



Technique: Push

Your first move when the engine fails By Julie K. Boatman

The message had been delivered via cell phone just a few minutes before: There's been a terrible accident; we think it was Leo; there were no survivors. The details were, of course, sketchy, but it was day visual meteorological conditions at Falcon Field in Atlanta that morning. Calm winds, a long runway — and an engine failure after takeoff. The airplane stalled, lost the hundred feet or so it had gained since liftoff, and became a crumpled pile of parts on the ground.

Leo was the second of Dan Gryder's friends to lose his life at that airport: the same runway, the same accident, with the same result. Gryder, a flight instructor and owner of The Aviator Network, a flight-training operation in Griffin, Georgia, immediately sought some explanation as to why a competent, experienced pilot would be unable to cope successfully with such an emergency — especially when there were plenty of options ahead of him for a safe off-airport landing.

The preliminary accident report reads similarly to that of so many: After hearing a "change in engine noise," witnesses described the airplane leveling off, beginning a descent, then making a shallow turn, followed by a steep bank, loss of altitude, and "spiral" out of view.

Your classic stall-spin accident, right? The one you inoculate yourself against by practicing departure stalls, and taking heed when your instructor admonishes you not to turn back to the runway in this situation but to land straight ahead, right?

Well, it's not quite that simple. What if turning back had nothing to do with it? Have you ever practiced a power-on stall with an engine failure? Me either. Has anyone ever told you how much you have to push first to make that off-airport landing happen safely?

The guidance

Advisory Circular 61-21A was for decades the FAA-produced bible for flight training — you know it as the *Flight Training Handbook*. This tome was superseded in 1999 by the *Airplane Flying Handbook* (now in a second edition, published in 2004 as FAA-H-8083-3A). Although a wide variety of aviation authors have expanded on their framework for primary pilot texts, these books have been the references. Only in the latest revision (made in May 2004) is any mention made in the *Airplane Flying Handbook* of what to do if the engine fails after takeoff. In Chapter 5, "Takeoff and Departure Climbs," there are just two paragraphs on the scenario, with an emphasis on the urgency of the situation.

The FAA adds to its reference library with advisory circulars, and one in particular, AC 61-67, "Stall and Spin Awareness Training," should address more fully the "engine failure after takeoff" scenario. And it does — by admonishing pilots not to turn back to the runway.

Although this is a problem, it's not the first problem encountered by a pilot when the engine quits after takeoff. The first order of business is maintaining control of the airplane — and it may be all the pilot has time for. And capturing best-glide airspeed when you're already climbing out at a comparable speed — and a high deck angle — is very different from capturing it from cruise flight.

The most critical thing is to prevent a stall from occurring on the heels of the engine failure — and to maintain the energy to control your descent and landing flare. If you're like most pilots, this wasn't part of your primary training.

What's happening here?

When you first learned to fly, your instructor followed a syllabus, whether it was bound and full color or whether it existed only on Post-it notes. That syllabus was designed to help you acquire the skills and knowledge needed to become a safe pilot, and to accomplish the requirements for the private pilot certificate laid out in the practical test standards (PTS).

You made your way through stalls, including power-off (or approach-to-landing) stalls and power-on (or departure) stalls. Instructor's techniques vary, but most stall recovery procedures involve relaxing the back-pressure, which lets the nose come down to about the horizon, to regain airspeed. Your right hand is probably on the throttle (in most light aircraft) to ensure you have all the power in. The goal is to lose as little altitude as possible without inducing a secondary stall.

Setting up for a power-off stall is much the same. To recover, you reduce the angle of attack, bring in full power (and shut off the carb heat if necessary), clean up the airplane, and pitch to the horizon. Again, you're trying to minimize your altitude loss, because the stall itself is the primary problem.

A bigger problem

Now think about a different situation. You take off, climbing out at V_x to maximize your altitude (and perhaps get a little higher over the houses that surround your airport). At about 200 feet agl, you're just crossing the airport boundary fence. And your engine quits.

