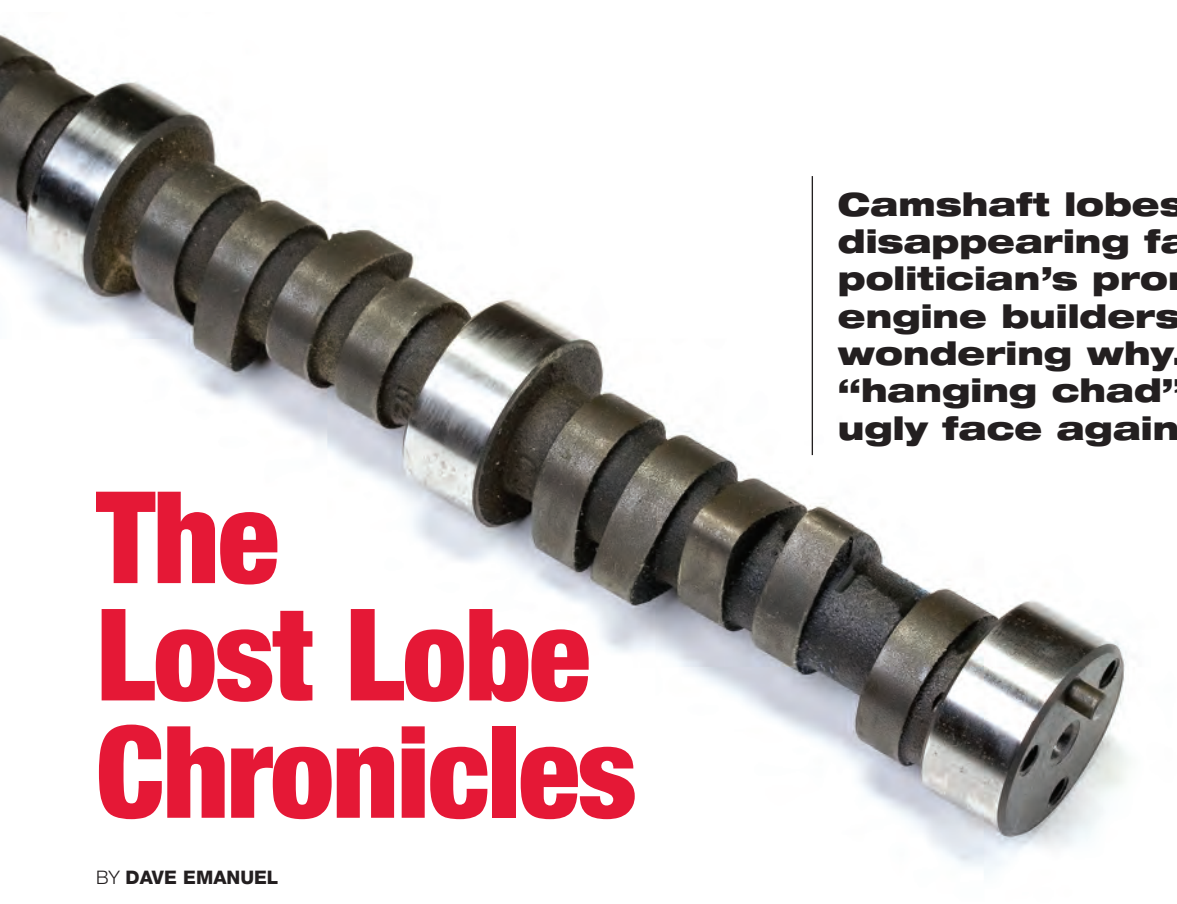


Camshaft lobes have been disappearing faster than a politician's promise, and engine builders have been wondering why. Has the "hanging chad" reared its ugly face again?

The Lost Lobe Chronicles

BY **DAVE EMANUEL**

Whenever conversation rolls around to the "secrets" of building high performance engines, someone invariably notes that he would like to have been "a fly on the wall" at a shop that's known for its engine-building prowess. These days, a fly wouldn't hear much besides a string of expletives normally uttered by politicians, followed by statements like, "I've been building engines for 30 years, and I've never had a cam failure until two years ago. What the hell is going on?

