Part One: *What is motor oil really made of?*

Oils Well That Ends Well?

by don smith

EDITOR'S NOTE: *This is Part One of a special* Sport Rider *comparison test, where we unlock the mysteries and debunk some of the myths of motor oil. We examine just what goes into motor oil, why those ingredients are there and what it means for your engine. In the next issue, Part Two will feature a scientific analysis of all major motorcycle-specific motor oils, plus a wear and dyno test of specific oils to determine whether there is a power difference.*

When motorcyclists discuss engine oil, they quickly polarize into two groups. There are those who think all oils are basically the same, and that anyone spending more for premium oils is wasting his money, and there are those who feel there *is* a difference and are willing to spend the money to get the best product available. However, both groups share a lack of scientific information allowing them to make an informed decision. To offer some insight into this heated topic and help you determine which oil is right for you, we've decided to delve into this outwardly simple—but very complex—product. In Part One of this two-part series, we'll dissect the real what, how and whys of motor oil.

The first thing you need to know about motor oil is what it does for your engine. Motor oil actually has several purposes, some of which may surprise you. Obviously, lubrication is the main purpose. The oil serves as a layer of protection between the moving parts, just like shaving gel does between your skin and a razor.

However, oil also acts as a dispersant, which means it holds damaging stuff like dirt and metal particles suspended in the oil (rather than letting them settle to the bottom of the oil pan where they can be recirculated through the engine) so they can be removed by the oil filter. Then there is the job of corrosion retardant. By reacting with the nasty acids created by combustion, oil actually prevents these byproducts from damaging the internals of the engine. For instance, when combustion takes place, sulfur molecules in gasoline occasionally combine with air and water molecules, forming a vile brew called sulfuric acid. Left unchecked, this acid will eat away at internal engine compounds. Good oils, however, contain enough of the right additives like calcium, boron or magnesium to neutralize these acids.

Cooling is another important factor. Oil serves to cool hot spots inside an engine that regular coolant passages cannot reach. Since coolant usually only deals with the hottest parts of the engine, like the cylinders and cylinder head, there are many internal engine components that depend on oil for cooling as well as lubrication. For example, the transmission and clutch rely heavily on oil to regulate temperatures, since excessive heat expansion can change tolerances and cause clearance-related problems. Another area that uses oil for cooling purposes is the undersides of the pistons; with pistons becoming thinner for less weight, yet dealing with ever-increasing compression ratios, keeping the piston assembly cool is vitally important. Parts such as these can expose oil to extreme temperatures, so this is one reason that thermal stability is so important for motorcycle engines. We will do a

These three oils have the proper JASO label, which shows they have tested and passed the JASO certification standards. The MA standard is for high friction motorcycle applications, so you'll know the oil is specifically tailored for use in your sportbike—not some econobox car.

specific test in Part Two to predict the oils' ability to survive in extreme heat.

WHO IS THE API?

The American Petroleum Institute (or API) was established in 1919 as an industry trade association with one of its goals stated as "promot(ing) the mutual improvement of its members and the study of the arts and science connected with the oil and gas industry." Today, the API impacts the consumer market through the development and licensing of engine oil industry standards. On most oil containers, you will find a small circular label that says "API" along with letters like SG, SH, etc. Each of these letters represents a very complex set of specifications and tests that have to be met in order for an oil to carry the API designation. When you see an oil with the API symbol, this means the company has paid a license fee to the API, and in turn the API has tested its product to ensure it meets the applicable standard. If the API grades are simply listed on the bottle without the circular API symbol, this means the company claims to meet the API standards, but has decided not to obtain API licensing. This process is very expensive, and therefore many smaller producers choose not to be members, even though their products may be good enough to pass.

Every few years the API releases a new standard that is often specified by auto manufacturers, with the changes usually aimed at achieving lower levels of friction to obtain higher fuel economy, and to deal with other emissions-related issues. This is a never-ending battle in the automobile industry, as stricter federal emission and fuel economy standards are being imposed on automobiles. The API works with the auto industry to ensure that the oils are doing everything possible to reach these goals.

The motorcycle industry followed the ever-changing API service designations until a few years ago, when the SJ designation lowered maximum levels of certain additives used to reduce metal-to-metal friction. (The latest API designation is SL.) Specifically, the maximum allowable phosphorous content was lowered from 0.12 percent to 0.10 percent due to its negative effect on some catalytic converters. An engine burning oil will pass this phosphorous through the exhaust system, resulting in damage to oxygen sensors and catalytic converters.

This is the proper API "donut," which signifies that the oil manufacturer has paid for and successfully passed the API standards test for SL/CF designation. These standards/designations change constantly every few years, as the auto manufacturers struggle to deal with ever-stringent federal fuel economy and emissions standards.

Since the EPA requires all emissions-related parts to be covered under warranty for seven years, this was a major motivator for manufacturers to meet the new standard.

WHO IS THE JASO?

The motorcycle OEMs felt that lower levels of phosphorous and the introduction of more friction modifiers (aimed at higher fuel economy in cars) was not in the best interest of motorcycle engines. Since phosphorous is an important antiwear component, lower levels could reduce the ability of oil to protect transmission gears, since motorcycles share engine oil with the gearbox. Plus, added levels of friction modifiers could cause problems with slipping clutches, as well as less than optimal performance of back-torque limiting devices that lessens wheel lock-up on downshifts.

Rather than continue to rely on specifications dedicated to automobiles, the Japanese Automotive Standards Organization (or JASO) developed its own set of tests specifically for motorcycles. JASO now publishes these standards, and any oil company can label its products under this designation after passing the proper tests. JASO offers two levels of certification, MA (high friction applications) and MB (low friction applications). JASO requires that the entire product label be approved before it can carry its label. If a label does not have a box with a registration number above the MA or MB lettering, it could be nonapproved oil whose manufacturer claims its products meet JASO standards when it may not have actually passed the tests.

These standards also include a test specifically designed to measure the oil's effect on clutch lock-up, as well as heat stability and several other factors related to motorcycle engines. Our advice here is pretty simple: Read your manual, and if it calls for an API SG oil, use that. Don't substitute a higher API designation oil like SL, because it will contain less of some additives like phosphorus, and it may contain other additives that will yield higher fuel economy in a car but could cause slippage in your clutch. (More on that later.)

While it may not be the perfect answer,

Note that these labels list only the API and JASO standards in text form without the proper labels. This means the manufacturers claim their product meets or exceeds both standards, but haven't paid the fee for licensing (and testing). Note that the process to carry the official labels is very expensive, so smaller oil manufacturers may choose not to obtain licensing, even though their products may pass the tests.

you can also be safe by selecting JASO-labeled oil, because you will know that it has passed a bank of tests developed by the motorcycle industry. A quick look in several 2002-'03 owner's manuals showed that an '03 Kawasaki ZX-12R and most Hondas were the only sportbikes in our shop carrying a mention of JASO.

WHAT ARE BASE STOCKS?

Motor oils start with a base oil mixed with various additives. These base oils often account for approximately 80 to 90 percent of the volume, and are therefore the backbone of oil. Everyone knows that some oils are petroleum-based and some synthetic, while others are labeled semi-synthetic. What does all this mean? Well, not as much as it used to, because the lines are now blurred in the case of synthetic oils.

