THE LEAN OF PEAK Saga


Paul Ferraris sets up his immaculate Seneca V to show both rich of peak and lean of peak ops at 150 KIAS.

Is the hugely controversial Lean of Peak operation really all it's claimed to be? Won't it damage your engine and so cost far more than any fuel saving? Guy Leitch flies along with Lean of Peak guru, Paul Ferraris, to finally put the debate to rest.

THE first question is: What do Lean of Peak (LoP) operations entail?

The answer is simple. We normally operate our engines with the fuel flows on the rich side of peak exhaust gas temperature (EGT). We lean the fuel flows to peak EGT and then enrichen a certain number of degrees (normally 50°F on the rich side). LoP operation means flying the aircraft by leaning it until you get peak EGT and then continuing the leaning process to a certain number of degrees lean of peak EGT (the number of degrees would depend on how you wish to run the engine – the higher the power output the more you would lean).

Many of us fly aircraft that are powered by Continental and Lycoming engines that hark back to 1940s' technology. They are air cooled and keeping temperatures under control is an important part of any pilot's duties. When I say that keeping temperatures under control is vital, I am not referring to the single probe located on the one cylinder CHT (cylinder head temperature) gauge that most factory aircraft are equipped with. This one cylinder may be fantastically cool while the rest of the cylinders are well above 400°F. What you require is a multi-probe digital engine monitor that has EGT and CHT readout for each cylinder.

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LoP is now considered the mainstream technique for engine management in the United States. This was not the case 20 years back, but now even new aircraft are produced with the Pilot Operating Handbook (POH) having graphs and figures for operating LoP.

It is no longer the question whether operating LoP is the preferred procedure. It has been accepted by all major engine manufacturers that running LoP is beneficial to engine longevity.

I urge everyone who is even remotely interested in LoP operations to read John Deakin's engine related columns which can be obtained on the AVweb website. I'm no expert on engine management, but being an attorney I tend to listen when hard and fast empirical data backs up the claims. I have borrowed extensively from John Deakin's columns, and in certain instances I have taken direct quotes from them. All credit to John Deakin.

A little theory if I may. Our current aircraft engines have terrible fuel distribution. A typical Continental TCM IO-520 motor when leaned from a rich of peak (RoP) operation to a LoP operation will typically have the EGT of cylinders one and two peaking at 14.5 GPH, cylinders three and four will peak the EGT at around 13.9 GPH and the last two cylinders will peak the EGT at around 13.3 GPH. Thus the fuel spread of the EGT of the cylinders peaking would be around 1.2 GPH. What this in effect means is that when the EGT of cylinders five and six peak, the first two cylinders EGT (being cylinders one and two) are already around 40°F LoP. What then occurs is a very rough running engine. That is one of the reasons why the engine manufacturers initially stated that LoP operations were to be avoided.

The boys at General Aviation Modifications Inc (GAMI) has solved this problem. By using state of the art instrumentation they are able to balance the fuel injectors to obtain a much smaller fuel spread with all cylinders at peak EGT. My current aircraft, a Seneca V, has a fuel flow spread of 0.3 GPH from the first to the last cylinder to peak. I am therefore able to run LoP smoothly.

Next question: Why would I want to run LoP? If you look at the graph at the end of this article (obtained from John Deakin's Mixture Magic column), you will be able to see the difference between one cylinder operating RoP and one cylinder operating LoP (at exactly the same percentage HP). The pink line graph depicts a cylinder being operated at 75°F RoP (244 HP) and the blue line graph depicts a cylinder operating 50°F LoP (also at 244 HP).

A key thing to note is the cylinder pressures. The cylinder operating RoP has an internal cylinder pressure of around 780 psi and the cylinder operating LoP has an internal cylinder pressure of around 695 psi.

What happens to the cylinder operating LoP is that a longer, slower and more gentle push on the piston develops, as the peak cylinder pressure develops later from piston top dead centre than the cylinder operating RoP. In other words, the peak cylinder pressure develops when the piston is further along the downward stroke. This results in there being less of a hammer blow against the piston and more of a push because the piston is already far into the downward stroke of the cycle. Operating RoP will result in higher internal cylinder pressures which equate to higher CHTs. In the graph (depicting a turbo normalised Continental TCM IO-550 motor) the cylinder operating LoP at exactly the same HP as the cylinder operating RoP has a 35°F lower CHT. Thus you can operate an engine LoP at a lower CHT with the exact same horse power being produced as if you operated an engine RoP.

