AN ABS SPECIAL REPORT

FUTURE FUELS

Additional news on the subject of alternative fuels—GAMI G100L and SwiftFuel UL 102.

GAMI's G100UL

ABS Executive Director Tom Turner and Board Technical Committee Chairman Tom Rosen traveled to Ada, Oklahoma, on July 14 for a detailed briefing on GAMI's proposed G100UL fuel. G100UL is designed to provide the same detonation margins as 100LL but without harmful substances like lead.

The demonstration was originally scheduled specifically for ABS, but grew into a larger industry event with Teledyne Continental Motors Chief Engineer Bill Brogdon, Twin Cessna Flyer Technical Advisors Tony Saxton and Tim Meyer, Cirrus Co-founder Alan Klapmeier, and volunteer ABS Future Fuels Member Advisory Committee member John Whitehead participating.

After a short facility tour, the group spent roughly two hours in the control room of GAMI's engine test cell with George Braly (GAMI's lead engineer). Braly explained fuels performance at length, then led a real-time demonstration of detonation performance of G100UL, the standard "FBO-quality" 100LL fuel (which measures at about 102 octane), and a minimum specification, or "min-spec," 100LL, representative of a "worst case" 100LL formulation. Min-spec 100LL does not usually get into the distribution network, but is used as a certification standard fuel. It tests at just over 100 octane.

Tests were run on a turbonormalized IO-550N engine as installed on the Cirrus SR22, boosted for purposes of the tests to about 350 hp. The version of G100UL fuel used for the demonstration is a "middle of the road" G100UL fuel. Braly explained it is rated on the laboratory engine at about 98.5 octane, but has better detonation margins on the full-scale aircraft engine than min-spec 100LL, but not quite as good at FBO 100LL—"about 60 percent above min-spec," according to Braly. That was consistent with the engine run we observed.

The test demonstration was followed by a boardroom presentation on fuels formulation and discussion of the approvals process. We were joined by GAMI President Tim Roehl. Using lab analysis of 100LL samples, Braly demonstrated the wide variance in the chemicals used to create existing 100LL and the argument that the specific 100LL formulation is precisely controlled does not hold up.


George Braly, Tom Rosen and Tom Turner in GAMI's engine test cell control room.

Braly clarified GAMI's strategy of pursuing a dual track of (ASTM) American Society for Testing and Materials certification of its fuel specification and an STC for turbonormalized Bonanzas and Cirrus SR22s. With an approved STC in place and a small number of airplanes actively flying with G100UL ("30 to 50 airplanes," obtaining fuel at Ada and perhaps one or two other locations with high concentrations of turbonormalized SR22s," says Braly), fuels manufacturers could develop a confidence that the product works and has a market.

No fuel firm will commit to production without this confidence, says Braly. And without production, obtaining STCs for additional airplane and engine types is pointless.

GAMI dispelled a fairly widespread view that it was trying to "short-cut" the approvals process based on its earlier public statements it is pursuing STCs to get airplanes to "generate data" on flying with G100UL.

Tim Roehl and George Braly of GAMI; TCM Chief Engineer Bill Brogdon; Alan Klapmeier; ABS Technical Committee Chairman Tom Rosen; Tony Saxton of *Twin Cessna Flyer* magazine; ABS Executive Director Tom Turner; Tim Meyer of *Twin Cessna Flyer*. Not pictured: ABS Member Advisor John Whitehead.

GAMI has proposed to the FAA that it be allowed to follow the long standing FAA Advisory Circular AC 20-24B to obtain an STC for a new fuel, a process other firms have used to earn STCs for alternative fuels in the past. GAMI asserts, however, that the FAA has put up roadblocks to prevent GAMI from beginning the 20-24B process. All in the room agreed that all firms seeking a replacement for 100LL fuel should have an equal opportunity to attempt certification as detailed in 20-24B.

What can ABS do? Braly suggests that owner groups continue to put pressure on senior FAA officials to ensure that the 20-24B process (as written and as used in prior STC approvals) is available to all firms seeking a 100LL replacement, including continued long-term work with AOPA and EAA.

SWIFT FUEL: NOW UL102

By Curt Nehring, Emerald Hills, California

Swift Enterprises (swiftenterprises.com) has been developing an unleaded replacement for 100LL since 2005. Their early fuel formulations were multi-component, and some of those components were petroleum derivatives. Since 2007, they've settled on a primarily two-component formulation code-named "Swift 702 fuel." Those two main components, mesitylene (1,3,5-trimethyl benzene) and isopentane (2-methyl butane), can be derived from biomass. Thus, 702 can be made from completely renewable resources as described in Swift's most-recent patent application (http://www.faqs.org/patents/app/20080244961). The ASTM taskforce recently agreed to the designation UL102 to fit into the new ASTM nomenclature; it has a minimum octane rating of 102, compared to the 99.6 rating for 100LL under ASTM D910.