For our purposes, petroleum oils are the most basic and least expensive oils on the market. They are created from refined crude oil and offer good properties, though they are generally not as heat resistant as semi-synthetics or full synthetics. On the other end of the spectrum are synthetic oils. A synthetic oil has been chemically reacted to create the desired properties. Semi-synthetics are a blend of the two base stocks.

The API groups oils into five major categories, each with different properties and production methods:

Group I: Solvent frozen mineral oil. This is the least processed of all oils on the market today and is typically used in nonautomotive applications, though some of it may find its way into low-cost motor oils.

Group II: Hydro-processed and refined mineral oil. This is the most common of all petroleum oils and is the standard component of most petroleum-based automotive and motorcycle engine oils.

Group III (now called synthetic): The oils start as standard Group I oils and are processed to remove impurities, resulting in a more heat-stable compound than possible as a standard Group I or II oil. Some examples are Castrol Syntec automotive oil and Motorex Top Speed. These are the lowest cost synthetics to produce, and generally do not perform as well as Group IV or V oils.

Group IV: Polyalphaolefin, commonly called PAOs. These are the most common of the full synthetic oils, and usually offer big improvements in heat and overall stability when compared to Group III oils. They are produced in mass quantities and are reasonably inexpensive for full-synthetic oils. Since they are wax-free they offer high viscosity indexes (low temperature pour point) and often require little or no viscosity modifiers. Examples include Amsoil and Motorex Power Synt.

Group V: Esters. These oils start their life as plant or animal bases called fatty acids. They are then converted via a chemical reaction into esters or diesters which are then used as base stocks. Esters are polar, which means they act like a magnet and actually cling to metals. This supposedly offers much better protection on metal-to-metal surfaces than conventional PAOs, which do not have this polar effect. These base stock oils also act as a good solvent inside the engine, translating into cleaner operation. Esters are the most expensive to produce, and oils manufactured with them usually cost much more. Due to this higher cost, many companies only fortify their oils with esters. Some examples are Bel-Ray EXS, Torco MPZ Synthetic and Maxum 4 Extra. Motul 300V, however, uses 100 percent ester as its base oil, and is one of the more expensive oils.

The grouping of these oils is the source of much controversy. One topic that has been debated is what can be labeled a "full synthetic oil." In 1999, Mobil brought a complaint against Castrol for changing the base oil in its Syntec product. They had used a Group IV PAO, but had changed to a Group III base oil. Mobil contended that Group III oils were not really "synthetic oil" and should not be labeled as such. After many expert opinions were heard, the National Advertising Division of the Better Business Bureau sided with Castrol and said that Group III oils could be labeled synthetic. Since that time there has been a lot of growth in this product type due to its low cost and similar performance to traditional synthetics. Many traditionalists still argue that Group III oils are not true synthetic oils.

ADDITIVES TO THE OIL

Additives are the other 10 to 20 percent of the product that help the base oil do things that it otherwise could not. Additives fall into several basic categories:

Detergents/Dispersants: These ensure that foreign materials in the oil stay in suspension to allow the filtration system to remove dirt or debris.

Corrosion Inhibitors: These prevent oil from deteriorating from the attack of free radicals or oxidation.

Antiwear: These are perhaps the most-discussed additives, which serve to protect the engine from metal-to-metal wear. Common antiwear additives are phosphorous and zinc. Other antiwear additives include friction modifiers like molybdenum disulphide (or moly).

Acid Neutralizers: Additives like calcium, magnesium and boron act to absorb acids created during combustion to protect the engine. They are typically indicated by the TBN (Total Base Number). A higher number means the oil should last longer and provide increased protection against combustion-based acids.

Other additives such as foam inhibitors, viscosity modifiers and antirust components may also be present in motorcycle oils. In particular, antifoaming additives are important due to the high RPMs that can create cavitation and starve bearings from necessary lubrication in the process.

VISCOSITY

If you ask someone with years of riding under his belt what viscosity oil he uses, he may answer "20W-50." All multiviscosity oils carry two numbers. In simple terms, the first number is the oil's viscosity when cold (32°Fahrenheit/0°Celsius), and the other is the oil's viscosity at operating temperature (212°F/100°C); the "W" stands for "weight" or viscosity, which is simply the liquid's resistance to flow. In other words, when the oil is cold it will flow like a 20-weight, but when hot it will act like a 50-weight. In order to overcome the natural thinning that occurs as oil heats up, a component known as a viscosity modifier is added. This is a complex polymer that swells due to heat, the net result being that the oil thins less.

Typically, synthetic oil contains less of this additive, or in some cases none at all due to its naturally higher viscosity index. This is another reason why they are better suited for the wide range of temperatures and riding conditions associated with motor-cycle use. Viscosity modifiers are one of the first additives that wear out in oil, and a big reason that some synthetic oil manufacturers claim longer service life. Since they are naturally a multi-grade product without the chemical modification mineral oils require, synthetic oils will hold their viscosity grade longer.

The reason the old-timer may suggest thicker oil is because in older engines with higher tolerances, thicker oils were necessary to keep oil pressure up. Others believe the use of higher viscosity oils results in better protection because high-performance engines are harder on oil. This isn't true in modern engines, and using oil thicker than specified can actually harm an engine. Internal oil passages and galleys may not be large enough to allow thicker oils to penetrate and flow as well, which can possibly cause starvation. In fact, many race teams use the thinnest oil possible to gain extra horsepower by lowering the parasitic losses that occur when using thicker-than-necessary oil. The higher film strength offered by synthetic base stocks helps racing engines survive even endurance races when running ultra-lightweight oils. Of course, these engines are typically rebuilt after each race, so we do not suggest using a racing oil in your streetbike. Refer to your owner's manual and use the viscosity of oil corresponding to your riding conditions as specified by the manufacturer. The manuals often have a table with various temperatures allowing you to select the right viscosity.

CAN SYNTHETIC OILS CAUSE MY CLUTCH TO SLIP?

To answer this in one word: No. Clutch slippage is caused by many things, but the use of synthetic oil alone is usually not the culprit. The truth is that some bikes seem to suffer clutch slippage no matter what oil goes in them, while others run fine with any oil. This is most likely caused by factors other than the oil, such as the spring pressure, age and clutch plate materials. If you have a bike known for clutch problems, you may have to be more selective in your oil choices.

Moly is often blamed for clutch slippage, and it can have an effect—but moly alone is not the problem. We wish there was a hard and fast rule to follow, but it is just not that easy. Simply put, you will have to try an oil and evaluate it. If you experience slippage with the new oil, and have not had problems before, it may be the oil. The plates and/or springs could also be worn to the point that they have finally started to slip. Simply change back to the previous oil and see what happens. You can also check the test data in next issue's article to see if that particular oil has a significant amount of moly. If so, try one that does not have as much moly next time.

