AIRCRAFT ACCIDENT REPORT 3/83

Accidents Investigation Branch

Department of Transport

Report on the accident to Scheibe SF 28A G-BBGA at Enstone Airfield, Oxfordshire on 26 May 1982

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Department of Transport
Accidents Investigation Branch
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14 July 1983

The Rt Honourable Tom King MP
Secretary of State for Transport

Sir,

I have the honour to submit the report by Mr D A Cooper, an Inspector of Accidents, on the circumstances of the accident to Scheibe SF 28A G–BBGA which occurred at Enstone Airfield, Oxfordshire, on 26 May 1982.

I have the honour to be
Sir
Your obedient servant

G C Wilkinson
Chief Inspector of Accidents

Accidents Investigation Branch

Aircraft Accident Report No. 3/83
(EW/C787)

Operator:	Oxfordshire Sport Flying Club
Aircraft: Type:	Scheibe SF 28A Tandem Falke
Nationality:	British
Registration:	G–BBGA
Place of Accident:	Enstone Airfield, Oxfordshire Latitude 51° 56′ N Longitude 01° 25′ W
Date and time:	26 May 1982 at 1955 hrs All times in this report are GMT

Synopsis

The accident was reported to the Accidents Investigation Branch by the Thames Valley Police at 2100 hrs on 26 May 1982. The investigation commenced the following morning.

A Scheibe SF 28A motor glider had just completed a loop over Enstone airfield when the wings detached from the fuselage. The pilot and the passenger were killed.

The accident was caused by the failure of the centre-line wing attachment assembly allowing the wings to separate from the fuselage. The failure resulted from the loss of full rigging pin engagement due to the fitting of the safety pin in an additional and incorrect hole that had previously been drilled in the rigging pin. The possibility that the pilot had exceeded the aircraft's maximum permissible airspeed could not be ruled out. A contributory factor was that the CAA did not require special inspection of the SF 28 following an accident to an aircraft with a similar wing attachment system

Following the accident to G–BBGA the CAA directed that all Scheibe and Slingsby motor gliders which had the same method of wing attachment be examined before the next flight. A safety recommendation proposes that all aircraft cleared for aerobatics should have comprehensive flight load limits available to the pilot, and be fitted with a cockpit accelerometer.

1. Factual Information

1.1 History of the flight

The aircraft was operated by the Oxfordshire Sport Flying Club for the purpose of giving instruction in motor gliding. The pilot was a qualified gliding instructor and a regular instructor at the club. The passenger was a prospective new member of the flying club who had arrived there earlier in the afternoon. After a discussion with the pilot it had been arranged that he would be given a short introductory flight at the end of the planned flying programme for that day. It was also arranged that this flight should include some aerobatics.

The pilot and his passenger boarded the aircraft at about 1930 hrs, the passenger occupying the rear seat. Prior to take-off an engine power check established that the engine was some 200 RPM low at full power; however, the pilot elected to continue with the flight. The take-off was uneventful and the aircraft was seen to climb and to circle the airfield at about 1,000 feet. After a flight of some 10 minutes, the aircraft was observed flying across the airfield from south to north and diving under power to gain speed. It then carried out a loop and on completing it at an estimated height of 500 feet as it pulled up again, either to regain height or to enter another loop, both wings were seen to detach from the fuselage. The fuselage then fell to the ground a few metres from the main runway at Enstone airfield, the starboard wing landed close by and the port wing fell some 350 metres away. Both the pilot and the passenger were killed instantly on impact with the ground.

1.2 Injuries to persons

Injuries	Crew	Passengers	Other
Fatal	1	1	–
Serious	–	–	–
Minor/None	–	–	

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

Nil.

