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SERVICE LETTER #45

DATE: September 21, 1995

SUBJECT: Ensuring proper fuel system performance

APPLICABILITY: All Kitfox models with wing tanks

COMPLIANCE: As required

FROM: SkyStar Aircraft Engineering Department

The fuel system on a Kitfox is a gravity feed design that will provide adequate fuel supply to factory-approved Rotax and Continental engines. This service letter is intended to emphasize the importance of the installation methods and operational practices that will ensure proper fuel system performance.

In a gravity feed fuel system, fuel passes through a finger strainer mounted in the tank(s), through fittings and hoses to the header tank and on to the shut off valve, through the gascolator or filter, and finally to the engine. It is vitally important that restrictions to the flow be minimized. The carbureted Rotax and fuel-injected Continental engines use a fuel pump to supply fuel to the engine. These pumps, however, are designed to push fuel and not pull it, and their presence does not in any way relieve the aircraft builder/operator from the responsibility of ensuring an unrestricted flow of fuel to the pump. Furthermore, the fuel that does arrive at the engine must be fresh, free of water and other contaminates, and of the proper grade and type for the engine.

Strict adherence to the following procedures will help keep your fuel system working properly.

FUEL LINE FABRICATION

1. Be careful not to cut the inner lining of a hose when installing it over a barbed fitting. This is an easy mistake to make because pushing on the hose and tearing the lining doesn't feel very different from a proper assembly. If the hose tears internally, a small flap of rubber is raised that can act as a flapper valve and intermittently stop the flow of fuel. Check the barbed fitting for burrs or sharp edges before installing the hose, and use a few drops of motor oil on the barb to help prevent tearing the hose lining.

2. All the aluminum flared fittings that are provided with the Kitfox kit are AN-standard aviation parts and have a flare angle of 37°. All non-aviation flaring tools and flared fittings (the inexpensive, heavy kind that you get at the hardware store or auto parts shop) have a flare angle of 45°; to mix the two flare angles is to build in a guaranteed fuel leak. To make a high quality flare, start by cutting the ends of the tube square and debur the cut end. Clean and lubricate the cone of the flaring tool and, after flaring, inspect the tube flare for signs of galling (insufficient lubrication), splitting (too much flare), under flare, and non-concentricity (improper handling of the tool). If your flare fitting is properly tightened (70-90 in-lbs for $^{5}/_{16}$" aluminum tubing) and is leaking, find out what is wrong and fix it (the face of the fitting may be scored, for instance), and avoid the temptation to apply a sealant to the flare face. No sealant should ever be required on the flare, and it is bad practice to accept 'band-aid and bailing wire' quality workmanship anywhere on an aircraft.

3. It is always best when bending aluminum tubing to use a bending tool. Successful bends can be made by hand, but care must be taken to prevent kinking the tube or creating a flat spot, both of which can restrict the flow of fuel or cause the tube to fail. When routing hoses, pay particular attention to the hose for signs of kinking (too tight a radius) or twisting. Make sure that any clamps or cable ties are not so tight as to pinch the hose shut.

4. Fittings with pipe threads should always be installed with an aviation-grade, pliable (non-hardening) thread sealant (like Fuel Lube or Tightseal) on the pipe threads only. NEVER use teflon tape-type products, as bits of tape often get into the system during installation or servicing and can cause blockages or mechanical failures. SkyStar sent out approximately 25 header tanks on which our vendor used teflon tape on the fitting inserts. If you have one of these tanks and it is not leaking, it is best to leave it alone. If the fittings are ever rotated for any reason, the system should be drained, the fittings removed, and all traces of teflon tape cleaned out (an old toothbrush works well to clean out the threads in the tank). Reassemble the fittings using the proper sealant, and check your filter and/or gascolator for contaminants. Also, avoid over-tightening the pipe fittings on the header tank, as this may damage the tank material itself.

FUEL LINE ROUTING

1. Fuel lines and hoses must be routed free of conflict with moving parts and should be secured so they will not vibrate against the airframe. Also consider the human factors, i.e. will a passenger stretching their legs crush or tear open a line?

2. Fuel lines should be routed below electrical wiring and the two should never be bundled together. This helps to minimize the possibility of fire due to leakage.

3. It is best to secure fuel lines and hoses using cushioned clamps where possible.

4. The fuel line from the wing tank to the header tank must be routed continuously down hill. If this is not maintained, air pockets or bubbles can get trapped in any high spots and severely restrict the flow of fuel. Be sure to check for this condition with the aircraft in a level flight attitude.

