The EGT Myth

Your presenter…

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President — Savvy Aviation, Inc.

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Mo 1300 #7	How Healthy Is Your Engine?
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A brief history of EGT

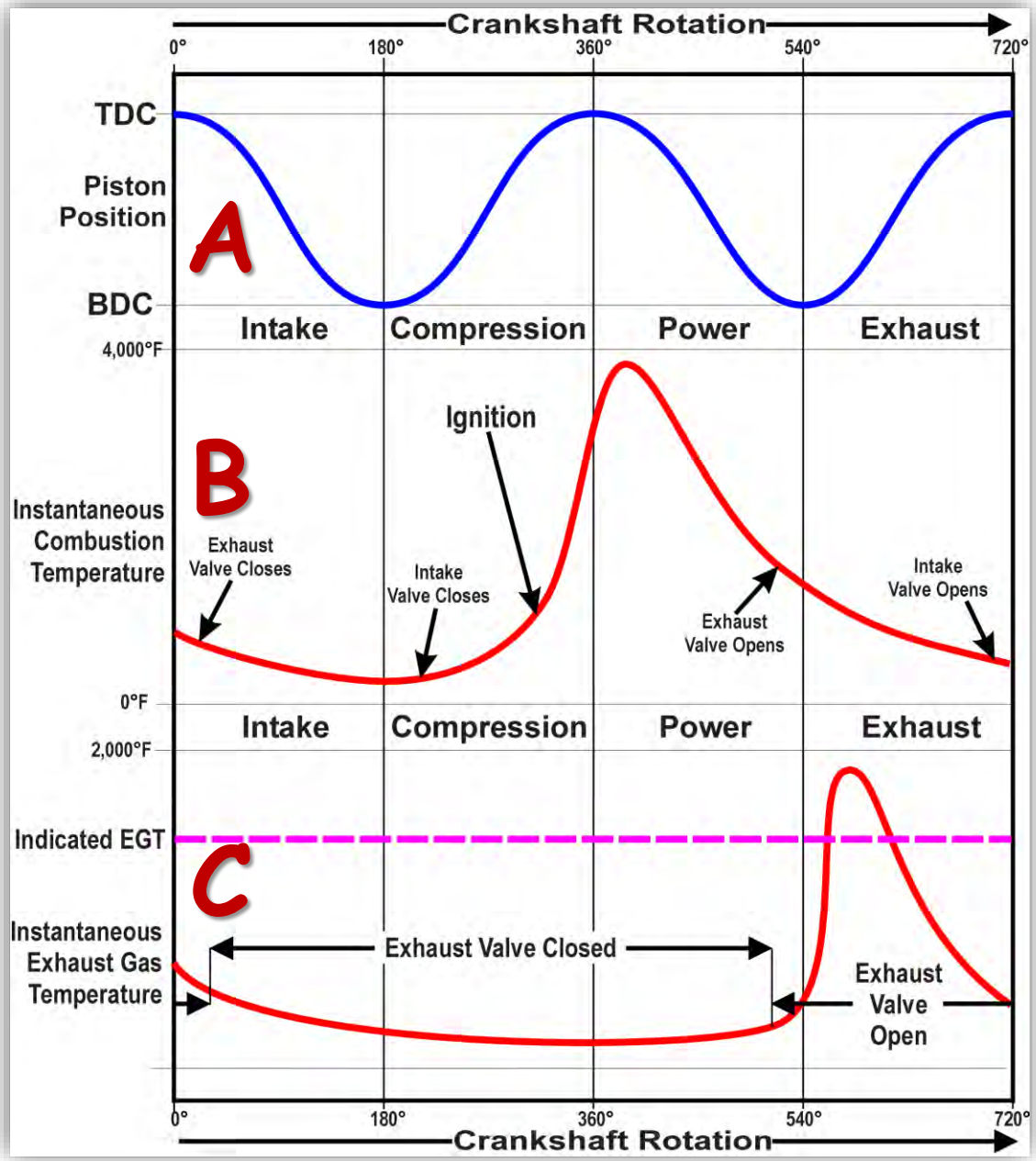
Early EGT gauges (Alcor, KSA, Insight) displayed solely **relative** EGT

- **Relative EGT:** *e.g.*, 100°F ROP or 25°F LOP
- **Absolute EGT:** *e.g.*, 1,344°F

A brief history of EGT

Trouble began when instruments started displaying **absolute** EGT

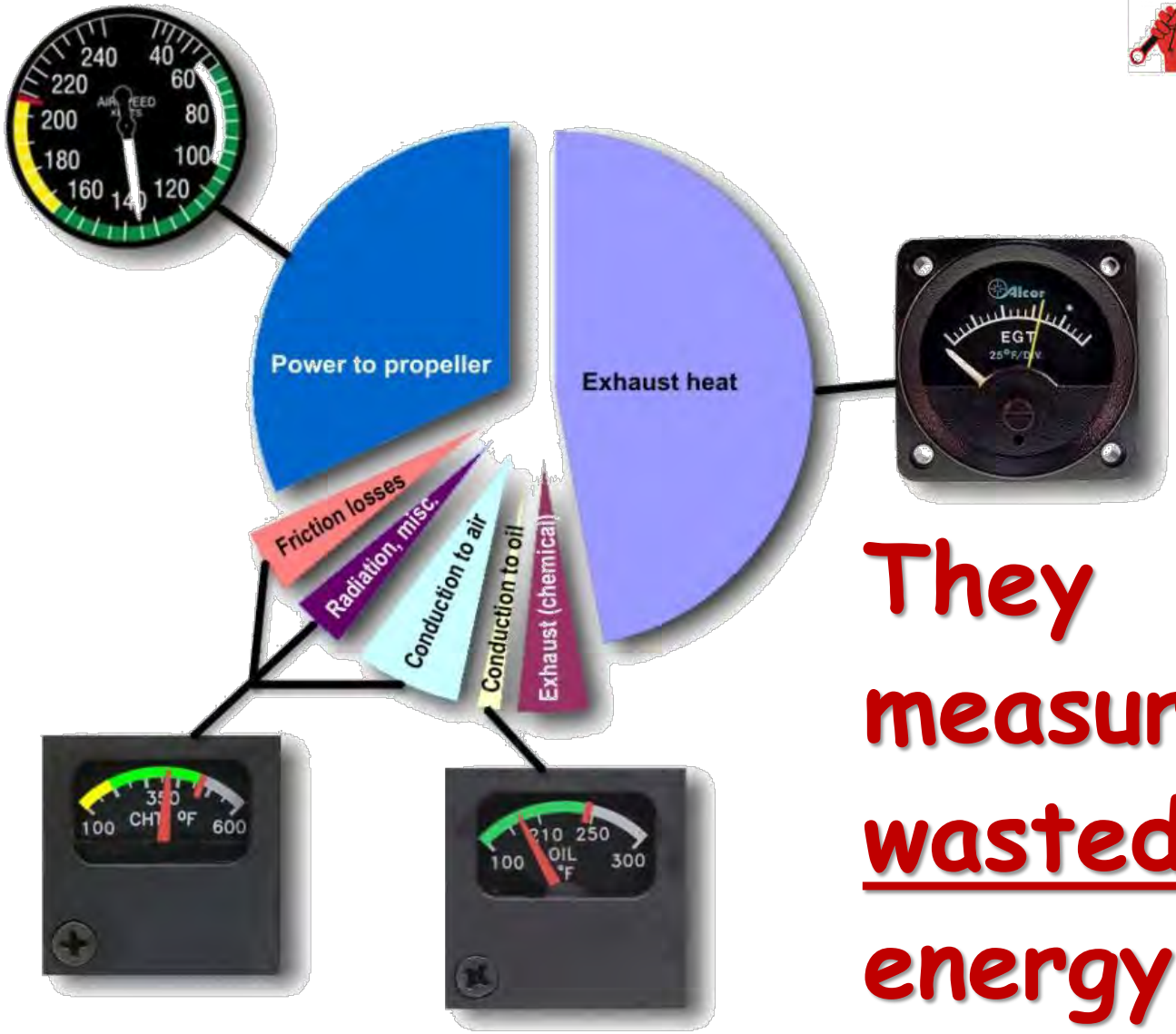
- E.I.'s US-8, JPI's EDM-700, E.I.'s UBG-16
- **This was a BAD thing!**
- Why? Because absolute EGT is meaningless. **EGT is not real temperature!**



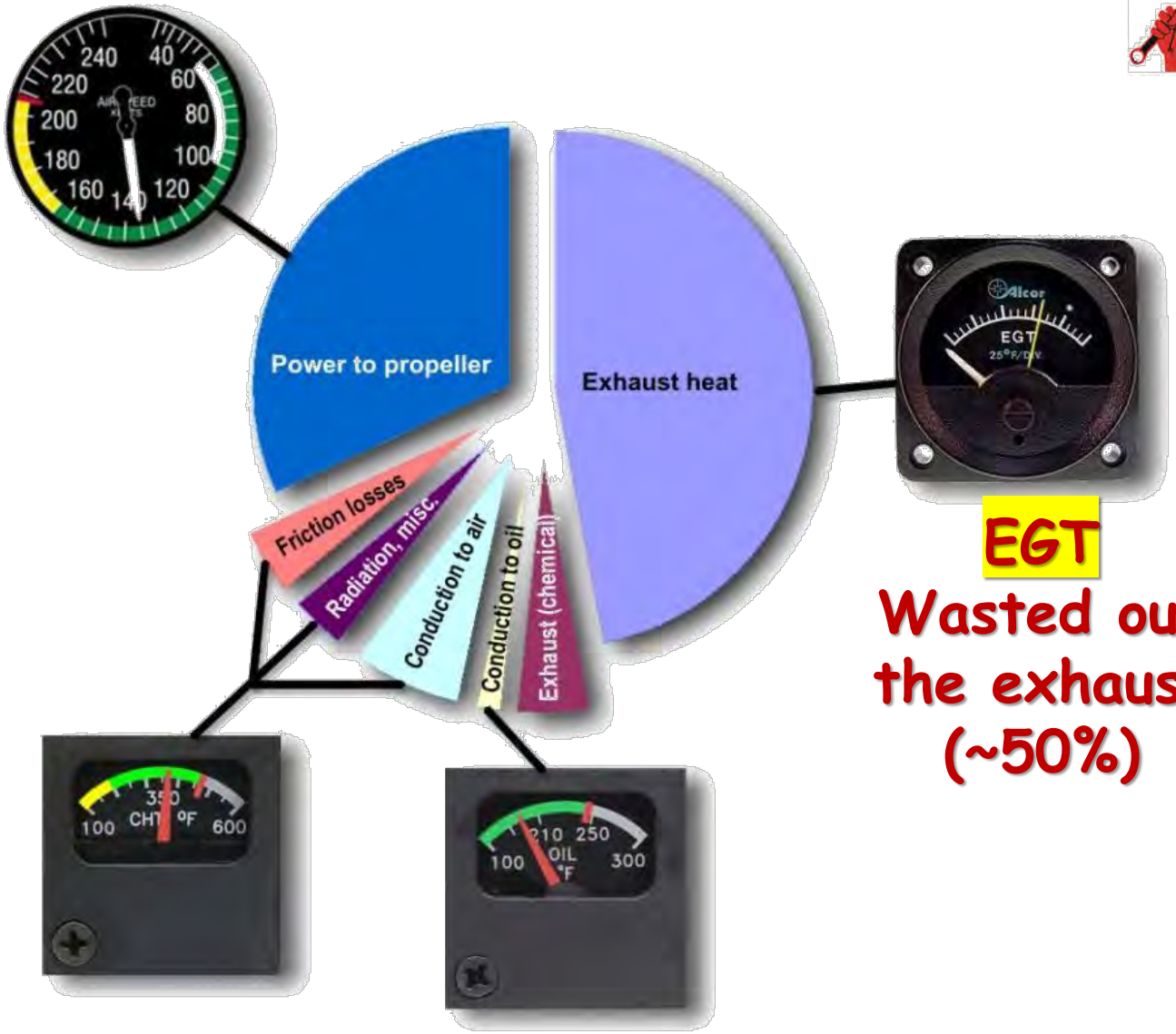
Why EGT is not a real temperature

and why absolute EGT is meaningless

What Do Engine Temperatures Mean… Really?

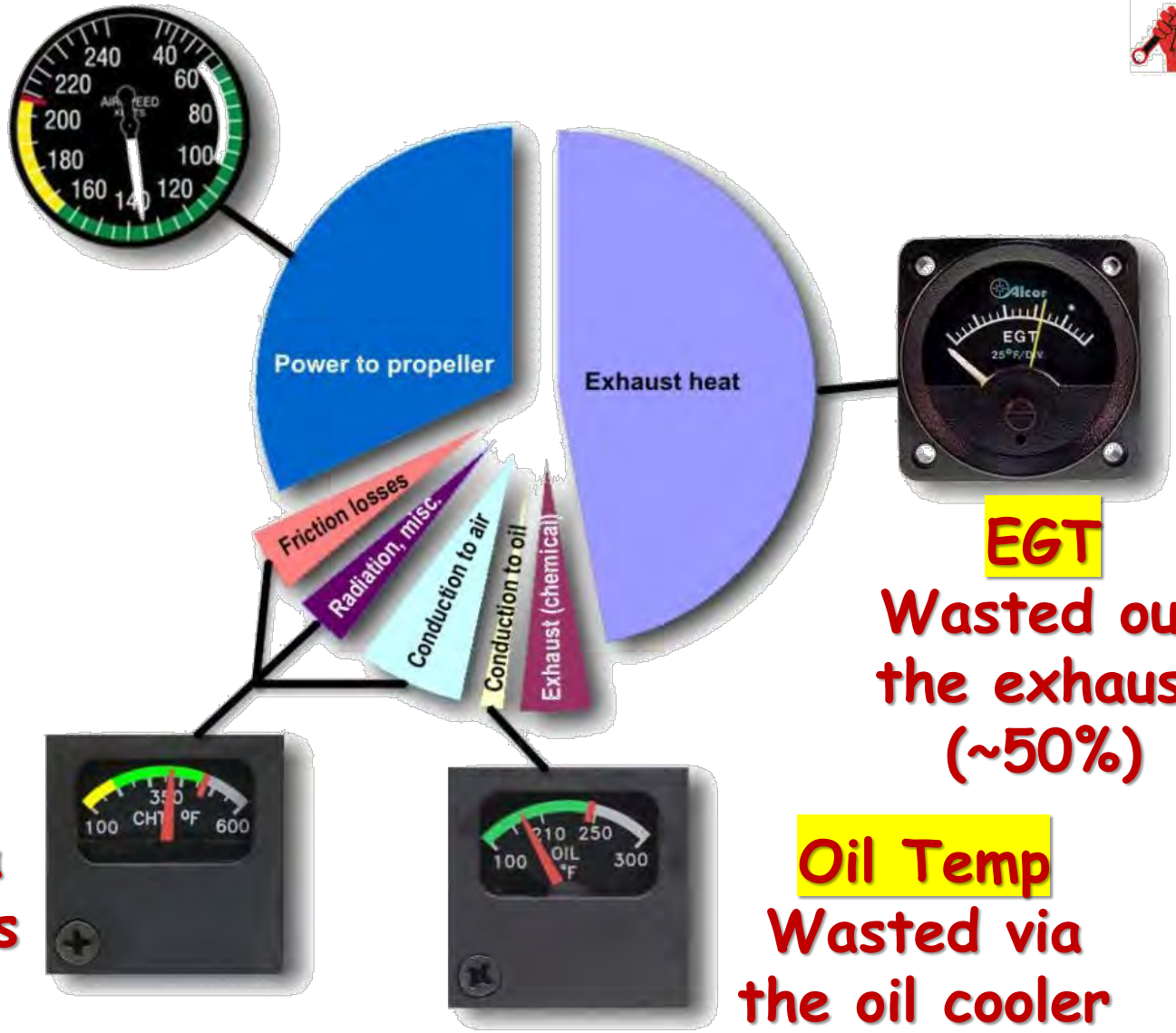


They measure <u>wasted</u> energy!