1.5 Personnel information

1.5.1 *Pilot:* Male, aged 32 years

Licence:	Private Pilot's Licence (permanent)
Last medical examination:	Class 3, renewed 10 February 1982, valid for 2 years
Certificate of Experience:	23 March 1982, valid for 13 months
Flying experience:	Total hours: 956
	Total hours on type: 174

The pilot had been approved by the British Gliding Association to give dual instruction in gliders, and he held a Motor Glider Instructor's Rating (Restricted) valid for gliding exercises only. Since 7 February 1982 he had been acting as an instructor at the Oxfordshire Sport Flying Club, an organisation sponsored by Gordonair Ltd, the registered owner of the aircraft.

1.5.2 The passenger was aged 25. He had served in the Royal Air Force as a trainee pilot although he had not qualified as a pilot. He did not hold a civil pilot's licence.

1.6 Aircraft information

1.6.1 *General*

Manufacturer:	Scheibe-Flugzeubau-G.MB.H., Dachau, Federal Republic of Germany
Type:	SF 28A
Year of manufacture:	1973
Constructors serial number:	5739
Registered owner:	Gordonair Ltd
Certificate of Airworthiness:	United Kingdom Private Category, valid until 26 April 1983
Total airframe hours:	1283
Total engine hours:	898

Hours since last inspection: 29

Hours since last wing assembly: 46

1.6.2 Description of aircraft

The pilots' seats of the SF 28A were arranged one behind the other. The nose mounted engine drove a two-bladed propeller, the blades of which could be fully feathered when the engine was not operating. The wing structure and tail surfaces were constructed of wood, while the fuselage was a steel tube structure with mainly fabric covering. The flying controls were conventional for a light aeroplane, but in addition the aircraft was fitted with spoiler type air brakes on the upper wing surface. In common with most conventional gliders the SF 28A could be de-rigged for ease of ground transport and storage. In the case of the wings this was facilitated by a joint on the centre-line which allowed the two wing halves to be separated and withdrawn from the fuselage. The centre-line joint carried wing bending loads by means of a system of engaging lugs formed on four metal brackets attached to the inner ends of the top and bottom spar booms on port and starboard wings respectively (see Appendix, figures 1 and 2). The lugs on the starboard wing were secured within the lugs on the port wing by means of a single vertical rigging pin passing downwards through all eight lugs. This rigging pin was secured in the engaged position by a safety pin passing horizontally through a hole drilled in it, positioned so that the safety pin would bear against the bottom of the lowest lug on the top spar boom, thereby preventing upward movement of the rigging pin.

1.6.3 Certificate of Airworthiness

The aircraft was manufactured in 1973; flown to the United Kingdom and placed on the British register. A Special Category Certificate of Airworthiness was issued which contained the following Compulsory Conditions:

"13. The aircraft shall not be flown at airspeed indicator readings in excess of 103 knots.

17. Aerobatic manoeuvres involving negative g are prohibited.

18. Aerobatic manoeuvres may only be carried out with the engine inoperative. The following aerobatic manoeuvres only are permitted.

(a) Tight turns up to 2g.

(b) Inside loops.

(c) Chandelles."

The aircraft was later sold to new owners in Eire. In 1980 it was re-registered as EI–BFD and the Irish Certificate of Airworthiness required that the conditions in the Flight Manual be observed. This document was a translation from German of the manufacturer's Flight Manual and contained the following conditions:

"Flight Speeds

Maximum permissible speed:	102 kts
Manoeuvring speeds:	84 kts
Maximum speed with spoilers open:	102 kts"

"Simple aerobatics and cloud flying are not allowed."

In 1981 the aircraft was purchased by Gordonair Ltd and returned to the United Kingdom, although it remained on the Irish register until 27 April 1982 when it was re-registered as G–BBGA and a British Certificate of Airworthiness was issued containing the following conditions:

"9. The aircraft must not be flown at airspeed indicator readings in excess of:

Maximum permissible speed:	102 kts
Maximum rough airspeed:	84 kts
Maximum speed with spoilers:	102 kts

A notice to this effect must be displayed in the pilot's cockpit."

"11. The following aerobatic manoeuvres are permitted:

Inside loops, Chandelles and tight turns up to 2g.

The above manoeuvres may only be performed with the engine inoperative. A notice to this effect must be displayed in the pilot's cockpit."