5. The service loop in the fuel hose that allows the wings to fold deserves particular attention to ensure the hose does not kink from too tight a radius. It is possible that the hose will not kink initially, but in time the stresses imposed will slowly force the hose to collapse. For this reason, check this hose during each preflight inspection. Also, after unfolding the wings, be sure to check that the hose has not come to rest in a position that creates a high spot in the line.

FUEL TANK CAPS

1. Before each flight remove the fuel tank caps and blow through the vent tube to verify that it is free from obstructions. While you've got each cap off, check the seal for signs of deterioration and the tank for proper fuel level, and then firmly replace the cap. A bad seal or missing or improperly tightened fuel tank cap can allow large quantities of fuel to be lost overboard in a very short period of time.

FUEL SIGHT GAUGE INSTALLATION

1. If you are in the process of installing or have already installed one of the new style fuel level sight gauges (made from a piece of butyrate tubing which you must heat form), follow the directions given in the assembly manual carefully. When installing the spring washer over the end of the sight gauge tube, be certain that none of the tabs get bent. A bent tab on this washer can prevent the fitting from being secured properly to the tube. Also be careful not to over-tighten the fitting to prevent the threads from stripping. Once the gauge is installed on the tank, you should be able to firmly pull on the top and bottom of the tube simultaneously and it should not come out of the fittings. If it does move when pulled, it has been installed improperly and the fittings must be reinstalled correctly.

FUEL QUANTITY AND UNUSABLE FUEL

1. It is very important to properly calibrate your fuel tank sight gauges in both a taxi attitude and a flight attitude. Use a measured container to incrementally fill the tanks with fuel, and mark the gauges accordingly.

2. As of September 1 we will have revised the outlet port location on our 13 gallon fuel tanks to reduce the amount of unusable fuel in all flight attitudes. The previous wing tank designs (both 6 and 13 gallon) had the fuel outlet fitting at the rear of the tank, creating the potential for fuel starvation during long, steep, high-speed descents with the tanks low on fuel. During such a descent, fuel tends to run forward, away from the tank outlet, and during those periods fuel will be provided to the engine from the supply in the header tank. Because of variations from aircraft to aircraft, we recommend that each owner drain both tanks, set the aircraft up at a wings-level, 5° nose down attitude (measured across the headrack tubes), and then add measured amounts of fuel to each tank until the fuel just begins to flow into the header tank. This amount of fuel added is the unusable fuel quantity per tank in a steep descent. To help remind you of this limitation while flying, make a red mark on the fuel sight gauges at the unusable fuel level while in this descent attitude. If you find that you are required to make a fast and steep descent when you have little usable fuel remaining, check the header tank vent hose that runs to the top of the right wing tank. If the level of the fuel in this vent hose is lower than the outlet port on the wing tank, then the engine is running on header tank fuel only. Fly the descent in steps, leveling out every few minutes for a minute or so to replenish the fuel supply in the header tank. A retrofit kit is available for those with the old style tanks who would like to relocate the outlet ports to reduce their unusable fuel quantity. This retrofit will increase the usable fuel in each tank by approximately 2½ gallons in a cruise descent attitude. Ask our Customer Service department for kit number 10678.000, which is currently priced at $87.50 per tank.

LOW FUEL WARNING SYSTEMS

To help provide an additional measure of safety against fuel supply problems, SkyStar has developed (and strongly recommends) a low fuel warning system to alert the pilot of a low fuel level in the header tank. With this system a red warning light on the panel indicates that the fuel level in the header tank is dropping, giving you time to troubleshoot the problem (or land the airplane) before it gets quiet up front. Builders with the newer style Series 5 header tank already have the provision in the tank for the sending unit. This kit is P/N 10017.000 and costs $105.00. A kit that includes the header tank with sending unit provision and warning light system is also available (P/N 10637.000) and costs $219.95.

FUEL

1. Use only the grade and type of fuel recommended by the engine manufacturer.

2. Check for fuel contamination by sampling your sumps before every flight.

3. Keep you fuel filters and/or gascolator screens clean.

4. Bear in mind that gasoline ages rapidly and that unless you have had the foresight to use a gasoline stabilizing product, you may have stale fuel in the tanks, particularly for the first flight after a season of storage.

