

Department of Trade

ACCIDENTS INVESTIGATION BRANCH

**Bell 47G Helicopter G - BBKP
Report on the accident at
Grange Farm, Kingswood,
near Wotton-under-Edge, Gloucestershire
on 20 March 1975**

LONDON
HER MAJESTY'S STATIONERY OFFICE

List of Aircraft Accident Reports issued by AIB in 1976

<i>No.</i>	<i>Short title</i>	<i>Date of Publication</i>
1/76	Sikorsky S-Blackhawk N671SA at Farnborough, Hampshire, England September 1974	April 1976
2/76	Hughes 269C Helicopter G-BABN at Beech Farm, Nr Barnby Moor, Notts January 1975	April 1976
3/76	Hot Air Balloon G-BCCG at Saltley Trading Estate, Birmingham October 1974	June 1976
4/76	Handley Page Dart Herald 203 G-BBXJ at Jersey Airport, Channel Islands December 1974	(forthcoming)
5/76	Aero Commander 680 G-ASHI near Rochester City Airport February 1976	June 1976
6/76	Douglas DC6B, OO-VGB at Southend Municipal Airport, Essex October 1974	May 1976
7/76	Cessna 310 G-APTK at Norwich Airport, Norfolk October 1974	May 1976
8/76	Turkish Airlines DC-10 TC-JAV in the Ermenonville Forest, France March 1974	June 1976
9/76	Piper PA25 Series G-BCAK at Wootton nr Woodstock, Oxfordshire June 1975	July 1976
10/76	Piper PA28 Model-140 G-AVLA south of Biggin Hill Aerodrome, Kent May 1975	August 1976
11/76	Wessex 60 Series 1 G-ATSC in the North Sea north-east of the River Humber Estuary March 1976	November 1976
12/76	Piper PA28 Series 180 (Cherokee) G-AVSB at Denham Aerodrome, Bucks June 1975	October 1976
13/76	Boeing 747 Series 136 G-AWNB north-west of Prestwick Airport, Scotland May 1975	November 1976
14/76	Piper PA 23-250 Turbo Aztec 'D' N6645Y at Arkley golf course, Hertfordshire November 1975	December 1976

<i>No.</i>	<i>Short title</i>	<i>Date of Publication</i>
15/76	Piper PA-31 Model 350 G-BBPV at Little Sandhurst, Berkshire October 1975	<i>(forthcoming)</i>
16/76	Cessna F150 G-AVSS and Cessna F150 near Guildtown, Perthshire November 1975	<i>(forthcoming)</i>

Department of Trade
Accidents Investigation Branch
Shell Mex House
Strand
London WC2R ODP

17 December 1976

The Rt Honourable Edmund Dell MP
Secretary of State for Trade

Sir,

I have the honour to submit the report by Mr P J Bardon, an Inspector of Accidents, on the circumstances of the accident to Bell 47G Helicopter G-BBKP which occurred at Grange Farm, Kingswood, near Wotton-under-Edge, Gloucestershire, on 20 March 1975.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch
Aircraft Accident Report No. 17/76
(EW/C514)

1. Factual Information

Operator: Alan Mann Helicopter Ltd
Aircraft: *Type:* Bell 47G Helicopter
Model: 5A
Nationality: United Kingdom
Registration: G-BBKP
Place of Accident: Grange Farm, Kingswood, near
Wotton-under-Edge, Gloucestershire
51° 37' 40" N, 02° 22' 45" W
Date of Accident: 20 March 1975
All times in this report are GMT

Synopsis

The accident was notified by the police to the Department of Trade on 20 March 1975. The Accidents Investigation Branch of the Department of Trade carried out an investigation and operations, engineering and human factors groups were established.

The accident happened when the aircraft went out of control following a main rotor blade strike on the cockpit canopy and the port side elevator.

It is concluded that though the cause of the accident could not be established, it is probable that rotor instability occurred following the loss of rotor rpm in association with a loss of engine power due to overheating.

1. Factual Information

1.1 History of the flight

The helicopter with just the pilot on board took-off from Fair Oaks Airport shortly after 1100 hrs and flew to a private estate at Axford, a distance of about 24 miles, where it landed at about 1135 hrs. On the ground the engine was switched off and shortly afterwards another pilot, who had been a former student of the first pilot, boarded the aircraft and occupied the left hand pilot's seat. The first pilot remained seated in the right hand pilot's seat.

The aircraft took-off from Axford about 1145 hrs bound for Hereford following a route familiar to the first pilot. