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The Cessna 182 SAFRAN SR305-230E Compression Ignition (Diesel) Engine Conversion

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with: Steve Phoenix

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Lewis County Composite Squadron (PCR-WA-110)
Washington Wing

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Soloy”s First Aircraft Conversion

1975

Hiller 12D/E Engine Conversion
Lycoming 540 to Allison 250C20B

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1984 - Soloy Enters Fixed Wing Modification STC's

Soloy Cessna 206

Soloy A36 Bonanza

Soloy Cessna 207

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1969

Joe Soloy answers the call to provide an economical path to turbine helicopter ownership and opens Soloy Conversions Ltd.

1975 April

Soloy Conversions Ltd. gains FAA approval of the Hiller UH12E4 Turbine Conversion.

1975 September

Produces over 300 turbine conversion kits.

1978 September

Gains FAA approval of the Bell 47 Turbine Conversion.

1984 May

Designs, builds, tests and FAA approves FAR Part 33 propeller reduction gearbox for the Allison 250 Series turboshaft engine. Follows on with the certification of the first FAA approved single engine turboprop by installing the Soloy Turbine Pac in to the Cessna 206

1986 Feb

Replaces LTS101 engine with the Allison 250 series engine in the AS350D Model Helicopter

1986 April

Follows Cessna 206 conversion with the Cessna 207 turboprop

1986 July

Produces Proof of Concept turbine powered A36 and follows on with FAA approval of the turbine A36 Bonanza

1988 April

Develops Bell 206 Series engine installation and produces over 250 engine conversion kits

1980s & 1990s

Produces 9 Proof of Concept aircraft engine conversions and over 15 accessory STCs

1989 April

Converts Allied Signal Boeing 720 to a flying engine test bed

1992 April

Develops and approves 60 gallon long range fuel for the MD500

1993 November

Receives contract from Tridair Helicopters to produce a Soloy Dual Pac® and convert the Bell 206L1/ L3/L4 to an Allison 250 C20R powered twin engine aircraft

1997 November

After a 7 year gearbox design effort and development of new FAA regulations, Soloy gains FAA approval for the FAR Part 33 Soloy Dual Pac® utilizing two PT6 engines

1997

Produces Proof of Concept aircraft to prove Soloy Dual Pac® single propeller/twin engine certification

2000s & Beyond

Continuing to Provide Innovative and Custom Solutions

2006 Feb

Develops LTS101 engine replacement for the AS350B2 Helicopter

2006 December

Develops and produces bleed air heated inlet nacelle for Grob Aerospace SpN G180 Business jet

2008 October

Produces improved MKII Cessna 206H engine conversion and multiple STC's for aerial surveillance

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Proof of Concept Projects

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Beechcraft A36 Turbine Conversion

Airbus AS350B2 SD2 Conversion Kit

Cessna 206 MkII Conversion Kit

Soloy Aircraft Conversion Kits

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- STC Approval Assistance
- Aerospace Engineering
- Research & Development
- Proof of Concept Development
- Prototype Production
- Integrated Manufacturing
- Flight / Static / Dynamic Testing
- Existing Aircraft Modifications
- FAA Repair Station

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What will we talk about today?

What is the difference between a Compression Ignition Engine & a Diesel Engine?

Why are we talking about Diesel engines with the Civil Air Patrol

The Compression Ignition Engine.

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/01/

What is the difference between a Compression Ignition Engine & a Diesel Engine?

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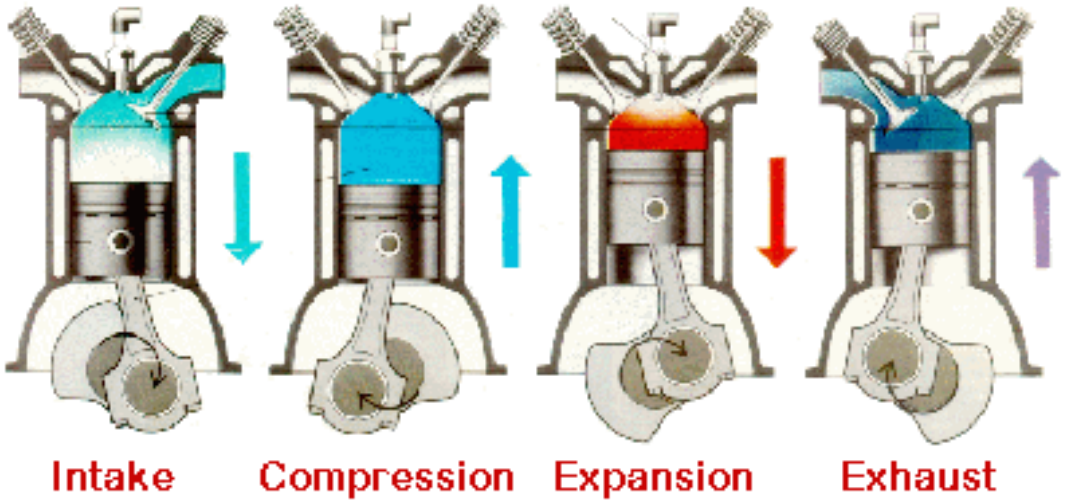

Nothing!!

We mainly want to convey that Compression Ignition (CI) engines:

- Are aviation specific engines, not redesigned automobile engines.
- Will use Jet-A, other Kerosene based fuels, or Bio fuels. NOT diesel fuel.

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SAFRAN (SMA) SR305-230E Compression Ignition Engine

The same engine chosen by Cessna for the C182R.