OXYGENATED FUELS

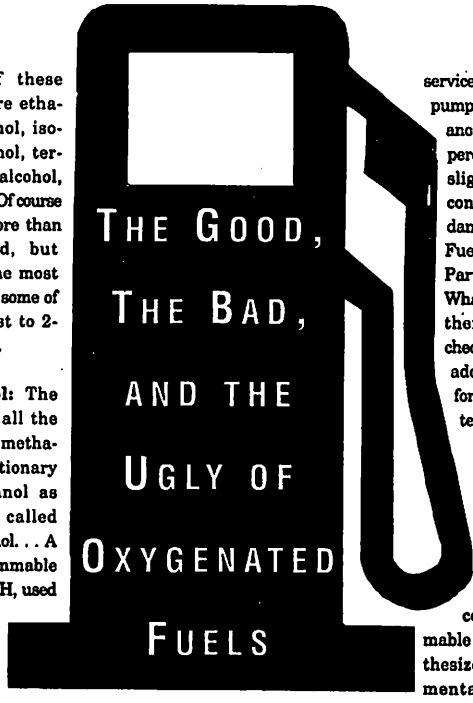
Recently there has been some concern regarding the use of oxygenated fuels in the Kitfox. Some studies have indicated that these fuels may be harmful to fuel systems similar to those in the Kitfox. Although most of the fiberglass fuel tanks which have been supplied with the Kitfox aircraft have had a sealing agent applied to their interior, this may not render the tank impervious to the effects of these fuels. The purpose of the sealing agent is merely to seal any pinholes which may have been in the tanks following the manufacturing process. In addition to the tanks, the fuel lines which are used in the aircraft may be susceptible to deterioration from these fuels, including the aviation-grade MIL-spec hose which is currently supplied with the aircraft. Because of this, SkyStar does not endorse the use of any oxygenated fuels except those which have MTBE added to them.

For more information regarding the use of oxygenated fuels in your aircraft, please refer to the reprint of the following article by Mike Stratman of California Power Systems.

THE PROPER CARE & FEEDING OF THE ROTAX MOTOR

PART 37

by Mike Stratman



Thanks to a multitude of government bureaucrats, what you buy at the gas pump may or may not be hazardous to your 2-cycle engine. Ever since the Sharp-Rockefeller Alternative Fuels Act of 1988 (Bill #PL100-494), which mandates increasing levels of oxygenated fuels all the way to the year 2004, operators of 2-cycle engines must be more educated and vigilant than ever. Way back in 1989 in Part #19 "Taking Control of What Your Engine Burn," we first discussed the various types of gasoline additives. As we predicted then, the quality of fuel has taken a real beating in the name of the environment.

This month we'll take an in-depth look at the common types of additives, the positive and negative effects they have on combustion in 2-cycle engines, and what you can do to be a smart operator and avoid trouble.

Remember these names so you can be sure to vote them out in the next election!

Increasing Use Of Additives: As the Alternative Fuels Act is implemented, the percentage of additives will continue to increase. The term "Oxygenated Fuels" is now commonly used to characterize additives that burn cleaner and produce less pollution when added to pure refined gasoline. Some of the more common of these additives are ethanol, methanol, isopropyl alcohol, tertiary butyl alcohol, and MTBEs. Of course there are more than these listed, but these are the most common and some of the deadliest to 2-cycle engines.

Methanol: The "ugliest" of all the additives is methanol. The dictionary lists methanol as also being called Methyl Alcohol. . . A colorless flammable liquid, CH3OH, used as an anti-freeze, general solvent, fuel, and denaturant for ethyl alcohol. Also called "wood alcohol" or "wood spirits." This highly corrosive additive will literally "eat" rubber, aluminum, steel, fiberglass, which includes your crankshaft, pistons, gaskets, fuel tanks, etc. If this isn't bad enough, methanol has an unlimited ability to consume water. Remember the TV commercials that stated "Rolaids consumes 47 times its weight in excess stomach acid"? Methanol's ability doesn't stop at 47 times its weight. It will attract all the water it can find in the air, in condensation, or anywhere during transportation and never gets tired. If you live in a humid climate, this will obviously be accelerated. Methanol also leans out carburetion, causes poor cold weather starting, decreases fuel economy, and increases chances of vapor lock.

