Autogas vs Avgas

We extended our questions and investigation to virtually everyone involved in the process. Consider it all before deciding if it's for you.

by Mike Berry

There are many questions on the safe use of autogas as a substitute for avgas. Our goal is to present the facts from a broad array of industry people, not just the engine manufacturers.

This includes fuel system engineers, autogas manufacturers, the EAA, engine makers, major autogas STC holders, and the like. We thank all the companies and individuals for their cooperation and assistance.

Petersen Aviation was especially helpful to us. This company represents the lion's share of the autogas STCs, with over 30,000 in the field sold by them.

If you decide to use autogas, *LPM* can help you understand the requirements in accordance with the STC. With more than 50,000 total STCs issued for the use of autogas in low-compression piston engine aircraft, it would hardly seem that there is a problem with the use of autogas in aircraft.

That statement is based on users closely following the STC, including testing the fuel for alcohol or other problem agents or contaminants.

Airplanes that have been approved for use with autogas run the gamut. Being able to burn autogas is a real boon to such high fuel usage engines. ft also enables operation where avgas may not be readily available. Petersen photo.

The promised benefits from using autogas are increased economy in terms of the price of the fuel and a reduction of wear of certain engine and airframe parts such as spark plugs and exhaust system components.

Chemistry

The formulation for aviation gasoline continues to be relatively unchanged for the past 50 years.

It must satisfy these basic requirements: 1) Vaporization must occur easily at low temperatures but yet not so easy that it will cause vapor lock; 2) It must have a high energy content per unit weight (BTU), and permit high compression engine operation without detonation; 3) It must be relatively free of gum-forming compounds; 4) It must have a low sulfur content to reduce corrosive action; 5) It must be stored and delivered free of contaminants.

Volatility considerations are important because of the effect on carburetor icing and "vapor lock." Vaporization of fuel in the carburetor venturi cannot take place without heat being extracted (latent heat of vaporization). If too much heat is taken out during the vaporization process there is danger of carburetor ice forming with float-type carburetors.

Highly volatile fuel extracts more heat from its surroundings than does a less volatile fuel and tends to allow vapor (bubbles) to form in the fuel lines.

Bubbles in the fuel delivery system, prior to reaching the point of atomization in the carburetor, cause an interruption or reduction in fuel flow (vapor lock) and complete or partial engine failure due to improper fuel-air mixture. Reid vapor pressure is a measure of fuel volatility and is closely monitored and controlled within an acceptable range for use in aircraft.

Achtung, Octane

Octane ratings for aviation gasoline have been rated differently than automotive gasoline in that actual fuels are tested in aviation engines. They are rated according to an antiknock value or "performance number" based on octane values lower than 100-octane or performance-rated for fuel rated at 100-octane or higher.

The term 80/87 describes the observed actual performances (resistance to detonation) when the engine is operated with a lean condition (80-octane) and then rich condition (87-octane).

Automotive fuels are not rated in this way but use an "antiknock index" and an average of the research octane method, and motor method.

The antiknock index posted on autogas pumps is approximately five points higher than the actual octane rating of aviation fuel—thus an antiknock index of 87 posted on an autogas pump would equate to about an "average" 82-octane aviation fuel. Autogas STCs for 80-octane aviation engines require a minimum of 87-antiknock index.

Leaded aviation fuels use tetraethyl lead in small quantities, primarily to improve antiknock qualities, and is a necessary additive to aviation fuel to produce 100-octane or greater fuel. Lead is also used to provide lubrication of upper cylinder components such as valves, pistons, cylinder walls and valve guides.

Currently, 100-octane 100LL) av-gas contains about 2 grams of lead per gallon and 80/87-octane contains 0.5 grams per gallon.

Additives

One problem with lead mixed with avgas is that lead requires the addition of a bromine compound to scavenge lead residue from the engine.

The burning of the lead with the bromine compound produces lead bromide that is carried out with the exhaust gasses; however, a small amount remains within the engine. This lead bromide, when mixed with water, metals, and lubrication oil, produces a corrosive liquid very damaging to engine components.

Significant water is produced as fuel is burned. The presence of water and the corrosive properties of the lead bromide are always lurking to damage an engine.

This lead bromide by-product is just one of the reasons why aviation lubricating oil is different from automotive lubricating oil. (Note aviation lubricating oil, according to engine makers' specs, should always be used in aircraft engines regardless of the type of fuel used.)

