Fuel for the Future - PART I

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Many decades of lead in aviation gasoline is likely to go away sometime during the next several years. When that happens, it will become a problem for all the 260 hp, 285 hp and 300 hp Beechcraft fleet.

There is probably more misinformation on the subject of aviation gasoline, lead and octane than almost any other area of general aviation. The only exception that comes to mind is the now resolved issue over lean-of-peak (LOP) engine operation that raged for a decade after GAMI introduced its novel fuel injectors in 1996 that enabled many engines to successfully operate LOP EGT/TIT. (One estimate suggests that the widespread adoption of the LOP engine operating technique since 1996 has saved general aviation more than 140 million dollars worth of avgas.)

TERMINOLOGY DEFINED - It is important when dealing with a technical subject such as this one to be clear with the terminology, so here are some definitions:

Motor octane number (MON) The octane number of gasoline is determined by subjecting a sample of the gasoline in question to testing on a specific, made-for-purpose small laboratory engine that is calibrated by reference to a designated reference fuel, known as isooctane.

A gasoline that operates detonation-free when leaned to the same high level of power on the laboratory test engine, as does isooctane, is defined to be a 100-motor octane number fuel. This test was developed during the 1930s, and became a standard just before WWII. Note: Do not confuse MON with other octane measures. MON is the real thing!

Research octane number. Another measure. Forget about it. It is largely a "car thing," with little application to aircraft under present circumstances.

(R+M) / 2. Another car-thing octane rating. Forget about it. That is the research octane number added to the motor octane number (MON) and divided by two. It has little to do with aircraft. It is on every car pump at every local gas station.

D 910 Spec. This is the American Society for Testing and Materials (ASTM) D910-07a specification for purchasing agents to use to define the universal Grade 100LL avgas that we all use as well as several other grades.

FBO 100LL. This is a term commonly used by people involved in research for a replacement for the fuel you get from your local Fixed Base Operator. It not only meets the D910 Spec for octane (99.6 MON, minimum) but typically exceeds that value and is typically measured at around 102.5 MON from most FBOs.

Min-Spec 100LL. This is another term used by people involved in research for a replacement for 100LL. This is a fuel that would just barely meet the D 910 Spec for Grade 100LL fuel. It would typically have a MON value of around 100 to 100.5.

Rich Rating. Another octane rating. This one is an airplane thing. It is important for the high-powered supercharged engines and turbo supercharged engines, like a Duke or a 325-hp P Baron. There is a long list of aircraft for which this number is significant: B36TC, Malibu, Mirage, Navajo, Cessna 400 series, Cessna P 201, T210, etc. It is the number that defines how the engine operates with a rather rich mixture, which is very different from how it operates with a less rich and more typical mixture, associated with the MON.

Tetraethyl Lead (TEL) was discovered in the early 1920s. A lot of people think it was later in time and that the introduction of lead into aviation gasoline saved the British in the Battle of Britain. Maybe. But lead in gasoline had been known for well more than a decade before the Battle of Britain in the summer of 1940. The real story there is the discovery in the United States, just before the war, of an efficient means to refine from heavier oils, large volumes of high octane gasoline using the then newly developed sulfuric acid alkalization process–and then combine that with the previous discovery of TEL–and get the magic performance of 100+ octane fuel from the Hurricanes and Spitfires. –GWB

When "airplane engine people" talk about octane, they always mean either MON or "Rich Rating."

Some recent history

Two years ago at Oshkosh in the summer of 2008 everybody was in a buzz about Swift Fuel. A "bio-fuel" that had high octane. But one of the dominant components is not commonly manufactured in refineries at the present time. Swift Fuel has been tested. The FAA has tested it. GAMI tested it at about the same time as the FAA and confirmed the results that the FAA obtained in September 2008. Swift Fuel has a performance with respect to detonation resistance that is on a par with the nice FBO 100LL we all enjoy flying in our aircraft.

Further, there is hope that the Swift Fuel effort can succeed in acquiring a manufacturing facility and that they could thereby manufacture that fuel at reasonable prices. Right now, the Swift Fuel is a "binary fuel." It has two primary components. One of them, the one that makes up about 82-85 percent of Swift Fuel, is very expensive. Even in shipload quantities, it is over $8 per gallon, as a raw material. The hope is that Swift fuel can figure out a less expensive way to make that component and then industrialize that process.

Also in 2008, the EPA started making the rounds of the general aviation piston world with a simple message: *"...we need the FAA and the general aviation industry to cooperate with us to get rid of the lead in aviation gasoline."*

That message included the observation that lead from aviation gasoline is the largest single source of lead in the atmosphere. (There is

very little hard data that lead from aircraft harm anybody, but that is another discussion.)

In 2009, the EPA said the same things. Once again, at Oshkosh, I was there. I saw that. But the general aviation community, including the alphabet groups, were largely not paying attention anywhere near as closely as they should have been.

In November 2009, I watched the EPA point person, Glen Passavant, make a presentation at the AOPA convention in Florida. I observed him engage one of the key FAA representatives in a rather pointed conversation before the presentation. It was obvious to me that Mr. Passavant was not a happy camper. I watched him closely after his presentation when he was down on the floor after the meeting and was surrounded by a number of ordinary pilots who were asking him questions. One of the questions was something like "...what kind of cooperation are you getting from the FAA.?" It was clear from his response, which was all perfectly correct in a bureaucratic manner, that he was, none-the-less, very unhappy with the lack of progress that had been made in the previous two years.

