

RESTRICTED

PART 2: SECTION 3

CHAPTER 3

STALLING AND SPINNING

STALLING

Introduction

1. An aircraft stalls when the smooth flow of the air over its wings changes to a turbulent flow and the lift decreases. As this may happen suddenly, a pilot must be able to recognize the approach of a stall and know the best recovery action required to prevent loss of control and minimize any loss of height.

Stalling Characteristics

2. The stalling characteristics of an aircraft should be investigated at an early stage while becoming familiar with a new type of aircraft. Pilot's Notes deal with stalling behaviour, but age and use may produce differences between individual aircraft of the same type.

3. In general, stalling follows a common pattern. As speed is reduced, a warning of the impending stall is given in the form of buffeting which can vary from being fairly severe to almost imperceptible depending on the aircraft type and configuration. The buffet may start at some 5 to 15 knots before the stall, and usually increases in strength as the stall is approached. On some aircraft an artificial indication of the approaching stall is provided. Several methods are used, for example, either the whole control column or an inset portion of the handgrip can be made to vibrate strongly at a preset speed close to the stall.

4. On all aircraft, as speed is reduced the controls become less effective and larger movements are needed to correct or achieve a given displacement of the aircraft. On aircraft without power-operated controls, the feel of the controls becomes noticeably sloppy and their effectiveness decreases as the stall approaches. Just before the stall the aircraft may start sinking in spite of correcting movements of the control column.

5. At the stall, either wing and/or the nose may drop suddenly and to a varying degree. With power on, the stalling speed is lower, the nose-up attitude of the aircraft at the stall is more pronounced, the sinking is less marked, and any wing-dropping tendency is aggravated; the lower speed is due to the vertical component of the upwards inclined thrust line which provides

an additional lifting force and so allows level flight at a lower speed. The greater the power used, the lower the stalling speed.

6. On many types of aircraft, when the initial wing or nose drop occurs, the control column may not be fully back and any further backward movement of the control column in these circumstances may aggravate any wing-dropping tendency and tend to induce a spin. **In general, recovery should be made when the initial nose or wing drop occurs.**

7. If an unintentional spin occurs when stalling with the flaps and undercarriage down, these must be raised immediately to ensure that they do not affect the recovery and to prevent damage due to excessive speed in the dive following recovery.

Recovery from the Stall

8. Recovery must be made as quickly and decisively as possible with a minimum loss of height. **Recovery with a minimum loss of height necessitates the use of full power.**

9. The recommended recovery action is to ease the control column forward far enough to unstall the wings, and to apply up to full power simultaneously as quickly as engine limitations permit. If the control column is moved too far forward additional height is lost. If sufficient thrust is available, it should only be necessary to move the control column forward slightly, as the thrust will be adequate to accelerate the aircraft to a higher speed and, as stated in para. 5, the use of power reduces the stalling speed.

10. If a wing drops, sufficient opposite rudder should be applied to prevent any further yaw and to raise the wing. This action should be taken simultaneously with the forward movement of the control column and increase of power. As the wings become unstalled the natural stability of the aircraft also causes a dropped wing to rise and this can be assisted by use of the ailerons. **The aircraft must be eased gradually out of the dive following recovery ; any attempt to force a return to level flight will induce a g stall (para. 15) and cause a further loss of height.**

RESTRICTED

RESTRICTED

A.P. 129, VOL. 2, PART 2, SECT. 3, CHAP. 3

Swept-Wing Aircraft

11. The general stalling characteristics of aircraft with swept-back leading edges may differ considerably from those of straight-wing types, and Pilot's Notes should always be studied carefully before practising stalling for the first time, otherwise difficulty may be experienced during recovery.

12. As on any other aircraft, as the stall is approached on swept-wing types it is usual for stall warning buffeting to be felt, increasing in strength as the stall approaches, although the amount of buffet may, in some cases, be barely discernible.

13. Before the stall, there may be a sudden nose-up change of trim, known as *pitch-up* or *tuck-in* which occurs as the wing tips stall. This is not usually strong but necessitates a push force or relaxation of the backward pull on the control column to maintain a set attitude. Unequal stalling of both tips may cause sundry rolling and yawing movements at the same time. When the stall spreads over the whole wing, the nose pitches down. However, during the time that the angle of attack has been increasing the drag has also increased to a high figure (*i.e.* the L/D ratio is very low) and this induces a very high rate of sink which may be sufficient to mask the development of the full stall. In this condition the aircraft descends steeply in an almost level or slightly nose-down attitude with the control column well back. Very little encouragement is needed to make the aircraft spin and therefore the rudder and ailerons should be kept neutral. In practice stalling, there is nothing to be gained by reducing speed much below the point at which the stall warning buffet is encountered, and recovery should be made before the stall has reached its more advanced stages. Pilot's Notes advise on this point when the stalling characteristics include the aforementioned features to a marked degree.