You now enter new territory: You have the deck angle of the power-on stall, yet the power's off — and you're not getting it back. You have a healthy amount of rudder pressure in to counteract torque — so you're uncoordinated unless you neutralize the rudder. You haven't stalled yet, but you will if you keep the nose up. If you just pitch down to the horizon — which worked for you on all those practice recoveries before, and where you'll certainly want that nose to stay because the ground is coming up at you — you won't recover all the energy that you lost when the prop stopped moving. And you'll still stall. And if you continue holding rudder pressure, you may fall off into an incipient spin, even if you keep the airplane pointed straight ahead.

Better practices

Rich Stowell, the FAA's 2006 national Certificated Flight Instructor of the Year (see "[Pilots: Rich Stowell](#)," October *Pilot*), includes all varieties of stalls in his *Emergency Maneuver Training* syllabus. And under the topic "critical flight conditions," he adds another kind of stall practice to the mix: stalls from a V_Y climb and power loss.

After talking with Gryder and Stowell, I went out to test these maneuvers.

I measured the difference between the time it took for the airplane to stall from level cruise flight (slowed to V_Y) when the power was reduced to idle and the pitch attitude held in place, and the time it took to stall from a V_Y climb when the power was reduced to idle and the pitch attitude similarly fixed.

In a Cessna 172S, the time it took to reach imminent stall in the first scenario was 12 seconds. The time it took to stall in the second scenario? Five seconds. It's even less if you're climbing at V_X . If you wait to pitch down, if you allow precious seconds to pass as the gravity of the situation sinks in, you'll be edging into stall territory.

V_Y in most light singles can be pretty close to best-glide airspeed; V_X is often several knots below best glide, as it is in the 172S, and only marginally above the corresponding wings-level stall speed. At most, V_Y is about 20 knots more than best glide — but the moment the engine stops, that airspeed starts going away. And in your shock, you give up airspeed to maintain your "climb." With that deck angle (in some high-performance singles it can be up to 10 degrees pitch up on the attitude indicator), and the airplane trimmed for the climb, the airspeed ticks away quickly.

The longer you keep the nose in the climb attitude, the more you will need to pitch down deeply below the horizon to regain airspeed and arrest the sink rate — up to 10 degrees below the horizon, depending on the airplane, its configuration, the sink rate, and the density altitude. Pitching down this much can require a significant amount of stick or yoke travel — for example, in Gryder's tailwheel Cessna 150, it takes about 3 inches of travel, overcoming aerodynamic and trim forces in the process. It takes a push.

Your flight path has already headed down — you can start to feel it in the seat of your pants — and your wing is still at a climb angle, making your angle of attack significantly higher than it was when the engine was running.

And no matter what is rising up to greet you — trees, buildings, a herd of cattle — if you don't make that push, the airspeed will quickly bleed off into stall territory. Regardless of what you see ahead, you have to reduce the angle of attack.

In my flight testing, the pilot in the right seat also noted that by the time I'd recaptured best-glide airspeed, we had lost at least 200 feet. Getting that energy back so you can flare may be the only thing you have time to do.

Catherine Cavagnaro, who gives spin and aerobatic training at Ace Aerobatic School in Sewanee, Tennessee (see "[Spin Masters](#)," August *Pilot*), also points out that if you have the airplane configured with takeoff flaps, the pitch down can be even more dramatic — and those flaps can exacerbate a spin condition if you stall, depending on the airplane.

Adding the load

Keep in mind, too, a couple of things. You need to bring the nose down significantly below the horizon to regain your airspeed straight ahead. As Stowell points out, "The airspeed indicator may lag by several seconds, so it is crucial to memorize the sight picture of gliding flight in your airplane. Airspeed by itself is imprecise as an indicator of stall, so lowering the nose instantly increases your stall margin."

