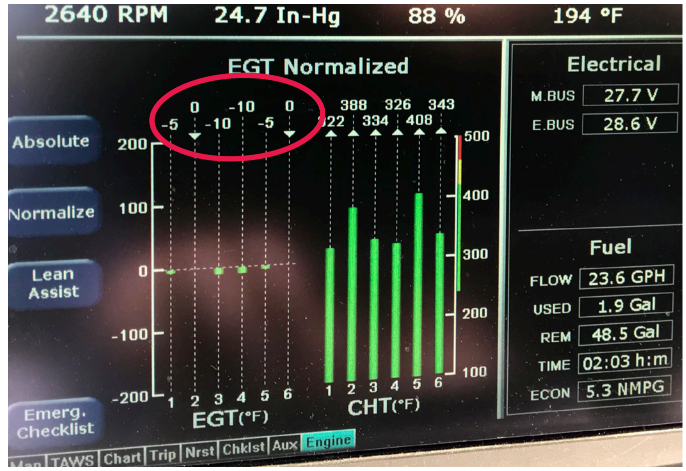
Lean for Climb

Pilots generally understand that a normally aspirated engine must be leaned during climbs. But few pilots have a system to do so. Some just pull the mixture back "a bit" as the altimeter winds up. Others don't bother until reaching cruise altitude. Running over rich in climb means a slower climb rate and wasted fuel. That's better than over leaning during climb, which could lead to overheating and even engine damage, but it's hardly ideal.

The simplest method to lean for climb is by EGT. Whether you have an engine monitor or a single EGT gauge, you can simply note the EGT you see right after rotation. With a multi-probe this should be 1250-1300°F if your sensors are in the typical positions, you had the correct fuel flow on takeoff (page 35), and you leaned for a high altitude takeoff, if appropriate (page 36). As you climb, the EGT reading(s) will fall as the air density drops and the mixture setting becomes too rich. Lean just enough to maintain the takeoff EGT with a single probe. Or with a multi-probe, lean to maintain your reference temperature on the hottest cylinder.

If you have a gauge for fuel flow, you can create your own fuel schedule using the rule of a three-percent reduction. This isn't as dynamic as using EGT, but it helps if you don't have a reliable EGT readout, or as a cross-reference that should roughly agree with leaning using the EGT method.

Start with the fuel flow value for a sea level takeoff on a chart with room for values every 2000 feet.



If your engine monitor has a normalize mode, normalize the EGTs as soon after rotation as you can safely do so. Then simply lean to maintain a zeroed EGT as you climb.

Multiply the sea level value by 0.97 for the expected full power fuel flow at 2000 feet. Multiply the sea level value by 0.94 to get 4000 feet, and so on. One advantage of this method is that you can calculate expected fuel flows for a full-power climb and a cruise climb at a reduced power setting.

If you have no gauges to watch fuel flow or EGTs, you must err conservatively when leaning during the climb. Perhaps the best way is noting the mixture position you normally see when leaning for cruise at various altitudes (page 46) and leaning during climb to a point no more than one third of the way between full rich and that cruise setting. With such

TURBOS NEED NOT APPLY

When flying a turbocharged airplane, this doesn't apply. You lean relative to the manifold pressure you set with the throttle control. That might be none at all, or it might be lean of peak similar to leaning for cruise (page 46).

For engines that automatically lean with altitude, you don't need to do anything. (See "Automatic Altitude Compensation" on page 37.) However, you must be confident that the leaning system works by ensuring you see the correct fuel flows (page 35). If your POH publishes a fuel flow schedule with altitude, then you can lean to that schedule so long as you maintain full power during the climb. It will be different if you conduct a cruise climb at less than full power.

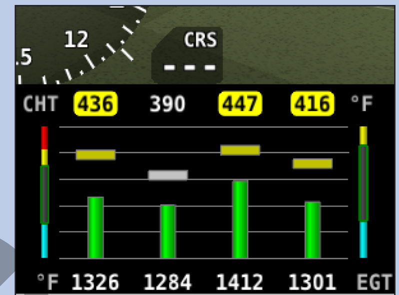
INCREASING COOLING DURING CLIMB: AIR FLOW, FUEL FLOW, AND POWER SETTING

If oil temperature or CHTs climb too high (page 60) in climb, your first tool for cooling them down is airspeed. (That's presuming you have cowl flaps open, if your plane is so equipped.)

When that's not enough, or your need for climb performance precludes increasing airspeed, your next tool is probably fuel flow by enrichening the mixture. The upside is that throwing more fuel into the cylinder will promote cooling, presuming you're not climbing LOP EGT. The downside is climb performance will suffer. You'll also use more fuel.

Sometimes the only choice is reducing power for the climb. This obviously reduces performance, but it's pretty effective in reducing the heat generated in the climb. Consider spiraling up to altitude at a higher airspeed if you're trying to clear seriously high terrain so you can fly with both reduced power and a higher airspeed for cooling.

Some installations just run hot. But if your CHTs are routinely high in climb. there could be an underlying problem. Ensure the engine baffles are in good shape (page 88) and that the high power fuel flow is correct (page 35). Advanced timing can cause high CHTs across the board and a partially clogged fuel injector can cause this for individual cylinders. This will show up as problem patterns on an engine analyzer (page 60).



an imprecise method, it's also best to wait until 3000 feet above your departure airport elevation.

No matter what method you use, watch your CHTs and oil temperature while climbing. Fuel flow is part of your engine cooling system, so you may have to run a bit extra rich as a trade off against over heating (see above). That's why there's no need to lean obsessively as you climb, so long as you're climbing on the rich side of peak EGT. As you climb, the mixture only gets richer. Make an adjustment every 1000-2000 feet and then attend to other cockpit tasks.

Reduce Power and Lean for a Cruise Climb

It's rarely a good plan to climb at maximum power and best rate of climb speed (Vy) all the way up to cruise altitude. Climbing at a higher airspeed improves engine cooling and forward visibility with only a small hit to climb rate. The exception is when outclimbing high terrain or other hazards, or when climbing at high altitude without turbocharging.

If all you change is pitching forward for a faster speed, you're still climbing at full power so your leaning system remains unchanged. However, some engines have time limits on operating at full power. Noise abatement might require an early power reduction. When you reduce power, you'll probably need to set a new baseline for the right mixture, but this is simpler than you might think if you're using the EGT method. Simply note the change in EGT as power is reduced, and either re-normalize your EGT setting or use the new value on the EGT gauge as the one to maintain. It might not change at all, especially if all you do is reduce RPM but keep the throttle wide open. Yes, it's OK to reduce RPM without touching the throttle in most cases (page 42).

Closing the throttle a bit will naturally reduce fuel flow. In some installations, it reduces fuel a lot due to an "economizer circuit" that adds extra fuel into the engine at wide-open throttle. You can see this on a fuel flow gauge as a larger drop during the first part of throttle closure compared to closure from there on. If so, watch your CHTs. The increased airflow of a faster airspeed will likely be enough to compensate, but every airplane and situation is unique.

Altitude	Max climb 75-70 KIAS	Cruise Climb 95 KIAS
Sea Level	28 GPH	26 GPH
4000 feet	25 GPH	23 GPH
8000 feet	21.5 GPH	20 GPH
12,000 feet	18 GPH	17GPH
16,000 feet	14 GPH	14 GPH

A fuel flow gauge lets you create a customized leaning schedule for both full power and cruise climb.