

Stalls and Spins

Stall/Spin Awareness

By Rich Stowell (From Flight Training, December 1993.)

Contrary to popular belief, spins are not caused by stalls. If they were, every stall we ever attempted would wind up spinning earthward. The real culprit is excess yawing at the onset of stalled flight. Part n of this series identified good rudder skills as an essential ingredient for stall awareness. Proper control coordination improves stall characteristics as well. During a spin, full rudder inputs become our main course of action for recovery, with elevator inputs being relegated to a supporting role.

Coping with an unplanned autorotation (spin) demands adhering to a set of rules specific to spins. Reacting haphazardly with inputs learned during straight-and-level flight can adversely effect spin recovery. Entering a spin is like walking into a mine field: You better be able to retrace your steps exactly to get out of it alive!

Let's illustrate the importance of spin awareness by looking at the autorotation process from start to finish.

Incipient

This is the first rung on the spin ladder and is a transient phase that's a cross between an aggravated stall and a true autorotation. To set the spin in motion, picture a coordinated stall in which there is no net yawing or rolling. If we "uncoordinate" the stall by applying left rudder, the airplane will Respond by yawing left. This left yawing increases the airflow over the right wing. Increasing the airflow creates more lift, thus inducing a roll to the left.

This yaw-induced left roll alters the wings' angles of attack, increasing it on the left while decreasing it on the right. Coefficients of lift and drag now differ on each side of the airplane: Greater drag on the left wing generates more left yaw. Greater lift on the right wing generates more left roll. These differences, spawned by uncoordinated stalled flight, begin to drive the nose earthward in a left spin. While rotation occurs simultaneously around all three flight axes, it's the coupled yawing and rolling motion that give the spin its classic look.

The rate of rotation tends to increase as we advance through the incipient phase. Transitioning from this phase into a developed spin can happen in as few as two turns. Incipient spins are typically pilot-driven, especially in the very early stages. In other words, the forces of autorotation alone cannot sustain the spin. Pro-spin inputs must be held to continue the process. Merely relaxing your grip on the controls at the onset of rotation may stop the incipient spin in its tracks in many light airplanes.

It's important to note that all single-engine normal category airplanes, and those utility category airplanes placarded against intentional spins, have demonstrated recovery from one-turn incipient spins only. This requirement is merely a check of the airplane's controllability in an aggravated stall. There is no assurance that the airplane will be recoverable if rotation continues beyond the first turn. You have a one-turn margin of safety in which to stop the process.

Developed

Fully developed spins occur when aerodynamic and inertia forces and moments acting on the airplane have balanced. Indicated airspeed stabilizes around 8–10 mph above the +1 G stall speed. The rate of descent can range from 7,500 feet per minute (fpm) during nose-tow spins to 5,000 fpm during flat spins. (Spins are generally considered "flat" when the nose attitude is within 45 degrees of the horizon.)

Unlike incipient spins, developed spins tend to be driven aerodynamically. Sufficient differences in lift and drag on each wing exist to self-propel the autorotation. Should we release the controls now, they will tend to float in the direction of rotation.

Airplanes placarded against intentional spins, as well as any airplane loaded outside of its approved weight-and-balance limits, may become locked into the spin if it fully develops. The airplane will not respond to recovery inputs in that case, and will remain in the spin until the ground intervenes.

Unfortunately, specific cues may not be present to warn us that a spin from which we cannot recover is imminent. This is why acute stall/spin awareness, good rudder coordination, and the ability to

recognize and recover from the start of an incipient spin should be given due consideration during training.

Recovery

Spinning ceases if and when forces and moments opposing autorotation overcome pro-spin aerodynamics. Since yaw coupled with roll powers the spin, we must forcibly uncouple them to effect recovery. Full opposite rudder is the primary means through which this is accomplished.

During the recovery phase, the nose attitude steepens. The rate of rotation ultimately decreases, too. Recovery can occur in as little as a quarter of a turn, or can take several additional turns depending on the airplane and the dynamics of the spin.

Inherent design differences between airplanes influence the effectiveness of spin recovery actions. Flight within the acrobatic category, for example, demands greater control effectiveness than operation in the normal or utility categories. Acrobatic category designs also must comply with more stringent spin test requirements. (See "A New Pilot's Guide to Aircraft Categories," August 1993.) As a result, acrobatic airplanes tend to display good-to-excellent recovery characteristics by design.

Since recovery capability from developed spins is not a design criterion for normal category aircraft, it's reasonable to assume that such airplanes might display poor recovery characteristics by design. This assumption was validated repeatedly during the NASA spin test program (1977–87), where unrecoverable spins often were encountered beyond the one-turn margin of safety.

Recovery inputs must be applied in the proper sequence whenever an inadvertent spin is entered. Knowing what to move, where to move it, and when to move it are the keys to successful spin recovery. Since an inappropriate input could negate other recovery actions, let's briefly describe how our control inputs influence spin characteristics.

Power — The application of power usually drives the airplane deeper into the spin and can delay recovery. Gyroscopic effects associated with a rapidly rotating propeller can lead to increased

rates of rotation and shallower spin attitudes –flat spins. In fact, flat spins, which are resistant to recovery procedures depending on the airplane, can be excited simply by applying full power. Therefore, the throttle should be retarded to idle as soon as possible to avoid aggravating the spin.

Ailerons — Deflecting the ailerons in the direction of rotation tends to steepen the spin attitude, reduce the yaw rate, and increase the magnitude of any roll or pitch oscillations. Deflecting the ailerons in the opposite direction tends to flatten the spin attitude, increase the yaw rate, and dampen any roll or pitch oscillations. The combination of full power and opposite ailerons can drive an airplane into a fully developed flat spin. Neutralizing the ailerons by moving the stick or yoke to the "wings level" position, therefore, is the best course of action during an inadvertent spin.

