Unleaded Aviation Fuel (UL94)

Unleaded Aviation Gasoline Available Now

CAAPSO at RHV airport

Federal Aviation Administration

Why Talk About Unleaded Avgas?

- **Strong community concerns voiced regarding lead from Avgas at Reid Hillview**
  - Lead from ALL sources considered contributor to child-development problems

- **Pilots, fuel operators, aircraft mechanics are the ones most highly exposed to lead**
  - EPA estimates 468 tons of lead released from avgas annually[1]
  - E.g. Fueling operations, run-up area, maintenance activities

- **Pilots want to be good citizens and help the environment**
  - We want to be part of the solution as soon as possible

- **Lead is not good for our engines either**
  - Fouled plugs, engine/oil residue
  - Increased maintenance costs

✓ **Help the community**

✓ **Benefit from doing good!**

[1] 2017 National Emissions Inventory. Note that this estimate of lead emissions may be high, as EPA assumes that all 100LL avgas contains the maximum amount of TEL permitted by ASTM, or 0.56 grams per liter. Actual TEL amounts are likely less.

UL94 – Unleaded 94 Octane

- **Industry's only 100% aviation grade unleaded fuel**
  - Meets ASTM D7547 spec for unleaded aviation fuel
  - Quality, octane, storage stability, compatibility with fuel system, etc

- **FAA-certificated, safe to fly, and insured for aviation use**
  - FAA TC, STC, or SAIB allows use in 125,000+ piston aircraft
  - Compatible with 68% of the US piston fleet

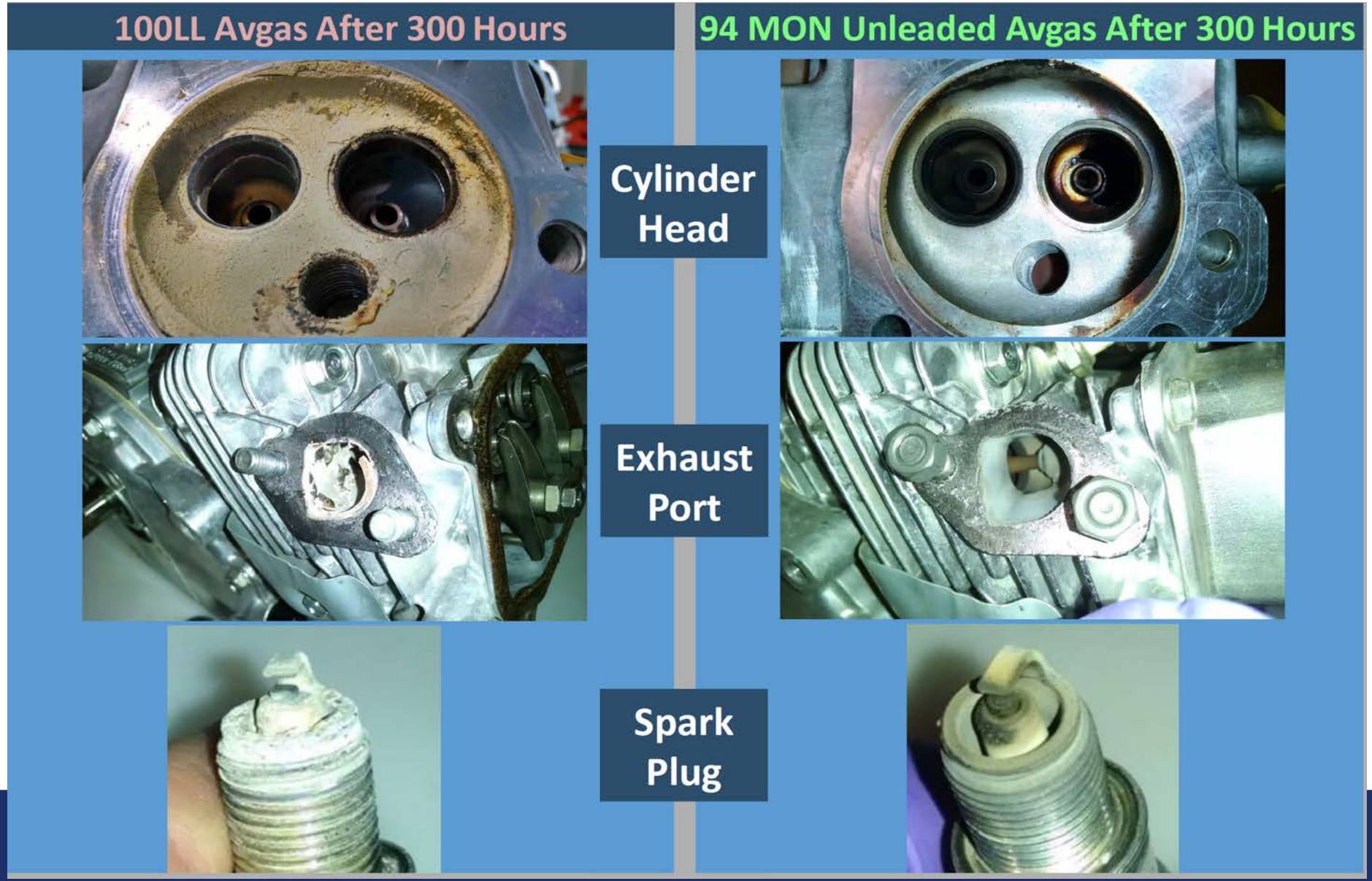
- **Available nationwide since 2015**
  - Manufacturer: Swift Fuels
  - Licensing model enables refiners to produce locally

What Is UL94?