What is "good" about methanol is that it is an excellent octane booster, has potential to boost power, reduce exhaust emissions, and is widely available. Obviously a load of this stuff in a tank full of fuel can have some lasting effects. The government does require that service stations must label the pump if more than 3% methanol exists in the fuel. This percentage figure may vary slightly by state and will continue to rise in accordance with the Alternative Fuels Act. As discussed in Part 19 "Taking Control of What Your Engine Burns," there is a simple way to check for methanol or other additives with an affinity for water. More about this test in a minute.

Alcohol: As the name suggests, alcohol could be considered the "bad" of the gasoline additives. The dictionary lists alcohol a colorless volatile flammable liquid, C2H5OH, synthesized or obtained by fermentation of sugars and starches, and widely used, either pure or denatured, as a solvent, in drugs, cleaning solutions, explosives, and intoxicating beverages. Also called "ethanol," "ethyl alcohol," or "grain alcohol".

Generally alcohol is not considered corrosive like methanol, but does have the same affinity for water and will draw water in from the air. This is a real drawback to good, clean combustion vitally important in all 2-cycle engines. Law requires that more than 10% alcohol (including methanol) must be labeled on the pump.

Methyl Tertiary Butyl Ether (MTBEs): MTBEs are commonly found in the better grades of pump gas. They have no affinity for water, but do not have the excellent octane boosting characteristics of methanol or alcohol. Therefore the percentage needed to boost octane will be considerably higher, up to 15% in many cases. Because this additive lacks the drawbacks of alcohol or methanol, it is considered to be okay for use in 2-cycle engines. On the other hand, it is fairly expensive to produce meaning you will only find this additive used by more famous or recognizable gasolines. Currently law requires pump labeling of MTBEs at more than 15%. While the major oil companies will not be specific for proprietary reasons, Chevron's "Techroline" or Shell's "SU-2000" are some of the places you will find MTBEs.

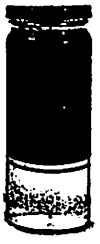


Figure #1—The Olive Jar Test is a sure fire way to detect alcohol or methanol in fuel. Any rise above the marked water level indicates their presence.

Testing For Additives: For what we have discussed so far, the "Olive Jar Test" is an extremely accurate way to spot these additives at the pump. Let's review this method for those readers not aware of how it works. Locate a tall slender glass jar or test tube with a sealing lid. I've seen fancy test kits with markings for percentages on the glass, but the $15 price tag makes them a little silly. An olive jar for less than $2 will do fine after you eat the olives. Permanently mark the jar at a point about 1/4 from the bottom. Fill the jar exactly to this mark with water. Fill the rest of the jar with your fuel sample and seal the lid. Shake the sample vigorously for a few seconds and let stand. Because methanol or alcohol has such an attraction to water, any percentage present in the fuel will mix immediately with the water sample, causing the water level to rise. The amount of rise is, of course, equal to the additive percentage present in the fuel. Of course MTBEs will not show in the test because they lack the affinity for water. The nice part of this test is you can usually get enough fuel out of the pump hose before you buy the gas, although the station attendant may not share your enthusiasm.

AV Gas - Friend or Foe?: Aviation gas is a controlled substance that meets FAA specifications which is largely the reason it sells for considerably more than pump gas. The positive quality of AV Gas is that you will not find any strange additives and certainly not alcohol or methanol. Any water found in AV Gas is a result of poor storage and testing by the FBO and can be removed easily with the use of a water separator funnel. More about this device in a minute.

AV Gas is found in three grades: 80 Low Lead (red in color) is becoming rare as it is only used in older Lycomings and Continentals. If you must rely on AV Gas, 100 Low Lead (blue in color) is the best choice for your Rotax. But the lead content will foul plugs quicker and will lead to more carbon deposits than unleaded fuel.

The third grade of AV Gas is 100/130 Octane (green in color) and should be avoided for use in a Rotax. At most airports you will find only 100LL or 100/130LL.

STC-Certified Auto Gas is available at some airports. Generally the octane rating is considered too low for use in Rotax engines. Certified auto gas is allowed to have MTBEs but not alcohol or methanol. A mix of Certified Auto Gas 50-50 with 100LL would actually be an excellent choice when buying aviation fuel.

