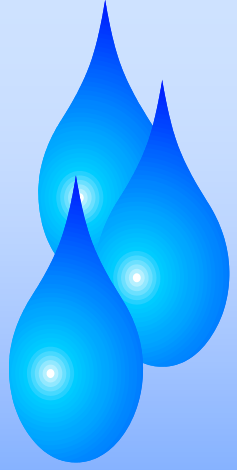
Unleaded Aviation Gasoline

California June / July 2012

HJELMCO OIL AB

Lars Hjelmberg

Executive Director



Aviation Gasoline

=

AVGAS

versus

Car Gasoline

Aviation Gasoline

A specialty product.

Estimated global production

~ 1,600,000 tons/year

In volume

< 0.5 % of automotive gasoline

or

< 1/4 of automotive gasoline system evaporation

Aviation Gasoline

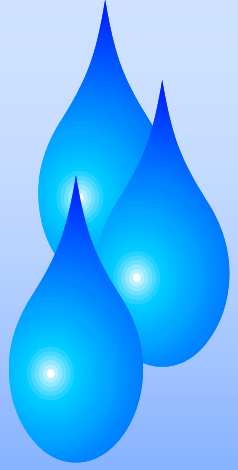
Tailored to meet challenges at surface all the way up to 35,000 feet anywhere in the world

Why Aviation Gasoline and not Car Gasoline ?

- Higher octane
- Lower vapor pressure
- No ethanol
- Lower freezing point
- Guaranteed energy content
- Tailored distillation

Why Aviation Gasoline and not Car Gasoline ?

- Better storage stability
- Less corrosive
- Known hydrocarbon components
- World-wide standardized product (ASTM D910)



However some piston powered aircraft fly locally and at low altitudes.

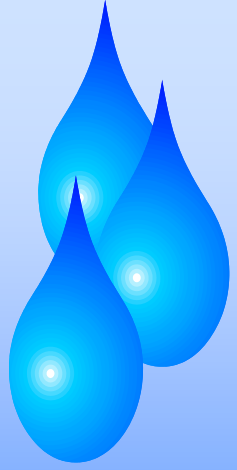
Aircraft built in small volumes for a world market.

Aviation Gasoline 100 Octane Low Lead - AVGAS 100 LL

Typical Formula

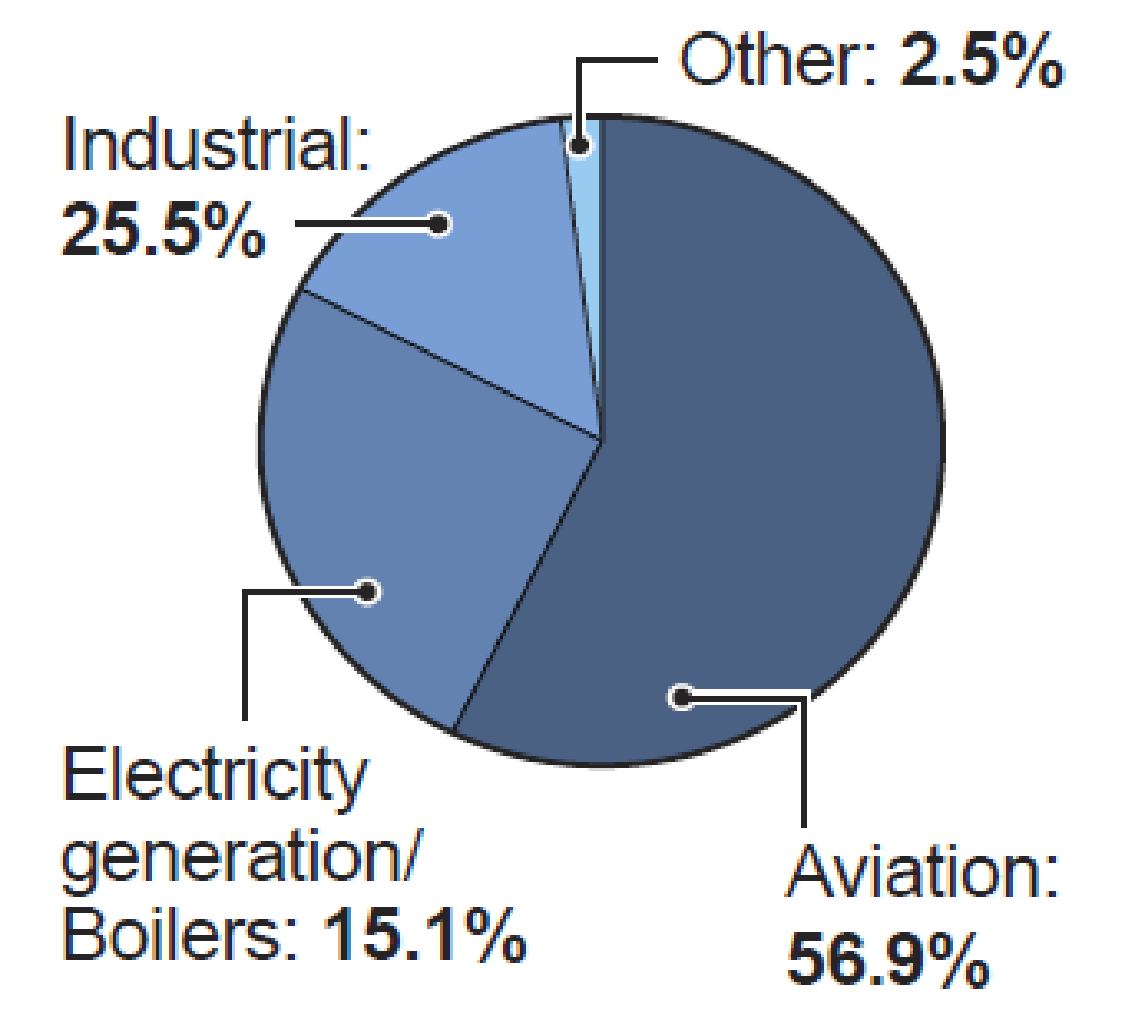
- Alkylate ~ 70 %
- Isopentane ~ 15 %
- Toluene ~ 15 %
- Lead
- Dyes
- Scavenger
- Antioxidant

