Zinc, ZDDP (Zinc Dialkyl Dithio Phosphates) – Whatever That Is

The following article was reviewed and is presented for supplemental information to the discussion at the Canada's Capital A's meeting of November 16, 2023. …. Colin

ZDDP – An article for understanding why it is important to use the adequate oil type for flat tappet cams and lifters – just like the ones in your Model A Ford.

Summary of information presented at the November meeting:

The short rule – stay with conventional oil, not synthetic.

Use standard oil with rating less than API SL for engines older that 2001. The reduction of ZDDP in API SL of 2001 is further explained in the following article. Several motorcycle oils are rated at SG or SJ. Some types of oil identified as racing oils with higher API ratings are reported to have higher ZDDP levels and not usable for cars with catalytic converters. Viscosity of over 30 is preferred (40 or 50) for oil leakage control.

Diesel oil with rating of CI-4 of 40 or 50 viscosity may be usable if already using detergent oil. Diesel has high detergent levels for its original purpose which competes with the ZDDP level.

The normal oil for non-filtered Model A's is non-detergent SAE40 oil unless the engine has been cleaned to convert to detergent oil.

Non-detergent SAE40, LubiDelta, Sunlight Oil Co., St Laurent Blvd Ottawa
Castrol Motorcycle 10W40 or 10W50 API SG, CTC, NAPA, Home Hardware
Valvoline VR1 Racing viscosity 40 or 50, NAPA
Shell Rotella T4 15W40 Diesel, CTC, NAPA
Lucas Hot Rod & Classic 10W-40, 20W50, NAPA test results by PQIA -
https://pqia.org/lucas-hot-rod-classic-sae-10w-40-motor-oil/
CAM Oil 15w40, https://www.camoils.com/, Wicked VW, Mallorytown, ON

THE ARTICLE:

ZDDP: When, Where, What, Why, How?

From https://www.enginebuildermag.com/2012/03/zddp-when-where-what-why-how/

By Dave Sutton Mar 26, 2012

Government regulations and demands for lower emissions levels become more important than power and performance. Proven components are no longer acceptable and the inevitable changes occur – not always for the best.

Things seemed to be much simpler in the 1930s. Engine bearings were made from a soft tin/copper/antimony alloy, commonly referred to as babbit. This alloy is relatively inert chemically and has the ability to absorb small amounts of foreign particular material. But, as engine horsepower increased, babbit alloy surfaces proved to be inadequate to bear the increased loading on these surfaces.

Harder bearings of cadmium/silver, cadmium/nickel, and copper/lead construction were developed. These bearings were much stronger, but were not as chemically inert as babbit and could be attacked by the acids generated from oil oxidation. They were also unable to absorb foreign material such as grit and wear debris into the bearing material and improvements in oil filtration were developed.

Bearing corrosion inhibitors, anti-wear agents and acid inhibitor compounds were developed to protect these new bearings. Protection for bearings against both corrosive and mechanical wear was needed and many of these compounds served both functions. These compounds included sulfurized sperm oil, organic phosphates, dithiocarbonates and dithiophosphates. In 1941, the oil and gasoline additive company Lubrizol developed Zinc Dialkyl Dithio Phosphates, or ZDDP.

Commonly referred to simply as “Zinc” in today’s vernacular. ZDDP was first used in low concentrations (less than .3%) as a bearing passivator (meaning “to treat or coat a metal in order to reduce the chemical reactivity of its surface”). It also acts as an oil anti-oxidant. In addition, it was found to be a remarkably effective anti-wear agent, a true extreme pressure or EP additive for heavily loaded steel-on-steel sliding mechanisms such as camshafts and valve lifters or tappets.

For years, these additives provided sufficient anti-wear service in the early days of gasoline non-detergent motor oils. Diesel engines of the time, which generally operated at lower speeds and were more massively built, did not exhibit the same wear problems. But in a gasoline engine, the valve train is more heavily stressed due to the higher engine speeds.

This produces high sliding speed and friction between camshaft and lifters, which tend to be poorly lubricated since they are dependent on oil splash for lubrication. High impact loads also resulted from the reaction between cam lifter, pushrod, and the rocker.

Impacts in this system start at the camshaft and ending at the valve stem were increased in severity as valve spring pressures and thus loading increased. These loads cause scuffing from metal-to-metal contact. Small additions of additives such as ZDDP were sufficient to provide anti-wear protection for these mechanical parts.

Diesel engine oils contained detergent additives to combat the pollutants caused by diesel fuels and their combustion. There were many failures with heavy wear resulting particularly in the cam and tappets when attempts were first made to use diesel oils containing detergents or to introduce detergent additives into the oils of gasoline engines.

Theories abounded. It was erroneously thought that these detergents were either chemically attacking the metal or that these metallic compounds were actually abrading the metal surfaces. The problem is simply real estate – there is only so much metal surfaces for the boundary layer and anti-wear additives in the oil to attach.

