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ZPlus™ Tech Brief #14

ZDDP and Pre-WWII Engines

Questions have been raised to us about the suitability of the additive ZDDP in pre-WWII engines. These engines were initially supplied with oils which ranged from the unclassified oils of 1889 to the 1947 API rating of Regular (straight mineral oil), Premium (oxidation inhibitors added), or Heavy Duty (oxidation inhibitors and detergent/dispersants added).

Beginning in the 1880s in France with the Panhard and Levassor automobile and others, the engines of the time were lubricated with custom formulations of oil usually supplied by the auto dealer. These custom oils were formulated by the established industrial machine oil manufacturers. The state-of-the-art in refining was not very advanced by today's standards, so by current measures, all of these oils were relatively low-performance lubricants.

The Regular grade of oil pre-1952 was free of additives, so some pre-WWII car owners feel that the engines which were originally supplied with this oil will not benefit from additives such as ZDDP. Let's examine the situation, comparing the base stocks now and then, additives of the WWII era, and those currently available.

A Brief History of Engine Oil

1859 - First oil well was dug in Titusville, PA.
1879 - Vacuum process for refining oil.
1911 - SAE developed an oil classification system organized by viscosity.
1919 - API formed.
1921 - First synthesized petrochemical product - isopropyl alcohol.
1936 - First catalytic oil cracking distillery built in Paulsboro, NJ.
1942 - First fluid catalytic cracking.
1947 - API designates three motor oil classifications: Regular (straight mineral oil), Premium (oxidation inhibitors added), and Heavy Duty (oxidation inhibitors and detergent/dispersants added).
1952 - API & ASTM develop Engine Service Classification System (ESCS), separated out gasoline engine performance with Service Categories ML, MM, and MS. API and ASTM revised ESCS in 1955 and again in 1960.
1970 - API, ASTM, and SAE established a new classification system that would satisfy the changing requirements of the automotive industry. Initially there were four Service Categories: SA to replace ML, SB to replace MM, SC to replace MS through 1964 - vehicles, and SD to replace MS in vehicles between 1964 and 1968.
1971 - Category SE motor oil standardized. Supersedes all previous Service Categories.
1979 - Category SF motor oil standardized. Supersedes all previous Service Categories.
1988 - Category SG motor oil standardized. Supersedes all previous Service Categories.
1993 - Category SH motor oil standardized. Supersedes all previous Service Categories.
1996 - Category SJ motor oil standardized. Supersedes all previous Service Categories (ZDDP limit lowered).
2001 - Category SL motor oil standardized. Supersedes all previous Service Categories (ZDDP limit lowered).
2004 - Category SM motor oil standardized. Supersedes all previous Service Categories (ZDDP limit lowered).

From this timeline it is obvious the history of PCEO (Passenger Car Engine Oil) development is one of incremental change, and until the lowering of the ZDDP limit with the advent of SJ oil in 1996 it was always a backward-compatible improvement. Some of this change was in order to increase the productivity of the refineries, and some change was driven by the need to address specific shortcomings in the current oil.

Makeup of Early Oils

The first generation of automotive oils were straight machine oils taken from industrial oil manufacturers. These oils were designed to be used in lathes, milling machines, large gearboxes and other machinery. This oil was sufficient to keep bearings and other mechanisms lubricated adequately in dry weather and moderate temperatures, but it was not specifically formulated for the very different environment found in an automobile engine.

Industrial equipment operates in a relatively benign environment with little condensing humidity, no combustion products, and a relatively small operating temperature range. Although some equipment has to deal with debris, seals designed into industrial equipment can be very efficient at excluding debris, but are often expensive and elaborate. The economies inherent in manufacturing low-cost automobiles dictate simple, inexpensive seals. In addition to ingress of contaminants from outside the bearings and engine, early gasoline contributed large amounts of contaminants to the engine oil. As a result of these factors, these early engine oils were poorly suited to the abuse meted out by an internal combustion engine. When doing an oil change, the vehicle owner had little information with which to correctly choose oil. The lack of research and standardization resulted in weak recommendations for the correct oil.

Early oil base stocks were poorly refined mineral oils, with a low Viscosity Index and many impurities. Their performance was so poor that very short oil change intervals were mandated by automobile manufacturers, indeed intervals as short as 500 miles were common. Of course, there were many reasons why engine oils turned black very fast and needed to be changed[1,2] :

- Manual chokes, which were often overused or forgotten, with resulting excessive rich mixture.
- Relatively short distances driven.
- Long warm up to operating temperature associated with older thick-wall castings.
- Many older vehicles had no thermostat in the cooling system further delaying warm-up.
- Low engine operating temperature in the order of 140°-170ºF, causing fuel condensation.
- Partial by-pass oil filters were not introduced until about 1927.
- Most roads were dirt or gravel surface, and the air filters were ineffective.
- Low compression in the order of 4:1 until the advent of anti-knock additives in the late 20s.
- Low combustion efficiency and poor carburetion causing fuel blow-by which diluted the oil.
- Oils did not have dispersants, anti-corrosive or anti-wear agents.
- Lack of crankcase ventilation allowing condensation of blow-by.