EGT

Wasted out the exhaust (~50%)

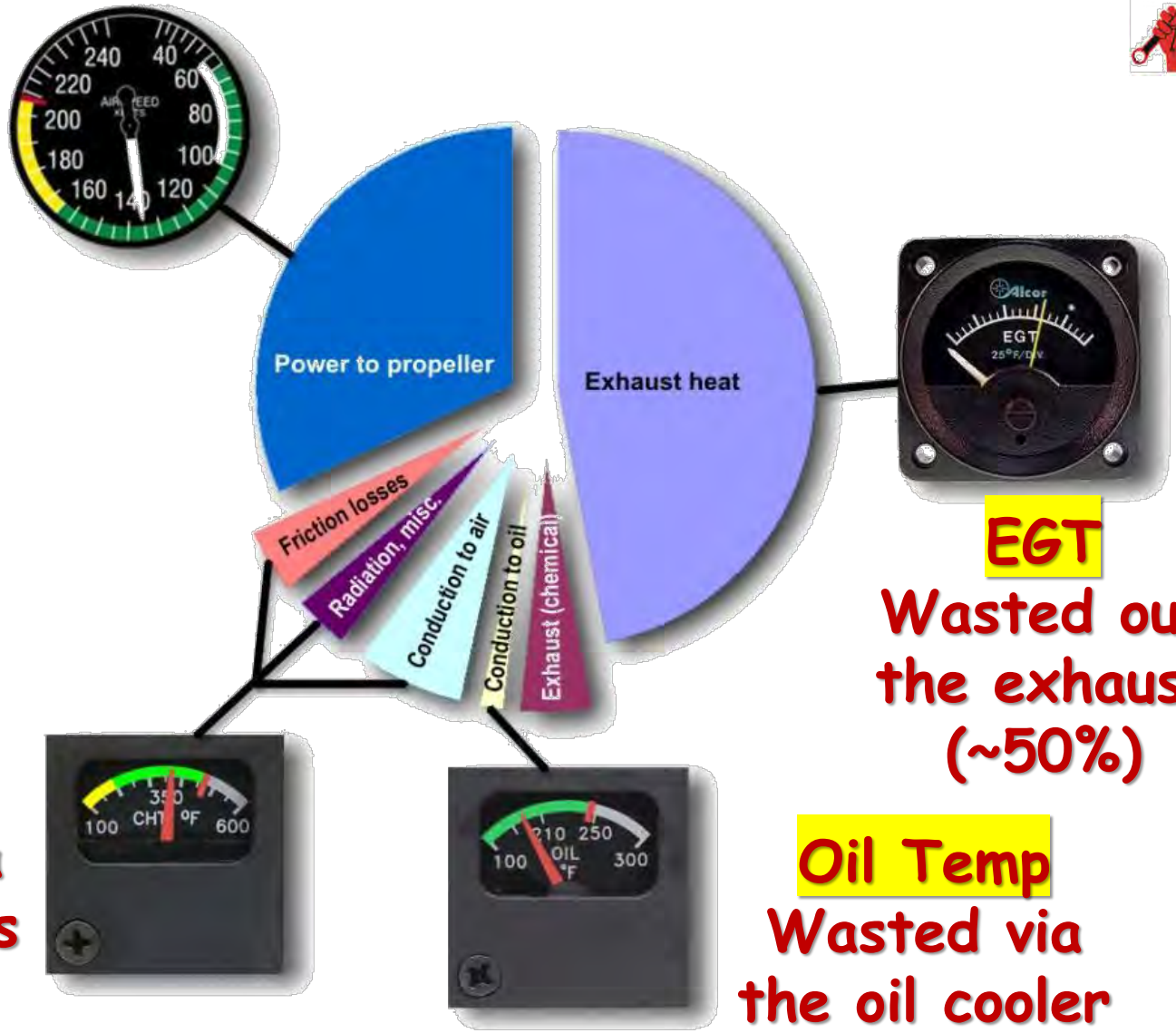


EGT
Wasted out the exhaust (~50%)

CHT
Wasted via cylinder fins (~15%)

Oil Temp
Wasted via the oil cooler (~2%)

Airspeed
Useful work (~33%)



EGT
Wasted out the exhaust (~50%)

CHT
Wasted via cylinder fins (~15%)

Oil Temp
Wasted via the oil cooler (~2%)

When is this heat wasted?

CHT measures heat energy wasted during the **power stroke**, when the cylinder is under <u>maximum</u> stress from high internal pressures and temperatures.

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EGT measures heat energy wasted during the **exhaust stroke**, when the exhaust valve is open and the cylinder is under relatively low pressure, temperature and stress.

Therefore…

Limiting CHT is essential to limit stress and ensure cylinder longevity

Limiting EGT makes no sense at all

Leaning to absolute EGT is a silly practice with no engineering basis

Therefore…

Limiting …

limi… …vity

Limi…

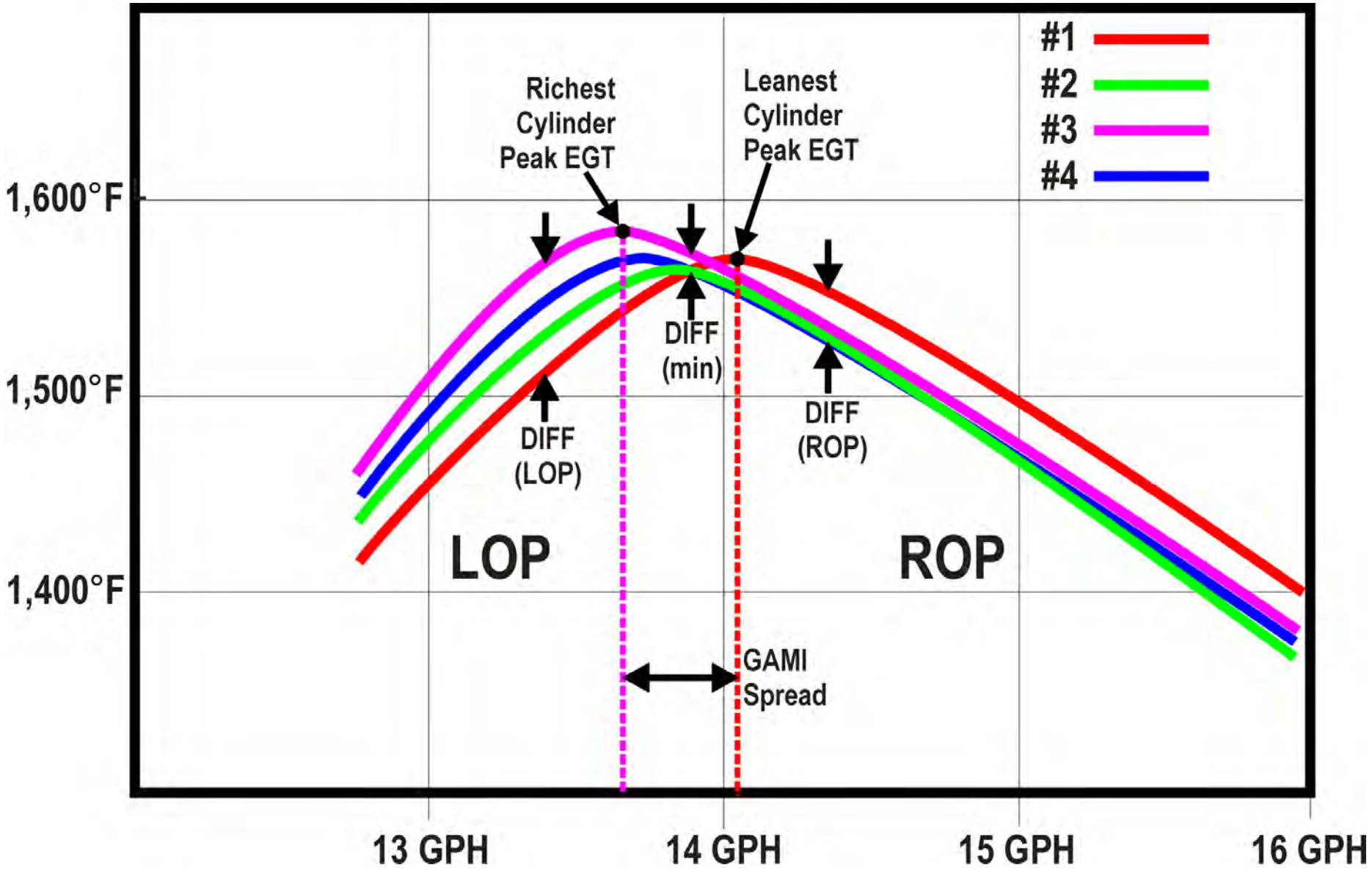
Leani… …e EGT is a silly practic… …no engineering basis

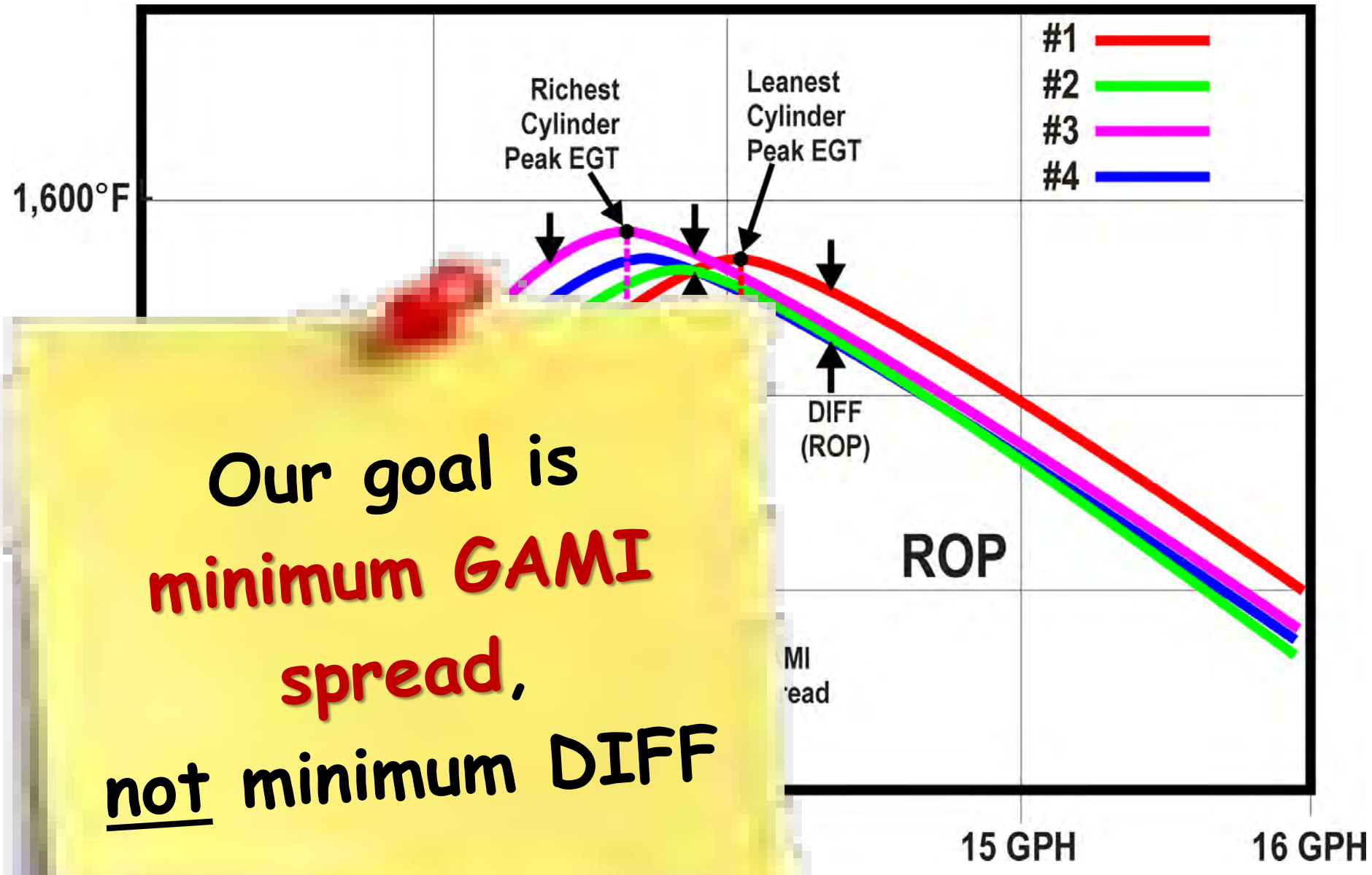
NOTE: In turbocharged aircraft, limiting TIT is necessary to protect the turbocharger turbine. (TIT is a real temp.)

The "flat top" myth

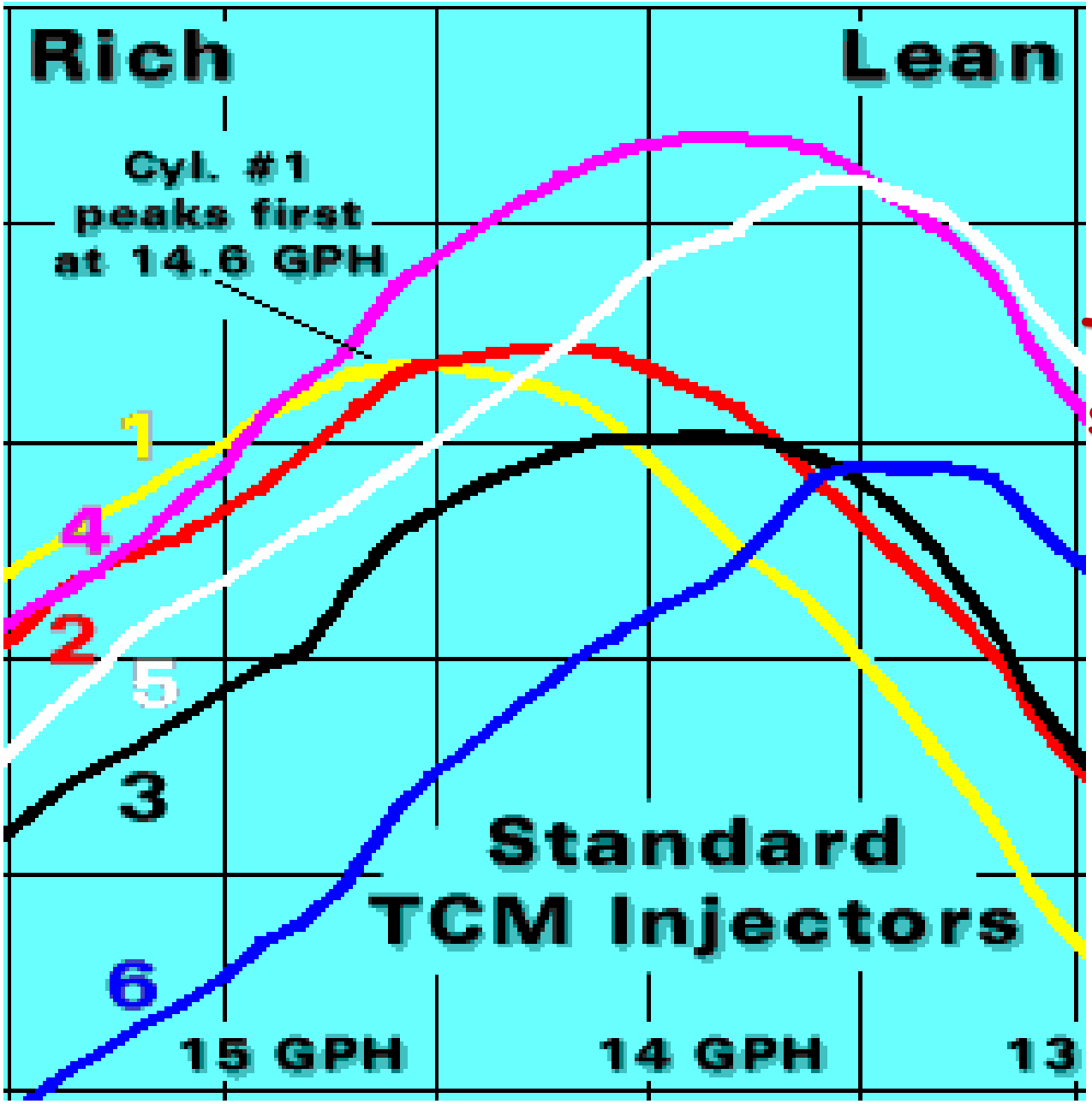
The "flat top" myth

The goal is NOT to have all the EGT bars be level!