At that precise moment, I became convinced that the EPA was going to push forward and that sometime in the following six to eight months the EPA would publish in the federal register a formal notice to begin the process to issue an "endangerment finding." [Note: In April of this year (2010), they did.]

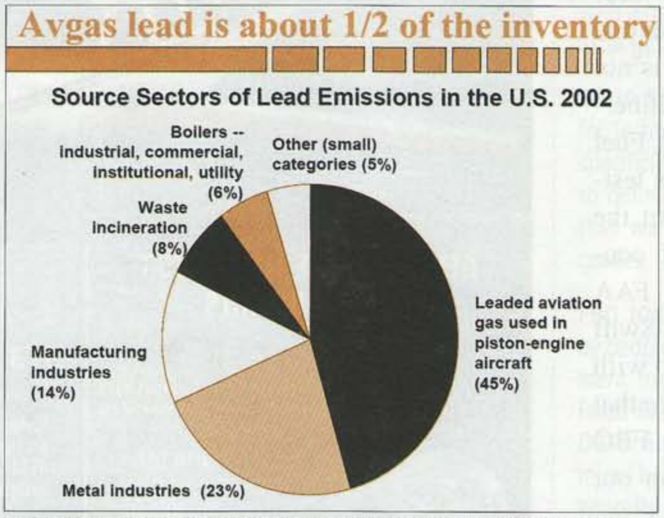

Figure 1: Pie chart from EPA Presentation to the American Society for Testing and Materials (May 2009).

Tim Roehl (President and co-founder of GAMI & Tornado Alley Turbo) and I left the AOPA "Summit" in early November, and went back to Oklahoma. Discouraged. The industry was built on engines that simply would not run "good enough" on 94 octane unleaded avgas, even with all sorts of magic electronic doo-dads. (We designed one of these electronic doo-dads and built and tested it in 2001, and it works better than all of the rest of them. Thus, we do have some considerable appreciation of the limitations and capabilities of electronic engine controls.)

This requires a bit of further elaboration. In the last 10 years, a large number of high-performance aircraft owners have become accustomed to operating their engines very efficiently at very high power settings (75, 80, 85 percent of rated power) while still remaining LOP. This enhanced operating technique brought the first significant new performance and fuel efficiency improvements to general aviation piston aircraft since the introduction of the TSIO-520 series of engines nearly 50 years ago in the 1964-1965 time frame. The current widespread acceptance and use of this efficient operating methodology is almost entirely due to the efforts of GAMI and the Advanced Pilot Engine Management Seminar series.

The crisis from the EPA threat to 100LL now puts all of that now commonly accepted and greatly appreciated "high" performance and increased fuel efficiency seriously at risk. While it is true that the electronic controls can allow most of our engines to operate on lower octane fuel, they simply will not be able to operate in the same extremely efficient way that TN Bonanza and Malibu and Cirrus pilots now routinely enjoy—*unless we find a legiti-*

This is likely the only aircraft engine test facility outside of the FAA tech center that has detonation sensor equipment installed on a high compression turbocharged engine that can measure aircraft engine detonation in the same precise manner as the FAA reference method." —GEORGE BRALY

GAMI's aircraft engine test facility and small fuel farm off to the right.

mate replacement for 100LL avgas, or something that performs very close (within 1 or 2 octane points.)

Back at GAMI, in mid-November 2009, Tim Roehl and I decided to try out a theory I had developed on avgas components and fuels that we had been thinking about for several months. There was then a nearly "universal understanding" about how "unleaded" high octane avgas "worked" or didn't work. However, we suspected that there might be a class of unleaded avgas components that would behave differently than what was then (and until our research last winter) universally believed to be "true" in the avgas R&D community.

Of course, it did not hurt anything that we already had a high compression IO-550 engine, fitted with twin turbochargers, sitting on our test stand—along with a very expensive system for precisely measuring internal cylinder pressures and associated detonation events. Even the engine OEMs were not set up to do that kind of critical fuel testing. So we did what any pair of red-blooded American entrepreneurs would do under those circumstances. We put together a little 40-gallon test batch of fuel and tried it.

It worked. First time. We didn't believe it. So we kept trying it over and over again. It kept working. What do we mean by "working"?

We have this very nice capability to "compare" up to three different fuels against each other during a single test stand engine run.

The fuel farm supplies three separate fuel streams to each of the two engine bays. At those bays, very close to the engine, is a set of solenoid valves. We can "switch" the engine from one fuel to another. Because the fuel line from the solenoid manifold is so short, it only takes about 20 seconds for the fuel to fully "change over" from one fuel to another.

After convincing ourselves that this new fuel worked, we gave it a name: G100UL. We filed a series of patents. (There are multiple ways to "make" G100UL fuel.)

We then asked the FAA to let us obtain an STC for the use of that fuel on the fleet of turbonormalized SR 22 Cirrus and Bonanza aircraft over which we already owned an STC for the turbonormalizing systems. That was December. December 2009.

In Part II, George Braly will provide evidence that G100UL performs as needed and an update on action (and inaction) since last December.

—Editor