Keeping the wings level also increases your margin from the stall, especially when you consider that turning flight always means higher stall speeds: The very act of the turn, even the shallowest bank, will increase the load factor and the stall speed. If you can feel the load factor increasing — and you feel this by sensing how your relative weight in the seat increases — you're entering dangerous territory. You have to trade back some of the energy by dropping the nose farther, reducing the angle of attack, and getting your margin back. You've gotta push first, or there's no doubt you'll become part of the accident data.

Looking at the data

As it turns out, there's no single category that "engine failure after takeoff" accidents fall into. Instead, they lie buried in at least three separate categories within the GA accident data. Because these accidents happen with the takeoff, some are classified as — yep — "takeoff" accidents. Because some are the result of mechanical failures (as opposed to fuel starvation or exhaustion, for example), some are classified under this category. Accidents may also go into the "maneuvering flight" bucket, if the pilot is believed to have attempted a turn back to the airport — once you start to turn, you're maneuvering, the way the NTSB sees it.

According to a search of the AOPA Air Safety Foundation's Accident Database covering the past five years, accidents fitting the profile occurred more than five times a year in airplanes weighing less than 12,500 pounds. In addition, at least three accidents occurred involving instructional flights in which the instructor was demonstrating or observing a student managing a power loss after takeoff at low altitude, with an attempted return to the airport. All of these instructional accidents were fatal. However, there's another side to the story, by definition one that the accident data don't include. Because the typical accident profile involves a power failure and happens in close proximity to an airport (and potentially open areas around it), there is an opportunity for a pilot to successfully manage the power loss and land the airplane without damage. These "success stories" would not necessarily fall within the criteria for reporting as an accident or incident, and thus be off the radar.

Even though the maneuver isn't in any PTS, some astute primary instructors have trained their students to cope with this specific combination of power loss and impending stall — without teaching them to turn back to the runway (that's another set of accident data — those instructional flights gone wrong) or making the demonstration at low altitude.

The combination of how the accident data are sorted and the invisible nature of certain success stories leads us to wonder how prevalent the situation (an engine loss after takeoff) and the solution (appropriate management of angle of attack [airspeed] and aircraft control) really are.

As we went to press, I learned of a similar accident involving a student pilot: just after takeoff, an engine failure, on a solo flight. The pilot survived this time, but the airplane was destroyed.

[Access the AOPA Air Safety Foundation's Accident Database online.](#) Links to additional information about departure emergencies may be found [on AOPA Online](#).

E-mail the author at julie.boatman@aopa.org.

Departure Emergency Stalls

At a safe altitude (we suggest at least 3,000 feet agl) and perhaps with an instructor, practice the following maneuvers. Follow guidelines in your airplane's pilot's operating handbook to ensure no limits are exceeded. Also, avoid abrupt power reductions in high-performance aircraft. Keep in mind that when you transition from a climb, you may still be holding in rudder correction to counteract the torque, creating an uncoordinated situation that could lead to an incipient spin if the stall recovery isn't prompt. In each maneuver, pay close attention to the pitch-down force required to maintain — or in the case of a real power loss, regain — airspeed.

Power-off stall, clean configuration. This will establish a baseline from which to determine how the pitch attitude, deck angle, timing, and stall profile change in the next two maneuvers.

Climb profile to best-glide attitude. Establish a climb at V_X , pull the power, and pitch to recover best-glide airspeed promptly. Note your altitude loss; you can work to minimize this while acquiring best glide in a timely fashion.

Climb profile to a power-off stall, clean configuration. Start with one from a climb at V_Y , then do another one from a climb at V_X . Measure the amount of time between the power reduction and the incipient stall. Remember to neutralize the rudder.

Climb profile to a power-off stall, takeoff configuration. Use the normal takeoff flap setting, and try one with the gear up, and one with the gear down. — JKB

Technique: Push — Again

More thoughts on engine failures after takeoff By Julie K. Boatman

The response made me feel much better: You get it, or at least you got it after reading about it in these pages.

What's this to "get"? The response — the *push* — you need to condition yourself to make if you experience an engine failure immediately after takeoff in a light airplane.