On this last point, Dyke's Automobile and Gasoline Engine Encyclopedia states in the 1942 edition: "Renew oil...at periods not in excess of 2000 miles...on cars equipped with crankcase ventilation and oil filter. On cars not so equipped oil should be changed every 500 miles in summer and 300 miles in winter." Although the criterion on which this recommendation is based is not stated, the point is valid: the presence of blow-by gases condensing in the crankcase is a prime source of oil contamination which must be removed, if not by ventilation, then by an oil change.

Some of these contaminants created by early fuel were acids like hydrochloric acid. To make the situation worse, the gasoline was of poor quality by today's standards, with very high asphaltine (heavy hydrocarbons) varnish, soot, water and sulfur content. Combustion of this gasoline liberated a stew of sulfuric acid, tar and varnish. Compared to today's engines there was considerable blow-by of combustion gases past the rings of these early engines, and once condensed in the oil, these contaminates began wreaking havoc on the engine internals.

Soot from the burned oil and gasoline deposited out on the internal engine parts and clogged oil pickups. To combat this, starting in the 1930s in the Heavy Duty grades, detergents were added which show an affinity for these particles. This detergent keeps the particles from clumping and rapidly settling until the oil is drained from the sump.

In addition, the early oils broke down by a number of mechanisms: Hydrolysis from combustion water diluted the oil, oxidation at high temperatures turned the oil to sludge, and

figure 1 Deep Rock Oil Co. Salesman's Sample Kit

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1 Coulombe, Richard, Discussions with the author about pre-WWII engines, Quebec, CA 2010

2 Dyke, A.L., *Dyke's Automobile and Gasoline Engine Encyclopedia 19th edition*, Goodheart-Wilcox Company, Inc., St. Louis, MO, 1942, pp 157-170

the viscosity constantly increased due to evaporation of the lighter fractions of oil. This last factor often went unnoticed due to the thinning effect of fuel dilution, but oil diluted with gasoline is a poor lubricant.

The earliest engine oils did not have detergents or corrosion neutralizing agents so the acids in the oil would dissolve the copper and lead bearing materials, as well as corroding the steel oil pans and blocks. To combat this, ZDDP was originally used as a potent anti-corrosive agent, a job it performs admirably.

Quality Criteria of Early Oils

Early on in the history of oil refining, one of the toughest challenges faced by the petroleum industry was getting high yields from an oil refinery without leaving excess impurities in the oil. Subsequently the highest quality, and most expensive to make oil, was the purest oil. In 1893 a newly-formed oil company was even named “Pure Oil Company” to capitalize on the association between purity and quality. The state-of-the-art engine lubrication at the time merely focused on getting slippery oil in between moving parts and little else.

We were lucky enough to find an oil salesman’s sample kit from the year 1938 (figure 1) and the oils contained in it tell volumes about how oil was marketed pre-WWII.

Most oil companies offered various grades of oil at graduated price points, based on the “purity” of the oil. Since oil generally becomes lighter in color when impurities are removed, the lightest grades were the most highly prized and priced. A close examination of the vials of sample oil in the sales kit (figure 2) show that there are three different grades of SAE 40W oil offered, and in order of increasing quality and cost they are called “*Val-u-lube Oil,*” “*D.R. Motor Oil,*” and “*Prize Motor Oil.*” As you would expect, as the cost increased, so does the clarity or “purity” of the oil.

The Prize Motor Oil was probably the best oil of the three, shown in figure 2. By today’s standards it would not be considered adequate for even the most rudimentary lubrication jobs, never mind an internal combustion engine. This connection, as perceived by the consumer between an oil’s purity and it’s lubricating quality, would last for many years. Indeed, in the antique car community this association is still the source of much confusion regarding the inclusion of “additives” to fully formulated passenger car engine oil.

While it is definitely true that the more unwanted substances which are removed from the crude oil in a distilled mineral product, the better quality it *can* be, this is not the entire consideration. If the petrochemical engineers of the time could have designed a machine to extract ONLY the molecules they wanted and leave the rest, they would have used it. The multiple grades of refinement found in the early oils was a reflection of the fact that the refining equipment used at the time was crude (pun intended).

figure 2 Varying Grades of 40-Weight Oil

Mineral oils, which are merely fractionally distilled, and no matter how “pure” are merely a subset of the molecules found in the original crude oil. This does not mean they exhibit better or worse characteristics than synthetic oil, just that the contents are less well characterized, since they consist of a wide range of molecules that happen to have similar condensation temperatures. As a point of comparison, a modern synthesized oil molecule can be replicated to a high degree of purity.