The apparent contradiction between condition 11 of the current Certificate of Airworthiness and condition 18 of the earlier document was drawn to the attention of the CAA who stated that it was the intention that the 2g limitation should apply to steep turns only. There was no normal acceleration limit laid down in the Certificate of Airworthiness, or in documents available to the pilot, for manoeuvres in the looping plane – although the SF 28 had been designed to a requirement of 5.3g at

the design manoeuvring speed (V_A) reducing to +4.0g at the design maximum speed (V_D). The 2g limit on tight turns had been laid down because it was considered that such turns might be executed at the maximum permissible airspeed (V_{NE}) with the possibility of +4.0g being exceeded. The CAA added that motor gliders cleared for aerobatics now carry the restriction 'Positive Loops, Chandelles and Steep Turns to 3.5g'.

The CAA also stated that the manufacturer had conducted successful flight tests of aerobatics with the engine running and that, provided that the limit load factor was not exceeded, a looping manoeuvre with the engine running would be perfectly safe. The requirement that the engine should be inoperative during aerobatics was introduced to maintain commonality with other motor gliders such as the PIK 20E fitted with a retractable pylon mounted engine and in which powered aerobatics are not permitted.

1.6.4 Aircraft maintenance

All Certificate of Airworthiness inspections throughout the life of the aircraft had been carried out in accordance with procedures laid down by the British Gliding Association or the Irish Gliding Association, as appropriate.

In April 1979 the wings were returned to the manufacturer in Dachau, West Germany, for refurbishing following damage caused by ingress of water and returned to the owners of the aircraft in Eire. Upon its return to the United Kingdom register a Certificate of Airworthiness Inspection and Flight Test was carried out by the Managing Director (MD) of Gordonair Ltd. The aircraft had at this time completed 931 hours flying. At the time of the accident the aircraft had done 1283 hours flying.

On 18 May 1982 the wings were removed to facilitate fabric repairs to the fuselage. They were re-assembled by the MD (who was a licensed aircraft engineer) on the 19 May; the re-rigging took place with no apparent problems and the aircraft flew for a further 46 hours before the accident occurred. During this period a 50 hour airframe check was carried out and no problems were revealed.

1.6.5 Weight and Centre of Gravity

The exact weight of the motor glider is not known, neither is the position of its Centre of Gravity. No weight schedule could be traced for the aircraft. However, the manufacturer's data allows for a 'spread' of weights from 390 kg to 415 kg to allow for individual variations in construction and the absorption of water into the timber. The heavier weight was used, together with the associated C of G, as being the pessimistic case. The weights of the pilot and passenger were deduced from medical records and it was calculated that 2.2 Imperial Gallons of fuel remained in the aircraft at impact.

The all-up weight of the aircraft was estimated at 562.3 kg and the position of the C of G as 35.7 cm aft of datum at the time of the accident. The Certificate of Airworthiness provides for a maximum all-up weight of 590 kg with a C of G range 17.4 to 41.4 cm aft of the datum.

1.7 Meteorological information

An aftercast prepared by the Meteorological Office shows that a fairly dry north-easterly airflow was affecting the Enstone area. A weak and slow moving cold front lying from north Yorkshire to west Wales was producing medium and high level cloud over central England, but with little or no precipitation.

Wind and temperatures:

Surface	NNE to N	5 to 8 kts	16–18°C
1,000 feet	020°	12 to 15 kts	16°C
2,000 feet	040°	15 to 20 kts	13°C

Cloud:

Remnants of Cumulus cloud, base 3-4,000 feet, cloud tops 6,000 feet. Variable 3/8 to 6/8 Stratocumulus base 5,000 feet, tops 6,000 feet. 5/8 to 8/8 Altocumulus, Altostratus and Cirrostratus all above 8,000 feet.

Visibility:	15 kilometres or more
Precipitation:	Nil
Height of 0°C Isotherm:	8,000 to 9,000 feet
Turbulence:	No significant turbulence would have been expected between the surface and 5,000 feet
Time of sunset:	2008 hrs.
Time of civil twilight:	2053 hrs.