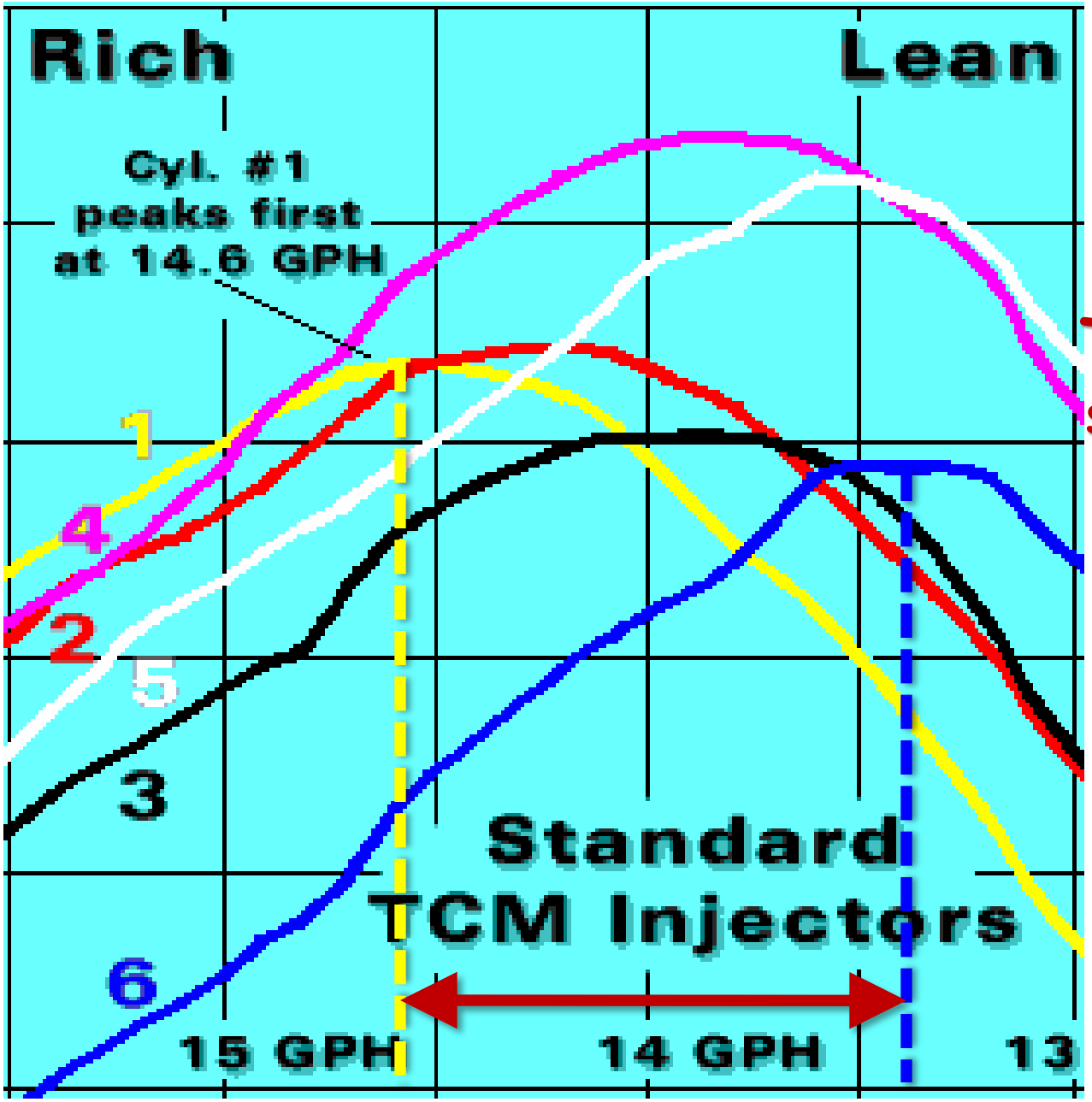




Our goal is
minimum GAMI
spread,
not minimum DIFF

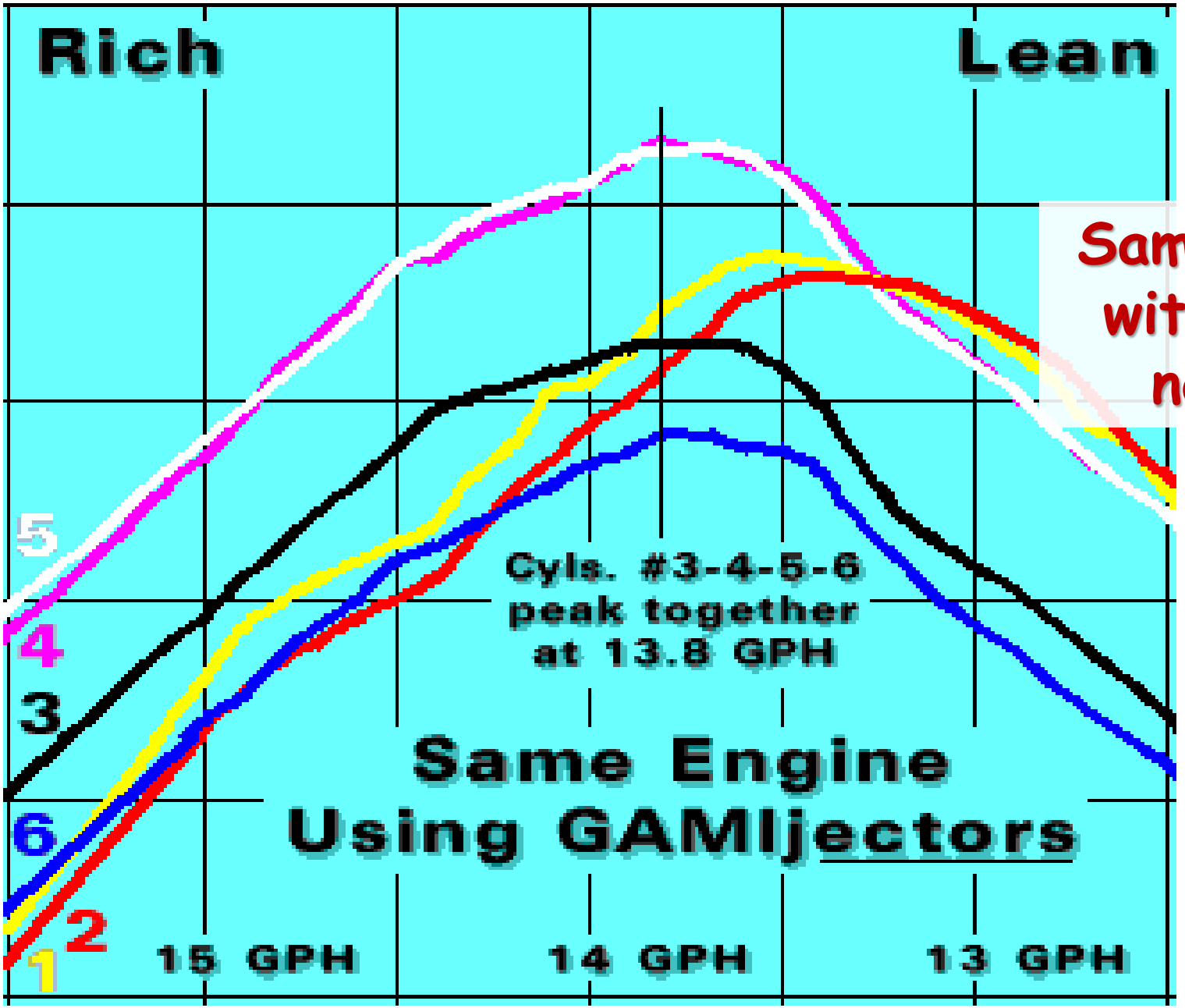


TCM IO-550-B
stock fuel nozzles

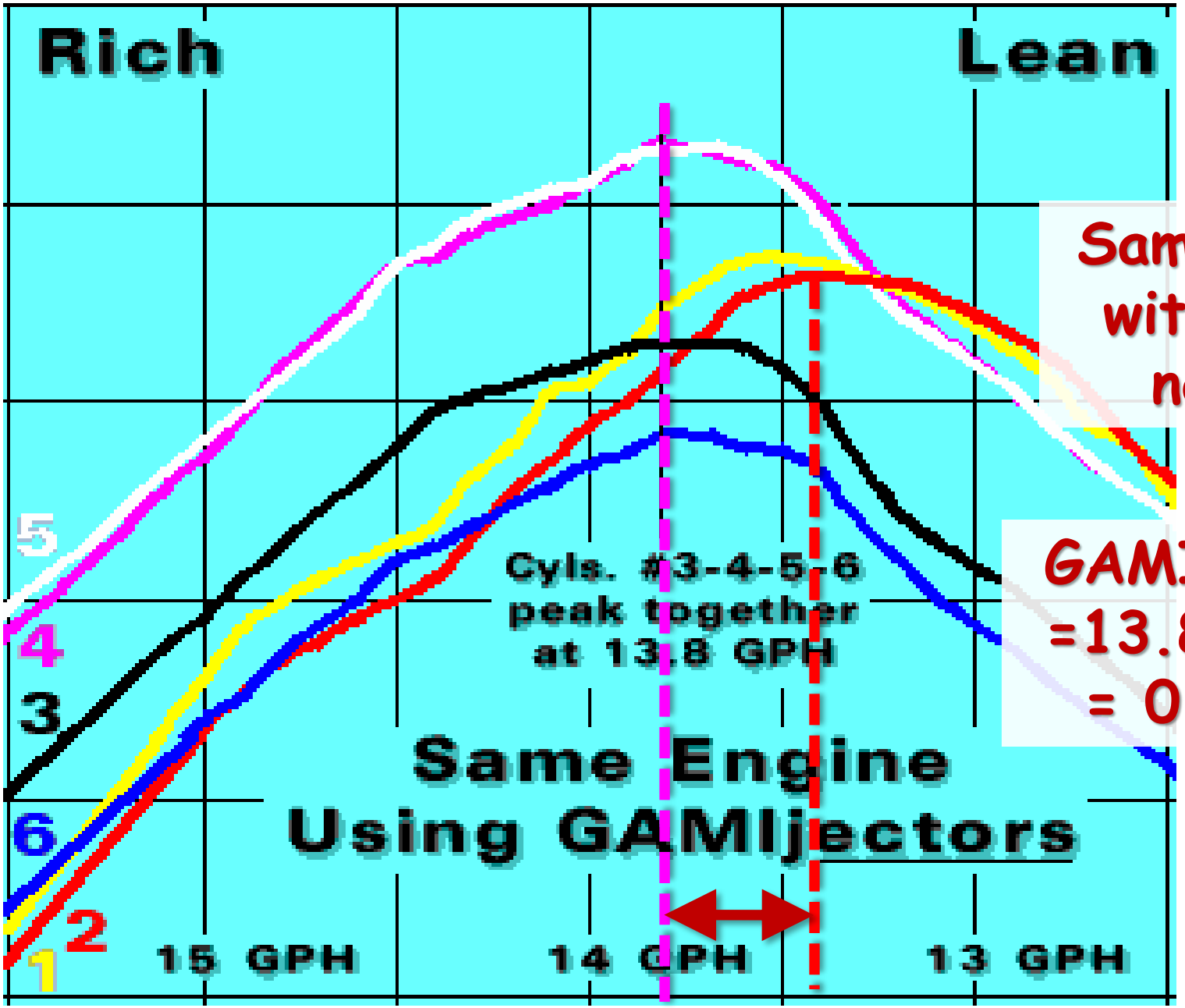


TCM IO-550-B
stock fuel nozzles

GAMI spread
=14.6 – 13.3
= 1.3 GPH



Same engine with tuned nozzles



Same engine with tuned nozzles

GAMI spread =13.8 - 13.4 = 0.4 GPH

So what good is EGT?

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It's fabulous for troubleshooting!

Elevated EGT on all cylinders…

If it happens mid-flight, it's probably a failed magneto. Confirm with an in-flight mag check.

If it happens right after an annual, it's probably retarded magneto timing. Ask the shop to re-check the mag timing.

Elevated EGT on one cylinder…

Probably a fouled or defective spark plug.
(Usually the bottom plug.)

Sometimes self-resolves.

Confirm with an in-flight mag check, noting which mag causes the cylinder to go cold.

EGT and CHT on one cylinder both go up (if ROP) or both go down (if LOP)…

Probably a partially clogged fuel nozzle.

Go full-rich, land, and dump your engine monitor data.

EGT on one cylinder goes cold, CHT drops, engine runs rough…

Probably a totally clogged fuel nozzle.

Attempt to unclog by going full-rich and momentary high boost pump.

If engine still rough, land ASAP.

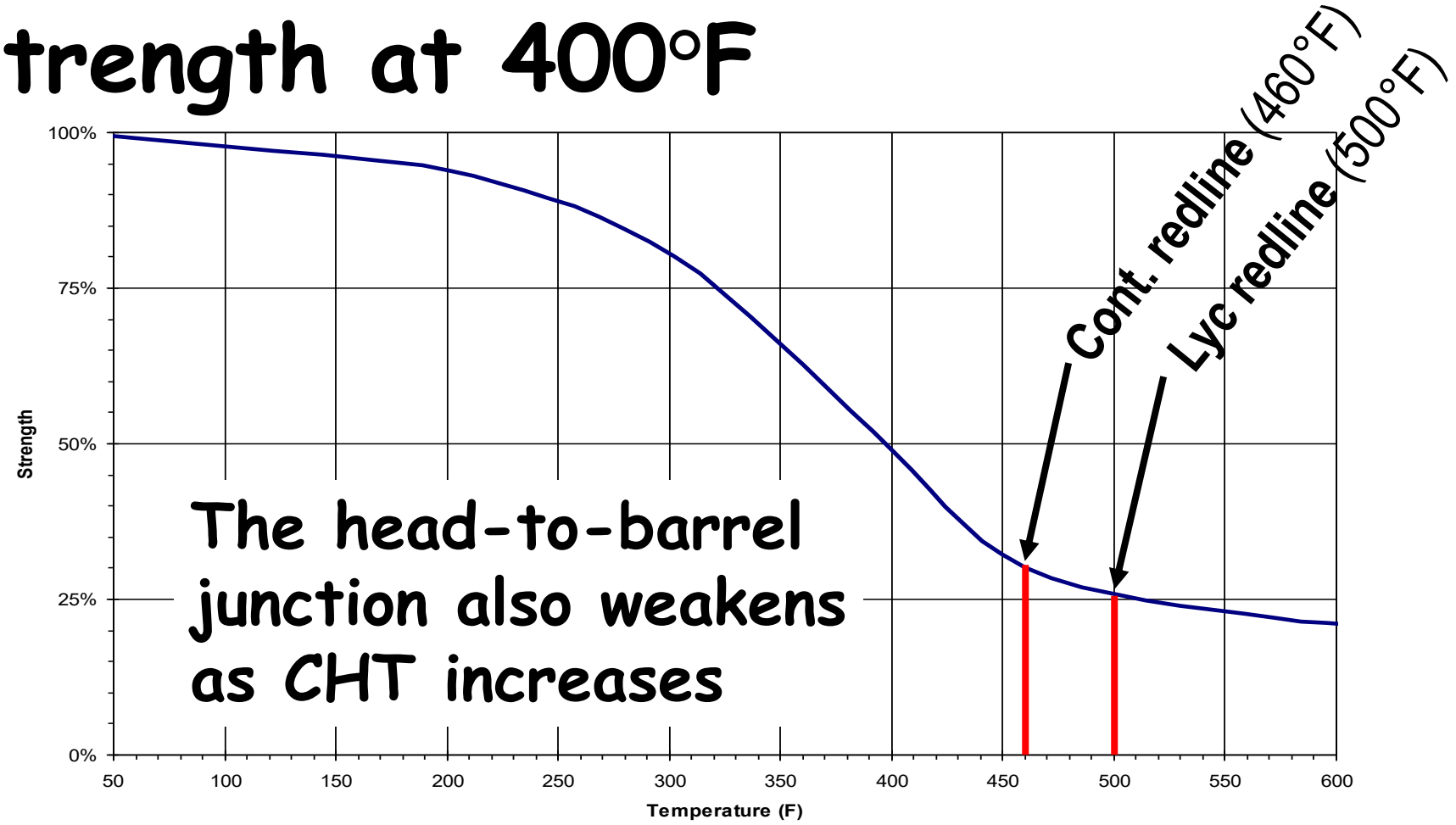
Limiting CHT is key to engine longevity

- CHT is best proxy we have for peak pressure
- High peak pressure means high engine stress
- High CHT increases probability of head cracks, burned exhaust valves, and detonation

Limiting EGT is not helpful or logical

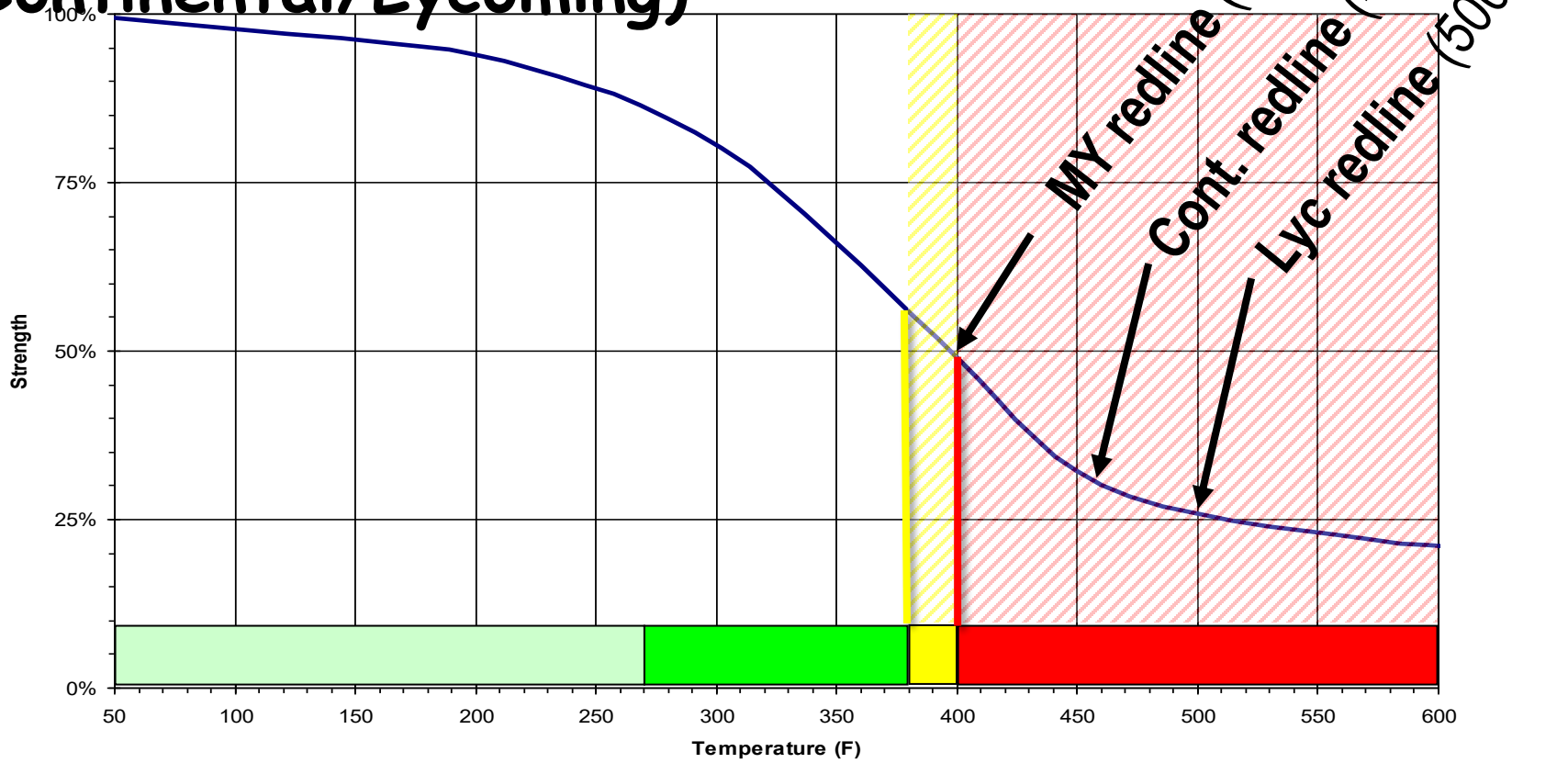
- EGT is <u>not</u> a measure of engine stress
- EGT often increases when stress decreases
- EGT is primarily useful for troubleshooting