- **Minimum 94 Motor Octane Unleaded Avgas**
  - Traditional all-hydrocarbon blend
  - Chemically identical to 100LL without lead or lead scavengers
    - No tetraethyl lead (octane booster) or ethylene dibromide (lead scavenger)

- **Benefits**
  - Burns cleaner ➔ No lead-fouled plugs or engine buildup
  - Longer interval between oil changes and maintenance
  - Compatible with fuel system (rubber, valves, pistons, etc)
  - Mixable with 100LL in the aircraft
  - Easily separates from water
  - Aviation-grade quality
  - Doesn’t use dangerous or corrosive components to increase octane

Comparison of Engine Components Following 300-Hour Trial



Source: Chris D'Acosta, CEO Swift Fuels

100LL Impact

- ✕ More sludge in oil and engine
- ✕ More fouling of spark plugs
- ✕ Lead acidity corrodes the engine

MON – Motor Octane Number

Federal Aviation Administration

What Airplanes Can Use UL94?

- **Any engine that can use 87 or 91 octane Avgas can burn UL94 safely**
  - FAA Special Airworthiness Info Bulletin: SAIB-HQ-16-05R1

  - Most Lycoming O-235, O-320, O-360, O-540 and injected versions
  - Most Continental O-200, O-300 and O-470 and injected versions
  - All Rotax engines
  - Most radial engines found in antique aircraft

- **Requires one-time UL94 STC ($100) for engine**
  - Receive FREE FOREVER STC with purchase: any future Swift Avgas STC will be issued free of charge
  - Available online through Swift Fuels (https://www.swiftfuelsavgas.com)

- **Logbook entry by aircraft mechanic**

Lycoming Engines Supported

Lycoming Engines Approved for UL94

Lycoming Engine Models		AVGAS ASTM D910 100LL	AVGAS ASTM 7547 UL94
O-235	-C, -E, -H	•	•
O-235	-K, -L, -N	•	•
O-235	-M, -P	•	•
O-290	-D	•	•
O-320	-A, -B, -C, -D, -E	•	•
IO-320	-A, -B, -D, -E	•	•
AIO-320	-A, -B, -C	•	•
LIO-320	-B	•	•
AEIO-320	-E	•	•
O-360	-A, -B, -C, -D, -F, -G, -J	•	•
HO-360	-C	•	•
IO-360	-B, -E, -L, -M, -N	•	•
LO-360	-A	•	•
HIO-360	-B	•	•
HIO-360	-G	•	•
IVO-360	-A	•	•
LIO-360	-M	•	•
O-435	-A, -C	•	•
GO-435	-C, -C2	•	•
GO-480	-B, -D, -F	•	•
O-540	-A, -B, -E, -F, -G, -H, -J	•	•
IO-540	-C, -D, -N, -T, -V	•	•
IO-540	-W, -AB, -AF	•	•
VO-540	-A, -B	•	•

Lycoming Engines Approved for UL94

Lycoming Engines Requiring 100LL (DO NOT USE UL94)

Lycoming Engine Models		AVGAS ASTM D910 100LL
O-235	-F, -G, -J	•
O-320	-H	•
IO-320	-C, -F	•
LIO-320	-C	•
AEIO-320	-D	•
O-360	-E	•
HO-360	-A, -B	•
IO-360	-A, -C, -D, -F	•
IO-360	-J, -K	•
LO-360	-E	•
TO-360	-A, -C, -E, -F	•
VO-360	-A, -B	•
AIO-360	-A, -B	•
HIO-360	-A, -C, -D, -E, -F	•
LIO-360	-C	•
LTO-360	-A, -E	•
TIO-360	-A, -C	•
AEIO-360	-A	•
AEIO-360	-B, -H	•
LHIO-360	-C, -F	•
IO-390	-A	•
AEIO-390	-A	•
VO-435	-A, -6, -23	•
VO-435	-B	•
TVO-435	-A, -B, -C, -D, -E, -F, -G, -25	•
O-480	-1, -3	•

Lycoming Engine Models		AVGAS ASTM D910 100LL
O-480	-A	•
GO-480	-C, -G	•
GSO-480	-A, -B	•
IGO-480	-A	•
IGSO-480	-A	•
O-540	-L	•
O-540	-9, -9A	•
IO-540	-A, -B, -E,- G, -J, -K, -L, -M,	•
IO-540	-P, -R, -S, -U, -AA, -AC, -AE	•
VO-540	-C	•
HIO-540	-A	•
IGO-540	-A, -B	•
IVO-540	-A	•
TIO-540	-A, -C, -E, -F, -G, -H, -J, -N,	•
TIO-540	-R, -S, -U, -V, -W, -AA, -AB,	•
TIO-540	-AE, -AF, -AG -AH, -AJ, -AK	•
TVO/TIVO-540	-A	•
AEIO-540	-D	•
AEIO-540	-L	•
IGSO-540	-A, -B	•
LTIO-540	-F, -J, -N, -R, -U, -V	•
TIO-541	-A, -E	•
TIGO-541	-D,-E,-G	•
IO-580	-B	•
AEIO-580	-B	•
IO-720	-A,-B,-C,-D	•

Lycoming Engines Requiring 100LL (DO NOT USE UL94)

