The Late Great Oil Debate

By Robert Verret

There are very few subjects that stir the emotions of PWC performance enthusiasts more than to ask, what 2 stroke oil do you use and why? This site has dedicated more 'bandwidth' to this subject than just about any other topic. Most of the discussions end up in heated debate with no one really changing anyone else's mind on what oil is the best anyway. We tend to vehemently defend our choice as if our very reputation depended on it. I sometimes think we are more loyal to our favorite brands of oil than to our favorite brand of ski (hopefully Sea-Doo). Well, maybe we're not quite that loyal to our oils, but close to it. If it's any consolation, PWC performance enthusiasts are not the only group of "motorheads" that staunchly defends their choice of oil. I belong to several other performance oriented motorsport discussion groups (Ford-Diesel and Racetech-KTM) and they do it also. With all this said, let's all take a deep breath and put our emotions and biases in a closet somewhere and try to look at this magic miracle 'brew' we call 2-stroke engine oil.

What's in the stuff anyway?
2-stroke engine oils, like most other engine and gear lubricants, are composed of base oil plus an additive package. The additive package can be as simple (only one or two components) or as complex (multiple components), depending on the requirements of the oil.

Base Oil Types
Base oils compose from 50% to 95% of the total weight of the 2-stroke engine oil. They fall into 2 general categories: synthetic and petroleum based. There is a third category, vegetable, I will discuss later. Since synthetic oils are manufactured from petroleum, there has been a lot of litigation flying around about what really constitutes a 'true synthetic' oil in the last several years. There is no universally accepted definition for synthetic oil. Each manufacturer is free to label their product 'synthetic' by whatever rules the manufacturer chooses. The API (American Petroleum Institute) has defined base oils into 5 different grades or groups rather than use the terms synthetic and conventional (petroleum). The groups are classified by quality of their VI (viscosity index). The VI is a relative measure of the base oil's ability to not thicken at low temperatures and not thin out at high temperatures. The higher the VI number, the more resistant the oil to changes in viscosity as its temperature changes. Perfect base oil would have no viscosity change at all with temperature change. Some silicone-based oils have extremely high VI, but, unfortunately, they are terrible metal lubricants, so they can't be considered for engine lubrication. The higher the API group number, the higher the VI number. Most, if not all, high performance 2-stroke oils are manufactured using API group III and IV and occasionally group V base oils. GroupIII (hydrocracked/hydro-treated petroleum oils) are used in non-synthetic and synthetic blends and Group IV (VHVI and PAO synthetic oils) are used in full synthetic and synthetic blends. Group V (Ester synthetic base oils) is rarely used because of their expense and they do not mix easily with gasoline and they

are not compatible with some other oils. There are a number of advantages to using synthetic base oil in addition to the better VI. Synthetics have a much higher flash point than petroleum base oils.
Synthetics will not decompose as easily at high engine temperatures as petroleum. The engine stays cleaner because less varnish deposits on the power valves, ring lands and piston crown. They also transfer heat better than petroleum-based oils. In summary, it's fair to say synthetic based oils (with the correct additive package) will out perform their petroleum-based cousins at extreme loads/temperatures. I mentioned a third category of base oils earlier, vegetable or Castor (not Castrol, that's a manufacturer) bean oil. This oil is derived from pressing oil out of castor beans and distilling it. 'Bean Oil' as it is often referred to, has some very unique characteristics; some very good, others not so good. The good is that it is an excellent lubricant. It seeks out hot spots in the engine and clings to those hot surfaces much better than petroleum type oils. The bad is that it does not mix with gasoline easily and it burns 'dirty' (excessive carbon/varnish deposits). In the early 70s, before power valves were used, castor bean oil was very popular in racing 2-strokes. Now that power valves are common and we have improved petroleum and synthetic oils, castor bean oil is seldom used anymore. Several companies still market it in the form of a degummed castor oil for racing applications only. It should be avoided for recreational use unless you enjoy tearing your engine down for a top end cleanup fairly often. Several manufacturers formulate their oil with castor bean oil as an additive (antiwear agent) rather than base oil. They blend it with their petroleum and synthetic base oils. When castor bean oil burns, it has an unmistakable 'sweet' smell.