1.8 Aids to navigation

Not relevant.

1.9 Communications

Not relevant.

1.10 Aerodrome information

Enstone airfield is a disused military aerodrome. The land areas have reverted to agricultural use, and the runways and a grass landing strip were in use by a gliding club and other light aviation organisations based at the airfield. No air traffic control services were provided, nor was there any fire or rescue service.

1.11 Flight recorders

No flight recorders were required and none were fitted.

1.12 Examination of wreckage

1.12.1 Examination on site

The fuselage impacted the ground close to the north side of Runway 26 at Enstone. The forward section was destroyed by the impact in a manner consistent with the fuselage including the tail unit having fallen nose first, nearly vertically and at high speed, into the ground.

The starboard wing fell near by on the runway edge. It showed evidence of having hit the runway after falling at a much lower speed. The port wing was found about 350 metres to the south-east of the fuselage, and a number of canopy fragments and loose items from within the cockpit fell within 100 metres of that wing. The wing had also suffered some damage to its centre-line attachments on ground impact in addition to damage inflicted in the actual separation.

The rigging pin was found to have fractured, the lower part coming to rest close to the starboard wing root. The upper part was found still in lug A of the port wing, (see Fig 1) the lug having become bent upwards and outboard relative to its normal position, thus trapping the top part of the rigging pin.

The safety pin was not recovered, having apparently been sheared into three sections as the top part of the rigging pin was pulled through a lug during the latter part of the wing break-up.

The complete wreckage was transported to the Accidents Investigation Branch engineering facility at Farnborough for more detailed examination.

1.12.2 Detailed examination

Examination of the wing root area indicated that a failure of the lower attachment had occurred (figure 3). This had permitted the wings to pivot upwards about the upper attachment causing secondary failures which then allowed both wings to separate completely. The initial failure occurred in lug E of the port wing (figure 1). Lug H, however, showed evidence of having been bent downwards and its internal

bore had apparently been in contact with the curved section at the bottom end of the main rigging pin. The nature of the damage to lug H, coupled with the absence of damage to lug G and to the section of the rigging pin normally passing through these two lugs, indicated that lug E had failed due to overloading while virtually no load was being carried by lugs G and H.

Inspection of the upper part of the rigging pin revealed that an additional safety pin hole had been drilled approximately 0.2 in (5 mm) below the normal safety pin hole and at about 90° to it. The original hole was centred 1.95 in (49.5 mm) below the lower face of the flange at the top of the pin. The lower hole was believed to have been drilled since the rigging pin was manufactured but it could not be established when or by whom this had been done. From examination of witness marks on the rigging pin it was evident that at the time of the failure of the wing attachment the safety pin had occupied the lower (incorrect) pin hole.

Detailed examination of the rigging pin revealed evidence of two polished bands on the lower cylindrical section of the pin. One extended upwards from the blend of the bottom radius with the lower end of the cylindrical section to a point 0.6 in (15.2 mm) above the blend (see figure 4). There was evidence of a very thin unpolished ring midway up this polished band. Approximately 1.32 in (33.5 mm) above the blend on the rigging pin was the beginning of a further polished band about 0.6 in (15.2 mm) wide, again with a thin unpolished ring midway up the band. Although the damage to the rigging pin was such as to render it impossible to establish its original length accurately, it was apparent that it had for a considerable time in its history been positioned so that lugs E and F were aligned with the upper of the two polished sections and lugs G and H with the lower, ie, the rigging pin had been driven fully home so that the cylindrical section passed through all the lugs and contacted the full depth of the internal bore of lug H (see detail in figure 2). In this position the safety pin was capable of being inserted in either the correct or the incorrect hole. However, examination of the geometry of the system indicated that whilst the rigging pin would be held securely in its proper position by a safety pin in the correct (upper) hole, if the safety pin was placed in the other hole the rigging pin could migrate upwards by the amount of the distance between the holes ie, by a maximum of 0.2 in (5 mm).

