground.

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Overall, these 5 chassis dyno's ranged a whopping 86 RWHP, or 11% on the SAME car, with the exact SAME setup. Good luck trying to ever back calculate engine HP from these numbers, or even trying to determine how much HP is actually delivered to the ground.

However, if you only look at the 3 dyno's above that used the same correction factor as the engine dyno, you'll see that they produced reasonable numbers that actually are usable. They ranged only 24 HP or 3%, which is about as good as you are ever going to get. And this backs up the statement that you MUST use the SAME correction factor for both the engine dyno and the chassis dyno.

Also, new cars since '72 have been rated in SAE NET engine HP. So, you can fairly reasonably use a chassis dyno that uses the same SAE NET HP correction factor for comparison there. But even that is a little iffy because the OEM's often underrate their HP levels, so that introduces more error back into any comparison/back calculation.

If you don't use the same correction factors for comparison, then all chassis dyno's are really good for is to compare back to back changes you make while on that dyno. That way you are only looking at the differences, and not caring about what the absolutes truly are. If used in this manner, any random chassis dyno "can" be a useful tool for modifications (though it's wise to make a few back to back pulls with no changes to see if the dyno is repeatable, because some are not).

And if you are using mismatched correction factors for comparison, don't even bother trying to back calculate your engine HP, because you won't get valid results. In addition to that, with all the other variables between dyno's (due to different makes and models, strap tension, tire pressure, tire rubber compound, dyno cooling fan airflow, etc, etc), don't put much stock in the amount of HP they claim you are putting to the ground either, since the numbers will be all over the place

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So, at the end of the day, you have to decide for yourself if you think a Chassis Dyno session is even worth the time, cost and effort.

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20. **STD VOLUME OIL PUMPS VS HIGH VOLUME OIL PUMPS – IS THERE REALLY A HP DIFFERENCE?**

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When it comes to discussing/debating the topic of "std volume oil pumps vs high volume oil pumps", we need something more than just opinion, emotion and speculation. We need actual real world comparison data. So, consider the following:

Awhile back, Car Craft Magazine used a 372ci SBC to do an oil pump volume comparison test. So, we can look at that actual real world test data to see how things stacked up. Here are the results using **conventional petroleum 30 wt** for each test:

Oil Pump…………………….**Peak HP**………………**Ave. HP**……………**Ave. press.**

Std volume/std pressure.………485……………………392…………………50 psi

High volume/High pressure……481……………………390…………………66 psi

High volume/std pressure……..477……………………387…………………64 psi

As you can see, surprisingly the std pressure version of the high volume pump made the worst HP of these three small block pumps. It was down 8hp or down 1.6% for peak HP, and down 5hp or down 1.3% for Ave HP. It also provided a 14 psi increase in ave pressure, or a 28% increase in ave pressure.

But the High volume/high pressure pump was down only 4hp or down .8% for peak HP, and down only 2hp or down only .5% for Ave HP. This one provided a 16 psi increase in ave pressure, or a 32% increase in ave pressure.

Of course the most important number is the "average" HP loss, NOT the peak HP loss. Because peak is only a single data point, while average is across the whole rpm range being used.

Only the most hardcore racer could ever notice a 2hp or .5% HP loss, using the high volume/high pressure pump. So, THE USE OF THAT HIGH VOLUME/HIGH PRESSURE PUMP DID NOT CAUSE A SIGNIFICANT LOSS OF PERFORMANCE, as is the common "belief". And the higher volume pump will provide better low rpm oil pressure, and allow for switching to much better thinner motor oils. More on that below.

And in the same article, Car Craft also tested different oil viscosities using the **High volume/std pressure** oil pump. Here are those results:

Oil………………**Peak HP**………**Ave. HP**………**Ave. press**…**Ave. Flow in GPM**

0W10 syn…………480……………387………………56………………7.4

5W20 syn…………479……………386………………59………………7.2

20W50 syn………..477……………387………………67………………6.5

30W conventional..475…………….384………………67………………6.1

The 0W10 is probably thinner than all but the hardest of hardcore racers would care to use. And 20W50 is thickish and somewhat similar to the straight 30W.

But 30W conventional petroleum oil was used for the oil pump volume test at the top, so let's use that as the main reference here for viscosity comparisons. And that leaves the more reasonable 5W20 synthetic for a quick viscosity comparison.

The 5W20 made 4hp more peak HP or about .8% more peak HP than the 30W. It also made 2hp more ave HP, or .5% more Ave HP than the 30W. So, HP increases with the thinner oil is not significant here, but it does offset the slight loss of hp from going to a high volume pump in the first place. The thinner 5W20 also drops a little oil pressure, but it's still quite reasonable.

So, a larger volume oil pump loses a tad bit of HP and increases the oil pressure, but the thinner synthetic oil gains a tad bit of HP and decreases the oil pressure. In the end, it's all pretty much a wash. So then what's the point of making these changes at all?

To answer that, we need to look at the average flow in GPM (gallons per minute). The 5W20 flows a whopping 18% more than the straight 30W. So what's the value in that you ask?

Well, many folks "believe" that oil pressure = lubrication, but that is simply NOT the case. Pressure is only a measurement of resistance to flow. But, oil FLOW is lubrication, and you get more flow with thinner oil as we just saw above. Lubrication is what is used to separate moving parts, and keep them from making metal to metal contact, which results in wear/damage. And increased flow also has another very important advantage. An engine's vital internal components are all DIRECTLY OIL COOLED, but only INDIRECTLY water cooled. And thinner oil will flow more freely, carrying away more heat, thus providing better cooling for those vital internal components. And of course that extra cooling is even more important in high performance engines.

So, going to the trouble of achieving almost an extra 20% in flow, is well worth the effort. If someone asks why use a high volume pump, the answer is so that you can maintain reasonable oil pressure with thinner oil. And with thinner oil, you can improve both lubrication and cooling. So, it's all good.

NOTE: To best see those oil temp changes and cooling improvements, you really need to observe that in a running car on the road or on the track. Because trying to observe this during brief dyno pulls, will likely result in you not getting a worthwhile picture of the true potential.

So, here are some comparison numbers for you from an 830 HP road race engine, on the track:

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15W50 oil = 80 psi = 265* oil temp

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5W20 oil = 65 psi = 240* oil temp

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Here you can see how the thicker oil flowed more slowly through the bearings, thus getting hotter and driving up bearing temps. If an engine is running hot, use a thinner oil to increase flow and increase cooling. And running a high volume oil pump allows you to do that.

For me personally, I run 5W30 in my own 781 HP, 710 ft lb, 540ci BBC Street/Strip motor, which I intentionally built with .003 clearance on the rods and mains. And with a Titan gerotor “high volume/high pressure” oil pump, it has a hot idle oil pressure of about 30 psi, and a rock steady max oil pressure of 80 psi, which also shows that there is no sign of aerated oil with this setup. No issues, no problems.

CONCLUSION:
No matter what anyone else tells you, the “Ideal Lubrication Setup” for most traditional engines, is a high volume/high pressure oil pump with a thinner multi-viscosity motor oil such as 5W30.

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21. **Points Ignition vs Electronic Ignition**

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Every time I hear about someone having a failure with an aftermarket electronic ignition system that has been added to a traditional non-computer controlled car, it makes me wonder why those people are causing their own misery. For those cars, the only advantage an electronic ignition system has over a points ignition system is reduced maintenance/tuning, and a rev limiter feature, if a given system even has that feature. Keep in mind that a rev limiter, if you have one, is intended to only be a safety feature for the engine to prevent over revving in the case of a missed gear for example. You should NOT be shifting by bouncing off the rev limiter, you should be shifting by the tachometer’s shift light set to your shift point, if you have one of those. And you don’t need an electronic ignition system to have a tachometer shift light. You just need a tachometer that has one.

The advantages of an electronic ignition system is only a benefit until you have a failure that occurs without any warning, which is how electronic ignition systems fail. They work great right up until they suddenly fail without warning. And if this happens when you are out on the road, there is no roadside tinkering you can do to get it working again, which leaves you stranded dead in the water. All you can do at that point is call for a flatbed ride home. But, you don't have to subject yourself to this possibility. Because the fact is, an electronic ignition system is NOT really going to help most Sportsman Racers, Hotrodders or Enthusiasts who are running old school traditional cars.

Guys who perform a lot of engine dyno testing, know that an electronic ignition system will NOT make even one more HP than a points ignition system. It seems that most people use electronic ignition systems in old school traditional cars, just because everybody else is doing it.

However, I don't do things just because everyone else is doing it. So, I built my 540ci BBC as an old school throw back. And I used a brand new billet Mallory "dual point" distributor. That distributor has the best, easiest and largest mechanical advance adjustability of any distributor I've come across. I'm not afraid of a little bit of occasional points maintenance/tuning, because making adjustments and tuning, is all part of the fun of wrenching on Hotrod cars. And for most weekend cars, they have so little mileage put on them, that even points maintenance/tuning is a fairly rare thing. And the best thing about a points ignition system is its reliability. Because it won't experience any weird failures without warning, so it won't leave you stranded along side the road. If you ignore it long enough without any maintenance/tuning, the worst it will do is experience a slow degradation of starting and/or running performance. It will let you know it needs some attention long before it stops working altogether.

But, getting stranded by an electronic ignition system failure has happened to people I know, to people I've talked to, and to people I've just read about, who use MSD and other aftermarket electronic ignition system brands. It doesn't always happen of course, but it happens way more often than you might think. In fact, one buddy of mine kept getting repeatedly stranded in his 500 HP, '69 Corvette Hotrod by his electronic ignition system. He finally went back to points on my recommendation and has never had a problem again. So, I run points in my own 540 BBC, because there is no reason not to, and to avoid that dreaded flatbed ride home.

With an old school points ignition system, my 540 Street/Strip engine made the following numbers on the engine dyno:

Peak hp = 781 at 6,300 rpm
Peak torque ft lbs = 710 at 4,800 rpm

Ave hp between 4000 and 6700 rpm = 681
Ave torque ft lbs between 4000 and 6700 rpm = 670

Ave hp between 5700 and 6700 rpm = 764
Ave torque ft lbs between 5700 and 6700 rpm = 649

On top of all that, the engine starts immediately, and the throttle response is surprisingly crisp and quick. So, points ignition systems are still far better than most people think. They work just fine for me, even in the 21st century. And they can work just fine for you too.

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22. How to choose your own Camshaft

Camshaft selection methodology can vary widely. Some people look through Cam Company Catalogs and try to follow the general guidelines provided there. Some call Cam Companies and talk to a representative. Some have software available that they can plug various cam numbers into, to see how they compare. Some decide based on their own previous experience. Some with a dyno, will test multiple cams. Some will test multiple cams at the track over time. Some use whatever their engine builder recommends. And some just ask their buddies.

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But, because of all the variables related to selecting an optimum camshaft for any particular vehicle and its intended purpose, the final cam chosen can be one that many people do not agree on. People will argue about all the specifications of a camshaft, but LSA (lobe separation angle) is often the most hotly debated. Some will insist that you need a wide LSA for the best performance, while others will argue that a narrow LSA will provide the best performance. But, the fact is, both have proven to provide excellent performance in various applications.

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So, where does all this leave the average Gear Head, Sportsman Racer, Hotrodder or Enthusiast who doesn't have much, if any, cam selection experience, but would still like to understand how to choose his own cam rather than have someone else choose it for him? Of course he wants to get it right the first time, because he will typically have to live his choice.

I have software available, but instead of using it, I find myself working out all the details manually, because I can more precisely arrive at what I really want. Here is the methodology I used to select the cam for my own 540 cubic inch BBC (Big Block Chevy) Street/Strip Hotrod engine. This methodology is straight forward and can be used by anyone to select a proper cam for their own needs.

• I had decided up front that I wanted a bad boy solid roller for the HP they can produce. So, that was my starting point.

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• I also knew that I wanted a Hot Street/Strip cam that had an approximate max operating range up to 7,000 rpm (which is where I'd be setting my redline/shift point), and would also put the peak power in the desired mid-6,000 rpm range. I didn't really need a higher rpm range because truth be told, it was going to be primarily a Street Hotrod.

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• The max operating range is determined by the duration. If you look through various cam catalogs, you'll see that for fairly large displacement BBC engines, an .050 duration of around 266/271 or so, will give you that 7,000 rpm max operating range. And this cam duration also calls for a static CR of about 11 to 1, to support that duration. So, that also gives you good direction on the static CR to target to work properly with the cam.

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• Most cams of this duration range already come ground with a lift of around .700″ (with 1.7 rockers for a BBC) give or take a bit, depending on the cam company or particular grind you select. So, the amount of lift available, more or less falls out automatically for you. You just need to confirm that the amount of lift you get with your chosen duration, is acceptable with your heads. I would have liked a little more lift to take full advantage of the airflow capacity of the AFR 335cc CNC heads I'd decided to use. But, to get more lift, I'd typically have to choose a cam with more duration, which would be more duration than I wanted or needed. So, I stayed with the lift of about .700″. I had decided to go with Comp Cams which narrowed things down quite a bit. And I liked the aggressiveness and the tight lash design (only .016″ hot) of their Extreme Energy line of lobes. The lobes I chose, provide 303*/309* duration at .015, 266*/272* at .050, and 187*/193* at .200.

Look at the difference between the .050 duration and the .200 duration. My .050 to .200 intensity is 79* (from 266*-187* or 272*-193*). The larger the .200 duration, thus the smaller the .050 to .200 intensity, the larger and more aggressive the lobe. So, if you compare these to other lobes, you'll see that they are fairly aggressive. I was happy with this selection direction, and was nearly done, with the exception of LSA (lobe separation angle) still remaining. Comp offered my cam lobes in different LSA's, so I had to decide what I needed/wanted.

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• Deciding on LSA is what really separates the men from the boys, when it comes to cam selection. This topic has generated many nasty arguments on the various Hotrod and Racing

Forums over the years. I'll say right up front that LSA is only a "by-product" of the chosen overlap, and is NOT the up-front goal. And this is what often causes discussions to degrade into an argument. The reason I say this is, for example, you can find a 110* LSA cam in any catalog that is intended for grandma's grocery getter. You can also find a 110* LSA cam in any catalog that is intended for a Street/Strip Hotrod. And you can also find 110* LSA in any catalog that is intended for a dedicated Sportsman Drag car. So, as you can see, setting out to run a 110* LSA cam as your up-front goal, is of no value what so ever, because it DOES NOT define anything about a cam's operational characteristics, since all three of those totally different cams, have the same LSA.

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• Because I work out all the details up front, in order to arrive at the best possible end result, I had to determine the best "OVERLAP" for my needs, which absolutely defines a cam's operational characteristics. I wanted an overlap value that would make serious power and torque as well as turn heads at any local cruise-in with an old-school lumpy sound. So, OVERLAP is the up-front goal, and LSA is only its by-product. Here's what I used to focus in on the desired overlap:

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"APPROXIMATE" SOLID LIFTER ADVERTISED OVERLAP PERFORMANCE REFERENCE CHART

300ci…………………400ci…………………500+ci……….Typical usage
10*…………………….25*………………. ….40*…………. towing
30*…………………….45*……………….. ….60*…………..ordinary street
50*…………………….62.5*…………….. ….75*……………street performance
70*…………………….80*……………………90*…………..street/strip
85*…………………….92.5*…………………100*…………..race
95*…………………….105*…………………115*…………..Pro race

Here's the CORRECT way to calculate your cam's ADVERTISED OVERLAP which is needed for the chart above:

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• Add your intake and exhaust advertised duration (typically shown as duration at .015 tappet lift. NOTE: duration at .050 tappet lift will NOT give you the correct advertised duration value)

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• Divide that answer by 4

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• Subtract the lobe separation angle (LSA) from that answer

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• Multiply that answer by 2, and you have the CORRECT advertised overlap to use in the chart above

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NOTE: Because of the differences resulting from not having any lash, and the way hydraulic cam advertised duration is rated, if you want to figure the "advertised overlap" for a HYDRAULIC LIFTER cam, so that you can use the chart above, REDUCE the Hydraulic cam's listed ADVERTISED DURATION (typically shown as duration at .006 tappet lift) by 8*, for both intake and exhaust, then follow the calculation procedure as shown above.

If you want to get an idea of what a given cam will sound like, you can take a look at this chart below. Here are some common engine sizes, and the approximate minimum, solid lifter advertised overlap needed, for that lumpy idle (at around 1,000 rpm) that will turn heads at the local cruise-in.

