# *ANATOMY OF A SPIN*

**A Complete Study of the Stall/Spin Phenomenon**

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# *Introduction*

The stall/spin accident has been with us since the first airplane. Even at this late date NASA and the various aircraft manufacturers are investing considerable effort in an attempt to design-out this major cause of fatal accidents. And the results look promising, with "T" tails, spoilers, round-bottomed fuselages, ventral fins, wing fillets, and improved CG envelope, to name a few design improvements. Each combines with wing and tail design to provide good, safe spin-recovery characteristics. But our quest for faster, more maneuverable and economical airplanes means the accidental spin will remain an ever-present possibility. Consequently, thorough stall/spin training is a necessity. Spin training was eliminated from pilot-certification requirements in the late forties because new aircraft designs were to be stall- and spin-proof. This goal proved impractical, however, and at this writing only the Helio series is truly stall/spin-proof. The general-aviation accident record thoroughly documents the need for spin training of all private, commercial, and instructor pilots. With most of our general-aviation fatalities attributed to stall/spin problems, it seems obvious that more training is required. Many flight instructors show a great weakness in both knowledge and proficiency in this area. This weakness is thus passed along to students.

The basic aerobatics course available from several fixed-base operators emphasizes spin training, which makes it an invaluable investment to pilots of all categories. The training this type of course provides is like life insurance, and every serious pilot and flight instructor should attend one. Even the airlines have recognized this need; their training programs include loss-of-control and upset maneuvering.

Surprisingly, a large number of stall/spin accidents occur in aircraft certified for spins. Again, this points toward a weakness in training and proficiency. While NASA, FAA, and the manufacturers work on improved designs, it behooves the rest of us to work on our proficiency.

Each airplane is, of necessity, the product of aerodynamic compromise. To obtain a fast cruise speed with four to six passengers requires certain design limitations that may not be compatible with acrobatic maneuverability. An empennage that provides adequate stability and minimum weight and drag for cross-country flying may be inadequate in stopping the gyroscopic inertia generated when an aircraft encounters a fully developed spin.

This book has been written with the hope that increased knowledge of the stall/spin phenomenon will help pilots avoid some of the more hazardous pitfalls. For example, how do wing and tail design combine with center of gravity to affect an aircraft in a spin? Why will an aircraft recover with opposite rudder and neutral stick with one pilot aboard, yet require opposite rudder and full forward stick with two pilots?

Why will neutral controls or "unloading angle of attack" effect recovery of a spin entered from a high-speed stall, while these same neutral controls may delay recovery from a spin entered at a very low or zero airspeed (a situation sometimes encountered during acrobatic practice or unusual-attitude recoveries on instruments)? Or why will a four-place single-engine aircraft **certified** for spins in the utility category recover in one turn with two pilots aboard yet require from two to four turns to recover with all four seats filled?

Then, how about engine power? Whether it aids or delays recovery depends on the slipstream effect of a specific airplane. In some aircraft a high power-setting may delay recovery. For a few singles and light twins, high engine power during a developed spin may cause it to go flat. And for all but a few acrobatic types, a flat spin is unrecoverable.

Then there is asymmetrical engine power in a twin that is flown below $V_{mc}$ or to full stall. This guarantees a spin, and without a quick power reduction, it will, in some models, go flat.

Why does a light twin require a spin recovery technique entirely different from that for a corporate jet?

Finally, why do some T-tailed swept-wing aircraft "pitch up" into a locked-in deep stall while T-tail straight-wing trainers and turboprop aircraft have exceptionally good stall characteristics?

Weight distribution, wing and tail design, aileron deflection, fuselage shape, and the pilot's training and proficiency all play a part in the stall/spin phenomenon. But no amount of education or training can protect the pilot who spins an aircraft not approved for spins. Nor can we help the pilot who, on a flight demonstration with a full load of passengers, takes a light twin to the stall point or $V_{mc}$ and then suddenly pulls a mixture to demonstrate single-engine controllability.

We are all indebted to Monty Navarre, Publisher, Airguide Publications, who in 1981, saw the need for more pilot-oriented information on stalls and spins. Without his foresight, much of the information presented in this book would be moldering in NASA's files.

To NASA's James S. Bowman of the Langley Research Center and his Spin Research Team, a very special thanks for their many contributions to flight safety through their stall/spin research. To Jim this book is gratefully dedicated.

We hope you may find some extra bit of knowledge in these pages that will help you enjoy a long and happy flying career.

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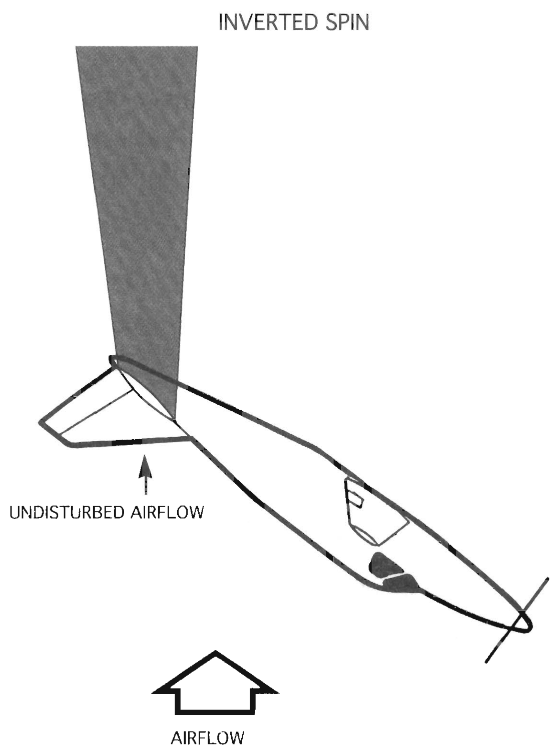
**1971 Cessna 150 Aerobat**

It was academic, though, because neither of us could reach the flight controls due to the negative-G and the fact that our seat belts had worked loose. But, after about two rotations, the aircraft recovered itself, a characteristic you'll find true in most general-aviation airplanes. It requires more altitude, but leave the controls alone and the aircraft should recover without your help.

Obviously elevator position is important. Here again things are different. Upright, forward stick (down elevator) helps unload angle of attack. Inverted, placing the stick forward (down elevator) is a pro-spin input, since it perpetuates the inverted stall. If you encounter an accidental inverted spin and you are unsure of the recovery procedure, apply full rudder against the turn needle's indication and keep the control stick neutral.

Aileron position is quite important since the drag produced by a deflected aileron can, as mentioned in Chapter 2, be as powerful as rudder. This is especially true with acrobatic aircraft, since the control deflections are usually greater than with a passenger airplane. Inverted or erect, an adverse aileron deflection can cause your spinning gyroscope (airplane) to go flat.

In an inverted spin the rudder on an airplane with a conventional tail is very effective because the airflow is totally undisturbed. This emphasizes the necessity to correctly identify the direction of yaw with the turn needle. The vertical stabilizer and rudder are completely free of the stalled wake of the wing and horizontal stabilizers (see Diagram 6–1). Of course in a T-tail airplane just the opposite is true.




**Vertical tail is free of the stalled wake of horizontal stabilizers. TDPF is strong; therefore recovery is positive.**

**Diagram 6–1**

Former test pilot Eric Shilling reports that to enter an inverted flat spin to the right in his Aeroduster, following a full stall inverted, he applies full forward stick, full left aileron, and full right rudder. After two turns in a normal inverted spin he places the control stick fully right while maintaining right rudder and forward stick. The right stick causes the aircraft to go flat in about one turn.

The addition of power during recovery can also be a mistake. Whether upright or inverted, high engine power in a steady-state spin causes the attitude to flatten out. So, unless the spin or stall is broken, full power in an inverted spin must be avoided.

Upright or inverted following loss of control, pilots are taught to place the stick forward of neutral to unload angle of attack in an effort to prevent a developed spin. This is good technique in an upright incipient spin. But a panicky application of full forward control stick can cause an upright spin to go inverted. Or, if loss of control occurs at a very low airspeed, as at the top of a loop, then full forward stick would be pro-spin elevator for an inverted spin.

A fatal accident illustrates this point. It involved the pilot of a Pitts S-1 who got into an accidental inverted spin during an airshow performance. A bystander photographed this unfortunate event. The film shows a classic case

**Pitts Special that crashed in a flat inverted spin following an entry from nearly zero airspeed. Film analysis shows that the pilot made three recovery mistakes: He applied and held full forward stick; he added full power, which caused the spin to go flat; and he attempted to use ailerons in the recovery.**

of misuse of elevator, aileron, and power, each of which helped cause the spin to go flat.

First he dropped into an inverted spin from an attempted tail slide. The film shows that he fell out of his smoke trail with an airspeed obviously at zero. A frame-by-frame analysis shows the elevators fully down (stick fully forward), full aileron deflection, and a high power setting. Then the spin attitude steepened, indicating idle power. As he neared the ground he added full power and the spin again went completely flat. And he hit holding full forward stick, full aileron deflection, and full power. In this case an experienced acrobatic pilot appeared to panic at a critical moment and use emergency control inputs that created the inverted flat spin.

Before you begin serious practice of aerobatics, get a veteran instructor to teach you inverted spins at a safe attitude. Remember too, that an error during vertical low-speed maneuvering close to the ground can lead to a demonstration crash, as the photograph on page 68 shows.