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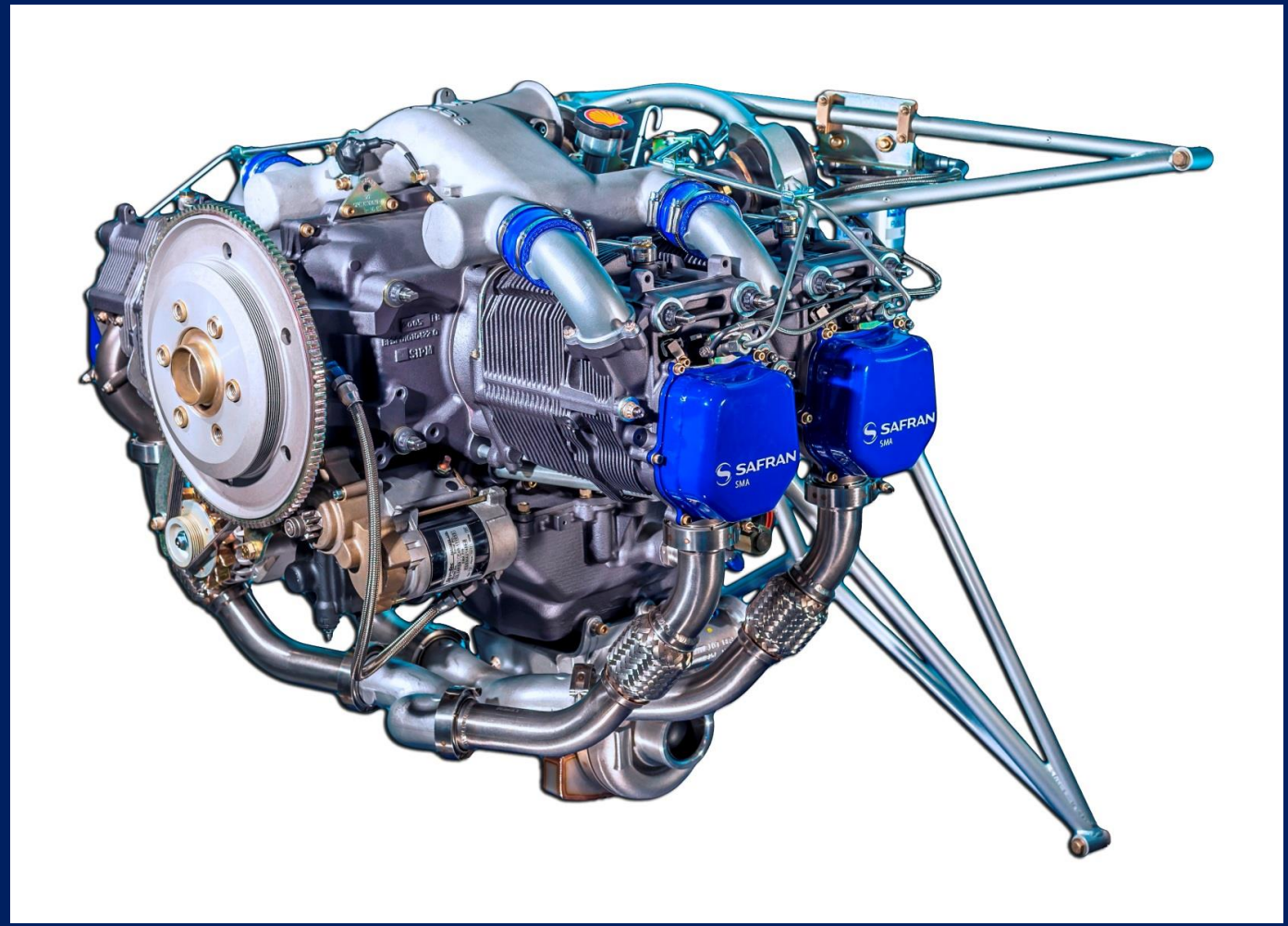
SMA SR305-230E TECHNICAL CHARACTERISTICS

- 4 Cylinders
- Horizontally opposed
- Direct drive
- Diesel cycle
- 4 Stroke
- Direct Injection
- Turbocharged
- Air and Oil Cooled
- Single Control Lever
- Electronically controlled with a Mechanical back up



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SR305-230

- First flew on a Socata TB-20 in March 1998.
- Introduced at the Paris Airshow in 1999.
- French approval in July 2001.
- FAA approval received in 2002.
- July 2006 a converted C-182 (F-GJET) flew from Le Bourget, France to Oshkosh, WI.
  - 4480 NM
  - 7 days
  - 9 legs
  - Avg. 7.7 gph

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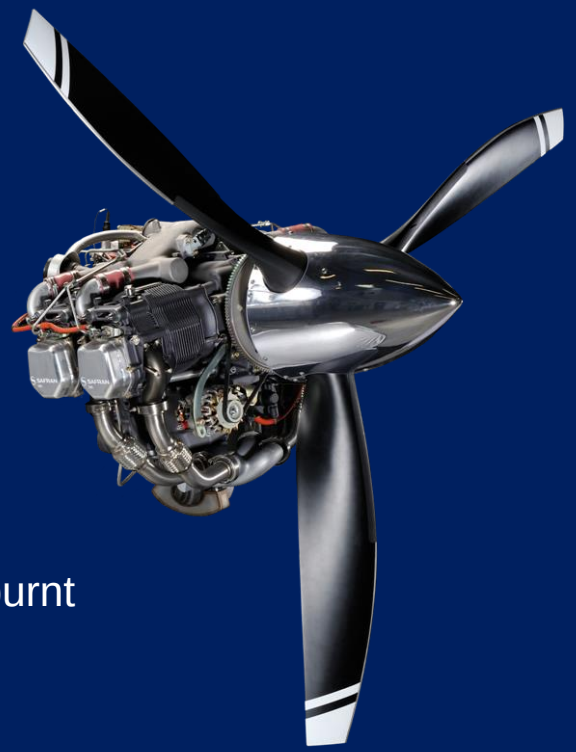
Compression Ignition propulsion solutions