The need to use *currently available* technology is a fixed constraint of all engineering, indeed the need for better technology is what drives engineering innovation. It follows that the need to make a lubricant consisting entirely of the molecule types exhibiting the best lubricity is the underlying reason for advancements in refining and additive technology as well as synthetic oil research.

Many people who believe in “straight weight plain oil” think only inferior base oil stocks require additives to address the weaknesses of that oil. The truth is: if the word “inferior” is removed, we have a statement which we can confidently make, one which applies to ALL base oil stock including the best synthetic:

Additives are added to all base oils to address the weaknesses of that oil in a particular application.

Demands of Modern Engines vs. Old Engines

Modern engines have it good with respect to the quality of both the gasoline and oil available to them. Current gasoline has relatively few impurities which would cause oil degradation if an engine is properly fueled and aspirated. In general, the most recent oils such as API SL and SM represent the current state-of-the-art petrochemical engineering, and can take far more shear, heat and contaminants without losing their functionality. It would be easy to make a compelling case that the longevity of current engines is largely due to the increase in quality of fuels and oils, fuel injection, and the degree of accuracy and repeatability available with modern materials and machining. It is an interesting exercise to compare engines of the past with current engines. In order to minimize the differences, let’s pick two engines of similar displacement and number of cylinders.

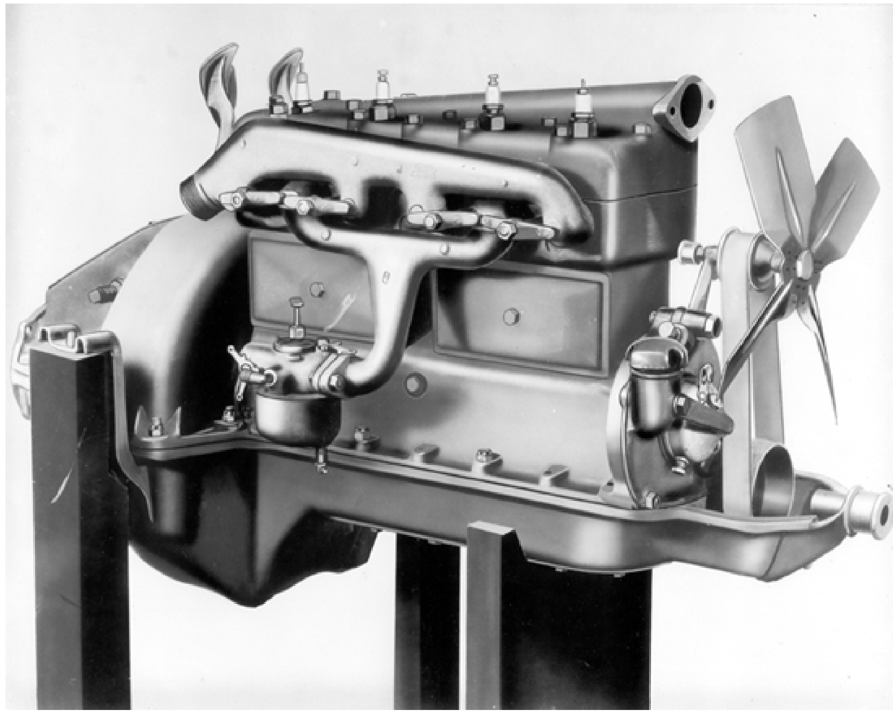

figure 3 Ford Model T Engine (1908 shown, similar to 1913)

1913 Ford Model T

The 1913 Model T engine (figure 3) displaced 177 cu. in., or just about 2.9 liters, developed 22.5 hp @1600 rpm, and had 83 ft. lbs. torque at 900 rpm. In the 1200-pound Model T, the engine averaged 10-12 mpg and could go 35-40 mph max. It was designed to use the finest oils of the time and had a factory mandated 500-mile oil change schedule[3]. This is Ford’s oil recommendation, taken from the 1911 Model T Operating Manual[4]:

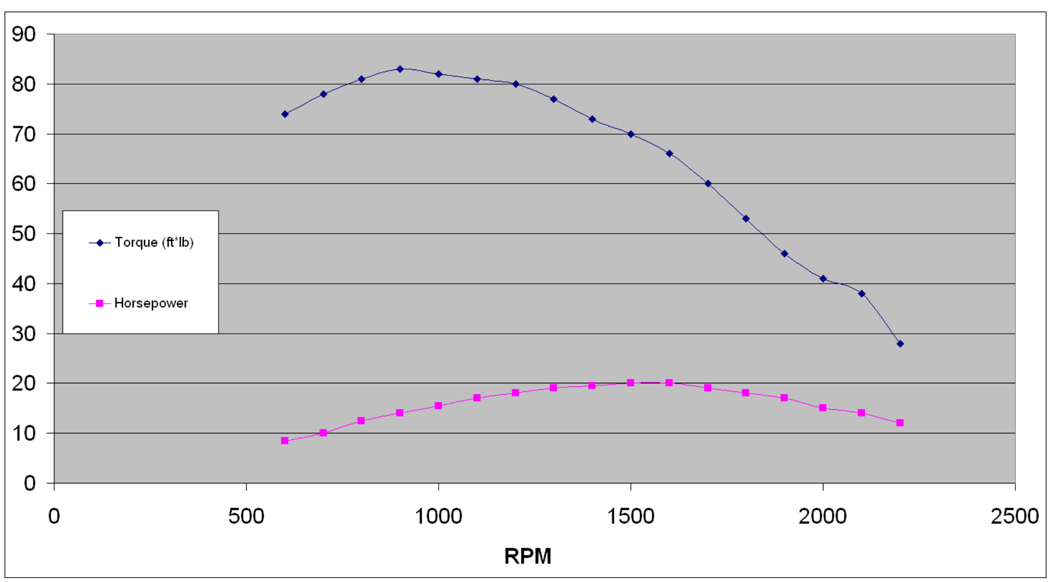

figure 4 Ford Model T Engine Dyno Test Results

“*We recommend only light high-grade gas engine oil for use in the Model T motor. A light grade of oil is preferred as*

[3] http://www.mohicanmodela.org/index2.php?option=com_content&do_pdf=1&id=68

[4] http://www.modelt.ca/faq-fs.html

it will naturally reach the bearing surfaces with greater ease, and, consequently, less heat will develop on account of friction. The oil should, however, have sufficient body so that the pressure between the two bearing surfaces will not force the oil out and allow the metal to come in actual contact. Heavy and inferior oils have a tendency to carbonize quickly, also gum up the piston rings and valve stems."

1993 Porsche 968 Turbo RS

The closest modern 4 cylinder engine of equivalent displacement is the engine found in the 1993 Porsche 968 Turbo RS (figure 5). If you think it is going to an extreme comparing a Model T engine with a modern high-performance sports car engine, bear with us, this is part of the point we are trying to make.

The 968 Turbo RS had a 3.0 liter (183 cu. in.) displacement engine which generated 350 hp @ 5400 rpm and 369 ft. lb. of torque @ 3000 rpm. The 2976-pound car was capable of exceeding 175 mph, and could average 23 mpg for highway fuel economy. It was designed to use the standard 15W-50 API SH oils which were available in 1993, and recommended a 3000-mile oil change interval. Porsche has continued to update their oil recommendations, and makes these recommendations retroactive to older models. They are currently recommending 5W-50 for these engines (as of 2004), reflecting the fact that lower viscosity at cold temperatures helps cold weather lubrication between the time of first start and when the engine is fully warmed up.

figure 5 Porsche 968 Turbo Engine (1994 shown, similar to 1993 model)

To compare the two engines is to appreciate the advances in both engineering and oil performance over the intervening 80 years. The Porsche engine develops more than 20 times the horsepower and 5 times the torque of the Model T. The forces acting on the oil as it lubricates the bearings and camshaft and rings in the newer engine are several orders of magnitude higher than they are in the older engine. How can the newer engines withstand the higher forces without damage? Part of the explanation can be found in the superior materials and more precise machining. But the importance of oil in this increased performance can be found by analyzing the flow of power and force in an engine.