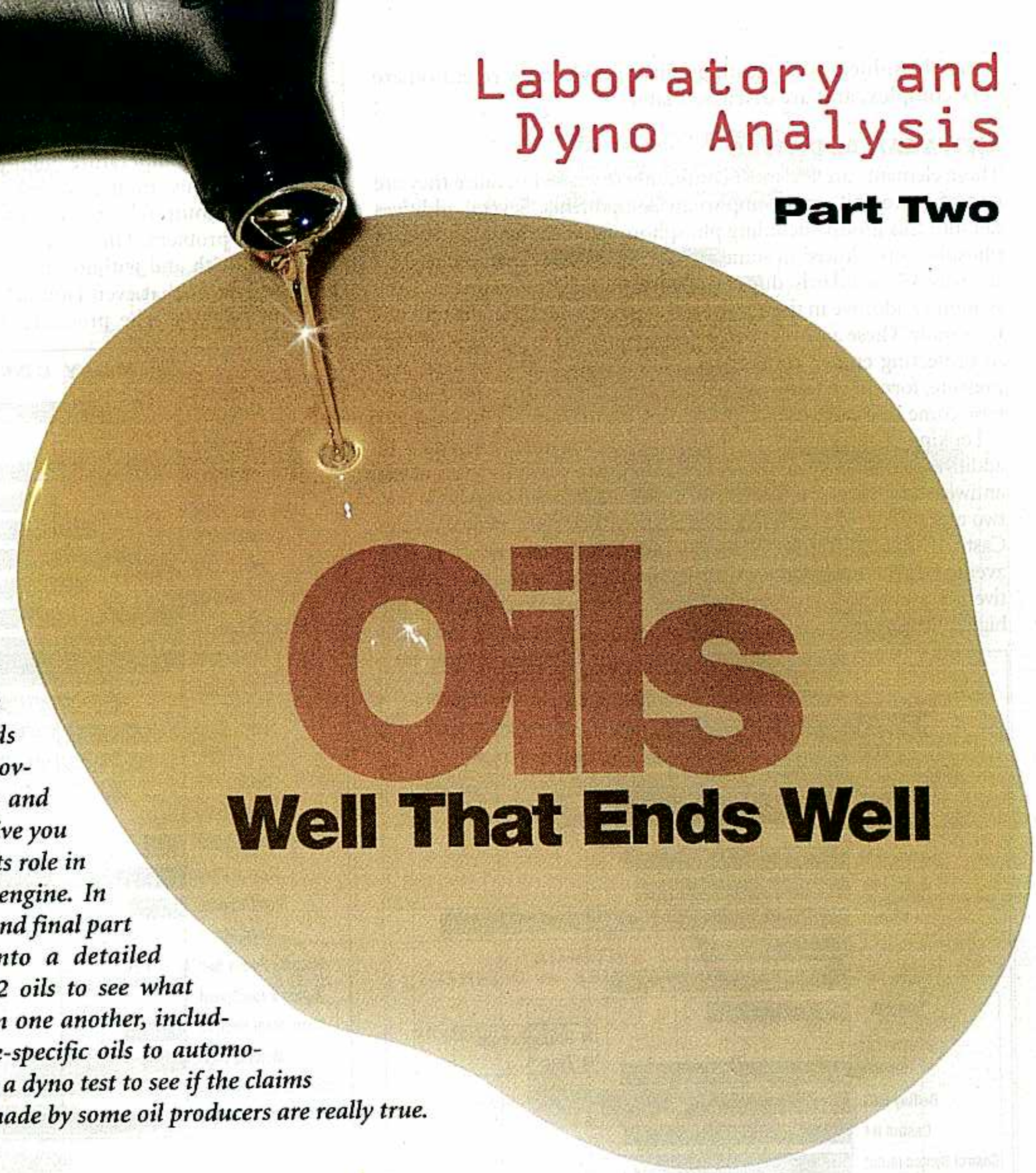
We talked to Mark Junge, Vesrah's Racing representative, who has won numerous WERA national championships using Vesrah's clutches. He said that in his years of engine work he has yet to see a slipping clutch that could be pinned on synthetic motor oil. Junge felt that nearly every time the clutch was marginal or had worn springs, the new oil just revealed a problem that already existed.

STAY TUNED FOR PART TWO: ANALYSIS, WEAR AND DYNO TESTS

This is the first part in a two stage article, so please stay tuned to the next issue where we will reveal the test data from an analytical oil laboratory as well as the results of our dyno horsepower shootout, where we will have a face-off of two different products to see if changing oils can yield horsepower gains as some manufacturers claim.

Laboratory and Dyno Analysis

Part Two



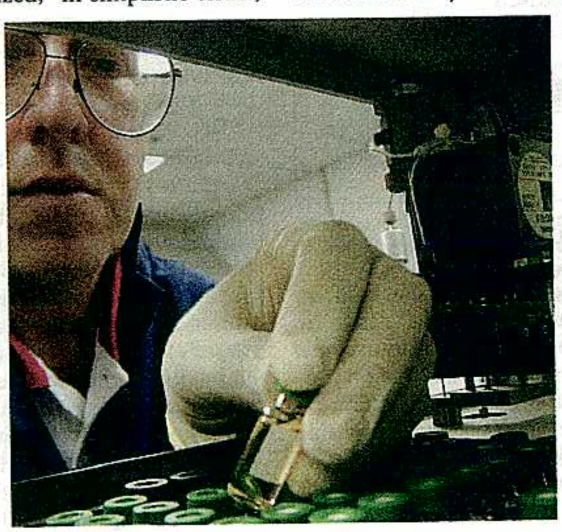
Oils Well That Ends Well

by don smith

In the first portion of* Sport Rider's *oil test ("Oils Well That Ends Well?" August 2003), we covered the overall makeup and functions of motor oil to give you a basic understanding of its role in the performance of your engine. In this portion—the second and final part of the article—we go into a detailed analysis and testing of 22 oils to see what makes them different from one another, including comparing motorcycle-specific oils to automotive products. We also run a dyno test to see if the claims of increased horsepower made by some oil producers are really true.

SPECTROGRAPHIC ANALYSIS

Presented first is the spectrographic analysis of each of the tested oils. Using units of parts per million (ppm) to show the amount of additives in each product, this test utilizes an atomic emission spectrometer to measure the wavelength of light emitted from each oil sample as it is "ionized;" in simplistic terms, this is similar to sticking the oil into a microwave oven, then using a prism to split the light emitted as the oil burns. Since each element has its own light wavelength, a computer compares each light measurement to a standard emission, and then calculates the amount of that particular element.