The question is not, "What's going on? it's, "What's going out?" The answer is zinc—specifically zinc dialkyl dithiosphosphate (abbreviated as ZDDP or ZDP). Zinc/phosphorous compounds provide a number of tangible benefits when included as a part of the motor oil's additive package. Although base stock influences an oil's lubrication performance, the additive package is what sets one brand or type of oil apart from others. Obviously, oils with high ZDP content have different lubricating qualities than those with low or no ZDP blended in. Primary among zinc's benefits are its anti-wear characteristics, particularly between mating surfaces that are under extreme pressures. ZDP also has beneficial anticorrosive and anti-oxidant properties.

Ironically, the elimination of ZDP has more to do with sulfur (in the form of sulfated ash) than the zinc compound itself. "Sulfated ash" pertains to the metallic compounds contained in traditional motor oil's additive formulations. Some amount of ash invariably finds its way into an engine's combustion chambers and ultimately into the exhaust system. The compounds produced when the ash is combusted reduce the efficiency of catalytic converters and oxygen sensors. It's specifically the effect on catalytic converters that is the primary motivation behind the elimination of sulfated ash compounds—which is a bit of a mystery considering that a Federally-mandated warranty covers all original equipment catalytic converters for a period of 8 years or 80,000 miles (for all new 1996 and later vehicles). You have to wonder how real the threat is from sulfated ash, considering that catalytic converter warranty claims are extremely rare, and converter failures usually result from other causes (like engine misfire or faulty injectors).

Whether or not sulfated ash has had a measurable effect on catalytic converter operation, its reduction has changed the face of the oil cans found on the shelves of auto parts stores. It wasn't too many years ago when those shelves were filled with cans of oil that met requirements of both gasoline and diesel engines. Since 2004, when "SM", the latest API (American Petroleum Institute) category was introduced, such oils have been increasingly harder to find because of the drastic reduction in ZDP levels. As a result, the latest and greatest oils for gasoline engines, (API "SM" rating) are not suitable for use in diesels, which means they're also unsuitable for use in engines equipped with flat tappet camshafts. Although ZDP levels have also been reduced in diesel oils, (CJ-4 being the latest category) they are still high enough to offer extreme pressure anti-wear protection.

The reduction and elimination of ZDP in motor oils is possible because roller lifters have eliminated the use of flat tappet lifters in virtually all engines produced during the past few years. Were that not the case, camshaft and lifter failures would keep every engine rebuilder in the country working 24 hours a day. The cam lobe/flat tappet interface is continually subjected to the highest pressure loads encountered in an internal combustion engine and ZDP in motor oil enables the long term survival of this interface.

Obviously, shops that rebuild older engines are left out in the cold without adequate protection if they use "SM" or similar oils during break-in— or if they neglect to advise their

customers against doing so. Unfortunately, reduction of ZDP content hasn't been widely advertised, and as a result, the incidence of rebuilt engine failures reported by AERA members has increased dramatically in recent years, and is directly related to use of motor oils with insufficient ZDP content.

Excessive wear resulting from use of motor oil with insufficient zinc content typically occurs during break-in of a newly rebuilt engine. That's the worst possible time for an engine builder because a customer with a flat-lobed camshaft in a newly rebuilt engine will undoubtedly blame the failure on the engine's builder. The best way to eliminate the problem is to get the zinc back in. You can accomplish this by simply adding an engine break-in lubricant. For decades, General Motors' "EOS" (Engine Oil Supplement) has been a popular "do it yourself" ZDP additive. Obviously, EOS works well in any engine, not only those produced by GM. In fact, some Porsche repair shops recommend the addition of EOS at every oil change. Another readily available ZDP source is camshaft break-in lube offered by Comp Cams and other performance camshaft manufacturers.

