Omnav Aviation

Light Sport Sales, Repair & Maintenance

Good Fuel, Bad Fuel

Scope

The information contained in this presentation pertains to fuels available

In the US only

Fuel specifications, formulations, ethanol blends, and additives, as well as availability, differ greatly in other countries, even in Canada and South America, from those in the US.

Overview – What We'll Cover

1. Rotax Fuel Requirements
   What Rotax approves — and why specification compliance matters.
2. Understanding Octane
   RON, MON, AKI, etc. and why aviation octane ≠ automotive octane.
3. AVGAS, Swift Fuels, MOGAS
   What's really in each, and what happens when you mix or substitute.

Overview – What We'll Cover…

4. Auto Pump Gas and Ethanol
   Why ethanol blends are unpredictable and damaging to Rotax engines.
5. 100LL and Lead Issues
   Effects on oil, spark plugs, gearbox wear, and maintenance intervals.
6. Cleaner Alternatives
   Swift UL94, 100R, and the real MOGAS.
7. Practical Recommendations
   Fuel choices ranked by performance, maintenance, and availability.

Rotax's Requirements for Fuel

See: SI-916 i-001R6 / SI-915 i-001R7 / SI-912 i-001R12 / SI-912-016R17 / SI-914-019R17 The SI

Selection of suitable operating fluids for ROTAX® Engine Type 916 i (Series), 915 i (Series), 912 i (Series), 912 and 914 (Series)

This SI states what Rotax approves for:

- Oil
- Coolant
- **Fuel**

Rotax's Requirements for Fuel…

In the US, Rotax approves:

- AVGAS (ASTM D910)
- Real MOGAS (ASTM D4814 + FAA)
- Unleaded Auto Fuel that meets ASTM D7547

Also Ok to use:

- Swift Fuel UL94
- Swift Fuel 100R (aka UL100)

Field experience shows you can mix and match at any ratio, provided each individual fuel meets the Octane requirements

Understanding Octane Rating

Octane rating measures a **fuel's resistance to knock** compared to iso-octane (100) and n-heptane (0).

Several different rating systems:

- **RON** – Automotive in Europe & Asia
- **MON** – Automotive in Europe & Asia, but more demanding tests
- **AKI** – Automotive in the US: (RON + MON)/2 – The Average)
- **Aviation Octane Rating** - Based on mixture detonation characteristics under lean and rich condition – ASTM D910 (similar to MON)

Understanding Octane Rating…

100LL AVGAS uses the **Aviation Octane Rating**
It is **roughly** equivalent to:

MON: ~100 (estimated)
RON: ~130 (estimated)
AKI: ~115, or (100 + ~130)/2 (estimated)

Understanding Octane Rating…

Swift Fuels UL94 uses the **aviation fuel specification ASTM D7547 (Hydrocarbon Unleaded Aviation Gasoline)** and a MON as an octane rating system.

It is **roughly** equivalent to:

MON: 94+
RON: ~102 RON (estimated)
AKI: ~98 AKI (estimated)
Aviation Octane Rating: ~94 (estimated)

Understanding Octane Rating…

When mixing, don't try to do the math.

What if you mix half and half, 100LL and 87 AKI?

- You don't know. There's a lot of chemistry there.
- But, if you mix 100LL and 91 AKI we know the result will be 91 AKI or greater
- Unless – Ethanol is in the mix

Understanding Octane Rating…

Your Rotax engine wants **91 AKI or better** (MON 85+, RON 95) Octane Rating

These are all high-compression engines

If you fall below that (accidentally or intentionally) you may cause catastrophic harm to your engine.

Ethanol is a big reason some accidentally fall below the minimum

Knock Sensors

All iS engines have a knock sensor that informs the ECU

- 912iS – Only one sensor, and it's not used
- 915iS and 916iS – Dual sensors
- No ECU, no knock sensors on 912ULS and 914

ECU adjusts timing to compensate, but it can only do so much

Understanding MOGAS, or When MOGAS isn't MOGAS

- MOGAS (Motor Gasoline for Aviation Use)
- Per FAA's AC 91-33 guidelines, but references ASTM D4814
- Specifically tested and approved formulation
- Must be free of ethanol
- Meets Vapor Pressure and Stability requirements
- Most STCs for MOGAS require AKI 91 or better

Understanding MOGAS, or When MOGAS isn't MOGAS…

- AC91-33 still in effect, but now rarely found at airports.

MOGAS ≠ Auto pump gas (ethanol or not)

Auto Pump Gas

Has many, many different formulations

- Changed over time
- Additives & Detergents
- Ethanol as an oxygenate
- Winter Blend fuels
- Ok, even good to use in Rotax
  - If Ethanol-free
  - If Octane >= 91 AKI/95 RON
  - Assumed unleaded

Auto Pump Gas - Ethanol

Yes, Rotax approves 10%

Some Aircraft Manufacturer's do too:

> "The aircraft is able to use fuel which contains up to 10% of ethanol. In case this type of fuel is needed, **use high-octane fuel.**"

I'm going to advise HIGHLY AGAINST using it.

Ethanol-laced fuels have, of course, Ethanol

But also a lot of screwy **additives** that do damage, **real damage**.

Winter Blend Fuels

1. Butane is added to increase vapor pressure(RVP) to maintain volatility in colder weather
2. Not consistent between states, times of the year
3. Helps cold starts but increases the risk of vapor lock — especially in aviation use.