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APPROXIMATE "MINIMUM", SOLID LIFTER ADVERTISED OVERLAP LUMPY IDLE REFERENCE CHART

350ci………..77*
383ci………..78.5*
400ci………..80*
454ci………..84*
496ci………..87*
540ci………..90*
572ci………..92*
632ci………..96.5*

This chart is for idle speeds in the 950 to 1,000 rpm range. Slower idle speeds, will sound even lumpier. And LARGER advertised overlap numbers than shown here, will sound even lumpier as well.

So, as I said above, I wanted to choose an overlap that would make serious power and torque as well as turn heads at any local cruise-in. And for the Street/Strip performance category I targeted, 90* advertised overlap was the value in the ADVERTISED OVERLAP PERFORMANCE REFERENCE CHART above.

Likewise 90* advertised overlap just met the threshold of making a nice lumpy idle in the LUMPY IDLE REFERENCE CHART. So, now that the required overlap had been decided on, I just needed to choose a LSA for my cam, that Comp Cams offered, that would be closest to this overlap value. In the end their cam with the 108* LSA met this requirement the 90* advertised overlap exactly. You might say that I pretty much came up with a sweet spot for my intended build. Now my cam selection was complete and after installing the cam "straight up", meaning not advanced or retarded, the engine performance met or exceeded all my intended goals. So, I was more than pleased with my cam selection.

Here are some engine dyno values from this 540 ci Street/Strip BBC engine:

Peak hp = 781 at 6,300 rpm
Peak torque ft lbs = 710 at 4,800 rpm

Ave hp between 4000 and 6700 rpm = 681
Ave torque ft lbs between 4000 and 6700 rpm = 670

Ave hp between 5700 and 6700 rpm = 764
Ave torque ft lbs between 5700 and 6700 rpm = 649

My cam selection methodology is not unusual. Because after I had already selected/bought/installed my cam, I found that my methodology is essentially identical to what Comp Cams guru Billy Godbold recommended in a magazine interview. He said the following:

- Choose duration based on desired rpm
- Choose lift based on head flow
- Choose desired overlap, then let the LSA fall where it may

It's not surprising that he and I would use the same process for cam selection, because this is how cams/engines work. So, we "should" be using the same methodology.

You can use the methodology above to make an informed decision about the cam you select "yourself" for your own engine, by taking into consideration its displacement, desired operating rpm range, and the intended usage. This will get you extremely close to the optimum cam for your needs. To get any closer, you'd need to dyno or track test various very similar cams in order to split hairs to determine which one might be slightly better.

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23. Multi-viscosity motor oils are not exactly what some people think

Multi-viscosity motor oils are in "one way" what most people think they are. And that is, rated as a thinner viscosity when cold, than when they are hot. But, that's where it ends for many people, because the details are NOT as simple as they might seem. So, many people get confused and misunderstand what all this means.

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When cautioned about running a stone-cold engine too hard, some will say they don't have to worry about that because they are running a multi-viscosity oil. And that is not coming from kids in High School Auto Shop Class who are just starting out. That has come from old timers who have been car guys for decades, and they still do not understand how multi-viscosity motor oil works. So, here is some basic motor oil tech information to clear things up.

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• A multi-viscosity motor oil is identified by its viscosity rating at two temperatures. It is rated at the cold temperature of 0*F, which is represented by the first number, the one in front of the "W". It is also rated at the hot temperature of 212*F, which is represented by the second number, the one after the "W". For example, 5W30 is rated as a 5wt when cold and rated as a 30wt when hot. These are the type of numbers everyone is most familiar with.

But, that DOES NOT mean that 5W30 is thinner when it is cold. And that is where people get confused and misunderstand what is really going on. The confusion comes in because of the temperatures at which the oil was rated. 0*F and 212*F are apples and oranges, or two completely different scales.

• EVERY motor oil thins out as it heats up and thickens as it cools down, no matter if it is a straight weight or a multi-viscosity. You can get a feel for this by checking the oil on your dipstick when it is cold, thick, and drips slowly. Then check it again when it is hot, thin, and drips almost like water. And keep in mind that thinner oil flows more freely through all the restrictions inside an engine, compared to thicker oil that flows more slowly through those restrictions.

Mechanical Engineers design engines with certain clearances, to be used with a certain motor oil viscosity, in order to provide the proper oil flow rate/lubrication/cooling needed for a long and trouble free life. Of course the engine has to start-up and run when cold, but it will spend

99% of its operational life at normal operating temperatures. So, if an engine was designed to use 5W30, that means it was intended to be properly lubricated 99% of the time, by a motor oil rated as a 30wt when hot.

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But, also keep in mind that oil pressure, in and of itself, is NOT what we are after. Oil pressure is only a measurement of resistance to flow. And oil pressure is NOT lubrication. You can have lots of oil pressure, such as at cold start-up, while at the same time having very little oil flow, such as with heavy viscosity oil, which is NOT a good thing. We need oil pressure only to generate the oil flow we need. Oil FLOW is lubrication, so that is what we are after.

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And any reduction in the intended oil flow rate/lubrication, would compromise the wear protection an engine was designed to have. Of course oil flow rate/lubrication is important throughout an engine, but it is extremely important to have sufficient oil flow to maintain the incompressible hydrodynamic liquid oil wedge that is formed between the crankshaft journals and the rod and main bearings. And any oil thicker than a hot 30wt for the engine example above, would reduce that intended oil flow rate/lubrication. If the flow rate/lubrication is reduced enough, unnecessary wear can occur. And if flow rate/lubrication is reduced even more, actual engine damage can result (more on that below).

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So, let's take a look at what is specifically going on with motor oil at cold start-up vs what is going on with it at hot operating temperature. For this comparison purpose, multi-grade motor oil viscosity properties are typically given at 40*C (104*F) and at 100*C (212*F). And its thickness is given in an accurate measurement called **centistokes (cSt).** The HIGHER the cSt value, the THICKER the oil.

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The cold 40*C (104*F which is only slightly above normal temperature for humans) temperature shown below will be used to represent cold start-up conditions, though at more common colder temperatures, the oil will be even thicker yet. And the hot 100*C (212*F) temperature shown below will be used to represent hot operating conditions, though at more common higher temperatures, the oil will be thinner yet. Keep in mind, as mentioned above, EVERY motor oil thins out as it heats up and thickens as it cools down, no matter what its identifying viscosity rating is.

Typical Examples of Actual Motor Oil Thickness (But, any individual oil's specific thickness may vary)

cSt @ cold 40*C (104*F) / cSt @ hot 100*C (212*F)

0W20 = 44.9 / 8.5, or 5.3 times thicker when cold

0W30 = 53.8 / 9.6, or 5.6 times thicker when cold

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0W40 = 79.9 / 14.3, or 5.6 times thicker when cold

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5W20 = 51.6 / 9.0, or 5.7 times thicker when cold

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5W30 = 62.4 / 10.8, or 5.8 times thicker when cold

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5W40 = 87.2 / 14.7, or 5.9 times thicker when cold

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10W30 = 71.8 / 11.5, or 6.2 times thicker when cold

SAE 30 = 98.0 / 11.4, or 8.6 times thicker when cold, this straight weight oil was added to the list for comparison purposes

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10W40 = 96.5 / 14.7, or 6.6 times thicker when cold

SAE 40 = 165.0 / 14.0, or 11.8 times thicker when cold, this straight weight oil was added to the list for comparison purposes

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10W60 = 168.5 / 24.1, or 7.0 times thicker when cold

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15W40 = 105.0 / 14.8, or 7.1 times thicker when cold

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15W50 = 133.8 / 20.2, or 6.6 times thicker when cold

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20W50 = 170.0 / 20.2, or 8.4 times thicker when cold

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Notice how the thickness of the hot viscosity rating (the number AFTER the W) of any given oil above, also affects the thickness of the cold viscosity rating (the number BEFORE the W). For example, 5W20 and 5W40 both have a cold viscosity rating of 5, but the cold thickness of 5W20 is 51.6 cSt, while the cold thickness of 5W40 is 87.2 cSt, or 1.7 times thicker when cold, even though they both have the same cold viscosity rating of 5.

And as you can see above, even at these modest cold and hot temperatures that motor oil thickness values are typically available for, the oil is WAY, WAY THICKER when cold, than it is when hot. And the difference is even GREATER at more normal colder start-up and hotter operational temperatures. So, that means that at cold start-up, oil flow rate/lubrication will be GREATLY REDUCED, even if you are using the recommended multi-viscosity motor oil. But even so, multi-viscosity oils are still a good thing, because they would be even thicker yet when cold, if they were straight wt oils.

For example, comparing SAE 30 straight weight oil above, to 0W30, 5W30 and 10W30, we see that SAE 30 when cold, is 1.8 times thicker than cold 0W30, 1.6 times thicker than cold 5W30, and 1.4 times thicker than cold 10W30. So, that means that SAE 30 provides extremely poor flow/lubrication during cold startup, compared to multi-viscosity 30 weight oils. And since 90% of engine wear takes place during cold startup, using SAE 30 is one of the worst things you can do to your engine, compared to using multi-viscosity 30 weight oils.

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NOTE: This will likely surprise a lot of people. Notice that cold 5W20 at 51.6 cSt, is 2.6 times THICKER, than hot 20W50 at 20.2 cSt. Now you know that a low viscosity cold rating does NOT mean the oil is thin when it's cold.

CONCLUSION:

The best way to protect your engine, when dealing with thick, poor flowing, cold oil, is simple. If you run an engine too hard when it's stone-cold, you can cause unnecessary wear or even damage, due to the reduced oil flow rate/lubrication. But, all you have to do to avoid that problem, and to protect your engine, is to run it easy (small throttle openings and low rpm) for the 10 or 15 minutes it takes for it to reach normal operating temperature. All you need is a little patience, and then you can run it hard without any concern about lubrication.

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NOTE: You DO NOT need to start-up your engine, then let it sit and idle to warm-up. That is a complete waste of fuel, and makes useless exhaust pollution for absolutely no good reason. Just start it up, put it in gear, and drive it easy, as discussed just above, until it is fully warmed up.

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But, if you don't have the patience to wait for an engine to reach normal operating temperature before hammering it, then here is an example of what can happen to it. I have a next door neighbor lady who used to drive a Chevy Tahoe SUV. And when I happened so see her leave in the morning, I noticed that she would back out of her driveway, put it in Drive, and floor it………on a stone-cold engine. I thought, if she keeps that up, she's going to ruin her engine. And every time I saw her leave, that was her normal routine. Of course she is just a normal lady who is not the least bit technical, so she had no idea she was doing anything wrong. To her, flooring her Tahoe with a stone-cold engine, was no different than switching her blender on to "high".

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She kept up that routine for maybe a year or more. Then when I would happen to see her leave, I started hearing a rod knock as she took off, which didn't surprise me at all. And she continued to drive it like that for maybe another year. But, the knock continued to get worse over time, which is a perfect example of the engine not having sufficient oil flow to fully maintain the extremely important incompressible hydrodynamic liquid oil wedge that is formed between the crankshaft journals and the rod and main bearings.

The rod knock finally got so bad, that she traded the Tahoe off for another vehicle. Funny thing, someone must have clued her in, because she has never once driven the new vehicle like that. And it has been fine now for two or three years. I guess she learned her lesson……..the hard way. So, it would be wise to learn from her mistake and avoid doing the same thing to your own engine.

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24. Air conditioning isn't just for cooling your vehicle

Everyone knows of course, that air conditioning (A/C) cools a vehicle's interior to keep it comfortable in hot weather. But, what many people do not know, is that A/C can do more than just cool a vehicle. There's a reason it isn't just called "air cooling".

In my Tech Article, "23. Multi-viscosity motor oils are not exactly what some people think", I mentioned:

"You DO NOT need to start-up your engine, then let it sit and idle to warm-up. That is a complete waste of fuel, and makes useless exhaust pollution for absolutely no good reason. Just start it up, put it in gear, and drive it easy, until it is fully warmed up."

This was in reference to any cold motor oil, including multi-viscosity oil, being much thicker, thus much slower flowing, than normal operational temperature oil flow that engines are designed for.

But, some people told me they have to let their vehicle sit and idle to warm-up in cold damp weather, so that their defroster can work to remove the fog from the windows inside the vehicle. And if they don't wait long enough, the defroster can actually make the inside fog even worse, to the point that if they were driving, they'd have to pull over to the side of the road and wait, because they could not see out to drive safely.

That is true, BUT ONLY if you don't know what is available at your fingertips, in most street driven vehicles. The A/C is called air "conditioning" for a reason. It also conditions the air by acting as a dehumidifier. And A/C systems are designed to work just fine, no matter if you

have the temperature set to cold, hot, or anywhere in between.
In fact, something many people don't know, is that an air conditioning "cycle", is either "ON" or "OFF", like an ordinary light switch. There is no "in-between", the cycle is either operating or it's not. So, air conditioning systems are designed to have their "coldness" controlled by adding heater "heat" to the cold air, as desired. The amount of heat added, is what you are adjusting when you change the interior temperature controller, to a level that is warmer than max cold, aside from the recycled air or fresh air setting.

So, in cold damp weather, when you fire the vehicle up in the morning, and the windows start trying to fog up inside, just turn on the A/C, set the fan speed and the temperature heat level as desired, and the fog will very quickly disappear. That way you don't have to let the vehicle sit there and "warm-up" before you can drive away. This works very well, no matter if you have the controls set to recycled air or fresh air. It also works very well, no matter which vents you have flowing air.

This allows you to have a comfortable interior without the inside windows being fogged up. And as the interior warms-up, you can adjust the amount of heat as desired, and leave the A/C on to prevent any fogging on the inside. In this mode, you are operating what you might call an air conditioned heater, which is a nice capability to have. But, if you want, you can turn the A/C off once the fog is all gone. And if the fog starts to return, just turn the A/C back on. You paid handsomely for this feature, so you might as well make full use of its design capabilities.

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25. Recommended Oil Change Interval – For Automobiles "AND" Motorcycles, including Motor Oil Age Info

I normally don't mention anything about oil change intervals, figuring that everyone can decide that for themselves. But, I've had a number of people contact me to ask what oil change interval they should use. So, I put together the following write-up, to address that question.
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There is quite a wide variation when it comes to recommended oil change intervals for normal daily driven street vehicles. Vehicle owners get recommendations from:

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• Quickie Oil Change places that usually call for 3,000 mile change intervals.

• Owner's Manuals that now can often say 7,500 miles or more.

• Modern vehicle computerized dashboard oil change indicators that can vary anywhere from about 5,000 to 10,000 miles, depending on the model, brand and driving habits.

• Then there are the premium synthetic oils from mainstream Oil Companies and from Companies that only sell premium synthetic oils, who try to get you to buy their extra expensive motor oil, by saying you can use extra long oil change intervals, such as anywhere from 15,000 to 25,000 miles, or even annually.

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Trying to make sense of all those conflicting recommendations is enough to give some people a headache. So, let's see if we can make some sense out of all this.

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• You can completely ignore the 3,000 mile oil change interval called for by the Quickie Oil Change places. There is no technical reason to change oil that often in normal daily driven street vehicles. Of course it doesn't hurt the engine if you do, but it is simply a waste of money and resources, while increasing environmental waste, with virtually no benefit to your engine. This recommended change interval is only so those Oil Change places can make more money off the unsuspecting motoring public.

• Owner's Manuals have been known to drastically revise their recommended oil change intervals to far longer, at a model year change, even when nothing has changed on the model involved. This happens because Auto Makers can use longer oil change intervals to claim a reduced cost of ownership, while at the same time reducing environmental waste.

But, the reality is, it does not truly mean that the same vehicle as the previous year model, with the same oil, can now magically go perhaps an extra 50% or more between oil changes. These longer intervals are driven by Corporate Business decisions, not by Engineering decisions. It has gotten so ridiculous with some vehicles, that you are better off to ignore the overly long oil change intervals that are now commonly printed in Owner's Manuals.

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• It is fairly common for the computerized dashboard oil change indicators in modern vehicles to not match the vehicle's own Owner's Manual. Of course the Owner's Manual numbers are an overall approximation of driving conditions and driving habits, where the computerized dashboard indicator takes into account engine temp, throttle opening, rpm, etc, etc. So, some people might assume that the computer is more precise than the Manual. But, don't believe it, because the computer is programmed for extra long oil change intervals for the same reasons as the extra long oil change intervals printed in the Manuals.