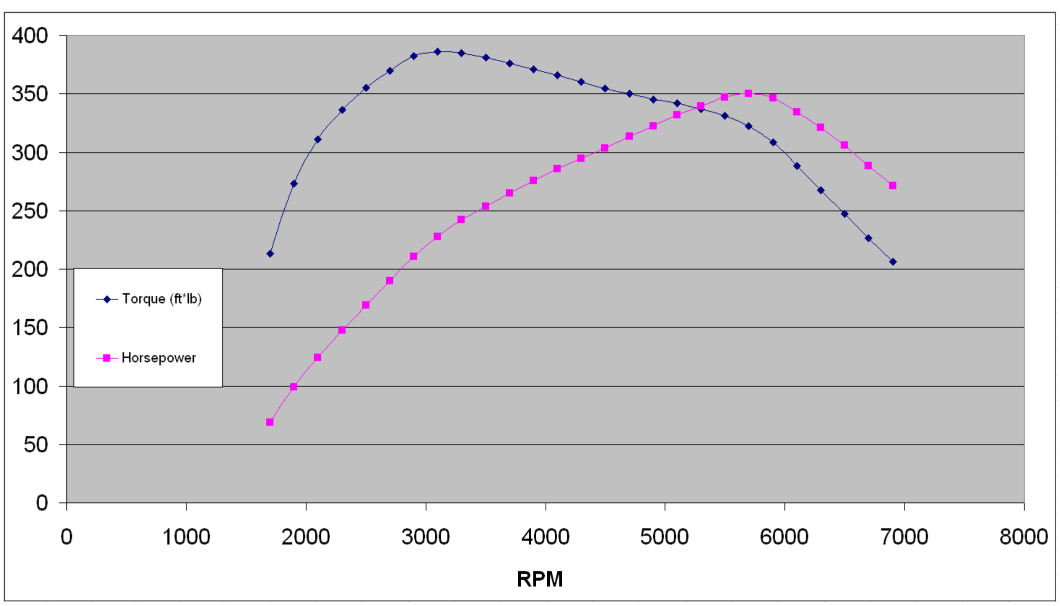

figure 6 Porsche 968 Turbo RS Engine Dyno Test Results

The Path of Force in Internal Combustion Engines

Many people think the sole function of oil is keeping rotating bearings and sliding engine parts from contacting and wearing each other. This is certainly an important function, but it must serve this function successfully while transmitting force through the thickness of the film, and each foot pound of torque that is delivered to the tires has to pass through many oil films on its way there.

The pressure of combustion directly acts on the piston, and most of the force is then transferred through an oil film at the wrist pin at the top end of the connecting rod. A small percentage of the force of combustion pushes the compression rings down, and due to design clearance between the piston and ring, pushes the rings outward as well to seal against the cylinder wall.

The wrist pin operates in an oscillating hydrodynamic lubrication mode, and the minimum film thickness occurs at 90° from BDC and TDC, at a point of reversal of rotation of the wrist pin. Wrist pin lubrication is achieved by oil thrown out of the connecting rod bearing side clearance, as well as side leakage from the main bearings which is caught in the air turbulence in the sump.

The force transferred to the top of the connecting rod is transferred through the connecting rod to the oil film between the connecting rod bearing and the crankshaft. In modern engines this oil film is a continuous hydrodynamic bearing with oil pressure fed through the crankshaft cross-drilling.

The oil film at the crankpin then transfers the force to the crankpin itself, and is translated into rotational torque by the leverage of the crank arm. The pivot point of this lever arm is the crankshaft main journal, so the force is transmitted through the oil film in the main crankshaft bearings, and in an I or V engine to the bearing inserts in the main bearing caps, or in an opposed engine to the bearing inserts in the crankcase.

The point is ALL engine power is transmitted through several oil films on its way to the transmission. If these films rupture or yield to the pressure, metal-to-metal contact occurs causing wear. The oil film strength required to adequately lubricate modern engines is much higher than was required for pre-WWII engines.

Now, just because modern engines can exert far more stress on the oil film than an old engine, both in terms of peak pressures and shear, does that implicitly make modern oil better than old oil? Of course, the answer is no. However, if an off-the-shelf API SH oil from 1993 has the film strength to properly protect all internal parts for 100,000 miles and more in a Porsche 968, then the correct viscosity version of it is certainly suitable to the job of protecting the internals of a much lower performance engine of similar displacement. A high-performance oil from 2010, such as a API SM or SN rated oil, is better still. Much progress has been made in the intervening 17 years since the 968 was built, and the demands on engine oil have continued to increase.

Oil achieves the API certification by successfully passing a series of API Test Sequences. As the requirements have increased, the Sequences have updated, and become more and more difficult for an oil to pass. A lot can be learned by examining the progression of the API Sequence tests from the initial SE oil, to the SH oil of 1993, and up to the current SN standard. You will realize that the driving force (pun intended) is failure of the preceding oil Test Sequence to adequately test and qualify oil for some performance characteristic such as high temperature stability, evaporation, or some other characteristic. As engines have demanded higher performance from oil, the oil chemists have responded by addressing each weakness of the existing oil and improving it. The result of this incremental progress is today's oil which outperforms older oils in every way, except one: anti-wear performance for cams and non-roller lifters of high-performance engines and some classic engines. Full backward compatibility was assured until the 1996 release of the API SJ oil standard, which for the first time limited the phosphorus found in the anti-wear chemical ZDDP. This downward trend in ZDDP levels is shown in figure 7.