} Additives



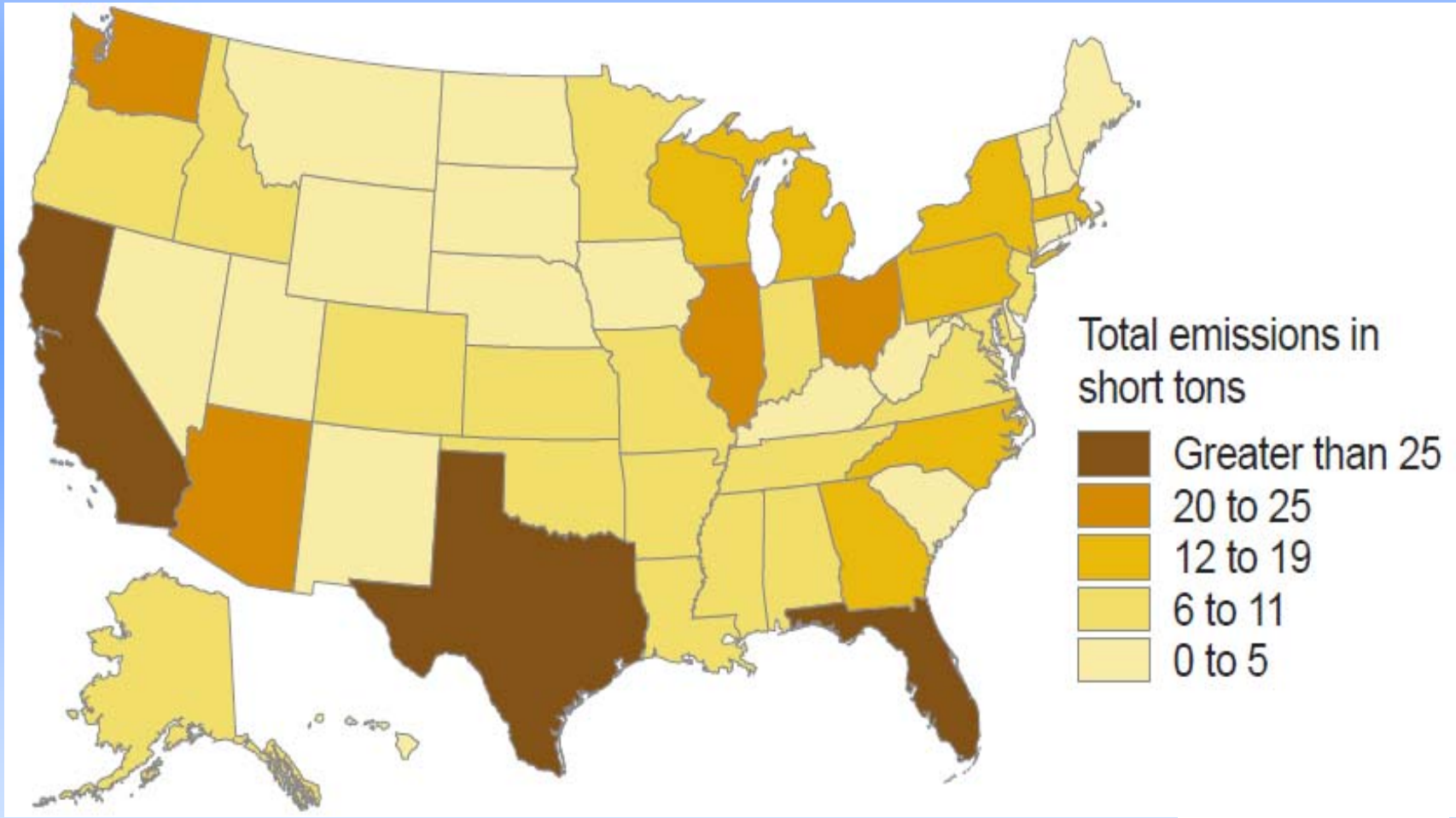
The Problem

Sources of Lead Emissions

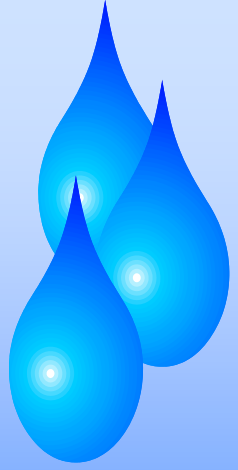


Source: *2008 Environmental Protection Agency survey.*
Graphic: *David Evans BGOVgraphics@bloomberg.com*

State-by-State Aviation Lead Emissions (Piston Engines)



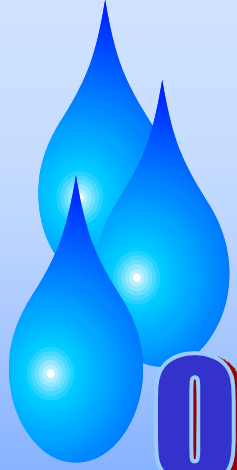
Source: *Bloomberg Government.*



The problem can be solved by reducing lead

eliminating lead

is not necessary



One country in the world has their solution to the AVGAS lead problem in use since 1981

Sweden

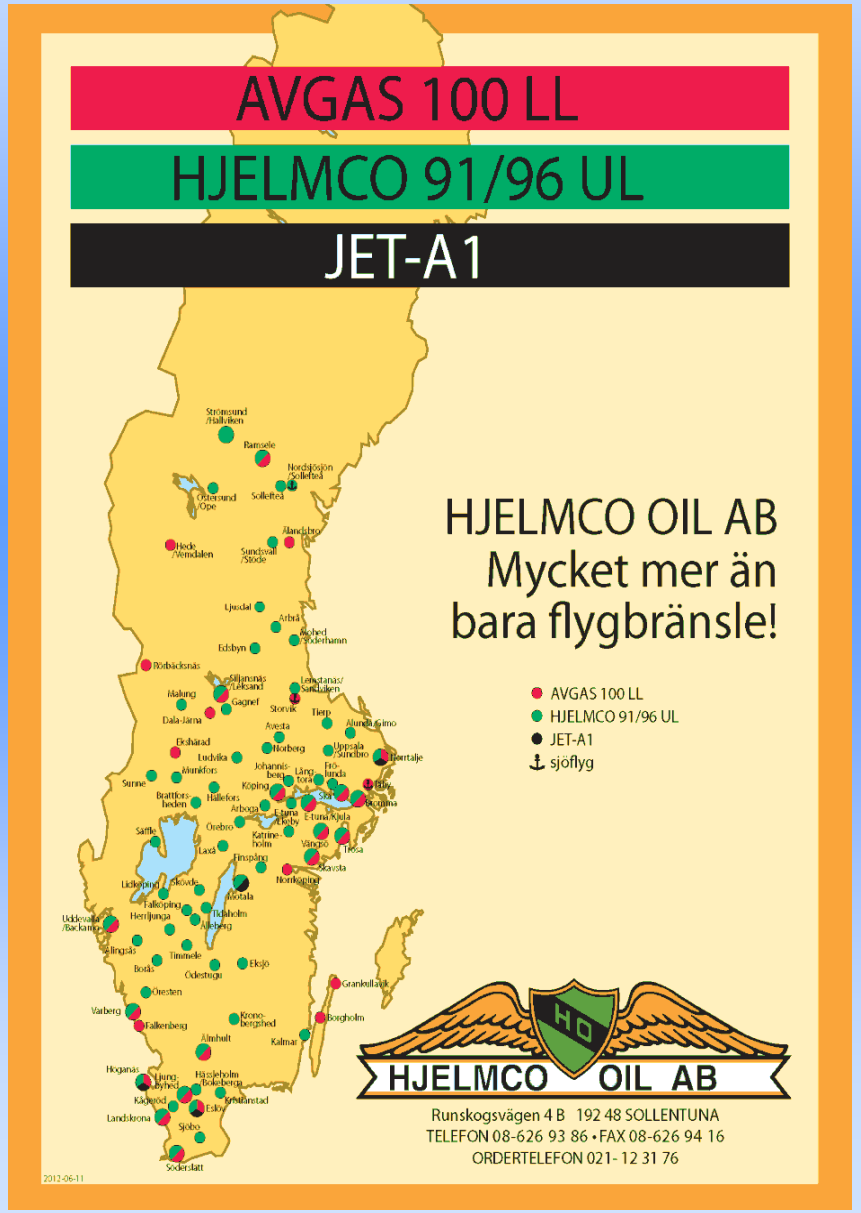
Source: *se.freepik.com*

Sweden Year 2012

- Green dots are airports with unleaded AVGAS
- Unleaded area ~

800 miles long

400 miles wide



Sweden

- ~9 million inhabitants
- ~1,500 aircraft
- ~200 airports
- ~30% north of polar circle

Hjelmco 91/96 UL™

Fuel is transparent to AVGAS 100 LL

- Made of similar components but of higher purity and quality
- 100% mixable with leaded AVGAS
- A drop-in fuel
- Follow Lycoming SI 1409 (correct engine oil)