Winter Blend - Vapor Lock

Things that increase the chances of vapor lock in the fuel system

- Ethanol
- Butane – added to Winter Blend fuels

The condition has more to do with the engine installation rather than the engine

Largely, the iS engines are somewhat immune to vapor lock - return-style fuel injection system.

100LL AVGAS

Aviation Octane Method = 100
developed to consider lean vs rich mixtures

Meets all the Aviation requirements for

- Octane
- Volatility
- No screwy additives
- Vapor Lock resistance
- Stability
- Assured performance

100LL AVGAS…

BUT it also has **Tetraethyl-lead TEL**

- Lots of it – not low lead at all
- 2 grams/gal

100LL IS NOT Clean-burning for Rotax engines

From the SI:

"If possible, operate the listed engine types using unleaded or low-lead fuel. (AVGAS 100LL is **not considered low-leaded in this context**.)"

100LL AVGAS…

100LL ≠ Clean-burning for Rotax engines

Why is it bad for Rotax and not Ly-Con?

- Rotax designed from the start to run on unleaded fuels
- Built with tight tolerances, smaller oil passages, and gearbox
- Liquid-cooled (cooler) heads promote lead deposits
- High-RPM, high-compression, liquid-cooled, and fuel-injected

Lead is bad for humans too!

100LL AVGAS…

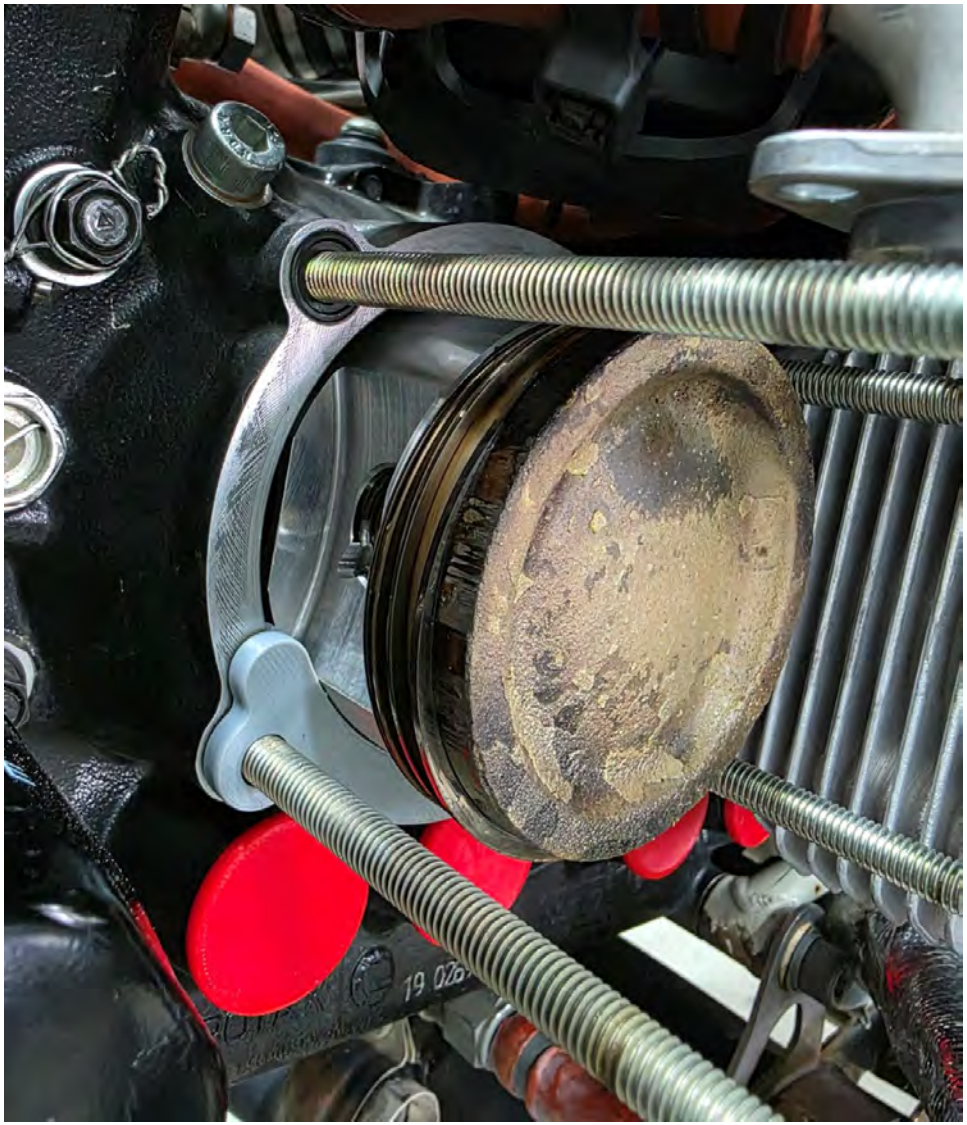
What happens in Rotax engines?