I have a late model daily driver vehicle myself, with a computer oil change indicator that shows that I should go "TWICE" as long between oil changes, compared to my previous similar model from the same maker, which was only a few years older, all while they both were driven exactly the same. And of course the computer doesn't know if I'm using cheapo discount conventional motor oil or very expensive premium synthetic oil, labeled as extended change interval motor oil. So, once again, you are better off to ignore the overly long oil change intervals that are now commonly indicated by the computer.

• Then we have the premium synthetic oils from mainstream Oil Companies, as well as from Oil Companies that only sell premium synthetic oils. And retail prices on those premium oils tend to be so high that their sales are weak in the marketplace. So, those Companies devised a Marketing strategy which advertises that their oils are so good that buyers can use far longer change intervals, such as anywhere from 15,000 to 25,000 miles, or even annually. Their idea is, since customers can buy their oil less often, that it will offset the super high cost of the oil, in an attempt to convince the general public that the high price is justifiable. All in hopes of increasing sales and profits. But of course, Marketing/Advertising being what it is, they leave out the dirty little secret that, no matter how good any oil is, or how much it costs, it will still get extremely dirty and contaminated, thus needing changing, WAY, WAY BEFORE that many miles. More on that below.

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Now we've seen that all the various recommendations above have only the interests of others in mind, rather than your best interest or your engine's best interest in mind. Therefore, it is best not follow those oil change interval recommendations, if you really care about doing what's best for your wallet and for your engine. So then, what oil change interval should we use?

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I'll answer that by telling you the oil change intervals I've used in normal daily driven street vehicles for years, why I do it, and why I recommend others do the same. Then you can decide for yourself.

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I use a 5,000 mile oil change interval in my own normal daily driven street vehicles. This interval is long enough that it lets you get your money's worth from the cost of the oil change without causing any negative impact to an engine. Changing oil much sooner than that, obviously does not hurt engine, but you'd be throwing money away for no reason, since shorter intervals provide no benefit to an engine.

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I've sent a number of quality used oils with 5,000 miles on them, to a motor oil Lab for component quantity testing, to see how much the additive package components had been depleted during that interval. Here's what I found, on average, for that group of oils:

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- The overall anti-wear package component levels had dropped by about 24%

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- The detergent level dropped by about 9%

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- And the TBN (acid neutralizer) dropped by a significant 51%

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The reason so much of the additive package was still available in the used oils I had tested, was because those oils were subjected to only normal daily driving. And additive package component quantities are typically high enough to begin with, so that they won't be totally depleted prematurely by severe/extreme usage, such as racing, heavy loading, towing, mountainous or off/road operation, extended idling, mostly short trip operation, or extended hot or cold operation, that could take place, where the additive package would be used up at a faster pace.

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I also "wear tested" those used oils myself, and found that there was no loss of wear protection, even though the zinc/phos (ZDDP) level in particular, had dropped by about 25%. And that is clear proof that ZDDP levels DO NOT determine wear protection capability.

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Additive package component quantity depletion, as mileage accumulates on the oil, is normal. The various components are used up as they do their job. And after 5,000 miles of normal daily driving, there was still plenty of additive package remaining in the oils tested above. BUT, that absolutely does NOT mean that you should keep using motor oil until those components are completely exhausted. Here's why.

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One of the primary reasons your oil gets dirty, is because of combustion by-products getting past the rings from blow-by, and entering the crankcase into your oil. And this has nothing to do with how high tech the engine may be, or how good or how expensive an oil might be. This happens to ALL motor oils in all engines. And oil filters CANNOT filter out this contamination from the oil, no matter how good some filters may be. Because oil filters only filter out particulate matter. Filthy contaminated dirty oil will flow right through any oil filter. So, continuing to run filthy dirty contaminated oil in your engine, would be like using the same filthy dirty contaminated bath water for months, and months, and months. You could physically do that, but you would never be clean. The same thing applies to your engine.

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In addition to this, small amounts of fuel also get past the rings, particularly during cold start-up and during initial warm-up, when the engine is running extra rich with fuel. This fuel slowly dilutes your oil, again no matter how good the oil is, or how much it costs. So, this is another important reason to use reasonable oil change intervals, rather than extended change intervals.

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And if filthy dirty contaminated diluted oil isn't a good enough reason to avoid using extended oil change intervals, consider the following. Every motor oil is different, so it would be very difficult to establish a general oil change guideline to use, to get closer to the limit of total component quantity depletion, that would be safe to use for every motor oil, without going too long on certain oils and run the risk of totally depleting those critical additives. And if an oil is subjected to severe/extreme usage, then it makes this issue even worse.

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And to further complicate things, even motor oils that are marketed as extended change interval motor oils, don't all follow the same plan for the amount of extra additive package quantity put in an oil, which might allow you to even consider going longer. If you look at " Section 4 – Motor Oil component quantity Lab Test results", in my Blog, you will see that some name brand motor oils have extra additive package component quantities in their oils marketed as extended change interval oils. But, other name brand oils marketed as extended change interval oils, only have normal change interval additive package component quantities. And the normal change interval oils they sell, actually have below average quantities of additive package components.

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So, the only way you could ever safely consider running motor oils longer than reasonable (if you don't care enough about your engine to consider the filthy dirty contaminated diluted oil aspect), whether the oils are marketed as extended change interval oils or not, is to take a small sample of the oil being used, and send it into a motor oil Lab for component quantity testing every few thousand miles, after you've reached a normal change interval mileage. That way you could make sure you don't ever run completely out of critical additive package components. But, of course that is simply way too much trouble for most people to ever bother with.

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And if all that isn't bad enough, remember that motor oil also deteriorates any time it reaches its onset of thermal breakdown point. And that thermal breakdown point varies widely from oil to oil, with many oils reaching that point as low as 250*F. Oil temps are not the same everywhere inside a running engine. Typical main bearing oil temps can be 55*-90*F higher than sump temps. So, oil temp gauges installed in an oil pan can give a false sense of what max oil temps actually are inside an engine. And once any oil, conventional or synthetic, has reached its onset of thermal breakdown point, the lighter oil fractions will begin to vaporize, leaving thicker and heavier oil. This will over time, contribute to poor circulation, reduced fuel economy, increased oil consumption, increased wear and increased emissions. So, with extended oil change intervals, you need to consider that most oils have also been deteriorating from exposure to temps that have exceeded its thermal breakdown point.

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Are we done looking at all the bad things about using extended drain intervals? Not yet. Many multi-viscosity motor oils, particularly conventional oils, use viscosity modifiers/improvers to reduce how much they thin out as their temperature increases. Unfortunately, viscosity modifiers/improvers break down when exposed to heat and mechanical shearing, thus reducing the oil's viscosity as mileage accumulates. So, oils that use a lot of viscosity improvers, should not be used for extended change intervals. However, true synthetic oils are typically Engineered to meet multi-viscosity requirements without viscosity modifiers/improvers. So, those synthetics do have an advantage over other synthetics and conventional oils in that regard. But, for those synthetics having this one advantage, it does not cancel out all the other problems that every oil has regarding extended change intervals.

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In addition to that, when using extended oil change intervals, wear accumulations and insolubles that are too small to be filtered out, can build up in the oil and become abrasive. Of course the only thing you can do about that, is to change the oil.

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And finally, to add insult to injury, extended oil change intervals have resulted in excessive sludge build-up, which can destroy engines, if it gets bad enough. Some years back, wide spread engine sludge problems cost Toyota millions and millions of dollars, to replace a huge number of engines in Toyota and Lexus vehicles. And their sludge problem was traced to, you guessed it, their recommended unusually long oil change intervals.

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Therefore, there is absolutely NO technical benefit what so ever, to using extended oil change intervals. All of the above, points out that extended oil change intervals make no sense at all, because only bad things are very likely to happen.

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IS ADDITIONAL EXTRA-FINE BY-PASS OIL FILTRATION A GOOD IDEA FOR GASOLINE ENGINES, IN ORDER TO EXTEND OIL CHANGE INTERVALS?

Oil filters can only filter out "particulate matter", nothing else, no matter how small a particle they can filter out. You need to carefully re-read this Tech Article, and you will see that particulate matter elimination is "only one" of the many reasons to change your oil at reasonable intervals.

Using additional fine particulate by-pass oil filtration in an attempt to extend drain intervals, CANNOT possibly stop normal additive package component depletion that takes place as the oil does its job in a running engine. Those additive package components will ALWAYS be used up a little at a time, as the engine is operated. And Companies that sell additional fine particulate by-pass filtration systems, and claim that filtering out additional fine particulates will prevent depletion of the oil's additive package components, are spewing total nonsense, and are committing blatant snake oil false advertising. Buyer beware.

Similarly, an analogy would be that the tread on your tires will ALWAYS wear down a little at a time, as you drive your vehicle. But, if a town claimed that their super clean road surfaces would prevent tire tread wear, that would be total nonsense in the same way.

As shown above, and I will repeat it here for your convenience, I've sent a number of quality used oils with 5,000 miles on them, that used conventional oil filters, to a motor oil Lab for component quantity testing, to see how much the additive package components had been depleted during that interval. Here's what I found, ON AVERAGE (some of those oils didn't even do this well), for that group of oils:

- The overall anti-wear package component levels had dropped by about 24%

- The detergent level dropped by about 9%

- And the TBN (acid neutralizer) dropped by a significant 51%

The reason so much of the additive package was still available in the used oils I had tested, was because those oils were subjected to only normal daily driving in gasoline vehicles. And additive package component quantities are typically high enough to begin with, so that they won't be totally depleted prematurely by severe/extreme usage, such as racing, heavy loading, towing, mountainous or off/road operation, extended idling, mostly short trip operation, or extended hot or cold operation, that could take place, where the additive package would be used up at a faster pace.

Claims are sometimes made that heavy-duty diesel trucks using additional by-pass filtration systems can extend their drain intervals without affecting the additive packages.

They carefully worded their statement so that it was not technically wrong, since as I said, particulate filtration has no affect on additive package component quantities. And what that misleading statement suggests to unsuspecting customers, that they don't have to be concerned with the additive package component quantity, is only sales propaganda. Because they intentionally left out the critical fact that extra particulate filtration CANNOT possibly "stop" additive package components from continued depletion over time and accumulated mileage.

Other claims stating that extensive on-road testing and oil analyses, on gasoline engines using additional by-pass filtration systems, even after 30,000 miles, does not adversely affect the viscosity, wear metals and oxidation (TAN/TBN) levels in the oil.

But, that statement is also misleading, because as I said before, additional by-pass filtration affects nothing more that particulates. So, of course it does not adversely affect anything else. But, their implication that everything is still wonderful after 30,000 miles on the oil, is NOT supported by the facts. Just look at the additive package component depletion numbers I provided above, ON AVERAGE, after only 5,000 miles of normal daily driver street usage, using conventional filtration. Some of the oils didn't even do that well. So, if anyone believes they can magically go "6 times longer" on their oil's additive package before it reaches total depletion, by simply using extra particulate filtration, they are falling victim to completely false advertising. All these Companies want to do is separate gullible buyers from their money.

And as you've seen in this Tech Article, there is a lot more to changing oil at reasonable intervals than just particulate matter removal and additive package component depletion. So, even if you used extra particulate by-pass filtration to stretch your oil until just when the last of its additive package components reached total depletion, you will have ignored all the other important reasons to change your oil at reasonable intervals.

In conclusion, just because diesel trucking companies typically get away with using the extra by-pass filtration, to save money by changing their oil far less often, does NOT mean it is the right thing to do for all engines. Keep in mind that diesel engines are designed and built extremely ruggedly for the heavy duty type of work they are used for. So, their internal components are quite large, which results in significantly lower psi loading on those components, compared to the same components in most gasoline engines. And that is why traditional heavy duty diesel oils are not formulated to provide the impressive levels of wear protection we'd expect to see with gasoline engine oils. Gasoline engines are typically much more highly stressed in terms of component psi loading, than diesel engines are. That is why using traditional heavy duty diesel oil in high performance gasoline engines, is such a bad idea.

Comparing diesel engines to gasoline engines is comparing apples to oranges. So, do not allow yourself to be convinced that what you can get away with regarding diesel engines, is automatically the right thing to do with gasoline engines. Therefore, I do NOT recommend using additional extra-fine particulate by-pass filtration on gasoline engine vehicles, in an attempt to extend the oil change intervals. If you want to provide your gasoline engines with the best possible protection, see just below, and then read this entire Tech Article again, very carefully.

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Recommendation if additional Oil Filtration is Desired

The use of an oil filter snap-on external magnet such as Filtermag, is an excellent additional improvement to any engine's oil filtration system. I use them myself. The whole point of an oil filter snap-on external magnet, is that it can pull out finer metal particles than the oil filter's own element can, with NO increase in flow restriction. It installs instantly and can be removed instantly. It is very simple and does not add to the oiling system's complexity. And there are no connections to leak or fail. This is a one-time purchase that can be reused indefinitely, so it is a good value. It is another layer of protection that enhances the overall filtering capability, with no down side, no matter what oil filter you are using.

But, it does NOT affect oil and filter change intervals at all. I do NOT recommend using this with the misguided idea that you can then change the oil filter "every other time". That is pure nonsense. When you change oil, you should ALWAYS change the oil "AND" the filter at the same time. Because you should get rid of the particulates and the old oil that are in the old filter. So, you should still change your oil and filter at reasonable intervals, whether or not you use an external magnet on your oil filter.

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BOTTOM LINE:

By the time a normal daily driven street vehicle reaches 5,000 miles on its conventional or synthetic oil, that oil is dark, dirty, contaminated, is becoming more and more diluted as time goes on, has been suffering some thermal breakdown deterioration, if it uses viscosity modifiers/improvers, it is nearing the point where those viscosity modifiers/improvers will be breaking down enough to start affecting the oil's viscosity, and abrasive wear accumulations and insolubles will have started to build-up.

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So, by that point, any motor oil is in definite need of changing. And by changing it then, you will also prevent any concerns about sludge formation. People who go much longer than a 5,000 mile oil change interval, just don't understand the numerous technical reasons why that is NOT a good idea, even if they use very expensive premium synthetic oils marketed as extended change interval oil. But, now they know, so they can make a more educated decision about the oil change interval that is best for their engine.

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CONCLUSION / RECOMMENDATION:

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• I use 5,000 mile oil change intervals for conventional or synthetic oils, in my own normal daily driven street vehicles, for all the reasons discussed above. And it works out that it is also convenient to see when an oil change is due, by simply looking for 5,000 mile increments on the odometer.

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• I would NOT use shorter change intervals for normal daily driven street vehicles. But, I would and do, use shorter change intervals for vehicles that are subjected to severe/extreme usage. And keep in mind, that severe/extreme usage also includes vehicles that are subjected to mostly short trip operation, which is one of the worst things you can do to a motor oil. Naturally forming condensation never has a chance to get quickly and fully burned off, since the engine never gets hot enough for long enough. This will dilute the oil and combine with combustion blow-by products, along with excess fuel from frequent extra rich cold startups. All that contaminates and further dilutes the oil, requiring more frequent oil changes, such as at every 3,000 miles.

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• In "Hybrid vehicles", depending on the conditions when the vehicle is underway, the engine is sometimes running, and sometimes not running. And they usually also employ an "engine-off" feature when the vehicle comes to a stop. All this on-again/off-again engine operation creates a severe/extreme usage condition for the engine's motor oil. That is because the oil cannot maintain a high enough temperature to keep normal condensation removed, which comes from the constant over, and over, and over, partial heating and then re-cooling of the oil. This is a textbook example of short trip operation on the motor oil, which, as mentioned above, is one of the worst things you can subject a motor oil to. As a result, in order to provide a Hybrid vehicle's engine with the best possible wear protection, its motor oil should be changed much more frequently, such as at every 3,000 miles, because of this severe/extreme usage. So, it is in your best interest to ignore the ridiculously long oil change interval in the Owner's Manual or the dash's oil change indicator.

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• I would NOT use longer change intervals, not even with premium synthetic oils labeled for extended change intervals, or annual change intervals, for all the reasons discussed above.

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• For vehicles that don't get driven very often, or in other words, vehicles that sit a lot, such as "occasional weekend only" Hot Rods, Classic Cars, and Motor Homes, change the motor oil once a year, even if the oil has less than 5,000 miles on it.

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• According to the USA motor vehicle Insurance Industry, the national average for vehicle mileage accumulation is 12,000 miles. Personal vehicles that are driven at continuous, extended, steady-state long distance cruising, totaling WAY MORE than that national average per year, are operating their vehicles under a condition that is much more ideal for an engine, than the start and stop type of driving experienced by normal daily driver vehicles. Operating an engine at continuous, extended, steady-state long distance cruising, allows for a somewhat longer oil change interval.