API Certification	Date Adopted	Parts per Million of Phosphorus (maximum)	Parts per Million of Phosphorus (minimum)
SF	1980	HD~1400	n/a
SG	1989	1200	n/a
SH	1992	1200	n/a
SJ	1996	1000	800
SL	2001	1000	600
SM	2004	800	600
SN	2010	<800	600

figure 7 API Service Classification and ZDDP Levels

When the U.S. EPA mandated extended warranty periods for catalytic converters beginning in 1996 with the adoption of OBDII (On Board Diagnostics II), car manufacturers soon realized that a re-engineering of the valve train was going to be necessary due to the lowering of ZDDP in the oil. The result was a change in new engine design from flat-tappet cam followers to a roller-follower system. Of course, this modification is neither desirable nor necessary for a classic car. Much of the value in a classic car is predicated by the owner's adherence to the details of the original vehicle build. Changing to a roller-cam system is hardly keeping an older vehicle stock.

Fortunately, the solution is fairly straightforward: keep the ZDDP levels at a level which provides anti-wear protection like that found in the API SF through SH formulation. These formulations were the standard during the period when the highest-performance flat-tappet engines were designed. The highest level of protection for flat-tappet cams and lifters was achieved at that time by using one of these formulations with between 1400 to 1800 ppm of phosphorus, often labeled "Heavy Duty."

These old formulations are not available today in 2010, and that is fortunate, because they are no longer truly high-performance oils by any current definition, in any way other than the level of the anti-wear agent ZDDP. Some owners of cars manufactured before the API SA specification (1971) think SF, SG or SH oil would be incorrect for their cars. If the vehicle was driven or maintained at all during the 1970 to 1993 period, the owner has probably already used SF through SH oils. If the engine worked well with that oil, the higher-performance oil of today with additional ZDDP will work even better.

Structural Differences between Modern Engines and Old Engines

Some people say modern oils and additives are contra-indicated in pre-WWII engines due to the internal differences between these engines and current engine technology. Let's look at some of the systems in each engine type and see if this idea has merit.

Cast Iron Block and Components - There has been some evolution in cast-iron technology in the last 100 years, namely in the inclusion of anti-wear elements such as silicon and alloys containing nitrides. Other refinements have been high-nickle alloys for increased strength. These alloys exhibit slightly enhanced corrosion resistance as well, but the basic corrosion resistance of cast iron is comparable to that found 100 years ago. The corrosion of engine components in engines was the original reason the anti-corrosion agent ZDDP was added to oils. Many ZDDPs are manufactured to achieve a potent anti-acid action to neutralize combustion acids. Modern oils contain other anti-corrosive agents in addition to ZDDP, and are far superior at stopping corrosion compared the earliest, non-additive containing oils.

Crankshaft and Camshaft Bearings - Prior to WWII, the Babbitt used in classic car engine poured-in-place bearings was one of several alloys of tin, copper and antimony. The most common high-quality Babbitt is approximately 85% tin, 7% copper and 8% antimony. Modern engines use a multi-layer sandwich of metals laminated on a steel backing. The actual wear surface can be a Babbitt alloy or aluminum-tin alloy. Corrosion of bearing materials was the first reason why ZDDP was formulated into PCEO. ZDDPs anti-corrosive action neutralizes acids, thermally stabilizes oils, and makes them less likely to oxidize and break down. ZDDP also deactivates the surfaces of many metals at relatively low temperatures, reducing oxidation of these metallic parts.

Steel and Iron Cams and Lifter - The same corrosion protection afforded to the block by ZDDP is afforded to cams and lifters. The special consideration for these components is their unique wear mechanism as they rotate in a sliding boundary lubrication mode. This is the third and most unexpected benefit of ZDDP. As discussed at length in previous Tech Briefs, ZDDP has a unique mechanism of forming a glassy anti-wear coating between rubbing parts. Oils began incorporating ZDDP in the late 1930s, and when the horsepower race began in the 1950s, the demands on the anti-wear characteristics of oil became severe. It was then noticed that the formulations containing the most ZDDP afforded the greatest anti-wear protection to the cam and lifters. This gave additional impetus to oil formulators to increase the levels of ZDDP in their heavy-duty formulations. To date there has been no anti-wear agent which has equalled the protection afforded to flat-lifter cams by ZDDP.

Gaskets and Seals - This subject can start a debate on synthetic oils causing leaks in old engines. Our research shows that the documented kernel of truth in this idea harkens back to a time at the beginning of synthetic oil use in automobiles. The first formulations of synthetic PCEO had lower solvency in the older natural rubber or neoprene seals than did mineral oil. This could potentially cause seals to shrink slightly. If the seal was old and stiff and didn't have the resiliency to flex and retain a seal, it would then leak. Also, when degraded seals shrink, they sometimes crack, especially those made of older hardened neoprene, natural rubber, or leather. By the mid-1970s this phenomenon stopped occurring, as manufacturers abandoned use of the diester base and switched to a PAO (Poly Alpha Olefin) base with additives that matched the seal-swelling characteristics of mineral oils with their own seal-swelling additives. Increased leaking can even occur when switching from one mineral oil to another if the seal-swelling characteristics are different.