More than a solution to avgas engines shortcomings

Operating costs
- 30-40% lower fuel burn
- lower Jet A cost
- low maintenance

Logistic
- high Jet A availability
- round trip flights w/out refueling
- large support networks

Environmental footprint
- low noise (use in urban airfields)
- no fuel used for cooling and rejected unburnt
- low emission (CO2…), no leaded fuel



Performance
- cruise at max power
- higher payload / range
- large flight envelop

Safety
- redundant systems
- no CO risk in the cabin
- low flammability of Jet A

Comfort
- low cabin noise
- low cabin vibration
- low pilot workload

Pb lead-free

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Why are we talking about Diesel Engine’s with the Civil Air Patrol?

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The main reasons are:

REDUCED FUEL COSTS

REDUCED MX COSTS

INCREASED PERFORMANCE

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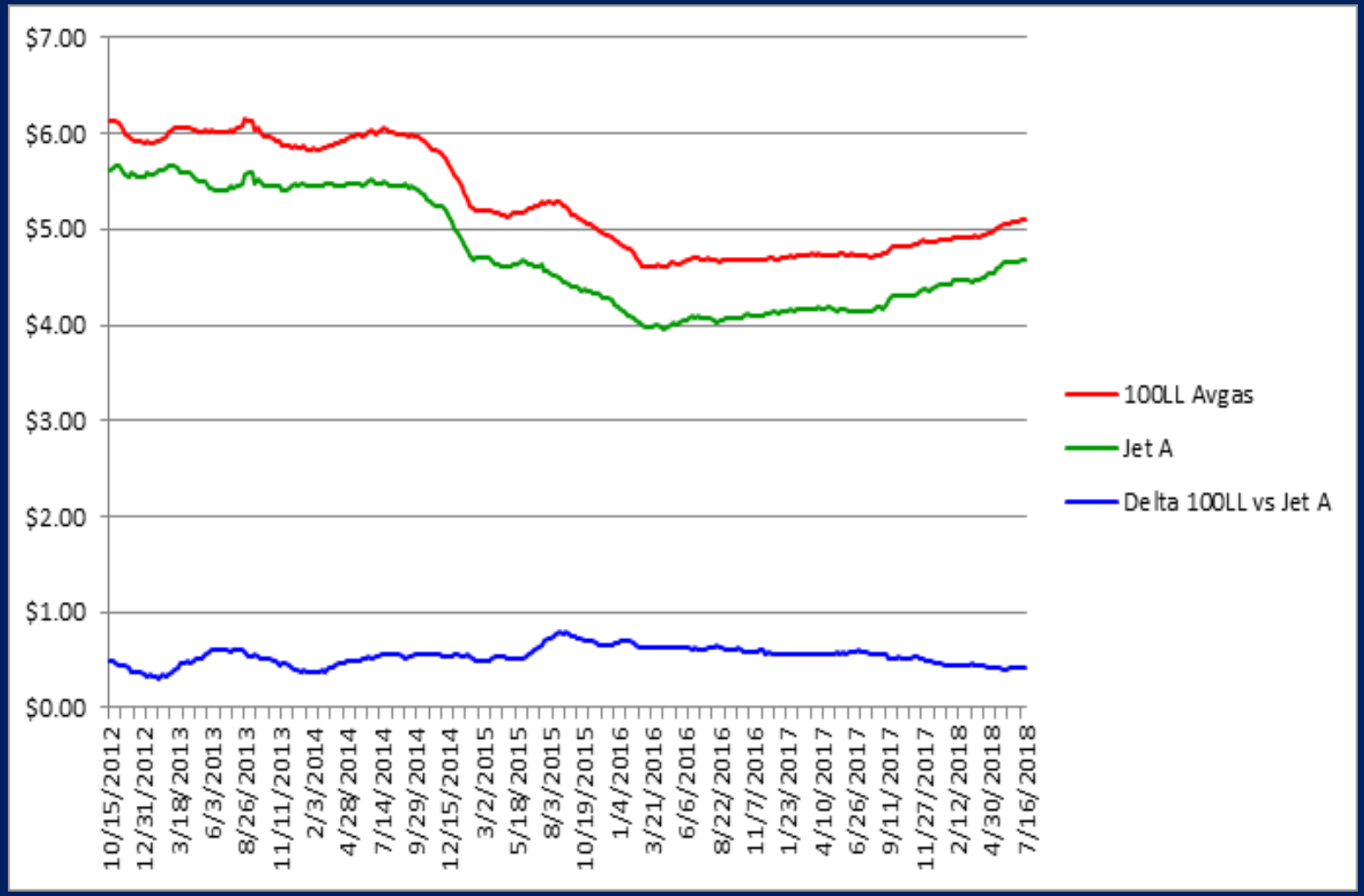

- National Fuel Prices
  - Avgas = $5.11
  - Jet-A = $4.69
  - Delta (Δ) = $0.42
  - As per Aug. 17, 2018
- Mx Costs
  - TBO @ 2400 Hrs. instead of @ 1500 – 2200 Hrs.
  - 50% less inspections.