31 Years of Unleaded AVGAS in Sweden

Hjelmco 91/96 UL today 2012

- Available at > 70 airports
- Used by ~ 1,000 aircraft
- Excellent technical history
- Approved by piston engine manufacturers covering > 90% of the entire world piston aircraft fleet.
- Produced by Hjelmco Oil in Sweden

EASA =
European Aviation Safety Agency

Similar responsibilites as the FAA in the USA

Developments Summer / Autumn 2010 in Europe

- Air TOTAL launches UL 91 AVGAS
- ROTAX approves UL 91 AVGAS
- Both meeting US standard D7547
- EASA issues SIB 2010-31 for “orphaned” aircraft
- Swedish CAA to propose lower fuel taxes in Sweden on unleaded AVGAS

Breakthrough 2010 by EASA SIB 31

- **If the unleaded AVGAS is a traditional AVGAS (D910) and as such approved by the engine manufacturer no extra approval is required from the airframe type certificate holder or for orphaned aircraft.**

EASA Facilitates the Introduction of Unleaded Aviation Gasoline in EASA Territories

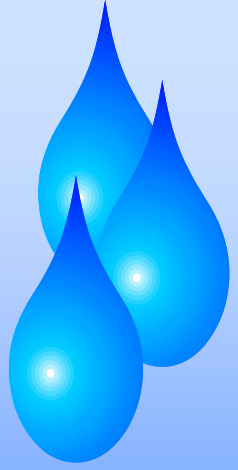
EASA SIB No: 2010-31

EASA Safety Information Bulletin

SIB No.: 2010-31
Issued: 08 November 2010

Subject: **Unleaded Aviation Gasoline (Avgas) Hjelmco 91/96 UL and Hjelmco 91/98 UL**

Ref. Publication(s): **Standards and Specifications**:
ASTM D7547-09 “Standard Specification for Unleaded Aviation Gasoline”.
ASTM D910-07 “Standard Specification for Aviation Gasoline”.
Defence Standard 91-90 Issue 3.
Military Specification MIL-G-5572 (now obsolete and replaced by ASTM D910)



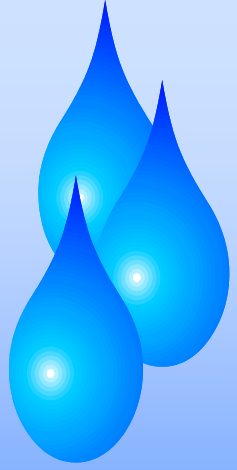
All of Us
It is Time to Think

- **Why is there in 2012 no unleaded certified aviation gasoline to purchase in the USA when such certified and approved products have been on the market in Sweden for 31 years?**

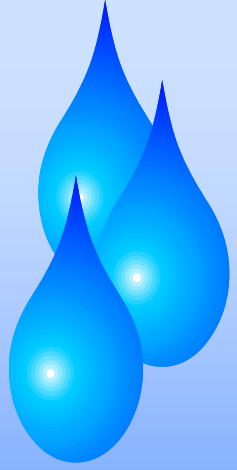
Conclusion

Unleaded AVGAS is not about technology availability etc.

It is about ECONOMICS



What can I do?



Who is taking the decisions ?

You and Me !

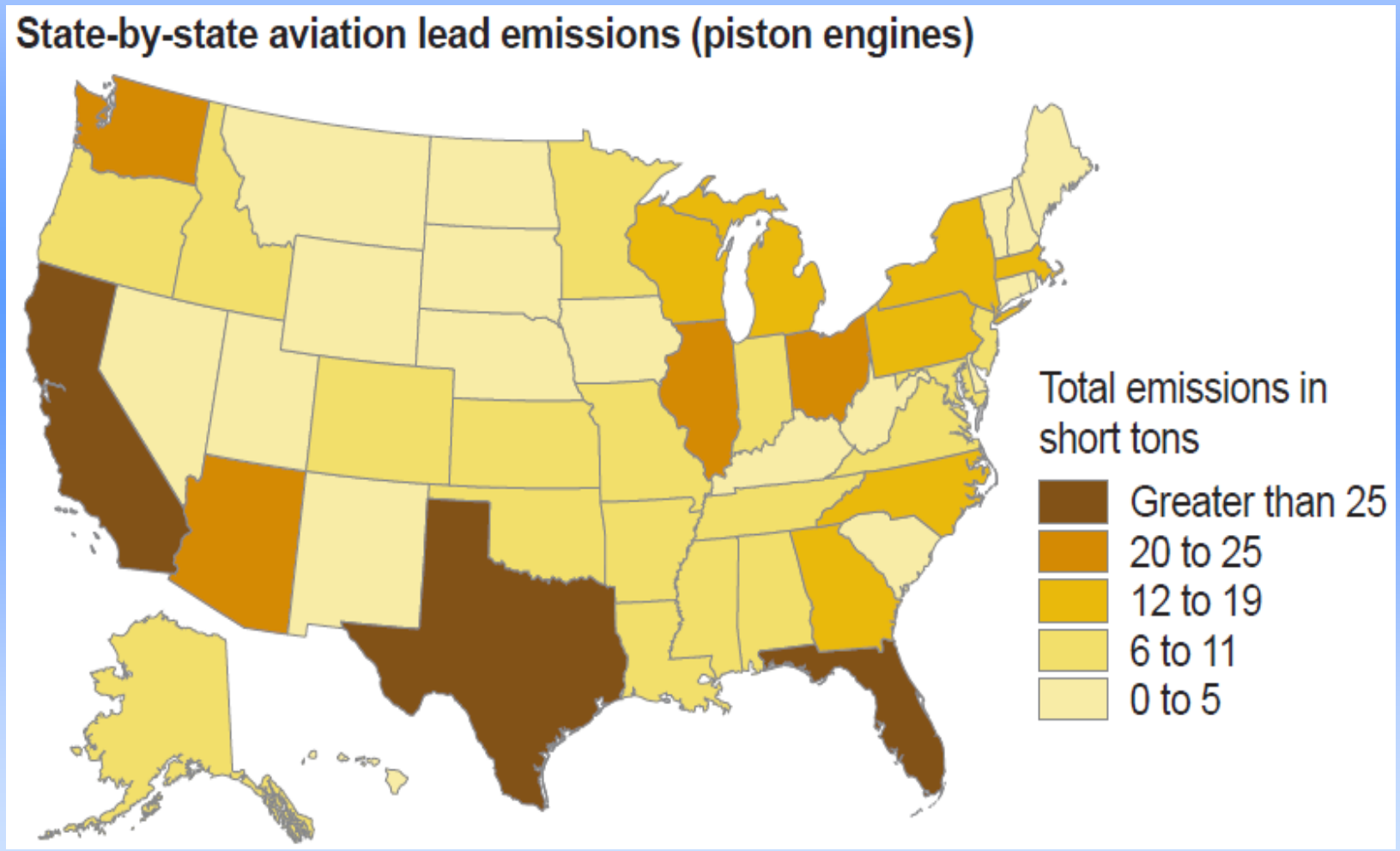
Easiest way to get a change is to create incentives such as reductions in

- Fuel taxes
- Landing fees
- Asset taxes
- Immediate write off of fuel station investments
- etc.

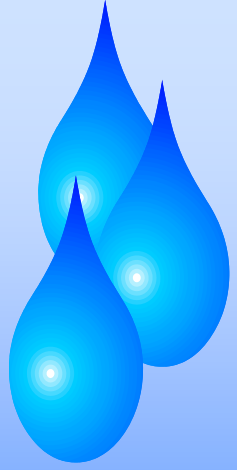
Create Regional Markets

- Unleaded AVGAS has to start somewhere
- Lower fuel prices will increase volume and decrease down stream costs

Regional Markets for Action



Source: *Bloomberg Government.*



Technical Backgrounds & Solutions

From the Beginning All AVGAS was Unleaded

What Will be the Future AVGAS?