But, due to a lack of data for that kind of operation, I don't have a specific oil change interval recommendation for that. Though I would not recommend going more than a couple of thousand extra miles between changes. Because beyond that point, you could well be running into complete additive package depletion, along with all the other reasons for changing the oil.

• I recommend following the oil change intervals mentioned above, for those who want to provide their engines with the best protection.

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NOTE: Few people bother to make sure the gasoline engine oil or the Diesel engine oil they use, has every last certification called for in their vehicle's Owner's Manual. And I have never seen, nor heard of that ever being a problem. Because engines are just not that sensitive to the oil being used.

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FINAL WORDS to be absolutely clear:

Here are the two primary decisions you need to make regarding the motor oil you use in your engine, in their order of importance.

1. The NUMBER ONE most important decision is to select an oil from my Wear Protection Ranking List that provides the level of wear protection that you feel comfortable with for your particular engine. The higher the psi value, the better the wear protection. Racing engines and High Performance street engines that load their oil near its limit, especially traditional American flat tappet pushrod V-8 engines, are best protected with highly ranked oils. Ordinary low performance daily drivers that only lightly load their oil, can get by well enough with low ranked oils, if absolute maximum life out of the engine is not critical.

NOTE: There are synthetic oils on the market that perform very well, while other synthetics do not. There are conventional oils on the market that perform very well, while other conventional oils do not. My Wear Protection Ranking List shows you which oil is which.

2. The NUMBER TWO most important decision is to decide when to change the oil you are using, no matter what that oil may be.

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RECOMMENDATION FOR MOTORCYCLES:

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Most motorcycle engines:

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• Make far more power per cubic inch, than car engines.

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• Rev far higher than car engines.

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• Share the same oil for both the engine and transmission (which subjects the oil to considerably more mechanical shearing).

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• Have wet clutches that also share the engine oil.

• Often get run much harder than most car engines.

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So, most motorcycle engines are far harder on their motor oil than normal daily driven automobile engines are, which results in semi-severe usage, to severe usage of their motor oil. Therefore, I recommend the following to provide the best protection:

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• Do NOT follow the ridiculously long 8,000 mile oil change interval typically found in motorcycle street bike Owner's Manuals. That outrageously long interval is Marketing driven only to reduce Cost of Ownership numbers. It is NOT what is best for the engine, and was NOT driven by Engineering.

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• For liquid cooled street motorcycles, use the range: 3,000 mile oil change interval if operated aggressively, up to a 4,000 mile oil change interval if operated modestly.

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• For air cooled street motorcycles which will often get their oil much hotter than liquid cooled bikes, use the range: 2,000 mile oil change interval if operated aggressively, up to a 3,000 mile oil change interval if operated modestly.

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• For motorcycles that don't get ridden very often, or in other words, motorcycles that sit a lot, change the motor oil once a year, even if the oil has fewer miles than shown above.

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MOTOR OIL AGE

Oil Companies in the U.S. don't post how long their oils are good for. But, history has shown that there is no technical reason for quality motor oil to go bad inside its factory sealed bottle, even after quite a few years. However, I have seen the additive package components settle to the bottom of the bottle. So, if the bottle is not shaken well, before the oil is poured out, then depending on how long it has been sitting, the oil could be lacking much of its critical additive package. And that could compromise the oils performance capability. So, it's quite important that motor oil bottles are always shaken well before pouring the oil into an engine. That way, you can be sure to get the full capability that the oil was formulated with.

Other than on Quaker State and Pennzoil bottles, I almost never see manufacturing dates on motor oil bottles. And I have never seen an expiration date on a bottle of motor oil in the U.S. So, I typically never know how old motor oil really is.

In my experience, motor oil has always been perfectly fine whenever I have opened a new factory sealed bottle. In fact, I also have never seen a problem when using motor oil from an old partially used bottle that had the cap put tightly back on.

From what I have been able to determine over the years, for motor oil that has been in a tightly sealed bottle, and therefore not exposed to the open atmosphere, age is simply not a critical issue. And I do not have any technical data that would indicate otherwise.

It appears that the clock on motor oil aging, really begins when it is poured out of its bottle, where it is then exposed to the open atmosphere, and to the conditions inside an engine.

So, in addition to recommending that motor oil be changed at reasonable mileage intervals, I also recommend changing the oil if it has been inside an engine for a year or more, even if it has not reached a normal oil change mileage interval. That will prevent any concern there may be about motor oil aging.

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26. Failure Data from a Bushing type Solid Roller Lifter

Let me say right up front, that this write-up is in no way slamming ISKY' EZ Roll bushing type solid roller lifters. On the contrary, this info will show how well they hold up, considering that ANY solid roller lifter is a maintenance item that will need to be replaced regularly.

Here's a little background info on solid roller lifters in general. Keeping an eye out for any lash changes, as well as regular removal and inspection is basically the standard recommendation for running solid roller lifters. But, the problem is, that ultimately may not save your engine. Here's why, the root cause of their failure is metal surface fatigue failure from all the jackhammer pounding they take from not following the carefully designed cam lobe ramps, when they bounce around within the lash slop. They are not forced to ride nicely on the lobes like hydraulic lifters are. And since solid roller lifters don't always directly ride on a lobe, the opening/closing lobe ramp design goes right out the window, and the roller gets smacked by the lobe, or smacks down on the lobe, depending on if it is rising of falling. The larger the lash, the worse this is. Eventually, this repeated over and over jackhammer pounding takes it toll, and metal surface fatigue failure bites you. You can't predict it, you can only see it once it begins. And to add insult to injury, you could inspect your lifters one day when they look and feel just fine, and the next day they can suffer metal fatigue failure and things go south.

Bushing type solid roller lifters are way more durable than the needle type, because the needles only make a very tiny line contact (thus extremely high psi loading values are seen), so they are severely overloaded in this application. Plus, in .842 lifters, only the bottom 3 needles take all the load. They are just a failure waiting to happen.

But, the bushing type lifters provide a far larger surface contact (thus they see far lower psi loading values). ISKY says their EZ Roll bushing type solid roller lifters provide a 350% higher load rating than comparable needle type solid roller lifters. However, even the bushing lifters are not immune to failure. The bushing type lifters are subject to roller OD metal fatigue failure, but the needle lifters are subject to "BOTH" needle and roller OD metal fatigue failure.

And this brings us to the subject of this write-up. A car Forum member contacted me about a solid roller lifter that had failed in his engine. He knew I had performed root cause failure analysis on a few sets of failed needle type solid roller lifters, a few years back. So, he sent me his bad bushing type solid roller lifter for failure analysis.

He runs a 467ci Mark IV BBC in his street Hotrod, that see's a lot of "spirited driving". The rev limiter is set to 6800 rpm, though the most common normal rpm seen is in the 3000 to 3500 range. his cam specs are 243*/249* duration at .050 tappet lift, 112 LSA, and .668 lift. Lash is .008 cold, .014 hot with aluminum heads. Spring pressures are 210 lbs on the seat, and 525 lbs open. His solid roller lifters are .842 diameter ISKY EZ Roll bushing type.

He doesn't let it idle. As soon as it fires, he starts driving although not too heavy on the gas until it warms up. He also pre-heats it on chilly mornings with an oil pan heater and a block heater. He also uses an Amsoil pre-luber. And he has been using Valvoline 10W-30 with a can of Moly Slip E added with each oil change, at approximately 1500-2000 miles. Valve lash gets checked a couple of times a summer, as does spring pressure. He put 25,000 miles on these lifters when he had this lifter failure that took out the associated lobe, and the debris from all that also opened up the lifter bore. The whole thing required an engine rebuild. Not fun, to say the least.

Here are the results of my analysis:

The remaining good lifter of the pair, for comparison:

Roller OD looked fine, and OD = .7500

Bushing ID looked fine, and ID = .3200

Axle looked fine, and OD = .3176 to .3179, with average = .31775

Bushing/axle clearance = .0021 to .0024, with average = .00225

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Failed lifter:

Roller OD was completely destroyed from a text book case of metal surface fatigue failure, which is exhibited by flaking and pitting called spalling. The OD = .5870 to .6178, with average = .6024, so about .150 worth of diameter had flaked and crumbled off, thus destroying the associated lobe in the process.

Bushing ID generally looked alright, but there were signs of debris having worked through the clearance, causing wear and some scratches. The ID = .3223 to .3230, with average = .32265.

Axle looked fine, and OD = .3173 to .3182, with average = .31775

Bushing/axle clearance = .0041 to .0057, with average = .0049
BOTTOM LINE:

He did quite well with these ISKY EZ Roll lifters in terms of how many miles they lasted, even though it ended up causing a rebuild. Solid roller lifters in general, are a fairly poor design, because, as mentioned above, they are subject to the non-stop jackhammer pounding as the lifters bounce around within their lash slop. They get pounded because they cannot faithfully follow the lobe's opening and closing ramps. Eventually, the pounding takes its toll, and the unavoidable metal surface fatigue failure results.

And for the record, NOTHING you do with oil or oil additives will make any difference here, because oil has absolutely nothing to do with this type of failure. Idling also has NO affect on this failure either. Idling generates the lowest loading and pounding these lifters will ever see, because the valve train acceleration is at its lowest value during idling.

This problem is simply a fact of the Physics involved, and cannot be avoided with this design. So, there is no absolutely safe plan when it comes to running solid roller lifters. They can fail at seemingly any amount of time or mileage. All you can do is replace solid roller lifters with fresh ones at an interval before metal surface fatigue failure results, which may take out your engine as well. What that interval is, is the million dollar question, for which there is no clear absolute answer. Everyone has to make their own judgment call on that. Words to live by – you can never replace solid roller lifters too often…

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27. Maximum Safe Redline

OEM's typically consider 80 ft/sec as their "max safe ave piston speed". Of course a piston's speed varies between zero at TDC and BDC, and max when the crankshaft is at 90* to the cylinder centerline. So, the "average piston speed" is simply the "average" of those different speeds, as the name implies.

Here are some stock production engines' redlines and the resulting ave piston speeds:

2011 5.0 Mustang GT V-8 redline = 7,000 rpm = 71 ft/sec ave piston speed
2010 Harley XR-1200, 2 cylinder motorcycle redline = 7,000 rpm = 74.1 ft/sec ave piston speed

As you can see, both of these factory engines fall below the recommended 80 ft/sec limit.

Now let's look at an engine that spins to the moon, and see what it shows.

2011 Yamaha YZF-R6, 4 cylinder 600cc motorcycle redline = 16,000 rpm = 74.4 ft/sec ave piston speed

WOW, this one is STILL under the safe 80 ft/sec limit for production engines. How can that be? The stroke length makes all the difference. Take a look…….

Their stroke lengths:

5.0 Mustang = 3.650 in.

Harley XR-1200 = 3.812 in.

Yamaha 600 = 1.673 in.

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But High Performance Hotrod and Racing engines that use good quality aftermarket forged parts, can generally use a more aggressive 90 ft/sec. as their "max safe ave piston speed".

So, for High Performance Hotrod and Racing engines, you can calculate the max safe redline, using that 90 ft/sec figure and an engine's stroke length. For example:

Big Block Chevy (BBC)
For a 540ci BBC with a stroke of 4.25"

At 90 ft/sec ave piston speed, its max safe piston speed/redline would be 7,624 rpm

Using the OEM's 80 ft/sec, you'd get a redline of 6,776 rpm, which is 848 rpm lower.
Small Block Chevy (SBC)
For a 383ci SBC with a stroke of 3.75"

At 90 ft/sec ave piston speed, its max safe redline would be 8,640 rpm

Using the OEM's 80 ft/sec, you'd get a redline of 7,680 rpm, which is 960 rpm lower

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For your own engine build, you can use this equation:

MAX SAFE REDLINE = (max safe average piston speed in ft/sec x 360)/ stroke in inches

You can plug OEM's 80 ft/sec, or High Performance/Racing engine's 90 ft/sec into the equation.

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28. Eight 0W20 Oils Tested and Compared

The following oils were tested in Spring 2016 for their Wear Protection Capability at the normal test temperature of 230*F, which is representative of normal operating conditions. They were also tested for their onset of Thermal Breakdown points, rounded to the nearest 5* increment. They are ranked here just among themselves, based on their film strength/load carrying capability/shear resistance psi values.

The Wear Protection reference categories are:

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• Over 105,000 psi = INCREDIBLE wear protection

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• 90,000 to 105,000 psi = OUTSTANDING wear protection

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• 75,000 to 90,000 psi = GOOD wear protection

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• 60,000 to 75,000 psi = MODEST wear protection

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• Below 60,000 psi = UNDESIRABLE wear protection

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The HIGHER the psi value, the BETTER the Wear Protection.

1. 0W20 Quaker State Ultimate Durability, API SN, synthetic (gold bottle) = 124,393 psi
Its onset of Thermal Breakdown = 270*F

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2. 0W20 Toyota Motor Oil, API SN, synthetic = 101,460 psi
Its onset of Thermal Breakdown = 255*F

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3. 0W20 Mobil 1 Extended Performance, API SN, dexos 1 approved, synthetic = 100,229 psi
Its onset of Thermal Breakdown = 265*F

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4. 0W20 Pennzoil Platinum, Pure Plus Technology, made from Natural Gas, API SN, synthetic (silver bottle with blue vertical stripe on the label) = 92,504 psi
It's onset of Thermal Breakdown = 275*F

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5. 0W20 Castrol Edge, Fluid Titanium Technology, API SN, dexos 1 approved, synthetic (black bottle) = 90,745 psi
It's onset of Thermal Breakdown = 270*F

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6. 0W20 Valvoline SynPower, API SN, synthetic = 89,556 psi
It's onset of Thermal Breakdown = 270*F

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7. 0W20 Mobil 1 Advance Fuel Economy, API SN, dexos 1 approved, synthetic = 79,612 psi
It's onset of Thermal Breakdown = 270*F

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8. 0W20 Kendall GT-1, with liquid Titanium, API SN, synthetic = 71,385 psi
It's onset of Thermal Breakdown = 260*F

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As you can see, the wear protection capability of these oils varies widely. In fact, the number 1 ranked oil in this group, the 0W20 Quaker State Ultimate Durability, which is in the INCREDIBLE wear protection category, provides a WHOPPING 74% MORE wear protection than the last place 0W20 Kendall GT-1, which is only in the MODEST wear protection category.

Yet, if you look at the bottles, every single one of them boasts about the excellent wear protection they provide, to try and convince you to buy that product. But, obviously some of those claims do NOT stand up when put to the test.

So, if you did not have my test data as proof of their actual capability, and simply looked at the claims on the bottles instead, you would think all of them provide comparable wear protection. But, that is simply NOT the case. Motor Oil Companies are among the worst, for what some would call, blatant false advertising.

Unfortunately, since there is often no truth in advertising, it is in your best interest to never believe anything you read related to motor oil advertising. And that is why I started motor oil testing in the first place. To find out the truth about how various motor oils actually perform. Without my Wear Protection Ranking List, selecting the best oil for your engine, is only a guessing game.

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29. Eliminating BMW M3/M5 Rod Bearing Failures

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The BMW M3/M5 models have had an ongoing problem with rod bearing failures for a number of years now. The M3's S65 V-8 engine was derived from the M5's S85 V-10 engine. They share the same basic architecture and aluminum construction.

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And I was asked if I could offer a recommendation on how to deal with this problem, by reviewing a comprehensive rod bearing failure thread on the M5Board Forum with many, many failed rod bearing pictures as well as additional supporting data, which also included an M3 link to extensive engine tear down inspection/examination data, as well as additional M3/M5 information and data. This is an enormously long Forum thread (it had reached nearly 70 pages when I was looking at it) that was started in 2013 and was still going in 2016.

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After going through all that, it turned out that the root cause of all those failures was that BMW had designed/built the engines with insufficient rod bearing clearance (barely large enough for 5W30 motor oil and WAY too tight for super thick oil), insufficient connecting rod side clearance, and they called for insanely thick 10W60 motor oil, which is WAY too thick for acceptable oil flow/lubrication/cooling. It was a perfect storm of doing multiple things completely wrong to actually "cause" rod bearing failures. It was extremely disappointing to see BMW do such a poor job at designing/building those engines. They actually unintentionally designed the engines so that the rod bearings "would" fail. I would have expected far better from them.