Engines that are operated infrequently are prime candidates for damaging corrosion from this corrosive mixture of water and lead bromide. The corrosive effects of lead bromide can be reduced by regular flying, frequent oil changes according to manufacturers' specs, and preservation of engines not operated frequently (at least once a month).

Additional additives to avgas are compounds such as dye, for identification purposes and aromatics such as benzol to resist knocking. Toluene is added to make for low freezing point, good volatility, and rubber solvent properties less damaging than benzol. In addition to these compounds there are other compounds blended in small amounts with avgas for reducing gum residue.

Fuel Purity

The requirement for purity in aviation fuel is a given; gasoline must be free from all impurities such as water, dirt, or other fuels and additives. Additives not certified for aircraft use should not be added to fuels as their performance numbers may be adversely affected, and these possible reductions of antiknock properties have not been tested or approved for aircraft.

Of the several lead substitutes sold in automotive supply stores that have been tested, none have proven to be beneficial for aviation engines.

Automotive additives that claim to remove water from fuel ("dry gas") should not be used, as often these are just alcohol and are not to be used in aviation fuel systems. It cannot be stressed enough to use only additives proven and tested for use in aircraft.

The most unwanted impurity in gasoline (auto or aviation) is water. The transfer of fuel from cans, external fuel tanks, or other non-aviation transfer systems introduces the possibility of water mixed into the fuel.

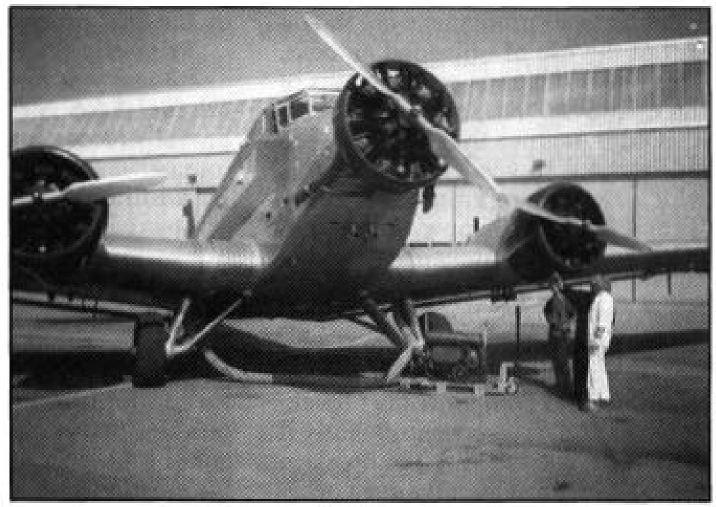
Care must be taken to ensure that a filter system or other water removal device is used. One such device is a fuel-water separator funnel available from Aircraft Spruce under part number F3C or F8C that allows the user to see water or other contaminants that are in the fuel filter/funnel. They're important when fueling with cans directly into an aircraft fuel tank.

Aircraft fuel filters are limited in capability, and can remove only a small amount of water or contamination in the fuel before allowing water to pass directly into the fuel delivery system.

Operators with Marvel Schebler float-type carburetors should at least annually drain the float bowl and check for contaminants. Check the finger screens for contamination whether autogas or avgas has been used. Water introduced into aircraft fuel injection systems is extremely damaging and expensive, as damaging rust can develop in a matter of days.

Old Issues

While many mechanics and repair shops do not recommend the use of autogas, this seems to be founded partially on facts from problems experienced several years ago.



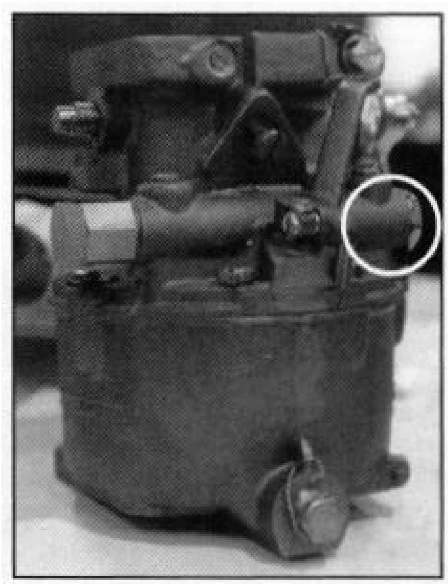
Autofuel testing and certification is not limited to the U.S. Here aJU-52is being prepped for fuel testing in Switzerland under a Petersen license. Petersen photo.