Diesel, "racing oil" and some motorcycle oils, like Harley-Davidson's Syn3, have relatively high ZDP content, making them viable sources of ZDP. Chevron Delo 400, Mobil Delvac and Shell Rotella are all designed for use in "heavy duty diesel engines" and consequently contain reasonable quantities of ZDP. Air-cooled engines have unique lubricating requirements compared to their water-cooled counterparts, and consequently have higher ZDP levels. However, ZDP levels found in motorcycle oils and racing oils can vary widely, so if you plan to use one of these, make sure it does contain a useful amount of ZDP.

Unfortunately, ZDP content data is not easy to find. Although you'll find several web sites with extensive listings of motor oils and their ZDP content, most of the information is several years old and does not apply to currently available oils. If you have any doubts about the ZDP content of a specific motor oil, just look at the API "donut" on the label— if it doesn't contain a "CF" "CF-2", "CF-4" "CG-4", "CH-4", "CI-4" or "CJ-4", the oil isn't rated for use in diesel engines and consequently contains little or no ZDP. Also keep in mind that CJ-4 oil has a lower ZDP content than other "C" category oils. ZDP levels are measured in parts per million or ppm, but in some cases, you may find "zinc and phosphorous" or ZDP content expressed as a percentage. (Phosphorous refers to the phosphate in zinc

What you need to know about oil

Oil Today vs. Yesterday

Today's engine oils are not the same as they were even a few years ago due to clean emissions regulations.

API & ILSAC:

- Sets the standards for oil specifications
- Works with Auto Mfg's & EPA

Phosphorus and Zinc Reduction:

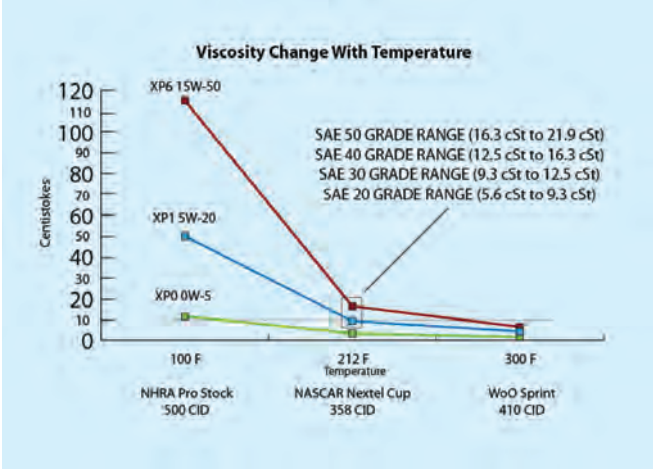
- Phosphorus degrades catalytic converters
- Zinc & Phosphorus content unlimited before 1993
- Zinc & Phosphorus now limited to max. 800 ppm
- Diesel oils now limited to 1,200 ppm Phosphorus (Oct. 2006)
- European and North American standards are set to change again in 2010

Lake Speed, Jr. says, "Any oil that carries the most current API rating (SM passenger car / CJ-4 Diesel) is limited in the amount of zinc, which can create a balance issue between detergents and the anti-wear additives. The best solution is an oil designed for the application. If you have a vintage car or street rod, you need an oil designed for it. Remember you get what you pay for when buying special engine oils."

How Does Oil Work?

In heavily loaded applications — a flat tappet cam and racing engines — an oil wedge can not be sustained. As a result, metal to metal contact will occur unless a sacrificial coating is formed.

ZDP (aka Zinc) and Moly (MoS2) are polar molecules, so they are attracted to carbon steel surfaces where they react with heat, to create a sacrificial additive coating. The protective coating prevents metal to metal contact, which reduces friction and wear. Moly can withstand pressure up to 500,000 psi. (Key protection for: Lifters, Push Rods and Wrist Pins, Distributor Gears, Bearings, etc.)



The viscosity of the oils are different. The operating temperatures are different, but the operating flow rates are very similar.

Significant Properties

To achieve maximum lubricant performance, an oil must be formulated to meet the specific need of the application.

Viscosity is a measure of flow. Viscosity Index is an oil's resistance to thinning as temperature increases.

Viscosity Modifiers — Polymers that expand with heat.

Oxidation Resistance — High temp stability.