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It was noted that along the way since all this began, that BMW has increased the rod bearing clearance a little, and now also allows the use of thinner oil (though many owners still seem to think they should use super thick oil for protection). But, there was no mention of them increasing the rod side clearance, which needs to be correct in order for oil to properly flow through and out of the rod bearings to provide the critical lubrication and cooling they need to survive.

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For owners of one of these models, there isn't a lot most of them can do about the rod side clearance problem, or about the rod bearing clearance issue that their particular model year may have, unless they tear down the engine and have it rebuilt correctly. However, there is one thing owners can easily do to significantly help with this problem.

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First of all, everyone needs to understand that motor oil "viscosity" is NOT what determines wear protection. That is just an old MYTH, which some people who don't understand anything about motor, still believe. So, ignore anything you've been told about needing thick oil for wear protection, because using thick oil is one of the worst things you can do to your engine.

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Consider the following:

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Below is actual motor oil viscosity test data that came out of my Engineering Tests on Motor Oil film strength/load carrying capability/shear resistance:

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20 wt oils rank between number 2 and 212

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30 wt oils rank between number 1 and 223

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40 wt oils rank between number 5 and 211

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50 wt oils rank between number 37 and 220

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The one 60wt oil tested ranks 97 out of 223

The one 70wt oil tested ranks 169 out of 223

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So, as you can see, the various oil viscosities all overlap each other regarding their wear protection ranking position, which clearly shows that oil viscosity does NOT play a role in an oil's wear protection capability. An oil's wear protection capability is determined by its base oil and its additive package "as a whole", with the primary emphasis on the additive package, which contains the extreme pressure anti-wear components. And that has nothing to do with viscosity.

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Oil "flow" is lubrication, and using thicker oil will simply reduce critical oil flow for no good reason. Plain bearings, such as rod and main bearings, are components that are not designed to be lubricated just by an oil film, they are designed to be lubricated by a flow of liquid oil. Keep in mind that oil pressure is NOT what keeps these parts separated. Oil pressure is a measurement of resistance to flow, and the pressure only serves to supply/move the oil to the clearance between the bearings and the crankshaft journals, and of course to move oil throughout the entire engine. The crankshaft journals and its bearing shells are kept separated by an incompressible hydrodynamic liquid oil wedge that is formed as the liquid oil is pulled in between the spinning parts. All liquids are incompressible (that's how hydraulics work, including brakes with their watery thin brake fluid), so it does NOT matter what the viscosity of any liquid is. Thick oil or thin oil will create the same incompressible liquid oil wedge.

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As long as sufficient oil is supplied by reasonable oil pressure to maintain that critical incompressible hydrodynamic liquid oil wedge, the crank journals and bearings cannot come in contact with each other, so no wear can occur. And the higher flow rate of thinner oil, supplies more oil volume to the main and rod bearings, which helps ensure that the critical incompressible hydrodynamic liquid oil wedge is always maintained.

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Thinner oil will of course flow out from the bearing clearance quicker than thicker oil will. But, by making sure the engine provides "sufficient oil pressure", the oil supply will always be greater than the oil flowing out, which will maintain that all important incompressible hydrodynamic liquid oil wedge. As long as an M3/M5 engine generates at least 65 psi of oil pressure at higher rpm with thin oil, it will be in good shape.

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Oil flow is also what carries heat away from internal engine components. Those engine components are DIRECTLY oil cooled, but only INdirectly water cooled. And better flowing thinner oil will keep critical engine components cooler because it carries heat away faster than slower flowing thicker oil can. This is especially important with plain main and rod bearings, since the flow of oil through the bearings is what cools them. If you run thicker oil than needed, you will needlessly drive up engine component temps.

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Here are some comparison numbers from an 830 HP road race engine on the track:

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15W50 oil = 80 psi = 265* oil sump temperature

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5W20 oil = 65 psi = 240* oil sump temperature

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Here you can see how the thicker oil flowed more slowly through the bearings, thus getting hotter, driving up bearing temperatures and increasing sump temperatures. And the thinner oil flowed more freely and quickly through the bearings, thus cooling and lubricating them better than thicker oil. And this means the oil coming out from the bearings, and going into the sump, is also cooler. And that is why we see the cooler sump temps with this road race engine example.

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If an engine is running hot, use a thinner oil to increase flow, increase internal component cooling, and help keep sump temperatures down. Keeping oil temps down is important to help keep oil below the threshold of thermal breakdown.

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Almost no engine should ever need to run oil thicker than a multi-viscosity 30 weight. The lower the hot viscosity rating, the number after the W, the better the hot flow. For example, hot 5W30 flows WAY better than hot 10W60. Thinner oil will also typically increase HP because of less viscous drag and reduced pumping losses, compared to thicker oils.

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The churning action of rotating and reciprocating internal engine components, along with oil spraying out from between pressurized components, and overall windage, all contribute in varying degrees, to causing the engine oil to become aerated, which is exhibited by air bubbles/foam in the oil. Air bubble-filled foamy oil, is what typically causes engines running on a dyno to experience oil pressure drops, assuming they have acceptable oil drain-back from the top end, and are keeping the oil pump pickup submerged. Also, air bubble-filled foamy oil, is what typically causes engines being run hard in cars, to experience drops in oil pressure, assuming the oil pump pickup is still submerged in oil. And if that isn't bad enough, air bubble-filled, foamy oil cannot lubricate critical internal components properly. For proper lubrication of critical components, you need incompressible "liquid" oil, NOT compressible air bubble-filled foamy oil.

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This is an issue to take very seriously, if you want to provide your engine with the best possible lubrication protection. If this aerated oil issue is bad enough, it can cause wear, damage or outright engine failure. And it can be extremely difficult to diagnose, in the event of an outright engine failure. Because when you take the engine apart for examination, you typically can't find anything wrong at all, other than say the rod and/or main bearings that failed. That's because the air bubbles/foam are long gone by then.

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Heavy thick oil such as 10W60, is of course 60 weight oil at normal operating temperature, is slower to release and eliminate air bubbles/foam, than thinner oil such as 5W30 which is 30 weight oil at normal operating temperature. Motor oils do of course contain anti-foaming agents to help control (though not altogether eliminate) air bubbles/foam. But, the air bubbles that will still be present in the oil anyway, have to travel through the oil to be released. And thicker heavier oils slow down that process, leaving compromised lubrication. However, thinner oil such as 5W30, allows air bubbles to travel through the oil and be released quicker, making it a better viscosity choice to fight motor oil aeration issues, and provide the best possible lubrication protection for your engine.

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Thinner oil will also drain quicker back to the sump, to help keep the oil level high enough to prevent the oil pump pickup from sucking air during hard braking or cornering, in wet sump systems.

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CONCLUSION

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Short of rebuilding those engines correctly with proper clearances, which is what is actually needed, the one thing owners can easily do to significantly help with this rod bearing problem, is to run a much thinner oil than the insanely thick 10W60 that BMW had specified for years. I recommend selecting a highly ranked 5W30 API SN oil from my Wear Protection Ranking List, which will make a HUGE improvement in rod bearing oil flow/lubrication/cooling, compared to the more commonly used super thick 10W60. This one significant change may well prevent having to rebuild those engines, and would go a long way toward eliminating rod bearing failures in many M3/M5's.

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And below is a related message that I received from one of my BMW Blog readers:

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Hi Rat,

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Some time ago I wrote here that I changed the oil viscosity in my BMW S54-6-cylinder-M-engine from the suggested 10W60 to 0W40 using Mobil1 New Life.

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Now I have covered some 50,0000 kms since then (before it was 5 W 50 for two oil changes, equaling approx. another 15.000 kms). Engine has reached 92,000 and I decided to have the rod bearings replaced.

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Some owners make frightening experiences on this occasion: Wear patterns far from normal, rubbed-through layers with shiny copper exposed.

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Guess what?

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“Nothing to worry about here. Still enough life in the first layer of the bearing for another (!!) 90,000 kms. Wear pattern isn’t very unusual for this engine: Even and over the whole surface of the bearings each of them alike, no spotting visible.”

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Rooted back to two aspects: Quickest possible build-up of oil flow after cold start due to “0W” and best possible “oil cushion” in the bearing due to high flow with reduced temperature throughout the whole bearing.

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There were worries about the enormously high pressure in the VANOS-system were that the oil would shear down too quickly and thus failure of the VANOS would be the result. In addition much higher wear on the valve train would be the inevitable result.

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How wrong can that worry be?

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No visible wear on camshafts and valve train, VANOS working perfectly and very quiet even after cold start up. Valve clearances have to be adjusted for the first time in more than 90,000 kms.

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So – lesson learnt from practical experience:

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Oil flow and protection by a good quality engine oil are much more important than “steady oil pressure” at the highest possible numbers.

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As for using the suggested super thick 10W60 – Myth busted! It is not needed.

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Best wishes
Markus

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Then here is my response back to him:

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Hi again Markus, it’s good to hear from you.

Thanks for sharing your information. I always appreciate the feedback I continue to receive here and on Internet Car Forums, from many people who have also experienced the excellent results that you have, from using what I’ve been recommending all along – thinner quality motor oil.

You provided such good information, that the next time I update my Blog, I will add your experience at the end of my Tech Article "29. Eliminating BMW M3/M5 Rod Bearing Failures".

Take care and feel free to get in touch any time,

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30. **Five Lightweight Diesel Oils Tested and Compared**

Traditionally, heavy duty Diesel oils have been formulated specifically for Diesel engines, and have been intended for large trucks and heavy equipment. They have typically been 15W40 oils with a few 5W40's available as well. But, all of those are 40 weight oils at normal operating temperature. When I have tested those heavy duty Diesel oils for their wear protection capability, their psi values were almost always rather low, indicating poor wear protection performance. So, their poor wear protection performance, and the fact that they typically reach the onset of thermal breakdown BEFORE most gasoline engine oils do, made it very clear that in general, heavy duty Diesel oils are a poor choice when it comes to providing the desired wear protection for High Performance and Racing gasoline engines. That also shows that anyone who uses heavy duty Diesel oil in High Performance and Racing gasoline engines, simply has no idea what they are doing.

However, those traditional Diesel oils, when used in the engines they are intended for, do not need to provide the excellent wear protection that we like to see in gasoline engine oils. Because, what most people aren't aware of, is that Diesel engines are designed much more rugged and durable than gas engines. Diesel engines are designed with larger components than gasoline engines. And those larger components spread the load they see, out over larger areas, resulting in lower loading per square inch (psi). Therefore, even though these large truck and heavy equipment Diesel engines are hard working, they do not require oils that provide the high psi protection that we desire in our high performance gas engines. That's why, what we often consider poor performing Diesel oils, work just fine in heavy equipment.

Diesel and gas engines are on a different scale when it comes to evaluation of their oils regarding wear protection capabilities. You cannot compare them straight across, because they are apples and oranges. Traditional heavy duty Diesel oils should be compared to other traditional heavy duty Diesel oils, unless they are used in gasoline engines. Then they need to meet gasoline engine standards, to provide the wear protection we desire in gasoline engines.

But, now it is becoming more and more common for motor oils to be formulated for BOTH Diesel and gas engines, which results in those oils providing much better wear protection, due to their far better psi values. These oils are generally intended for Diesel cars and light trucks, and they typically come in thinner, lighter viscosities which are desirable in those cars and light trucks.

The following five lightweight 5W30 diesel oils, four of which were formulated for both Diesel and gas engines, with the last one formulated only for Diesel engines, were tested late 2016 for their Wear Protection Capability at the normal test temperature of 230*F, which is representative of normal operating conditions. They were also tested for their onset of Thermal Breakdown points, rounded to the nearest 5* increment. They are ranked here just among themselves, based on their film strength/load carrying capability/shear resistance psi values.

The Wear Protection reference categories are:

- Over 105,000 psi = INCREDIBLE wear protection
- 90,000 to 105,000 psi = OUTSTANDING wear protection
- 75,000 to 90,000 psi = GOOD wear protection
- 60,000 to 75,000 psi = MODEST wear protection
- Below 60,000 psi = UNDESIRABLE wear protection
  .
  The HIGHER the psi value, the BETTER the Wear Protection.
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1. 5W30 Pentosin Pento Super Performance III, for gas and diesel engines, API S"M", ACEA C3, synthetic, made in Germany = 122,711 psi .
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   Its onset of Thermal Breakdown = 275*F .
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   However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. But, this oil only had a very small 3.5% drop in capability. And even at that elevated temperature, it produced an extremely impressive 118,477 psi, which still kept this much hotter and thinner oil in the INCREDIBLE Wear Protection Category.
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2. 5W30 Mobil 1 ESP Formula (Emission System Protection), for diesel and gas engines, ACEA C2, C3, API SN, synthetic = 113,836 psi .

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   Its onset of Thermal Breakdown = 300*F .

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   However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil had a significant 22.4% drop in capability. At that elevated temperature, it produced 88,381psi.

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3. 5W30 Pennzoil Euro "AV" European Formula, for diesel and gas engines, ACEA C3, API SN, synthetic = 112,664 psi .

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   Its onset of Thermal Breakdown = 265*F .

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   However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil had a large 29.2% drop in capability. At that elevated temperature, it produced 79,792 psi.

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4. 5W30 Castrol Edge Professional "LL03", Diesel oil, ACEA C3, gold bottle, synthetic = 107,067 psi.

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   Its onset of Thermal Breakdown = 275*F .

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   However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil had a significant 18.2% drop in capability. At that elevated temperature, it produced 87,593 psi.

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5. 5W30 Pennzoil Platinum Euro "L", made from natural gas, for diesel and gas engines, ACEA C3, GM dexos "2" approved, API SN, synthetic = 97,051 psi .

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   Its onset of Thermal Breakdown = 275*F .

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   However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. This oil only had an extremely small 0.55% drop in capability. At that elevated temperature, it produced 96,519 psi.

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As you can see, the wear protection capability of this group of Diesel oils was quite good. The top four oils were all in the INCREDIBLE wear protection category, and even the last place oil was still in the OUTSTANDING wear protection category. This group of lightweight 5W30 Diesel oils are among the very best Diesel oils I have ever tested.

Three other Diesel oils I tested previously, that also performed very well are:

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5W30 Mag 1, FMX, European Formula, API S"M", ACEA C3-08, synthetic, for gas and diesel cars and light trucks = 111,622 psi

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Its onset of Thermal Breakdown = 280*F.

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However, I went on to also test this oil at the much higher temperature of 275*F. At that elevated temperature, any hotter and thinner oil is expected to experience a drop in Wear Protection Capability. And this oil did experience a 17.1% drop in capability. At that elevated temperature, it produced 92,508 psi.

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5W40 Mag 1, FMX, European Formula, API SN, ACEA A3/B4, synthetic, for gas and diesel cars and light trucks = 109,147 psi

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5W30 Amsoil Series 3000 Heavy Duty Diesel Oil synthetic, API CI-4 PLUS, CF, SL, ACEA A3/B3, E2, E3, E5, E7 = 102,642 psi

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For people who feel compelled to run Diesel oil in gasoline engines, the 8 oils shown above are the best oils to consider for that. And if these particular oils were used for that purpose, the users WOULD actually know what they are doing.

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31. The Truth about Motor Oil Temperature and Wear Protection Capability

This Blog is all about sharing Engineering test data FACTS related to motor oil. But, it's no secret that there is a LOT of BAD information out there about motor oil on Internet Forums. People on those Forums read a few lame Internet articles about motor oil, and suddenly they consider themselves motor oil experts. But of course, these self-proclaimed motor oil experts are not Engineers, they have no Credentials, they do not have extensive in-depth engine experience, nor have they ever done any testing of their own. And they don't understand that some motor oil Technical information is so highly theoretical, that it isn't even a factor in the real world.

So, they don't even know, what they don't know. Yet that does not stop them from spreading the INCORRECT conclusions they have drawn, or the WRONG assumptions they have made, along with their brainwashed MYTHS, opinions, theories and speculation. They spew that nonsense over and over again. Then people who simply want to learn about motor oil, read that and end up believing garbage, because they don't know any better.

There is a Motor Oil Forum where people are making incorrect claims about the temperature at which most engine wear takes place. They base that on an Advertising Campaign from a major Oil Company, which claimed that most engine wear takes place during the first 20 minutes of operation, as an engine is warming up. And people on that Forum are so gullible, that they embraced that whole claim, as if an Advertising Campaign, passes for an Engineering fact. That is completely laughable, because they don't even know that Motor Oil Companies are the worst when it comes to FALSE Advertising. The absolute worst motor oils on the market, and the absolute best motor oils on the market, all make the same claims about how great their motor oils are. Buyer beware.