Power plant and airframe manufacturers continue to not be in favor of the use of autogas in their products as well.

With continued testing and monitoring of operations using autogas, a wider experience level is being established and autogas problems generally have not been as significant now as in the past.

The major complaints of years past from mechanics was that upper

It's imperative to check carburetor filter screens regularly for any signs of contamination of any sort to keep the dean side of the airplane up.



cylinder wear problems were the Fe-suit of the use of unleaded autogas. This really depends on the status of the cylinders.

Older engines that had not seen an overhaul in years had old parts, which were more vulnerable to unleaded fuel. With new, hardened, valve system components designed for 100-octane fuels, the upper cylinder problems of the past are now mostly history.

Secondly, the initial high wear of cylinders and components at breakin have been reduced significantly if avgas was used during the break-in period and subsequently used occasionally to keep some lead "varnish" on the cylinders and valves.

Industry Disdain

In discussions with many aviation engine, airframe and fuel system manufacturers as well as avgas and autogas manufacturers, all have stated that they do not recommend, approve or suggest that autogas be used in aircraft. Furthermore, many go so far as to disallow warranty claims because autogas has been used in their products.

A few engine shops polled and at least one aftermarket cylinder manufacturer did not come out and say warranty would not be honored, but highly discouraged its use and said that the decision would be made on a case-by-case basis.

There are several more reasons for this industry discouragement for the use of autogas in airplanes. This is in spite of the acknowledgment by the FAA that autogas has been approved (after many hours of testing) for use in many low-octane airplanes

Autogas test rig as used by Petersen Aviation for dynamic testing of engines to obtain autogas STCs for specific engine models. Petersen photo.

by the STC process.

Primarily it's the liability issue, as autogas was not tested during the original FAA certification and approval process for engines and airframes.

Additional problems cited by every manufacturer are: 1) Quality control verification of autogas is not the same as avgas. Several major fuel companies were contacted (Shell, Texaco etc.) that supply both auto and avgas confirmed that the quality control is not the same once the product leaves the pipeline. 2) Alcohol mixed in autogas is not safe for aviation use, and it is up to the user to determine the presence of alcohol in the fuel.

All autogas STC limitations specifically state that alcohol mixed with autogas is not approved. 3) Vapor pressure of the autogas can vary widely as formulations are changed seasonally, and according to local requirements. High vapor pressure can promote vapor lock in aircraft fuel systems causing engine power to be reduced or the engine to completely fail.

Additionally, tests by the FAA technical center have concluded that autogas with high vapor pressure can accelerate the formation of carburetor ice in aircraft equipped with float-type carburetors. Some aircraft are more susceptible to carburetor ice than others, so this is an issue of concern.

Just the Facts

To address this issue for the use of autogas, consider the following: Avgas usage in the US is approximately two percent of the autogas used for cars and trucks. With these proportions and the EPA, it's clear we're fighting an uphill battle for avgas status-quo.

The quality of avgas is maintained and traced from the refinery to the aircraft fuel tank as evidenced by recent troubles of contamination of avgas supplies and wholesale replacement of aircraft engines at the expense of fuel companies as a result.

In addition to the tracking and purity verification during the transportation of avgas, the leaded aviation fuel can only be transported in dedicated tanks as leaded fuel cannot be transported trucks or pipelines used to transport unleaded fuel.

No matter where you buy a~ it is the same quality, and consistency no matter who sells ii "makes it." That cannot be said autogas. With high autogas volume. the distribution and supply system is very different and could not n the same quality verification that avgas is subjected to. Typically refinery supplies a large amount "generic," single-grade, unleaded autogas to a pipeline system with fuel shipped to several storage far ties in major metropolitan areas throughout the US.

When the fuel reaches the storage facilities it is transferred to tank trucks and at this time various additives, dyes, detergents, and other chemicals are added to the fuel give the fuel its branded identity a grade. No specific tracking or tracing of the autogas is done to determine what was added to the fu who transported it, and what ret outlet received the fuel.

A Pinch of This...

Additives are added to satisfy myriad state, federal (EPA) and local regulations, and seasonal requirements, including wintertime oxidizers. Alcohol is frequently mixed with gasoline in varying amounts up 10% so as to satisfy the requirement for air quality and sometimes as a way to boost octane for less cost than other additives.

