Choosing an Oil for Two-cycle Engines

There are several oils out there for an ultralight pilot to select from, and everybody has their favorite. Others are confused about claims as to which one they should use and why. How about oil injected versus the common fuel and oil pre-mix? What's the difference between an oil formulated for water cooled and an oil made for air cooled engines? The chart in Table 1 shows the general operating conditions of each type of engine.

Table 1
Two-Cycle Engine Operating Conditions

Characteristic	*Outboard*	*Aircooled*
Speed	Constant	Variable
Physical Use	Smooth	Active
Average Piston Temperature	Moderate	Low
Peak Piston Temperature	Moderate	High

To understand how two-cycle oils work in your engine, we need to cover some basic training on engine operating conditions and oil formulation. Outboard engines are characterized by their constant speed, high output operation. They are usually set at a desired high speed and continue at that speed until the destination is reached and then throttled down. Also, they are constantly cooled with fresh, cool, non recirculated water. Chain saws, on the other hand, are a high action operation. They are constantly started and stopped, used for short periods, and frequent overloads are its hard place in life. Additionally, they have smaller displacements than outboards and are air cooled. By understanding how the operation of an engine can affect the oil used and how an oil can affect the engine, we can better appreciate the difference between a water cooled two-cycle oil and one formulated for an air cooled two-cycle engine. The components used in these two oils, and reasons for their use are shown in Table 2.

Table II
Two-Cycle Oil Formulations

	Water Cooled		Air Cooled	
Component	*Amount*	*Comments*	*Amount*	*Comments*
Heavy Oil	High	Required to prevent piston cylinder wall scuffing and seizure.	Low	Prevents piston scuffing. High amounts can create exhaust port and system deposits.
Detergent	None	Could possibly foul plugs and exhaust port deposits under certain conditions.	Medium	Required to prevent piston ring sticking
Dispersant	High	Prevents deposits	Medium	Prevents deposits
Rust Inhibitor	High	Prevents rust	Medium	Prevents rust
Oxidation Inhibitor	High	Prevents deposits	Medium	Prevents deposits

Water cooled two-cycle engine oils require higher levels of a heavy oil to prevent piston and cylinder wall scuffing. Because of their high average piston temperature, lighter oils evaporate too quickly from the piston cylinder contact area. The heavy base oil, which vaporizes at very high temperatures, resists evaporation and remains in place to provide lubrication to the piston and cylinder. Air cooled oil formulations must have much lower levels of the heavy base oil than water cooled engine oils. These oils require only a small amount of heavy oil to provide protection against piston scuffing and seizure at peak temperatures. High levels of heavy base oils in an oil formulated for air cooled engines can cause engine deposits. These deposits form as a result of incomplete burning of the heavy oil. The deposits can cause piston ring sticking and can eventually plug or disrupt the flow of the exhaust system, resulting in power loss and possible engine damage. Detergent additives should not be used in water cooled two-cycle oil formulations. When burned with the fuel, detergents produce an ash deposit in the cylinders. This ash deposit can possibly foul spark plugs., form exhaust port deposits which cause loss of power, and possibly create cylinder hot spots that can cause destructive pre-ignition. On the other hand, the only way to protect air cooled two-cycle engines against piston ring sticking at their high peak temperatures is to include some detergent additives in the oil formulation. Detergents provide high temperature deposit control not available from other additives used in the oil. However, in the air cooled engine, any ash deposits that could form from the detergents are dislodged by engine vibration and exhausted from the engine.

Now is a good time for a lesson on ash. Ash is the non-combustible residue of a lubrication oil or fuel. Detergent additives contain metallic derivatives, such as calcium, barium and magnesium sulfonates that are common sources of ash. Ash deposits can impair engine efficiency and power. But, detergents are an important component of engine oil that help control varnish deposits, piston ring deposits, and rust (yes, rust) by keeping insoluble combustion particles from adhering to metal surfaces. in some cases, detergents neutralize acids formed from combustion of the fuel mixture. Ash deposits may have a grayish color, where carbon residue is usually black and sooty.

Carbon residue, on the other hand, is different from ash. Carbon residue is formed from unburned and

partially burned fuel, and from burning of the crankcase lubricant. Water from condensation of combustion products along with carbon residue from fuel contribute to engine piston deposits. Carbon deposits are normally black and have a sooty appearance.

Oils formulated for outboard engines require a large amount of antioxidant and dispersant additives to control deposit formation since these oils do not contain detergents. outboard oils also contain a large amount of rust inhibitors because an outboard engine's continuous contact with water makes rust prevention an important requirement. Air cooled oils contain lower amounts of antioxidants and dispersants, since the detergent additives do most of the work of preventing deposit accumulation. These oils also contain rust inhibitor additives to protect against rust that can form from water that enters the engine due to condensation.