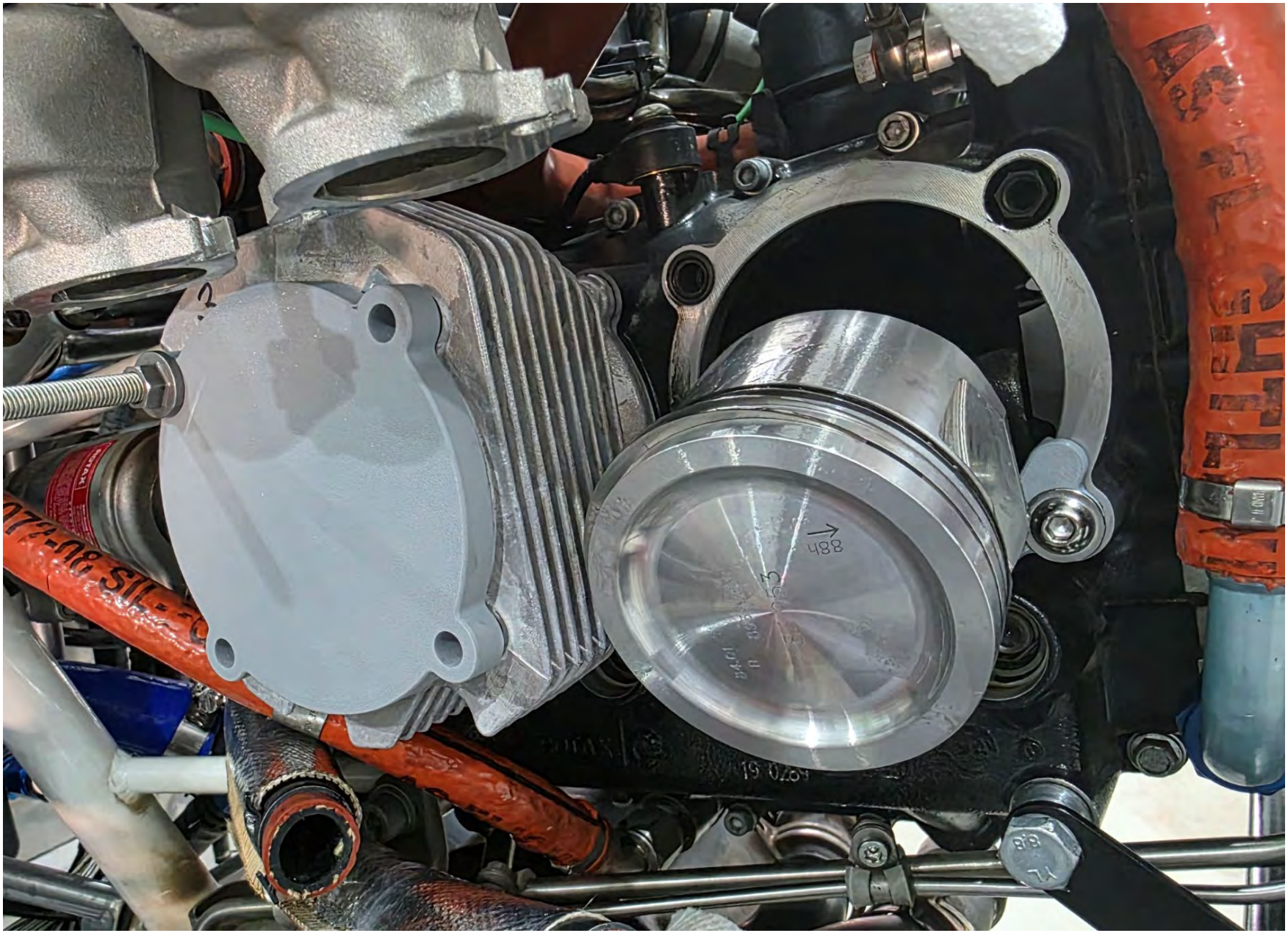
- Yellow/brown lead sludge in oil system and gearbox
- Increased spark plug fouling
- Deposits on valve stems and piston crowns
- Premature wear on gearbox components (gear lash from sludge)
- Clogged oil passages and oil pressure anomalies

100LL AVGAS…

100LL AVGAS…

100LL AVGAS…



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100LL AVGAS…

Rotax recommends unleaded fuels with AVGAS as a backup only

“When operating the engine with 100LL Avgas, a reduction of the TBO must be considered due to increased lead residues... Oil change intervals must be reduced and gearbox inspections increased.”

100LL AVGAS – Decalin RunUp

Consider using Decalin RunUp with AVGAS

- ~1.5ml/gallon of AVGAS (more is Ok)
- TEL (lead) when burned creates Lead Oxide
  - Sticky particles
  - Work their way into the oil to stick to things & cause problems
- **Decalin** reacts in the combustion chamber with Lead Oxide particles turning them to lead-phosphate ash.
- The ash is swept out the exhaust

100LL AVGAS – Decalin RunUp…

Rotax doesn't officially "approve" Decalin, but they do condone it. In person will recommend it.

The SI states:

"Additives under the names of Decalin® and Alcor®, which aid the scavenging of lead deposits have not been tested by BRP-Rotax. Field experience shows that these products significantly reduce lead deposits in the combustion chamber and piston/ring assemblies and have no detrimental effect on the engine, when used in the recommended manner.
Always follow the additive manufacturers instructions especially with regard to health and safety precautions. BRP-Rotax only has field experience with Decalin Runup® and Alcor TCP® brands…"

100LL AVGAS – Decalin RunUp…

The use of Decalin RunUp DOES NOT change the reduced maintenance intervals when using 100LL AVGAS.

