Turbo Charged Aircraft Check Out:

Flying a turbo charged aircraft has many advantages, but a smart pilot also knows the limitations imposed by the plane. To successfully fly a turbo charged aircraft the pilot must take care of the turbo and the engine, or you may find it very quiet some night over the mountains at night!

Below is an article from AOPA followed by a quiz for your check out. Please let me know if you have any questions.

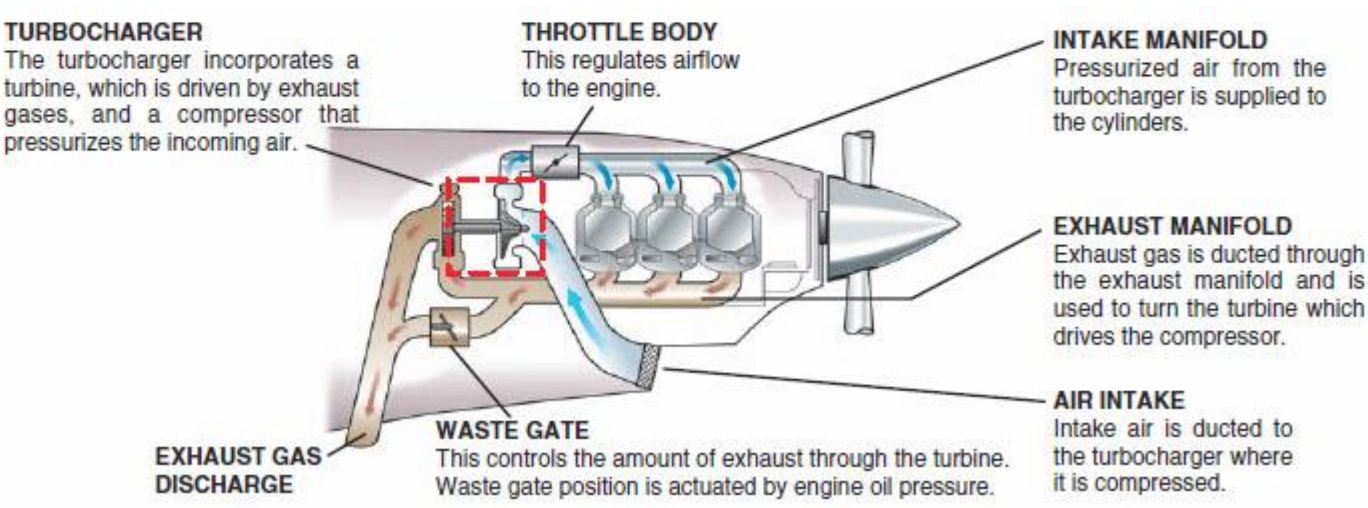
FAA Reference: Airplane Flying Handbook 11-7-9

Better engine performance at altitude

By C. Hall "Skip" Jones

A piston engine produces its maximum power when it breathes air at sea-level pressure. Because air pressure and density decrease with altitude, an engine becomes increasingly breathless as it climbs. As a result, its power output decreases. Exhaust-driven turbochargers solve this problem because they compress the thin air, restoring its density, before the engine inhales it.

Most piston aircraft designed for high-altitude cruising have a turbocharger. Some airplanes, such as the single-engine Piper Malibu/Mirage, have two turbochargers, one for each bank of three cylinders. Turbochargers also can provide pressurized air to the cabin. This is the method used to pressurize piston-engine aircraft.



Critical altitude

Turbochargers increase a piston engine's critical altitude, which is the maximum altitude at which an engine can maintain its full, rated horsepower. Because the maximum horsepower of a normally aspirated (nonturbocharged) engine is achieved in standard, sea level conditions, sea level is this engine's critical altitude. However, since most airports are above sea level, normally aspirated engines—which account for the vast majority of piston aircraft engines including those on almost all trainers—don't produce their full, rated power on takeoff. This is why aircraft performance charts give performance data for various pressure altitudes.

A turbocharger compresses the engine's intake air to maintain sea-level takeoff manifold pressure and full, rated power up to the engine's critical altitude. This altitude depends on the individual engine/turbocharger installation. But when the aircraft climbs above its critical altitude, the manifold pressure and resulting power decrease, just as a normally aspirated engine does when climbing away from sea level.

Manual pressure

The turbocharger consists of a circular housing that contains a small turbine wheel connected by a shaft to a small impeller wheel. (The turbine and impeller are miniature versions of the turbine and compressor wheels that form the basic components of a jet engine.) Engine exhaust is piped directly to the turbocharger, where it spins the turbine. The turbine drives the impeller, which compresses (pressurizes) engine intake air before it flows into the engine intake manifold. The faster the turbine spins, the more it compresses the intake air, and the higher the possible manifold pressure.

The exhaust gas spins the turbine much like a stream or creek turns a waterwheel. The turbine's rotational speed (rpm) depends on the amount of exhaust flowing through it. In the simplest systems, the pilot controls the amount of exhaust flowing through the turbine by turning a separate cockpit control knob that, in turn, adjusts a valve, commonly called a wastegate. The wastegate is located upstream of the turbine (between the engine exhaust manifold and the turbocharger) and controls the amount of exhaust gas that goes to the turbine. As the pilot closes the wastegate, more exhaust gas flows to the turbine, and the turbine spins faster.