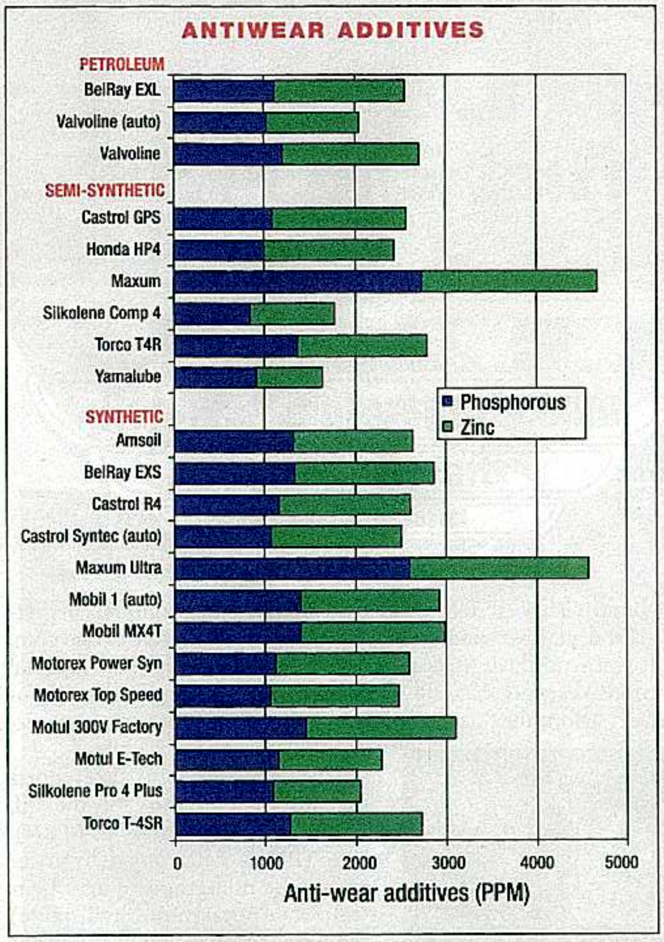
We called on Analysts Inc. in Norcross, Georgia (www.analystsinc.com, 800/241-6315), to perform the spectrographic analysis testing. An ISO-9002-certified facility (meaning their lab meets strict worldwide quality-control specifications), Analysts Inc. has been in business since 1960, and is considered one of the top oil-testing labs in the country. They are able to identify extremely small amounts of metals and additives, and in some cases can detect as little as one ppm. If you send them used oil for analysis, they can generate a metal contents report that will help you discover internal engine problems before they occur. Most large diesel fleets use this to determine maintenance schedules.

This type of analysis also reports the absolute viscosity of the oil, and the total base number (TBN). The TBN is determined by measuring the milligrams of acid neutralizer (potassium hydroxide) required to nullify all the acids present in a one gram sample of oil. Viscosity retention and TBN are very important in deciding when to change your oil. A TBN of three or less typically denotes a failure of the oil to absorb acids. Oils with a higher initial TBN are therefore better suited for longer change intervals, assuming the base oil is of *sufficient quality to maintain its specified viscosity over* *time.* The subjects of base oil quality and viscosity retention are very complex, and are discussed later.

ANTIWEAR ADDITIVES

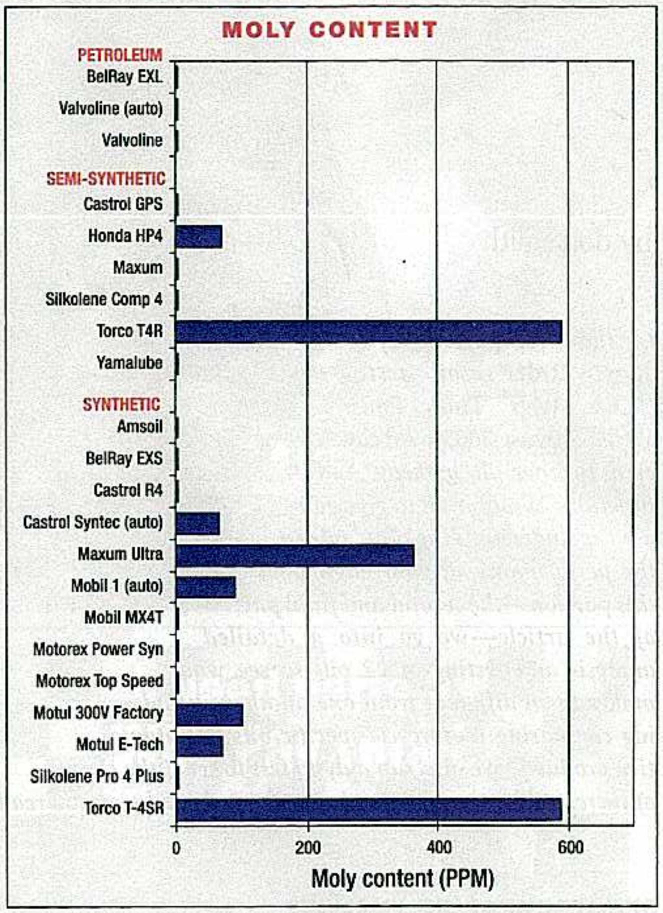
These elements are the most commonly discussed because they are one of motor oil's most important components. Several additives fall into this group, including phosphorous. The maximum level of phosphorous allowed in some automotive oils has been reduced by the new API standards, due to its effect on catalytic converters. Zinc is another additive in this group, as is molybdenum, usually referred to as moly. These antiwear additives serve as a back-up to the oil film in protecting engine components. They are activated by heat and pressure, forming a thin layer between metal parts that would otherwise come in direct contact, preventing permanent engine wear.

Looking at the graphs, it's interesting to note a wide variation in additive amounts. For instance, examining phosphorous levels in the antiwear additive graph (remembering the API limitations) shows that two automotive oils contain approximately 1000 ppm (Valvoline and Castrol Syntec), while the Mobil 1 product contains 1391 ppm. The average of the motorcycle-specific oils is 1322 ppm; the automotive oils average 1157 ppm. The Maxima Maxum products have the highest levels overall, with almost three times the amount found in the lowest product tested. The products with the lowest levels are Silkolene Comp 4, Yamalube and Honda HP4.



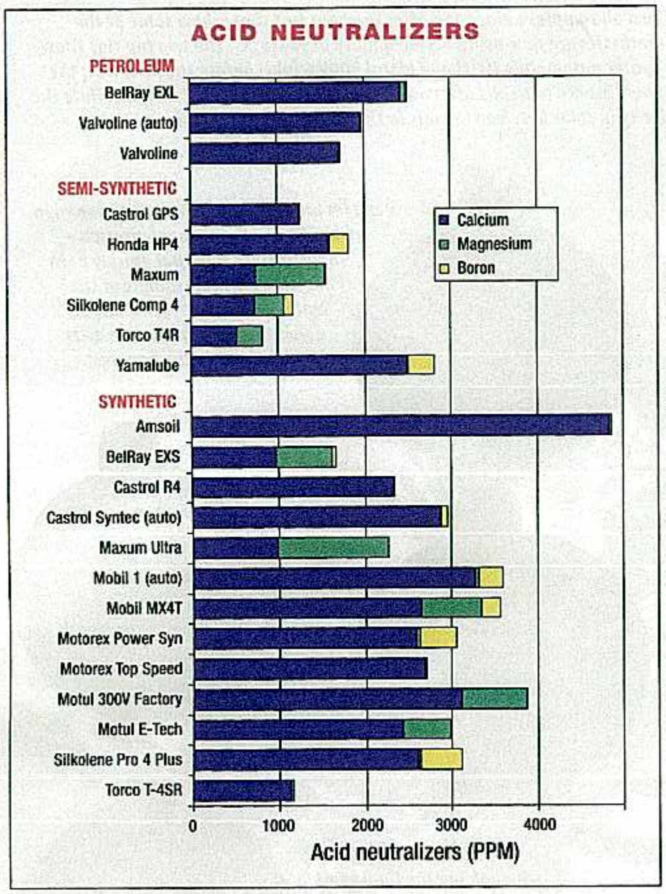
A similar correlation can be seen with zinc. The Maxima products again show the highest levels at almost 2000 ppm, while the Yamalube and Silkolene products again end up on the bottom of this list. The difference here between automotive oils and motorcycle-specific products is not as great, presumably because this additive is not regulated by the API. In fact, Valvoline is the only auto oil containing less than 1400 ppm. While the average motorcycle-specific product contains 1414 ppm, the automotive oils average 1328 ppm—not a huge difference.