Rudder — Applying full rudder opposite to the direction of rotation is always recommended for spin recovery. This is the primary action that needs to be performed. If unsure of which way the airplane is spinning, look at the airplane symbol on the turn coordinator and step toward the "high" wing (the attitude indicator, heading indicator, and the slip/skid ball are unreliable in a spin); or look straight down the nose of the airplane and step in the direction in which the ground appears to be "flowing" past the nose; or feel for a rudder pedal that offers more resistance and step on the "heavy" one.

Full opposite rudder alone may not always be sufficient for recovery from developed spins. It often must be used in conjunction with other spin recovery actions. Even so, once the direction of the spin has been determined, briskly push opposite rudder all the way to the control stop.

Elevator — Moving the elevator around in developed spins can aggravate spin characteristics and may delay recovery. Common to all airplanes, pushing the elevator forward during an upright spin accelerates the rotation. This phenomenon may even be observed briefly during the normal recovery process. In some configurations, premature elevator inputs can induce a nonrecoverable flat spin! Applying the opposite rudder first, then pushing the elevator forward is a critical sequence of events for recovery from developed, upright spins. "Pushing forward" means different inputs

for different airplanes. Don't experiment on your own — fly with a qualified flight instructor.

The final position of the elevator control during spin recovery depends on the airplane and the dynamics of the given spin. In developed upright spins in non-aerobatic airplanes, anticipate the need for brisk elevator movement forward of neutral, possibly fully forward, following the rudder input. With the enhanced control authority typical of aerobatic airplanes, anticipate having to move the elevator control briskly to neutral, or slightly beyond. In either case, the elevator control should be driven forward after the application of full opposite rudder.

Procedure vs. technique

Spin recovery actions do not follow a pilot's natural instincts, nor the reactions reinforced during normal training. Spin recovery actions are a learned response. They are purely a mechanical process devoid of the usual sense of control feel developed in normal flight.

Efficient spin recovery is predicated on the occurrence of specific actions, namely: Power — Off, Ailerons — Neutral, Rudder — Full Opposite, and Elevator — Briskly Through Neutral. These actions form the essence of spin recovery procedure. They outline "what" needs to happen. "How" these actions are implemented defines spin recovery technique. Maximizing the probability of recovery hinges on applying appropriate techniques to satisfy the intent of the procedure.

For example, there are at least three techniques that will satisfy the Power-Off requirement: retard the throttle, pull the mixture to idle cut-off, or run out of fuel. In most cases, retarding the throttle is the most efficient way to get the power off. Option two would come in handy if the throttle linkage was broken. Option three ... it's not really a viable or desirable option, is it?

Whether spin recovery technique describes a simultaneous application of recovery controls, a step-by-step application, a timed delay between the opposite rudder and forward elevator inputs, a prescribed amount of forward elevator, or a hands-off-the-stick

approach, the procedural elements outlined above must be addressed.

Looking to simplify the learning process, the PARE™ (pronounced "pair") acronym evolved in the late 1980s as a convenient way of presenting spin recovery information to pilots engaged in spin training. It offers the same recovery actions recommended by NACA, NASA, the FAA, and many spin experts and airplane manufacturers, but in a more concise format.

Consolidating, simplifying, and prioritizing the rudimentary spin recovery actions yields the PARE procedure:

P=Power — Off.

A=Ailerons — Neutral (& flaps up).

R=Rudder — Full Opposite.

E=Elevator — Briskly Through Neutral.

Hold these inputs until rotation stops, then:

Rudder — Neutral.

Elevator — Recover to Straight and Level.

The letters in the PARE acronym spell out the sequence of events. Each item in the checklist is performed one step at a time. As soon as one item is completed, the next one is initiated until all four primary controls have been positioned for spin recovery.

The important rudder–then–elevator sequence appears twice: first to stop the spin, then while returning the airplane to level flight. Remember, reversing the order of these inputs during a spin can aggravate the situation. Reversing them after the rotation has stopped could lead to a secondary spin in the opposite direction!

While classroom discussions about stalls and spins are educational, there is no substitute for hands–on experience in a controlled, dual–instruction environment. The value of spin training lies in its ability to stretch your operating envelope. It strives to improve your coordination and awareness skills.

An FAA study conducted in 1976–77 found that such training positively reduced the number of unintentional stalls and spins.

Although mandatory spin training is required of flight instructor applicants only, bear in mind that the regulations offer minimum acceptable standards. Becoming the best pilot you can be requires a commitment to exceed those minimum standards.

Presenting the volumes of detailed information available about stalls and spins is impossible in three magazine articles. The purpose of this series was to expand your awareness and understanding of stall/spin phenomena. We hope that you've found answers to some lingering questions. Perhaps this series has raised additional questions that can be posed in the classroom, or that can be debated over breakfast at the airport coffee shop.

If these articles have inspired you to take some spin training, find a qualified instructor who has access to an approved, well-maintained spin trainer. Most of the ingredients necessary for safe, quality spin instruction usually can be found at schools specializing in emergency maneuver and aerobatic training.

With a qualified instructor in an appropriately certificated airplane, gauge your growing spin awareness and the efficiency of your recovery inputs during precision one-turn spins against a target altitude loss of 500–600 feet in the typical, two-seat spin trainer, applying 2.5–3 Gs when pulling out of the dive. You'll probably find the experience to be extremely rewarding, and you'll be a safer, more competent pilot for it.