Fuel Prices are National Average, as per Airnav.com

HIGH OPERATING COSTS PRESSURE

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Olympia (KOLM) – Oshkosh (KOSH)

- Date: July 24, 2017
- Flight: Non-stop
- Distance: 1,485 NM
- Duration: 9:25 (8 hours + 75 min. hold)
- Fuel: Jet-A
- Fuel Use: 80 gallons
- Fuel Burn: 8.5 GPH
- Oil Burn: ¼ quart
- Airspeed: 156 Kts. TAS
- Altitude: 17,500 ft (cruise)
- Power: 60% at cruise
- Crew: 2 (Steve +1)

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The same 1485 NM flight today would offer the following fuel savings.

	O-470	SR305-230E	SAVINGS
Fuel Burned (Gal.)	122	80	**42 gal.**
Fuel Type	100LL	Jet-A	**-**
Fuel Price (/Gal)	$5.11	$4.69	**$0.42 (9%)**
Fuel Expense	$622.20	$374.40	**$247.80**

Fuel prices are current national average courtesy of Airnav.com.

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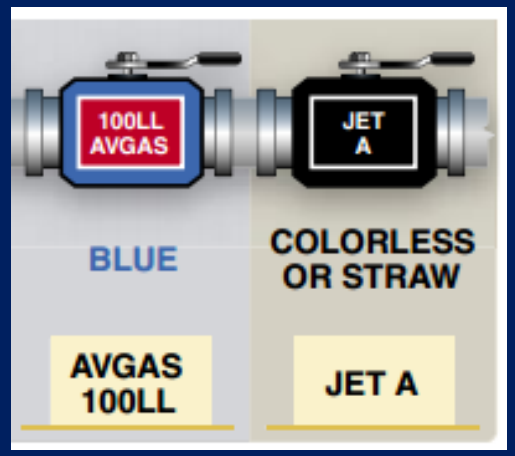

Airport	AVGAS (U$)	JET-A (U$)	Δ (U$)
Genk, Belgium	$9.13	$4.55	**$4.58**
Middleburg, Netherlands	$11.45	$7.92	**$3.53**
Vesthimmerlands, Denmark	$10.92	$6.75	**$4.17**
Kampala, Uganda	$11.40	$2.47	**$8.93**
Aswan, Egypt	$15.14	$2.83	**$12.31**

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PERFORMANCE COMPARISONS

	CAP C182R (100 LL)	C182N (Jet-A)
CAP Fuel (gal.)	64	64
Fuel Burn / Hour (cruise)	13	8
Endurance	5 Hrs.	8 Hrs.
Fuel Difference (Endurance)	-25 gal.	[-40 gal.]
Cruise Speed	142 kts.	142 kts.
Range	815 NM	1140 NM
Actual Cruise Range	@ 156 kts.	1248 NM

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CAP C182 Utilization Info	
Total C182's	346
Non-NavIII	~ 121
Total C182 Hrs. (2017)	~ 64,500
Avg. C182 Hrs./month	~ 17
Avg. C182 Hrs./year	~ 200
Avg. C182 DMC/year	~ $15,000

C182R Utilization		
200 Hrs.	@ 13 gal./Hr.	2600 gal./yr.
2600 gal./yr.	@ $5.11	$13,286
200 Hrs.	@ 8 gal./Hr.	1600 gal./yr.
1600 gal./yr.	@ $4.69	$7504
	- 1000 gal./C182R	$5782/acft.
	For 81 C182R's	$468,342

SOLOY AVIATION SOLUTIONS

CAP C182 Utilization Info	
Total C182's	346
Non-NavIII	~ 121
Total C182 Hrs. (2017)	~ 64,500
Avg. C182 Hrs./month	17
Avg. C182 Hrs./year	~ 200
Avg. C182 DMC/year	~ $15,000

CAP 2017 Avgas vs. psbl Jet-A Useage		
64,500 Hrs./year	@ 13 gal./Hr.	838,500 gal./yr.
838,500 gal./year	@ $5.11/gal.	$4,259,580 / year
64,500 Hrs./year	@ 8 gal./Hr.	516,000 gal./yr.
516,000 gal./yr.	@ $4.69/gal.	$2,399,400 / year
		$1,860,180

MAINTENANCE COMPARISON

SR305-230E Maintenance Schedule

	Maintenance activity			
Hours	50 hr	100 hr	200 hr	600 hr
25				
50	X			
100		X		
150				
200			X	
250				
300		X		
350				
400			X	
450				
500		X		
550				
600				X

2000h

21 inspections

Avgas Engine Maintenance Schedule

	Maintenance activity			
Hours	25hr	50 hr	100 hr	400 hr
25	X			
50		X		
100			X	
150		X		
200			X	
250		X		
300			X	
350		X		
400				X
450		X		
500			X	
550		X		
600			X	

2000h

41 inspections

50 % fewer inspections

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REDUCED MAINTENANCE

Visit (flight hours)	Oil filter	Oil (l)	Fuel filter	Injector	Turbo	Estimated labor (h)
50	x1	8	x1			4.0
100	x1	8				3.0
200	x1	8	x1			4.0
300	x1	8				3.0
400	x1	8	x1			4.0
500	x1	8				3.0
600	x1	8	x1	x4		8.5
700	x1	8				3.0
800	x1	8	x1			4.0
900	x1	8				3.0
1000	x1	8	x1			4.0
1100	x1	8				3.0
1200	x1	8	x1	X4	x1	10.5
1300	x1	8				3.0
1400	x1	8	x1			4.0
1500	x1	8				3.0
1600	x1	8	x1			4.0
1700	x1	8				3.0
1800	x1	8	x1	x4		8.5
1900	x1	8				3.0
2000	x1	8	x1			4.0
2100	x1	8				3.0
2200	x1	8	x1			4.0
2300	x1	8				3.0
2400	Engine overhaul					

	New part (included in service kit)
	Standard exchange
	Overhaul or standard exchange

- Periodic inspections every 100 hrs. instead of 50 hrs.
- 8 liters = 8.45 qts.
- The inspections are essentially visual checks.
- Fewer parts than a conventional Avgas engine.
- Low engine speed and use of jet fuel results in less wear on components.
- Less parts to remove.
- High reliability of injection system.