And because most detergents do not have significant anti-wear capability, the surfaces become unprotected, and wear takes place where loads are the heaviest. To overcome this, a concentration of anti-wear additive, such as ZDDP, must be increased substantially to compete successfully with the detergent and get some measure of protection to these metal surfaces.

The American Petroleum Institute (API) standards for auto and diesel oils are represented by the alphabetical codes we see on the containers. The “S” is the automotive designation and this stands for “Service.” Heavy-duty diesel oils carry a “C” designation, which stands for “Commercial.”

Some are simply no longer useful: SA contains no additives and was designed for engines built before 1930; SB was for engines previous to 1951; SC for engines previous to 1967 and so on up to SH, now obsolete, which was for engines built in 1996 or older.

Today we can still find SJ-for 2001 and older automotive engines, SL-for 2004 and older automotive engines and the most current SM. The API service category for SM oil reads as follows:

“For all automotive engines currently in use. Introduced in 2004, SM oils are designed to provide improved oxidation resistance, improved deposit protection, better wear protection, and better low-temperature performance over the life of the oil. Some SM oils may also meet the latest ILSAC specification and/or qualify as Energy Conserving.”

In 1992, an API-rated SH oil contained 1,200 parts per million (ppm) of phosphorus; in 1996 SJ contained 1,000 ppm. It was not until 2001, when the rating went to SL, that we all started to see camshaft problems appear.

In 2001, SL-rated oil still contained 1,000 ppm of phosphorous, and it is the phosphorous that limits are set on. But this limits the amount of ZDDP an oil manufacturer can use. The rating was changed due to demands for increased engine cleanliness standards.

Higher levels of detergents were introduced to meet these standards and camshaft problems began. It was not until 2004, when SM rated oils, with their limited 800 ppm phosphorus were introduced, that cam failures greatly increased.

Why then, you ask, have API standards pushed for higher detergent levels and lower levels of ZDDP? ZDDP attacks or “poisons” catalytic converters. The same attraction properties that allow it to adhere to or “plate” cams and lifters also happens to the catalyst in converters, thus rendering them ineffective.

Conversely, detergents have the same “cleaning effect” on the catalyst as they do on metal surfaces inside the engine. I must point out that these phosphorus level mandates are on SAE 10W-30 and lower viscosity grades only.

Most higher viscosity grades have adopted lower phosphorus content levels, but it was not mandated. They still must meet the higher detergent and dispersant levels to meet the API cleanliness requirements of an SM rating.

The then-current CJ-4 rated diesel oil had a phosphorus limit of 1,200 ppm. There were no previous limits to the amount of phosphorus or sulfur in “C” rated oils. But the high level of detergents and dispersants in diesel oil still compete with the ZDDP for metal surface areas.

ZDDP is a “class” of additives today, not just one particular chemical. These additives are the predominant anti-wear agents. Because diesel engines tend to run considerably hotter around the piston rings, ZDDP tends to decompose and produces a lacquer on cylinder walls. But, because of their heavy duty design and superior metallurgy, they have fewer wear problems than their gasoline counterparts.

For simpler diesel oil, a more stable, less potent form of ZDDP can be used. When developing multipurpose motor oils, for gasoline engines and high-speed passenger car diesel engines, careful decisions must be made in selecting the form of ZDDP, or a balanced mixture of 2 or more types may be used.

This is also true when comparing break-in oil, API rated motor oils for street use and true racing oils. A different type or types are used to control the rate of time the additives work to “plate” and “maintain” their protective barrier shield.

Concerns for the poisoning effect caused by ZDDP to catalytic converters have caused restrictions for its use in some countries. Japan has maintained a maximum limit on phosphorus of 0.05% for many years, while most countries have a limit set at 0.1%. In October of 2010, API SN/ILSAC GF-5 oils hit the shelves.

The requirements for an SN rating are the same 800 ppm maximum of phosphorus, but a new test has been added. A phosphorus retention test that may require the use of different or alternative ZDDP compounds.

The effects of these alternate additives on older flat tappet camshafts and valve train are just beginning to be seen, but can include roller camshaft wear! More changes are slated to come. California is even debating legislation that would require the complete removal of some additives, including ZDDP.

Some of today's motor oils can have strong negative effects on older, non-roller lifter design engines as we all have found. It becomes more important as valve train loads increase to use oils that are designed specifically for flat tappet camshafts, as in the use of high performance camshafts and high-pressure valve springs.

Dave Sutton's *sources for this column include Lake Speed, Jr – Certified Lubrication Specialist & Member of the Society of Tribologists and Lubrication Engineers; The American Petroleum Institute web-site; www.gf-5.com website; and the "SAE Automotive Lubricants Reference Book."*