And because that Advertising Campaign referenced the Sequence IVA Wear Test (ASTM D6891), these people have drawn completely WRONG conclusions and assumptions. They have now taken it upon themselves to claim that the Sequence IVA Wear Test (ASTM D6891), is a warm-up test performed at the temperature where most engine wear takes place. But, as you will see below, they are COMPLETELY WRONG.

The problem is, they apparently have never actually read the Sequence IVA Wear Test (ASTM D6891) spec. Because nowhere in its 48 pages does it mention that it is called a warm-up test. Nowhere in its 48 pages does it say anything about twenty minutes being involved in the test. Nowhere in it 48 pages does it say that it is a test where most engine wear takes place. These people don't understand that you cannot conclude that the specified test temperature is the temperature at which most engine wear takes place, without also repeating that same test at both lower and higher temps, for data comparison to determine that.

The Official Spec for Sequence IVA Wear Test (ASTM D6891), says it is an extended idle speed, camshaft lobe wear test for spark-ignition engines equipped with an overhead valve-train and sliding cam followers, for the particular oil being tested. The Steady-State Test Spec calls for the Stage I test to be for 50 minutes at 800 rpm, at 120*F oil temp, and the Stage II Test to be for 10 minutes at 1500 rpm, at 138*F oil temp, making one cycle. The procedure conducts the testing for a total of 100 cycles (100 hours), with no scheduled shutdowns. That's the basic test in a nutshell. Yet somehow, those people twisted it into their false propaganda. They don't even know that Engineering does NOT work that way. They simply have no idea what they are doing or saying.

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A QUICK SIDE NOTE:

Sequence IVA Wear Test (ASTM D6891), is referenced as the spec used to determine if a motor oil's wear protection capability, is sufficient to meet the "wear protection portion" of the requirements to be awarded an API SN certification. At the time of this writing, the lowest performing oil on my Wear Protection Ranking List, that had an API SN certification, only produced 66,099 psi, and was ranked a pathetic 186th out of 214 oils tested at that point. That means 185 OTHER oils on my Wear Protection Ranking List provided BETTER wear protection than that API SN certified motor oil. So, the Industry Wear Protection Requirement to earn an API SN certification is NOT very strict at all.

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Now back to the primary purpose of this article. To see where that estimated 20 minutes idea comes from, see my Tech Article, "23. Multi-viscosity motor oils are not exactly what some people think", for more details. But, for a quick preview, here is a paragraph from the CONCLUSION of that article:

"The best way to protect your engine, when dealing with thick, poor flowing, cold oil, is simple. If you run an engine too hard when it's stone-cold, you can cause unnecessary wear or even damage (again see my Tech Article, "23. Multi-viscosity motor oils are not exactly what some people think", for an example of major damage that can result), due to the reduced oil flow rate/lubrication. But, all you have to do to avoid that problem, and to protect your engine, is to run it easy (small throttle openings and low rpm) for the 10 or 15 minutes it takes for it to reach normal operating temperature. All you need is a little patience, and then you can run it hard without any concern about lubrication."

So, the approximate 10 to 20 minute warm-up period has to do with the poor oil flow rate of motor oil when it is cold and thick, which greatly reduces lubrication. During that period, the oil is not flowing at a rate the engine was designed for at its normal operational temperature. Therefore, real world engine warm-up is NOT about an oil's wear protection capability at some "specific" cold temperature. It's all about that reduced cold oil flow.

Assuming that an engine is allowed to warm-up fully before being run hard, as mentioned above, then it is a FACT that most engine wear takes place during cold start-up before oil flow reaches all the critical internal components, in engines that have been sitting for a length of time. The amount of time sitting is what determines how critical cold start-up wear is.

On the safe end of the extreme, is a daily driver operating in mild weather, which will typically experience little to no wear during cold start-up, because of sufficient residual oil on components and in oil passages, from being run every day.

But, on the worrisome end of the extreme, is an engine that has been sitting for an extended period of time, which allows maximum oil drain off from components, maximum oil drainage/seepage out of oil passages, and general drying up of protective motor oil. In the case of an engine that has been sitting for an extended period of time, with very little protective oil still in place, you are looking at a condition that is closer to a dry start than anyone would desire. In this case, it could take perhaps as long as five seconds or even more, for oil to reach all the critical components. If that engine's fast idle speed is say 1,250 rpm, then that would mean that the last components to receive oil five seconds later, would have rotated about 104 revolutions for those turning at crank speed, or 52 revolutions for those turning at cam speed, before oil flow gets there. And the engine is depending entirely on whatever bit of oil film may still be present. That is a LOT of spinning when the engine is nearly dry to begin with.

So, it's not hard to see how this can result in engine wear or perhaps even damage. In a case like this, it would be in the engine's best interest to use a highly ranked motor oil with excellent film strength capability, from my Wear Protection Ranking List, with a low cold viscosity rating, such as 0WXX or 5WXX, to protect nearly dry critical components as much as possible, and to ensure the quickest possible oil flow to those critical engine components. And priming the engine with oil before firing it up, would add even more protection against start-up wear. This is NOT Rocket Science, but the people on that Motor Oil Forum, can't understand any of it.

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So, all this brings us to the Engineering test I performed on motor oil for this Article, which is to show the FACTS once and for all, as to how temperature affects a motor oil's wear protection capability. I tested the current synthetic 5W30 Amsoil Signature Series motor oil again in late Fall 2017, at a different temperature than the two temperatures I tested it at a few weeks prior. That will allow us to can compare all three test temperatures, to see how wide temperature differences affect a motor oil's wear protection capability. That new test temperature is:

• 130*F which is an oil temperature in the middle of the range of the Sequence IVA Wear Test (ASTM D6891)

• I previously tested that oil at 230*F, which is representative of normal operating oil temperature, where engines spend 99% of their life, which I use in my normal Engineering Testing on Wear Protection Capability.

• I also previously tested that oil at 275*F, which is a much higher oil temperature that I sometimes test certain oils at.

The Wear Protection reference categories in my Engineering tests are:

* Over 120,000 psi = FANTASTIC wear protection

* 105,000 to 120,000 psi = INCREDIBLE wear protection

* 90,000 to 105,000 psi = OUTSTANDING wear protection

* 75,000 to 90,000 psi = GOOD wear protection

* 60,000 to 75,000 psi = MODEST wear protection

* Below 60,000 psi = UNDESIRABLE wear protection

The HIGHER the psi value, the BETTER the Wear Protection.

Test result differences between oils of less than 10% are not significant, and oils within that range can be considered approximately equivalent.

The Science of Physics and Chemistry that determines the resulting data from these tests, will PROVE how temperature affects motor oil wear protection capability. Here are the test results to use for comparing all three test temperatures:

• The new test temperature was 130*F, which is an oil temperature in the middle of the range of the Sequence IVA Wear Test (ASTM D6891) = 123,882 psi, which is about an 8% drop from the normal 230*F test temperature's psi value. At the time of this writing, at this temperature, the oil provides such excellent wear protection, that this psi value would rank 7th out of 209 oils tested at that point. An engine warming up, will transition right past this temperature as it heats up to its normal operating temperature.

• The previously tested normal operating temperature of 230*F = 134,352 psi

• The previously tested extra high temperature of 275*F = 124,573 psi, which is about a 7% drop from the normal 230*F test temperature's psi value.

As you can clearly see, all three test temperatures are in the FANTASTIC wear protection category. There was no meaningful difference in wear protection capability across the three test temperatures, showing that oil temperature is NOT a primary indicator of a motor oil's wear protection capability.

So, with such impressive wear protection capability at all three temperatures ranging from 130*F to 275*F, no one in their right mind, could possibly say that any of these temperatures represent a temperature where the most engine wear takes place, just because of how temperature affects an oil's ability to provide wear protection.

These empirical Engineering test results PROVE that the Sequence IVA Wear Test (ASTM D6891) test is NOT a test of the oil temperature where most engine wear takes place.

These empirical Engineering test results PROVE that most engine wear does NOT take place as an engine warms up with oil flowing and lubricating throughout an engine.

These empirical Engineering test results PROVE that my statements above are correct, that most engine wear takes place under one or both of the following conditions:

• During cold start-up before the oil reaches critical components, in engines that have been sitting for an extended period of time.

• And/or if an engine is run too hard during warm-up, while the oil is still too cold and too thick to flow sufficiently, and therefore is not capable of flowing properly to lubricate critical components. And that this condition is strictly an oil flow issue, and NOT related to an oil's wear protection capability based on its temperature.

These empirical Engineering test results PROVE that the unqualified people on that Motor Oil Forum are completely clueless, regarding the facts about motor oil.

As always, this Blog is "THE" place to go for those wanting to know the FACTS about motor oil.

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32. V-8 Head/Intake Alignment Procedure

The machining tolerances, even on top of the line brand name parts, quality control, and tolerance build-up overall, of the whole assembled engine, can result in less than ideal cylinder head and intake manifold alignment on traditional American V-8 engines. That means that the intake manifold gaskets can end up not having uniform clamp-up. And all that can cause oil leaks, or coolant leaks, or air leaks which cause a leaner than intended air/fuel ratio on carbureted engines, as well as possible squeezed out and broken intake gaskets.

I've checked this out by using a razor blade to cut notches out of the intake gaskets, in between the intake bolts, so that I could measure the gap clearance between the intake and the heads. I've found that the gap from one end of the intake to the other end, is not always the same, which means the intake gasket will not be clamped-up equally at all the bolts, no matter how tight they are.

So, I developed a procedure that works very well to establish proper intake gasket clamp up along the whole length of the intake manifold. But, the heads need to be slightly loose in order to do this procedure:

Put the heads on the block for final installation, but only FINGER TIGHTEN the head bolts for now. Then temporarily install intake manifold with its intended gaskets, but no sealer, and no end gaskets/sealer. (You will be using the intake only to position the heads here, the manifold can be installed permanently later on).

Position the intake manifold centered over the bolt holes as you normally would. Install all intake bolts, but only tighten them MEDIUM SNUG, **do not** fully tighten them. The heads have now been pulled up tight against the intake manifold and its gaskets for proper even gasket clamp-up (the heads will have some "float" even with dowel pins in place, so they can move around a little, we are not talking spacecraft precision here).

Now torque the head bolts in the normal sequence, while the snug intake bolts hold heads in the proper position inboard/outboard. When done torquing the heads, remove the intake and install it permanently whenever you like. Now you have the heads in perfect alignment with YOUR intake and its specific machining, for the best gasket clamp-up you'll ever get on your particular combo.

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33. CAN WET CLUTCH MOTORCYLES USE AUTOMOTIVE MOTOR OILS?

The controversy about whether or not wet clutch motorcycles really require a special motorcycle oil, is a commonly debated topic on Internet Motorcycle Forums. And questions about all that have come up in this Blog's Q&A Section a number of times over the past year or so. It has to do with claims that wet clutch motorcycles can experience clutch slippage if 5W30 Automotive "Resource Conserving" motor oils are used. But, the problem with that claim is that many motorcyclists use a variety of 5W30 Automotive "Resource Conserving" motor oils in their motorcycles with no problem at all.

I have an extensive background with motorcycles. Before College, I spent the early part of my technical career first inside the Japanese Motorcycle Industry at the Dealer level in the Service Department, then later, inside at the Corporate level, in the Motorcycle Service Division. Because of that experience inside the Industry, I do NOT trust the Japanese Motorcycle Industry nor the Japanese Automotive Standards Organization (or JASO for short), to do the right thing. One of the reasons I don't trust them, is because they made a huge, completely unnecessary change many years ago, that created the reason we are even talking about all this in the first place.

Motorcycle clutches used to be properly Engineered with the correct amount of spring pressure for excellent performance and trouble free operation. But, later the Japanese Motorcycle Industry decided that they wanted the clutch lever pull to be lighter, to make their bikes seem "nicer", in order to appeal to a broader audience to increase sales and profits. So, they violated proper Engineering design in order to follow that Marketing goal. In doing so, they reduced clutch spring pressure so much, that the clutch lever pull became light enough for an 85 year old Great Grandmother with arthritis to operate it. Now, all this discussion about what oil is required, is nothing more than a "work around plan" to deal with that Marketing driven mistake.

If motorcycle clutches had continued with sufficient spring pressure, as proper Engineering calls for, there would be no talk about a supposed need for so-called motorcycle oil. But, the Japanese Motorcycle Industry and JASO came up with the idea of "motorcycle oil" to address the newer poor clutch design they created just for Marketing reasons. How convenient for them. Now they can increase their profits by selling their own motorcycle oil, to try and cover up what they did, rather than lose face and go back to proper clutch design. They obviously believe that two wrongs, make a right. Nothing is ever what it appeared to be at first glance. And once people know what actually went on in the background, they really have their eyes opened.

And adding to all this, is the fact that JASO does not post any specific test data showing the actual "difference" between so-called Motorcycle oils that they want you to buy, and Automotive oils that they don't want you to buy. All they post is a list of oils that supposedly meet their requirements. There is no transparency at all, for people to actually know what is truly going on. All that secrecy regarding hiding their test data, makes many people think that the whole motorcycle oil requirement is nothing but a scam, especially since no problem shows up in the real world in most cases. As a comparison, I post "ALL" the data that comes out of my Engineering testing, for the whole world to see.

So, what is a motorcycle owner to do? Investigation reveals that reports of motorcycle clutch slippage with 5W30 Resource Conserving Automotive motor oil, comes from high mileage motorcycles, that have old worn clutches, which are glazed, hardened, and have lost their normal gripping capability. "High mileage" is the common thread between all clutch slippage complaints, but the particular oil being used is not. You don't come across reports of slippage with wet clutches that are new or are in good condition.

An Engineer Colleague of mine has a wet clutch 2006 Suzuki GSXR 1000cc Sport Bike with around 7,000 miles on it. He is running 5W30 Quaker State Ultimate Durability synthetic, Resource Conserving Automotive motor oil in it. And he has not had any problems at all with the clutch or shifting.

Simply put, it is NOT true to say that wet clutch motorcycles cannot use 5W30 Resource Conserving Automotive oil. The fact is:

Virtually any wet clutch motorcycle will work just fine with most any automotive oil, including 5W30 Resource Conserving oil, as long as the clutch is in good condition.

However, those who wrench on their own motorcycles, can easily improve their clutches for even better performance, to the way they should be when properly Engineered. For motorcycle clutches that use coil springs, those springs can be changed to stiffer springs, if any are available. Or the stock springs can be shimmed at their base, with proper sized washers, if there is enough clearance to still avoid clutch spring coil bind, when the clutch lever is pulled all the way in.

You can easily check that by doing a test assembly of the clutch, with the shimming washers in place. Then pull the clutch lever to see if the lever pulls all the way to the handlebar with no binding. If there is no binding due to clutch spring coil bind, you are good to go, and will have a much better clutch. I did this a number of times, when I used to own motorcycles. And the small increase in clutch lever pull effort was never an issue for me. In fact, I actually liked it better than the weak limp feel of the factory setup.

On a related note, you can also further improve the clutch action by carefully bending the clutch lever end further outward away from the handlebar, so the clutch lever to handlebar contact point, is about 10 mm or 3/8″ further away from the handlebar, when the lever is released to its resting position. This provides a little extra clutch disengagement, which makes it easier to find neutral, and allows for easier shifting. I also did this with the motorcycles I used to have.

The way to do that without damaging or breaking the clutch lever, is to wrap the lever in a couple of layers of rags. Then use a large box end wrench for leverage to carefully, controllably, slowly, and repeatedly bend the lever forward a little at a time. For that bending operation, position the box end of the wrench over/around the lever, at several places along the lever, for a little bending at each location, between about a third of the way out from the pivot, to about two thirds of the way out from the pivot. You don't want to try and bend it too close to the pivot, or too close the tip. I have done that many times with no problem.

Even if people don't want to deal with changing or shimming clutch springs, they can still run a quality high performance 5W30 Resource Conserving Automotive motor oil that provides FAR BETTER engine and transmission wear protection than all but one Motorcycle oil I have tested. And high performance automotive oils will also typically provide more HP and better MPG, compared to low performing motorcycle oils.

When motorcycle clutch discs do eventually become old, worn, glazed, hardened, and have lost their normal gripping capability, they can be more prone to slippage with 5W30 Resource Conserving Automotive motor oils than with poor performing motorcycle oils. But, by then the clutch discs are due for replacement anyway. And it is far better to replace the clutch then, rather than compromise their bike's engine and transmission wear protection for years, from using poor performing motorcycle oils.

