# FUTURE FUEL

## AN ABS SPECIAL REPORT

Although there is no official deadline ending production of 100LL aviation fuel, some regulators and industry analysts agree that production of leaded aviation fuels may end sometime around 2017 when states must meet new ambient air standards for lead. Why do we need lead in our airplanes' fuel? What is forcing an end to leaded fuel production? What's happening to keep piston airplanes flying once there is no more leaded gas? And what is ABS doing about the issue of "future fuel?"

**Why lead?** Lead is added to aviation fuel to increase octane ratings and provide a safe detonation margin at high power settings. Without the buffering effect of the lead additive tetraethyl lead (TEL), high-powered airplane engines would suffer adverse effects—ranging from an annoying knock to long-term damage to sudden failure—with little predictability of the outcome until detonation begins.

**Why is 100LL threatened?** Over the last several decades there has been a move to eliminate lead from all fuels to avoid the environmental effects of burning lead. Racing cars were the last non-aviation users of TEL, with NASCAR switching to unleaded fuels in 2003 and now making a second switch to biofuels, and in 2007 the Indianapolis 500 and other events began racing with 100 percent unleaded ethanol. Outside the U.S., only India, and to a lesser extent, Australia, still make any significant use of TEL. While the current 100LL (low lead) formulation of aviation gasoline contains much less lead than in previous fuels, the trend is clearly to eliminate the use of lead entirely.

According to the Aircraft Owners and Pilots Association (AOPA) "…most industry experts agree that 100LL will be unavailable within the coming years. Therefore, a truly viable unleaded replacement for 100LL must be found in the next few years and certified for use in the general aviation (GA) piston fleet." Today there is no true 100 percent unleaded replacement for 100LL that does not require significant modification and recertification of aircraft that require 100LL.

The end of TEL production will be driven by one or more of these factors:

• **U.S. Environmental Protection Agency (EPA)** regulation. America's 1970's Clean Air Act banned all lead from fuels. The aviation industry received an exemption only on the condition that FAA would work to develop a replacement. In 2007 an environmental group called Friends of the Earth sued EPA, stating it has not compelled FAA to live up to its Clean Air Act obligations. U.S. Federal courts ruled in favor of the Friends of the Earth, and in early 2010 EPA published a Notice of Proposed Rulemaking calling for the elimination of all leaded fuels.

• **Transportation costs.** Under current law, pipelines, trucks, tanks and tankers must be purged of all TEL before they can be used to store or transport unleaded fuels to prevent contamination. The time and costs of purging are so great that leaded fuels are transported only in dedicated pipelines, tankers and rail cars. There is only one dedicated avgas pipeline in the U.S. The cost of maintaining a dedicated transportation system for a low-demand fuel (less than half a percent of the total petroleum market) limits TEL production profitability. Meanwhile, major transportation industry unions are beginning to prohibit their members from working with 100LL because of the health risk from lead exposure. Even if production and use of 100LL fuel remains legal, it will become increasingly expensive.

• **Shrinking market.** The quantity of 100LL produced annually is "smaller than tiny," according to AOPA. "Avgas amounts to 0.5 percent of the yearly U.S. gasoline production." Since refineries can produce a three- to six-month supply of avgas during a one- or two-day production run, stabilizing agents and storage also add to the cost.

New aircraft production has declined significantly in recent years. Fewer new airplanes to replace those leaving the fleet mean an even smaller market for leaded fuels. The added costs of producing, transporting, storing and delivering 100LL, spread over a diminishing market, may be too great for the industry to bear as demand drops.

### The "Sole-Source" problem

There is only one producer of TEL additives worldwide, Associated Octel/Innospec in the United Kingdom. To date, Associated has only publicly committed to TEL production through 2010. It has, however, not stated it will *cease* production, either. Even if business pressures do not affect TEL production, the sole source of 100LL additive is susceptible to interruption at any time from fires, equipment failures, natural disasters, employment actions and European political events.

So, if our planes can't fly without 100LL, what will happen if or when there's no more 100LL?

## Create a new fuel

Most fuels research money to date has been allocated to refining new fuels that can be used in existing aircraft. Seventy to 80 percent of existing airplanes have adequate detonation margins at current rated power on a completely unleaded variant of 100LL without modification, according to EAA and AOPA. Unfortunately, most ABS-type airplanes are in the "other 20 percent" that would not have the detonation margin necessary at full power without TEL. AOPA believes that research into new fuel additives able to provide this detonation margin is the best approach for the "other 20 percent" airplanes. But to date, says AOPA, "no additive has been found that is nearly as economical as lead." NASCAR's additive to bring octane up to the 104 level, for instance, pushed its fuel price above $9 a gallon in 2009.