These additives can have an adverse impact on the energy content of autogas, so the lower cost autogas can sometimes be offset lower energy values and decrease range on an airplane.

With the discovery of MT] (autogas additive) as a contaminant of ground water systems, the addition of alcohol to autogas is becoming more prevalent.

Alcohol/gasoline mixtures, whether Ethanol or Methanol, ha never been approved for use in a craft with autogas STCs. Alcohol is known to entrain water, which could cause water in fuel to freeze at low temperatures when aircraft climb higher altitudes.

Fuel volatility is increased with the addition of alcohol, and the vapor pressure obtained with the use of the Hodges Reid vapor pressure tester sold by Petersen Aviation will reflect alcohol in the fuel by its reading—but not the alcohol itself, which must be checked by a different means.

Therefore, it is important that fuel be tested for alcohol presence, as fuel station operators frequently do not know if the fuel they are selling contains alcohol.

There is an easy way to check for alcohol in the fuel you buy with an inexpensive, simple test kit available from Petersen Aviation at (308) 832-2050, www.webworksltd.com/petersen or Sporty's pilot shop (800) 543-8633. They offer improved test kits for octane range and alcohol presence.

Alternatively, another graduated cylinder method with instructions is available from the EAA (920) 426-4843) as listed on their web site www.EAA.org, regarding autogas STCs.

Generally, with a careful mix of nine parts gasoline and one part water, shaken thoroughly, and allowed to stand for 10 minutes, this mixture should yield the same amount of water and gasoline by volume. If the amount of "water" appears to increase, then suspect alcohol mixed in the fuel and separated out with the water.

The Vapors

Vapor pressure problems have been addressed throughout this article and are an important factor to consider when using autogas. Vapor pressure is important as high vapor pressure increases the likelihood of vapor-lock during flight.

Avgas vapor pressure remains constant at a 6.5-psi level regardless of the time of year or area of the country it is used. Autogas vapor pressure is often changed in some parts of the country from a high of 15 psi to a low of 7 psi. (California regulations define a maximum of 7 psi.)

While vapor pressure of automotive gasoline supplied in major metropolitan areas has been limited in recent years in an attempt to reduce air pollution, there are still issues to be concerned with when using autogas in many parts of the country. The chemical makeup of autogas is changed from time to time, and additives contained in autogas alter the apparent vapor pressure. The more varied sources of autogas you use, the more critical your individual testing becomes.

Autogas (intended for use with autos) reacts differently in aircraft fuel systems than automobiles since autos rarely experience rapid temperature and altitude changes (unless dropped out the back of a cargo plane in a TV commercial).

Moreover, most modern autos are equipped with electronic fuel injection, in-tank fuel pumps, and higher fuel operating pressures to lessen the chances of vapor lock.

High altitude operations, high undercowling temperatures with highly volatile fuel, and complex fuel systems all increase the likelihood of vapor lock, as do the convoluted designs of carburetor air boxes designed for avgas. Poor fuel system maintenance such as substitution of parts (90 degree elbows vs 45 degree as specified), replacement of insulated (fire sleeved) fuel hoses with plain fuel hoses, (affecting heat loss or gain) or removal of heat shields in the engine compartment, have contributed to vapor-lock problems. In some cases, avgas was the fuel being used.

As a precaution during periods of high ambient temperature or higher altitude airport operations, check to see that your fuel pressure gauge is indicating within limits, and make a full-power run up check prior to takeoff to confirm the presence of maximum available power.

Failure of vapor lock testing during the STC process is the principal reason why some aircraft are not approved for autogas use although the engine is approved.

That's why both the engine and airframe must be approved as a unit for the autogas STC. It's also why just because a particular engine is fine with autogas in airplane "A," it may not work reliably in airplane "B."

People, unfortunately, do make this erroneous assumption and don't bother with obtaining the STC, if it exists, and operate illegally.

In part deux, next month, we delve more deeply into the specifics of the STCs, as well as 82-unleaded fuel. Stay tuned. You know our email address if you would like to add your opinion.

Mike Berry is an airline captain and an active IA. He is a frequent contributor to LPM *and lives in Spencer, Mass.*

Below, testers from Petersen Aviation. Inexpensive, $10 tester for alcohol is fast and reliable. Bottom, the Hodges Reid Vapor Pressure tester is designed for quick testing of autogas to make sure it's up to STC standards; costs under$50.