Source:
Swift Fuels

Continental Engines Supported

Continental Engines Approved for UL94			
Continental Engine Models	Cylinders	Fuel Grade	CR
C-85	4	80/87	6.3:1
C-90	4	80/87	7.0:1
C-115	6	80/87	6.3:1
C-125	6	80/87	6.3:1
C-140	6	80/87	6.3:1
C-145	6	80/87	7.0:1
C-175	6	80/87	7.0:1
E165	6	80/87	7.0:1
E185	6	80/87	7.0:1
O-200-AF	4	UL94	7.0:1
O-200-A & B	4	80/87	7.0:1
E225	6	80/87	7.0:1
O-300	6	80/87	7.0:1
IO-346	4	91/98	7.5:1
IO-360-AF	6	UL94	7.5:1
O-470-J, K, L, M, R, S	6	80/87	7.0:1
IO-470-C	6	91/96	8.0:1
IO-470-J & K	6	80/87	7.0:1
Continental Engines Approved for UL94			

Continental Engines Requiring 100LL (DO NOT USE UL94)			
Continental Engine Models	Cylinders	Fuel Grade	CR
O-200-D, X	4	100/100LL	8.5:1
IO-240-A & B	4	100/100LL	8.5:1
IOF-240-B	4	100/100LL	8.5:1
IO-360-C, CB, D, DB, G, GB, H, HB	6	100/100LL	8.5:1
IO-360-ES, J, JB, K, KB	6	100/100LL	8.5:1
TSIO-360-A, AB, C, CB, D, DB	6	100/100LL	7.5:1
TSIO-360-F, FB, H, HB, JB, LB, MB, SB	6	100/100LL	7.5:1
L/TSIO-360-E, EB, KB, RB	6	100/100LL	7.5:1
O-470-U	6	100/100LL	8.6:1
IO-470-D, E, F, H	6	100/130	8.6:1
IO-470-L & M	6	100/100LL	8.6:1
IO-520-B, BA, BB, C, CB, D, E, M, MB	6	100/100LL	8.5:1
IO-520-F, L	6	100/130	8.5:1
TSIO-520-B, BB, E, EB	6	100/100LL	7.5:1
TSIO-520-C, H, J, JB, N, NB	6	100/130	7.5:1
TSIO-520-(M), P, R, T, U, UB, VB, WB	6	100/100LL	7.5:1
GTSIO-520-D, H	6	100/130	7.5:1
GTSIO-520-L, M	6	100/100LL	7.5:1
IO-550-A, B, C, D, E, F, G, L	6	100/100LL	8.5:1
IO/IOF-550-N, P, R	6	100/100LL	8.5:1
TSIO-550-B, C, E, K, N	6	100/100LL	7.5:1
TSIOL-550-A, B, C, G	6	100/100LL	7.5:1
TSIOF-550-D, J, K	6	100/100LL	7.5:1
Continental Engines Requiring 100LL (DO NOT USE UL94)			