A dual AVGAS situation?

Keeping AVGAS 100 LL (VLL) for a/c that really need 100 LL and UL 94 (Hjelmco AVGAS 91/96 UL)

or

UL91 for the rest of the fleet.

Requires an agreement with EPA and industry.

Air-quality will rule

(amount of lead in the air next to major GA-airports)

MINIMUM

HJELMCO 91/96 UL

(Avgas 91/96 UL, Hjelmco 91/98 UL, Avgas 91/98 UL)

FARA

OBLYAD FLYGBENSIN. FARLIGT VID INANDNING.

Mycket brandfarlig vätska och ånga. Kan vara dödligt vid förtäring om det kommer ner i luftvägarna. Irriterar huden. Kan göra att man blir dåsig eller omtöcknad. Misstänks kunna skada det ofödda barnet. Kan orsaka organskador genom lång eller upprepad exponering. Mycket giftigt för vattenlevande organismer med långtidseffekter.

Använd inte produkten innan du har läst och förstått säkerhetsanvisningarna. Får inte utsättas för värme/gnistor/öppen låga/heta ytor. – Rökning förbjuden. Används endast utomhus eller i väl ventilerade utrymmen. Undvik utsläpp till miljön. VID FÖRTÄRING: Kontakta genast GIFTINFORMATIONSCENTRAL telefon 112 eller läkare. Framkalla INTE kräkning.

Innehåller: Nafta > 99%. Nafta innehåller bl.a. toluen < 25%, n-hexan < 5%, isopentan < 25%, 2,2,4-trimetylpentan < 40%, 2,3,4-trimetylpentan < 13%, 2,3,3-trimetylpentan < 10%, *m*/*o*/*p*-xylen < 9%, etylbensen < 2%.

Leverantör: Hjelmco Oil AB, Stuvargatan 9, 721 32 Västerås Tfn. 021-12 31 76 © 2011-06-02

AVGAS 100 LL

(Avgas 100 VLL)

FARA

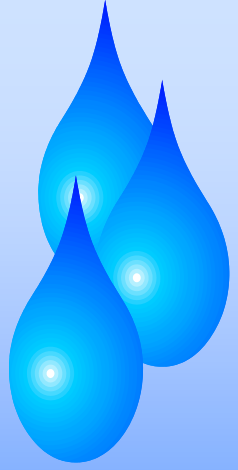
BLYHALTIG FLYGBENSIN – FÅR ENDAST ANVÄNDAS SOM FLYGBRÄNSLE
GIFTIGT VID INANDNING, HUDKONTAKT OCH FÖRTÄRING

Mycket brandfarlig vätska och ånga. Kan vara dödligt vid förtäring om det kommer ner i luftvägarna. Irriterar huden. Kan göra att man blir dåsig eller omtöcknad. Misstänks kunna skada det ofödda barnet. Kan orsaka organskador genom lång eller upprepad exponering. Mycket giftigt för vattenlevande organismer med långtidseffekter.

Använd inte produkten innan du har läst och förstått säkerhetsanvisningarna. Får inte utsättas för värme/gnistor/öppen låga/heta ytor. – Rökning förbjuden. Används endast utomhus eller i väl ventilerade utrymmen. Undvik utsläpp till miljön. VID FÖRTÄRING: Kontakta genast GIFTINFORMATIONSCENTRAL telefon 112 eller läkare. Framkalla INTE kräkning.

Innehåller: Nafta > 99%, bly < 0,56 gPb/L, 1,2 dibrometan < 0,43 gBr/L. Nafta innehåller bl.a. toluen < 17%, n-hexan < 5%, isopentan < 18%, 2,2,4-trimetylpentan < 31%, 2,3,4-trimetylpentan < 35%, *m*/*o*/*p*-xylen < 9%, etylbensen < 2%.

Leverantör: Hjelmco Oil AB, Stuvargatan 9, 721 32 Västerås Tfn. 021-12 31 76 © 2011-06-02



Dual AVGAS will not eliminate lead but may reduce lead to safe levels.

Dual AVGAS

Benefits:

- Drop in replacements fuels for 100 LL
- Cheap to produce
- Known products
- Allows for slow elimination of leaded AVGAS during xx-years
- Allows for new a/c to be certified on UL94

Dual AVGAS

Disadvantages:

- Production of 2 AVGAS
- Logistics – storage and distribution
- Costs for 2 products
- Cost for 2 fuel tanks at the airport

New fuel tank not necessary extra investment for unleaded AVGAS – old 100 LL tank might only be good for xx years allowing for a transition to UL fuel

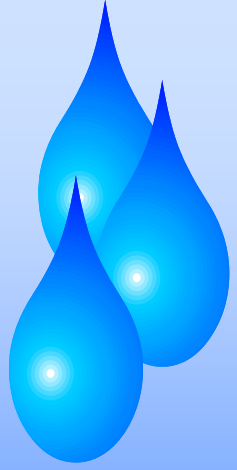
Dual AVGAS
1500 gallon tank Hjelmco 91/96 UL

Cost for Fuel Tanks in Sweden

800 gal. $12,000
1500 gal. $15,000
2500 gal. $35,000

6500 gal. fuelstation
$105,000

Dual AVGAS
Gasoline Producers
Distributors
Airport Fuel Providers
take Investment Costs.



Single Unleaded Fuel Solution

Low Octane Route

Unleaded AVGAS Certified Today

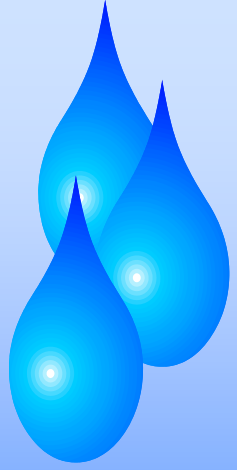
- **ASTM D910 Without Lead**
  - Hjelmco 91/96 UL for all 91/96, 80/87 octane, Rotax and Kalisz (radial) engines
- **ASTM D7547**
  - UL 91 for Rotax, 80/87 octane and certain 91/96 engines
- **ASTM D6227**
  - 82 UL + 87 UL for certain 80/87 octane engines, Rotax and certain 91/96 engines. (car-gasoline without ethanol)
- **Nothing for 100/130 Octane Engines**

Single Unleaded Fuel Solution
Low Octane Route

- Hjelmco 91/96 UL is an ~ 93 octane fuel similar to UL 94 as per ASTM test specification
- Increase octane to ~ 96 through adding mesitylene, ETBE, amines pending location in the world.
- Resulting fuel will be a fuel meeting 100 LL in ”all” aspects except for 0-lead and octane.

Single Unleaded Fuel Solution
The Fleet (Estimate)

- ~ 90% = req. AVGAS 80+91
- ~ 5% = req. 100 LL turbocharged
- ~ 4% = req. 100 LL non turbo
- ~ 1% = specials, war-birds etc.



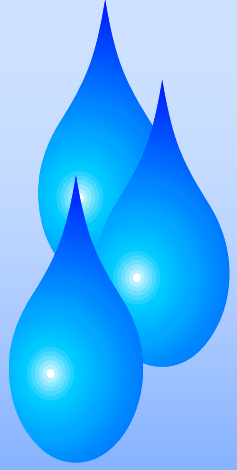
~ 90% = req. AVGAS 80+91

These are safe today

No cost.