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REDUCED MAINTENANCE

Every 100 hrs or 1 year*	Standard Engine Run-up
	Check the oil consumption
	Drain engine oil
	Replace and inspect the oil filter
	Visual checks for cracks, leaks, damages, corrosion…
	Check the connectors and the wires for clamping and damages
	Perform anti corrosion procedure
	Check the starter and starter ring gear for damages
	Check the compressor inlet and the turbine outlet for oil leaks and damages

First 50 hrs** & every 200 hrs or 2 years*	Perform a 100 hrs maintenance
	Replace the engine fuel filter
	Perform Turbocharger oil valve assembly cleaning
Every 600 hrs or 4 years	Perform a 200 hrs maintenance
	Check the cylinder compression leak rate
	Replace the fuel injectors
	Replace the turbocharger ball bearing pin as needed
Every 1200 hrs	Perform a 600 hrs maintenance
	Remove the turbocharger for overhaul

**Whichever comes first*
***First 50hrs after engine new or overhaul*

Note: This chart is a summary of the scheduled maintenance actions. Refer to the Engine Maintenance Manual for more information.

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Projected Performance Numbers

Service Ceiling:	20,000 ft.
Ground Roll @ Sea Level:	775 ft.
Landing Roll @ Sea Level:	590 ft.
Dist. To clear 50 ft. Obstacle:	1385 ft.
Ldg. Dist. To clear a 50 ft. Obs.	1350 ft.
Max. Climb Rate @ Sea Level:	1000 fpm.
Max. Speed @ 10,000 ft.	156 kts / 180 mph
Max. Range & Endurance	1480 nm / 12.3 hrs
(60% pwr / 14,000 ft.; MP 60”)	
Max. Range & Endurance	1025 nm / 6.6 hrs
(@Cruise: 90% pwr / 14,000 ft.; MP 90”)	

Manifold Pressure use:

- 90 inches at SL or unlimited
- 70 inches for Normal Cruise
- 60 inches for Economy Cruise

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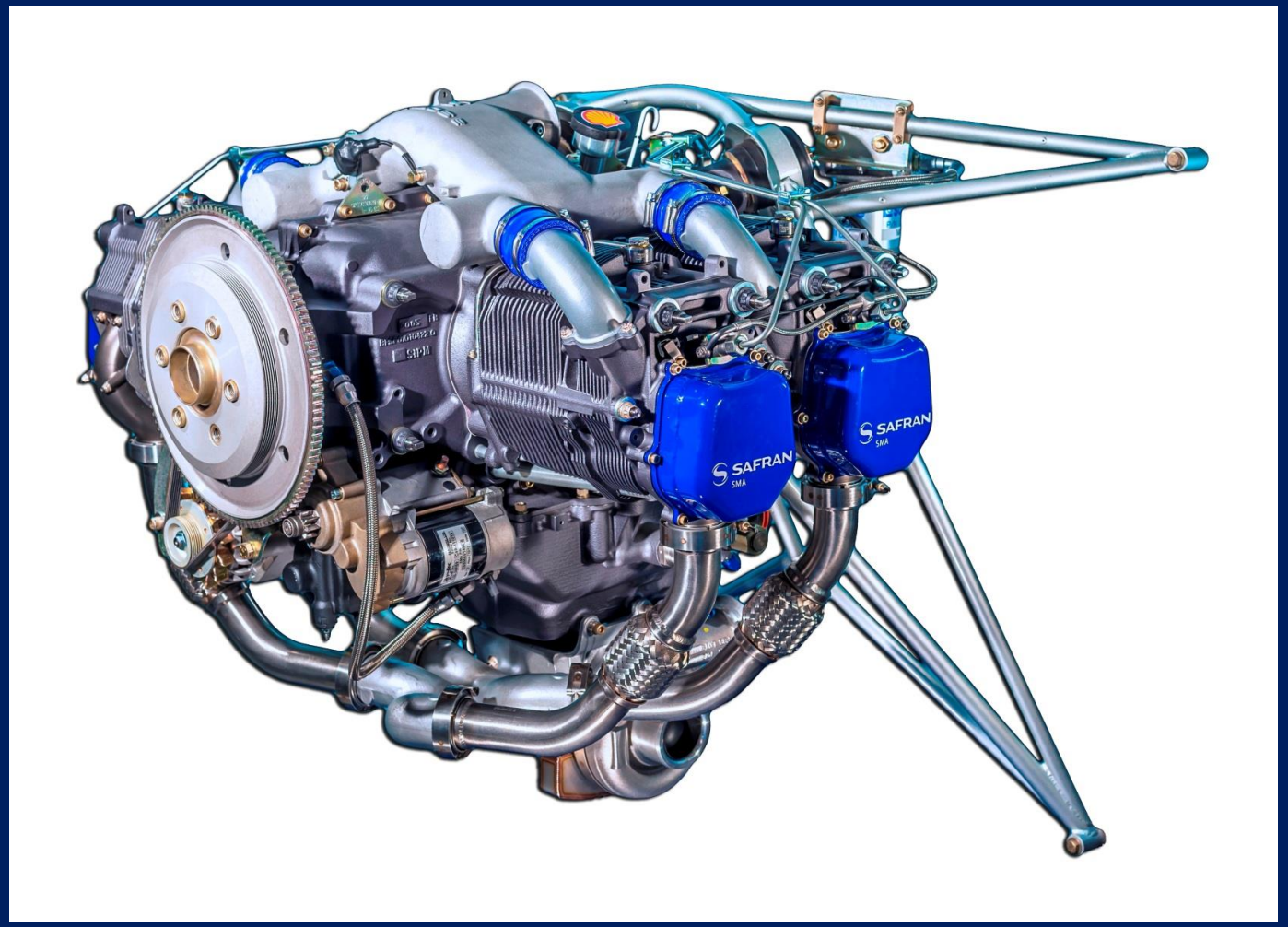
THE COMPRESSION IGNITION ENGINE