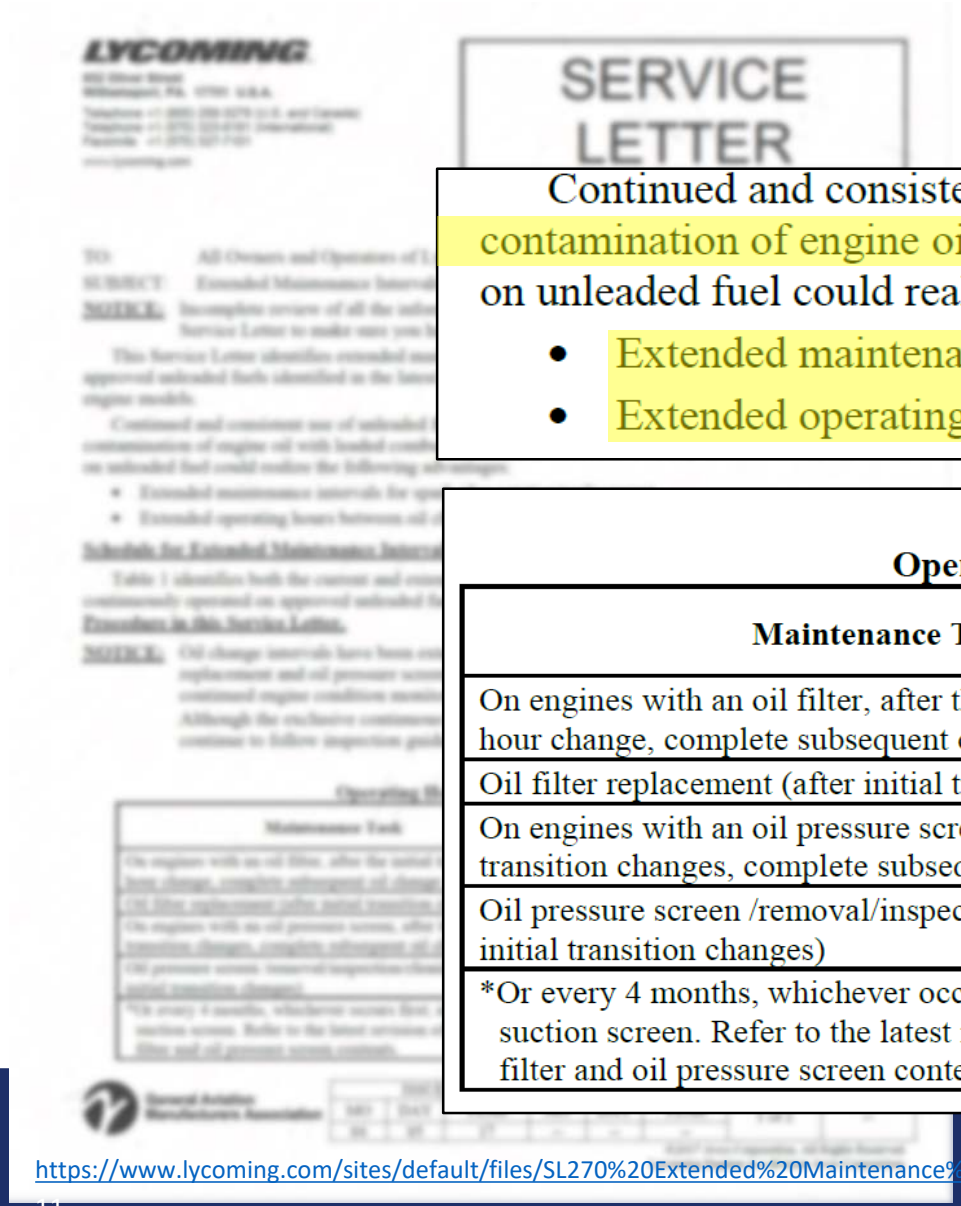
Source:
Swift Fuels

Survey Question 1

Do you have an engine that can use UL94?

Indicate Yes, No, or Don’t know in the survey

Maintenance Benefits (Lycoming Service Letter L270)


LYCOMING

SERVICE LETTER

Continued and consistent use of unleaded fuel decreases the risk of lead fouling of spark plugs and contamination of engine oil with leaded combustion byproducts. As a result, engines continuously operated on unleaded fuel could realize the following advantages:

- Extended maintenance intervals for spark plug rotation/replacement
- Extended operating hours between oil changes.

Table 1
Operating Hour Maintenance Intervals

Maintenance Task	Operating Hour Maintenance Interval	
	Leaded Fuel	Unleaded Fuel
On engines with an oil filter, after the initial transition 50-hour change, complete subsequent oil change	50 hours*	100 hours*
Oil filter replacement (after initial transition change)	50 hours	
On engines with an oil pressure screen, after the initial transition changes, complete subsequent oil change	25 hours*	50 hours*
Oil pressure screen /removal/inspection/cleaning (after initial transition changes)	25 hours	

*Or every 4 months, whichever occurs first; also, remove, examine, clean and re-install/safety the oil suction screen. Refer to the latest revision of Service Bulletin No. 480 for guidance on inspection of oil filter and oil pressure screen contents.

Note: Read complete service bulletin for transition inspection instructions!

https://www.lycoming.com/sites/default/files/SL270%20Extended%20Maintenance%20Intervals%20for%20%20Engines%20Operated%20on%20Unleaded%20Fuels_0.pdf

Maintenance Benefits (Rotax 914 Series Maintenance Manual)

BRP-Powertrain

MAINTENANCE MANUAL

Points of Inspection	Interval Operating hours		Chapter Reference	Signature
	as indicated	100 hr.		
Check oil tank. Refill oil tank with approx. 3 litres of oil. For oil quality, see Operators Manual and SI-914-019, latest edition.	50 hr.(1	X	12-20-00 sec. 13.2), 13.6)	
(1 In the case more than 30% of operation with leaded fuel e.g.: AVGAS 100 LL			12-20-00 sec. 13.2) SI-914-019	

100LL Impact on Rotax Engines

- ✕ Increased oil changes
- ✕ Increased inspections
- ✕ Increased spark plug replacement

Renewal intervals

NOTES:

Operation with leaded fuels (e.g. AVGAS 100LL) can result in increased wear of the spark plugs. Reduce renewal intervals accordingly.

Source: https://www.rotax-owner.com/pdf/MML_914_Series_ED2_R2_E.pdf

Maintenance Benefits (Rotax 914 Series Maintenance Manual)

NOTE: AVGAS 100LL places greater stress on the valve due to its high lead content and forms increased deposits in the combustion chamber and lead sediments in the oil system.

7. Depending on the type of fuel used, operating conditions, and the demands of the engine mission profile it may be necessary to increase the frequency of oil changes to avoid the excessive build up of lead and other residues in the engine oil. Always adjust the engine oil change intervals to avoid excessive build up of sludge in the engine oil.

Increased cautions and maintenance required with leaded fuel!

Maintenance Benefit: $0.38/gal Savings vs 100LL

- **$0.38/gal == $500 savings / (100 hrs * 13 GPH)**
  - Assumptions:
    - One inspection vs two in hundred hour period
    - ~$500 for cost of maintenance inspection, oil change, and spark plugs
    - ~13 GPH fuel consumption
  - Use your own numbers to determine your own financial benefits
- **Flight schools avoid 4-8 hours of downtime**
  - Opportunity cost from lost flight school hours

UL94 Tested By Industry Leaders

- **Burt Rutan**
  - 5 years running on two of their Rotax powered aircraft; runs great and great shelf-life
  - Swift Fuels CEO: “Fuel drum purchased by Burt was 100% on spec when tested five years later”

- **Rick Volker (Aerobatic exhibition pilot)**
  - 6+ Hours doing flight testing (UL94 and 100LL; one in each wing)

- **Wilga Twins (Aerobatic exhibition pilots)**
  - Used on their exhibition flights, as well as in their FBO and trainers

- **Mark Patey and the 10 Flying Cowboys (Aerobatic exhibition team)**
  - 2 weeks testing Swift’s new 100R (100 octane unleaded with 10% renewable content)
  - “Game Changer”

Video endorsements from the above at: https://www.swiftfuelsavgas.com/news/

UL94 Tested by AOPA

- **Same fuel consumption as 100LL**
  - All stages of flight

- **Cruise performance (11,500’)**
  - No performance differences
  - CHT ran 10 degrees hotter (360F)
  - EGT ran 50 degrees cooler (1350F)

- **Slightly different aesthetics**
  - Clear (not blue) and “smells different”

- **Tested engine:** 160-horsepower Lycoming IO-320

Source: https://www.aopa.org/news-and-media/all-news/2016/september/13/swift-fuels-94ul-put-to-the-test

Survey Question 2

Would you use UL94 if it was available and competitively priced?