Additives
If science could develop a base oil that would not thermally decompose (burn) until 1600 deg/f and not change in viscosity for –40 to 600 deg/f and not pollute the water or air, we would not need any additives in the base oil. Wouldn't it be nice if all the oil collected in the expansion chamber body stayed in the same pristine state it went into the engine? We could simply recycle it. Well this isn't going to happen in our lifetime (sorry, not even you younger guys will ever see this). Lubrication science is just not there yet. Additives are combined with the base oil to fix certain faults with the base oil or stretch the limits of the base oil in some cases. Additives are complex chemicals that account for most of the cost of a bottle of 2-stroke oil. Additives for 2-stroke oils fall into several general categories: Detergent/Dispersants, Antiwear agents, Biodegradability components, and antioxidants. Since the lubricating oil must burn as part of the combustion process in a 2-stroke engine, the residue resulting from this combustion process must be swept away after each firing stroke. If not, the residue (varnish, lacquer and other heavy hydrocarbon compounds) would build up and plug the exhaust port and stick the rings and power valve(s). Detergents/dispersants must be added to the oil to prevent this problem. The two types of detergents/dispersants most commonly used in 2-stoke oil formations are Ashless and Low Ash. Medium Ash and High Ash detergents are not used in 2-stoke oils. Ashless detergents are used in low temperature applications such as TCW3 oils where the ring land temperature is held below 300 deg/f. These detergents work well in engines where an excess of cooling capacity is available and power valves are not used. Ashless detergents are manufactured form organic nitrogen compounds (Hydrazine) instead of heavy metal compounds; therefore, they produce no ash as they are burned away. This is

where the name “Ashless” comes from. Oils containing this type detergent have a characteristic Ammonia odor. Ashless detergents were used in the first generation of Bombardier XPS engine oil. The formulation was later changed to a low ash type detergent because of the higher temperatures generated by the 787 engines. Low Ash type detergent/dispersants are used in most API-TC, Jasco FC and ISO GC certified 2-stroke oils. These oils are designed for air-cooled high performance engines that operate under severe load/temperature conditions. Low Ash detergents can keep the deposits to a minimum at ring land temperatures as high as 400 deg/f. These detergents are manufactured from compounds of Calcium and Magnesium (heavy metals). After these compounds (Calcium Phenate or Magnesium Phenate) do their job, they burn away, forming a heavy metal salt (ash) that is swept away during the normal combustion process. Hence, this is where the name Ash-type detergent comes from. Ash type detergents depend on the higher combustion temperatures (787 and 951 engines) to keep the resulting ash swept out. Therefore, the use of these high performance oils in outboard or other mildly tuned 2-stroke engines is not recommended. Some manufacturers are using a combination of detergent types (Ashless and Low Ash) to provide a broader range of uses for their oil. It is important to note that oil designed to meet TCW3 specs. only (Ashless) will not protect an engine requiring API-TC (Low Ash) type oil. The converse is also true. Using a Low Ash oil in an engine designed for an Ashless type oil only could result in fouled plugs and gummy combustion chambers. When 2-stroke oil is kept in its temperature limits, it provides an adequate protective film between all moving parts. When that maximum temperature is exceeded, the oil film breaks down and usually seizure occurs unless another line of defense is added to the oil mixture. These are the Antiwear agents. These Zinc compounds (Zinc Dithiophoshate) flow in with the oil and are never used unless the base oil breaks down. If the base oil breaks down, they form a protective barrier between the moving parts (usually piston skirts and cylinder walls). Since all 2-stroke engines partially burn and expel their lubricant in the exhaust, the resulting exhaust residue must be rendered harmless to the environment (air, water and land). All 2-stroke oil intended for marine use and many intended for land recreational use contain Biodegrading agents. These complex chemical compounds allow the microbes found in water and in the soil to consume the hazardous chemicals and oil from the exhaust as they fall in the water or on the ground. These Biodegrading agents do nothing for the performance of the oil (sometimes they even hinder it), but they help assure us that 2-stroke engines will be around for a while. As you can see, 2-stroke oils are a mixture of many different complex chemicals with base oil. Each specialty chemical has a job to do. Care must be taken to assure that these different chemicals detergents/dispersants, Antiwear agents, and Biodegrade agents) do not react or interfere with each other or otherwise impair the function of any other additive. Antioxidants are chemicals that reduce the chance of reaction between the various additives in the oil mixture. They effectively extend the ‘shelf life’ of 2-stroke oils.

What does ATP-TC and TCW3 mean?