14. On all swept-wing types, therefore, it is most important to take recovery action as soon as the initial wing or nose drop occurs.

Stalling in Manœuvres

15. If an attempt is made to change the flight path in the pitching plane too quickly, *e.g.* by turning at too high a rate or by recovering from a dive too sharply, a stall known variously as an accelerated or *g* stall, or less accurately as a high-speed stall, may occur. This last term is not

altogether suitable since the speed may be only a few knots above the level flight stalling speed when the control column is moved back to apply the *g*.

16. The manœuvres described in para. 15 involve accelerations in the pitching plane and result in an increased loading on the aircraft. Although the accelerated stall occurs at the same angle of attack as the normal stall, the I.A.S. at which it occurs is roughly equivalent to the level flight stalling I.A.S. times the square root of the load factor. For example, during a 60° banked turn (*i.e.* with a load factor of 2) an aircraft having a normal stalling I.A.S. of 100 knots would stall at an I.A.S. of 100×1.41 knots, *i.e.* 141 knots.

17. **Stall Warning.** Warning of the approach of an accelerated stall is given by airframe buffeting which increases in intensity as the stalling angle is approached. The stick force and control effectiveness are proportional to the I.A.S. at which the stall occurs, which may be any speed of which the aircraft is capable.

18. At the lowest speeds fractional amounts of *g* are sufficient to cause a stall. This applies particularly to aircraft with high wing-loadings. Steep approaches for landing should not normally be made on these aircraft, as the large backward movement of the control column required to round-out for the landing may apply sufficient *g* to stall the aircraft at the low speed used on the approach.

19. During dives and dive recoveries at low altitude, such as those used on air-to-ground armament practices, ample height must be allowed for recovery. Over-concentration on the aiming problem can result in insufficient height for normal recovery; and if in the subsequent attempt to recover excessive *g* is applied, the aircraft will stall and possibly flick into a spin. If the speed is high, even though the stalling angle may not be reached, the *g* threshold of the pilot and/or limitation of the aircraft may be exceeded.

20. **Pitch-Up in Manœuvres.** Any pitch-up tendencies (para. 13) possessed by a swept-wing aircraft are exaggerated when enough *g* is applied to stall the aircraft in a manœuvre. The higher the *g* required to cause the stall, the stronger is the pitch-up and the resultant unavoidable increase in *g* before the motion can be checked by a forward movement of the control column.

RESTRICTED

The increased g caused by pitch-up can be serious at high I.A.S. and low altitude, since high g is needed to promote pitch-up under these conditions and any temporary overshoot might exceed the g limitations. However, the g limitations placed on such aircraft take this possibility into account and, unless the g limitation is exceeded, pitch-up should not occur on a correctly loaded aircraft, *i.e.* an aircraft having the C.G. within the specified limits. At the highest altitudes, although forming an operational weakness, pitch-up does not usually result in a serious g overshoot as both the initiating g and the resultant g are low as a result of the reduced indicated airspeeds obtained at these altitudes.

21. When the stall occurs in a turn, depending on which wing stalls and drops first, the aircraft tends to roll either into or out of the turn. During recovery from a dive, either wing may drop. In certain aircraft the wing drop is sudden and may be severe. If the control column is held back the aircraft may execute a series of flick rolls which, at high speed, cause severe overstress.

22. **Recovery.** Recovery from any stage of an accelerated stall is made by moving the control column forward until the buffeting disappears.

Use of Ailerons

23. Pilot's Notes state whether the ailerons are effective at and below the stall; in general, it can be taken that the ailerons on high-performance aircraft are always effective under these conditions. If the stall is accompanied by a wing drop, a small amount of rudder away from the dropping wing (port wing drop—starboard rudder) should be used to check any tendency for this roll to produce yaw and the downward progress of the dropping wing can be checked with aileron. However, even when the ailerons are still effective, a wing dropping movement can often be arrested more positively and quickly by use of the rudder; in most aircraft only a small rudder movement is needed whereas a comparatively large amount of aileron is required. It should be noted, however, that on certain aircraft, aileron movements at the stall can, through aileron drag, induce sufficient adverse yaw to precipitate a spin. The effect of aileron at the stall should be investigated cautiously when stalling an aircraft for the first time; Pilot's Notes advise on the use of the ailerons under these conditions.