Indicate Yes, No, or Don’t know in the survey

Survey Question 3

If “Yes”, roughly how many gallons/month do you buy?

Indicate number in the survey

What about Unleaded 100 Octane fuel (UL100+ Avgas)?

Fleet Challenges

- Over 2000 models: Everything from crop dusters to medevac to amateur built
- Backwards compatible to 50 year old fleet ➔ some manufacturers no longer around!
- Compatible with existing aircraft fuel supply systems, valves, finishes, etc.
- Should require no or minimal aircraft modifications to use

Performance Challenges

- Comparable performance for all stages of flight
- Any altitude, any temperature, any humidity
- Impact on W&B and range

"Five years away for last fifteen years"

- Industry veteran

Transition Challenges

- Can't replace lead with different toxic material
- Fuel stock: maintaining quality over time
- Liability and re-certifying cost concerns for airplane manufacturers

What about Unleaded 100 Octane fuel (UL100+ Avgas)?

Economic Challenges

- "Big Oil" refineries focused on big business
- Reluctant to spend huge technical effort on a "boutique fuel"
  - GA annual volume == half day of automotive volume
  - Note: Often leaves only one avgas refiner per region (e.g., Chevron on west coast)
- Aviation R&D focused on Safe Alternative Fuel (SAF): "green" Jet-A replacement
  - Large market with large pressures
  - Enables carriers to avoid carbon taxes

Silver Lining

✓ Delays are causing engine manufacturers to support alternatives (e.g. UL94)

✓ National elections may change political focus on this environmental, health problem

What about MOGAS? First, some history …

- **Early 80s**
  - Many / most MOGAS (80/87 MON) STCs are 40+ years ago
  - FAA AC 91-33A (FAA, 1984) and STCs enabled many airplanes of the time to use mogas
  - MOGAS satisfied 80/87 MON STCs and FAA requirements
  - Met STCs and FAA requirements ➔ Life is good!

- **Mid 1980s: Ethanol blending introduced to increase octane**

- **1988: New automotive gasoline spec introduced (ASTM D4814)**
  - Standards reduced MON of fuel stock since ethanol was blended in for virtually entire market
  - Changed formulation of intermediate fuel stock to better blend ethanol

- **1990 (Clean Air Act Amendment) and 2005 (Renewable Fuel Standard)**
  - Finishes and cleaners introduced to fuel stock; 10% ethanol content essentially mandated

What about MOGAS?

- **MOGAS Now is not MOGAS Then**
  - Ethanol now in most MOGAS
  - MOGAS without Ethanol (if available) has lower octane level
  - Cleaners and detergents now often included in varying concentrations

- **Blending custom conforming fuel for a small market is non-starter for refineries**

- **Insurance limitations**
  - Some FBOs, fuel providers, and airports prohibited from using or dispensing

- **MOGAS is not AVGAS**
  - Different quality, different inspections, inconsistent fuel characteristics

Safety Tips If You Do Try MOGAS

Do not fly using MOGAS if the fuel tank temperature is greater than 20°C.

Do not fly above 6000 ft using MOGAS.

Only use MOGAS (leaded or unleaded) if your aircraft/engine combination is approved to do so.

Use Leaded MOGAS conforming with BS:4040, or Unleaded MOGAS conforming with BS:7070 or EN228 as applicable.

Always use fresh fuel from a major supplier with a high turnover (or fuel from a managed aerodrome installation).

Test for the presence of alcohol.

Filter the fuel to ensure it is free from contaminants and water.

When refuelling use metal containers and earth everything properly.

Certain aircraft must use the front fuel tank during take-off, climb, and landing (see CAP 747 Appendix 8, GC No. 2 and GC No. 5).

In the event of fuel pressure fluctuations or engine misfiring, switch any fuel pump on.

Be aware that carburettor icing is more likely.

Mogas more susceptible to vapor lock issues

Mogas loses octane and “gums up” after about 60 days. Use quality, fresh fuel

Mogas more likely to contain ethanol, water, and contaminants

Use fuel pump if concerned about fuel problem

Carb ice may also be culprit!

Source: http://www.avgas.pl/files/Ethanol%20in%20Rotax%20engines.pdf

Reducing Lead Exposure with 100LL

- **When doing runup**
  - Get efficient; limit time at high RPM, don’t go higher than POH recommended
  - Maintain “social distancing” with other aircraft if possible
  - Move away from fence and airport boundaries to protect neighbors
  - Avoid overlapping plumes with other aircraft in runup area or taking off
  - Point your prop wash into an open area or field rather than at another aircraft
  - Avoid loitering in the runup area
    - For example, do passenger briefing before starting your engine
  - Airports may benefit from relocating runup areas

Reducing Lead Exposure with 100LL

- **When fuel sampling**
  - Don’t dispose of it on the ground; put it back in your plane or an approved container
  - Some FBOs may have a fuel disposal container

- **When fueling**
  - Avoid breathing it in
  - Use a face covering
  - Avoid spilling, especially when “topping off”
  - Wash your hands

- **When taxiing or idling**
  - Low RPM, please
  - Consider leaning mixture

- **When teaching**
  - Include lead awareness training in your syllabus

Reducing Lead Exposure with 100LL

- **When flying**
  - Lean mixture appropriately
  - Flying rich is expensive and contributes to excess lead in the air