Oil and filter:

100hrs → 50hrs (or 25hrs)

Spark Plugs:

400hrs → to 200hrs

Gearbox/Slipper Clutch/Overhaul:

1000 hrs → 600 hrs

Swift Fuel UL94

UL94 is a 94-octane unleaded avgas with no ethanol or lead, specifically formulated and approved for aviation

Swift Fuel UL94

- Meets+ ALL requirements for Rotax engines
- Burns clean
- Can be expensive (> or = AVGA$)
- Not widely available
- Many FBOs are waiting for Swift 100R, all the goodness for everyone

Dangers of Ethanol

My Top 8 reasons to just say NO to ETHANOL

- Octane Instability & Variability
- Water Absorption & Phase Separation
- Chemical Attack on Fuel System Components
- Composite Structure Degradation
- Fuel Shelf Life
- Gum and Varnish Formation
- Reduced Energy Density
- Inconsistent Fuel Formulation

Ethanol - Octane Instability & Variability

Ethanol is used as an octane booster, however:

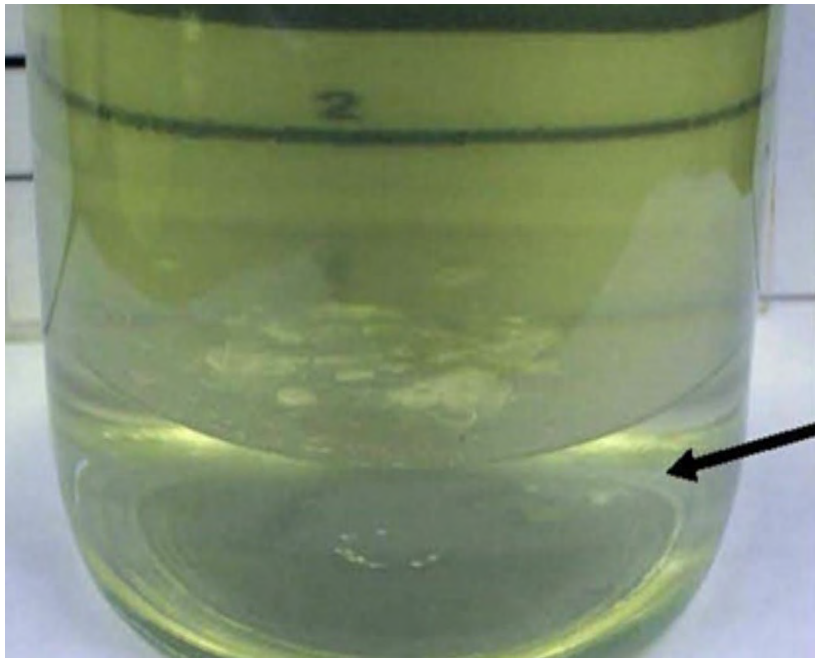
- It evaporates out of the fuel faster than the base fuel
- Absorbs water, neutralizing its anti-knock properties

ALWAYS LOWERS OCTANE LEVEL

Leading to possible destructive DETONATION

Ethanol - Water Absorption & Phase Separation

- Ethanol is hygroscopic - pulls moisture from the air
- When water exceeds ~0.5% → phase separation
- Settles to the bottom (where the fuel pickup is).
- This alcohol-water mixture burns poorly and may cause corrosion or engine misfire. (Right on Take-off)
- Worse in humid climates



Ethanol - Chemical Attack on Fuel System Components

- Ethanol attacks elastomers and polymers
  - Fuel hoses
  - O-rings
  - Carburetor seals
  - Fuel tank sealants and adhesives
- Can lead to
  - Leaks
  - Delamination
  - clogs from degraded materials
  - Fuel lines that sweat fuel vapors (leeching)

Ethanol - Composite Structure Degradation

Ethanol is a known solvent for epoxy

- Leads to softening, weakening,
- Possible structural failure over time

Also melts some common tank sealants

Super Petrel fuel tanks use decades-old design, with Jeffco sealant and Structural Adhesive seams. Time-tested.