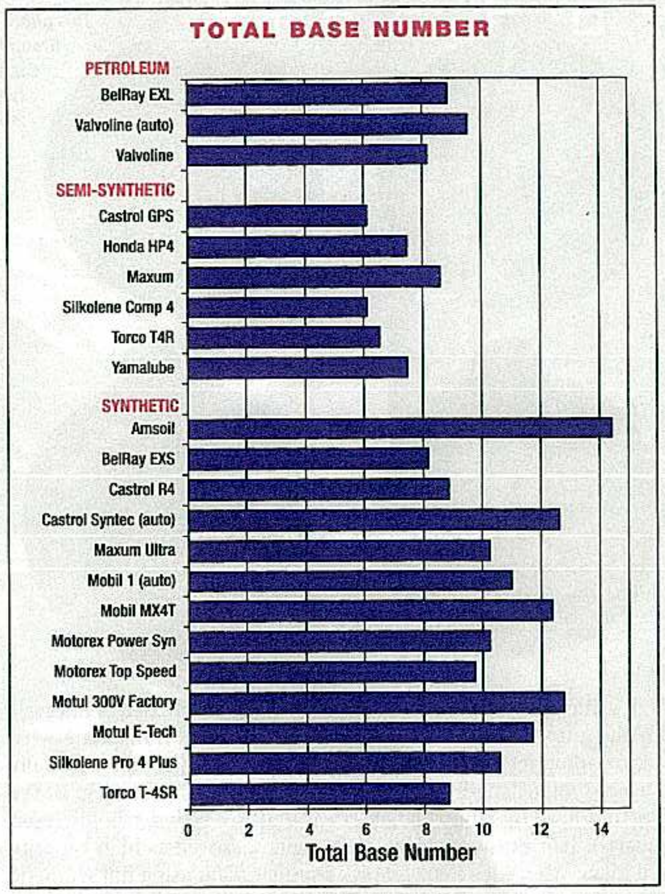
Moly is often referred to as a friction modifier, but it is actually a solid metal dispersed in some oils. Because it has such a high melting temperature (4730° F versus 2795° F for iron), it works great as a high-temperature, high-pressure antiwear agent. Some claim that because moly is so slick, it can cause clutch slippage. In fact, some motorcycle manufacturers specify oil without moly due to this problem. The moly issue is such that Honda offers its HP4 both with and without it. Looking at the moly graph data, however, shows that even Honda's "moly-free" product contains 71 ppm. Many of the products contain less than five ppm of moly, which is the threshold measurement on this test (meaning any amount less than five ppm will not be detected). Both Torco oils contain a significant dose of moly, while the Maxum Ultra and Motul 300V Factory contain far less. The Mobil 1 automotive oil contains 92 ppm, while the MX4T motorcycle-specific version has an undetectable amount. Only six of the 19 motorcycle oils we tested use moly at all. Those that do, however, average 298 ppm. Considering that many oils contain five ppm or less, 298 ppm is a significant dose.

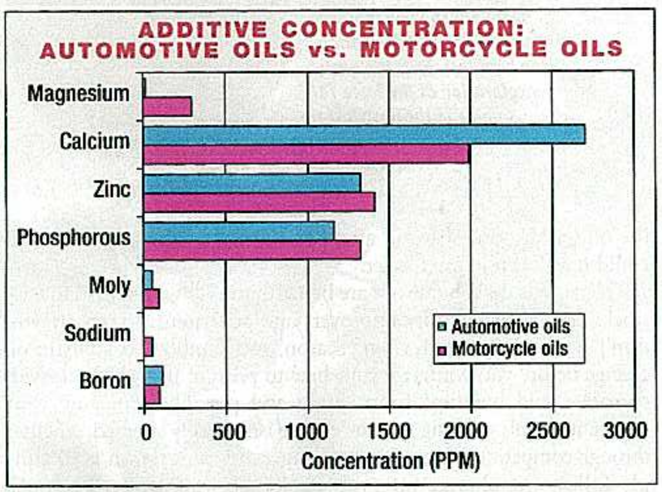


ACID NEUTRALIZERS

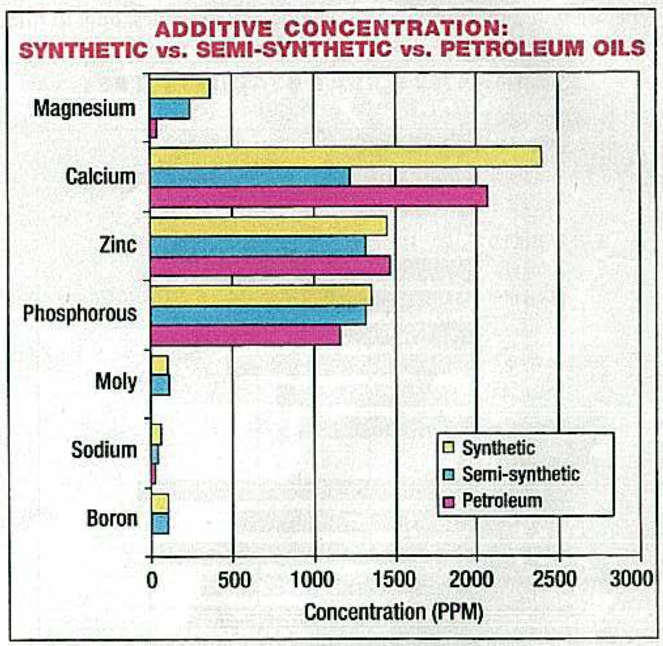
We charted the three most common additives (boron, calcium and magnesium) used to neutralize acids produced inside an engine during combustion. In this category, we can see that the car and bike oils are different in some cases. Every company seems to agree that some dosage of calcium is required. The highest amount is Amsoil at 4843 ppm, which explains its very high TBN of 14.42. Amsoil does not use significant dosages of either magnesium or boron, though; many other oils use both of these to bolster their acid-fighting ability. Maxum Ultra contains only 986 ppm of calcium, but supplements that with the highest dose of magnesium in the test at 1275 ppm. The Mobil MX4T product uses 699 ppm of magnesium and 221 ppm of boron. Another difference between the auto and bike products offered by Mobil is the use of magnesium.







One common claim is that motorcycle oils have specific additives that are more suited for motorcycle engines. Based on an average of the three automotive oils we tested, the bike oils do in fact contain more of everything except calcium and boron. Note that the average moly content, which is often the friction modifier of choice, is higher in the motorcycle oils than the car oils mainly due to the three bike oils that use an extremely high moly content.