- **When doing maintenance**
  - Take care when cleaning spark plugs and engine/fuel systems
    - E.g. Use a respirator if sandblasting a spark plug
  - Wear shop clothes or aprons and disposable shoe coverings
    - **Don’t bring the lead home!**
  - Wear disposable gloves when working with fuel and engine/fuel systems
  - Limit kids and other people in the work area
  - Wash hands thoroughly before eating or drinking

Call To Action: Create Awareness, Educate, Build Demand

- **Register your interest at SaveReidHillview.org**
  - From the home page select Unleaded Fuel Initiative
  - Fill in your name and email address

- **Let your elected officials know you'd like them to support bringing unleaded aviation gasoline to Bay Area (and California!) airports**

- **Let your FBO / fuel provider / airport manager / flight school know you are interested in unleaded options**

- **Spread the word and share this presentation!**
  - All materials available on the unleaded Fuel Initiative page at SaveReidHillview.org

Sources and Additional Information

Support Reid Hillview - Updates on UL94 and UL100 at RHV and nearby	SaveReidHillview.org
UL94 FAQ	https://www.swiftfuelsavgas.com/faq
UL94 Eligible aircraft for STC	https://www.swiftfuelsavgas.com/stc
UL94 Order STC online	https://www.swiftfuelsavgas.com/stc/forever-avgas-stc
FAA SAIB on UL94 for use in Grade 80 and UL91	https://rgl.faa.gov/Regulatory_and_Guidance_Library/rgSAIB.nsf/0/5efaf7b4e35481568625801f00642b6a/$FILE/HQ-16-05R1.pdf
"Options for Reducing Lead Emissions from Piston-Engine Aircraft", by National Academy of Sciences, Jan. 2021.	https://www.nap.edu/read/26050/
"Approved Fuels for Aircraft Engine Models" Lycoming Service Instruction 1070AB (Apr. 2020)	https://www.lycoming.com/sites/default/files/SI1070AB%20Specified%20Fuels.pdf
"Suitable Operating Fluids for Rotax Engines" Rotax Service Instruction 12-10-00 (Dec 2020)	https://legacy.rotaxowner.com/si_tb_info/serviceinfo/si-914-019-r11.pdf
Continental information on alternative fuels	http://www.continental.aero/Alternative_Fuels/?terms=unleaded
FAA Site on AvGas. Includes Piston Aviation Fuels Initiative (PAFI) Update (August 20, 2020)	https://www.faa.gov/about/initiatives/avgas/
Lycoming Service Letter re Extended Service for Unleaded Fuels	https://www.lycoming.com/sites/default/files/SL270%20Extended%20Maintenance%20Intervals%20for%20%20Engines%20Operated%20on%20Unleaded%20Fuels_0.pdf

End of Presentation on UL94 Fuel

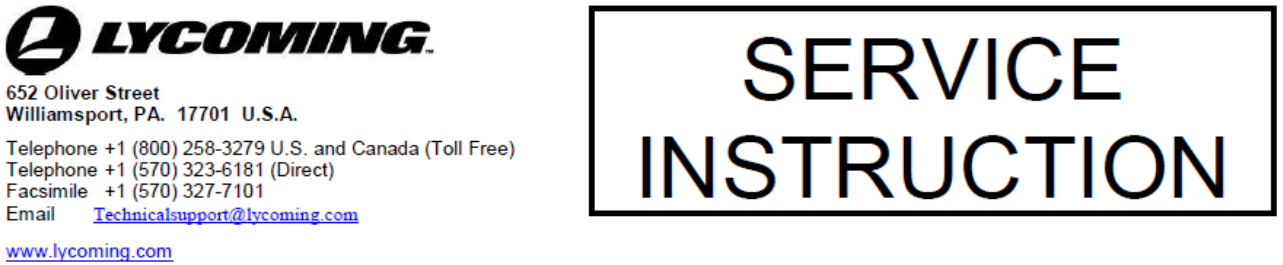
Questions?

Appendix

ADDITIONAL TECHNICAL COMPATIBILITY AND PERFORMANCE SPECS

- LYCOMING

- ROTAX



Approved Fuels For Aircraft Engines

LYCOMING SERVICE INSTRUCTION

Lycoming Service Instruction No. 1070AB (April 8 2020)

Engine Models	Leaded Aviation Fuels (Table 1)					Unleaded Aviation Fuels (Table 1)			Automotive Fuels (Table 2)		
	DEF-STAN 91-090	ASTM D910	TU 38	GOST 1012		ASTM D7547	DEF-STAN 91-090	HJELMCO	ASTM D4814		EN228
	100LL	100* 100LL 100VLL	91*	B91/115*	B95/130*	UL 91 UL 94	UL 91	91/96	91 AKI	93 AKI	Super Plus
O-235											
-C, -E, -H	●	●	●	●	●	●	●	●		●	●
-F, -G, -J	●	●			●						
-K, -L, -N	●	●			●	●	●			●	●
-M, -P	●	●				●	●			●	●
O-290											
-D	●	●	●	●	●	●	●	●		●	●
O-320											
-A, -B, -C, -D, -E	●	●	●	●	●	●	●	●		●	●
-H	●	●									
IO-320											
-A, -B, -D, -E	●	●	●	●	●	●	●	●		●	●
-C, -F	●	●			●						
AIO-320											
-A, -B, -C	●	●	●	●	●	●	●	●		●	●
LIO-320											
-B	●	●	●	●	●	●	●	●		●	●
-C	●	●			●						
AEIO-320											
-D, -E	●	●	●	●	●	●	●	●		●	●
O-360											
-A, -B, -C, -D, -F, -G, -J	●	●	●	●	●	●	●	●		●	●
-E	●	●									
HO-360											
-A, -B	●	●	●	●	●	●	●	●		●	●
-C	●	●	●	●	●	●	●			●	●