Specifications for 2-stroke oils are developed from the design of the engine and its intended use (no surprise). Since this type engine has a wide variety of applications its no surprise that the specifications for the oils might vary also. For marine and PWC application there are 2 widely accepted standards for certifying 2-stroke engine oils. These are, by no means, not the only standards for 2-stroke engine oils. The European (ISO) and the Japanese (JASCO) standards have been developed, but these standards are not widely accepted in the country (yet). The standards most used in this country are the National Marine Manufacturers Association (NMMATCW3) standard and the American Petroleum Institute (API API-TC) standard. Both of these standards address the oil ability to prevent wear, keep the engine clean and biodegradability. Since these standards were written for different types of 2-stroke engines it stands to reason these standards would be different. Hence, the oils developed from these standards would also be different. The NMMA TCW3 standard was designed by the various manufacturers of outboard motors (Mercury, OMC, Yamaha etc.). These manufacturers so not utilize power valves, limit their max rpms to about 6800 and have excessive cooking capacity. They also must be able to operate at lower rpms for long periods of time without oil fouling the spark plugs. Although it's true the performance of this type engine has increased in the last several years, the peak engine temperatures are still relatively low. The use of synthetic base oil in TCW# formulations has extended the useful range of these oils; their detergent system (Ashless) is designed for lower operating conditions. This is one of the reasons Bombardier specifically prohibits the use of these oils in their Rotax engines. The API API-TC standard was developed for Air-cooled, high rpm, high output 2-stroke engines operating under severe load conditions. Although this standard is no longer reviewed and updated since 1993 b the API, it still is in effect today. This standard most accurately addresses the condition Rotax and 2-stroke racing motorcycles and snowmobiles operate under. Almost all these oils are formulated with synthetic or synthetic blend base oils and all use a low ash type detergent. If you walk into a store that handles a variety of 2-stroke oils, it is relatively easy to find TCW3 certified oil. The manufacturer proudly displays that certification on each container. API-TC certified oils, on the other hand, are very difficult to find. There are two main reasons for this. First, many small API-TC oil manufacturers can't or won't spend the money (about $75,000) for the testing and certification process. Second, most engines requiring API-TC oils are for racing applications (Motocrossers and Crosscountry motorcycles) and don't offer warranties with their engines anyway. The owner/operators of these machines know what oils work and don't work. They do not need the API-TC certification on the bottle to help them decide what oil to use. There are many really good API-TC type oils on the market that have never been certified as such. Bombardier/Rotax is the only manufacturer that API-TC certified oils. The TCW3 market is about 10 times the size of the API-TC market. Outboard motor manufacturers require the use of TCW3 certified oils to maintain their warranty. With this great volume in oil sales at stake, it's easy to see why TCW3 manufacturers can afford to certify their oils.

Rotax's Position on What Oil to use

As we all know, Bombardier requires that an API-TC oil be used in their engines. Most other PWC manufacturers allow the use of TCW3 in their engines. So, what's the difference? A PWC is a PWC, right? No, it's not! Rotax marine engines evolved from their very successful snowmobile and motorcycle racing designs. These engines produce more power/cc than any other PWC manufacturer's engine. Rotax designs these engines to work harder and run hotter than other brands. They simply need more protection than TCW3 oils can give. Those that use TCW3 oils are risking high temp. Seizure if the engine cooling system plugs or and internal fuel filter plugs (lean condition). These things may not happen very often, but when they do, it's better to have a little extra protection that only a TI-TC oil can give.

So, what's the best oil to use?

I truly believe there are no bad oils anymore (well, maybe a few really cheap ones are not so good). Most problems with oils are the result of misuse. I had a friend once that insisted on mixing STP with his premix. He swore his motor made more bottom end with STP in the fuel. Well, it may have, but he invested considerably more $$ in spark plugs than just about anyone else on the planet. He was also responsible for single handedly stunting the growth of the entire mosquito population in southeast Texas (thank God he quit riding). I hear a lot of complaints about the high cost of some 2-stroke engine oils, mostly Bombardier XPS. Well, I have to agree, it isn't cheap, but neither are any of the other API-TC oils compared to the TCW3 type oils. Unfortunately it just costs more to manufacture API-TC oils than TCW3 oils. Despite its relatively high cost, I cannot recall any Rotax engine failing because of XPS oil. XPS oil was a joint development of Castrol and Bombardier. Bombardier wanted a 'universal' high performance engine oil that they could use in all their recreational products. That meant oil would flow freely at –40 deg/f and still maintain sufficient film strength at 350 deg/f. The first generation of XPS (1995) was formulated using Ashless detergents; this allowed the Rave valves in the then new 787 motor to stick. The formula was later changed (1996) to a low ash detergent that eliminated the rave valve sticking problems. There have been several minor improvements in XPS since 1996. Castrol remains the only manufacturer of XPS. This is a proprietary blend sold only by Bombardier.

There are a number of good API-TC type oils out there if you chose not to use XPS. If the oil you want to use does not have the ATP-TC certification on the container, contact the manufacturer. Most of them will be more than glad to provide you with information on their products.

Decisions, Decisions!

Well, I hope I answered most of your questions concerning 2-stroke engine oils. I've tried to keep brand names and my personal biases out of it so far. However, I, like you, have an opinion. My opinion is based on my 30 years experience working with 2-stroke motors and my relationship with some very knowledgeable people involved in lubrication research. I work for the world's largest manufacturer of oil additives. We make the additives for virtually all the oil retailers.

Now having said that, here are my recommendations. If you have a Sea-Doo PWC that is still in warranty: Stay with XPS or XPS-DI. Sure there are API-TC certified oils that should preserve your warranty, but in an engine failure the dealer could cause you grief getting your PWC warranted. In my opinion, it's just not worth the hassle to do battle with them. Stay with the XPS at least until the warranty expires. After the warranty expires, select API-TC oil that carries the certification or confirm in writing the oil you want to use is designed for your PWC. Then find someone else that uses the oil you are considering and get his or her opinion. Do not use TCW3 in your SeaDoo PWC. I don't care if it's a full synthetic or your brother-in-law uses it; for the reasons stated above, it will not protect your motor when conditions get tough in your motor.

Choose well, Grasshopper, the life of your motor depends on it!