~ 5% = req. 100 LL Turbocharged

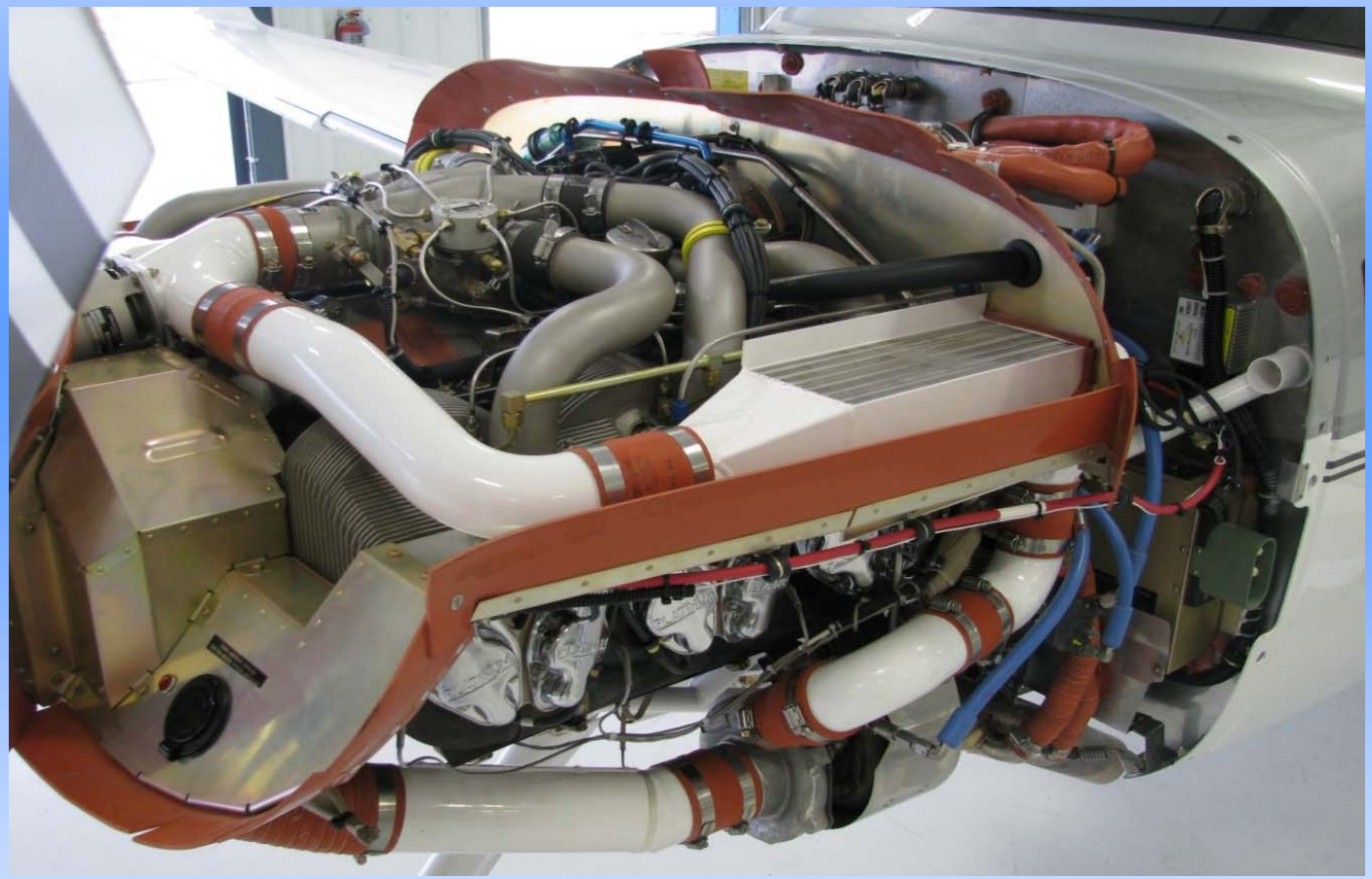
- Turbocharged engines have lower compression
- Proven in ground tests to give abt 95% power with 93 octane + intercooler + for certain engines electronic ingnition system
- - 2.5% power was OK as per old certification criteria.
- Should be fine with 95 - 96 octane
- Perhaps certain restrictions in cylinder head temp
- Cost if intercooler added est. $15,000 p. engine
- Additional cost elec. ign. est. $15,000 p. engine



~ 4% = req. 100 LL Non Turbo. The Challenge

1. Often same engine exists with lower c/r and less power due to lower pistons.
2. Decrease compression ratio (lower pistons) = less h.p.
3. After market installation of turbocharger + intercooler ? + electronic ignition system? gives original power back.
4. Cost est. $20,000 - $45,000 per engine

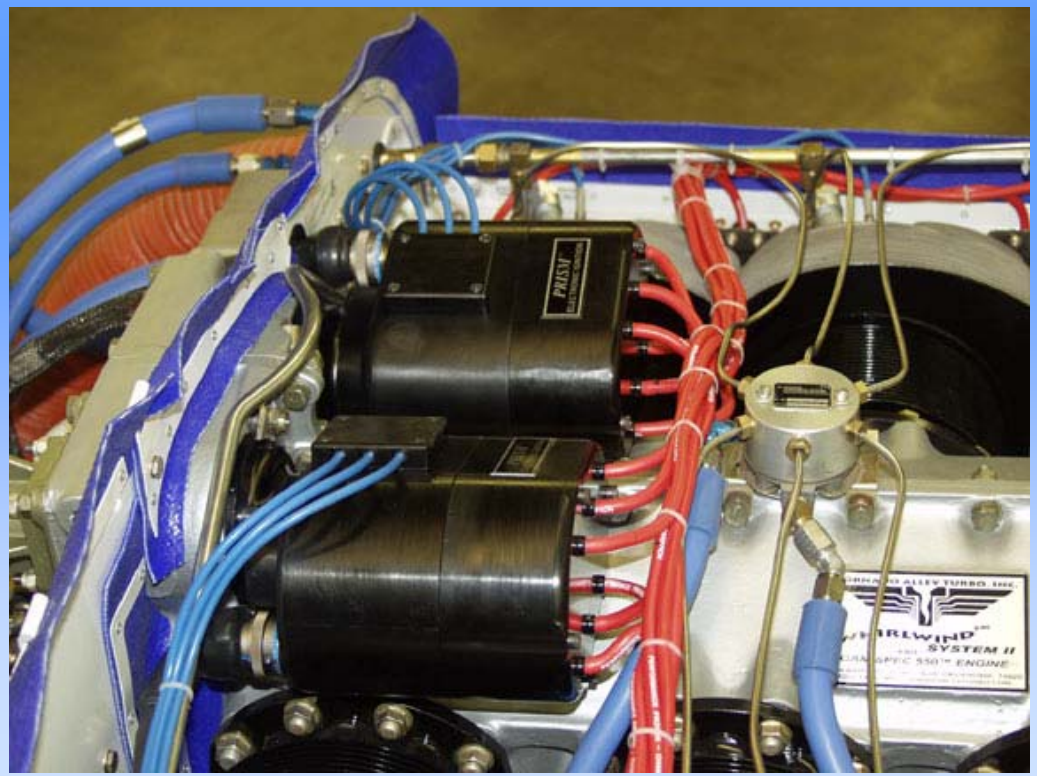
GAMI Aftermarket Turbo & Inter-Cooler Installation in Cirrus SR22