GAMI has developed a portable 128 channel data acquisition system which captures data to a laptop computer using specially modified sensors. GAMI can capture real-time data from the ignition system, crankshaft angle, fuel flow, a large array of temperatures (including several points around an individual cylinder) and anything else that can be sensed. This allows the below data to be captured.

So we now know that we can operate an engine at cooler CHTs if operated LoP. Now what about fuel flow?

Guy Leitch and I met at Krugersdorp in September with a view to go flying and compare operating the Seneca V firstly RoP and then LoP. It was a rather warm day (around 24°C at 6,500 feet). We picked a normal cruise setting of 29 inches MP, 2400 RPM and a fuel flow of 28 GPH (14 GPH per side). This setting is admittedly richer than the 12 GPH per side as depicted in the POH – but with good reason.

Off we set, configuring the aircraft in the above cruise configuration. After allowing the air speed indicator to settle, we were indicating 149 kt. This with the cowl flaps closed. The CHTs settled and the highest reading, being cylinder number four, was 363°F. This with the engines burning a total of 28 GPH. If I had operated at the POH fuel flows of 12 GPH per side, the CHTs would have been well over 380°F. I know this from experience. I would also have been running the engine at around 15°F RoP which is not a great place to run engines at higher power settings (worst still to run it at 50°F RoP).

I urge everyone to read Mike Busch's article titled "Red Box, Red Fin" to gain a better understanding of why this is so. It is available on the web.

I then configured the aircraft to cruise LoP. I bumped up the manifold pressure to 32 inches MP, left the RPM at 2400 and leaned the fuel flow to 10.7 GPH per side. This for a total fuel flow of 21.4 GPH. After allowing the aircraft to settle, the speed was 151 KIAS. The hottest CHT (also number four cylinder) showed 341°F. To

Magic numbers - 10.7 gph with everything happily in the green. There is no reason not to fly Lean of Peak.

summarise, we were going two knots faster on 6.6 GPH less fuel. The hottest CHT was 22°F lower than when operating RoP.

Oh, and by the way, all fuel was being utilised. This meant that there was no unburned product blowing back and contaminating the oil, and less carbon and other deposits settling on the internal engine components as well. I can confidently tell you that when running LoP my oil remains cleaner for a longer period.

What's not to like about running LoP?

If we calculate a very rough fuel saving

To run lean of peak you need balanced injectors - GAMI provide the best solution.

In the cockpit you need an engine monitor that measures EGT and CHT for each cylinder.

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over a typical engine TBO of 1,800 hours, this would total 6.6 GPH X 1,800 – 11,880 gallons. It is actually more of a saving than depicted as I operate my aircraft LoP in the climb as well. I climb at settings of 35 inches MP, 2500 RPM and a fuel flow of 13 GPH per side. Normally my climb settings RoP would be 33 inches MP, 2500 RPM and a fuel flow of 22 GPH per side. The fuel saving is astronomical. And my engine is cooler and cleaner with no deposits left on any spark plugs. And for single engine aircraft, there is virtually no risk of carbon monoxide poisoning should you have a faulty heater when running LoP.

A misconception is that you only utilise LoP operations at low power settings. Nothing could be further from the truth. I routinely operate my Seneca V at 75% engine power (fuel flows of 12 GPH per side). My hottest CHT would be no higher than 360°F. I would never operate this aircraft at 75% engine power RoP without pouring a LOT more fuel than stated in the POH for this specific power. The POH states 14 GPH per side. The CHTs would be well above 400°F. I would run a further 2 GPH per side to keep CHTs down. The problem is that I am then running 16 GPH per side RoP compared to 12 GPH per side LoP – a saving of 8 GPH total.

