BRITISH MICROLIGHT AIRCRAFT ASSOCIATION

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GUIDANCE ON SPIN TESTING MICROLIGHT AIRCRAFT

Young Lady, a spin is like a love affair;
you don't notice how you get into it
and it is very hard to get out of!

Aerodynamicist Theodore Von Karman to Pilot Amy Johnson.

Introduction

The BMAA, PFA and CAA all require that new microlight aircraft designs are assessed against the following paragraph of BCAR Section S issue 2:-

> S221 General
>
> For any aeroplane that is not controlled by weightshift:
>
> a) The aeroplane must be able to recover from a one-turn erect spin or a 3 second erect spin, whichever takes longer, in not more than one additional turn, with the controls use in the manner normally used for recovery. The recovery must be demonstrated with flaps, airbrakes and undercarriage in any allowable position and without exceeding the pilot effort limits for temporary application under S143 and the applicable airspeed and positive manoeuvring load factor limitation.
> b) It must be impossible to obtain unrecoverable spins with any use of the controls.
>
> For the flaps and airbrakes extended condition, the flaps and airbrakes may be retracted during the recovery.

S221 is a very short text to cover a very complex subject. In summary however what needs to be established is:-

1. Will the aircraft spin from a normal spin entry.
2. Will the aircraft spin from a mishandled manoeuvre (most commonly from either stalling off a steep turn or a power-on rapid stall entry).
3. What is the spin like.
4. How is the spin to be recovered from.

Regardless of the wording in BCAR Section S, spin assessment is vitally important in the assessment of a new aeroplane; it is not acceptable (as has happened in the past) for the first experience of the spin to be accidental and some time after introduction of the type into service.

Although a great deal of experience exists regarding the spin, most of this is for larger, heavier aircraft than Microlights. Consequently, the advice in this leaflet is based upon experience with larger aeroplanes, tempered by the experience of a handful of trials on microlights. BMAA would therefore be grateful for all additional information, reports, guidance or information which users of this leaflet can pass on in the light of their own experience.

Bibliography

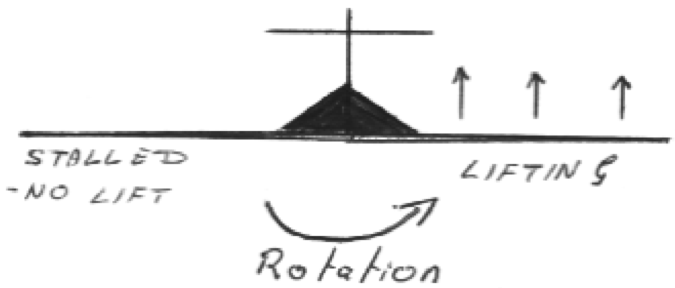
The spin is a complex and often poorly understood subject. It is hoped that this TIL will cover everything that the Test Pilot or Flight Test Engineer will require to safely plan and execute a spinning evaluation. However, the following may be useful for those who wish to explore the subject further:-

a) FAA Advisory Circular AC23-8, Flight Test Guide for the Certification of Normal, Utility and Acrobatic Category Aeroplanes.
b) Spin: Angles and Inertial Moments, Yangos and Yangos, Aeronautical Journal July / August 1981, pp270-276/.
c) ETPS flight test handbook.
d) Handling Qualities and Flight Testing of the Aeroplane, Darrol Sinton.

What is a Spin?

A spin is an autorotation in roll and yaw at low speed. It occurs when either roll or yaw is introduced at the point of stall, causing one wing to unstall, but the other to remain stalled.

Figure 1



This rotation ensures that the lifting wing remains at a low angle of attack (and therefore unstalled) and the non lifting wing remains at a high angle of attack (and therefore continuously stalled).

Because of the difference between the lift at each wing, there will also be a difference between the drag at each wing. So, continuous yawing will also occur - often creating uncomfortable sideforces at the cockpit. Because one wing is partly stalled, the aircraft will also tend to pitch as the longitudinal stability of the aircraft is upset. Hence spinning is a Rolling / Yawing / Pitching autorotation.

Virtually all spins will be "erect spins", that is where the directions of yaw and roll are the same. If the directions of yaw and roll are opposing, this is an inverted spin. Whilst it is possible to enter an inverted spin through severe mishandling of the controls (e.g. full right rudder whilst stalling with 60° left bank) microlights have never yet been seen to suffer the inverted spin and this mode should not require assessment in microlight aircraft unless a specific problem is identified.

In most spins, the nose is pointed steeply downwards. This is normal, if the nose tends to come up towards the normal flying pitch attitude however, this may be a "flat spin". Flat spins are often unrecoverable and an aircraft which shows this tendency may well have unacceptable characteristics.