## Unleaded, leaded fuel

Make 100LL but leave out the TEL and you end up with a fuel measured at about 94 octane. Consequently this is sometimes called "94UL." Teledyne Continental Motors (TCM) has recently stated it wants to pursue 94UL as the new-standard fuel. In 2009, TCM and Cirrus flew a TSIO-550-equipped SR22 to Oshkosh on 94UL, showing that, at least under some conditions, 94UL works. More recently, however, TCM has stated its high-compression engines would have to be derated (power-limited) to run on 94UL, and turbocharged/turbonormalized airplanes might not make the cut at all. Meanwhile, Textron Lycoming says its products will not have adequate detonation margins on 94-octane fuel; and the FAA has made it clear that whatever becomes the 100LL replacement must work for *everyone*.

## Auto fuel

For many years lower-compression and lower-horsepower engines (below about 250 hp) have been eligible under U.S. STC authority to run on unleaded automotive fuel—"auto gas" or "mogas." Auto fuel STCs are limited to carbureted engines, including the E-series engines, and a few fuel-injected models, including the 225-hp IO-470 variants used on early Debonairs. An individual aircraft needs *two* auto fuel STCs: one showing engine compatibility, the other showing airframe/fuel system compatibility.

Auto fuel STCs are not compatible with alcohol in fuels (e.g. the ethanol/gasoline mix you typically put in your car). Alcohol additives have been shown to cause deterioration of fuel bladders and seals in aircraft. Most U.S. states now require alcohol in automotive fuel at least seasonally. This means pilots flying with auto fuel may still require aviation fuel at least part of the year. Pilots flying cross-country need to test individual fuel sources for alcohol before fueling the airplane. The Experimental Aircraft Association (EAA) says it is "not doable" to obtain auto fuel STC approval for higher-powered engines, or for the use of fuel containing alcohol in those airplanes already eligible for auto fuel STCs.

AOPA and EAA are both lobbying states to preserve 91-octane "premium" auto fuel as an "untarnished" blend containing no alcohol, as a source of fuel for airplanes being operated under auto fuel STCs (as well as vintage automobiles and other vehicles that may be harmed by alcohol in fuel). This will require a state-by-state effort for that to be successful, and again, will only apply to engines currently eligible for auto fuel STCs.

## Ethanol

The University of North Dakota has flown an IO-360 (200-hp) Mooney powered (in cruise) with what it calls "AGE (Aviation Grade Ethanol) 85"—a proposed straight-ethanol aviation fuel. AGE85 has since been dubbed simply "AGE" to avoid the widespread assumption that the "85" indicates the octane rating, which is not the case.

AGE is more powerful and cooler-running than 100LL. Whereas a test-cell engine was determined to develop 195 hp on 100LL, on AGE the engine was measured to develop 240 hp with lower CHTs and a satisfactory detonation margin. The downside is that AGE requires substantially higher fuel flows to achieve the same power—fuel flows increased 43 to 47 percent in a test Cessna aircraft, and aircraft range is reduced 20 to 40 prcent compared to 100LL if flown at the same true airspeed. If price estimates and range reductions are accurate, flying with AGE would not be much (if any) less expensive than 100LL is currently, although it would address the availability issue.

There are safety issues with AGE that still need to be resolved on materials compatibility with airframe parts, including common aluminum alloys, soft parts such as fuel bladders, and rubber parts such as hoses and O-rings. There are also calibration problems with fuel indicating systems, incompatibility problems with fuel-fired combustion heaters and AGE instability during long-term storage. Further, most ethanol comes from food grains, and already there have been issues concerning crop production turning from food to fuel.

## SwiftFuel

One promising proposed 100LL replacement for higher-powered engines is a biofuel being developed by Swift Enterprises. Testing has been very encouraging, and Beech has test-flown an IO-550 Bonanza with SwiftFuel that it says can meet all certification criteria. The fact that it is a non-petroleum product made from biomass waste products, rather than primary food sources (like ethanol), makes SwiftFuel an even more attractive replacement fuel.

Swift Enterprises says it can produce its product in any of the numerous inactive ethanol plants that did not survive the economics of recent years, and since it has no lead, it does not require a dedicated transportation network. The biggest challenge to SwiftFuel as a 100LL replacement may not be technical hurdles, but the business economics of creating a large-scale production capability.