The turbocharger's impeller generally turns at the same speed as the turbine. The faster the impeller spins, the greater the pressure of the engine intake air, and therefore the higher the engine power. Thus, a direct relationship exists between the volume of exhaust gas flowing to the turbocharger and the power output of the engine.

You don't see many turbocharged aircraft with manual wastegates today. They are usually found on normally aspirated aircraft retrofitted with a turbocharger. Such an aircraft likely will have separate throttle, propeller rpm, mixture, and turbocharger wastegate controls.

When flying an aircraft with a manual wastegate, you must understand the system and pay careful attention to the manifold pressure gauge. If you close the wastegate and thus increase intake pressure when taking off at an airport with a low elevation, you can easily exceed the allowable manifold pressure and damage the engine. Likewise, if you've been operating at high altitude with the wastegate fully closed, but forget to open it as you descend, the increasing ambient air pressure will lead to overboosting.

Automatic pressure

The potential for overboosting a turbocharged engine is greatly reduced when the wastegate operates automatically, not through a cockpit control. Normally, this system is found in a factory-installed turbocharged engine.

An automatic wastegate is controlled by engine oil pressure and an absolute pressure controller (APC). An APC is a device that senses the pressure of the air being discharged by the turbocharger compressor and uses that reading to control oil pressure to the wastegate. A spring tries to keep the wastegate open, thus dumping the intake pressure, while the APC uses oil pressure to try and close it, increasing intake pressure.

When the engine idles, the turbocharger compressor discharge pressure—known as upper-deck pressure—is low and the spring is able to hold the wastegate open. When you advance the throttle, upper-deck pressure increases, and the APC pumps more oil to the wastegate controller to overpower the spring and close the wastegate. This increases the manifold pressure to the extent you desire, based on the cockpit gauge. On takeoff, the APC limits the maximum manifold pressure automatically to prevent an overboost condition. As a backup, the system has a pressure relief valve that opens at a preset pressure to prevent overboosting the engine.

Upper-deck pressure decreases as the aircraft climbs because of decreasing ambient air pressure. The APC senses the gradual pressure drop and compensates by gradually closing the wastegate to maintain the manifold pressure that corresponds to the climb power you select. Eventually the aircraft climbs to an altitude where the wastegate is fully closed and the turbocharger cannot maintain the maximum manifold pressure. This is the engine's critical altitude. If the aircraft climbs above this altitude, the manifold pressure will decrease, just as it does in a normally aspirated engine.

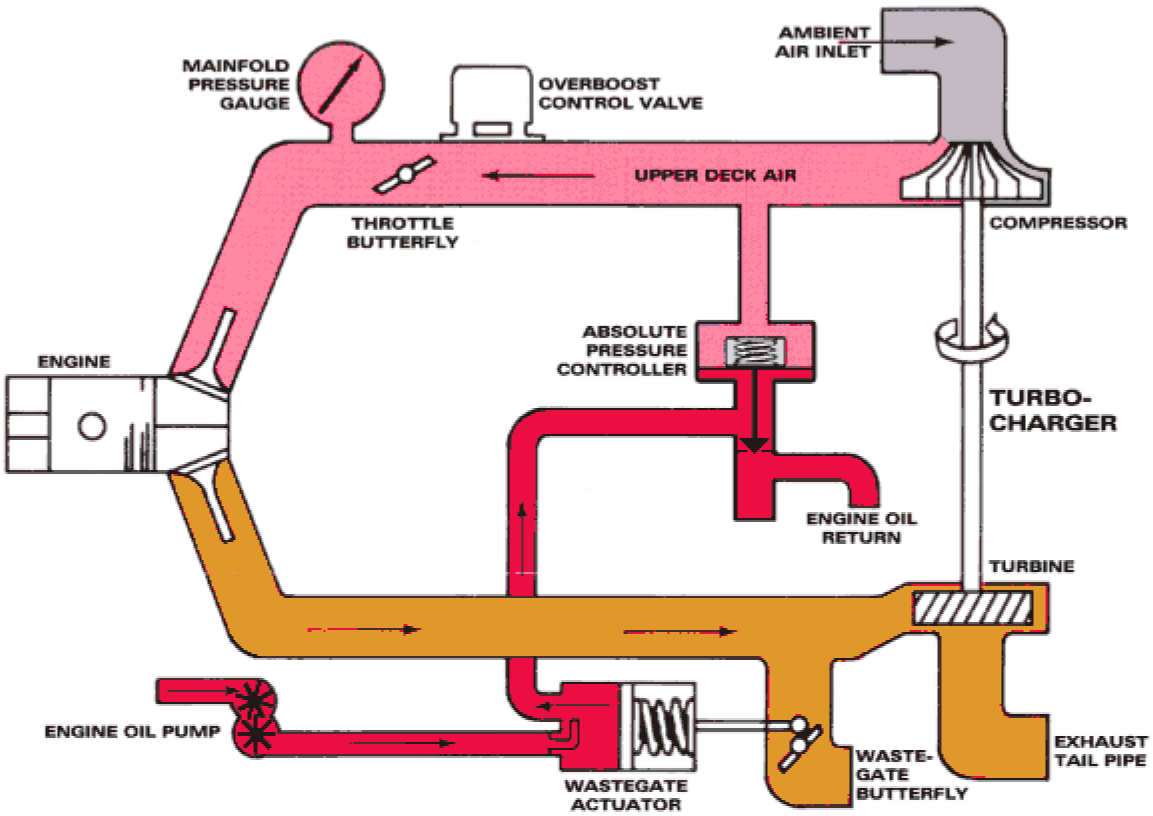
In addition to an APC, some turbocharger systems also incorporate a differential pressure controller (sometimes called a ratio controller). It senses both upper-deck and manifold pressure and limits the difference between the two pressures to a preset maximum. A differential pressure controller eliminates a condition called "bootstrapping." This can occur when the manifold pressure drifts up and down, or fluctuates, causing a corresponding drift in exhaust pressure, which causes a drift in turbocharger turbine and impeller speed, which causes a drift in manifold pressure, etc. Although it's not detrimental to the engine, bootstrapping (or fluctuating power) can be annoying to pilots and passengers.