A word on the Spin Recovery

The standard textbook spin recovery is "close throttle, centralise stick, apply full opposite rudder, move stick forward until the rotation stops". This recovery presents three problems for the microlight:-

1. It assumes a degree of recognition of the spin (and spin direction) which an average microlight pilot may not possess - also not that many microlights are equipped with a turn & slip gauge.
2. Because of the ability of a microlight to change energy state very quickly, there is a risk that use of opposite rudder may simply reverse the direction of spin.
3. It is only useful in the developed spin, in the incipient spin stage many aircraft will simply "wallow-around" out of control, and have not yet fallen into a particular spin direction. It is unhelpful to make the pilot wait until the spin is properly established before being able to recover.

Because of these factors, it is BMAA's recommendation that where possible the following spin recovery is used for microlight aeroplanes.

- Close throttle
- Centralise all controls
- Wait for spin to stop.

(Both spin recoveries are of-course then followed by some variation on "roll wings level and gently ease out of any ensuing dive, applying power as the level flight attitude is reached".)

So far, all microlight aeroplanes assessed by the BMAA have consistently responded to this recovery. As with other aircraft, pilots should be aware that some microlights may recover from the spin into a spiral dive - monitor the ASI regularly!

Preparation

Before embarking upon spinning tests the following safety precautions are essential:-

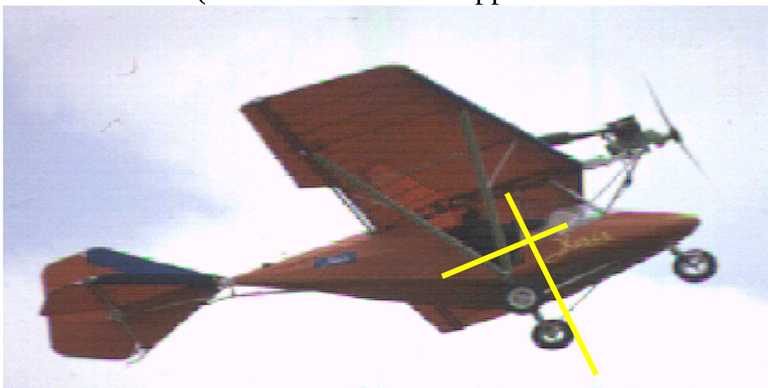
1. There must be some means of escaping from an unrecoverable spin. This generally means either personal parachutes (and confirmation that the aircraft can be easily be exited) or fitment of a Microlight Parachute Recovery System in accordance with Subsection K of BCAR Section S issue 2.
2. The Test Pilot(s) who are to carry out the assessment must have reasonable and current spinning experience. Unfortunately this is usually not possible to obtain in a microlight, and it must usually be obtained via a light aircraft school or club - preferably in an aircraft as lightweight as possible and including mishandled spin modes and spin entries from manoeuvre.
3. A full and thorough stalling evaluation must have been carried out, and all test team members fully aware of its results.
4. A full plan and safety assessment must be produced. Having said this, it is rarely possible to thoroughly plan the latter part of a spinning assessment until the first part has been executed. This is because it is very hard to accurately predict how any aeroplane will spin and so any areas of concern may not be known until part-way through the programme.

Why are Microlights Different

There are certain characteristics of microlight aeroplanes which can make them different to larger aircraft in the way that they spin. Specifically:-

1. They have greater drag for lower inertia than most light aircraft. This means that airspeed and conditions can change very rapidly.
2. They have a very low wing loading (this seems to usually lead to spins far slower than in larger aircraft).
3. They usually have very powerful flying controls (especially the rudder), designed to ensure good control of the aeroplane down to low speeds and for crosswind landings - this can often permit very efficient spin recoveries. BUT, before commencing always examine the tail for any possibility of the elevator blanking the rudder - this can happen on some designs with a low horizontal stabiliser but is highly unlikely on the “cruciform” tail common to many microlights (e.g. most Thruster and AX variants).
4. Microlights may be flown by very inexperienced pilots.
5. The propeller (particularly with large modern propellers such as the Ivoprop or Arplast) have a very high rotational inertia - this can lead to considerable differences between left and right hand spin characteristics.
6. The engine and propeller are often significantly offset from the horizontal and vertical centres of gravity (see figure 2) - this will amplify the effects of 5. above.

Figure 2 - Raj Hamsa X'Air.
(Crossed lines show approximate horizontal and vertical CG positions)



Note distance from prop!

Equipment for Spin Testing

The following are recommended equipment for any pilot / FTO engaged in spin testing:-

- A kneeboard
- A voice recorder (the easiest way to do this is to use a dictaphone with a small microphone inserted inside the earpiece of the pilots helmet).
- A stopwatch
- A fuel burn .v. W&CG plot for the aircraft as it will be flown.
- A radio.
- A hard shelled helmet.
- A four or five point harness, a 3 point harness or lapstrap is not sufficient.
- a g-meter (it is not unusual for several [up to 4]g to come on during spin recovery, particularly with power) located in the cockpit as near as possible to the CG.
- Some assessors have found that a small video camera, mounted in the rear of the cockpit and showing the "forward view" and main instruments is helpful as an aid to later analysis. This must, of-course, be well secured and able to withstand at least 9g forward load, 4.5g downward load and 3g sideward load.