The rigging pin had definite shear distortion some 1.38 in (35 mm) above the lower end of the bottom cylindrical section which must have been inflicted by lugs E and F. The associated shear loading had been inflicted over depths of approximately 0.3 in (7.5 mm) above and below the shear face. The position of the main shear distortion plane on the rigging pin was some 0.24 in (6.1 mm) below the unpolished ring in the middle of the higher of the two unpolished bands, showing that at the time the wings failed lugs E and F were positioned with their contact face some 0.24 in (6.1 mm) below the position it had previously occupied ie that indicated

by the higher of the two unpolished rings. The difference between this distance and that of 0.20 in (5 mm) between the two safety pin holes was considered to be due to the plastic deformation of the rigging pin and lugs and to the inclination of the rigging pin under single shear loading. This caused the shear load face to displace axially relative to the rigging pin as the loading increased.

The propeller, its hub, and the pitch change mechanism were examined to determine whether the engine was under power at the time of the accident. The damage to the front of the aircraft was so extensive that although the propeller was found to be in the unfeathered position it could not be established whether it had been selected to this position or had been driven there as a result of ground impact.

1.13 Medical and pathological information

1.13.1 The pilot

The pilot had been found fit at his previous medical examination for his Private Pilot's Licence in February 1982. A full autopsy with histology showed no evidence of previous disease and routine toxicology for alcohol, carbon monoxide and drugs was negative. The pilot's injuries showed that he had been holding the aircraft controls at the moment of impact with the ground, and that he had been killed instantly.

1.13.2 The passenger

A full autopsy with histology showed no evidence of previous disease and routine toxicology for alcohol, carbon monoxide, and drugs was negative. He was killed instantly at the moment of impact.

1.14 Fire

There was no fire.

1.15 Survival aspects

The accident was not survivable. The fuselage fell nearly vertically from an estimated height of 500 feet. Both occupants had been wearing full harnesses and these were still intact. It was impossible to assess the integrity of the harness attachment points because the fuselage was so severely damaged in the impact.

1.16 Tests and research

None.

1.17 Additional information

1.17.1 A related accident

In 1980 a Slingsby T 61 motor glider broke up in Finland during aerobatics. The T 61 was a licensed built derivative of the Scheibe SF 25 motor glider and was constructed by Slingsby Engineering Ltd. Its system of wing attachment was similar to that of the SF 28 Tandem Falke. The accident was investigated by the Finnish Accident Investigation Authorities. They concluded that the bottom end of the rigging pin had been slightly ground down during overhaul in Finland, the result being that there was insufficient parallel portion of the pin in contact with the lowest lug of the wing attachment assembly. This precipitated a failure when the maximum allowable load factor was exceeded during aerobatics.

Following this accident, in November 1980, Slingsby Engineering issued Technical Instruction No 94 requiring operators of T 61 motor gliders to inspect the wing root fitting before the next flight. At the same time the Airworthiness Division of the Civil Aviation Authority issued Letter to Operators (LTO) No 345, drawing the attention of the owners of Scheibe SF 25B and SF 25E motor gliders to the accident and requiring them to perform the following inspection before the next flight:

"1) Remove the wings from the aircraft. Determine the amount of ovality in all the main pin holes in the root fittings.

2) Fitting the main pin to the port (female) fittings pull the pin such that the safety pin is tight on the upper fitting and determine the amount of plain length of the pin protruding from the bottom fitting.

3) Measure the gap at the extreme end of the port (female) fittings between the plates to determine if the plates have been sprung apart during rigging etc. The correct dimension is 33.5 mm."

If ovality exceeded 0.01 in (0.2 mm) or the main pin plain portion did not protrude outside the lower fitting the aircraft was not to be flown until remedial action was taken.