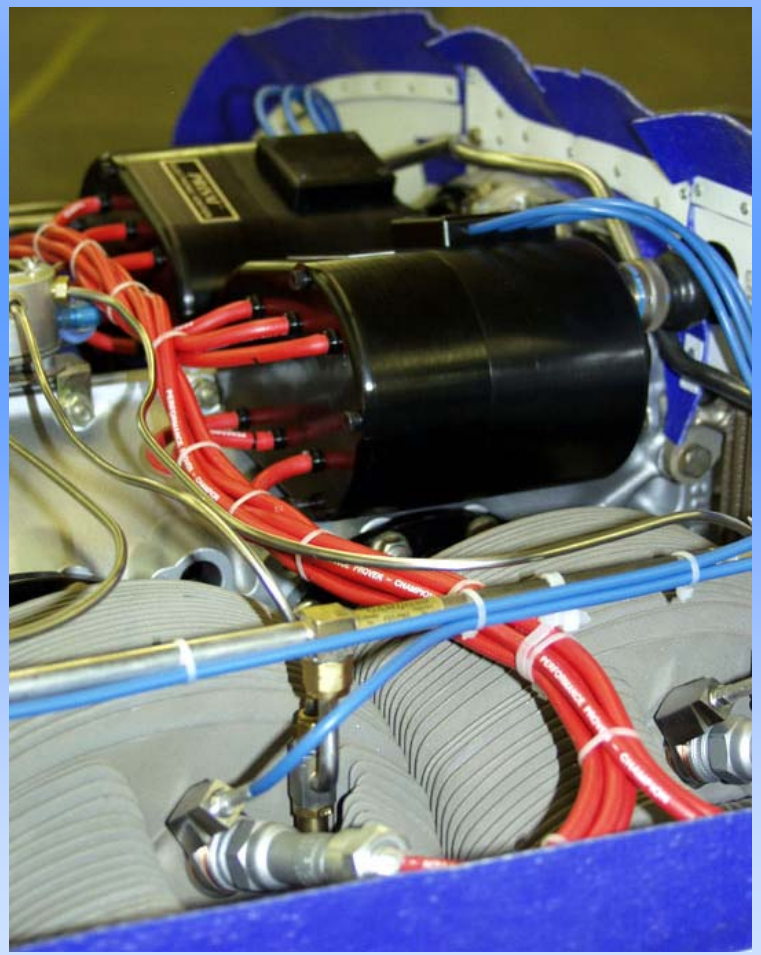


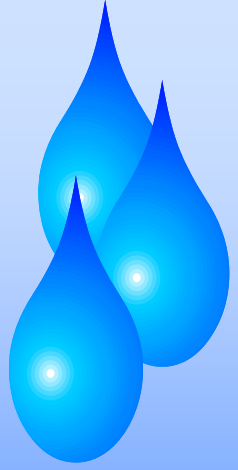
This is a turbo normalizer installation that will not increase power as suggested
This picture is only presented as a way to show an installation.

Source: *GAMI*

GAMI's Aftermarket Electronic Ignition System PRISM







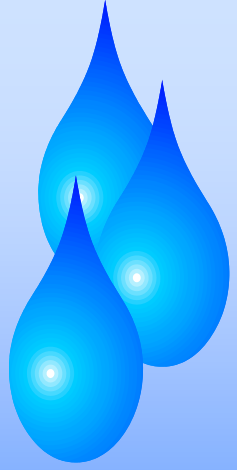
~ 1% = Specials, War-Birds etc.

- An anti-detonation injection system methanol/water will give ~ + 12 octane
- Alternate way of cooling the engine
- Might require small amounts of lead due to non hardened valve parts in old engines
- Cost est. from $15,000 and up per engine

ADI-system has the strength to cover 10% of fleet

Petersen Aviation Inc.
Electronic ADI-System

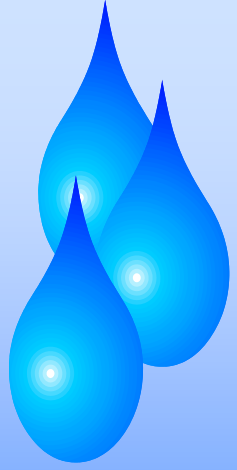
Source: *Petersen Aviation Inc.*



Single unleaded fuel solution

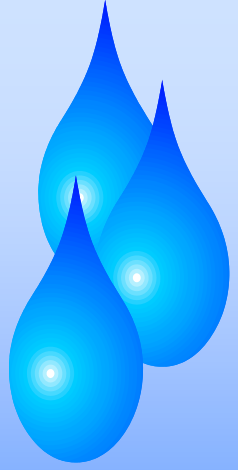
low octane route

Aircraft owners take investment costs



Single Unleaded Fuel Solution

High Octane Route



There is no high octane unleaded AVGAS in development that 100% meets existing AVGAS standard ASTM D910 but is without lead

High Octane Unleaded AVGAS Under Development not Meeting Current AVGAS Standard

SWIFT Fuel

GAMI G100UL™

Hjelmco 100UL

All may contain large % of biomaterial

GAMI and Swift Fuels

- Both fuels satisfies octane requirements of AVGAS 100 LL engines.
- Contain large amounts of aromatics and are more heavy than JET-fuel.

Hjelmco 100 UL

- **Hjelmco 100 UL satisfies octane requirements of AVGAS 100 LL engines.**
- **Contains large amount of ETBE (ether made from ethanol)**
- **ETBE is not favoured in the US**
- **Risk for ground water contamination**

Avgas Under Development Not Meeting Current AVGAS Standard

- Uphill battle to prove suitability
- Parameters in current standard are there for known reasons

Avgas Producers´ Solution

- Introduction of bio-material may open up for tax-incentives from politicians.
- End-product is cleaner and less toxic

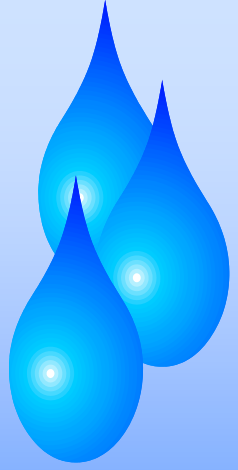
AVGAS Producers´ Concern

BUT

will tax-incentives etc. compensate for research and development costs of new fuels

&

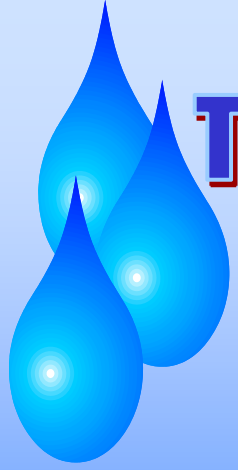
overall higher production costs?



Single unleaded fuel solution

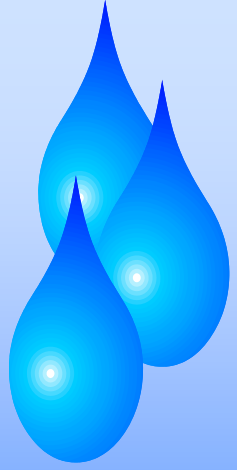
high octane route

Fuel developers take the investment costs



To make an investment is to take risk
So the reason why nothing has happened in the US for 30 years?

Could it be that none of the parties concerned are interested to take the risk because they can't evaluate the risk-reward situation?



Or

Everyone involved knows the light aviation market is very fragile (airlines are a forever ongoing loss business?)

The Story of Hjelmco 91/96 UL™ an Unleaded AVGAS

American AVGAS Standard ASTM D910

The aviation gasoline standard to which Lycoming and Continental aircraft engines among others are type-certificated to.

