2: Startup

If you want a stunning indictment of most pilots' poor training in the operation and care of engines, you have only to go to the local airport and spend a Saturday morning watching pilots trying to start their engines. What you'll see are pilots grinding their starter motors to molten slag; engines that roar to life at 1,500 rpm or more; engines that lope along on three cylinders while the bewildered pilot tries to figure out what to do next; engines that drip fuel straight to the tarmac; and (if you're really unlucky) engines that catch fire. It's a wonder more planes aren't destroyed on the ground, in their parking spots.

Pilots and instructors, of course, shouldn't get the full blame for this situation. Aircraft engines, with their huge displacements (a Lycoming O-320 piston measures over five inches across) and molasseslike oil, are extremely difficult to crank under the best of conditions. But now take a car battery and reduce it in size by half or two-thirds (the size of a typical light plane's battery), and put the battery two miles away from the engine compartment (under a rear seat, say, or behind the baggage compartment), and let everything sit idle for days or weeks between starts. That's a typical scenario, for an aircraft engine.

But wait. It gets worse! Now take your oversized engine, your undersized starter and battery, your molasseslike oil, and your two weeks of inactivity between starts, and factor in one additional major

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hardship: fuel that doesn't vaporize well. Aviation gasoline, it turns out, is *purposely* blended to have a narrow distillation curve, with few or no high-vapor/low-boiling-point components. (Although it's not immediately evident from Table 1, aviation gasoline vaporizes less at 80°F than winter automotive gasoline does at 40°F.)

But hold on, it gets worse. Aircraft engines mostly have *updraft* fuel-air delivery systems (which means that excess fuel from priming tends to wind up on the pavement, not in the intake ports), and—to compound matters—most aircraft engines use impulse-coupled magnetos for starting, which is tantamount to starting a PT6 with a Zippo lighter. (The only thing in aviation that even comes close to the effectiveness of an automotive ignition system, as far as starting a cold engine is concerned, is the TCM/Bendix shower-of-sparks ignition.)

TABLE 1. ASTM D 910 Requirements for Aviation Gasoline (all grades)

Property	Requirement
Distillation, ºC:	
Volume percent evaporated (VPE):	
10, max	75
40, min	75
50, max	105
90, max	135
Final boiling point	170
Sum of temps at 10 and 50 VPE, min	135
Distillation yields, % vol	
Recovery, % vol, min	97
Residue, % vol, max	1.5
Loss, % vol, max	1.5
Vapor pressure at 38ºC, kPa	
Min.	38.0
Max.	49.0
Freezing point, ºC	-58
Sulfur content, % mass (max)	0.05
Net heat of combustion, MJ/kg (min)	43.5
Corrosion, copper strip, 2 hr. @ 100ºC	No. 1
Oxidation stability, 5 hrs. aging, mg/100mL	
Potential gum, max	6
Lead precipitate, max	3
Water reaction, volume change (mL, max)	±2

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Whatever their other virtues, aircraft engines were not designed with easy starting in mind.

Still, once you understand what you're up against, and how all of the foregoing factors interact, there's no excuse for making the mistakes most pilots make in starting an engine. Where renters are concerned, simple unfamiliarity with the various systems encountered in rental aircraft of varying makes and year-models is part of the problem. But really, it comes down to lack of training.

There are only a few different configurations of fuel metering systems, primer systems, magnetos, and starters in current use. Let's take a look at the most common systems one by one.

Fuel Injection versus Carburetion

Aircraft engines come in O- and IO- versions, which means carbureted and fuel-injected versions. Carburetors for airplanes made after about 1962 are all of the Marvel Schebler (Precision Airmotive) single-barrel updraft or sidedraft variety. The Lycoming O-360-E and a handful of other engines use the HA-6 type of carburetor, which is a sidedraft model. (Its main use is on twins, where nacelle clearance precludes the use of a low-hanging updraft carb.) All other carbs are updraft.

Updraft carburetors, in turn, can either have or not have an accelerator pump. (The one model that does *not* have an accelerator pump is the MA-3A. All other Precision Airmotive carbs have an accelerator pump.) The accelerator pump is a tiny syringe-like arrangement for shooting an extra blast of fuel, syringe-like, into the carburetor nozzle when the throttle is actuated. Move the throttle in, and the accelerator pump squirts raw fuel. The real purpose of the accelerator pump is to make the engine accelerate smoothly when you open the throttle. However, many pilots use it as a priming device, particularly in warmer climes. If you learned how to fly in Southern California, for example, chances are you learned to prime the engine by stroking the throttle. You probably *didn't* use the primer. In fact, if you've flown in southern California, Mexico, or the tropics for your entire flying career, it's likely you've never each touched the primer. You might be wondering what it's really for.

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Answer: It's for ensuring that a carbureted engine can obtain sufficient fuel, while it's cranking over, to initiate combustion (in other words, get the engine to start). Notice that I didn't say it will keep the engine running, just that it helps get it started.

There's a special point to take note of here if you're flying a plane that has a Precision Airmotive MA-3A carburetor.

A carbureted engine whose carburetor lacks an accelerator pump cannot be primed by pumping the throttle.

Pumping the throttle does absolutely nothing if your carburetor lacks an accelerator pump.

In other words, if you are flying an O-235 or O-200 or other engine with a Marvel-Schebler MA-3A carburetor, use the primer when starting the engine. (Consult your owner's manual for details.) And if your plane has a feeble or inoperative accelerator pump, use the primer.

The truth is, you should use the primer, if that's what your operator's manual says to do, no matter what kind of carburetor your engine has. Why? Because the primer can get the job done better than the carb's accelerator pump, for two reasons:

1. It delivers more fuel.
2. It delivers the fuel where it's needed.

The Kohler primer is like a gigantic syringe, one that a veterinarian would use to obtain blood from a horse. It shoots a long, strong stream of fuel. You would have to pump the throttle 10 times to get as much fuel out of your accelerator pump as you would get in one full stroke of the Kohler plunger.

Just as important, the primer system is usually designed in such a way as to inject raw fuel into the induction system tubing somewhere well past the carburetor (i.e., closer to the cylinder intake ports). The accelerator pump, by contrast, is well-situated if your goal is to send raw fuel to the ground.

There's another reason why manufacturers provide a separate priming system for starting the engine (not just on carbureted engines but on some fuel-injected ones too), and that's because as a separate system with a separate cockpit control, you can command the rate or

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