

ZDDP and Older Automobile Engines

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The Problem

An article called “Oil is Killing Our Engines” by Keith Ansell (<http://www.mgtoronto.com/pdf/Tech/Oil.pdf>) has been making the rounds of internet automotive forums. There has been some discussion of it on the British Car Forum, which I frequent, as well. I’m always a little concerned when I read such mildly hysterical articles by people having no real expertise in the subject and are simply repeating what they have heard. Invariably the story is much more complex, and, in my experience, such articles regularly overstate or oversimplify their case. So, with a healthy skepticism, I decided to do a little independent research. I don’t claim to be an expert in lubrication; I’m an electrical engineer. But I do think I have considerably greater skill in evaluating and integrating technical information than most people commenting on this subject. Here is what I found.

The question concerns the reduction of zinc dialkyldithiophosphate (ZDDP) in API-SM rated motor oils, the standard for oils used in gasoline passenger-car engines today. The concentration of ZDDP in such oils has varied through the years in response to the needs of changing engine technology. In 2004, however, the US government mandated 120,000 mile lifetimes for catalytic converters, and since phosphorous contaminated them, the phosphorous content of oil had to be reduced. Thus, modern API-SM oils have reduced levels of ZDDP, to a greater or lesser degree. Zinc content is usually used as a measure of ZDDP content, although phosphorous is really the critical element. Phosphorous levels are typically 75% to 90% of the zinc concentration. The zinc concentration is often given in parts per million by weight (PPM); 1000 PPM is 0.1%. Maximum zinc content today is rarely more than 0.08% (800 PPM), compared to approximately 0.12% (1200 PPM) previously. Some modern oils have considerably less. In general, however, this is not a dramatic reduction.

The greatest concern is for camshaft wear in flat-tappet engines, especially those having high tappet pressure at the camshaft. Especially when they are new, the mating surfaces have microscopic high points that can interfere and “cold weld” under high pressure. These then break loose, creating even more microscopic roughness, and the process continues until measurable wear occurs. By creating a sacrificial layer that coats these high points and prevents microscopic high-pressure regions that lead to galling, ZDDP prevents this process from occurring. Modern engines have redesigned lifters that minimize this so-called *scuffing* action, so their need for ZDDP is much less.

A central implication of the “Oil is Killing Our Engines” article is that the ZDDP concentration was recklessly reduced with no concern for the needs of older cars. This is just not credible. In any technical field, concern for backward compatibility is absolutely in the forefront when such changes are made. Invariably, the goal is not simply to meet the new requirements, but to do so without creating new problems. In this case, the goal was to extend catalytic converter lifetime without affecting the huge number of older cars currently in use. To do anything else would be absolutely lunatic.

For this reason, motor oils still have some amount of ZDDP. SM oils are subject to standard tests for scuff resistance, to make sure they are compatible with older engines. However, the validity of these tests in some cases has been questioned, as they are largely for ordinary service and may not apply to high-performance engines with stiffer valve springs, more lift, and generally higher tappet pressures. Typical forces for the tests are 350 lb at the tappet; as this includes dynamic forces and lifter leverage, the valve-spring force may be less than half of this value. Many high-performance engines operate at much higher pressures, and smaller tappets have greater surface pressure for a given force.

The many anecdotal reports of camshafts wearing out after less than 1000 miles have been cited as evidence of this problem. Such stories are disturbing, but in reality they tell us nothing about the purported problem. Lots of things can wear out a camshaft too fast; for example, tappets that are too loose in the block, poor initial lubrication (e.g., no or poor quality assembly lube) or low-quality tappets. If this horrific wear is a direct result of low ZDDP, why don't all new camshafts wear similarly? This is a perfect example of something that looks like evidence of a problem, but really isn't.

In December, 2007, the publication *GM Techlink*, distributed to GM dealers, contained an article by a GM lubrication guru, Bob Oree, of the GM Powertrain Fuels and Lubricants Group. As well as debunking certain other erroneous ideas about oil, he addresses the ZDDP question in detail. In that article, he flatly calls the concern about ZDDP a “myth,” citing the extensive testing of modern oils for scuff resistance. One paragraph is especially worth repeating here:

A higher level of ZDDP was good for flat-tappet valve-train scuffing and wear, but it turned out that more was not better. Although break-in scuffing was reduced by using more phosphorus, longer-term wear increased when phosphorus rose above 0.14%. And, at about 0.20% phosphorus, the ZDDP started attacking the grain boundaries in the iron, resulting in camshaft spalling.