American AVGAS Standard ASTM D910 Issue Year 1981

“If mutually agreed upon between the purchaser and the supplier, Grade 80 may be required to be free of tetraethyl lead. In such case, the fuel shall not contain any dye and the color as determined in accordance with ASTM Method D 156, Test for Saybolt color of Petroleum Products (Saybolt Chromo meter Method) shall not be darker than + 20”

J3 Cub Model 1944
Continental A65

Source: *Björn Ek Vallentuna*

Cessna 172 Model 1973 Lycoming O-320 Engine

Cessna 150 Model 1968 Continental O-200 Engine

Sources:
Aeroclub of Eskilstuna.
Krister Lundholm Vallentuna.

Unleaded Avgas from Hjelmco Oil

Unleaded AVGAS 80

- Used in Sweden between 1981-1991
- Nationwide distribution and use
- More than 50 airports involved
- More than 400 aircraft
- Used by the Royal Swedish Air Force

Sweden 1991

Hjelmco Oil introduced unleaded aviation gasoline Hjelmco 91/96UL™

Reason:

80/87 UL potential market c:a 30%

91/96 UL potential market c:a 70%

USA 1995

Textron Lycoming recognizes Hjelmco 91/96UL™ unleaded AVGAS as an approved alternate AVGAS for the GA fleet In Service Instruction 1070 L

1995 Textron Lycoming SI 1070 L

TABLE OF SPECIFIED FUELS (CONT.)

Engine Models	SPECIFIED FUELS		Alternate Military and Commercial Grades
	Certificated For Use With Grade	Commercial Grade Designation	
O-320-B,-D; IO-320-B,-D; LIO-320-B1A; AEIO-320-D; AIO-320-A,-B,-C; O-480-A; O-360-A,-C; IO-360-B, -E; AEIO-360-B,-H; VO-360-A,-B; IVO-360-A; HO-360-A,-B; HIO-360-B; O-435-A2; GO-435-C2*; O-540-A,-D,-E,-F,-G,-H; IO-540-C,-D,-N,-T; AEIO-540-D	91/96	100LL or 100	91/96 UL or ④100/130 or ④115/145

Mooney M20C ~1970 Lycoming 0-360-A

Rockwell 114 Model 1977 Lycoming I0-540 T

Piper 28-161 Model 1988 Lycoming 0-320 D

Sources:
Wikimedia Commons.
Christer Dahlgren Stockholm.

Piper PA30/39 Twin Comance Lycoming IO-320 B Engines

Piper PA44 Seminole Lycoming O-360A

Sources:
Bror Axelsson Stockholm.
Wikimedia Commons

Beech Duchess 76 Model 1979
Engine: Lycoming O-360A

Source: *Wikimedia Commons.*

Engines Suitable for Hjelmco 91/96 UL

- **Basically all aircraft engines up to 180 hp and between 230-260 hp. (see type-certificate)**
- **Twin engine aircraft:**
  - **Aztec, Cougar, Seminole, Duchess, etc.**
- **Single engine aircraft:**
  - **Piper Cherokee, Warrior, Archer, Cherokee six, Robin 100, Rockwell 114, Cessna 150, 172, 182 (exceptions exist) Socata Trinidad, Tobago etc.**

HJELMCO 91/96 UL™

Swedish CAA safety review 1999

Fuel is and has been safe to use

EXTENSIVE SUPPORTING ENVIRONMENTAL DOCUMENTATION

DLR

MICROPHYSICAL AND CHEMICAL PROPERTIES OF NANOPARTICLES EMITTED BY FLIGHT ENGINES

Results from German PAZI Project

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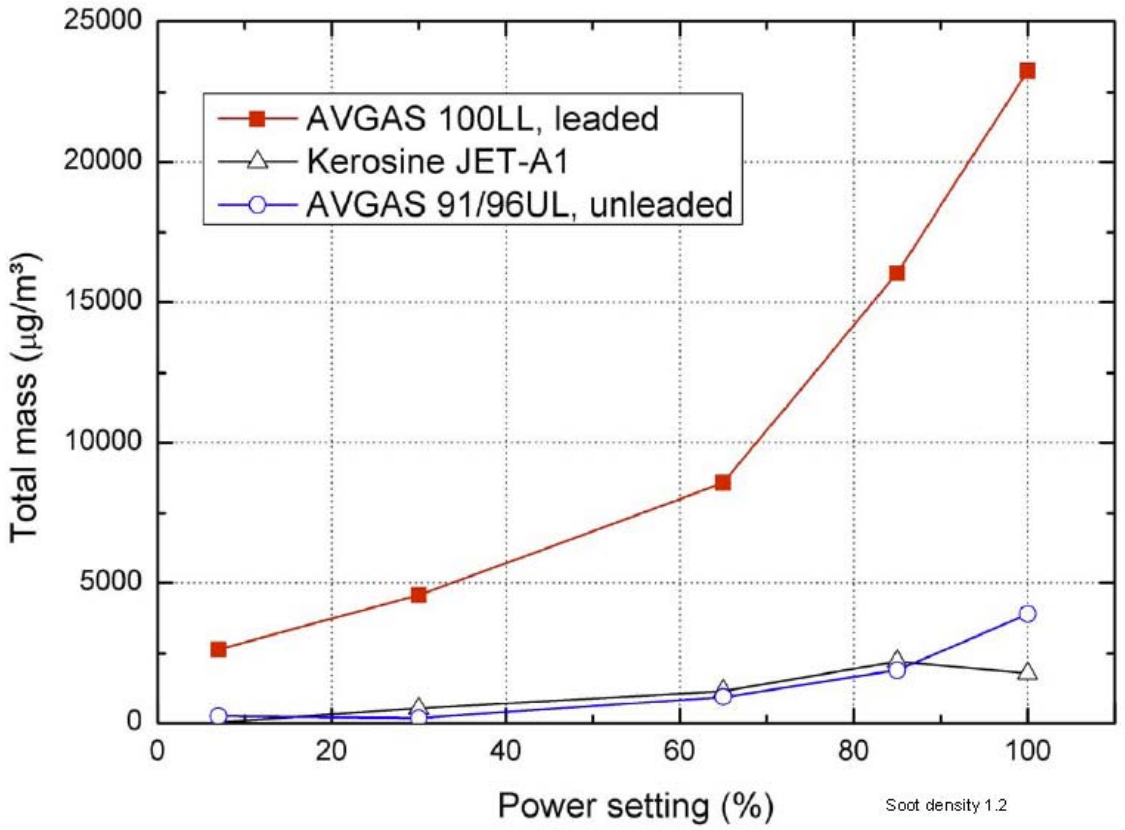
EXTENSIVE SUPPORTING ENVIRONMENTAL DOCUMENTATION

DLR

HB-EYS piston engine compared with flight gas turbine




MARINE POLLUTANT

Unleaded Hjelmco 91/96 UL™

Pure hydrocarbon fuel made from current low-cost, environmentally sound aviation gasoline components.

NO

ETHANOL, MTBE, ETBE, TAME, SYNTHETIC COMPOUNDS etc.

Cessna Service Letter 2012

Single Engine

SERVICE LETTER

Cessna
A Textron Company

SEL-12-01

CESSNA MODEL	LYCOMING ENGINE	EASA SIB 2011-01R2	EASA SIB 2010-31
		UL91 PER ASTM D7547	HJELMCO 91/96UL
172I	O-320-E2D	X	X
172K			
172L			
172M			
F172L*			
F172M*			
177			
172P	O-320-D2J		X
F172P*			
172Q	O-360-A4N	X	X
177A	O-360-A2F	X	X
177B	O-360-A1F6	X	X
	O-360-A1F6D	X	X
172RG	O-360-F1A6	X	X
172R	IO-360-L2A	X	X
172S		X	X

* Models F172L, F172M, F172P were produced by Reims Aviation S.A.