The results of this inspection were to be communicated to Slingsby Engineering who received replies from 24 owners. An analysis of these replies shows that there were 8 cases of lugs whose spacing exceeded 33.5 mm, 6 cases of insufficient pin penetration through the lower lug, and no cases of ovality in the lugs. There were also 4 reported cases of a second safety pin hole in the rigging pin, although this information had not been specifically requested. These owners were advised to obtain new pins or to rivet-up the lower hole to render it unusable.

The Airworthiness Division of the CAA had not included the SF 28 motor glider in these mandatory inspections although the method of wing attachment was similar to the SF 25. At the time of these inspections the accident aircraft (G–BBGA) was in Eire and there was only one SF 28 (G–BARZ) on the British register. No specific check was made of the rigging pin or wing root attachments of G–BARZ until after the accident to G–BBGA when the CAA, on 4 June 1982, issued Emergency Additional Airworthiness Directive 003–06–82 in LTO No 508. This called for the rigging pin of all marks and variants of Scheibe SF 25, SF 28 and Slingsby T 61 motor gliders to be inspected before further flight, and for certain other checks to be made at that time and subsequently at each rigging. As a result of these inspections the rigging pin of the G–BARZ was discovered to be unsatisfactory and was replaced.

Following the accident to G–BBGA the MD of Gordonair Ltd stated that he had been aware of the accident to the T 61 in Finland and that the CAA had called for inspections on certain types, but that these were not applicable to the SF 28.

1.17.2 Pilot's aerobatic experience on SF 28

The pilot's first flight on the SF 28 was on 7 February 1982. His log book records four occasions in March and April 1982 when he flew aerobatic manoeuvres in the aircraft. At this time the aircraft was on the Irish register as EI–BFD and, under the conditions of the Irish Certificate of Airworthiness, aerobatic manoeuvres were prohibited. On 10 May, while acting as an instructor to the Oxfordshire Sport Flying Club, he demonstrated a loop to a student. On this occasion he dived the aircraft to an indicated airspeed of over 110 kts before pulling up into the loop. The maximum permitted airspeed for the SF 28 is 102 kts. Earlier on 26 May, the day of the accident, he had again demonstrated a loop to a student, this time again diving to over 110 kts on entry. Both students had commented to the pilot upon the speeds and the amount of 'g' he used during the manoeuvre and were respectively told the aircraft 'was built like a tank' and that 'you have to get the speed high in order to loop without the engine on'. Information received from the aircraft manufacturer states that the recommended entry speed for a power-off loop is between 97–102 kts and that between 2 and 3 'g' is sufficient to complete the manoeuvre. It was not possible for the student – or the pilot – to assess the loading accurately as there was no accelerometer fitted to the aircraft. However, one student stated that the forces were higher than he had experienced in powered aircraft during aerobatics.

2. Analysis

2.1 The circumstances of the accident are well established. The aircraft was flying in the vicinity of Enstone airfield in fine weather at an estimated height of 1,000 feet when it was seen to dive with the engine running before entering a loop. As the aircraft completed the loop and was pulling up the wings detached from the fuselage. It was clear from the initial examination of the wreckage that the wings had suffered an upward bending failure at the centre-line attachment where the single rigging pin passes through four lugs on each wing root, and the investigation was directed at establishing the reason for this failure.

2.2 **Reason for the wing failure**

The evidence shows that a second hole had been drilled in the aircraft's rigging pin at approximately right angles to and 0.20 in (5 mm) below the correct hole made during manufacture. The positioning of the safety pin in the lower hole allowed the rigging pin to rise from its normal position and disengage sufficiently that the bottom lugs of the lower wing brackets (lugs G and H) were no longer transmitting load. In consequence the load normally carried by these lugs was transferred to lugs E and F, causing them to be subjected to more than twice the load they would otherwise carry during any particular flight condition. The accident occurred when the load imposed during recovery from a loop caused complete failure of lug E. This permitted the wings to pivot upwards about the upper centre-line attachment causing secondary failures which then allowed both to detach completely from the fuselage.