According to Dave Atwood's report (DOT/FAA/AR-08/53 issued January 2009), he and other researchers at the FAA's William J. Hughes Technical Center "performed detonation and power performance tests on the Swift 702 fuel as compared to a locally purchased 100LL in two of the highest octane requirement engines in the fleet. A Lycoming TIO-540-J2BD and a Lycoming IO-540-K were evaluated on both fuels... Any fuel satisfying the octane requirement of these two engines would satisfy the octane requirement of the majority of the piston, reciprocating engine fleet... The Swift 702 fuel had a motor octane number (MON) of 104.4, as determined by the international standard test ASTM D 2700, and the locally purchased 100LL had a tested 103.6 MON... A power baseline and detonation test was run in the IO-540-K engine, comparing the performance of the Swift 702 fuel to 100LL fuel, and a detonation performance test was run in a Lycoming TIO-540-J2BD engine... At all engine speeds and manifold pressures, the Swift 702 fuel produced more than 98% of the horsepower as the 100LL and produced an average increase in EGT of approximately 50°F... The Swift

702 fuel met most of the current leaded aviation gasoline specification ASTM D 910, except for the 50%, 90%, end distillation points, and heat content... and outperformed the 100LL in detonation testing... Further endurance testing is required to determine the significance of operating with 50°F higher EGTs... Future full-scale engine endurance tests will verify whether there will be issues with oil dilution, nozzle and fuel system deposits, bearing failure, induction varnish buildup, or cylinder and valve deposits from using Swift 702 fuel."

Aside from octane rating, there are two other significant differences between UL102 and 100LL. One is that UL102 weighs more; its density is about the same as jet fuel. Like jet fuel it also has greater per-volume heating value, although the per-mass heating value is slightly less. As Atwood explained in his January 2009 report, "The Swift 702 fuel was roughly 1.01 lb/gal heavier (or 17.5%) than the 100LL at 87°F. However, since the Swift 702 fuel had 96.3% of the energy density on a mass basis as the 100LL, the Swift 702 fuel has approximately 13% higher energy per gallon of fuel than 100LL. On a fuel mass flow basis, the Swift 702 fuel will produce slightly less power than the 100LL; however, on a fuel volume flow basis, which is typically more of a concern to a pilot, the fuel will produce more power than the 100LL. Therefore, the same number of gallons of fuel will weigh more for the Swift 702 fuel than the 100LL, but will provide a greater range of flight."

The other main difference between UL102 and 100LL is vapor pressure, or volatility. Avgas must be volatile enough for good vaporization when starting an engine at low temperatures, yet not so volatile that it boils easily at altitude. These characteristics were not investigated in the testing summarized in the January 2009 report. As Atwood stated, "The Swift 702 fuel did not meet the 50%, 90% or end point of the distillation curves. This was due to the high aromatic hydrocarbon content of the fuel.

Previous and extensive FAA tests determined that an unleaded fuel could meet the current detonation performance of the current ASTM D 910 100LL leaded aviation gasoline only if it contained at least 10% of a specific aromatic amine or it contained a very high concentration of aromatic hydrocarbon. In either case, it is highly unlikely that any such fuel would meet the distillation specification for an aviation alkylate-based fuel. Further tests are planned on the Swift 702 fuel using two separate high-power engines, a Continental and a Lycoming, for long-duration tests."

The full-scale engine endurance tests Atwood mentioned have been completed. A report is being written and should be available around 7/19/2010; look in: http://ACTlibrary.tc.faa.gov/ for DOT/FAA/AR-10/13 "Full-Scale Engine Endurance Test of Swift Enterprises UL102 Fuel" by D. Atwood.

Given differences in aircraft weight & balance, flying range, and possibly different starting procedures in cold weather, an STC looks like one way for a certified aircraft to use UL102. In a joint project with Swift Enterprises, Pat Anderson of Embry-Riddle's Eagle Flight Research Center in Daytona Beach, Florida is now doing certification testing for an STC allowing use of UL102 in its fleet of 172s; see http://www.eaa.org/news/2010/2010-02-25_swift_fuel.asp. After a little more than 40 hours of initial testing on their Piper Seminole, Anderson has noticed only two problems. One is relatively hard starting at temperatures below 30°F; this may be related to the fuel distillation curve differences vs. 100LL, as mentioned by Dave Atwood. Swift is working on that now. The other is that an engine adjusted to idle properly on 100LL will idle rough and emit black smoke on UL102; a clean idle is achieved by manually leaning the mixture during ground operation, which is good practice even when using 100LL.

According to Anderson, STC certification testing must be done with normal volume-production fuel, rather than with laboratory-prepared samples. This creates a chicken-and-egg situation; it's difficult to invest in a volume production plant without the STC-enabled markets.

An additional problem is that, using unoptimized processes and without economies of scale, early quantities of UL102 will probably be expensive. Fortunately, UL102 can be blended in any ratio with 100LL.

Curt Nehring is retired from a 40-year career in real time and instrument control software. He got his A&P certificate this year and has 1,000 hours flying time. Curt is launching a new career in the production of electricity and fuels from cultivated crops and is principal of a small venture called CaramelPower.

Watch for updates on this rapidly changing issue of future fuels in ABS NEWS and ABS Hangar Flying.