Additive Package

- Anti-Wear & EP protection (Moly & Zinc)
- Friction Reduction (Moly & Zinc)
- Detergents (Calcium & Boron – Cleans the engine)
- Total Base Number – Acid Neutralizers

Base Oil Choice (Group I, II, III, IV, & V)

- Group I, II & III are mineral oils (increasing purity)
- Group IV & V are synthetics (completely pure)

These are the building blocks of an oil. What parts you use and how you put them together determines how the oil will perform.

Viscosity

Viscosity is a measure of flow. Oil viscosity is generally thought of in terms of SAE grades, like 15W-50. An oil's flow rate increases as temperature increases. SAE grades are ranges, not an exact measurement of an oil's flow rate. The SAE grade ranges are measured at 0 and at 212 degrees. Kinematic Viscosity measures the exact flow rate of an oil at both 100 and 212 degrees.

Operating Viscosity

The "operating" viscosity is the centistoke flow of an oil at the operating oil temperature of an engine. Some engines run low oil temperatures, and other engines run extremely high temperatures. Low viscosity oils work well in low temp applications, and high viscosity oils work well in high temp applications. In fact, the operating viscosity of the XP0 in a NHRA Pro Stock engine, the XP1 in a NASCAR Nextel Cup engine and the XP6 in a World Of Outlaws 410 Sprint engine is within five centistokes of each other.

JOE GIBBS DRIVEN
CHAMPIONSHIP PRODUCTS INSPIRED BY JOE GIBBS RACING

Joe Gibbs Driven Racing Oil was created by Joe Gibbs Racing to meet the specific requirements of NASCAR Nextel Cup (flat-tappet) and Busch Series (roller-follower) engines. Countless hours of dyno testing and thousands of miles of competition have been spent perfecting this oil. Hundreds of engine builders in the United States and on 4 different continents use Joe Gibbs Driven Racing Oil to make more power, lower operating temperatures, and provide protection to make it to the finish line.

www.joegibbsdriven.com

diakyl dithiophosphate.)

So if some ZDP is good, conventional wisdom would have it that more is better. As usual, conventional wisdom is out of touch with reality. Even in oils that have extremely high levels of ZDP, those levels are typically only 1300 to 1500 ppm (Which is the equivalent of .13% to .15%.). And that's all you really need after initial break-in is completed. For reference, motor oils with an API rating of "SJ" have a ZDP content of .10% or less. "SM" motor oils have less than .08% ZDP and some have as little as .05%. On the other hand, once ZDP levels exceed 1500 to 2000 parts per million, the potential for burned ash accumulations in the ring lands and on the piston domes increases dramatically. It's for precisely this reason that most cam manufacturers recommend draining ZDP-spiked oil (and refilling the crankcase with unspiked oil) within a few hundred miles after engine break-in is completed.

It's only a concern if an excess amount of ash is present in the combustion chambers of engines equipped with catalytic converters, but ash accumulations in the ring lands is a potential trouble source for all engines. Over time, these accumulations can interfere with ring-cylinder wall seal and can actually lead to cylinder wall scoring.

One piece of conventional wisdom that is usually correct is to avoid using motor oils that don't have the API seal or donut on their containers. Such oils are usually of questionable quality at best. But if you're looking for oil that has a reasonable ZDP content, your best bet may in fact be "donut-less" oil because API requirements don't apply to oils labeled as "racing", "heavy-duty" or "off-road". However, the caveat about quality still applies. If you purchase any oil that doesn't contain the API donut, make sure it's manufactured by a reputable, well-known company.

It's obviously too late to make a long story short, and now that you know more about ZDP than you care to, it should be equally obvious that you have two choices—you can use current "SM" rated oils and pour in a ZDP additive, or you can find a diesel, racing, motorcycle or off-road oil and eliminate the need for an additive. One solution isn't necessarily better than the other, but one may be significantly less expensive. ■

With six technically oriented automotive books and over 1,500 magazine articles to his credit, Dave Emanuel is regarded as one of the nation's most respected automotive journalists. During the past 20 years, his work has appeared in popular publications such as Motor Trend, Road & Track, Hot Rod, Corvette Fever and Popular Science to name only a few of the more than twenty magazines.