It is understood that on SF 25, SF 28 and T 61 motor gliders considerable difficulty is sometimes experienced in service in inserting the safety pin. This has sometimes been diagnosed as being the result of too great a distance between the top face of lug A and the bottom face of lug D. If this should occur then it can prove difficult to fit the safety pin. It is conceivable that this might have been a problem with G–BBGA in the past, and that the second hole had been drilled to make it easier to fit the safety pin – a seemingly simple solution to the problem but potentially dangerous as it ignored the effect upon the other end of the pin and whether it still ensured that the cylindrical portion of the rigging pin extended for the full depth of lug H.

The wings had last been rigged on 19 May 1982, some 46 flying hours prior to the accident. On that occasion the owner, himself a licensed aircraft engineer, had fitted the safety pin. After the accident he stated that he was unaware of the existence of the two possible holes for the safety pin although he examined the rigging pin for damage and wear, but even if he had noticed the second hole he might well not have realised the effect of this on the engagement of the rigging pin

in lug H. Access to the lower lugs within the fuselage is very difficult; a visual check is impossible without the aid of lights and mirrors and it is only just possible to feel the end of the rigging pin in the lower lug. It is only by fitting the rigging pin into the lugs of the port wing when the wing has been removed from the fuselage that it is possible to observe the effect on the lower lug when the safety pin is fitted in the incorrect hole and the rigging pin then pulled upwards as far as the safety pin permits. Once the aircraft was rigged the wing attachment would have been weakened anytime after the rigging pin had begun to move upwards, as even when fully home the cylindrical portion of the pin did not extend below the lower face of lug H. However, failure would be more likely to occur when the airframe was being subjected to increased stress during manoeuvre or in turbulence. The only known occasion when aerobatics had been performed since the wings were last rigged (on 19 May 1982) was earlier on the day of the accident, when it is reported that the pilot exceeded 110 kts before pulling up into a loop. It is possible that the wing attachment lugs sustained damage during this manoeuvre. It was not possible to establish whether the pilot's handling of the aircraft on the final flight contributed to the accident since insufficient data was available to make an accurate assessment of the loading applied during the manoeuvre. However, the pilot's history of exceeding the aircraft's maximum permissible airspeed during loops makes this conceivable.

The aircraft was in the Republic of Ireland and on the Irish register when LTO No 345 was issued. However, it is reasonable to assume that if the LTO had included the SF 28 type then when G–BBGA was inspected for a C of A on its return to the UK in 1981 the LTO would have been carried out, the presence of the second hole detected, and remedial action taken. Indeed the final owner of G–BBGA, who carried out this inspection, had been aware of the LTO but knew that it did not apply to the SF 28. Because of this evidence the CAA's omission in not including the SF 28 in LTO No 345 is considered to have been a contributory factor in the accident. Additionally, the one SF 28 which was on the British register at the time the LTO was issued was found to have an unsatisfactory rigging pin as a result of inspections after the accident to G–BBGA. This potential hazard might well have been detected earlier had the SF 28 been included in LTO No 345.

2.3 Design consideration

The rigging arrangement of this type of aircraft has the advantage that a single operation normally ensures the safety of the wing attachment. The act of installing the single safety pin should have ensured that the rigging pin was correctly located and would remain so until the safety pin was next deliberately removed. It is evident, nonetheless, that what at first sight is a simple and foolproof system of rigging failed on G–BBGA after the rigging pin was unofficially modified. The circumstances of the accident to the Slingsby T 61 in Finland in 1980 were similar in that again an alteration of the rigging pin when the aircraft was in service caused a loss of engagement which led to an in-flight failure.

The general similarity in design between the wing attachments on the two aircraft and the broad similarity between their failures raises questions about the design of the rigging system itself. With hindsight it can be seen that it would have been possible in the initial design stage to produce a rigging pin which had some form of positive location of the lower end relative to the lowest attachment lug (lug H). This could have made accurate positioning of the rigging pin certain by rendering it impossible to fit the locking device unless the rigging pin was so positioned that all the wing attachment lugs were in contact with the parallel portion of the pin.