So how do some oils claim to be multi-purpose or formulated for water and air cooled engines? These oils have usually been formulated to meet the National Marine Manufacturers Association (NMMA) TC-WII(tm) or TC-W3(tm) specification. These specifications require the oils to be tested under rigorous test conditions. An air cooled engine test is part of these requirements. Therefore, a manufacturer can claim multi-purpose applications. Although these oils have been tested in an air cooled engine and will lubricate an air cooled engine, an oil formulated specifically for air cooled engine use may be the best choice for your engine.

Just what oil does Rotax recommend for their two-cycle engines? Rotax recommends using an oil meeting American petroleum Institute (API) Service Classification TC. API TC is a designation for high performance two-cycle engines (typically 50cc to 500cc), excluding outboard engines. This performance rating is determined by engine tests that evaluate (1) anti-scuff characteristics, (2) piston ring sticking and engine cleanliness, and (3) preignition. in the TC category, a 50cc and a 350cc Yamaha engine are used to evaluate the oil.

Rotax engines that require the fuel and oil to be premixed should use a 2% (50:1) concentration of oil in the fuel. It is very important that the fuel/oil mix is correct. in other words, don't add too much or too little oil to the fuel. If a little does good, more oil added to the fuel doesn't necessarily do better. in fact, too much oil will lead to excessive deposits and could also cause exhaust smoke and spark plug fouling. not enough oil can lead to piston skirt and cylinder wall scuffing and eventual engine damage.

Gasoline containing alcohol (ethanol and/or methanol) should not be used unless permitted by the engine manufacturer. Alcohol containing fuels can absorb water and separate from the gasoline. Additionally, the alcohol may not be compatible with some fuel system components, such as plastic and rubber compounds.

Rotax also recommends de-carboning the engine after 50 hours of operation. This procedure is designed to remove excessive piston deposits and to check for possible stuck piston rings. Rotax allows up to 0.040 in. of soot and carbon buildup on the piston crown before removal of the carbon is required.

Not only does Rotax recommend an API TC oil for the 277 through the 503 air-cooled engines, but also for the 532 and 582 water-cooled engines. These 532 and 582 engines run at internal temperatures similar to the air cooled Rotax engines, as evidenced by their use of the same spark plug.

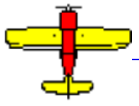
Special precautions should be taken when switching oils, even between the same brands. Because of the special formulation of air cooled engine oil, these oils generally are not compatible with water cooled engine oils. Caution should be exercised to ensure that these products are not mixed together. Special precautions should be taken when changing from a product designed primarily for water cooled engines to an air cooled product, particularly in oil injection systems where the undiluted oils would be mixed together. It is recommended that the oil reservoir and lines be drained when changing to another formulation. In applications where the oil is premixed with the fuel, it is recommended that the fuel tank(s) be drained and fuel filters changed.

Now, who makes an oil that has been formulated to meet these requirements and is readily available? Every ultralight pilot in this area I know has switched to the Pennzoil 2-Cycle Oil for Air Cooled Engines and has had good luck for the past three years using it. Teardowns of engines for overhauls and general maintenance have indicated very little wear and even the fine crosshatch hone marks are still intact on our engines. Articles in ultralight and other flying magazines indicate that this is the oil of choice in experimental applications as well as the true ultralight all across the country. Need an added benefit? Pennzoil is usually a lot cheaper in price and comes in 16-ounce plastic bottles. According to engineers at Pennzoil, this product contains a unique combination of detergents and ash-free dispersants to protect against high temperature piston ring sticking, spark plug fouling and port plugging. It also protects against rust and corrosion, plus has anti-wear protection for high RPM needle roller bearings. I don't know of any other major refinery other than Pennzoil that makes an oil that they actually recommend for use in ultralights. Try it; you'll like it.

Reprinted with permission of E.A.A. Experimenter(tm) Magazine, April, 1994. Article submitted by Charles Kudolis (EAA 299878)

Note:

> Pennzoil uses this article as an advertising brochure. The last paragraph is a lot like an advertisement, but I thought the article in general was quite informative. I am not advocating the use of Pennzoil, nor is this an advertisement for them. This article is quite relevant wether or not you decide to use Pennzoil. Any spelling or grammar mistakes are mine. If you see anything wrong, please let me know. --*Jon*


Back to the Ultralight home page

Jon N. Steiger / stei0302@cs.fredonia.edu / SUNY College at Fredonia