SPINNING

Note: The following paragraphs are general remarks on spinning. Pilot's Notes should always be read before spinning an unfamiliar aircraft.

Introduction

24. The spin is not a normal manoeuvre: it is the result of yawing or rolling at the point of stall. As it is possible to enter a spin through mishandling the controls during aerobatics, steep turns, and other quite normal manoeuvres, the pilot must be able to recognize a spin and recover promptly. This is done by practising spinning and spin recovery on suitable types of aircraft so that the pilot becomes accustomed to the sensation of spinning and quickens his assessment of the change of attitude and motion of the aircraft. The stick forces experienced during a spin may be high on some aircraft, necessitating the use of both hands to effect recovery; on other aircraft the forces may be so low that little or no effort is required to move the control column. In certain cases considerable snatching occurs on the control column and some strength is needed to hold the control column in a desired position. ► *During a rapid spin, or if a pilot is unaccustomed to spinning, considerable disorientation (giddiness) and mental confusion should be anticipated; instances have occurred when experienced pilots have been convinced about the direction of spin only to be proved wrong, and what appears to be correct recovery action in such cases only prolongs the spin. Thus, impressions gained during a spin should always be confirmed where possible by the instruments; this is particularly important with regard to the direction of spin which is indicated by the turn needle, deflection to the left indicating a spin to the left and vice versa. Often, a conscious effort is required to transfer attention to the instruments.*

Airmanship

25. Before practising spins, carry out the following checks:—

- (a) Ensure that the exercise is permitted and authorized and that the correct recovery action is known.
- (b) Warn the passenger or pupil when the exercise is about to begin.
- (c) Ensure that sufficient height is available to complete recovery at not less than 3,000 ft. A.G.L. in elementary aircraft, or as otherwise stated for more advanced aircraft.

(A.L. 4, Mar. 58)

RESTRICTED

A.P. 129, VOL. 2, PART 2, SECT. 3, CHAP. 3

(d) Ensure that :—

- (i) There are no loose articles in the cockpit.
- (ii) Full rudder can be applied.
- (iii) Undercarriage, flaps and air-brakes are retracted.
- (iv) Gyro instruments are caged and all harness straps are tight and secure.

(e) Immediately before starting the spin make sure that the area below the aircraft is clear of other aircraft and that there are no populated areas or aerodromes below. ◀

Entry into the Spin

26. When practising spinning, the throttle should be fully closed as the spin starts; entry is made by yawing the aircraft at the point of stall and maintaining the yaw and the high angle of attack, *i.e.* full rudder in the required direction and the stick held fully back. Out-spin aileron (aileron away from the intended direction of spin) may be needed to develop the spin, but Pilot's Notes will advise on this point. The commencing movements of the spin may be difficult to assess, and vary from a yawing of the nose around the horizon together with a small degree of roll, to rapid rolls involving an initial slow rate of yaw sometimes combined with varying rates of pitching. Some aircraft behave very erratically during the first few seconds of the spin and may even become temporarily inverted before settling down. If recovery is made during this period the attitude on the cessation of the spin is generally unpredictable.

Types of Spin

27. Spins may be divided into two main types. The first is the oscillatory spin in which the aircraft, perhaps after initial horizontal turns, will spin with varying rates of rotation, and changing nose positions (pitch attitudes) relative to the horizon. This may then develop into the second type of spin, which has a smooth and consistent motion in which there is less pitching but a faster rate of rotation.

Normal Spin Recovery

28. The standard spin recovery action is to apply full opposite rudder, holding the control column hard back and keeping the ailerons neutral (control column central), then, after a short pause, moving the control column progressively forward until the spin stops, *keeping the ailerons neutral*. These actions are taken to stop the yawing motion and unstall the wings. On many aircraft there may be a