This is in addition to all normal flight equipment and either personal parachutes or a Parachute recovery system fitted to the aircraft. If personal parachutes are to be used, the crew must satisfy themselves that they can exit the aircraft if required, and practice this on the ground.

Experience has not shown that force gauges and tape measures are particularly useful during spin testing.

The Spinning Test Plan

The following grid shows a **suggested** plan for the order of tests of a typical assessment. Before planning your own tests however, please bear in mind the following:

1. An examination of the direction of propeller rotation will show that one spin direction will be against the propeller torque reaction, the other for. Always execute spins against the propeller first, then with it. Spins with the propeller may be more stable but harder to recover, spins against may be more oscillatory but should recover more quickly. If an aircraft recovered from the spin against the torque, but won't recover in the same orientation, the pilot must be mentally prepared to turn the engine OFF.
2. Whatever mode seems least hazardous - do that first.
3. If test #8 has been reached and the aircraft has yet to enter a spin, it can reasonably be regarded as spin-resistant and testing can cease.
4. Always execute each spin mode at least twice (once left once right). However, you may require more spins that this simply to record everything - see under "the flight" below.
5. The grid below includes selected mishandling - this is essential to a proper spin evaluation, but consider the aircraft you are assessing and add extra tests (or occasionally delete them) if required.
6. This grid doesn't include flaps, airbrakes or retractable undercarriage. If fitted, these must be taken into account in the test plan.
7. If the testing is to be carried out by more than one pilot, the later pilot should not launch straight into the nasty stuff, always repeat some of the more basic spins for familiarisation first.
8. The worst case will always be with the CG at it's aft limit. Therefore, it is recommended that tests #1-#5 (shaded below) are initially carried out at the forward CG limit, then mid CG and finally at aft CG before progressing further. Tests 6-14 need then be carried out at the aft CG limit only.
9. It is important to understand the possible aileron effects before commencing spinning with mishandled aileron. In an aircraft with a particularly large wing, in-spin stick is likely to flatten and speed up the spin (and make recovery harder), whilst out-spin stick is likely to reduce the spin rate and push the nose down (assisting recovery). In an aircraft with a dominant fuselage, in-spin stick is likely to create a yawing moment aiding recovery; conversely out-spin stick may again make the spin faster and harder to recover from. Therefore tests #9 and #10 may well need to be swapped around depending upon the characteristics of the aircraft.
10. Depending upon aircraft, between 10 and 20 spins per flight is normal.

Figure 3 - Example test grid.

	No. turns			Entry		Mishandled Spin				Mishandled recovery		
Spin No. (a)	¼-½ turn (b)	1 turn (c)	2 turns (d)	std entry (e)	Entry from steep turn (f)	½ in-spin aileron (g)	½ out-spin aileron (h)	Cruise Power (i)	Full Power (j)	Stick held back (k)	Full power (l)	Full opposite rudder held in (m)
#1	X			X								
#2		X		X								
#3			X	X								
#4		X			X							
#5		X			X			X				
#6		X		X				X				
#7		X		X					X			
#8			X	X					X			
#9		X		X			X					
#10		X		X		X						
#11			X	X						X		
#12			X	X								X
#13		X		X							X	
#14			X		X			X				

Minimum: 48 spins.

There may be occasions after an aircraft has entered service when it is necessary to repeat spin tests before a change to the aircraft can be approved. This might include:-

- Introduction of flaps or other significant changes to the wings.
- Addition of floats
- Addition of cockpit doors.
- Change to a significantly more powerful engine, or significantly higher inertia propeller than previously fitted.
- Expansion aft of the CG limits.
- Addition of an extra fuel tank significantly away from the aircraft centre.
- Alteration of the canopy or fuselage shape.

All test plans must of-course be approved, for A1 manufacturers this is likely to be by either CAA Flight Department or the company Chief Test Pilot. For amateur constructors it will either be the BMAA CTO / Chief Test Pilot, or the PFA chief Engineer.

BMAA provides a pro-forma for test plans, form BMAA/AW/035; however, use of this is not mandatory.

The Flight

All test flight are potentially hazardous and should always be treated with caution; this includes ensuring that a proper crew brief is carried out, radio and safety equipment is checked and serviceable, only essential crew are carried, and that a copy of the sortie plan is left on the ground (in case of the worst!).