Modern synthetic API-rated PCEO does not have this problem. Still, some people think synthetic oil just somehow leaks more than mineral oil of the same viscosity. There is zero test evidence to show this to be true. When pushed for details, these same people will often reveal they had switched from a 15W-40 mineral to a 5W-40 synthetic oil, or from a 10W-30 to a 5W-30. This means the only time the synthetic oil is at the same viscosity as the old mineral oil would be at 212°F (100°C) (*see ZPlus Tech Brief #14 - Oil Viscosity*). Below 212°F (100°C) the oil with the lower first number will always be lower viscosity and would leak more, whether it was mineral or synthetic. In this situation, it is not the synthetic property of the oil that causes leaks, it is the viscosity.

Another factor which could explain a difference in leak amounts when changing oils is the fact that within any given stated viscosity there is a large range of actual viscosities. If you will refer to figure 8 below, you will see the SAE viscosity rating is in fact a range of viscosities, not a single viscosity point. Therefore, it is entirely possible to have substituted one 10W-30 for another 10W-30, and in reality have changed from an oil with 12.4cSt viscosity to one with 9.5cSt viscosity, a 25% drop. In a case of a marginally sealing crankshaft seal, this could indeed cause an increase in leaking. The situation is even more pronounced with 20-weight oils, where there a potential 60% viscosity difference between two different oils, each having achieved a SAE 20-weight rating.

SAE Viscosity Grade	Low Shear-Rate Kinematic Viscosity Range (cSt)	Viscosity Range in Grade (%)
20	5.6 to <9.3 at 212°F (100°C)	60
30	9.3 to <12.5 at 212°F (100°C)	34
40	12.5 to <16.3 at 212°F (100°C)	30
50	16.3 to <21.9 at 212°F (100°C)	34
60	21.9 to <26.1 at 212°F (100°C)	20

figure 8 SAE Viscosity Range Specifications

Also, keep in mind that with early carbureted engines oil viscosity steadily decreases after an oil change due to fuel dilution. This factor makes oil leaks even more apparent.

ASTM Standard D4485[5] describes a set of tests which an oil must pass in order to be API certified. One of the tests required in order to achieve API approval for a current PCEO is compatibility between seal materials and engine oil, which is described in ASTM D7216[6]. If the oil displays out-of-specification behavior in this test, it will not be API certified. In our research, we have seen no peer-reviewed studies showing incompatibility between any polymer, fiber or natural gasket or seal material and any current mineral or synthetic API approved PCEO.

Detergent vs. Non-Detergent Oil

There has been a lot of debate regarding the desirability of detergents and dispersants in older engines which lack an integral oil filter. Many feel using non-detergent oil is important in an engine without an oil filter. One reason given is to let the debris in the oil settle as quickly as possible, since there is no filter to remove it and the dispersant function of detergent oil would keep particles from settling. Continuing with this reasoning, once every so often the engine would have to be opened up and de-sludged. The other reason given is that the introduction of detergent could loosen the sludge in a very sludged-up engine. Chunks of sludge could conceivably then cause engine failure. Let's analyze each of these statements.

Certainly there is no substitute for a good filter in an engine oiling system. Indeed, the best engine oiling systems have two filters: Full-Flow and By-Pass. Almost all automotive engine oil systems employ just a full-flow filter and do not appreciably filter out particles smaller than 5 microns. Dispersants in detergent oils mainly affect particles smaller than 0.5 micron, therefore, the presence of an oil filter has little or no effect on these particles.

The factors which increase the rate of settling of particles in oil are: higher temperature, lower oil viscosity and larger particle size. A dispersant functions by keeping small particles from clumping and forming larger particles, which would then settle more quickly to form sludge. The agitation of the oil being pumped up into the engine and then thrown around in the sump thoroughly mixes the particles, keeping them in suspension while the engine is running. When the engine

[5] D4485-07, 2007, *Standard Specification for Performance of Engine Oils*, ASTM International, West Conshohocken, PA, 2004, www.astm.org

[6] D7216-07, 2007, *Standard Test Method for Determining Automotive Engine Oil Compatibility with Typical Seal Elastomers*, ASTM International, West Conshohocken, PA, 2004, www.astm.org

is not running, the mechanism which causes particles to stay suspended is called “Brownian Motion.” This is movement caused by the thermal energy of the particles and oil. Particles are pulled down out of suspension by gravity, but they are also being buffeted by the molecules of the oil and other particles, delaying settling. Dispersants only act on particles 0.5 microns and smaller, and the settling time for particles in the 0.5 micron and smaller range is measured in days or longer, regardless of dispersant additives. The effect of having a detergent/dispersant package in oil is to keep particles, which are too small to be filtered, from clumping and settling more quickly when the engine is off. This helps to keep them in suspension so they will be removed when the oil is changed. Dispersants have been an important part of virtually all fully formulated motor oils since the 1950s.