But you came back to me with so many other ideas and techniques for improving the outcome of this situation by practicing certain maneuvers, understanding the correct procedures and what happens during the emergency, and inoculating yourself against the wrong reaction — the reaction that could get you and your passengers killed.

So I'd like to share all these ideas with everyone. Because the better our collective situational awareness on this topic, the safer we'll fly.

A quick review

For those just joining us in the discussion, here's the scenario and some key concepts. In the November 2006 *Pilot* article, "[Technique: Push](#)," we discussed the proper actions you should take if you encounter a powerplant failure or power loss immediately after takeoff.

During your climbout, you have relatively low airspeed. So you must preserve that airspeed after a power loss by reducing the wings' angle of attack. Failing to do so — or even hesitating with the control wheel frozen in your hands — can and will eventually lead to a stall and loss of control. Regardless of the altitude you have to work with, loss of control is the biggest danger you face — if you must land off airport, doing so under control greatly increases your chances of survival.

What you may not realize is how deeply you need to pitch the nose down in order to maintain airspeed and arrest the sink rate. Depending on the airplane you fly, this can be up to 10 degrees below the horizon — and perhaps you were maintaining 5 to 10 degrees nose up to achieve V_X or V_Y during the climbout.

You'll also need to adjust the rudder pressure you had been holding to offset turning tendencies in the airplane produced by the high-power and high-angle-of-attack condition in the climb. If you don't adjust rudder pressure after you lose power, the airplane enters uncoordinated flight, which can lead to a stall and then spin if left uncorrected.

Tales from the field

Brian Spear, AOPA 5086108, from Florida, wrote to us following the article — like so many members did — to share his experiences. "Having successfully encountered a recent engine failure, I want to emphasize a point made in your article about sight picture. Prior to the engine failure, I had recently transitioned to a Helio Super Courier. During my initial training I learned to rely solely on sight picture and not the airspeed indicator for takeoff and landings. When the engine violently shuddered at 400 feet and quit, it was a natural reaction for me to push forward and regain the two-thirds-ground, one-third-sky sight picture recommended for a normal landing. I also had the benefit of having about 4,000 feet remaining of the 6,000-foot runway. Now that I'm flying other aircraft I make sure to know the proper sight picture for best glide and landing."

Spear's point on sight picture is well taken. In order to respond appropriately and immediately to the engine failure, you need to have a good idea of the outside picture that you're aiming for; you don't have time to waste with your eyes in the cockpit staring at the airspeed indicator (we'll assume you're in visual conditions; training for this scenario in instrument conditions is a topic for another article).

Neil Ulman, AOPA 3888431, of Vermont, also received excellent primary training, and shares this exercise with readers: "If I ever get in that dire, engine-failure-on-take-off situation...if I remember to 'push,' it will also be because of some creative and caring instruction. My instructor [who is also Ulman's son] and I flew a Cessna 172 from Palo Alto [California] out to the old Castle Air Force Base at Merced, California, and used the 11,000-foot, former B-52 runway for custom-tailored exercises, including power failure on takeoff. We started our takeoff roll from the approach end. After we had reached a couple of hundred feet, my instructor pulled the power off and had me land the airplane — straight ahead. I got the feel of how hard I had to push to maintain a safe airspeed and put the plane back down on the runway with the proper flare."

Unloading

A number of our readers have military aviation backgrounds, and shared a concept that is familiar to military aviators but should be well understood by every pilot who flies: unloading.

One member, Michael Friese, AOPA 1107144, explained the concept well: "The military uses a maneuver called 'unloading' to help their aircraft accelerate during combat maneuvering. By pushing the aircraft over to zero G, the induced drag goes to zero, and improves aircraft acceleration, or decreases aircraft deceleration. (If the wing has any geometric twist the drag will

not go exactly to zero, but it will be close enough.) An effect from this maneuver is that at zero G, your stall speed [effectively] goes to zero.

"While instructing I would teach my students that an engine failure from a nose-high climb attitude requires unloading the wing to zero G for the following reasons: First, getting rid of that induced drag, which is a large part of the total drag in climbing flight, will decrease your airspeed loss while pitching down. Second, in zero G, your stall speed is zero. Third, the pitch rate required to unload to zero G usually gets the nose down fairly quickly to minimize airspeed loss."