Under anything near normal bike riding conditions, any eventual old worn clutch slippage issue will be a gradual thing over time. It will not just suddenly slip completely and leave you stranded. And if push comes to shove, you can always change back to poor performing motorcycle oil, to stretch out the use of an old worn clutch, for a little longer.

Immediately below is a comparison between the top High Performance Automotive 5W30 and the motorcycle oils I have tested (the higher the psi, the better the wear protection). Keep in mind that this Engineering test data provides information on each oil's wear protection capability, based on “film strength/load carrying capability/shear resistance”, at a normal operating temperature, which exactly applies to motorcycle conditions with the transmission gears sharing the engine oil.

* 5W30 Amsoil Signature Series **“automotive oil”** = 134,352 psi, ranked 3rd out of 216 motor oils tested so far.

* 5W30 Motul 300V motorcycle oil = 112,464 psi, ranked 19th

* 10W40 Mobil 1 Racing 4T motorcycle oil = 93,661 psi, ranked 76th

* 20W50 Mobil 1 V-Twin motorcycle oil = 75,855 psi, ranked 142nd

* 10W30 ProHonda HP4S motorcycle oil = 66,852 psi, ranked 184th

* 10W40 Valvoline 4 Stroke motorcycle oil = 65,553 psi, ranked 189th

* 10W40 Spectro Motor-Guard High Performance Motorcycle Oil = 57,977 psi, ranked 203rd

As you can see, the best High Performance Automotive oils provide FAR BETTER engine and transmission wear protection than most “motorcycle oils”. And as mentioned above, automotive motor oils also typically provide more HP and better MPG, compared to the lower performing motorcycle oils.

Most motorcycle engines:

* Make far more power per cubic inch, than car engines.

* Rev far higher than car engines.

* Share the same oil for both the engine and the transmission, which subjects the oil to considerably higher levels of mechanical shearing.

* Typically get run much harder than most car engines.

Therefore, I recommend using High Performance Automotive oils in motorcycles, wet clutch or not.

So, at the end of the day, motorcycle owners have to ask themselves if they really want to run a poor performing motorcycle oil in their beloved bike, or if they would be better off using a FAR BETTER High Performance Automotive motor oil? The choice is theirs.

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34. How well do Traditional Heavy Duty Diesel oils perform, when they have the latest CK-4 certification?

Some of my Heavy Duty Diesel Blog readers have asked about the latest Diesel oils that now have the new CK-4 certification. So, here in one place, is a comparison of how the CK-4 Diesel oils have performed in my testing.

The Wear Protection reference categories are:

* Over 120,000 psi = FANTASTIC wear protection

* 105,000 to 120,000 psi = INCREDIBLE wear protection

* 90,000 to 105,000 psi = OUTSTANDING wear protection

* 75,000 to 90,000 psi = GOOD wear protection

* 60,000 to 75,000 psi = MODEST wear protection

* Below 60,000 psi = UNDESIRABLE wear protection

The HIGHER the psi value, the BETTER the Wear Protection.

NOTE: Traditional Heavy Duty Diesel oils typically do not perform anywhere near as well as the best gasoline engine oils do.

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At the time of this writing, traditional Heavy Duty Diesel oils formulated for big trucks and heavy equipment, rank overall between number 43 and 193. But, if you omit the two highest ranked Heavy Duty Diesel oils which are SIGNIFICANTLY MORE CAPABLE than most of the other Heavy Duty Diesel oils, the rest only rank between 95 and 193. Other than those two particular highest ranked Heavy Duty Diesel oils, the poor wear protection performance of most Heavy Duty Diesel oils, makes it very clear that in general, they are a poor choice for use in High Performance gas engines. Heavy Duty Diesel oils should be used only in Heavy Duty

Diesel engines, where they are intended to be used. Heavy Duty Diesel engines are designed MUCH differently than gasoline engines, so both types of oils are formulated for different requirements.

Here are the CK-4 Diesel oils I have tested:

• 10W30 LE (Lubrication Engineers) Monolec Ultra Diesel oil, API CK-4, CJ-4, CI-4, CH-4, CI-4Plus, conventional = 97,878 psi
This oil was tested Spring 2018. It is the best performing CK-4 Diesel oil I have tested to date. And it is the second best performing Diesel oil I have ever tested.

• 0W40 Amsoil Max-Duty Signature Series Diesel oil, API CK-4/SN, CJ-4, CI-4+, CF, ACEA E9, E7, synthetic = 90,307 psi
This oil was tested late 2017.

• 15W40 Amsoil Max-Duty Signature Series Diesel Oil, API CK-4/SN, CJ-4, CI-4+, CF, ACEA E9, E7 synthetic = 87,881 psi
It claims 6X more wear protection than required by Detroit Diesel DD13 Scuffing Test.
This oil was tested early 2018.

• 5W40 Amsoil Max-Duty Signature Series Diesel Oil, API CK-4/SN, CJ-4, CI-4+, CF, ACEA E9, E7 synthetic = 87,154 psi
It claims 6X more wear protection than required by Detroit Diesel DD13 Scuffing Test.
This oil was tested early 2018.

Comparing the three Amsoil Max-Duty Signature Series Diesel Oils above, that were tested late 2017/early 2018:
0W40 = 90,307 psi
5W40 = 87,154 psi
15W40 = 87,881 psi

The psi values of these three oils are all within a range of about 3.5%, which is very consistent for oils in the same product line. Therefore, any of these three oils would provide essentially the same level of wear protection. But, the 0W40 will flow the best when cold, making it the top choice of those three Amsoils.

These four CK-4 Heavy Duty Diesel oils rank above all the other Diesel oils I have tested, except for the absolute top ranked Diesel oil which is:
• 5W30 Amsoil Series 3000 Heavy Duty Diesel Oil synthetic, API CI-4 PLUS, CF, SL, ACEA A3/B3, E2, E3, E5, E7 = 102,642 psi.
But, this oil is formulated for Diesel engines not equipped with Diesel particulate filters (DPF).

If you need a CK-4 Diesel oil, you don't need to look any further than the four CK-4 Diesel oils above, which will provide excellent wear protection for Heavy Duty Diesel engines.

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35. PISTON TO CYLINDER CLEARANCE IS "NOT" WHAT MANY PEOPLE THINK IT IS

I have had a few people contact me here on my Blog with questions involving piston to cylinder clearance. And I've also seen a number of people on Automotive Forums who are completely confused and off-track about piston to cylinder clearance. They think the piston to cylinder clearance they see on a Spec Sheet, is "THE" clearance that an engine runs with, which is completely WRONG. So, I thought it was time to write-up a Tech Article addressing that, to help clear up the confusion that many people seem to have.

The piston to cylinder clearance specified by a piston manufacturer, or listed on an Engine Builder's Spec sheet, is NOT the piston to cylinder "operational RUNNING clearance" that an engine actually experiences when it is at its normal operating temperature. The piston to cylinder clearance you see written, or hear discussed, is the "cold room temperature ASSEMBLY clearance". The required "cold room temperature ASSEMBLY clearance" for any particular engine build, is determined by the specific piston material being used, the bore size, the type of build the engine is, and the type of use the engine will see. And there are a number of different variations for each of those considerations, such as naturally aspirated, Supercharged, Turbocharged, Nitrous, gasoline, alcohol, Nitro, as well as grocery getter, daily driver, towing, street performance, street/strip, Marine, dedicated drag race, road race, circle track, etc, etc. As you can see, it can get rather complicated. It is definitely NOT one size fits all. Plus, Engine Builders will have their own individual preferences, since no one thinks the same as the next guy.

If engines are built with the proper "cold room temperature ASSEMBLY clearance", after taking everything into consideration, then no matter what their variations may be, they were originally developed to end up with an approximately similar "operational RUNNING clearance". You want the "operational RUNNING clearance" in any engine, to be "small enough" to stabilize the piston, yet "large enough" not to seize/scuff the piston/cylinder bore, and to allow for proper lubrication of the piston skirt and cylinder. In general, after all the parts involved, have thermally expanded to the size they will be, due to the heat they are subjected to, under their normal operational conditions, they were originally developed to end up with an "operational RUNNING clearance" of around .0015 to .002 of an inch. Smaller clearance for smaller bores, and larger clearance for larger bores. You wouldn't want to press your luck by going much tighter, and you don't need it much looser, since the thermal expansion of all the parts involved, has already been accounted for. So, if an engine was built PROPERLY, you will NOT have piston noise, once the engine has fully warmed up to its normal operational temperature, even if it had rather loose piston to cylinder clearance to begin with.

Of course you cannot measure that ideal "operational RUNNING clearance" inside a running engine. So, you need follow piston manufacturer clearance recommendations. Because they determined that "operational RUNNING clearance" indirectly, when they were originally developing their pistons. They have already done the work for you. They know how tight you can go with different piston materials, used in different applications. They determined that from "testing" their pistons in running engines. Basically, they found out how tight they can go when seizing/scuffing of the pistons/cylinders takes place. Then they added a little more "cold room temperature ASSEMBLY clearance", and tested again, to arrive at what they ultimately need for a safe "operational RUNNING clearance". Since different piston materials are now well established, and different operational conditions are well understood, piston to cylinder clearance "reference charts" have been created by the piston manufacturers. So now, all you have to do, is follow their recommended piston to cylinder clearance, and you will be good to go.

You will see on piston manufacturer "reference charts", that in order to end up with that ideal "operational RUNNING clearance", wildly different "cold room temperature ASSEMBLY clearances" will be required, depending on the particular application. The type of engine, the type of usage the engine will experience, and the specific piston material being used, are all critical. The type of engine, and the type of usage, determines the amount of heat the pistons will see, which determines how much they will thermally expand as they heat up. The more power made, the more heat generated. More heat equals more thermal expansion. So of course, less heat equals less thermal expansion. But, the effect on piston expansion does not end there. The specific piston material involved, will determine just "how much" that particular piston will thermally expand, from the amount of heat it sees. Pistons are all aluminum, but they DO NOT all thermally expand the same amount when subjected to the same amount of heat. The amount of thermal expansion each type of piston material will experience, is determined by the amount of silicon it contains, and by the physical differences between castings and forgings.

The higher the silicon content a piston has, the less it will thermally expand as it heats up, the harder the material is, the better its wear resistance, and the more brittle it is.

The lower the silicon content a piston has, the more it will thermally expand as it heats up, the softer the material is, the worse its wear resistance, and the more malleable it is.

And forgings expand more than castings.

Here are the approximate percentages of silicon in each type of piston material:

• Ordinary inexpensive cast aluminum pistons contain approximately 10% silicon.

• Hypereutectic cast aluminum pistons contain approximately 16% silicon, so they thermally expand the LEAST of all pistons.

• 4032 forged aluminum racing pistons contain approximately 11% silicon.

• 2618 forged aluminum racing pistons contain approximately 0.2% silicon, so they thermally expand the MOST of all pistons.

The primary intended usage of each type of piston is:

• Ordinary inexpensive cast aluminum pistons, are for ordinary stock vehicles with low to moderate performance engines.

• Hypereutectic cast aluminum pistons, are stronger than ordinary inexpensive cast pistons, and are for stock street performance, and moderately modified engines. These pistons can typically go well beyond 100,000 miles when used in normally driven vehicles. But, they are not as strong as, and are more brittle than, forged racing pistons.

• 4032 forged aluminum racing pistons, are for High Performance modified Street/Strip and Racing engines.

• 2618 forged aluminum racing pistons, are for the utmost in toughness, durability, strength, and fatigue life, in all out brutal High Horsepower Racing engines, including Supercharged, Turbocharged, and Nitrous applications. These pistons can withstand a lot of damage without breaking, making them the most bullet-proof pistons available.

Now, let's take a look at some typical "cold room temperature ASSEMBLY clearances" that can be found on piston clearance reference charts from the piston manufacturers (unfortunately, various reference charts often don't provide the same recommended clearances for the same piston material), for the various piston material types, to see how those clearances compare for a particular engine application.

For this example, we'll look at pistons that would be used in a modified, naturally aspirated, Street/Strip Hotrod, with a traditional gasoline powered, cast iron block, 454 cubic inch Big Block Chevy V-8 engine, that has a 4.250 inch diameter bore. Here are those recommended clearances:

• Ordinary inexpensive cast aluminum pistons = .0045″

• Hypereutectic cast aluminum pistons = .002″

• 4032 forged aluminum racing pistons = .005″

• 2618 forged aluminum racing pistons = .006″

Keep in mind that these "cold room temperature ASSEMBLY clearances", for all these various piston material types, were originally developed to end up with an approximately similar "operational RUNNING clearance" of around .0015 to .002 of an inch. So, as you can see, "overall" the different piston materials will thermally expand quite differently in the same engine application, to take up much of that "cold room temperature ASSEMBLY clearance". And as mentioned above, if you follow the piston manufacturers' recommended piston to cylinder clearance reference charts, you will be good to go.

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But, for those who are interested in deeper tech info, we are still not done looking at what "actually" happens inside a real running engine, because things are just not that simple. There is another significant missing piece of the puzzle to be aware of as well. That missing piece of the puzzle to be aware is, that even though aluminum thermally expands more than cast iron, the cast iron cylinder bore will also thermally expand, or in other words, increase in diameter as it heats up. Yes, metal holes "increase" in diameter as they heat up. They do NOT get smaller as some people INCORRECTLY believe.

Typical gasoline engine combustion temperatures can exceed 1,000*F. But, those temperatures also happen to be approximately the melting point of most aluminum pistons. However, because of the continued ingestion of cold air and fuel, with every intake stroke, and oil cooling the underside of the pistons, damage is avoided. And the average temperature of a piston crown is approximately 600*F.

Since the cylinder's OUTER surface is in direct contact with the engine coolant, the average temperature of the cylinder is approximately the same as the engine coolant temperature. So, if the 454 engine in this example, is running a coolant temperature of 180*F, then that would be a 110*F increase over a 70*F cold assembly temperature. With that increase in temperature, the bore will increase its diameter by .003″, making it 4.253″.

What this means of course, is that in reality, when you take into account the thermal expansion of the cylinder bores, the pistons thermally expanded even more when they were in development, than what the reference charts would seem to suggest at a casual glance. So, with the example 454 engine being considered, for the "operational RUNNING clearance" of.002 of an inch, the pistons would have actually expanded by the following amounts:

• Ordinary inexpensive cast aluminum pistons = .0055″ actual thermal expansion

• Hypereutectic cast aluminum pistons = .003″ actual thermal expansion

• 4032 forged aluminum racing pistons = .006″ actual thermal expansion

• 2618 forged aluminum racing pistons = .007″ actual thermal expansion

You can see that in reality, the different piston materials do thermally expand quite differently overall.

Now you see why "cold room temperature ASSEMBLY clearances" and "operational RUNNING clearances", are COMPLETELY DIFFERENT things. And that piston to cylinder clearance is NOT what many people thought it was.

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540 RAT

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36. Is Motor Oil Viscosity Index (VI) Useful Information?

Three topics of conversation are absolutely guaranteed to generate passionate and nasty arguments between those involved. Those topics are:

• Religion
• Politics
• Motor Oil

Here, we will only look at motor oil. Some of the motor oil topics that are argued about are:

• Zinc level
• Oil base stock types
• Motor oil viscosity selection
• Diesel oil used in gasoline engines
• Break-In oils
• Oil change intervals/extended drain intervals
• Aftermarket additives
• HTHS (High-Temperature/High-Shear)
• Motor oil Viscosity Index (VI)

I have addressed all those motor oil topics in this Blog, except for Motor oil Viscosity Index (VI), which I will address in this article.

The fact is, the vast majority of the people involved in these emotional and ridiculous motor oil topic arguments, have NO idea what they are actually talking about. They read a few articles on motor oil, and then they think/believe they are motor oil experts. These people are made up of two distinct groups.

One group includes people who simply do NOT know any motor oil FACTS at all, and just rehash the same old myths that people have been brainwashed to believe. They just accept the old false info with no proof at all, backing up that old info. They think if something has been said over and over again a million times, it has to be true. But of course, that thinking is dead wrong.

The other group is made up of people who have seen the FACTS, but choose to bury their head in the sand, and continue clinging to those old myths, rather than admit to themselves or others, that they have been wrong all these years. So, both groups end up being their own worst enemies.

They don't even know that a lot of what they read about motor oil is either NOT correct in the first place, or else it is so highly theoretical, that it is meaningless in the real world. In other words, they don't even know, what they don't know. Seeing these people argue by using completely wrong or meaningless information, always makes me laugh. These people can never make sound decisions about anything related to motor oil. Very sad.