momentary increase in the rate of rotation after recovery action has been taken. The moment rotation stops, the rudder and control column should be centralized; the rudder to prevent another spin in the direction of application, and the control column to prevent too steep a dive during recovery. As airspeed increases, the aircraft should be eased into level flight and power applied, care being taken to avoid a *g* stall. If the undercarriage and flaps are down on entering the spin they should be raised as soon as possible since they may delay, or even prevent, recovery. If an inadvertent spin occurs when carrying jettisonable wing loads—such as fuel tanks, bombs, or rockets—these should be jettisoned as soon as possible to ensure a quick recovery. The attitude of the aircraft may at times have to be taken into consideration before taking recovery action; generally these occasions are when the aircraft is pointing steeply upwards during the incipient stage, or when full normal recovery action would obviously result in the aircraft passing through the inverted position and into an inverted spin. Only common sense and experience can guide the pilot in these circumstances and suggest to him when to wait until the nose falls below the horizon, or when he should hold the controls neutral until a more advantageous moment arises to apply full recovery action. In assessing the height available for recovery from spins, altimeter error should be considered.

▶ 29. When recovery action is taken it is not unusual for the spin to stop when the aircraft is inverted, particularly if recovery action is taken before the aircraft is settled in the spin. If this occurs it is best to ease the nose of the aircraft well below the horizon and allow the speed to increase before half-rolling.

Emergency Normal Spin—Recovery Action

30. Emergency recovery action should only be taken after normal recovery action has proved ineffective; the seriousness of the situation must be assessed and the first consideration is one of height. If sufficient height is available the following actions should be taken after checking undercarriage and flaps—up; airbrakes—in; throttles—closed, and external stores—jettisoned:—

- (a) Apply and maintain full rudder opposing the direction of turn, but see sub-para. (c) (i).
- (b) Ease the control column progressively forward and apply aileron as recommended in Pilot's Notes.

(A.L. 4, Mar. 58)

RESTRICTED

(c) If the aircraft does not respond try to change the stable character of the spin by:—

- (i) Applying full pro-spin control and then repeating the normal recovery action.
- (ii) Opening and closing the throttle or using full throttle on the "in-spin" engine.
- (iii) Inducing a fore-and-aft rocking motion by moving the control column backwards and forwards. In single-engined propeller-driven aircraft actions at sub-sub-paras. (ii) and (iii) should be combined; when the control column is moved forwards the throttle should be opened and vice versa.

If the "g" increases noticeably re-examination of the instruments may show that the airspeed has increased and the aircraft may be in a spiral not a spin. Recovery action appropriate to a spiral should then be taken. ◀

Effect of Aileron

31. Pilot's Notes indicate whether aileron should be used in spin recovery, but it is important to realize that the use of ailerons may make all the difference between recovering more quickly and not recovering at all. The aid of powerful ailerons (as fitted on high-performance aircraft) to recover from a spin in one direction may suddenly reverse the direction of spin. In general, the effect of ailerons on the spin depends on the weight distribution of the particular aircraft concerned, and this may alter completely during flight, *e.g.* as fuel or weapons are used. Since incorrect use of ailerons delays, or even prevents, recovery, ensure that the ailerons are neutral by *visually* checking the position of the control column, if necessary against a reference point in the cockpit. This applies particularly when the control column is cranked or the aircraft is very sensitive to the use of aileron. Aileron towards the direction of the spin is termed *in-spin aileron*; aileron away from the direction of the spin is termed *out-spin aileron*.

32. If an aircraft has most of its weight concentrated into a long fuselage and has proportionately light wings and a short span, then in-spin aileron assists recovery. The longer the fuselage in relation to the span and the greater the weight concentrated in the nose and tail, the greater is the beneficial effect of in-spin aileron during recovery.

33. If the aircraft has a short fuselage and a relatively heavy wing of large span, then out-spin

aileron is most helpful. The carriage of wing-tip tanks would mean that an aircraft of the type described in para. 29 would be brought nearer to the short fuselage/large span type from the viewpoint of the use of aileron during spin recovery.

34. Ailerons should only be used for recovery when the normal method of recovery has no effect. All aircraft on which spinning is permitted, recover if the normal action is taken (see also Chap. 1, para. 25). On the majority of aircraft, in-spin aileron has a beneficial effect. *The natural tendency, however, is to apply out-spin aileron, and this must be guarded against.*

▶ Inverted Spinning

35. Intentional inverted spinning is prohibited except in aircraft specifically cleared for this manoeuvre by the Air Ministry (A.M.F.O. 405 refers).