Dave's technical expertise and extensive hands-on experience, combined with his personal relationships with many of the nation's top high performance engine builders and Detroit engineers, allows him to provide readers with unique insights into the high performance and racing aspects of engines and drivelines. Dave is also involved with private enterprise and offers insight on yet another possible power source. Go online for more information: **www.randomtechnology.com**

Blackstone Labs:
The magic is the oil, not the additives

Elements in Parts Per Million	MI/HR ON OIL	14,229	UNIVERSAL AVERAGES
	MI/HR ON UNIT	43,382	
	SAMPLE DATE	3/4/06	
	ALUMINUM	2	2
	CHROMIUM	1	1
	IRON	99	17
	COPPER	44	4
	LEAD	8	4
	TIN	1	1
	MOLYBDENUM	3	20
	NICKEL	1	1
	POTASSIUM	2	1
	BORON	1	4
	SILICON	10	10
	SODIUM	1	3
	CALCIUM	3743	3202
	MAGNESIUM	28	75
	PHOSPHORUS	1139	1119
	ZINC	1237	1440
	BARIUM	0	1

Elements in Parts Per Million	MI/HR ON OIL	12,693	UNIVERSAL AVERAGES
	MI/HR ON UNIT	83,320	
	SAMPLE DATE	7/18/05	
	ALUMINUM	3	2
	CHROMIUM	2	1
	IRON	32	17
	COPPER	3	4
	LEAD	4	4
	TIN	0	1
	MOLYBDENUM	3	20
	NICKEL	1	1
	POTASSIUM	2	1
	BORON	4	4
	SILICON	8	10
	SODIUM	2	3
	CALCIUM	3410	3202
	MAGNESIUM	12	75
	PHOSPHORUS	1201	1119
	ZINC	1341	1287
	BARIUM	0	1

Oil brand does not necessarily make a difference. The oil guys might claim you can run tens of thousands of miles on the oil, but if you're doing something operationally that's causing excessive wear, we recommend changing the oil sooner because the extra metals make the oil abrasive and may, in the end, shorten the life of the engine.

Take a look at the report above. These are both 7.3L Power Stroke engines, and both owners are running a lot of miles on the oil. The difference in analysis between these two samples is huge. Total miles on the engine isn't making a difference — the one that has more miles on it is actually wearing better. The high iron, copper, and lead in the sample on the left indicate excessive bearing wear. We doubt the engine actually has a problem, because it has relatively few miles on it and a random bearing problem would be very rare to find. Instead, the owner is probably doing something that's causing extra wear on the bearings, such as towing, driving in the mountains, or other hard operation. We would not recommend long oil changes for him. The engine on the right, however, looks just fine after more than 12,000 miles on the oil, and we would recommend running even more miles on his next fill of oil.

Oil brand does not necessarily make a difference. The oil guys might claim you can run tens of thousands of miles on the oil, but if you're doing something operationally that's causing excessive wear, we recommend changing the oil sooner because the extra metals make the oil abrasive and may, in the end, shorten the life of the engine.

Since Blackstone Labs run all types of oil, they have the benefit of looking across application types, which provides a broader view of things.

Aircraft oils are as simple a subject as there is in the field and they work just fine. They have no TBN nor do they employ any additives that aren't ashless, so sulfur is out the window. These oils, usually 50Ws, operate in the toughest environment there is and they stay in use (usually) for 50-hours. The aircraft guys still believe in wear-in so they use straight mineral oils for the first couple of oil changes. Then they go either to AD (ashless-dispersent) straight weights or multi-grades for the life of the engine.

What is magic about oils is the oil. You can get a mild improvement in performance with additives of the various types, but that improvement isn't near as important as the manufacturers claim. The oil itself is doing the job.

BLACKSTONE LABORATORIES

Established in Fort Wayne, Indiana, in 1985, Blackstone Laboratories strives to provide an easy-to-use, understandable, and accurate oil analysis program with the fastest turnaround in the industry.
www.blackstone-labs.com