Spinning has special considerations which must be adhered to:-

- Turbulence must be light or nil.
- There must be a clear horizon and clear sight of the ground.
- It must be possible to climb to at least 5,000 ft (preferably higher) without the cloud layers being such that there is any risk of descending through cloud or losing a horizon reference.
- All ballast or other items fitted in the aircraft must be doubly secure.
- Under no circumstances must spinning be carried out over any human habitation.
- If there is tolerance on the flying controls settings, the controls must be set to give the lowest permitted range of movements. If the aircraft proves spin resistant, this should be changed to the widest permitted range and the tests repeated.
- If you are able, make your airfield or LARS controller aware of what you are doing and notify them at the start and end of tests, and of the range of heights you expect to be spinning through.
- It is not unknown for an engine to stop during a spin; ensure that a suitable landing site is available underneath the aircraft in case this happens. For the same reason, if an electric starter is fitted ensure that the battery is fully charged.
- Know your area, or have some means of locating yourself - it is very easy to get lost during a spinning exercise.
- Ensure that your abandonment, or BRS deployment criteria are well understood and briefed before the flight.

Test Cards

Whilst the style and format of test cards is always a matter of personal choice, presented here are suggestions from experience which may be helpful. Always include your test cards in the flight test report.

Falcon 2 Spinning Flight: 3 No: 5

Dewhurst / Gratton 5/6/99

Fuel: 45 L Weight : 420 kg CG: MID

Vs: 23 kn Vne: 92 kn Max 6,800 rpm

Mode: ~~Left~~ / Right
Entry: Standard / ~~60° turn~~
Power: ~~Idle~~ / Cruise (5,000) / ~~Max~~
No. Turns: ~~½ / 1~~ / 2
Recovery: ~~Central~~ / Opposite rudder

----

h1: 6,700 h2: 5,800 (1013 set!)
time of spin: __________
time to recover: 4 s.
actual Vs: __________

Comments
ABOUT 5 daN FWD STICK FORCE
NO TENDENCY TO REVERSE SPIN
ABOUT 3g IN RECOVERY

A standard card like this can be very useful, reproduced in a photocopier and then altered by hand for each test point. Always fly with spares.

Keep text and spaces large

Basic limitations are useful

Use standard lists to prevent omissions.

Don't expect to get all the data each spin. Do expect to repeat tests until you have.

Always leave room for comments.

Some test pilots prefer to use a "control position grid" on their test cards, so that the positions and movements of the flying controls can be drawn. Reference (d) describes this very well.

<u>The Report and Recommendations</u>

It is not the purposes of this TIL to describe how to write a flight test report. However, it is worthy of mention that spinning results (just like spinning test plans) are particularly well suited to tabular presentation. Most good spinning reports present most information as tables, with prose only being used to describe any handling peculiarities, and conclusions and recommendations.

The most important part of the report is however the recommendations. This will comprise two parts: -

The aircraft recommendations

Very simply, the assessing pilot or engineer must state (and support their case) whether or not the aircraft is acceptable for use as a microlight aeroplane with regard to its spinning characteristics and compliance with BCAR S221.

The manual recommendations

Since the aircraft has been spun, and presumably recovered, it is necessary to introduce advice into the operators manual about the spin. Bearing in mind that the aircraft is not cleared for deliberate spinning, this wording must be carefully constructed to be sufficiently clear to a pilot with no spinning experience, yet not give the impression that he or she should ever attempt to spin the aircraft. Therefore, the assessing pilot or engineer should recommend in their report, words to be included in the operators manual. These words should be brief (perhaps around half a side of A4), and include:-

- A warning that deliberate spinning is prohibited.
- Guidance on how to recognise a spin should one occur.
- A clear explanation of the spin recovery actions, and what should then occur.
- Instructions on what the pilot should do after recovery from the spin.

Normally, no more information that this should be required.

Approved for Issue:

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Further Information

Please contact Chief Technical Officer, BMAA, The Bullring, Deddington, Banbury, Oxon, OX15 0TT. cto@bmaa.org. Fax: 01869-337116.

Companies or persons who require a qualified test pilot to plan or execute tests are referred to BMAA TIL 023, “List of BMAA Test Pilots” which may be downloaded from the BMAA website or obtained from the BMAA tel. 01869-338888, general@bmaa.org, fax and address as above.

Notes on Sources and the development of this TIL

This TIL was prepared by the BMAA Chief Technical Officer, in consultation with experienced test pilots. Flight test results for the X’Air 582, Murphy Maverick, Thruster T600N, Grob G109b, and several light aircraft have been taken into account in its preparation.

It is hoped to develop this TIL further to particularly include “rules of thumb” permitting the assessing pilot and engineer to predict the spinning and recovery characteristics of new aircraft before tests commence. In aid of this, the BMAA would be very glad to receive copies of any opinions, spinning test reports or conclusions related to microlight or light aircraft which might be fed into this development process.