Water Separator Funnel: This device is ideal for removing water from gasoline. Just use the device like a regular funnel every time you transfer fuel. A special fine mesh screen filters out debris particles down to .005 microns and all water contained in fuel. A special sump captures the water as the fuel passes through the filter. This device is nearly 100% effective with the exception that some additives will assist a small amount of water through the filter screen. At my forums at Oshkosh the last couple years, I performed my best David Copperfield impression by pouring large quantities of water into this type of funnel. Nothing comes out the bottom! Next pour a fuel sample in and the fuel goes right on through. This year an old-timer approached me afterwards and said this idea is really not that new, he used a regular steel funnel lined with an old chamois skin for years before this device was available. So much for magic tricks!

A Mr. Funnel brand funnel is available in two sizes: 2.5 gallons per minute (about $10) and 5 gallons per minute size (about $25). It's an excellent product used by many safety-conscious pilots. Technically speaking, the funnel should be grounded with a safety ground strap during use. In rare instances, static electricity has created sparks and fires during fueling. A simple length of wire and two alligator clips works fine.

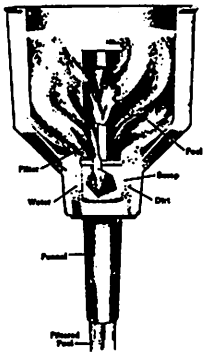


Figure #2—A water separator funnel, brand name Mr. Funnel, is a real necessity in the fight against problems associated with the use of oxygenated fuels.

Problems With Water: Now that you can see how to keep water out of your fuel, we need to explain why this is so important. In a regular 4-cycle engine, water in the fuel is nowhere near as deadly as in a 2-cycle engine. Unlike 4-cycle engines which use a dedicated lubrication system, two-strokes are lubricated by the fuel mixture which means all moving parts come in contact with the fuel.

Water causes two problems. First, like all metal parts, the crank and piston parts are highly susceptible to rust when exposed to water. Water also collects at the bottom of a fuel tank where the pickup line can suck it up all at once. This usually results in stuck rings and massive carbon deposits in engines even right after rebuilds. Oftentimes this is falsely blamed on "the oil."

Choosing A Two-Cycle Lubricant: Premature failures of con rod bearings are becoming a new problem plaguing 2-cycle engines. It is my opinion that this is a result of more exposure to oxygenated fuels (water) as well as pure synthetic 2-cycle lubricants with reputations for poor rust protection. Yes, that's right, I am pointing fingers at (or is it more like sticking my head in the lion's mouth?) some brands that boost superior quality lubrication through the use of "pure synthetic" ingredients. In actuality, these products are alcohol- or ester-based products. It has long been the Achilles heel of synthetics that they do not provide sufficient protection from rust or "inter-granular corrosion" as I have heard it stated by Rotax factory engineers. Makers of pure synthetic oils will insist that they have additives that take care of the poor rust protection problem, but the field results just aren't bearing this out. I have always advocated at least a substantial percentage of mineral base oil for rust protection. Due to oxygenated fuels, it is more important than ever to select the proper 2-cycle lubricant. [See Part #23, "Understanding Two-Cycle Lubricants," *Ultralight Flying!* magazine, June 1990 for more information.]

Conclusions: Now that we no longer avoid the presence of oxygenated fuels (unless you run AV Gas), what should the smart operator do to avoid falling victim to their ravages? Here is a guideline to follow:

1. Don't be afraid to ask questions. Asking the minimum wage employee at the Gas-Food Mart what type of additives his gasoline has is obviously a waste of time. Check the pump for additive warnings. It is law that over 10% alcohol and 3% methanol must be labeled as such.

2. Use the Olive Jar Test religiously. If you see an abundance of alcohol or methanol, move on to another gas station. Avoid the Rotten Robbie Brand gasoline (yes, there is actually a chain of stations in California that go by this name!). While their prices may be the lowest in town, it goes to reason that the quality of the gas may be too! Use only nationally known brands' high octane (91 or better) unleaded fuel.

3. Use a water separator funnel every time you transfer fuel. Be sure to use a grounding strap to avoid static spark.

4. Always agitate fuel tanks completely after mixing and before flight.

5. Never use fuel that is more than two months old. Old fuel is likely to have breathed off a good portion of its octane and has had time to attract water.

6. Always drain carburetors and fuel tanks before prolonged storage. Methanol should not be given all winter to eat away component parts.

7. Always use an oil with at least a substantial mineral base component, especially if you fly less frequently.

8. If you insist on using pure synthetic oils, be sure to run a mineral-based oil in the crankcase before prolonged storage.

Hopefully these guidelines will help take the mystery out of the oxygenated fuel situation. Remember there will never be a replacement for an educated operator and a good program of preventative maintenance.