While the improper action of the person who drilled the second hole in G–BBGA's rigging pin is recognised, and whilst no criticism of the care with which the original design work was executed is implied, nevertheless an important (although not unique) lesson emerges from this investigation. This is the need for designers to give particular thought when designing critical components as to how these may fare in service if those handling them do not follow normal procedures completely. Another lesson (again not unique) is the need for those concerned with sporting aviation to ensure that unauthorised modifications are not carried out on aircraft for which they are responsible.

2.4 Flight loads and accelerometers

The absence of any loading limit in the SF 28A's C of A for the approved looping manoeuvre and the lack of a cockpit accelerometer to enable a pilot to abide by the 2g turn limit raises the question of how a pilot can know and observe his machine's structural limitations.

The current relevant requirement is Joint Airworthiness Requirement (JAR) 22 for sailplanes and powered sailplanes. This requires that a sailplane in the aerobatic category be fitted with an accelerometer so that the pilot may see the loading, measured in gravitation ('g') units, that he is applying or has applied to the airframe. However, it is noted that there is no such requirement for sailplanes in the utility category, even though they may be permitted to perform aerobatics and may have lower loading limits to take account of their lower structural strength compared with an aerobatic category sailplane. Just as airspeed indicators are a requirement so as to operate the aircraft within its airspeed envelope, so also should an accelerometer be a requirement for all aerobatic aircraft so that flight load limits can be observed. The need for accelerometers in semi-aerobatic or utility sailplanes where the permissible load limits are easily exceeded in practise is at least as strong as that to fit them to fully aerobatic ones, in which the greater permissible load limits are less likely to be exceeded. The same argument is applicable to aerobatic aircraft of all types, not only sailplanes.

It is therefore considered that all aircraft approved for aerobatic manoeuvres should have their loading limits comprehensively laid down and a cockpit accelerometer fitted.

3. Conclusions

(a) *Findings*

(i) The pilot was correctly licensed and medically fit. He was qualified to give gliding instruction in a motor glider.

(ii) The aircraft had been maintained in accordance with the approved maintenance procedures.

(iii) No evidence could be found that the aircraft had been weighed or its centre of gravity established, but the weight and C of G position were assessed as having been within the approved limits.

(iv) At some time in the aircraft's life, an additional and incorrect hole had been drilled through the mainplane rigging pin to accommodate the safety pin.

(v) On the last occasion that the wings of G–BBGA had been assembled, the safety pin had been fitted in this incorrect hole.

(vi) This permitted the rigging pin to move upward out of engagement with the lowest lug on the port wing root, transferring the tensile loads due to wing bending to the remaining lug of the lower port wing attachment bracket.

(vii) This lug failed when the aircraft was pulling out from a loop, leading to wing detachment.

(viii) The CAA did not include the SF 28 when inspections were required of the SF 25 and T 61 motor gliders following a previous accident. Had they done so the second hole in the rigging pin would probably have been detected when the aircraft was inspected for a UK Certificate of Airworthiness.

(ix) The aircraft's engine was in use during aerobatics. This was in contravention of condition 11 of the Certificate of Airworthiness but was not a factor in the accident.

(x) Whilst the pilot had previously exceeded the aircraft's maximum permissible airspeed prior to the entry into a loop it could not be established whether he did so on the occasion of the accident.

(b) *Cause*

The accident was caused by the failure of the centre-line wing attachment assembly allowing the wings to separate from the fuselage during aerobatic flight. This failure resulted from the loss of full rigging pin engagement due to the fitting of the safety pin in an additional and incorrect hole that had previously been drilled in the rigging pin. The possibility that the pilot had exceeded the aircraft's maximum permissible airspeed could not be ruled out. A contributory factor was that the CAA did not require special inspection of the SF 28 following an accident to an aircraft with a similar wing attachment system.

4. Safety Recommendations

4.1 It is recommended that aircraft approved for aerobatics have comprehensive flight load limits available to the pilot, and be fitted with a cockpit accelerometer.

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