Aluminum alloy cylinder heads lose half of their strength at 400°F

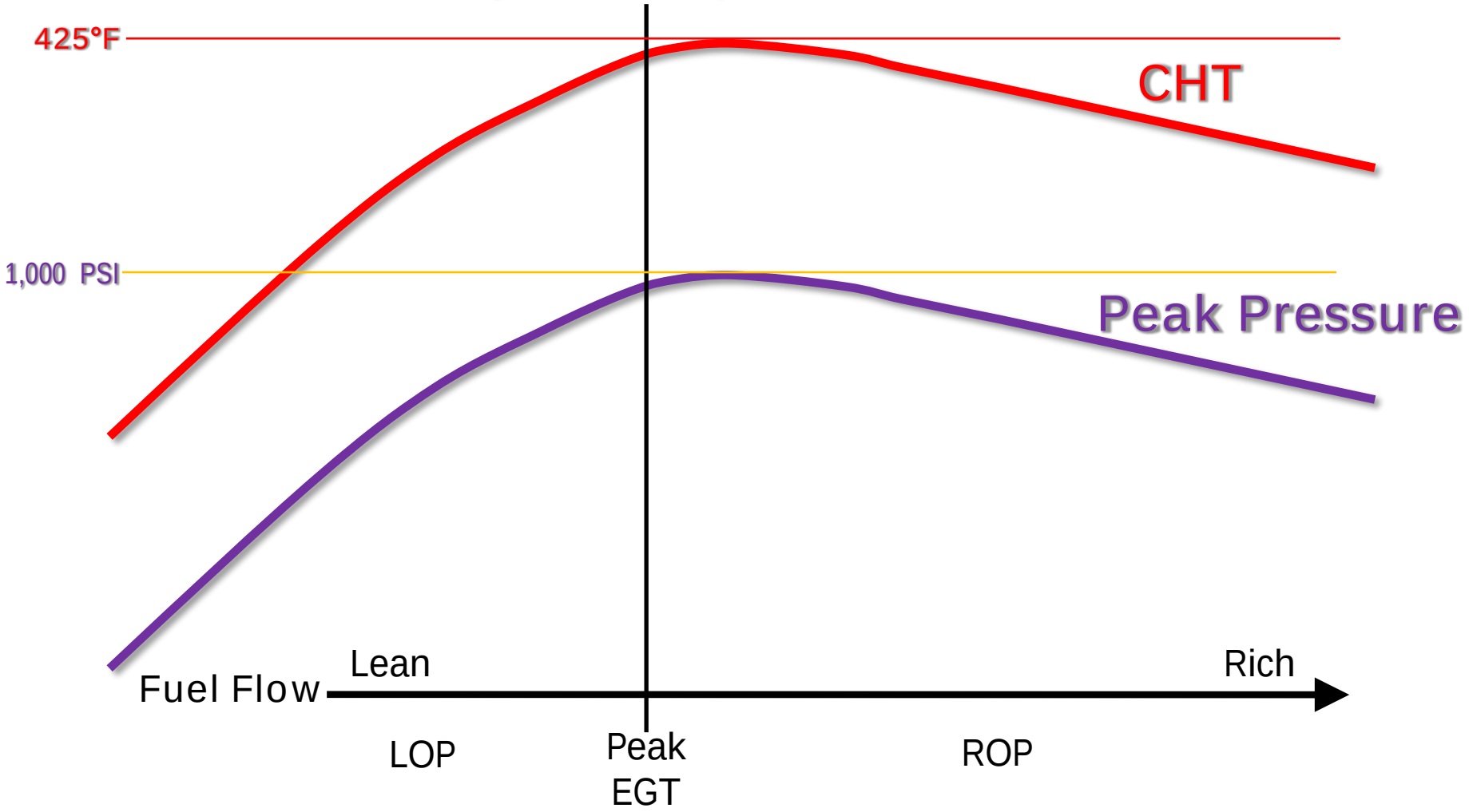


For optimum longevity…

always keep CHTs below 400°F/420°F, preferably below 380°F/400°F. (Continental/Lycoming)



CHT as proxy for stress



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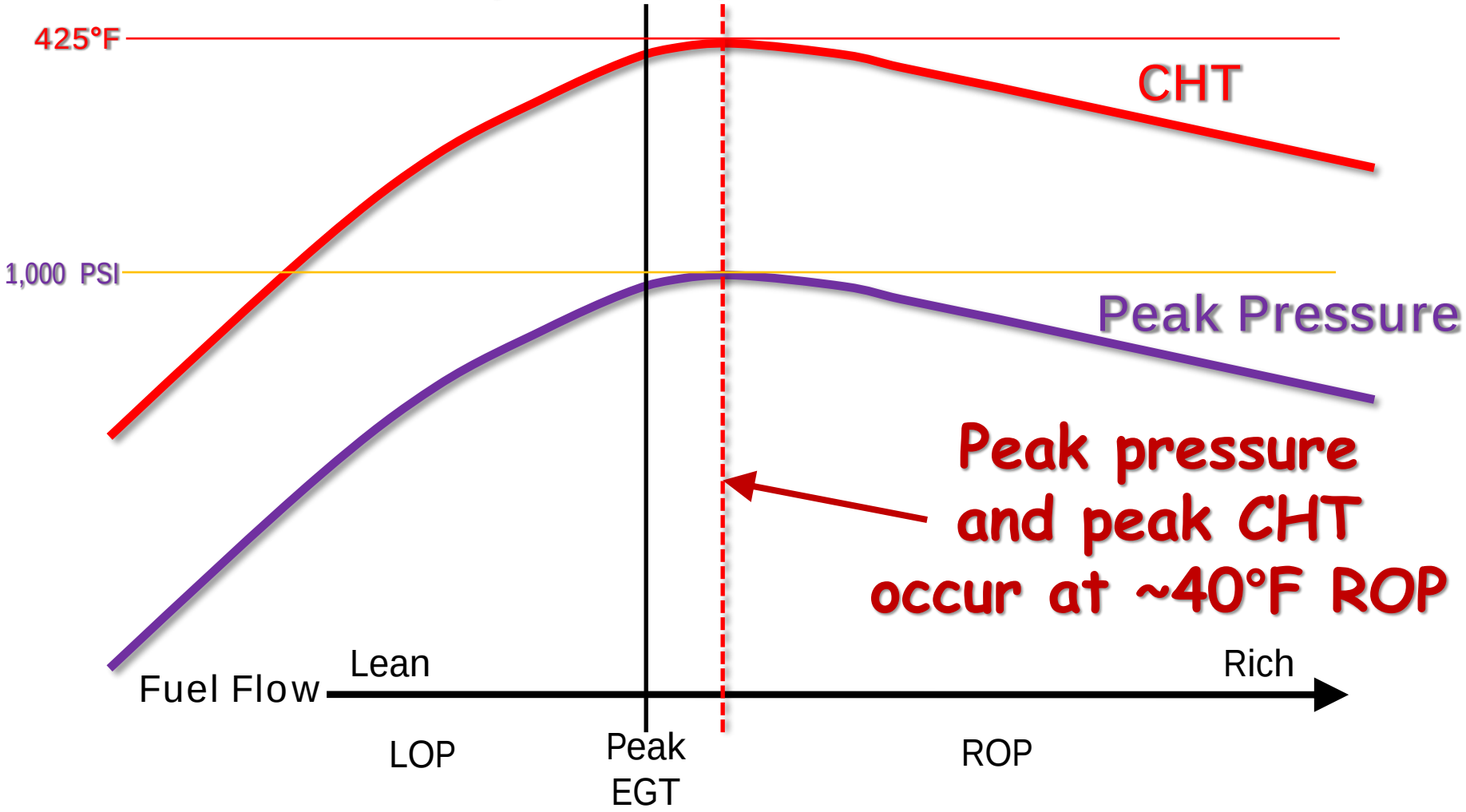

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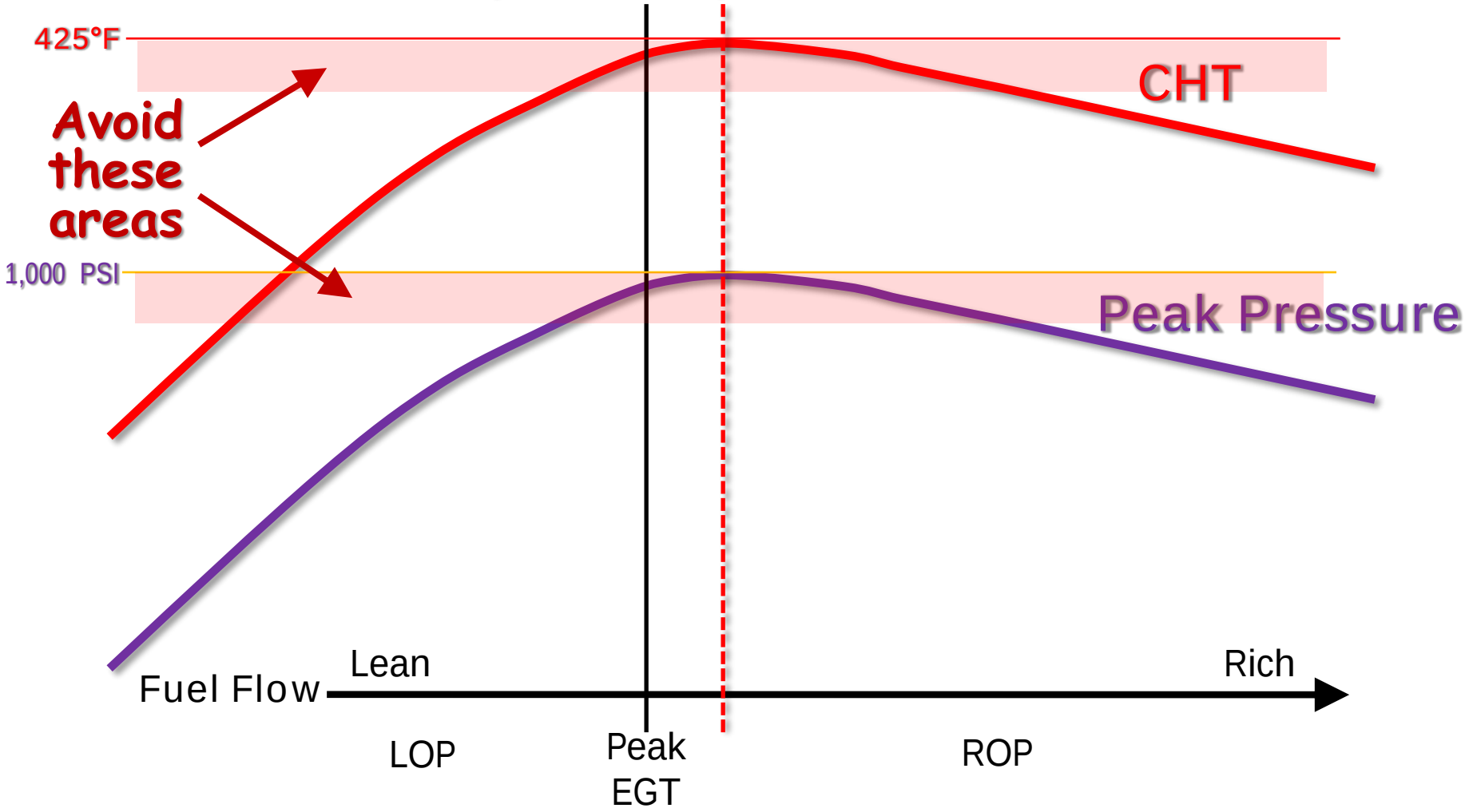

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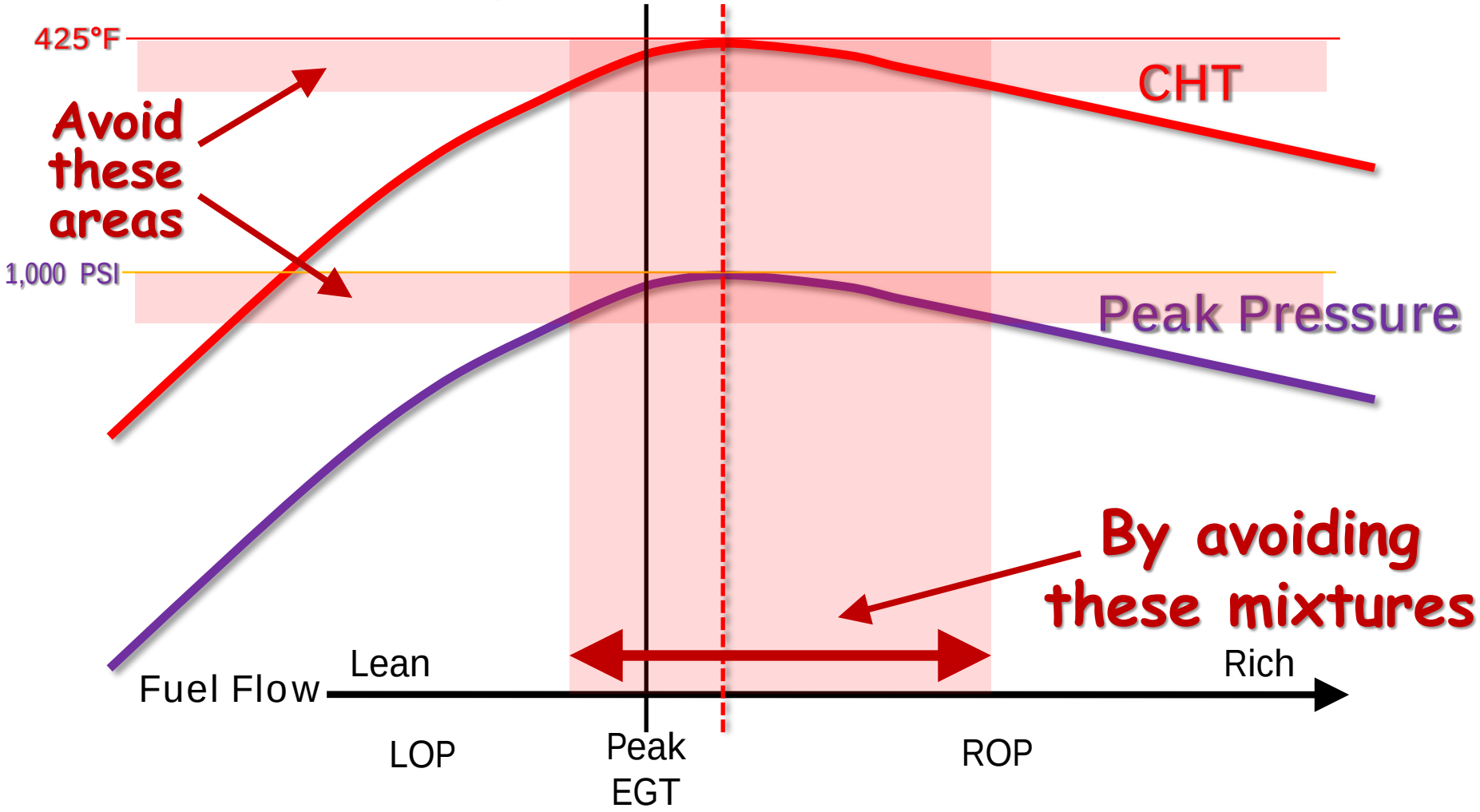