Turbo operation

If you fly a turbocharged engine, you need to know how the system works and be aware of several important operating techniques. Because oil pressure closes the wastegate, you must allow time for the engine and oil to warm up completely before taking off. If the oil pressure is low or the oil is cold and sluggish, the wastegate may be slow to close, which means the engine won't develop its full, rated power during takeoff and climb.

Also, engine oil lubricates the turbocharger, which can spin at more than 30,000 rpm at takeoff power During normal operation, several gallons of oil flow through the turbocharger's bearings every minute. Cold oil doesn't flow properly. If you apply high power settings before the oil warms to the proper temperature, the oil may not lubricate the turbocharger sufficiently.

Power should be applied smoothly and relatively slowly. If the throttle is shoved rapidly to the firewall on takeoff, the turbocharger controlling mechanisms may not have time to function properly, causing the engine to surge and possibly
overboost.



Turbocharged engines normally demand 100 octane avgas because of the high cylinder pressures. Use of lower octane fuel could lead to detonation, which is of more concern in a turbocharged engine than in a lower-compression normally aspirated engine.

Turbocharged engines generally run hotter than normally aspirated engines because compressing the intake air also heats it. Extreme heat is very detrimental to an air-cooled aircraft engine, so turbocharged airplanes are equipped with cylinder head temperature and exhaust-gas temperature gauges. Some have a turbine inlet temperature gauge as well. It's important to monitor these temperatures carefully.

Mixture is important when you're operating a turbocharged engine. Leaning the mixture increases cylinder head and turbocharger turbine inlet temperatures significantly—and rapidly. The aircraft's pilot operating handbook (POH) recommends the proper leaning procedure and gives the maximum cylinder head and turbine inlet temperatures. Manufacturers typically do not recommend leaning when the engine is operated above 75 percent power.

You also need to think about thermal shock, or shock cooling. Turbocharged airplanes fly at high altitudes where the ambient temperature may be 100 degrees below the surface temperature. If you abruptly reduce power at altitude, the engine may cool so quickly the cylinders will warp. Warped cylinders cause low compression and high oil consumption—and necessitate overhaul or replacement. You can avoid this problem by making small power reductions spaced over time, which allows the engine to cool more gradually.

Also, you must give the turbocharger time to cool slowly after landing. Remember, the turbocharger turbine and impeller wheels spin rapidly and are lubricated by engine oil. If you shut down the engine, which cuts the supply of lubricating oil before the turbocharger can slow and cool down, the result may be premature bearing failure.

Mechanics have to be alert for leaks in the turbocharged engine's intake and exhaust systems. Because the intake system may be pressurized above the ambient barometric pressure, intake leaks downstream from the turbo can cause a loss of manifold pressure, which reduces critical altitude and keeps the engine from producing its full, rated power. Exhaust leaks upstream from the turbo can reduce the exhaust pressure that drives the turbine. This reduces the turbine's speed, which reduces the potential maximum manifold pressure.

Turbochargers are relatively simple devices, but their operating speeds and temperatures demand attention for continued, reliable operation. If you understand how the system works and the procedures that keep them healthy, you'll enjoy reliable high-altitude, high-speed cruising.

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Turbo Charger Check Out Quiz:

What's TIT?

What is the absolute pressure controller (APC), what's its relationship to the waste gate?

What type of waste gate control does the aircraft have?

What is the critical altitude of the aircraft? What is critical altitude?

Is it required to lean the mixture for a high altitude take off with a turbo?

What is the proper cool down period for the plane?   And how do you do it?

What is overboosting? How does it occur?

What are emergency procedures for a seized turbo? -

What are emergency procedures for overboosting?

What are the emergency procedures for loss of pressure “ie” low manifold pressure” and the causes?