## GAMI's G100UL

General Aviation Modifications, Inc. (GAMI) entered the race fairly recently, after being involved in test-cell research for SwiftFuel. GAMI has a proprietary fuel formulation (actually, a series of possible formulations) that maintains detonation margins at 100 octane levels, meaning if it works as advertised, it is a "drop-in" fuel for 100LL engines with no loss of power or performance.

GAMI is negotiating the fuel's approval process through a parallel track of American Society for Testing and Materials (ASTM) approval and STCs for turbonormalized IO-550s, with a plan to expand to other engines after receiving initial approval. If successful, GAMI hopes to license production of G100UL to existing fuels suppliers to utilize existing production and transportation networks.

## Modifying existing engines

**TCM's POWERLINK™ system** - Teledyne Continental Motors' POWERLINK FADEC (Full Authority Digital Engine Control) system may permit existing higher-horsepower engines to achieve acceptable detonation margins on unleaded blends of aviation gasoline (94UL). The Cirrus that flew on 94UL to Oshkosh employed a TCM FADEC. To date there have been very few POWERLINK installations in Beech airplanes, but it is certified. Low acceptance of TCM's $8,900 (plus installation) POWERLINK may be due to the lack of a current imperative for the installation.

If a deadline is set for eliminating 100LL, POWERLINK would likely become much more popular among Beech owners. In a 2008 press conference, TCM said it was working on an improved "Generation II" FADEC designed specifically to address operation with unleaded aviation fuels.

**GAMI's PRISM™ system** - GAMI has publicized its PRISM (Pressure-Reactive Intelligent Spark Management) FADEC system as an answer to future 100LL unavailability. It has been tested successfully using a custom shipment of "unleaded 100LL" GAMI says is rated at about 95 octane. PRISM is a more sophisticated design than POWERLINK and is hotly anticipated by many Beech owners. GAMI has not yet published an anticipated kit or installation price. The first *ABS Magazine* reports of what has come to be called PRISM appeared in 2000, and there is as yet no public timetable for its certification.

## Replacing engines

Another option is to replace existing engines with new types that do not require leaded fuel. Most frequently, this means diesel engines, in large part because they can fly using jet fuels that are abundant and relatively inexpensive worldwide.

TCM announced in May 2010 it is "fast-tracking" certification of a diesel engine in the 350-hp range, presumably aimed at new Cirrus production but also retrofitable to Beech airplanes. Other manufacturers are working on Jet A-powered diesel aircraft engines, but all seem to be aimed at the 150-200 hp class, inadequate for even the lightest Bonanza airframe.

Whereas octane for avoiding detonation is the issue with spark-ignited fuels, cetane for combustion is the determinant for diesel powerplants. There is no minimum cetane specification for Jet-A fuel, and the cetane content varies widely from batch to batch. This means the pilot of a diesel airplane does not know whether the engine can develop rated power without testing the fuel for cetane at every top-off. For diesel engines to be certified under U.S. rules (as opposed to on the basis of foreign certification), the certification of Jet-A would have to be changed, and fuel suppliers alter their processes, to ensure a consistent cetane level.

## What is ABS doing?

ABS is investigating "future fuels" on several fronts. For a number of years we have kept in close contact with AOPA, EAA, TCM, GAMI and Swift Enterprises on their respective programs. In late June, ABS Executive Director Tom Turner met with technical representatives from General Aviation Manufacturers Association (GAMA), AOPA and EAA for a detailed briefing on the current state of 100LL replacements. Planned meetings with GAMI and perhaps Swift Enterprises will also have taken place shortly after this magazine goes to press.

ABS is in discussions with the Cirrus Owners and Pilots Association, the (Piper) Malibu/Mirage Owners and Pilots Association and other owners groups with a stake in 100-octane fuels, to see how we may best combine our voices and resources to ensure that a suitable fuel is chosen.

We have also reached out to the ABS membership for persons with expertise in fuels to help ABS develop a future-fuels policy. Watch ABS NEWS at www.bonanza.org for the latest in developments as they occur.

It's not certain what will replace 100LL. But if 250 hp-plus, piston-powered general aviation is to continue, we *will* need a replacement, later if not sooner. Several options show promise, including new types of fuel and engine modification technology. It's not known yet which will prevail, what it will cost us, or what *if any* compromises will be required. But it's very encouraging that, even as personal aviation comes under increasing scrutiny and attack, so many are doing so much work to solve the problem of future fuels.

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**What do you think?** Should ABS be addressing the "future fuels" issue? And if so, how? Let us hear from you in the 100LL Replacement Fuels forum on ABS Hangar Flying, or by contacting ABS headquarters.