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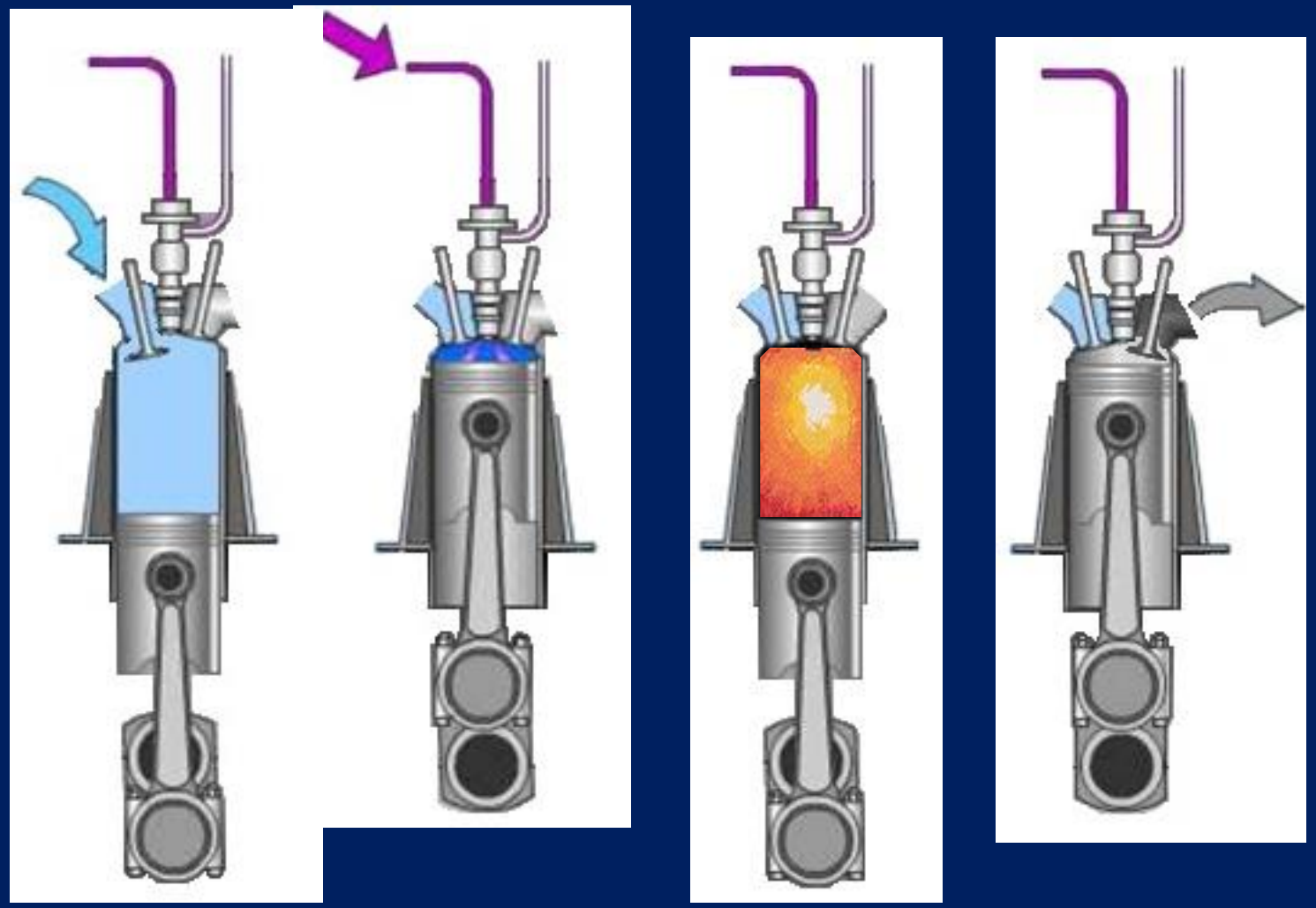
COMPRESSION IGNITION ENGINE TECHNOLOGY