Terry Slawinski, AOPA 821267, a former U.S. Air Force fighter weapons school instructor and F-16 pilot, added to Friese's discussion. "We taught our guys to unload by pushing or pulling, if inverted, until they were light in the seat. It wasn't exactly zero G, but it was close enough, perhaps 0.1 to 0.3 G. We taught this because it was close enough to zero G to gain all the drag-due-to-lift advantages of real zero G. More important, it allowed pilots to decrease the pitch rate so that they could keep control of the nose relative to the horizon and stay light in the seat longer (accelerating) before they needed to load up again to keep from burying the nose.

"It was amazing how fast a jet accelerated when you unloaded it versus staying at 1 G or more. It was also amazing how it could tumble or fall without stalling, departing [controlled flight], or spinning, if you kept it light in the seat. 'Unload for control' is a life-saving maneuver," Slawinski concludes.

Lucius Day, AOPA 864473, a former U.S. Navy pilot, describes specific maneuvers that he practiced in his military flying days (and that he continues to teach as a civilian instructor) that expand on those we suggested in the original article. "My first training plane was an SNJ. Later I taught in T-34Bs. We had two syllabus maneuvers that directly address the situation you discuss in your article.

"The first is what we called the power-off stall — except it was nothing like the FAA's power-off stall. The Navy's power-off stall was a power-off stall with a power-off recovery. The procedure was to complete the last 90 degrees of a clearing turn in a trimmed-up, stabilized, power-off glide. After verifying the stabilized glide, the nose was raised to the three-point landing attitude and held there (with increasing back-stick), noting the aerodynamic indications of the approaching stall, until just before the airplane was about to enter a spin. Then brisk, positive forward stick was used to lower the nose to somewhat below the normal glide attitude (and held there) until speed approached the normal glide speed. Then the attitude was adjusted to maintain the normal glide.

"The second maneuver was what we called a low altitude emergency (LAE). Basically it was a simulated engine-out initiated by the instructor cutting the power at an altitude below 1,000 feet, usually between 300 and 400 feet agl, when the student was in a climb. A student learned very quickly to respond with a positive and aggressive pitch correction."

Day concludes: "I am extremely critical of the FAA treating power as integral to the recovery from every syllabus stall. I'm convinced a student should realize that stall recovery depends entirely upon reducing angle of attack and that power is used, primarily, to conserve or regain altitude."

Lessons from other aircraft

A number of pilots wrote in to report on how experiences in other categories of aircraft had improved their airplane flying — and reinforced the need to preserve airspeed and controllability in the event of a powerplant failure (or, in the case of gliders, the total lack of one).

Myron Badstibner, of Pennsylvania, writes, "I am a very low-time (15 hours) student pilot, training in a 172. But I am a relatively high-time ultralight (Quicksilver MX) flier and aviation enthusiast. The ultralight that I am flying has a high drag level, and I can attest from first-hand experience that even it requires a lot of push in this type of event. I realize that many GA pilots downplay ultralights, but they really are flying at its most basic, and most fun, if done in a safe manner. A couple of hours with an ultralight instructor in a two-place ultralight trainer [or what is now a light sport aircraft] would go a long way in demonstrating the recovery from this type of condition."

Steve Hurst, AOPA 5177094, of Georgia, elaborates: "The push factor gets larger and the time window smaller when the aircraft has more drag. I experimented with simulated engine failures while climbing in ultralights. The light aircraft slows very quickly, and elevator response is slow because of the lack of prop wash over the elevators.

"If the engine quit, the stick had to go full forward now and the rudder neutralized to avoid a stall. There was no time available to recognize an engine failure. [Coupling] this with the lower dependability of [certain] ultralight engines and the lack of protection for the pilot made me change my normal takeoff to a much shallower climb. This [climb] does not look as spectacular both in and out of the cockpit, but I think it is much safer."