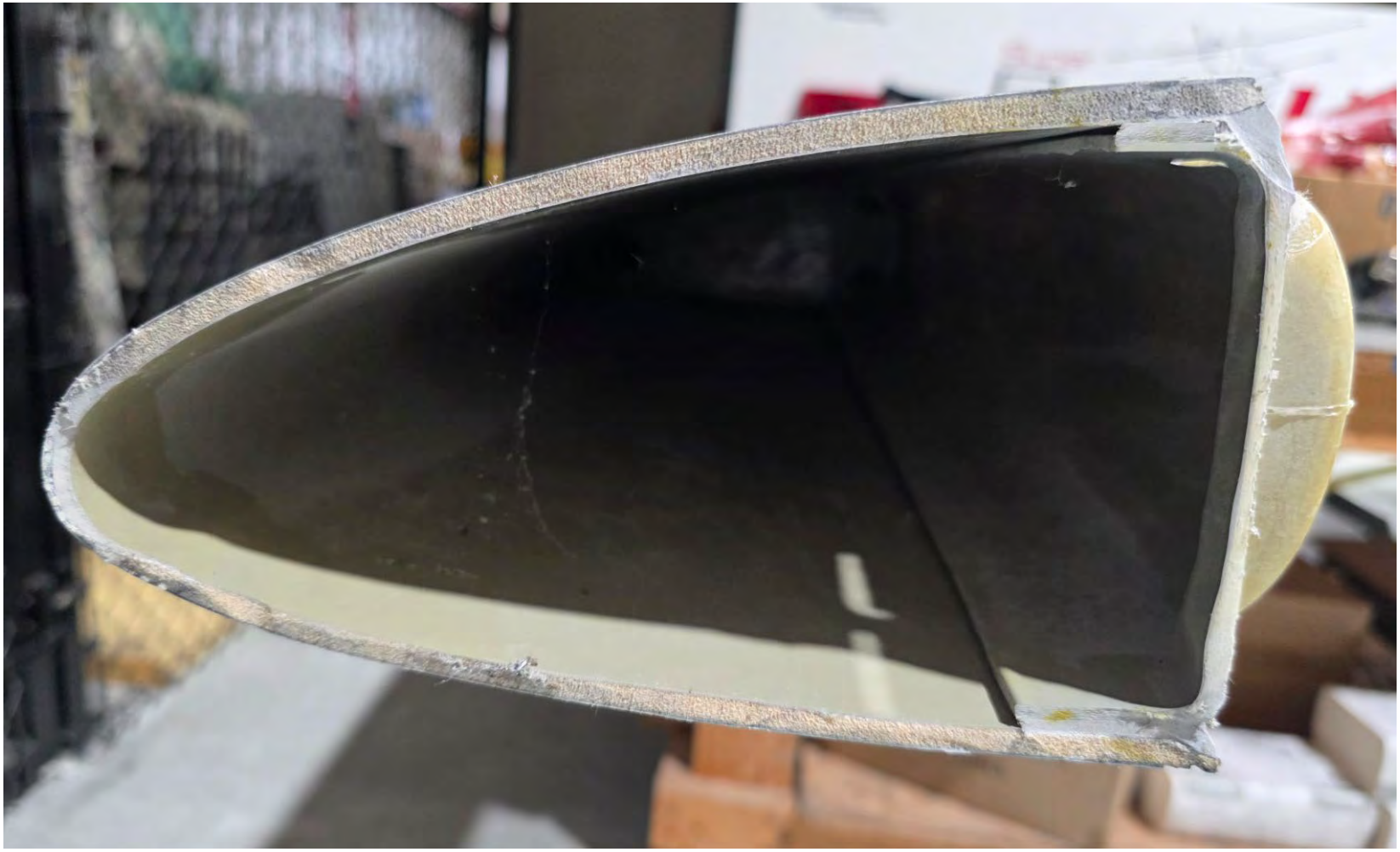
Ethanol - Composite Structure Degradation

Many composite fuel tanks use a time-tested Jeffco lined epoxy tank system

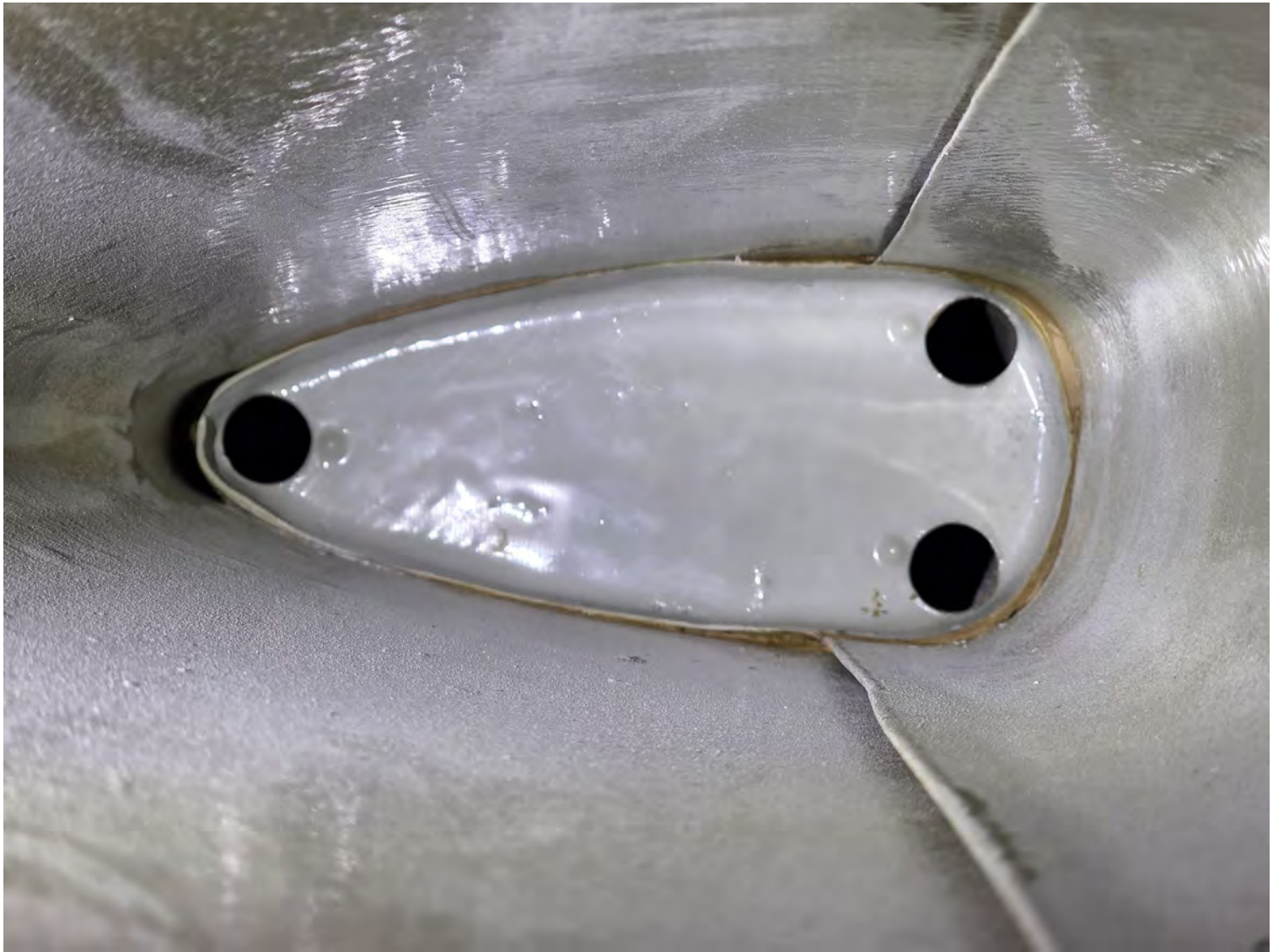
- Existed for decades on several well-known composite aircraft (Lancair, Velocity, etc.)
- Jeffco (gray) sealant – Very chemical resistant
- Structural Adhesive seams – Mostly chemical resistant