And that is what prompted me to start this Motor Oil Engineering Test Data Blog in the first place. So that people had a source for the FACTS about motor oil, based on actual Engineering tests, NOT just opinions and theories that they find everywhere else. The Science of Physics and Chemistry determine the results of my Engineering tests. And Science is ALWAYS correct, whether people like it or not. And it is completely foolish to argue with Science.

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The subject of this motor oil Tech Article is Viscosity Index (VI), and how valuable it may or may not be in the real world. But first, a little review is in order. Let's look at 3 motor oil aspects.

1. FILM STRENGTH

"THE MOST IMPORTANT" motor oil capability is its ability to prevent engine wear. PERIOD. Everything else motor oil does, comes "AFTER" that. In fact, everything else a motor oil does, is directly or indirectly in support of preventing wear.

A motor oil film can be defined as a coating of motor oil that is too thin to flow, run or drip. An example of a motor oil film at work, is the thin coating of oil between parts that slide or push/slide/twist over each other. Such as rocker arm type followers that slide over the cam lobes, DOHC engines where the cam lobes directly push/slide/twist on buckets, and traditional push rod engines where the cam lobes directly push/slide/twist on lifters.

And what separates the best motor oil on the market from the worst motor oil on the market, is their "film strength/load carrying capability/shear resistance/boundary lubrication limit" values, given in PSI in my motor oil Engineering test results. The psi value each oil is capable of producing, represents its ultimate failure point, which is what we compare to rank oils for their ability to prevent engine wear.

For our purposes here, we can just shorten all that to an oil's "film strength" PSI value. That film strength value is determined only by the oil's proprietary factory "additive package", which is what includes the extreme pressure anti-wear components. The base oil being used, and the viscosity rating involved, have absolutely NOTHING to do with an oil's wear protection capability, contrary to what many people believe.

2. Incompressible Hydrodynamic Liquid Oil Wedge

Motor oil film strength is only involved in protecting rod and main bearings from wear, when an engine has been sitting long enough that only an oil film remains between the bearings and crankshaft at start-up. That makes a highly ranked oil's film strength very important in that regard. However, 99% of the time, those parts are kept separated and protected from wear, by the incompressible hydrodynamic liquid oil wedge that is formed as the liquid oil is pulled into the clearance by the spinning crankshaft. Oil pressure serves only to supply the oil to that clearance between the bearings and the crankshaft journals.

Physics proves to us that no liquid can be compressed, which for example, is why watery thin brake fluid works in braking systems. So, "no matter how thin" the motor oil viscosity, as long as the oiling system is capable of providing sufficient HOT oil pressure to provide enough oil flow to maintain the critical incompressible hydrodynamic liquid oil wedge between the bearings and crankshaft journals, it is not possible for any wear to take place between those parts. In order to provide sufficient oil pressure/flow to maintain that critical incompressible hydrodynamic liquid oil with thinner oils, a high volume oil pump my well be needed, depending on the bearing clearances involved.

What this means is that when it comes to keeping rod and main bearings separated from crankshaft journals, to prevent wear or damage, it makes no difference if you use $3.00 per quart motor oil, or if you use $30.00 per quart motor oil, since no liquid can be compressed. So, the cheapest motor oil or the most expensive motor oil, both provide the SAME incompressible liquid capability.

3. Oil pressure

Oil pressure itself does not directly prevent engine wear. Oil pressure is only a measure of resistance to flow. So, it does not help an engine at all, to use super thick oil in order to increase the oil pressure. But, knowing that your engine makes sufficient HOT oil pressure is essential. Because that tells us if the oiling system is robust enough to keep up with the oil bleed-off out of the bearing clearances, in order to maintain that critical incompressible hydrodynamic liquid oil wedge between the bearings and crankshaft journals. So, even though oil pressure by itself does not directly help prevent wear, knowing that the oil pressure is acceptable, is extremely important.

In general, it is best to use the thinnest viscosity motor oil that will still maintain sufficient HOT oil pressure. Thinner oil is best because thinner oil flows, lubricates and cools critical engine components better than thicker oils can. Thinner oils reduce bearing temperatures and sump temperatures compared to thicker oils. Thinner oils can also help increase horsepower and miles per gallon. Using thicker oil than is needed, is going the wrong way. See my Blog's "Section 2" on motor oil viscosity selection, and the benefits of using thinner oil, for all the details.

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Now, on with the topic of Motor Oil Viscosity Index (VI).

The physical property used to quantify an oil's resistance to viscosity change with temperature is known as the Viscosity Index (VI). The higher the VI, the more resistant to viscosity change the oil is.

EVERY motor oil thins out as it heats up and thickens as it cools down, no matter what its identifying viscosity rating is.

Multi-grade motor oil viscosity properties are typically given at 40*C (104*F) cold value, and at 100*C (212*F) hot value.

Motor oil thickness is given in an accurate measurement called centistokes (cSt). The HIGHER the cSt value, the THICKER the oil.

ASTM D2270 is used to determine the Viscosity Index (VI) value.

ASTM D445 is used to determine the cSt @ 40*C and cSt @ 100*C, values.

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Here, we'll look at an assortment of synthetic and conventional motor oils, as well as some Bio-based motor oils.

SYNTHETIC PETROLEUM-BASED OILS:

.

5W30 Amsoil Signature Series
Viscosity Index = 162 / 59.7 cSt @ 104*F / 10.3 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

.

5W30 Quaker State Ultimate Durability
Viscosity Index = 170 / 66.65 cSt @ 104*F / 11.60 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

.

5W30 Valvoline Modern Engine Oil
Viscosity Index = 165 / 55.0 cSt @ 104*F / 9.8 cSt @ 212*F
viscosity reduction of 82% between 104*F and 212*

.

5W30 Valvoline Advanced Full Synthetic
Viscosity Index = 158 / 60.1 cSt @ 104*F / 10.2 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

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5W30 Pennzoil Platinum
Viscosity Index = 170 / 53.9 cSt @ 104*F / 9.8 cSt @ 212*F
viscosity reduction of 82% between 104*F and 212*

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5W20 Amsoil Signature Series
Viscosity Index = 153 / 50.6 cSt @ 104*F / 8.8 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

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5W20 Quaker State Ultimate Durability
Viscosity Index = 157 / 46.76 cSt @ 104*F / 8.41 cSt @ 212*F
viscosity reduction of 82% between 104*F and 212*

.

5W20 Valvoline Modern Engine Oil
Viscosity Index = 165 / 49.1 cSt @ 104*F / 9.0 cSt @ 212*F
viscosity reduction of 82% between 104*F and 212*

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5W20 Valvoline Advanced Full Synthetic
Viscosity Index = 147 / 46.5 cSt @ 104*F / 8.1 cSt @ 212*F

viscosity reduction of 83% between 104*F and 212*

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5W20 Pennzoil Platinum
Viscosity Index = 167 / 45.9 cSt @ 104*F / 8.6 cSt @ 212*F
viscosity reduction of 81% between 104*F and 212*

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0W20 Amsoil Signature Series
Viscosity Index = 169 / 47.1 cSt @ 104*F / 8.8 cSt @ 212*F
viscosity reduction of 81% between 104*F and 212*

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0W20 Quaker State Ultimate Durability
Viscosity Index = 165 / 44.61 cSt @ 104*F / 8.33 cSt @ 212*F
viscosity reduction of 81% between 104*F and 212*

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CONVENTIONAL PETROLEUM-BASED OILS:

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5W30 Quaker State Advanced Durability
Viscosity Index = 158 / 63.4 cSt @ 104*F / 10.6 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

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5W30 Valvoline Daily Protection
Viscosity Index = 168 / 63.0 cSt @ 104*F / 11.0 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

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5W30 Pennzoil
Viscosity Index = 158 / 63.4 cSt @ 104*F / 10.5 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

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5W20 Quaker State Advanced Durability
Viscosity Index = 150 / 49.2 cSt @ 104*F / 8.5 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

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5W20 Valvoline Daily Protection
Viscosity Index = 146 / 50.0 cSt @ 104*F / 8.5 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

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5W20 Pennzoil
Viscosity Index = 150 / 49.6 cSt @ 104*F / 8.5 cSt @ 212*F
viscosity reduction of 83% between 104*F and 212*

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BIO-BASED OILS:

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5W30 Renewable Lubricants Bio-SynXtra
Viscosity Index = 177 / 49.0 cSt @ 104*F / 11.0 cSt @ 212*F
viscosity reduction of 78% between 104*F and 212*

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5W20 Renewable Lubricants Bio-SynXtra
Viscosity Index = 179 / 45.0 cSt @ 104*F / 8.8 cSt @ 212*F
viscosity reduction of 80% between 104*F and 212*

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You would like to see an oil be thin enough to flow well during cold start-up, when the oil is thickest, yet not be overly thin at hot operating temperature, when the oil is thinnest. See my Tech Article, "23. Multi-viscosity motor oils are not exactly what some people think", for more details.

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The higher the Motor Oil Viscosity Index (VI) value, the less the oil is supposed to thin out when it reaches hot operating temperature.

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• So, let's look at Viscosity Index (VI) values and the percentage of cSt oil thickness drop seen between the 40*C (104*F) cold value, and 100*C (212*F) hot value. We'd like to see the lowest percentage of drop possible.

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5W30 synthetic oils:
The highest VI = 170 and 82% was the least amount of cSt oil thickness drop seen from the oils above.
The lowest VI = 158 and 83% was the drop amount seen.

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5W20 synthetic oils:
The highest VI = 167 and 81% was the drop amount seen.
The lowest VI = 147 and 83% was the drop amount seen.

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0W20 synthetic oils:
The highest VI = 169 and 81% was the drop amount seen.
The lowest VI = 165 and 81% was the drop amount seen

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5W30 conventional oils:
The highest VI = 168 and 83% was the drop amount seen.
The lowest VI = 158 and 83% was the drop amount seen.

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5W20 conventional oils:
The highest VI = 150 and 83% was the drop amount seen.
The lowest VI = 146 and 83% was the drop amount seen.

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NOTE: Conventional oils use "viscosity improvers" in order to prevent excessive thinning out as they get hot, to provide acceptable performance in running engines, and for them generate acceptable VI values for their spec sheet. However, viscosity improvers breakdown as mileage accumulates on the oil. So, that makes it important to change conventional oils at reasonable intervals, before those viscosity improvers can no longer do their job.

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5W30 Bio-based oil
VI = 177 and 78% was the drop amount seen.

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5W20 Bio-based oil
VI = 179 and 80% was the drop amount seen.

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SUMMARY of what all these numbers mean:

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•Let’s look at the oils in each type and viscosity that did the BEST job of NOT thinning out too much, when they reached the hot temperature evaluated, which is what we’d like to see.

.

5W30 synthetic Quaker State Ultimate Durability with a hot 11.60 cSt value

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5W20 synthetic Valvoline Modern Engine Oil with a hot 9.0 cSt value

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0W20 synthetic Amsoil Signature Series with a hot 8.8 cSt value

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5W30 conventional Valvoline Daily Protection with a hot 11.0 cSt value

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5W20 conventional, a tie between Valvoline Daily Protection, Pennzoil, and Quaker State Advanced Durability with a hot 8.5 cSt value

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5W30 Bio-based Renewable Lubricants Bio-SynXtra with a hot 11.0 cSt value

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5W20 Bio-based Renewable Lubricants Bio-SynXtra with a hot 8.8 cSt value

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•Let’s look at the oils in each type and viscosity that were the thinnest when cold, to provide the best flow at cold start-up.

.

5W30 synthetic Pennzoil Platinum with a cold 53.9 cSt value

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5W20 synthetic Pennzoil Platinum with a cold 45.9 cSt value

.

0W20 synthetic Quaker State Ultimate Durability with a cold 44.61 cSt value

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5W30 conventional Valvoline Daily Protection with a cold 63.0 cSt value

.
5W20 conventional Quaker State Advanced Durability with a cold 49.2 cSt value
.
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.
5W30 Bio-based Renewable Lubricants Bio-SynXtra with a cold 49.0 cSt value
.
*****
.
5W20 Bio-based Renewable Lubricants Bio-SynXtra with a cold 45.0 cSt value
.
CONCLUSION:
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•Let's look at "overall", which oil in each viscosity rating that was the thinnest for best cold start-up flow, no matter what type of oil it was.
.
5W30 Bio-based Renewable Lubricants Bio-SynXtra with a cold 49.0 cSt value
.
5W20 Bio-based Renewable Lubricants Bio-SynXtra with a cold 45.0 cSt value
.
0W20 synthetic Quaker State Ultimate Durability with a cold 44.61 cSt value
.
•Let's look at "overall", which oil in each viscosity rating that did the BEST job of not thinning out too much, or in other words, was the thickest at the hottest test temperature, which is what we'd like to see, no matter what type of oil it was.
.
5W30 synthetic Quaker State Ultimate Durability with a hot 11.60 cSt value
.
5W20 synthetic Valvoline Modern Engine Oil with a hot 9.0 cSt value
.
0W20 synthetic Amsoil Signature Series with a hot 8.8 cSt value
.
Unfortunately, as you can see in the cold and hot conclusion values just above, one single oil is not the best at both cold and hot temperatures.
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.
So, which oils provide the best "OVERALL" viscosity at "both" cold and hot temperatures, even if they are not the absolute best at both temperatures?
.
•5W30 Renewable Lubricants Bio-SynXtra with a cold cSt value of 49.0 and a hot cSt value of

11.0, is the best 5W30 overall, in terms of viscosity changes, because it "IS" the best when cold, and nearly ties for the best when hot, among the oils looked at here.

.

•5W20 Renewable Lubricants Bio-SynXtra with a cold cSt value of 45.0 and a hot cSt value of 8.8, is the best 5W20 overall, in terms of viscosity changes, because it "IS" the best when cold, and nearly ties for the best when hot, among the oils looked at here.

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And what about the question asked in the title of this article? Is Motor Oil Viscosity Index (VI) Useful Information?

Among all the petroleum based oils looked at here, the Viscosity Index (VI) values varied from:

A high of 170, with an 82 and 83% drop in viscosity from cold to hot.

A low of 146, with an 83% drop in viscosity from cold to hot.

So, the high and low Viscosity Index values varied by a quite significant 14%, yet the actual viscosity drop percentage was exactly the same.

Even if you select a high VI value of 170, you cannot expect any better performance than you could get from a low VI value such as 146.

That is clear proof that Viscosity Index (VI) values do NOT provide any useful information, and are effectively worthless.

And that is also further proof of what I often say, that a lot of what people read about motor oil is either NOT correct in the first place, or else it is so highly theoretical, that it is meaningless in the real world. Viscosity Index (VI) values are just one example of that.

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Before ending this article, let's see if there is any worthwhile information we can salvage from all these numbers.

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5W30 Renewable Lubricants Bio-SynXtra with a Viscosity Index of 177, had a cold cSt value of 49.0 and a hot cSt value of 11.0, which was a viscosity drop of only 78%.

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5W20 Renewable Lubricants Bio-SynXtra with a Viscosity Index of 179, had a cold cSt value of 45.0 and a hot cSt value of 8.8, which was a viscosity drop of only 80%.

.

The viscosity drop percentages for these two bio-based oils were the lowest and best of the entire group of motor oils considered in this article. What this means, is that you need to reach Viscosity Index (VI) values in the mid to upper 170's before they provide any useful guideline information.

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For the oils reviewed in this article, only those two bio-based oils had VI values that high. And while these two bio-based oils had good numbers here, and the 5W30 version performed very well in my Engineering Wear Protection Capability testing, it will be tough for these oils to be successful in the marketplace. Because almost no one has ever heard of them, they have little or no advertising, little or no distribution, and have not earned any API certifications.

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That leaves virtually the entire motor oil market for petroleum based motor oils, along with their worthless Viscosity Index (VI) values. So, the only thing people can do if they are interested in a motor oil's hot and cold cSt numbers, is to look them up individually, on the oil maker's website, and completely ignore their VI values.

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540 RAT

Mechanical Engineer (A Mechanical Engineer is clearly the most qualified Engineer to test motor oil that was formulated by Chemical Engineers, for wear protection capability between mechanical components under load.)

U.S. Patent Holder (Mechanical device designed for Military Jet Aircraft)

Member SAE (Society of Automotive Engineers)

Member ASME (American Society of Mechanical Engineers)

Lifelong Gear Head, Mechanic, Hotrodder, Drag Racer, and Engine Builder.

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