36. In a normal spin the yawing and rolling motions are in the same direction but in an inverted spin they are in opposite directions. It is this factor which may make it difficult to decide whether a spin is normal or inverted, particularly when the normal spin in that type of aircraft is very steep and when the entry may have involved a series of confusingly rapid rolling and pitching movements. However, an inverted spin is less likely to occur than a normal spin because one of the requirements is that the control column should be forward of neutral when the aircraft is inverted or becoming inverted at a low airspeed. The most common manoeuvres which can lead to inverted spins are a loop or half-roll off-the-top when the airspeed is too low at the top—the likelihood thus increases with altitude, and when a normal spin is stopped in the inverted position and an attempt is made to push the nose up to the horizon instead of allowing the speed to increase slightly, then half-rolling and easing the aircraft into level flight.

37. In an inverted spin as with a normal spin the direction is in the same way as the yaw which is indicated by the turn needle. In a flat inverted spin the amount of rolling motion is small but the yaw is very evident; in a steep inverted spin the yawing motion may be masked by the high rate of roll. It is a wise precaution therefore, to always inspect the turn needle to confirm the direction of spin. In an inverted spin slight negative "g" may be present but this also may be so masked by the rate of roll as to be unrecognizable.

(A.L. 4, Mar. 58)

RESTRICTED

A.P. 129, VOL. 2, PART 2, SECT. 3, CHAP. 3

Inverted Spin Recovery

38. The standard recovery from an inverted spin is to apply full rudder in the opposite direction to the yaw and move the control column progressively backwards until the spin stops. It is essential that the ailerons are kept centralized throughout the procedure, this usually requires a conscious effort particularly in aircraft with cranked sticks. Immediately the spin stops the controls should be centralized, and the speed allowed to increase slightly, then the aircraft should be gently half-rolled or eased out of the dive. Great care should be taken when easing out of the dive because a pilot's positive "g" threshold may be seriously reduced if negative "g" has been experienced during the inverted spin.

39. Often, when anti-spin rudder is applied the yawing motion will stop, the aircraft will pitch through the vertical, pendulum fashion, and continue to spin but in the opposite direction. It is essential to watch for this pitch change and recognize that an inverted spin has been converted into a normal spin. Normal spin recovery action should then be taken.

Emergency Inverted Spin—Recovery Action

40. The emergency actions for the normal spin recovery apply equally to the inverted spin except for the control column movement and the fore-and-aft rocking with changes in power. (See para. 39(b) (ii) and (iii)). In an inverted spin the control column should be eased backwards and to create fore-and-aft rocking the throttle should be opened as the control column is moved backwards, the opposite to the normal spin case.

Steep Spins

41. In a steep spin it may be difficult to determine whether the spin is normal or inverted. A pilot should therefore always refer to the turn needle to establish the direction of spin. External references may enable the pilot to establish the

direction of roll and if it is the same as the turn the spin is normal, if opposite, the spin is inverted. If it is not possible to establish whether the spin is normal or inverted and sufficient height is available, the following recovery actions are recommended:—

(a) Apply and maintain full rudder opposing the direction of turn,

(b) Take normal recovery action—stick fully forward, ailerons neutral, check ailerons neutral; if ineffective,

(c) Take emergency normal recovery action—stick fully forward, in spin aileron, check aileron in same direction as turn needle; if ineffective,

(d) Take inverted recovery action—stick fully back, ailerons neutral, check ailerons neutral; if ineffective,

(e) Take emergency inverted recovery action—stick fully back, outspin aileron, check aileron in opposite direction to turn needle; if ineffective,

(f) Attempt to change the stable character of the spin as described in para. 39(c).

The aileron application at sub-paras. (c) and (e) is usual and applies to most modern fighters and advanced trainers, but Pilot's Notes will advise for each aircraft type. If the amount of height available is marginal the actions at sub-paras. (b) and (d) should be omitted. Each action at sub-paras. (b), (c), (d) and (e) should be held long enough to be effective normally, Pilot's Notes will advise on this point but the usual period is during two turns. If none of the above actions are effective, the pilot should take his hands and feet off the controls and prepare to abandon the aircraft.

Abandoning a Spinning Aircraft

42. If a pilot considers that his height is insufficient to recover from a spin the aircraft should be abandoned. Generally, in high-performance aircraft such as fighters and advanced trainers, if control has not been regained at 8,000 ft. A.G.L. the aircraft should be abandoned. ◀

(A.L. 4, Mar. 58)

RESTRICTED

This file was downloaded
from the RTFM Library.

Link: www.scottbouch.com/rtfm

Please see site for usage terms,
and more aircraft documents.