WHEN RUNNING LoP MY **OIL REMAINS CLEANER FOR A LONGER PERIOD.**

I must concede that the Seneca V is one of the better aircraft to operate LoP (other than turbo normalised aircraft). The Seneca V has standard intercoolers which lower the air temperature entering the combustion chamber. It is also turbocharged which allows me to add 3 inches of manifold pressure when operating LoP. This to make up for the speed loss when operating LoP (normally around 6 knots for a normally aspirated aircraft).

Even if I were flying a normally aspirated aircraft I would gladly give up 6 knots in order to save around 2 GPH in fuel.

I can hear the naysayers already. LoP operations burn valves. Operating leaner is hotter. Fuel is cheaper than engines.

All of the above is hogwash. Not because I say so (I'm no expert), but because the empirical data obtained from the most advanced engine test stand in the world tells us otherwise.

And in respect of fuel being cheaper than engines, if I save 11,880 gallons of fuel over my 1,800 TBO engine times (for both engines), this equates to 44,906 litres of fuel. The cost of this fuel at an average of R17 per litre totals R763,408. Combine this with a severely reduced chance of having to top overhaul your engines during their lifetime, cleaner engines, cleaner oil, cooler engines etc. I say again, what's not to like about LoP operations?

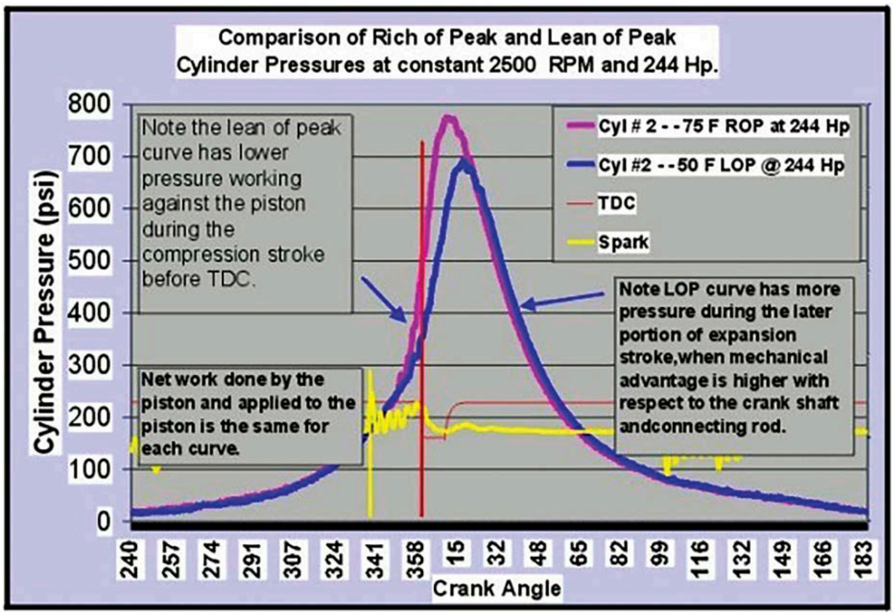
I must stress that the above is a basic explanation of LoP operations. Should you wish to know a lot more about the subject, I would strongly recommend the above mentioned Deakin articles. To find out more go to www.advancedpilot.com, which has updated versions of some of John Deakin's articles.

So how does one go about getting set up for LoP operations? Firstly, you must have an engine monitor with CHT and EGT sensors for each cylinder. Then go to the GAMI website and download a test form. Take your aircraft for a flight and carefully note, using EGT and fuel flows, when each cylinder peaks its EGT. Send the form to GAMI and they will advise whether you require GAMI injectors (you may be lucky and not require them). Install a multi-cylinder engine monitor and you're good to go.

John Deakin and his two partners, George Braly and Walter Atkinson, run Advanced Pilot Seminars. They offer an online course. This course will give you the confidence and understanding of not only how to operate LoP but also a much wider understanding of general engine management.

And should you be asking, no, I'm not part of, nor do I share any business dealings whatsoever with either Gami or Advanced Pilot Seminars. So you can take my word on all this.

BELOW - Detailed engine test bench runs show how much cooler and less strained the engine is running Lean of Peak.



This Seneca V has shown absolutely no ill effects from running lean of peak. It is now for sale.