So, more is not necessarily better. It's a good idea to keep this in mind before using high-ZDDP racing oil, diesel oil, or any other additives in a street engine.

ZDDP is higher in racing oils, often having phosphorous content approaching 0.20%, so it has been recommended occasionally as a substitute for modern oil. This may not be a good idea. People often assume that something good for racing is even better for less-severe street use, but this is not generally true. Racing and street use have different requirements, and characteristics of oil designed for racing may not be optimum—or could even be detrimental—to street engines. The corrosivity of a high phosphorous content is just one example. This corrosivity doesn't matter in an engine used for only a few hours and torn down frequently, but if such oil is used continuously in a street engine, it could become a problem.

Similarly, diesel oils have higher levels of ZDDP than API-SM oils, but these are formulated for diesel engines, not gasoline. They may not be appropriate, in other respects, for older gasoline engines.

Additives

For ordinary use, oils simply do not need additional additives. Even the most ordinary motor

oils have large amounts of additives as delivered, in concentrations chosen after considerable, sophisticated testing and research. In fact, additional additives can be detrimental; there are lots of horror stories of additives damaging engines, and the FTC has occasionally come down hard on oil-additive marketers. Whenever you see a claim that some additive (or any other substance, for that matter) has only positive effects and no downside, your BS detector should sound an ear-piercing alarm.

Often, additives work together and are ineffective in isolation. ZDDP, for example, requires a small amount of molybdenum disulphide to work properly. Increasing ZDDP without adequate moly won't help. (This point is well known, so, presumably, oils having high ZDDP levels and ZDDP additives include sufficient molybdenum disulphide.)

ZDDPlus is a popular ZDDP additive. Their website (<http://www.zddpoiladditive.com>) is worth a look, especially their "tech briefs" page. Unlike virtually all other additives, the information on the site is rational, well reasoned, and avoids the dishonest, hysterical, hard-sell marketing common among additive hucksters. The tech section includes a thoughtful rebuttal to the GM Techlink article, but, frankly, I find the latter more convincing.

Conclusions

My conclusions (not *recommendations*, since I'm not an expert):

- 1 I'll use a high ZDDP oil, such as a racing oil or conventional oil plus a ZDDP additive, for break-in of a new engine having flat tappets. I'll also use plenty of moly assembly lube.
- 2 After break-in, I'll use a good quality oil (either organic or synthetic) with a ZDDP concentration providing at least 0.08% zinc. Many oils meet this requirement: Mobil 1 synthetic oil, in its higher viscosities, and all viscosities of Valvoline conventional and synthetic oils, for example. Castrol, in particular, reportedly makes a synthetic oil especially formulated for older cars. If it's readily available, this might be a good option. In any case, I'll check the web site of the oil manufacturer to be sure of the ZDDP concentration; I won't just grab whatever looks good at the auto-parts store. I will not use racing or diesel oils.
- 3 I'm not likely to build an engine that has higher-than-standard tappet pressure, but if I do, I'll probably add some ZDDP. Even then, I won't exceed 0.12% zinc.

In summary, I don't think that the near-hysteria on this issue is justified. I do believe that some degree of consideration is necessary, if only to avoid oils having unusually low ZDDP concentrations and to take special care in break-in.

More Reading

Below are some articles I found worthwhile. All are available online:

- 1 The original "Oil is Killing Our Engines" article plus later addenda:
<http://www.mgtoronto.com/pdf/Tech/Oil.pdf>
- 2 The GM Techlink article is not available online from GM. It has been reprinted in a couple of places:
<http://www.turbobuicks.com/forums/buick-v6-turbo-tech/71378-oil-myths-gm-techlink>.

html

<http://www.cadillacforums.com/forums/northstar-performance-technical-discussion/125545-engine-oil-myths-including-zdp-gm.html>

3 Oil additives:

<http://www.nordicgroup.us/oil.htm>

http://www.ford-trucks.com/article/idx/18/141/article/Snake_Oil__Is_That_Additive_Really_A_Negative.html

<http://www.zddpoiladditive.com>

4 Two good articles from the muscle-car world:

http://www.hotrod.com/techarticles/engine/flat_tappet_cam_tech/index.html

http://www.highperformancepontiac.com/tech/hppp_0802_pontiac_performance_engine_oil/index.html

5 From a trade magazine called *Engine Professional*:

http://www.aera.org/ep/downloads/ep1/EP012008_8-16.pdf

6 Zinc and phosphorous content of Mobil 1 synthetic oil (an example of information available for specific brands of oil):

http://www.mobiloil.com/USA-English/MotorOil/Files/Mobil_1_Product_Guide.pdf