Cessna Skyhawk Model 2012
Hjelmco 91/96 UL™ = OK

Source: *Aeroclub of SAS in Stockholm.*

Piper Archer-III Model 2012
Hjelmco 91/96 UL™ = OK

Source: *Aeroclub of Ängelholm.*

Diamond DA42 L360 Model 2012
Hjelmco 91/96 UL™ = OK

Source: *Diamond Aircraft.*

2012 Textron Lycoming SI 1070 R

TABLE B-2 ENGINE MODELS APPROVED FOR UNLEADED AVIATION FUELS		
Lycoming Engine Models	**SPECIFIED FUELS ASTM D7547** **Certificated For Use With Grade**	**Military And Commercial Grades**
O-235-C, -E, -H **O-290**-D **O-435**-A, -C **O-290**-D2 **O-320**-A, -C, -E **IO-320**-A, -E **AEIO-320**-E **O-340**-B **O-360**-A, -B, -C -D, -F, -G, -J **IO-360**-B, -E, -L, -M **LIO-360**-M1A **LO-360**-A1H6 **IVO-360**-A1A **GO-435**-C2	UL 91	HJELMCO 91/96 UL

2012 Textron Lycoming SI 1070 R

TABLE B-2 ENGINE MODELS APPROVED FOR UNLEADED AVIATION FUELS		
Lycoming Engine Models	**SPECIFIED FUELS ASTM D7547** **Certificated For Use With Grade**	**Military And Commercial Grades**
(Contd.) **GO-480**-B, -D, -F **O-540**-B **VO-540**-A, -B	UL 91	HJELMCO 91/96 UL
O-320-B, -D **IO-320**-B, -D **LIO-320**-B1A **AEIO-320**-D **AIO-320**-A, -B, -C **HO-360**-A, -B, -C **HIO-360**-B **VO-360**-A, -B **IVO-360**-A **AEIO-360**-B, -H **O-435**-A2 **GO-435**-C2 **O-480**-A **O-540**-A, -D, -E, -F, -G, -H **IO-540**-C, -D, -N, -T, -V **AEIO-540**-D		HJELMCO 91/96 UL

Unleaded Hjelmco 91/96 UL™

YEAR 2012

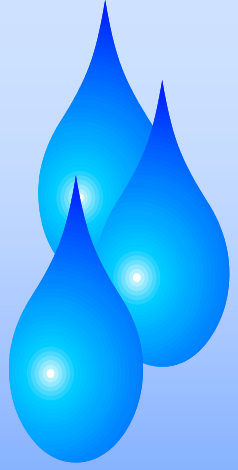
Existing, certified unleaded AVGAS 91/96 UL (91/98 UL)

Extensive > 21 years flight-experience

Recognized by the major US engine manufacturer Lycoming in 1995

More to Read About Unleaded AVGAS

www.hjelmco.com



Hjelmco is currently researching the interest for unleaded AVGAS HJELMCO 91/96UL™ to be produced and introduced in California.

Thank you

Lars Hjelmberg

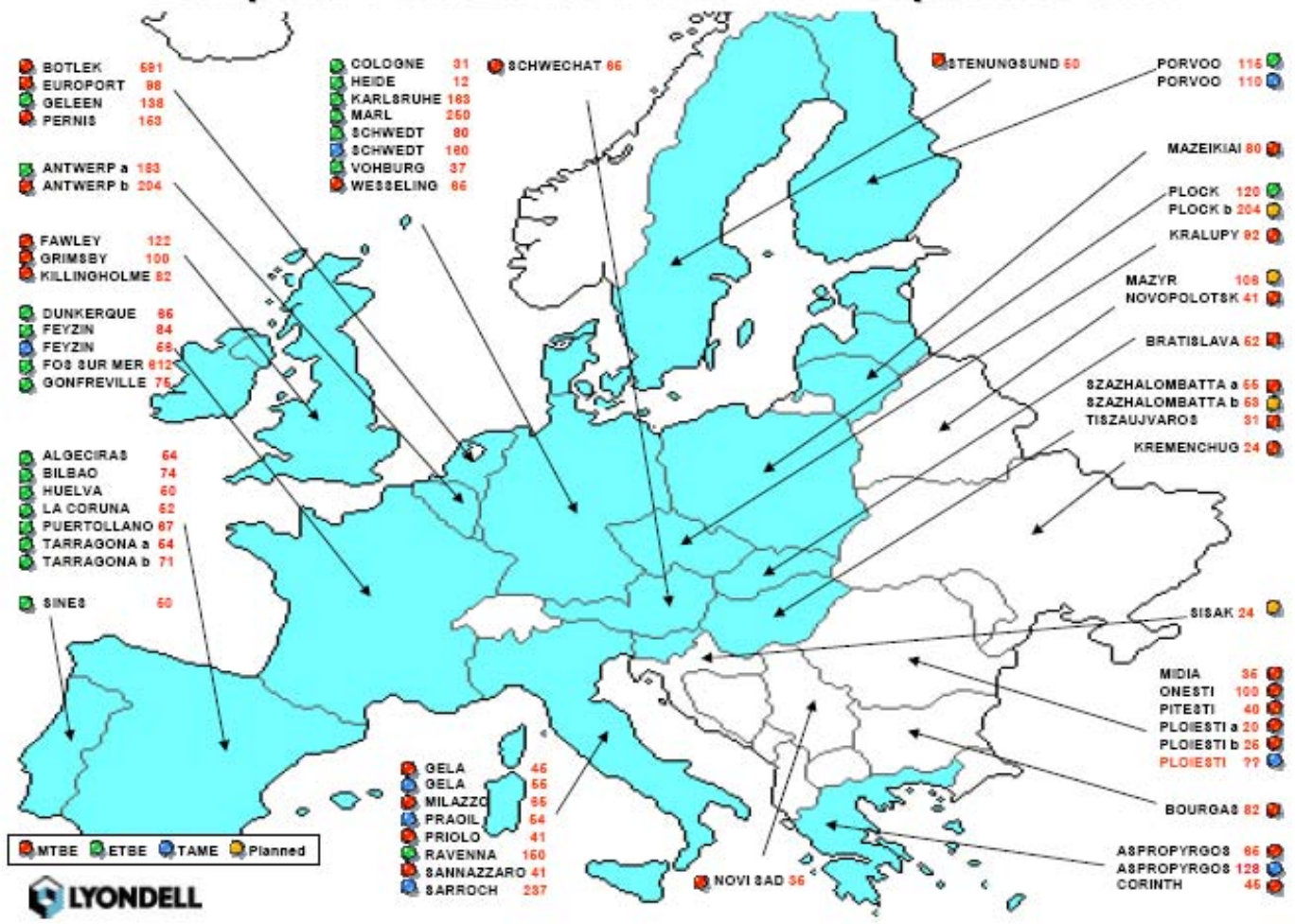
Executive Director

AVGAS Producers´ Solution

ETBE

- High octane number
- Low vapor pressure
- Good stability and solubility
- No deposits

AVGAS Producers´ Solution



AVGAS Producers´ Solution

ETBE cleared by the U.S. FAA in 1995

U.S. Department of Transportation

Federal Aviation Administration

Memorandum

Subject: INFORMATION: Approval of Ethyl-Tertiary-Butyl-Ether (ETBE) Oxygenate Additive for use in Autogas Supplemental Type Certificates (STCs)

Date: DEC _1 1995

From: Manager, Small Airplane Directorate, ACE-100
Manager, Engine and Propeller Directorate, ANE-100

Reply to Attn. of: Alpiser
(816) 426-6934