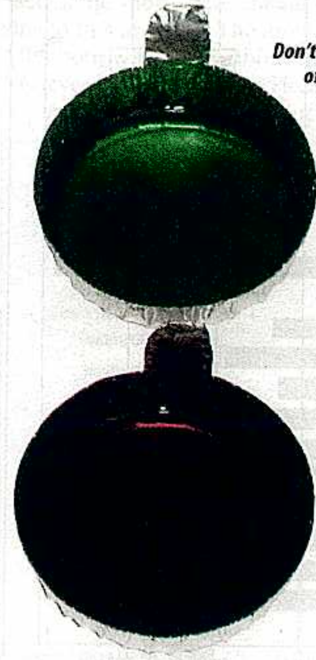
Another common claim is that the higher price of motorcycle-specific synthetic oils allows oil manufacturers to use not only better and more heat-resistant base stocks (as shown in the heat aging data), but also more additives. Our averaged data shows that in general, the synthetic oils contain as much or more of each additive. Note, however, that we only tested two motorcycle-specific petroleum oils, and results could vary with more oils tested.

Mobil 1 automobile oil contains only 33 ppm of magnesium.

Looking at overall averages, the bike oils have an average of 1986 ppm of calcium versus the car oils' 2702 ppm. While the bike oils average 296 ppm of magnesium, the car oils muster only 54 ppm. Since many of the bike oils do not use any boron, their average is only 96 ppm compared to the car oils' 116 ppm. However, looking only at bike oils that use boron as part of their additive package, the average is 253 ppm. The bike and car oils are clearly different in this category.

It's pretty obvious which of these products should do the best job of keeping corrosive acids in check when looking at the TBN. Topping the list is Amsoil, both Motul products and the automotive oil Castrol Syntec. A lower TBN does not mean the oil is bad, it just means that the drain-interval potential is not as great. If you change your oil every 1000–2000 miles, then you shouldn't be concerned with this value. Others should take at least a cursory look at this category, however.

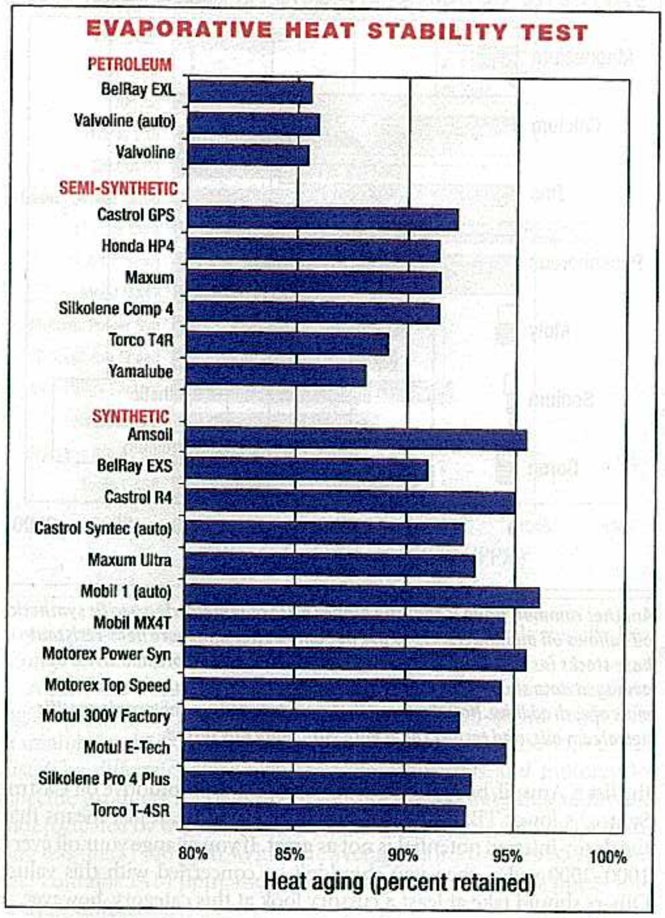
This photo of two oil samples before and after the heat test shows how some of the Group III synthetics are now using better-quality base stocks. The two top tins show Castrol Syntec automobile (left) and Motul 300V (right) before the heat test; the two lower tins are both oils afterward (again, Castrol left, Motul right). Note the similarity in color between the oils in the post-heat test samples.



Don't let fancy colors influence your opinion of an oil's quality or sophistication—some are just dyes that quickly burn off. Note how this sample of the Motorex PowerSyn synthetic oil quickly loses its green hue after just one hour in the heat test.

Although not the final word on an oil's overall quality, some oils showed marked degradation in color during the heat test. Note the nasty coloration of the Torco T4R sample in the post-test tin.

It's interesting to note a trend toward longer oil-change intervals in the automotive world. For example, BMWs now come with factory-proprietary synthetic oil, and the on-board computer usually suggests oil changes every 15,000 miles or so. However, BMW engines have oil sumps larger (their 2.5L six-cylinder holds seven quarts) than most similarly sized engines, as well as high-capacity oil filters. Mercedes-Benz follows a similar plan, using full synthetic oil with a change interval of 10,000–16,000 miles. Being the skeptical type, we tested oil from a BMW engine at 7500 miles, only to find the oil within viscosity and all other standard values—meaning it could have been left in longer.



The truth is that engine oils are better than ever with regard to base stocks, as well as viscosity improvers and acid neutralizers. If you don't have a 12-month riding season, you should add an extra oil change before you winterize your bike to prevent that used oil (with corrosive acid buildup) from sitting and possibly damaging your engine internals. As long as your engine isn't highly stressed, whether through competition or extreme mileage, our suggestion is to simply follow the change interval specified in your owner's manual, and spend more time riding and less time worrying. Of course, this assumes that your engine is in good mechanical condition; problems like fuel or coolant diluting the oil could mean disaster a lot sooner than 1500 miles.

EVAPORATIVE HEAT STABILITY TEST

The oil inside your engine is subjected to an extreme environment. Sure, the coolant-temperature gauge may only show 200° F, but there are many internal engine parts that become far hotter. In order to determine each oil's ability to survive in such a climate, we subjected samples to a test commonly known as the Noack method. This test takes an oil sample and cooks it at 250° C (the estimated temperature of the piston-ring area, which is the hottest an oil should get) for one hour. Before and after the exposure, the sample is carefully weighed on a precise laboratory scale. Because parts of some oils are unstable at these temperatures, they burn off during the test, and that loss can be accurately measured.

The higher the percentage of weight retained (meaning less oil has burned off), the better. As you can see in the charts, there is quite a difference between the best and worst oils. The top product on this test is the Mobil 1 car oil at 96.1 percent. What is not so clear is that Group III oils (synthetics processed from a mineral-base stock) like Castrol Syntec and Motorex Top Speed test about as well as Group IV (PAO synthetics) and V (ester synthetics) products such as Motul, Bel Ray, Maxum and Torco. This shows that Group III oils are getting better and more heat stable (i.e., using better base stocks) for these applications than they were a few years ago.