The strokes of four-stroke Diesel cycle engine

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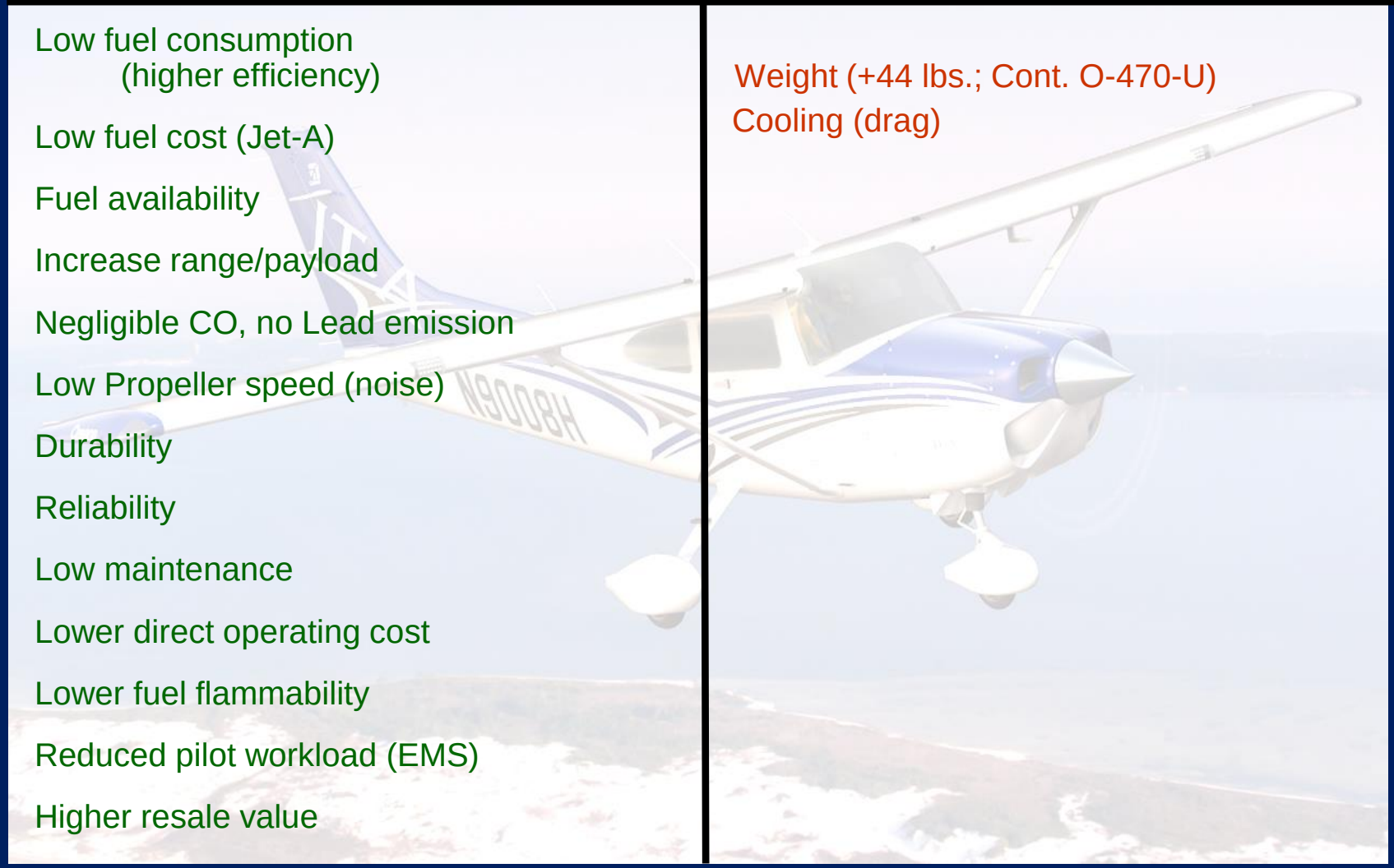
COMPRESSION IGNITION ENGINE TECHNOLOGY

Advantages	Disadvantages
Low fuel consumption (higher efficiency)	Weight (+44 lbs.; Cont. O-470-U)
Low fuel cost (Jet-A)	Cooling (drag)
Fuel availability	
Increase range/payload	
Negligible CO, no Lead emission	
Low Propeller speed (noise)	
Durability	
Reliability	
Low maintenance	
Lower direct operating cost	
Lower fuel flammability	
Reduced pilot workload (EMS)	
Higher resale value	



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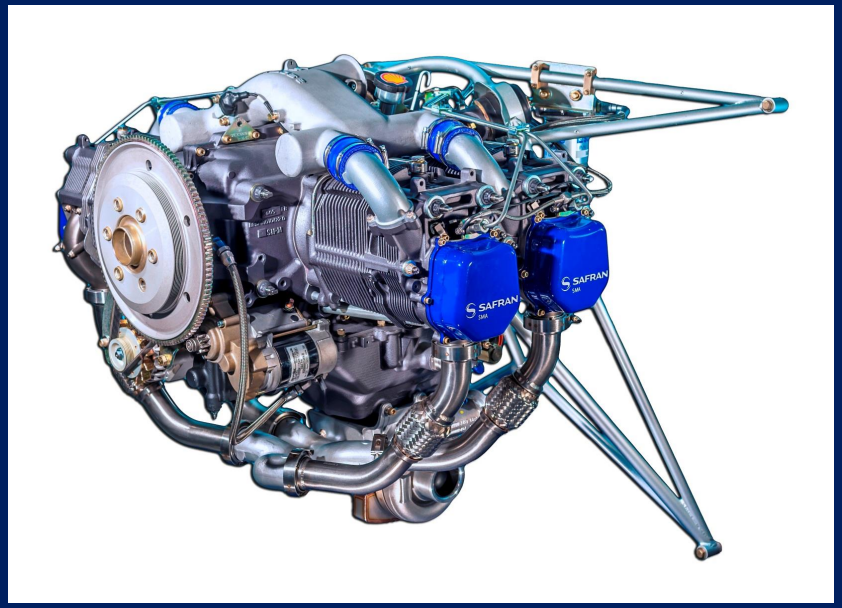
TECHNICAL CHARACTERISTICS

Power	230 -260 hp
Displacement	5 liters / 305 cu. In.
Thrust (Hartzell)	1000 lbs
Torque	550 ft. lbs
Fuel	Jet A, Jet A1, JP8, #3, TS1
BSFC	.35 lbs/hp/hr
Efficiency (C182)	Less than 12 mpg
Oil	Aeroshell oil diesel
Propeller Speed	2,200 rpm
Weight	456 lbs
Power to weight ratio	.50
Recommended TBO	2,400 hours