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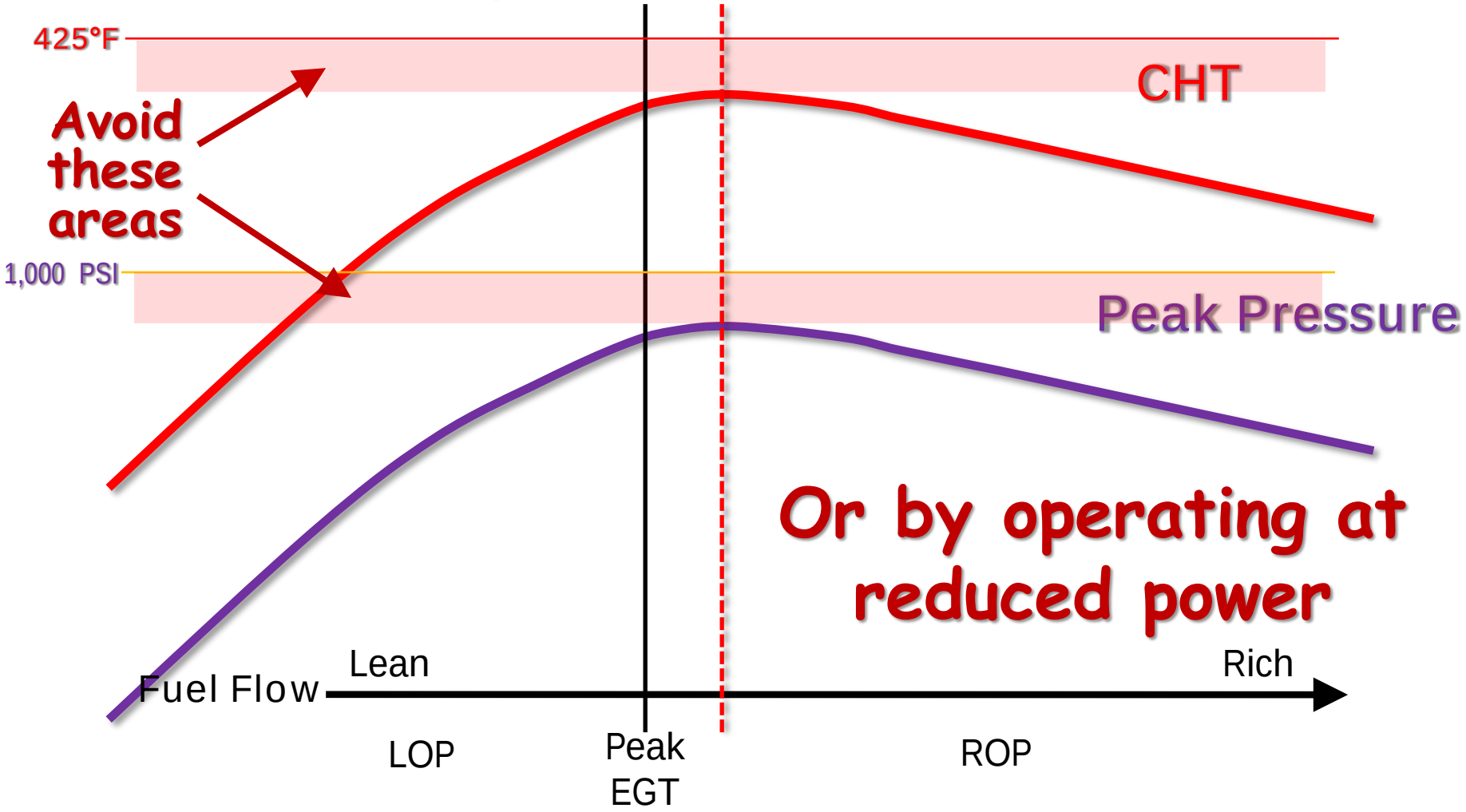
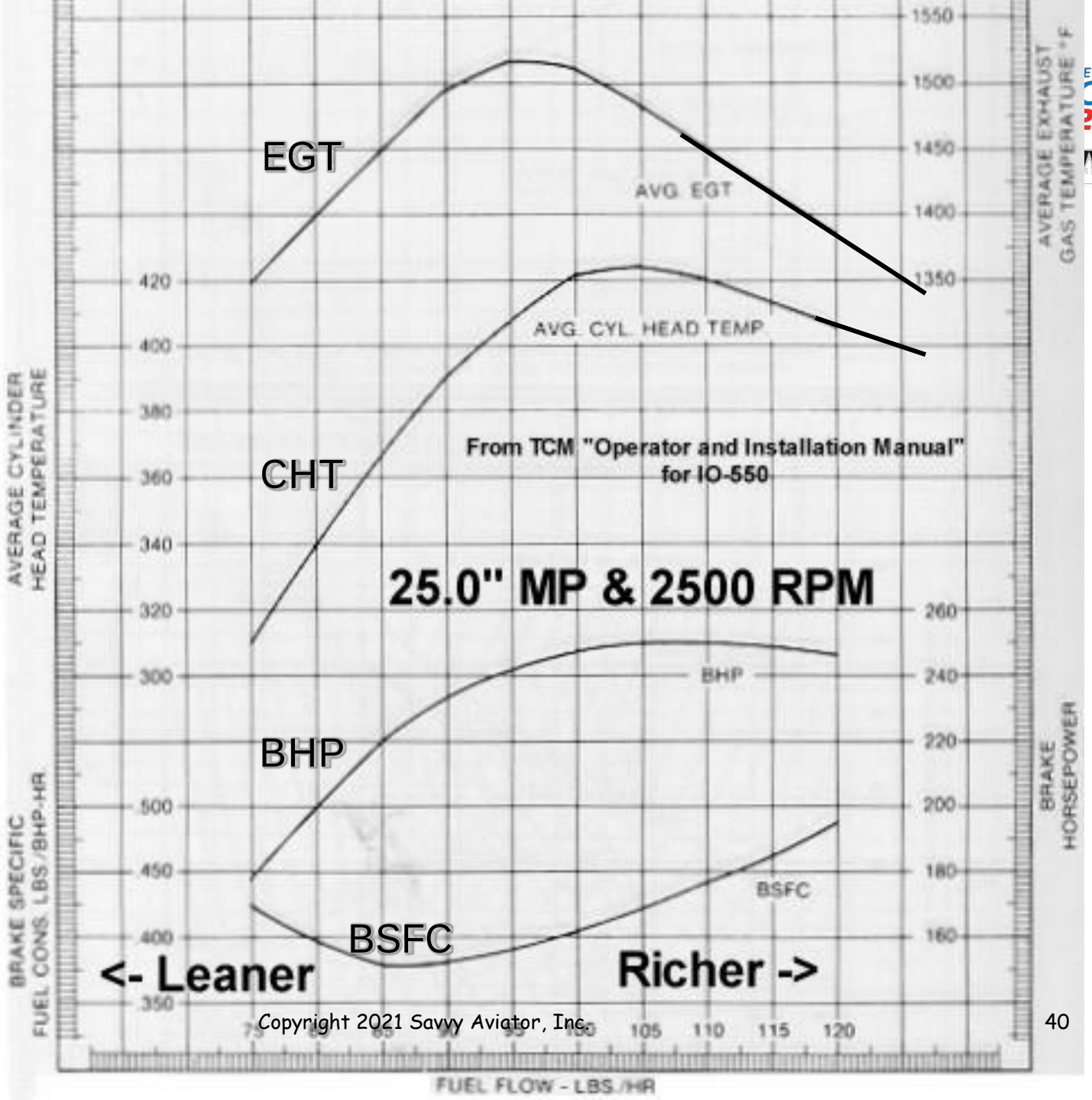
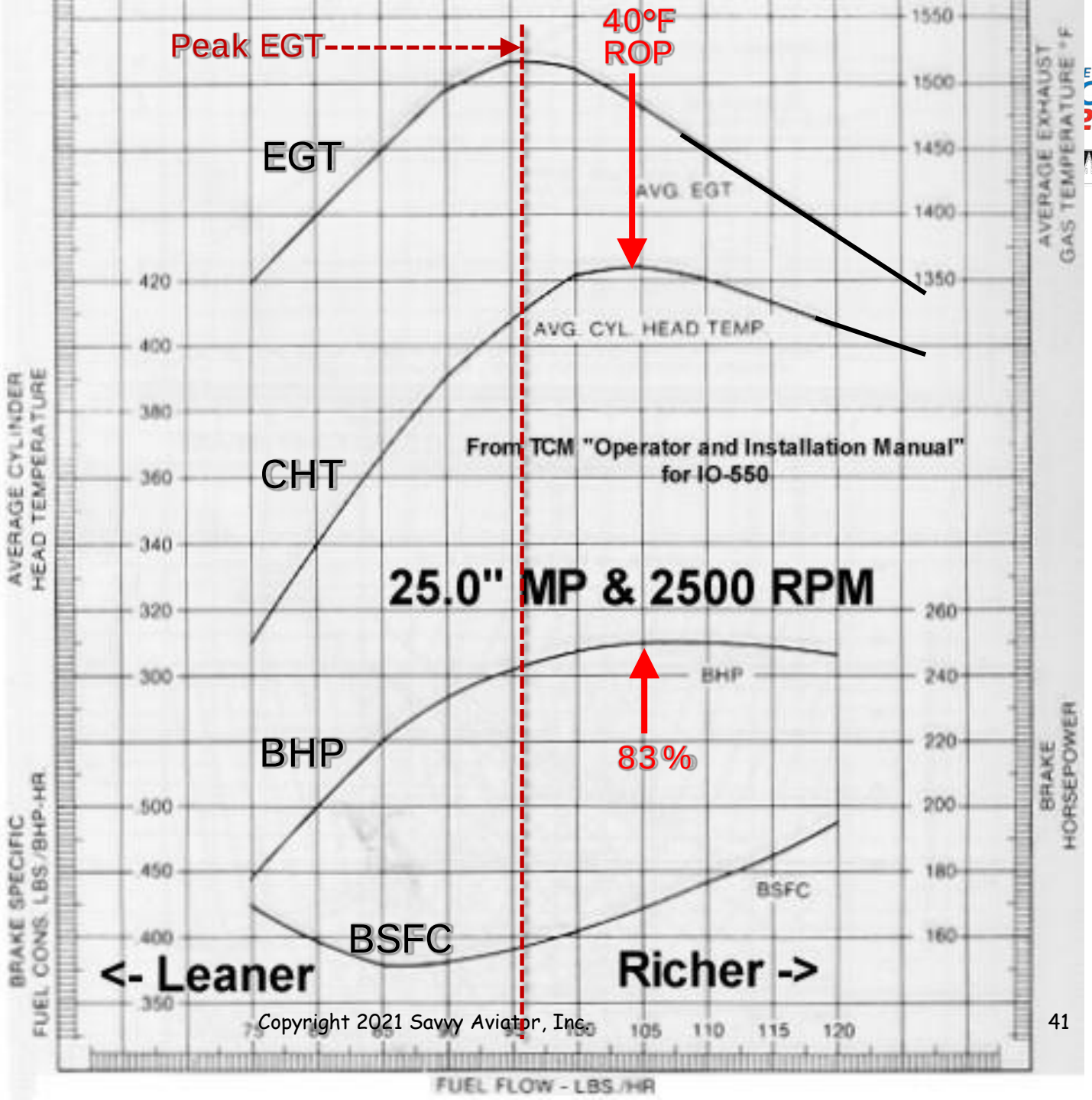
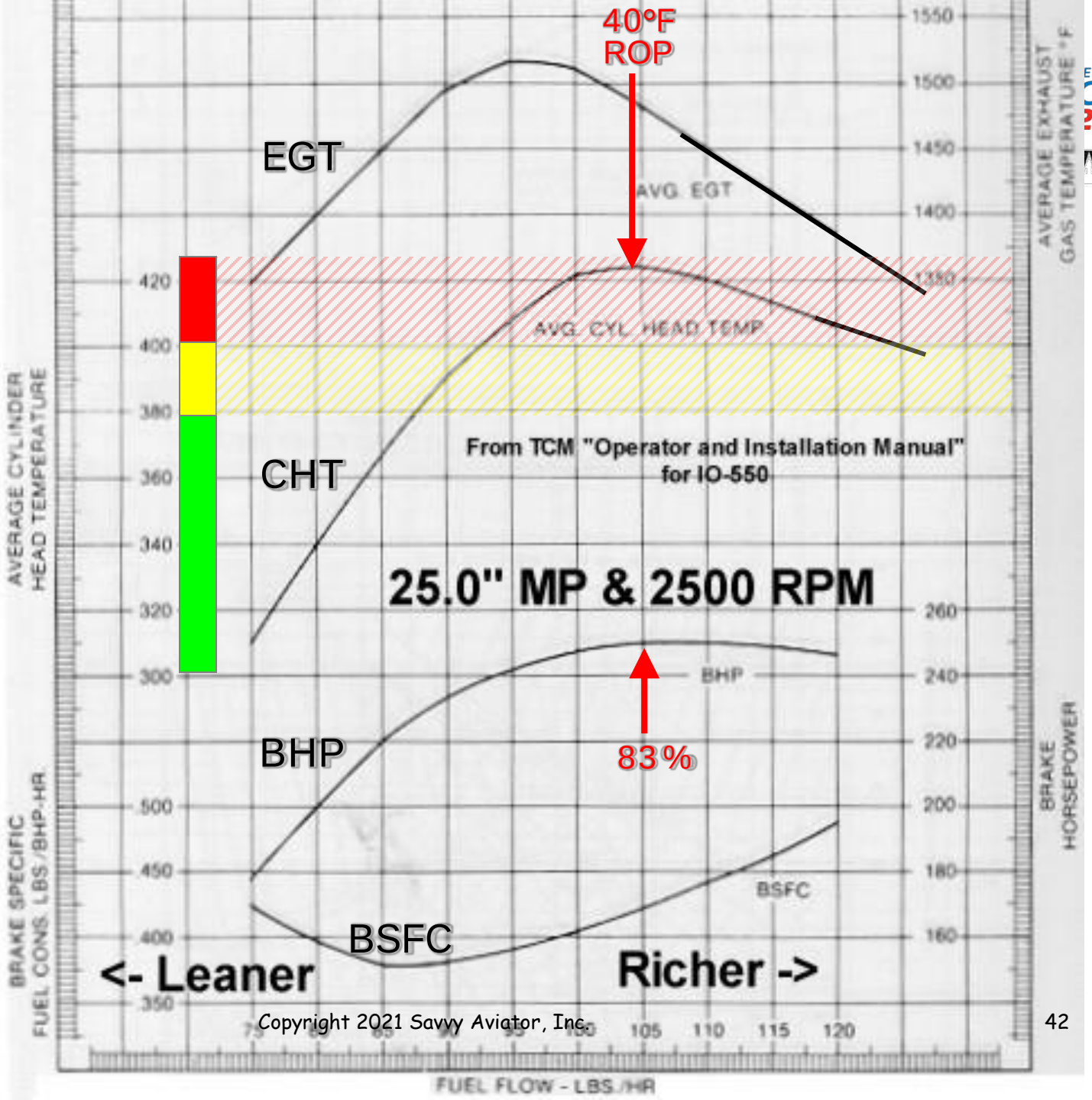
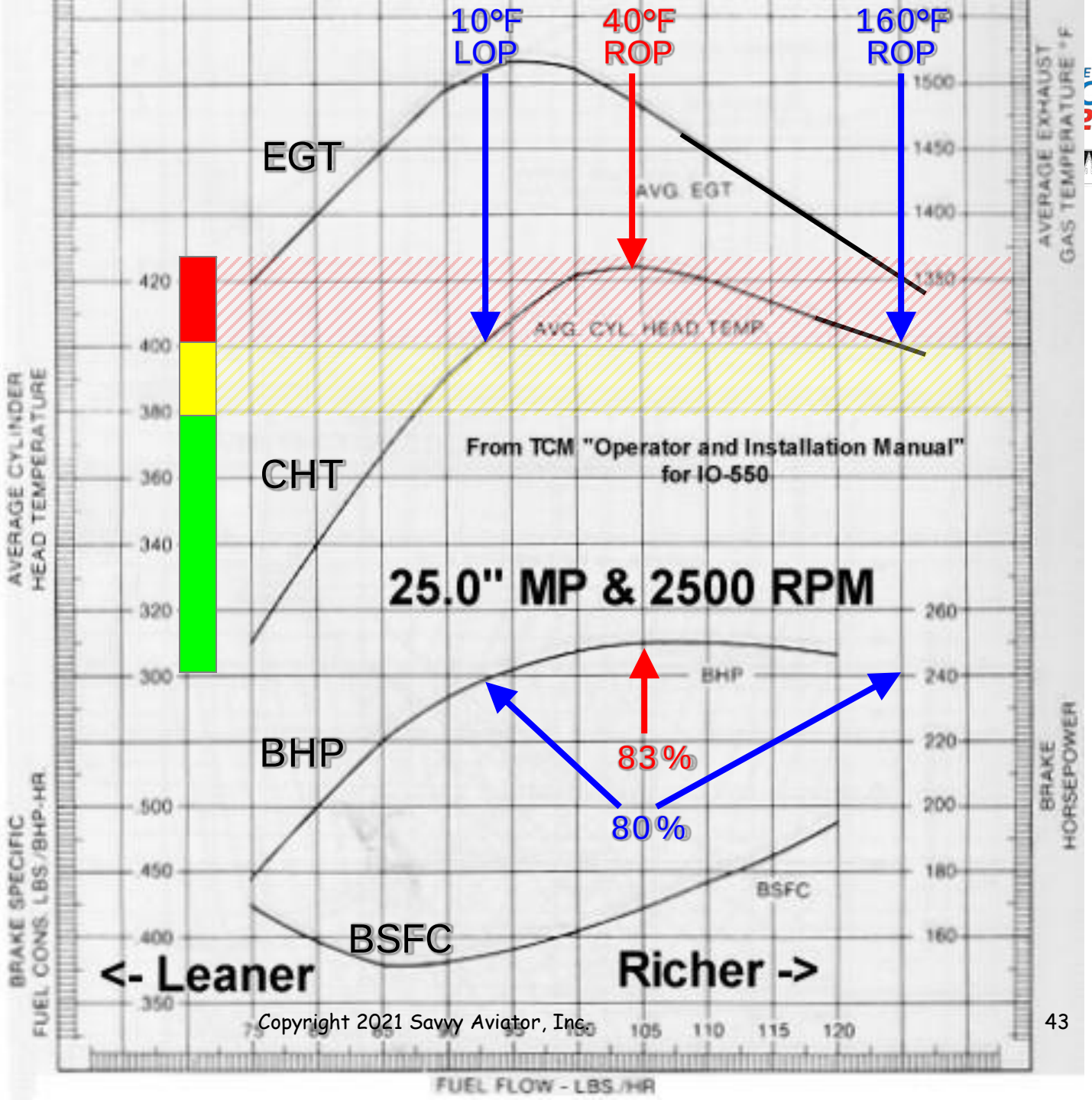
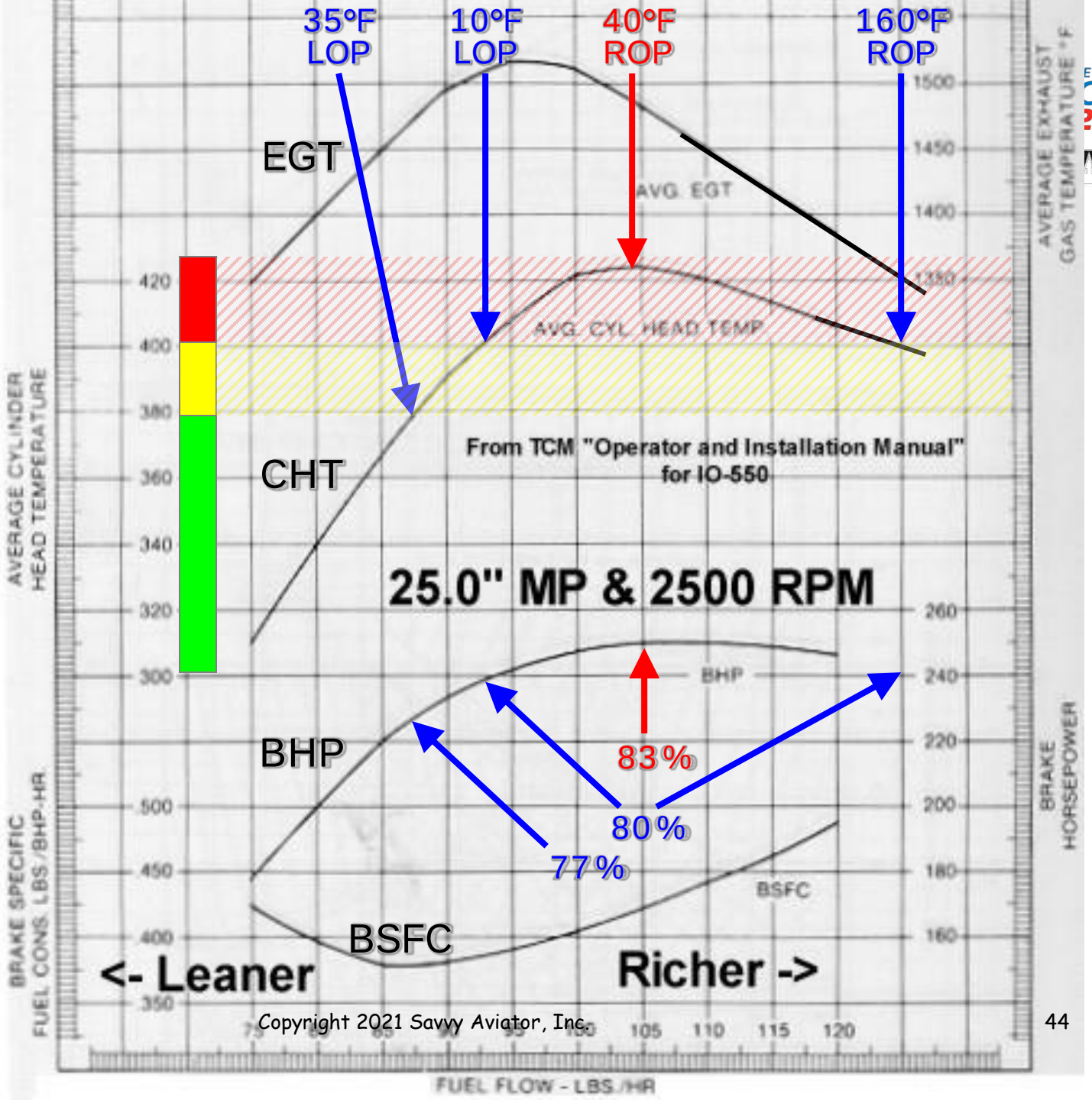