As expected, the petroleum-based oils such as BelRay EXL, both Valvoline oils and the Yamalube and Torco synthetic blends are on the low end of the scale. Proving how good some synthetic blends are, top blend performer Castrol GPS actually out-performs one of the full synthetic oils (BelRay EXS). In general, however, the full synthetic oils are the winners here, with an average value of 93 percent, compared to the synthetic blends at 89 percent and the dinosaur oils at 86 percent.

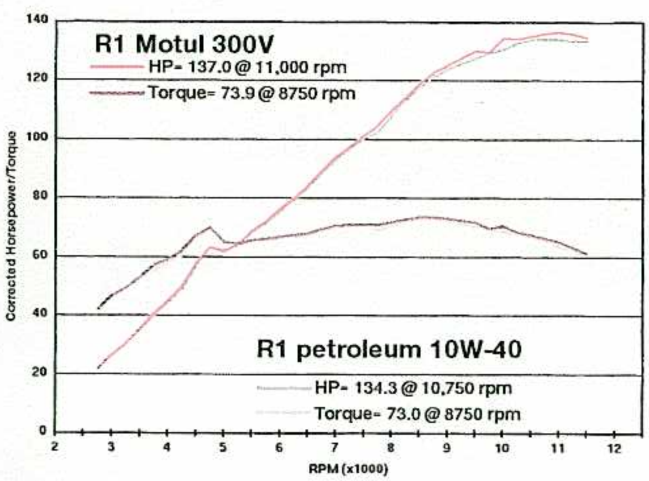
We suggest you look at this data carefully and determine your needs before picking an oil for your bike. While not the only important factor, heat stability is one of the top issues because most sportbikes are tuned to the highest levels of performance possible, usually generating intense heat in the process. Engine oil must be able to survive these temperatures and not evaporate when you need it most.

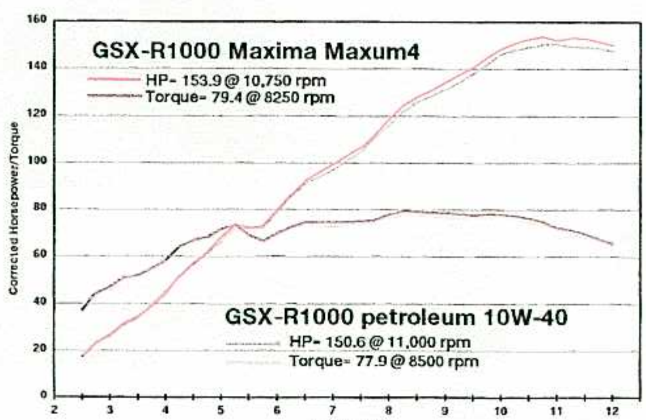
We ran both bikes with standard petroleum automobile oil (Valvoline 10W-40) to do our baseline dyno runs. We then drained the oil, changed oil filters and ran the synthetic oil for at least 15 minutes to circulate it through the engine.

DYNO TEST

Some oil manufacturers and their representatives claim that using their product will result in more horsepower. These are special ultra-lightweight-viscosity racing synthetic oils that are said to reduce the parasitic drag that oil has on an engine's internal reciprocating components. We decided to put these claims to the test—an actual dynamometer test. Two of the full synthetic oils in this test make these horsepower claims on their labels: Maxima Maxum Ultra (in 0W-30 and 5W-30) and Motul Factory Line 300V (in 5W-30). We took two open-class sportbikes—a Suzuki GSX-R1000 and a Yamaha YZF-R1—and ran them with common off-the-shelf Valvoline 10W-40 automobile mineral oil to set a baseline dyno run. That oil was drained and replaced with the 0W-30 Maxum Ultra in the Suzuki, and the 5W-30 Motul 300V in the Yamaha. After about 15 miles of running to get the oil fully circulated through the engine, the bikes were then dynoed again.

We were as surprised as anyone that just changing oil can produce a horsepower boost. Both the R1 and GSX-R1000 posted some significant gains in midrange and top-end, and were gaining power with every run until coolant temps got a little too hot. Before you go rushing to buy this stuff, however, check out the viscosity retention test.





Lo and behold, both the Suzuki and Yamaha posted horsepower gains. While not an earth-shattering boost in power, the gains were far beyond common run variations, and weren't restricted to the very top end. The GSX-R1000 posted an increase of 3.3 horsepower on top, with some noticeable midrange gains as well; even more interesting was that the power steadily increased for several dyno runs (as the coolant temp increased). The Yamaha responded nearly as well, with a 2.7 horsepower boost on top. It should also be noted that while riding both bikes, there was a noticeable ease in shifting with the synthetic oils compared to the automobile mineral oil. Pretty impressive for just changing oil, in our opinion.

But before you go rushing to buy these products, it should be noted that these are racing oils, and, despite manufacturer claims of viscosity retention performance identical to standard viscosity oils, are made to be changed on a much more frequent basis. You should take a close look at the Tapered Roller Shear Test that demonstrates an oil's ability to maintain viscosity over time.

FOUR-BALL WEAR TEST

With an eye toward evaluating oil's ability to lubricate under extreme pressure conditions, we picked a few candidates and ran them through the "Four-Ball Wear Test" (officially designated ASTM D-4172). To conduct this test, we enlisted the help of the Southwest Research Institute in San Antonio, Texas (www.swri.org; 210/684-5111). SwRI is a huge nonprofit independent testing and engineering firm with an entire group of people dedicated to motorcycle-related products.

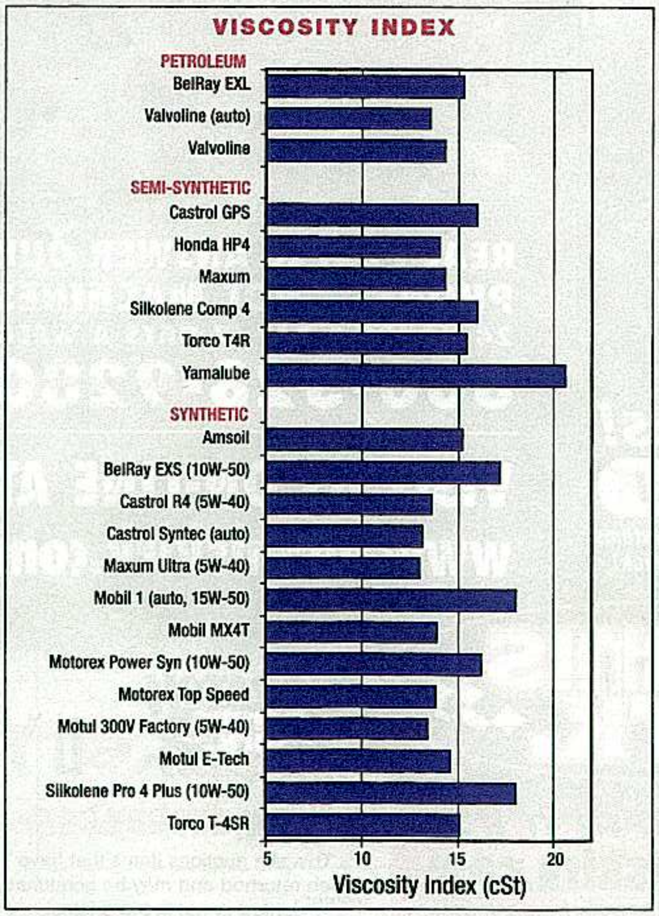
This test is used to determine the wear properties of engine oil in sliding contact (such as a piston sliding against a cylinder wall). Three half-inch-diameter ball bearings are placed in a triangular fixture, with a fourth half-inch ball in the center (in contact with the other three) held in place with a clamp. The balls are then immersed in the test lubricant while the top ball is spun at 1800 rpm for a period of one hour with a prescribed load of 40 kg (88 lbs.) and a constant temperature of 75° C (161° F). The "wear scar" on the three lower ball bearings is then carefully measured (in millimeters) using a microscope and averaged. The smaller the wear scar, the better the protection.