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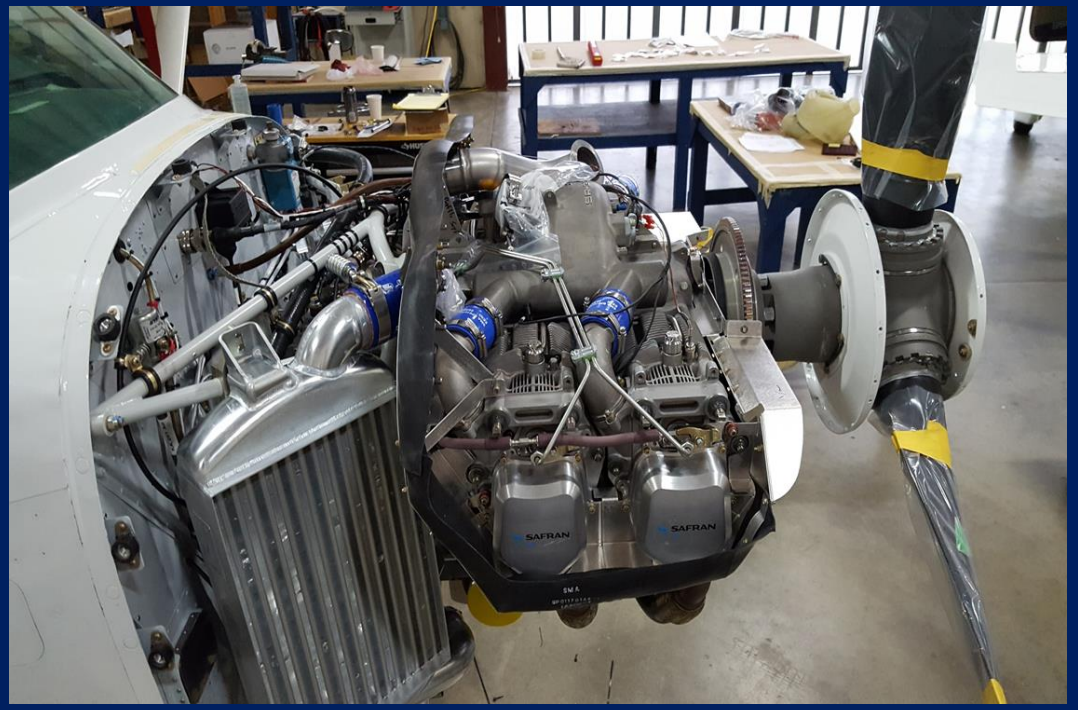
Standard Conversion Kit Components:

- Electronic Central Processing Unit (CPU) .
- Electronic engine management / display unit.
- Newly designed cowl & baffling.
- Oil Cooler
- Intercooler
- Engine mount
- Wire Harnesses
- Complete STC documentation.
- Installation drawings, instructions, etc.
- SAFRAN SR305-230E CI Engine
- MT 3-Blade Propeller

- Can be installed by any qualified A&P.
- Anticipated kit price: $180,000/kit with everything included.



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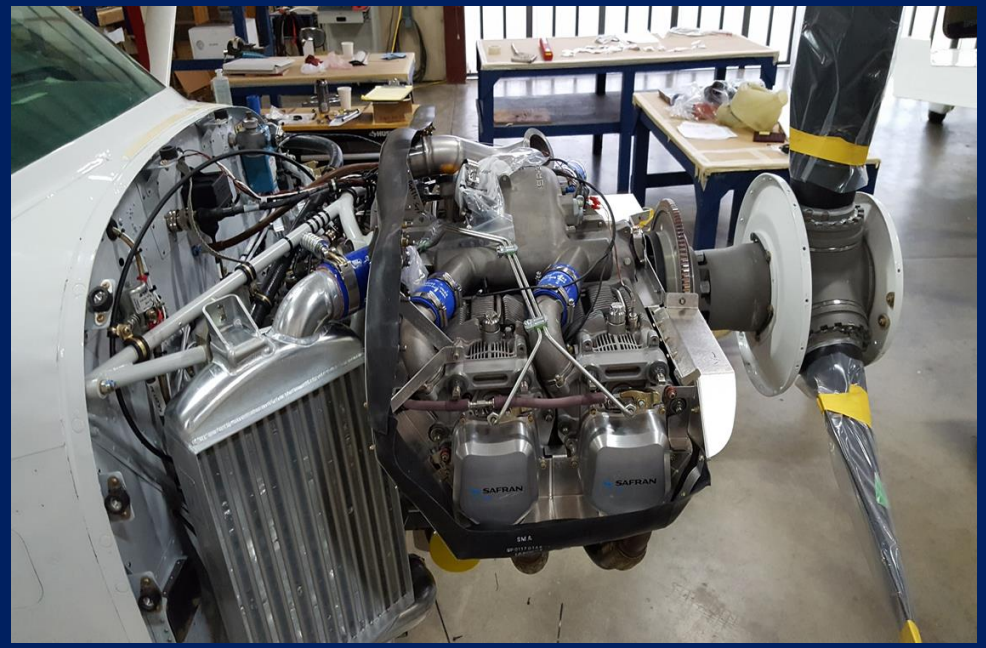
What is left to do?



- “Last minute” Engineering work.
- Modifying the cowl & baffling to achieve the temperature limit goal of ISA + 35.
- Final Flight Testing & Modifications.
- Regulation compliance (crossing t’s & dotting i’s)
- We are on track for STC approvals from EASA & FAA.
- EASA before the end of this year.
- FAA during the first quarter of next year.

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Questions & Answers

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