Roger Worden, of California, helped me recall the relationship between my own glider training and airplane flying by relating his experience flying gliders. "I was surprised by your statement, 'If you're like most pilots, this wasn't part of your primary training.' Nosing over in order to recapture flying speed is something we learn about — and practice — in glider training. We don't have engine failures, but we can have rope breaks when aero towing or winch launching. We are taught to push forward until the airspeed is stabilized at a safe speed before even thinking about whether to land ahead or to turn back. We declare a safe turnaround altitude before takeoff, and call out that altitude when we pass through it, so the decision is pretty much automatic. (That altitude is typically 200 to 300 feet agl, depending on wind and terrain.) Many pilots never experience an actual rope break, but I had one recently at exactly 300 feet, and this training made it a nonevent."

From the Kings

Renowned flight instructors John and Martha King (see "[Flying Together: King Air](#)," September 2006 *Pilot*) had a very positive reaction to the article, and when we had the opportunity to discuss it further, John King compared his experience instructing in airplanes with that of flying aircraft in other categories (the Kings hold flight instructor certificates in, at last count, every possible category of aircraft). "In the helicopter, you take off with the minimum power to let you get going," and with the minimum pitch up on the collective blades. "Rotor rpm decays precipitously; you can't get the collective down quick enough." Drawing from his experience in weight-shift-control aircraft, King posits that pilots ask themselves, "What am I doing with this wing?" He suggests the book *Fly the Wing* for further education on the concept. But in broad strokes, to preserve airspeed and energy, you must pitch the wing to the proper attitude. In an airplane, you're pitching the whole airplane.

For pilots who fly aircraft equipped with the Garmin G1000 primary flight display (or similar PFDs such as Avidyne's FlightMax Entegra EXP5000), King gives this tip: "Look at the aircraft's attitude indicator and recognize what the pitch attitude is for V_Y (numerically). We know it's 16 degrees in the [Dassault] Falcon, 11 degrees in the [Cessna] Citation we had, but didn't know what it was in the 172 because it's hard to see [on a standard attitude indicator] — until you have a large-format display" such as that on the G1000's or Entegra's PFD. "Now we know it's 9 or 10 degrees in the 172, and complete power-off glide is 1 degree down or on the horizon depending on the conditions."

With the PFDs, you can get virtually an exact pitch attitude — and use it to aid you in recognizing the exact sight picture outside. Of course, you will need to push the nose further below the horizon line initially to capture or retain the appropriate glide speed if you're already pitched up, as you would be in an initial climb.

Improving our collective SA

Quite possibly the greatest benefit from reading the article, as noted by many readers, was the increased situational awareness they now possessed from having thought through the various scenarios possible if an engine failed immediately after takeoff for them, in their airplane, at their airport. And many reported that they would practice these scenarios to refine their skills.

But here's an important point to keep in mind if you plan to practice, again from John King. "Sometimes training can give a student a false impression. For instance, if an instructor were to demonstrate the need to lower the nose after engine failure after takeoff, the demonstration would most likely be conducted in a lightly loaded airplane with a forward CG. In this demonstration the nose would lower on its own and the student might be left with the assumption that he had just witnessed a non-event. If in real life an engine failure were to occur at best-angle-of-climb speed in a heavily loaded aircraft at the aft CG limit, the pilot would be faced with an entirely different situation. Based on the demonstration received in training, the pilot might not understand the urgency to lower the nose."

Flying at a different weight means you are flying a different airplane (see "[Proficient Pilot: CG at the Aft Limit](#)," January *Pilot*).

"We need to have students who understand pitch plus power equals performance," says King. "To this end, another skill-enhancing task is to fly around the pattern with the instruments covered up [so the student cannot see them]. You'll learn quickly how vulnerable you are when you're pitched way up, as you are on climbout.

"If we're more 'pitch aware' we can make these associations," concludes King. So make it a point to improve your own pitch awareness with practice, planning, and rehearsing your every move in the event of a power loss on takeoff.