FOUR-BALL WEAR TEST

Product	Base Oil	Type	Wear Scar Size
Castrol GTX 10W-40	**Mineral/Dinosaur**	**Automotive**	**0.36mm**
Mobil MX4T 10W-40	**Synthetic**	**Motorcycle**	**0.38mm**
Amsoil Motorcycle 10W-40	**Synthetic**	**Motorcycle**	**0.37mm**

Because this test is expensive, we could not test every product listed in the spectrographic analysis, so we picked a few we thought would reveal the most information. We chose the Castrol GTX 10W-40 automotive oil because it is a simple Group II mineral-oil product that is widely used and inexpensive. As an example of motorcycle-specific oils, we picked the popular Mobil 1 MX4T motorcycle oil in 10W-40. It is a moderately priced full synthetic oil (approximately $8.99 per quart), and should represent all the technology and economy of scale that a large oil producer like Exxon/Mobil can offer. We also chose the Amsoil Group IV motorcycle oil. Amsoil makes product claims related to the performance of its oil on this test, so we decided to see if they could live up to their claims.

The four-ball wear testing did not show the huge variation expected. All of these oils basically perform the same. With any test there is some variation from sample to sample, and this data is so close we have to call it a tie, which means all these oils *in their new, virgin state* do a good job of protecting against sliding friction wear. Incidentally, Amsoil did perform up to the test claims stated on its label.



TAPERED ROLLER SHEAR TEST

We decided to conduct some additional testing aimed at evaluating an oil's ability to withstand the shearing loads present in a motorcycle gearbox (but not in the typical automotive engine). One of the claims made by most motorcycle-specific oil producers is that motorcycles present a different set of conditions than typical cars do, and that therefore you should spend more money to get oil formulated specifically for this environment. The meshing of transmission gears is said to shear or tear oil polymers over time, resulting in the degradation of oil viscosity and severely reducing its performance. As we stated earlier, this may not be so critical if you frequently change your oil. However, if you run longer than standard intervals, this oil property is something to strongly consider.

The test we selected to measure this effect is officially called the "Tapered Roller Bearing Test" (CEC L-45-99), commonly called TB-20. Recent trials have shown that this test provides the best correlation to actual performance compared to other industry shear tests. For the TB-20 test, a tapered bearing fitted into a four-ball test machine spins submerged in 40 mL (1.3 fluid ounces) of lubricant at 60° C (140° F) at a constant speed for 20 hours. The viscosity of the used fluid is measured and compared to the new/original viscosity, and the percentage of change compared to the original viscosity is reported. The higher the number, the more viscosity loss the oil experienced during the test.

TAPERED ROLLER SHEAR TEST

Product	Original cSt	After cSt	Percent Loss	SAE Grade before/after
Valvoline auto 10W-40	**13.5**	**7.96**	**41.0**	**40/20**
Motul 300V 5W-40	**13.6**	**7.49**	**44.9**	**40/20**
Mobil MX4T 10W-40	**13.75**	**10.78**	**21.6**	**40/30**
Motul 300V 10W-40	**13.21**	**10.21**	**22.7**	**40/30**

We picked Valvoline 10W-40 automotive, Motul 300V 5W-40 Factory line, Mobil MX4T 10W-40 and Motul 300V 10W-40 oils for this test. Part of the analysis also involves the testing of a reference oil with a known viscosity performance in order to measure the variation between tests. In our case the reference oil had a total variation of 2.5 percent. This means that differences of 2.5 percent or less should be judged as the same, and that these small differences are related to the test method rather than product differences.

The actual viscosity raw data test results are expressed in centistokes (cSt), the scientific unit of viscosity measurement. However, after the percentage of viscosity loss column, we have converted the centistokes to an approximation of SAE grade to give you an idea of how much viscosity breakdown has occurred.

We also found the viscosity index, or absolute viscosity, of each sample. This is a measure of how long it takes for a set quantity of the oil to flow through a hole at a certain temperature, and is expressed in centiStokes (cSt). Unless noted, each sample is a 10W-40 grade.

The various oils show large differences in their ability to endure this difficult test. The one commonly available automotive mineral oil tested suffered a 41 percent loss. While this limited data does not conclude that all mineral-based automotive oils are bad, it is definitely not a good sign. Looking at the motorcycle-specific oils, it's notable that the Motul 5W-40 version does not hold up nearly as well as the 10W-40 version (in fact, slightly worse than the auto oil). Motul and Maxima both claim that their ultra-lightweight-viscosity oils would last as long as normal 10W oils. Because we only tested the Motul version, we cannot say for sure that the Maxima Maxum Ultra would suffer the same loss. Yet our dyno test shows that both these oils post a horsepower gain. We consider ultra-lightweight racing oils such as 0W and 5W a special category of race products that should be changed on a strict regimen. Before you decide to run them, you need to weigh the risk of viscosity loss versus horsepower gains and make your own decision. Until more data convinces us otherwise, we would stick to something more practical for the street.

CONCLUSIONS

With all this testing data (and expense), you'd think making a clear-cut decision as to which oil is best would be easy. In the case of engine oils, however, there are too many products and variables that go into this equation. Due to the financial reasons stated earlier, not every test was run on every product, so crystal-clear conclusions aren't in the picture. You must weigh all the data we have made available; for instance, the fact that some oils may absorb acids better, but may not handle high heat as well. Or that while the four-ball wear test shows that particular automobile and motorcycle-specific oils perform identically, the heat and viscosity shear tests show otherwise.

We did, however, unequivocally answer a few questions. For one, most name-brand motorcycle-specific oils are indeed different than common automotive oils, even within the same brand, debunking a common myth. Mobil One automotive oil is definitely different than its motorcycle-specific version. The same is true for the three oils provided by Castrol, showing that both companies have different goals when formulating their automotive and motorcycle products. Whether they perform better—despite the data we've gathered—is still a matter of opinion. Another manufacturer, on the other hand, appears to have selected the same additives in both of its offerings, which begs the question: Are they actually identical and simply relabeled?

Once again, the final decision is up to you. It's your bike and your hard-earned money—so only you can make the decision whether to spend the extra bucks for full synthetic motorcycle oil or simple mineral-based car oil. Review the data we have presented, and select the product that is most suited to your bike and riding style.

For more information, visit www.sportrider.com/0310