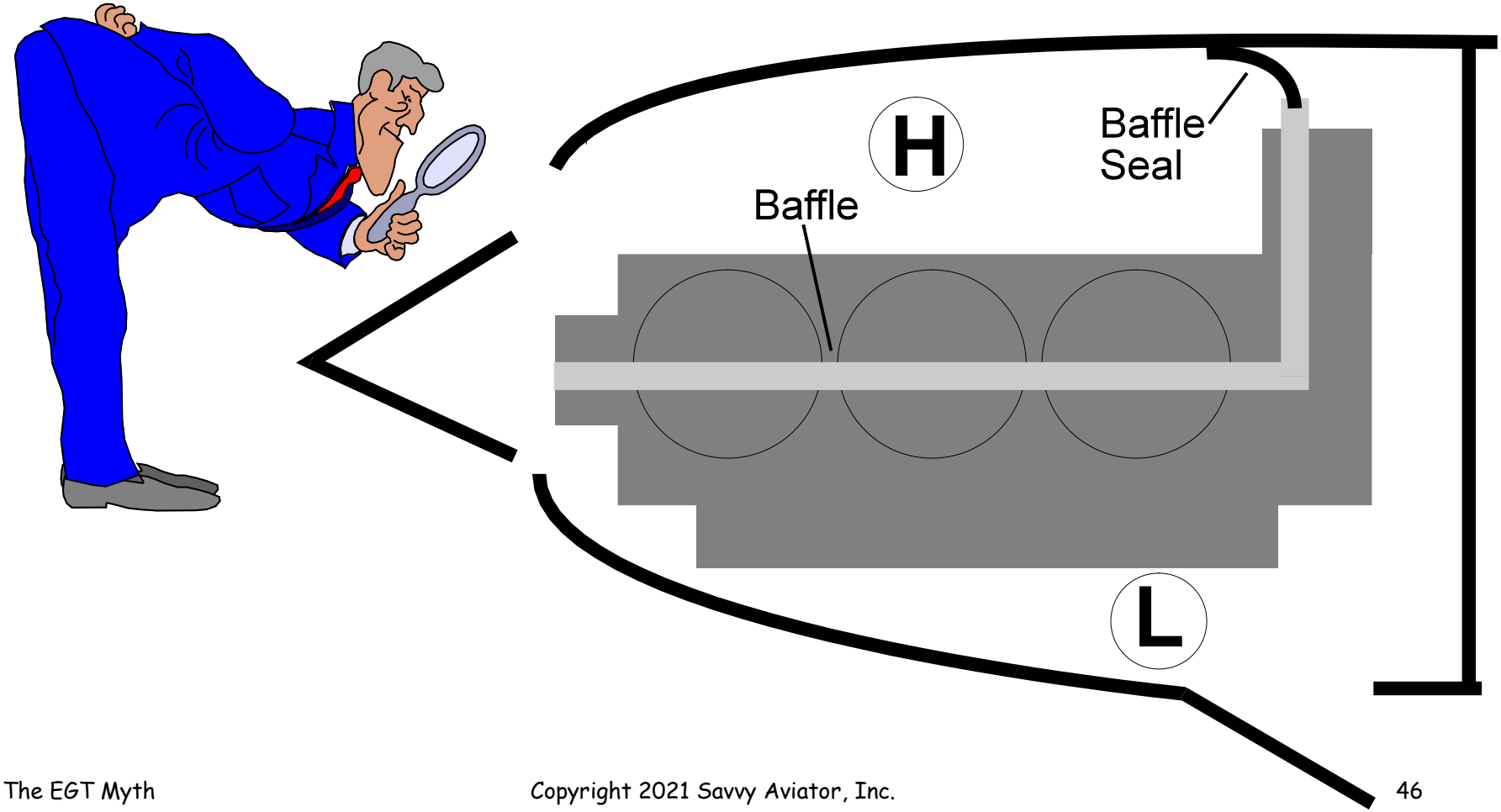


CHT is an imperfect proxy

In addition to stress (i.e., peak pressure), CHT also is affected by:

- **OAT** (deviation from ISA temp)
- **Airspeed** (less cooling at low airspeed)
- **Altitude** (less cooling at high altitude)
- **Cooling system efficiency** (design, condition)

The cooling system



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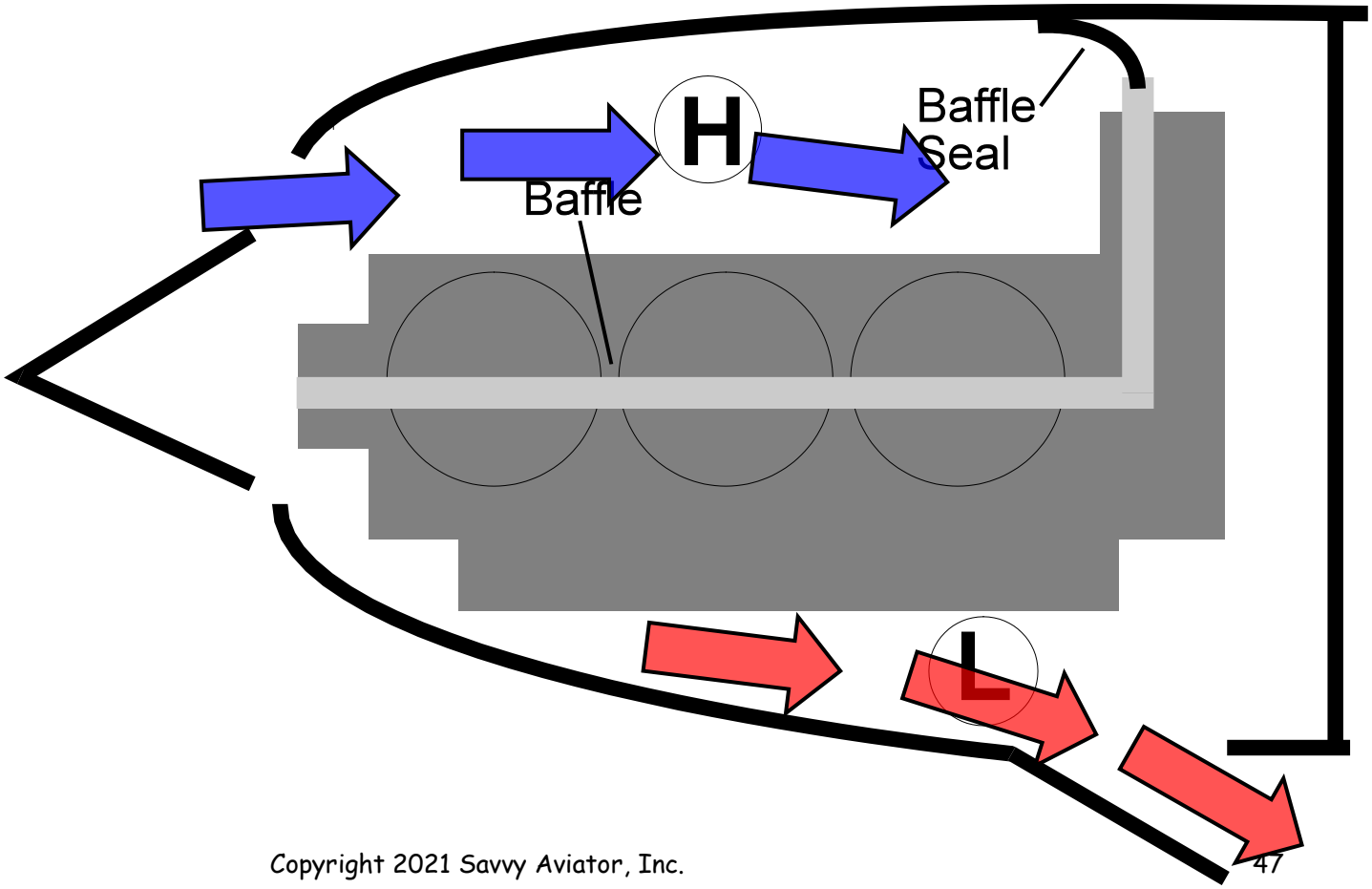

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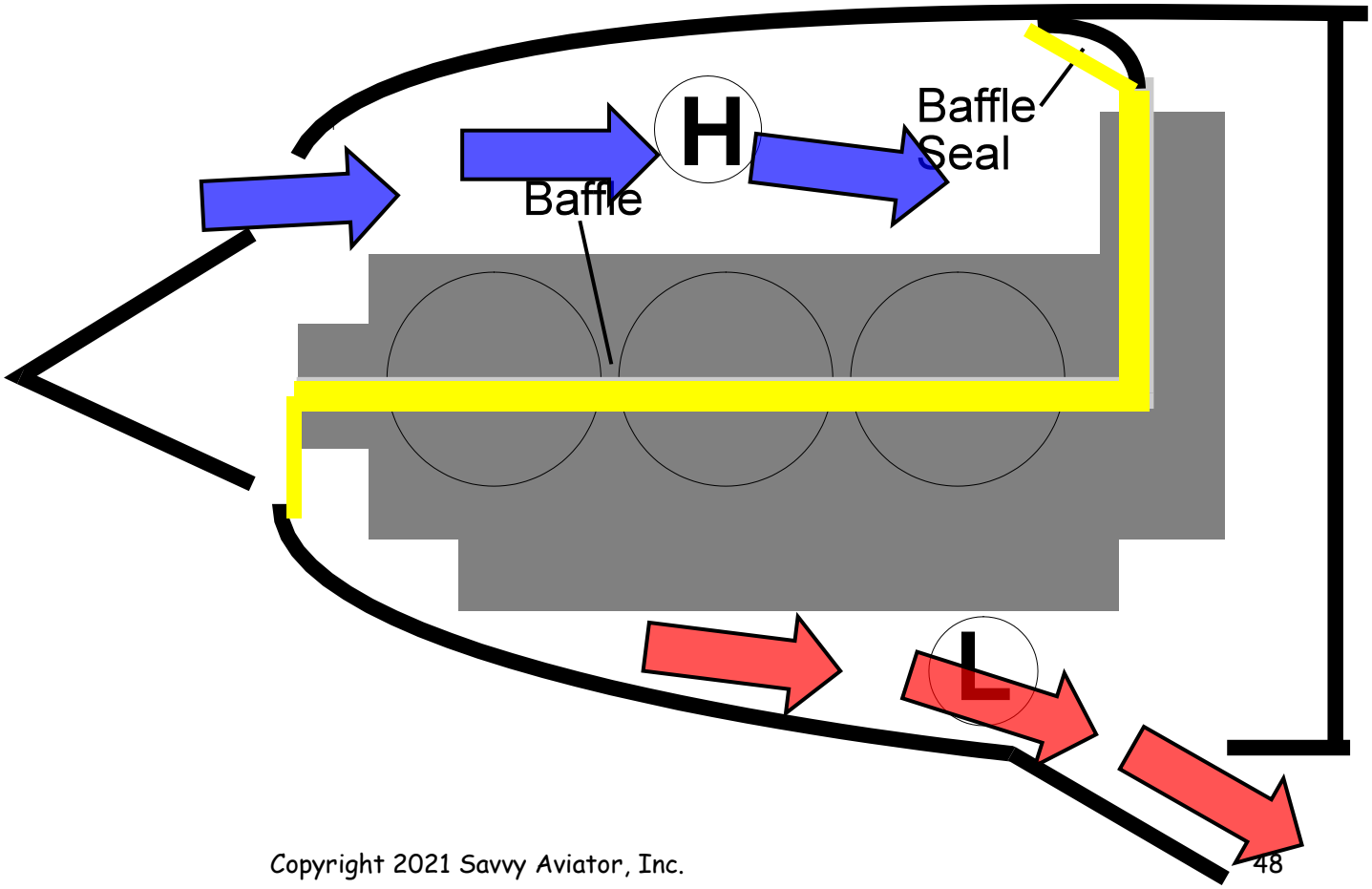

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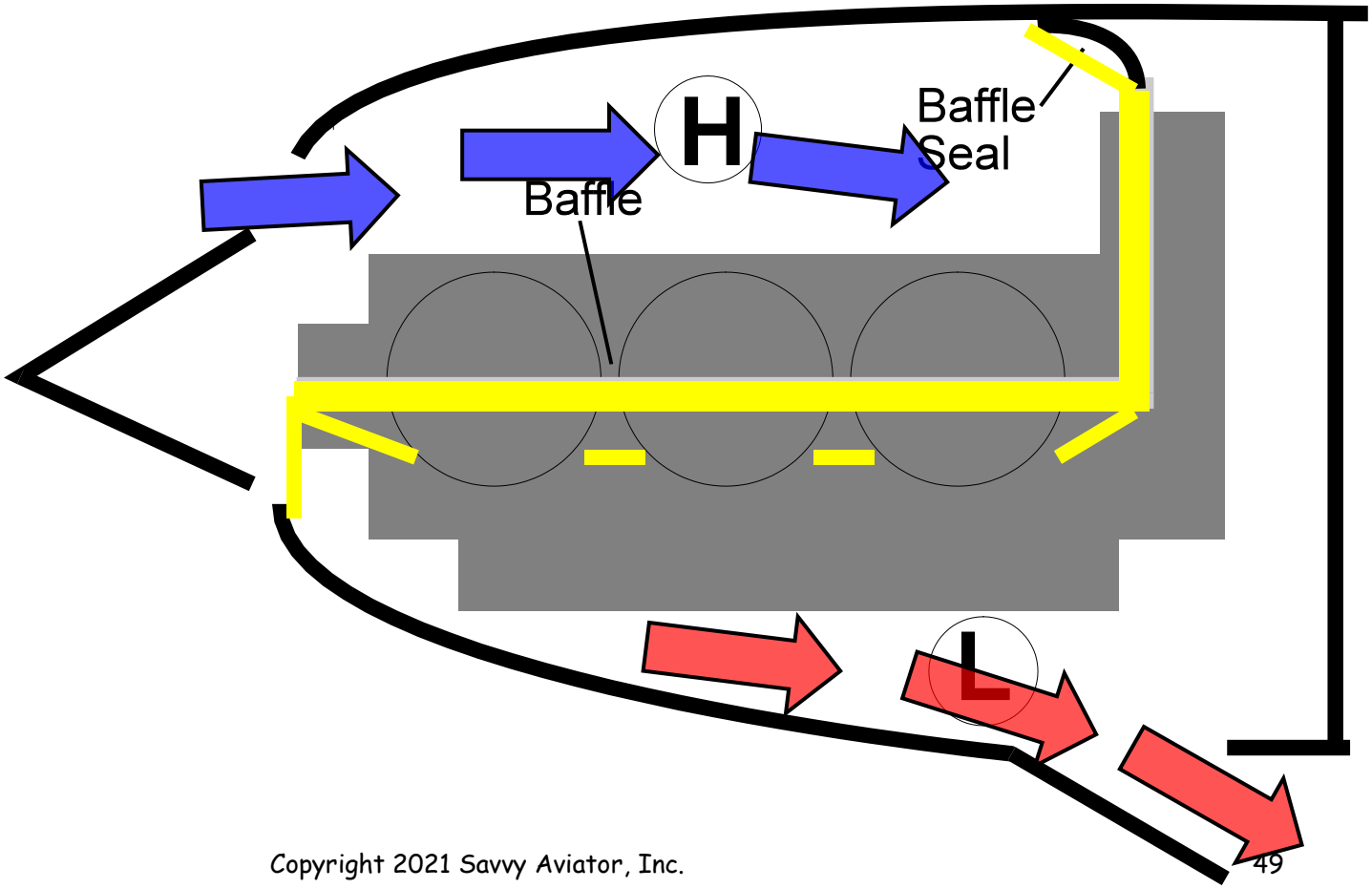