Lycoming Service Instruction No. 1070AB (April 8 2020)

Engine Models	Leaded Aviation Fuels (Table 1)					Unleaded Aviation Fuels (Table 1)			Automotive Fuels (Table 2)		
	DEF-STAN 91-090	ASTM D910	TU 38	GOST 1012		ASTM D7547	DEF-STAN 91-090	HJELMCO	ASTM D4814		EN228
	100LL	100* 100LL 100VLL	91*	B91/115*	B95/130*	UL 91 UL 94	UL 91	91/96	91 AKI	93 AKI	Super Plus
IO-360											
-A, -C, -D, -F	●	●			●						
-J, -K	●	●									
-B, -E, -L, -M, -N, -P	●	●	●	●	●	●	●	●		●	●
LO-360											
-A	●	●	●	●	●	●	●	●		●	●
-E	●	●									
TO-360											
-A, -C, -E, -F	●	●									
VO-360											
-A, -B	●	●	●	●	●			●			
AIO-360											
-A, -B	●	●			●						
HIO-360											
-A, -C, -D, -E, -F	●	●			●						
-B	●	●	●	●	●	●	●	●		●	●
-G	●	●	●	●	●	●	●			●	●
IVO-360											
-A	●	●	●	●	●	●	●	●		●	●
LIO-360											
-B, -M	●	●	●	●	●	●	●	●		●	●
-C	●	●			●						
LTO-360											
-A, -E	●	●									

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Engine Models	Leaded Aviation Fuels (Table 1)					Unleaded Aviation Fuels (Table 1)			Automotive Fuels (Table 2)		
	DEF-STAN 91-090	ASTM D910	TU 38	GOST 1012		ASTM D7547	DEF-STAN 91-090	HJELMCO	ASTM D4814		EN228
	100LL	100* 100LL 100VLL	91*	B91/115*	B95/130*	UL 91 UL 94	UL 91	91/96	91 AKI	93 AKI	Super Plus
TIO-360											
-A, -C	●	●									
AEIO-360											
-A	●	●			●						
-B, -H	●	●	●	●	●	●	●	●		●	●
LHIO-360											
-C, -F	●	●									
IO-390											
-A, -C, -D	●	●			●						
HIO-390											
-A	●	●									
AEIO-390											
-A	●	●									
O-435											
-A, -C (except -A2)	●	●	●	●	●	●	●	●			
-A2	●	●									
GO-435											
-C, -C2 (See note below for -C2)	●	●	●	●	●	●	●	●			
NOTE: GO-435-C2 engine models equipped with carburetor setting 10-3391 must use 91/ 6 HJELMC O grade or better fuel. Engines equipped with carburetor settings 10-3391-1 or PS-5BD can use fuels specified for GO-435-C model engines.											
VO-435											
-A, -6, -23	●	●	●	●	●			●			
-B	●	●			●						

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Engine Models	Leaded Aviation Fuels (Table 1)					Unleaded Aviation Fuels (Table 1)			Automotive Fuels (Table 2)		
	DEF-STAN 91-090	ASTM D910	TU 38	GOST 1012		ASTM D7547	DEF-STAN 91-090	HJELMCO	ASTM D4814		EN228
	100LL	100* 100LL 100VLL	91*	B91/115*	B95/130*	UL 91 UL 94	UL 91	91/96	91 AKI	93 AKI	Super Plus
TVO-435											
-A, -B, -C, -D, -E, -F, -G, -25	●	●									
O-480											
-1, -3	●	●									
-A	●	●	●	●	●			●			
GO-480											
-B, -D, -F	●	●	●	●	●	●	●	●			
-C, -G	●	●			●						
GSO-480											
-A, -B	●	●									
IGO-480											
-A	●	●			●						
IGSO-480											
-A	●	●									
O-540											
-A, -B, -D, -E, -F, -G, -H, -J	●	●	●	●	●	●	●	●		●	●
-L	●	●									
-9, -9A	●	●									
IO-540											
-A, -B, -E, - G, -J, -K, -L, -M, -P, -R, -S, -U, -AA, -AC, -AE	●	●			●						
-C, -D, -N, -T, -V	●	●	●	●	●	●	●	●		●	●
-W, -AB, -AF	●	●				●	●			●	●

Lycoming Service Instruction No. 1070AB (April 8 2020)

Engine Models	Leaded Aviation Fuels (Table 1)					Unleaded Aviation Fuels (Table 1)			Automotive Fuels (Table 2)		
	DEF-STAN 91-090	ASTM D910	TU 38	GOST 1012		ASTM D7547	DEF-STAN 91-090	HJELMCO	ASTM D4814		EN228
	100LL	100* 100LL 100VLL	91*	B91/115*	B95/130*	UL 91 UL 94	UL 91	91/96	91 AKI	93 AKI	Super Plus
VO-540											
-A, -B	●	●	●	●	●	●	●	●			
-C	●	●			●						
HIO-540											
-A	●	●			●						
IGO-540											
-A, -B	●	●			●						
IVO-540											
-A	●	●			●						
TEO-540											
-A, -C	●	●									
TIO-540											
-A, -C, -E, -F, -G, -H, -J, -K, -N, -R, -S, -T, -U, -V, -W, -AA, -AB, -AE, -AF, -AG, -AH, -AJ, -AK	●	●									
TVO/TIVO-540											
-A	●	●									
AEIO-540											
-D	●	●	●	●	●	●	●	●		●	●
-L	●	●									
IGSO-540											
-A, -B	●	●									
LTIO-540											
-F, -J, -K, -N, -R, -U, -V, -W	●	●									