Any exposed edge or softened adhesive can let ethanol fuel leach in and cause damage.

Super Petrel Wing Tank



Super Petrel Wing Tank



Pulsar Wing Tank

Pulsar Wing Tank

Pulsar Wing Tank

Ethanol - Fuel Shelf Life

- Ethanol-laced fuels degrade FAST
- Form peroxides and organic acids that corrode engine components
- Stale fuel (<=3 months in warm climates)
- Loses volatility and octane level
  ALWAYS LOWERS OCTANE

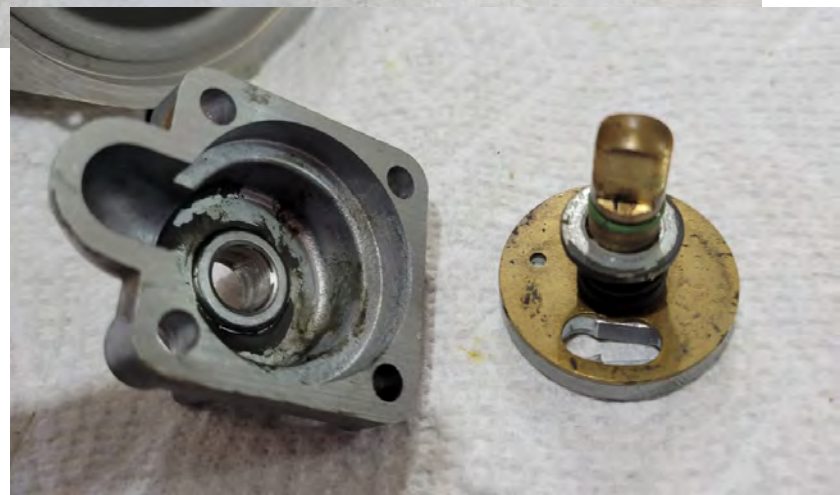
- 100LL, Swift and unleaded auto gas have a much longer shelf life (6–12+ months)

Ethanol - Gum and Varnish Formation

- Ethanol-laced fuels contain many additives to help stabilize the fuel
- These additives can polymerize as fuel evaporates
- Leave behind sticky varnish shellac-like residue (GUMS) that clog:
  - Carburetor jets and bowls
  - Fuel injectors
  - Valve stems and seats

Ethanol - Gum and Varnish Formation

Kitfox engine overhaul



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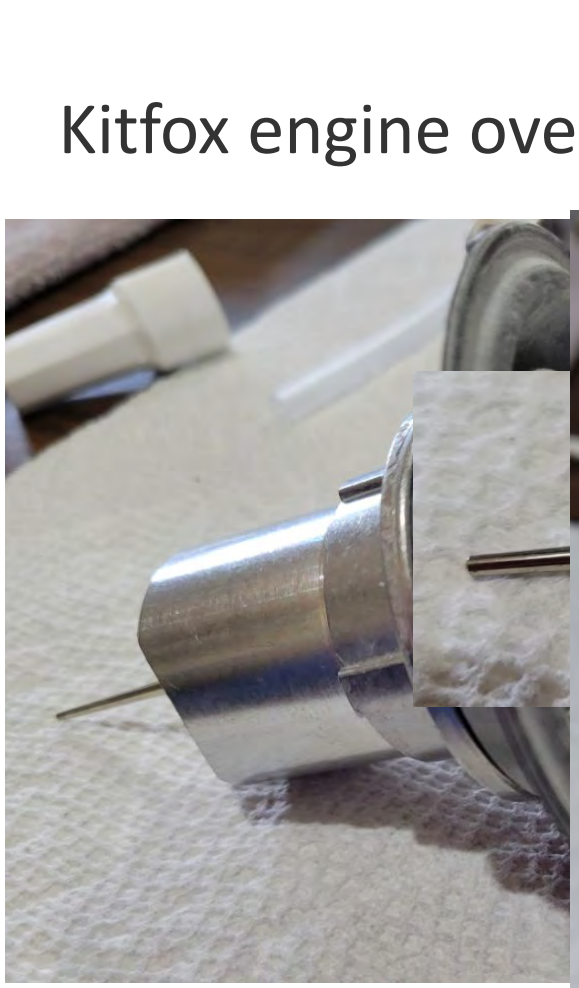