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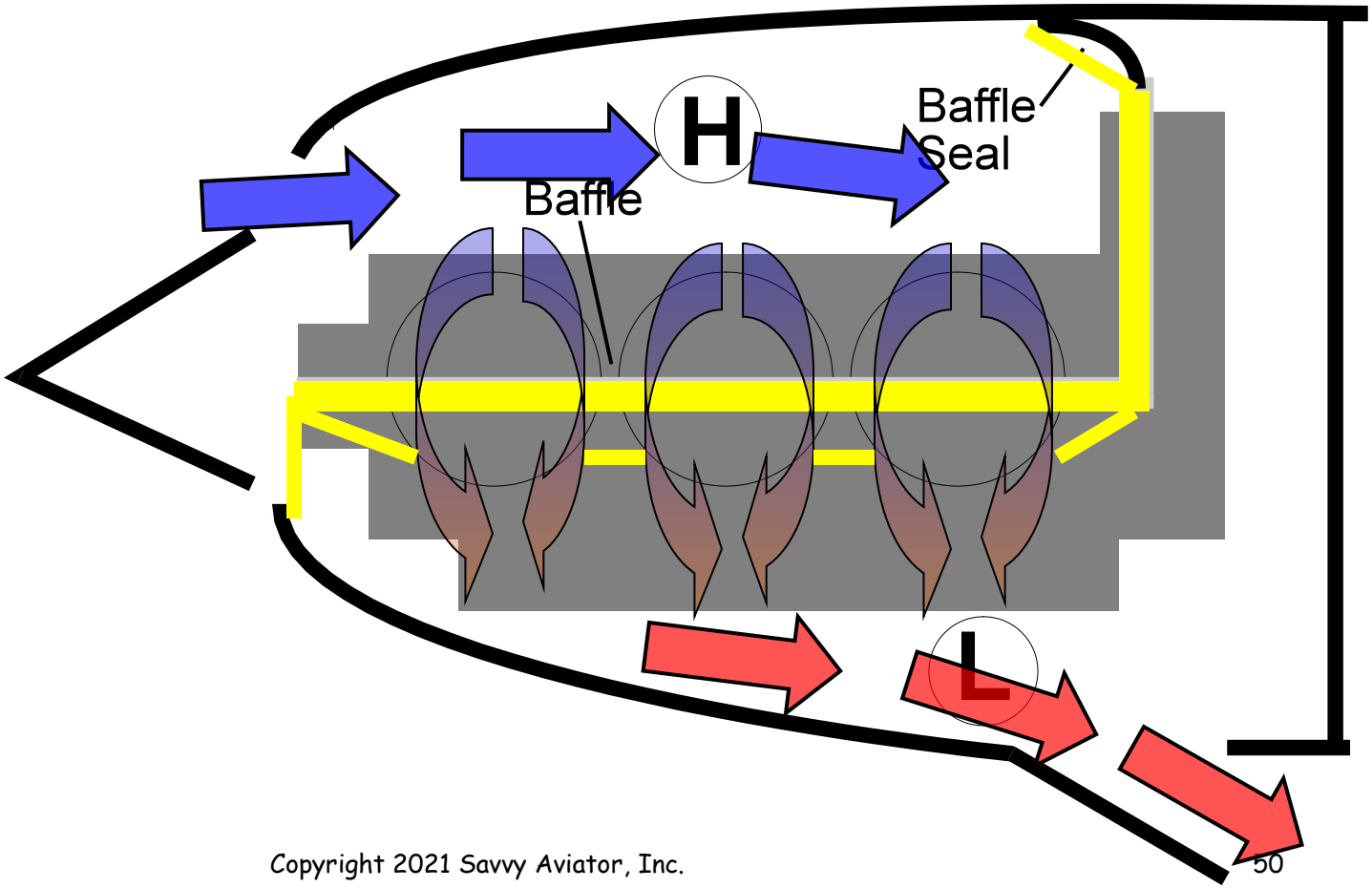


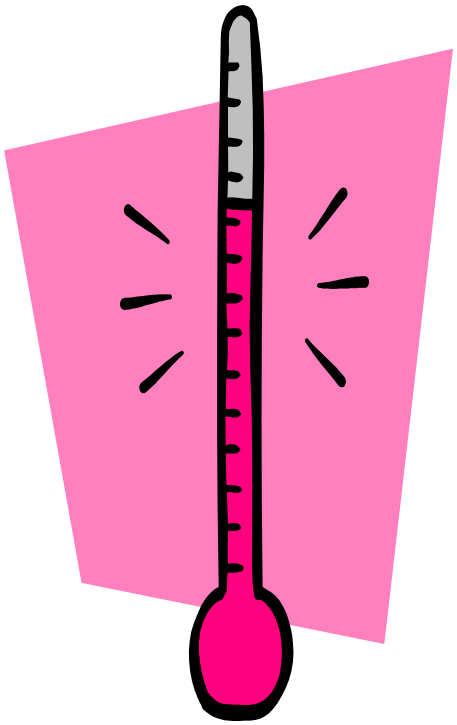
Do you know your CHTs?

Not unless you have a multi-probe engine analyzer!

CHT spread is often 50°F to 100°F

Hottest cylinder is often <u>not</u> the one with the factory probe

Reducing CHT

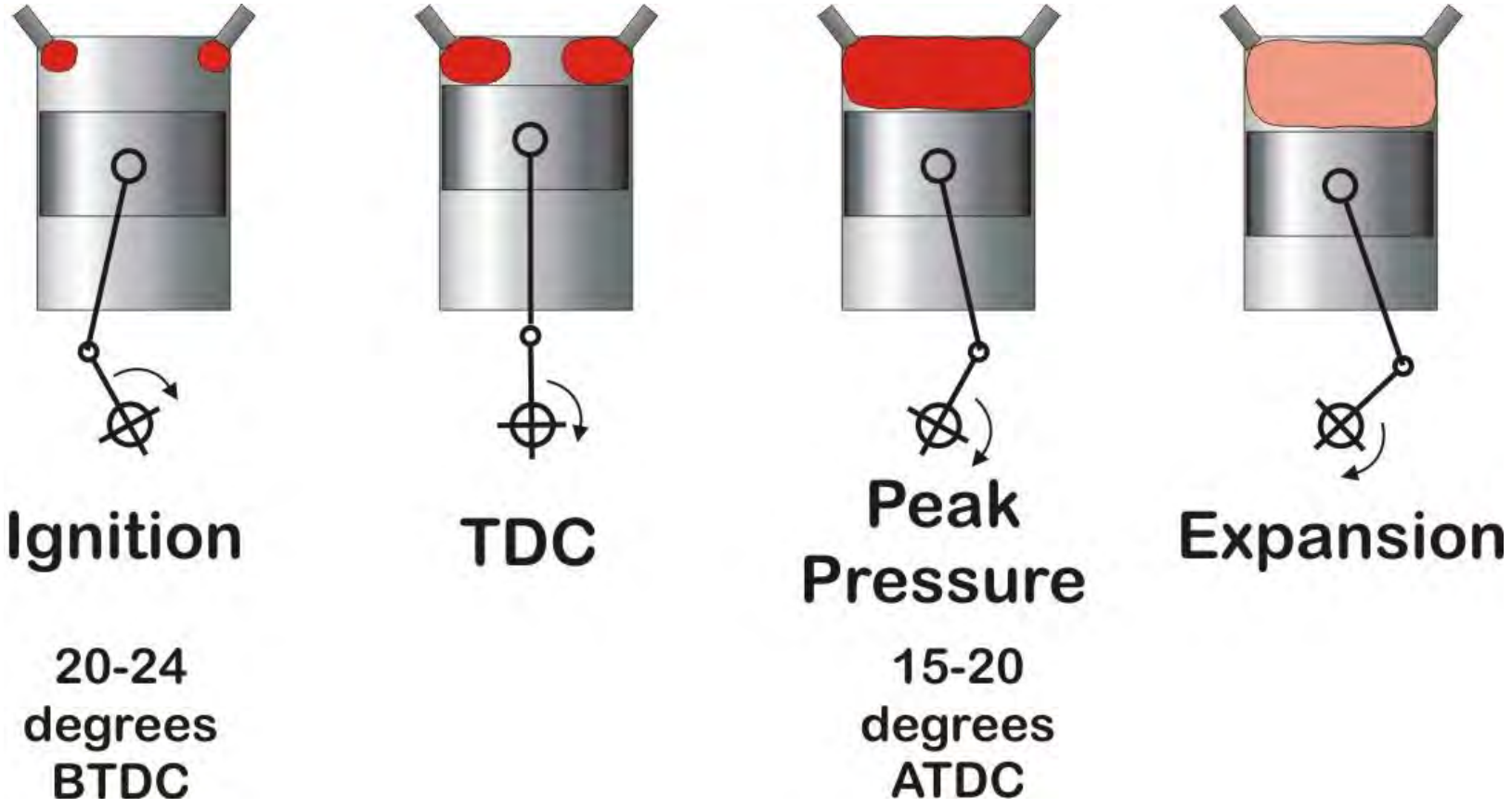


- **Open cowl flaps**
  (if you have them)
- **Increase airspeed**
- **Adjust mixture**
  - Hottest CHT occurs ≈ 40°F ROP
  - If ROP, richen a lot
  - If LOP, lean a little
- **Reduce power** (if all else fails)

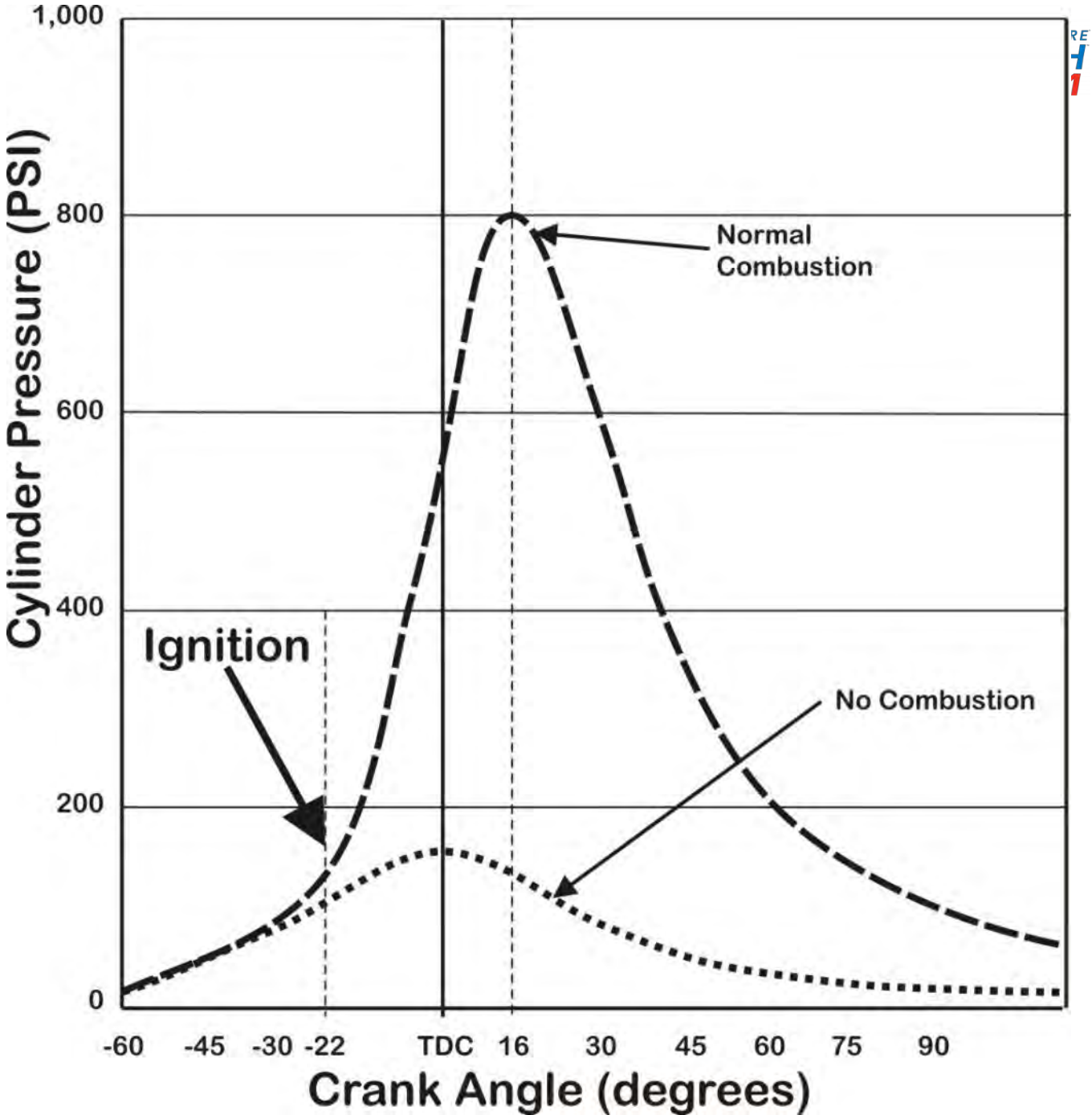
Abnormal combustion

- Detonation
- Pre-ignition

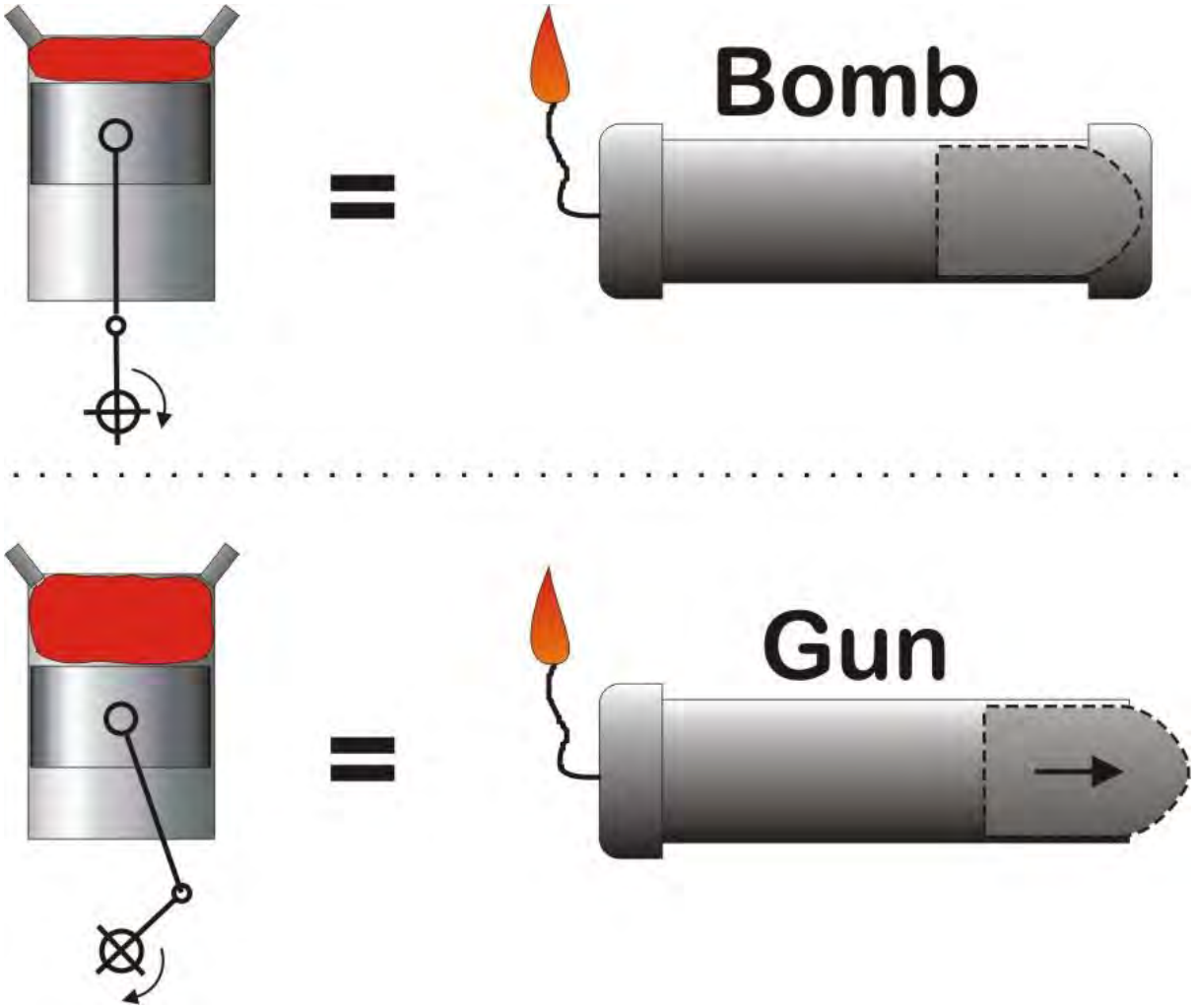
The combustion event takes a significant amount of time—roughly 6 milliseconds and 90° of crankshaft rotation.