Frictional interfaces like the cam and flat lifters are sensitive to particulates in oil due to the lack of a thick oil film between the moving parts. The main and connecting rod bearings operate in a hydrodynamic mode, and the minimum oil film thickness (as well as bearing clearance) is determined by loading and oil viscosity. In general, older low-performance engines using 30- to 40-weight oil have minimum bearing clearances under load greater than 1 micron. By keeping particles from clumping, the dispersant keeps the 0.5 micron and smaller particles from forming particles large enough to damage the main or connecting rod bearings. This alone is a good reason to use detergent oils in all engines.

All of these reasons taken together make a strong argument to use detergent oils in any engine, regardless of whether it has a filter or not.

There may be cause to avoid high-detergent oils if you are using an old, highly sludged-up engine. If the detergent should loosen pieces of the sludge from deposits and allow them to move around, it is remotely possible the sludge could end up accumulating around the oil pickup, blocking oil flow and resulting in engine failure. An engine this sludged up is most likely in need of a rebuild, after which detergent oils should be used. In all other situations, the use of detergent oil will greatly prolong engine life, whether or not your engine has a filter.

Extended Oil Change Intervals

One potential reason some may want to use a modern synthetic oil in a pre-WWI vehicle is the promise of extended oil change intervals. This certainly has a lure of less maintenance and lower cost.

The unfortunate fact is extended change intervals are only enabled with modern engine and power train control technology in conjunction with modern synthetic oil. Furthermore, extended change intervals can only be followed on vehicles where expressly stated by the manufacturer. This is due to the fact that some but not all modern engines, despite having fuel injection and close manufacturing tolerances, can maintain clean oil for an extended period.

If you read the oil manufacturer’s recommendations for extended change intervals, you will see wording similar to what Mobil put on their Extended Performance Fully Synthetic Oil: “*Excludes severe service applications involving racing and commercial use; frequent towing or hauling; extremely dusty or dirty conditions; or excessive idling. If your vehicle is covered by a warranty, follow the vehicle’s oil life sensor or the oil change interval recommended in your owner’s manual.*” In other words, only the most casual and normal driving conditions are allowed in order to take advantage of the extended interval, excluding harsh and dusty driving conditions, short trips, extended idling, sporty driving, towing, mountain driving, etc. The extended change interval can only be considered when an engine has the best control of its fuel mixture, the oil is the least stressed and few contaminants are introduced to the engine. If any of these conditions are not met, the oil change recommendation is reduced to the more commonly found 3000-6000 mile interval, or whatever is recommended by the vehicle manufacturer.

Older vehicles, especially those with carbureted engines or early fuel injected engines, are far less suited to long change intervals. Many have significant amounts of blow-by which contaminates the oil with soot, fuel and moisture that must be periodically removed. Despite using synthetic oil, which is vastly improved compared to older mineral oils, extended oil change intervals cannot be applied to these older engines.

Bottom line: Extended oil change intervals are a product of modern engine technology in conjunction with modern synthetic oil, and oil changes are the only way to remove the contaminated oil from the sump to maintain proper lubrication.

Conclusions

One of the greatest motivations driving people to collect, restore and obsess over old cars is the attempt to replicate the way they were at the time they were made; to capture a bit of history. This motivation should not be extended to oil selection. Indeed, if automotive engineers of the pre-1940 era had access to a modern oil, they would hardly be able to believe their luck and would drop the old formulations like burning coals.

Modern oils are more chemically and environmentally stable than any older oil and, as we have discussed, there have not been any proven chemical incompatibilities with older engine parts.

Modern oils are far superior in all mechanical and chemical characteristics to their predecessors from even 15 years ago. Their performance exceeds those older oils in every way except for anti-wear characteristics for flat-lifter cams. That is where the use of a quality ZDDP additive comes in. By adding a proven ZDDP anti-wear agent to a modern SM or SN oil, you get the best of both worlds: superior modern oil, with a stout anti-wear package which addresses the requirements of flat-lifter engines. We believe our ZDDPlus™ represents the best, highest performance mix of ZDDP types available, and it will protect your precious old iron better than any other.