Ethanol - Reduced Energy Density

- Ethanol has ~33% less energy per gallon than pure gasoline
- 10% Ethanol fuels contains about 3.5% less energy than 100% gasoline
- Impacts:
  - Reduced engine performance
  - Lower fuel economy
  - Reduced climb rate or reduced RPM in marginal aircraft performance scenarios

Ethanol - Inconsistent Fuel Formulation

- Formulations vary seasonally (summer vs. winter) and regionally
- Vary by Supplier (BP vs Shell, etc.)
- Winter blends often have higher Reid Vapor Pressure (RVP), which increases vapor lock risk.
- Lack of standardization = unpredictable in aviation applications, unless every batch is tested.

Ethanol – Not Pervasive until 2007

Composite fuel tank designs, sealants, etc. designed to hold gasoline, engines designed to burn gasoline.

- 70's-80's Ethanol began replacing lead for octane
- 90's MTBE used, but phased out due to ground water contamination
- 2005 Energy Policy ACT encouraged renewable fuels
- 2007 Further Acts made Ethanol additives required nationwide

It became "will it work" vs "designed for"

Ethanol – Just Say NO

Look for Non-Ethanol options

- Non-Oxy
- Recreational Blend
- No-Ethanol
- E0
- Etc.

Varies by region/state

Ethanol – Final Thoughts

If you hear "**I won't use any auto gas!! I've heard too many bad stories**"

I will guarantee these were all from **Ethanol-laced** gas

Or vapor lock from **Winter Blends**

Or **both**.

Ethanol is so pervasive, it's just assumed part of auto gas.

My Unofficial Recommendation

In Order:

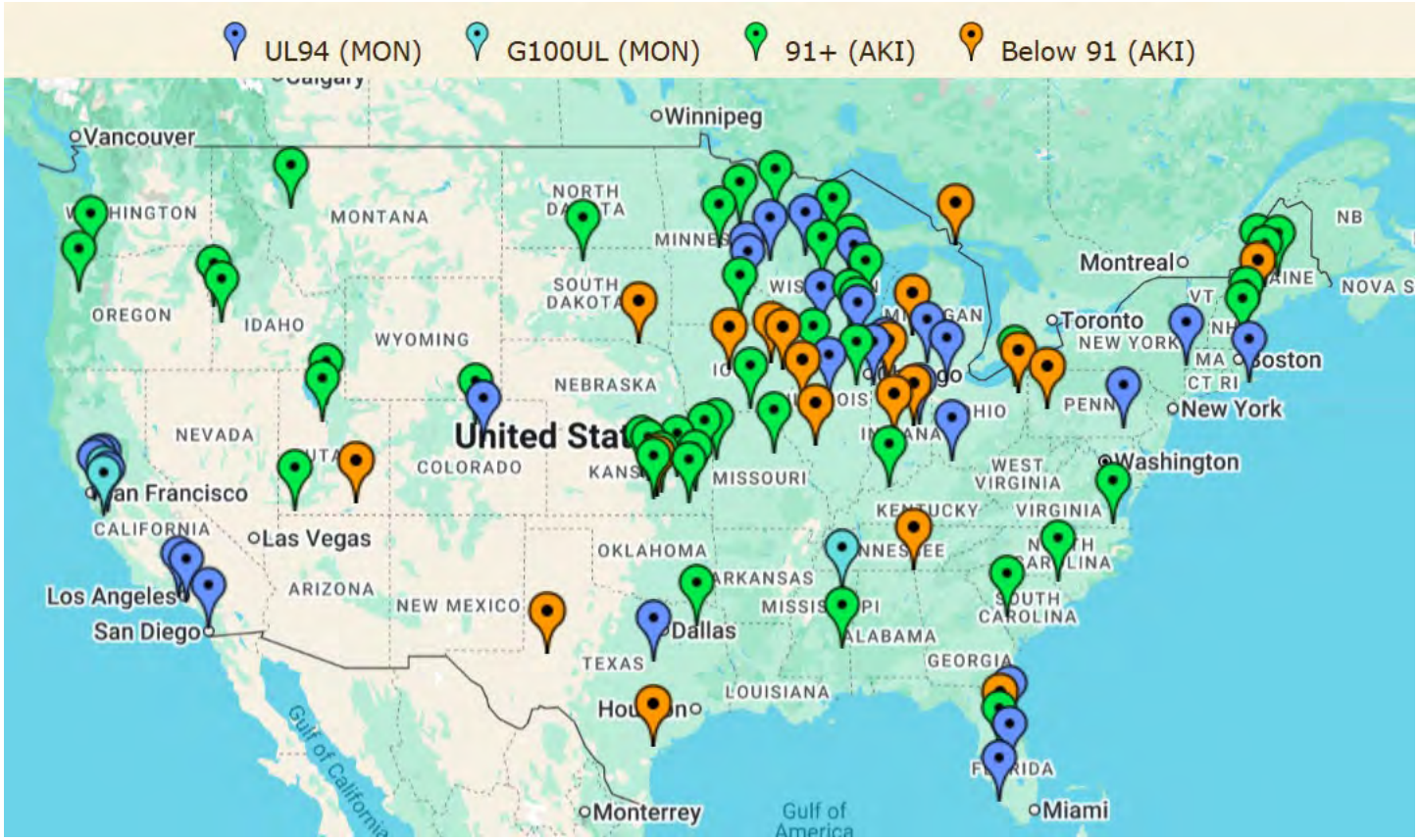
1. Swift UL94 is best, in every way (or 100R)
2. Real MOGAS (good luck finding it)
3. Non-Ethanol, 91 AKI or higher, Auto Pump Gas
4. AVGAS (but only with Decalin)