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Engine Models	Leaded Aviation Fuels (Table 1)					Unleaded Aviation Fuels (Table 1)			Automotive Fuels (Table 2)		
	DEF-STAN 91-090	ASTM D910	TU 38	GOST 1012		ASTM D7547	DEF-STAN 91-090	HJELMCO	ASTM D4814		EN228
	100LL	100* 100LL 100VLL	91*	B91/115*	B95/130*	UL 91 UL 94	UL 91	91/96	91 AKI	93 AKI	Super Plus
TIO-541											
-A, -E	●	●									
TIGO-541											
-D, -E, -G	●	●									
IO-580											
-A, -B	●	●			●						
AEIO-580											
-B	●	●			●						
IO-720											
-A, -B, -C, -D	●	●			●						

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

ROTAX SERVICE INSTRUCTION 12-10-00 (DEC 2020)

Applicability

All engines of type:

Engine type	Serial number
916 iSc B	all
915 i A (Series)	all
915 i B (Series	all
912 i (Series)	all
912 (Series)	all
914 (Series)	all

3.1) General

Foreign particles formed during combustion are suspended in the engine oil. Together with oil components that are not sufficiently resistant to heat, these foreign particles can cause parts such as pistons, piston rings, exhaust valves, etc., to seize and lead to problems.

Conclusions

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

[NOTE: There were multiple conclusions, but the first one was … **USE UNLEADED**!]

3.2) Operation with unleaded and low-lead fuel (less than 0.1 g/liter lead content)

NOTICE

When operating primarily on unleaded fuels or MOGAS, the maintenance intervals remain unchanged in regard to the published maintenance schedule found in the currently valid Maintenance Manual for the engine type.

100LL == 0.56g/liter (max)

3.3) Operation with leaded AVGAS fuels

Perform maintenance checks according to the latest Maintenance Manual.

More frequent oil changes will assure timely removal of residues and oil sludge thus avoiding increased wear or operating troubles.

Engine oils tested according to RON 424* for use with our ROTAX® engine types 916 iSc B, 915 i A/B Series, 912 i Series, 912 and 914 Series (use of leaded AVGAS):

Brand	Description	Specification	Viscosity
SHELL®	AeroShell Oil Sport Plus 4 [1) 2)]	RON 424*	SAE 10 W-40

1) with new formulation

2) in red bottle

Increased cautions and maintenance required with leaded fuel!

5) Fuel

	Usage/Description	
	912 A/F/UL Min. RON 90	**912 S/ULS - 914 F/UL** Min. RON 95
Indian standard (date: 2008)	IS 2796:2008	IS 2796:2008
	MG 91	
	MG 95	MG 95

AVGAS		
leaded	AVGAS 100 LL ASTM D910	AVGAS 100 LL ASTM D910
unleaded	UL91/UL94 ASTM D7547	UL91/UL94 ASTM D7547

	Usage/Description	
	912 iSc/iS Sport Min. RON 95	**915 iSc/iS A - 915 iSc B** Min. RON 95
US standard (date: 2020)	ASTM D4814 (min. AKI 87)	ASTM D4814 (min. AKI 91)

	916 iSc B Min. RON 98
US standard (date: 2020)	ASTM D4814 (min. AKI 91)

While UL94 was not specifically identified (presumably because that specific fuel was not tested on these engines), UL94 exceeds the minimum octane identified for these engines.

Federal Aviation Administration

Rotax 914 Series Line Maintenance Manual

2) Checking of the overload clutch

General note In the event of lead deposits and/or if slipping is suspected, it will be necessary to check the overload clutch.

NOTES: Slipping of overload clutch is apparent if at engine speed rise, the propeller speed does not increase at the same rate.

NOTES: The engine should be run for a short time just prior to the test, otherwise there is the risk of the clutch „drying out“, resulting in a higher torque.

Step	Procedure
1	Remove the propeller as per manufacturers instruction.
2	Lock the crankshaft. See chap. 12-20-00 section: 7)
3	***NOTICE*** Danger of damage to the engine suspension! Depending on the engine installation (e.g. in the case

Lead deposits lead to other issues!

Source: https://www.rotax-owner.com/pdf/MML_914_Series_ED2_R2_E.pdf

Related Safety Note on Rotax and mogas

Generally, the more ethanol or toluene, the more the octane rating is increased. However, this is not a golden rule and some high octane 'low aromatic' fuels – like BP Ultimate 98 – do not contain ethanol and have a low levels of aromatics such as toluene.

Both ethanol and toluene can affect rubber and plastic components in the fuel system. Toluene also has a high carbon content that may lead to sooty spark plugs – so don't assume that this indicates an overly-rich mixture.

So it seems some unleaded fuels which contain substantial ethanol and/or toluene levels may be having a negative impact on plastic and rubber components in your engine!

UL94 does not contain Ethanol
UL94 and 100LL contain toluene (1-10% by weight)
Mogas contains toluene (1-25% by weight) and Ethanol (0-10% by weight)

https://foxbatpilot.com/2014/04/08/auto-fuel-rotax-engines/
Contents of UL94, 100LL, and mogas come from MSDS