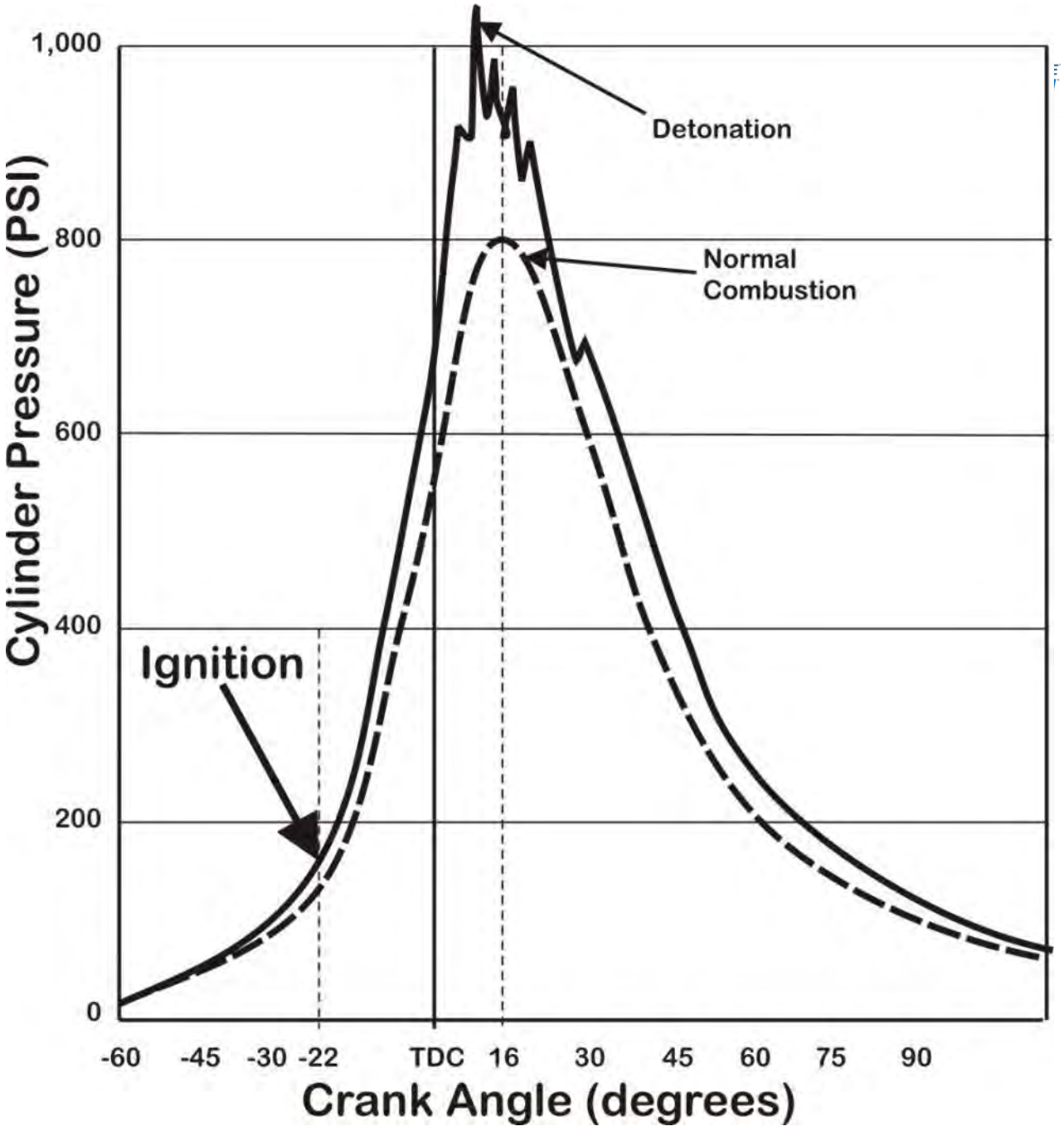
In a normal combustion event, peak pressure occurs roughly 16° after top dead center (TDC).



It's crucial that peak pressure occur well past TDC



If the combustion process peaks too early, the result is excessive pressure, temperature, & **detonation**.

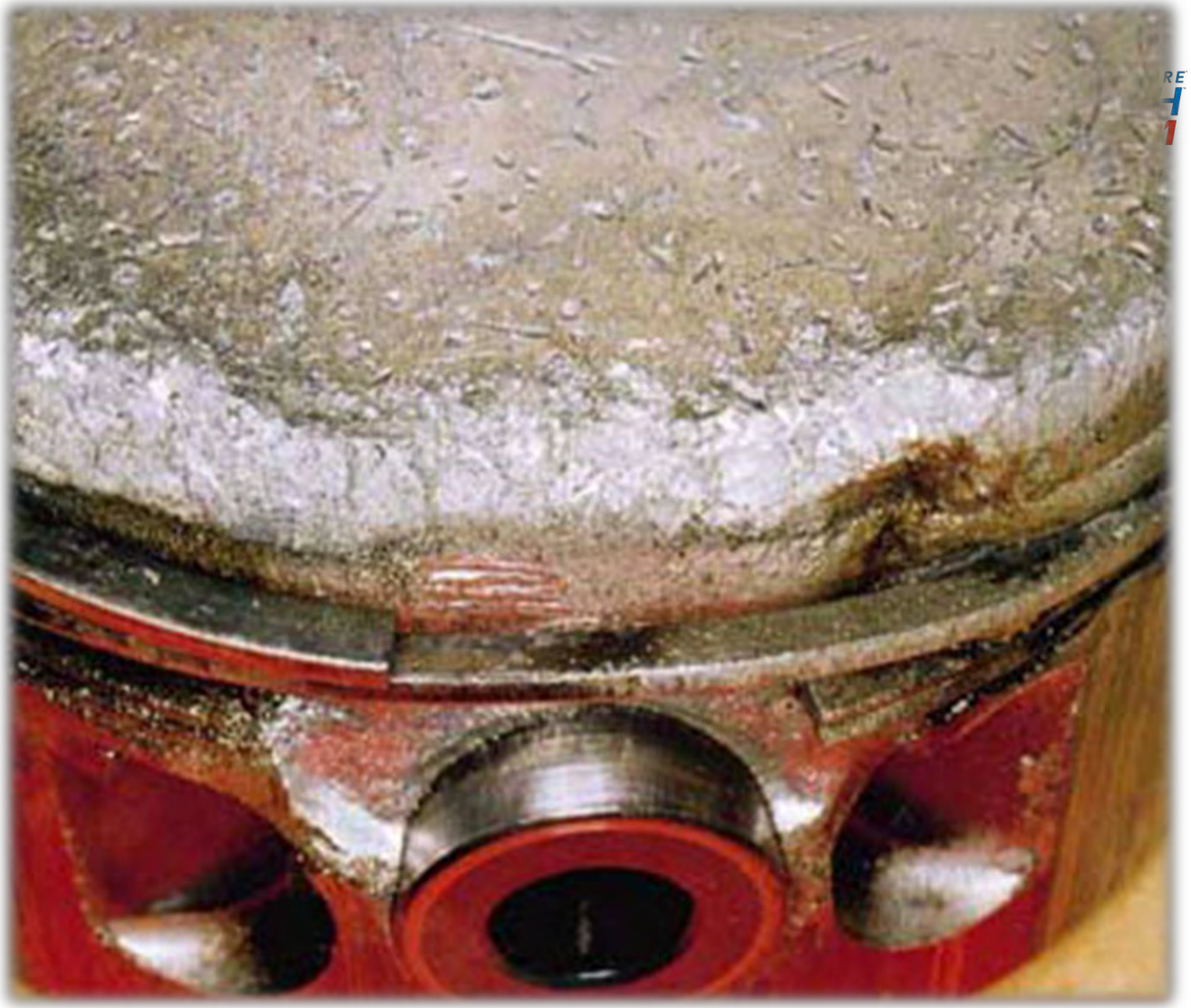


Detonation

Most engines can tolerate light to moderate detonation without damage, but **heavy detonation** can damage spark plugs, piston rings and lands, piston crowns (including melting), and can even lead to thermal runaway and devastating pre-ignition

If you keep CHT below 400°F/420°F, destructive detonation can't happen.

Heavy detonation damaged this piston and its #1 compression ring.



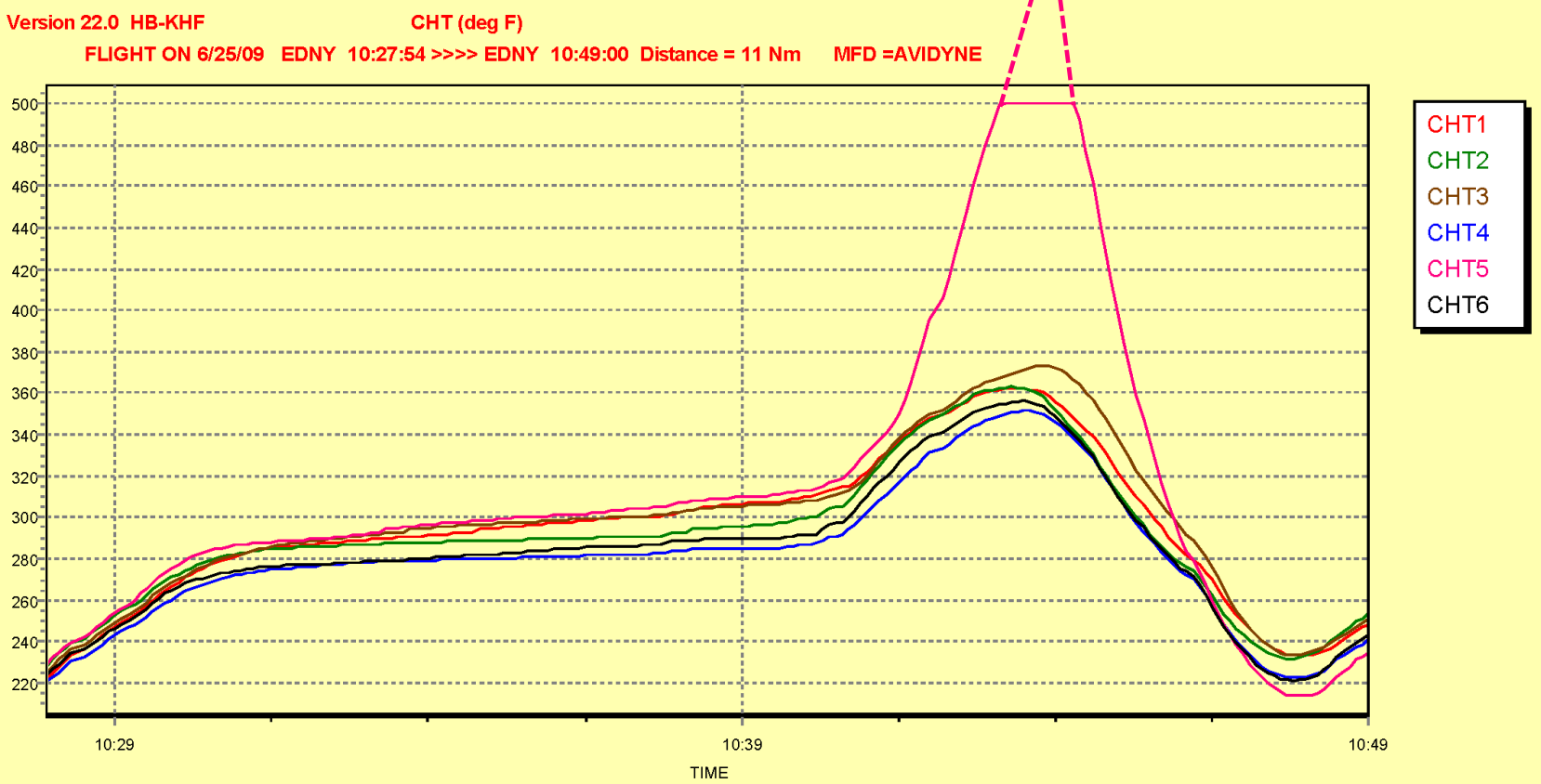
Pre-Ignition

Ignition of the air-fuel charge prior to the firing of the spark plug. Ignition source can be an overheated spark plug tip, carbon or lead deposits in the combustion chamber, or (rarely) a badly burned exhaust valve.

No engine can survive pre-ignition for long. Substantial damage is inevitable.

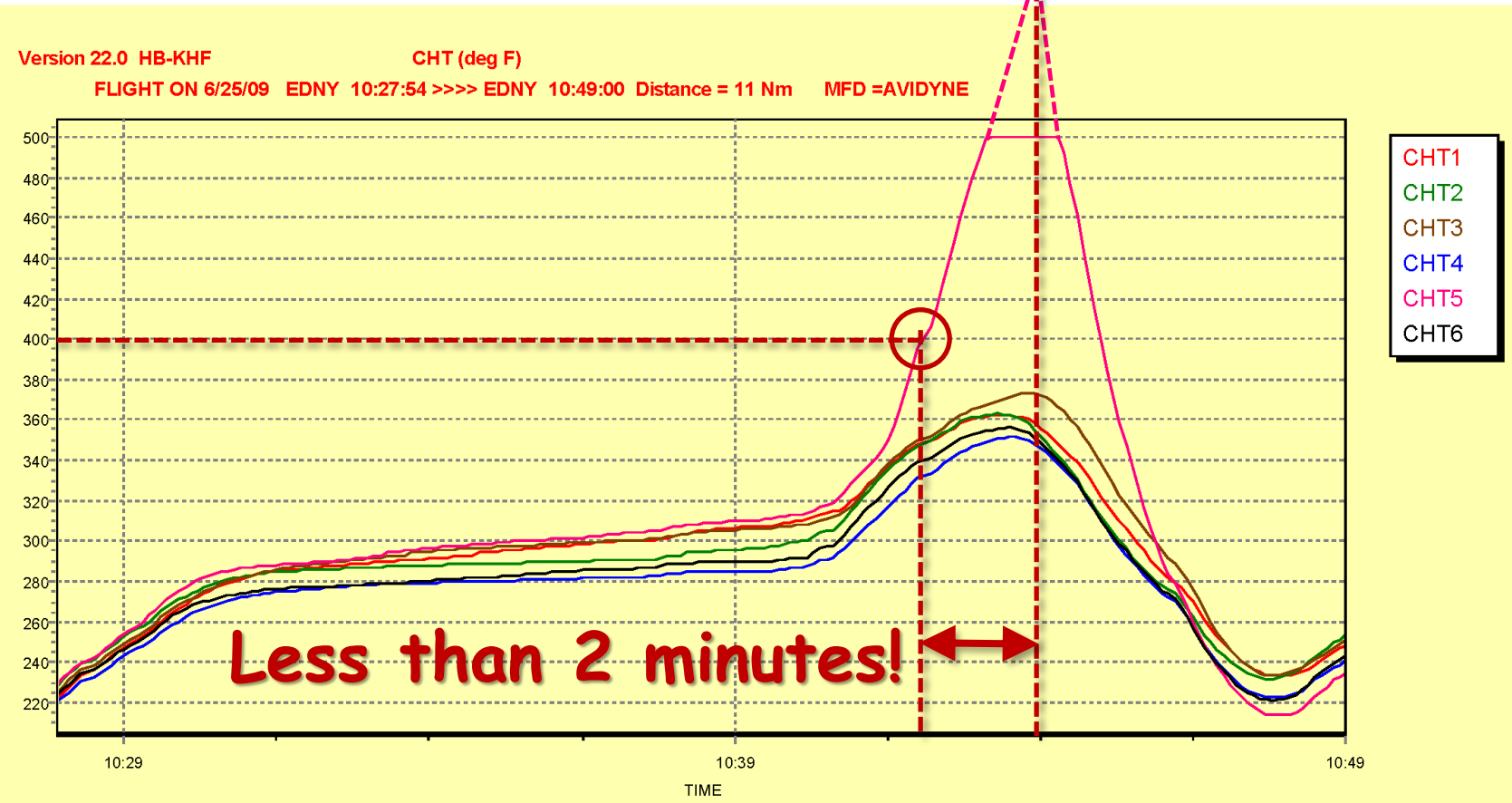
Pre-Ignition

About 600° to 650° F



Pre-Ignition

About 600° to 650° F




Join me
tomorrow
at 1:00 PM for
"How to Destroy
Your Engine in
One Minute!"

Key takeaways…

Relative EGT is meaningful, absolute EGT isn't

Limiting CHT is crucial, limiting EGT isn't

Don't lean to a target absolute EGT

Minimize GAMI spread, not EGT DIFF

Use EGT for troubleshooting, not leaning

Key takeaways…

For optimum longevity and to avoid detonation, keep CHT <400°F, preferably <380°F (20°F higher for Lycomings)

If CHT is >400°F and rising rapidly, THROTTLE BACK TO IDLE RIGHT NOW!

Then slowly add just enough power to maintain controlled flight, and land as soon as practicable.

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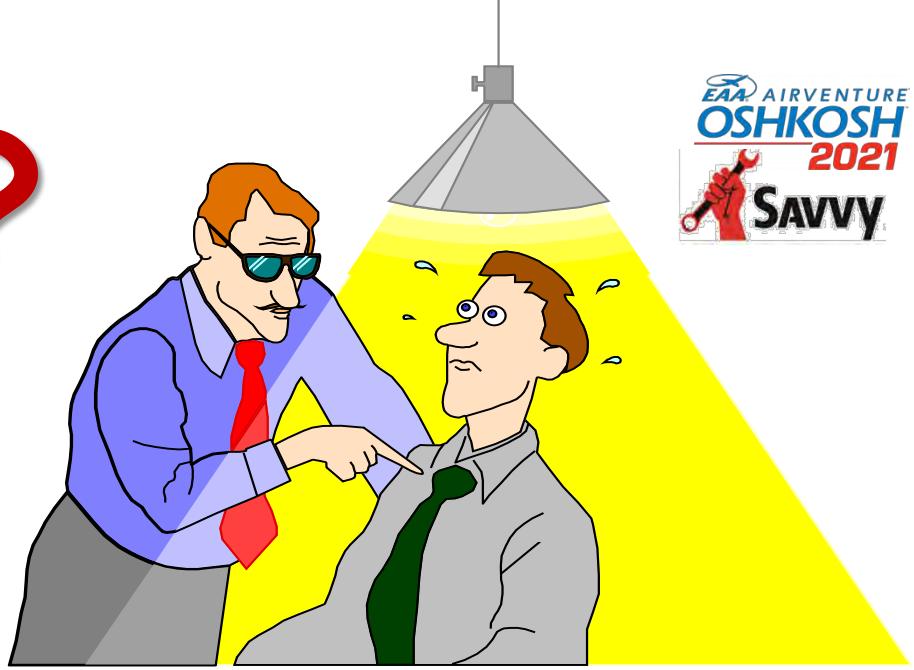

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