In an extreme pinch: AVGAS without Decalin

Never, never, nope, not at all: Ethanol-laced auto pump gas

Some useful websites

flyunleaded.com



Some useful websites

flyunleaded.com

AIRPORTS WITH UNLEADED FUEL

CLICK HERE TO SEND US INFORMATION TO ADD TO THIS LIST OR NOTIFY US OF ERRORS.

Click on Closest City to link to google map location of airport.
Click on ICAO ID airport identifier to link to AirNav information for airport.
Click on (map) to link to VFRMAP location of airport.

Fuel Type Legend: ■ **UL94** (MON) ■ **G100UL** (MON) ■ **91+** (AKI) ■ **Below 91** (AKI)

CALIFORNIA

Closest City	Airport Name	ICAO ID	Octane Rating	SVC	FBO / Vendor
San Martin	SAN MARTIN	E16 (map)	**UL94** (MON)	FS/SS	San Martin Aviation (408-430-3124)
Hayward	HAYWARD EXEC	KHWD (map)	**UL94** (MON)	SS	APP Jet Center (510-259-1347, M: 772-418-6818)
Long Beach	LONG BEACH (DAUGHERTY FLD)	KLGB (map)	**UL94** (MON)	FS	Signature Aviation (562-997-0700)
Livermore	LIVERMORE MUNI	KLVK (map)	**UL94** (MON)	SS	Five Rivers Aviation (925-315-4130)
SAN DIEGO	MONTGOMERY-GIBBS EXEC	KMYF (map)	**UL94** (MON)	FS	crownair (858-292-1181)
San Jose	REID-HILLVIEW OF SANTA CLARA COUNTY	KRHV (map)	**G100UL** (MON)	FS	Country of Santa Clara (408-918-7712)
Santa Monica	SANTA MONICA MUNI	KSMO (map)	**UL94** (MON)	SS	Aeroplex (562-981-2659)
San Carlos	SAN CARLOS	KSQL (map)	**UL94** (MON)	FS	Rabbit Aviation
Watsonville	WATSONVILLE MUNI	KWVI (map)	**G100UL** (MON)	SS	Watsonville Municple Airport (UNICOM 122.80, 218-510-0628)

***Note**: UL94 fuel is Swift's 94 MON unleaded avgas

COLORADO

Closest City	Airport Name	ICAO ID	Octane Rating	SVC	FBO / Vendor
Denver	CENTENNIAL	KAPA (map)	**UL94** (MON)	FS	jetCenters of Colorado (303-790-4321)
Longmont	VANCE BRAND	KLMO (map)	**91** (AKI)	FS	Fly Elite Aviation

***Note**: UL94 fuel is Swift's 94 MON unleaded avgas

FLORIDA

Closest City	Airport Name	ICAO ID	Octane Rating	SVC	FBO / Vendor
Tavares	TAVARES	FA1 (map)	**90** (AKI)	AS	Tavares Seaplane Base (352-742-6267)
Naples	NAPLES MUNI	KAPF (map)	**UL94** (MON)	FS	Naples Aviation (239-643-0404)
Deland	DELAND MUNI-SIDNEY H TAYLOR FLD	KDED (map)	**UL94** (MON)	FS	Deland Aviation (UNICOM 123.075, 386-740-1955)
Winterhaven	WINTER HAVEN RGNL	KGIF (map)	**93** (AKI)	SS	Winterhaven Air Services (122.775, 863-298-4551)
Sebring	SEBRING RGNL	KSEF (map)	**UL94** (MON)	SS	Sebring Flight Center

Some useful websites

pure-gas.org

pure-gas.org

The list of ethanol-free gas stations in the U.S. and Canada

stations maps POI file KML file about this site Donate

Welcome to the definitive list of stations that sell ethanol-free gasoline in the U.S. and Canada!

We currently have **17677** stations (**27** added and **9** removed in the past seven days).

AB AK AL AR AZ BC CA CO CT DC DE FL GA HI IA ID IL IN KS KY LA MA MB MD ME MI MN MO MS MT
NB NC ND NE NF NH NJ NM NS NT NV NY OH OK ON OR PA PE QC RI SC SD SK TN TX UT VA VT WA WI
WV WY YT

Summary

Right now, the best fuel you could use is Swift UL94 and (real) MOGAS

Or Unleaded, No-Ethanol, 91AKI+ auto pump gas

If you use 100LL, use Decalin

Avoid at all costs Ethanol-laced fuels – BAD!

Understand Octane and don't compromise

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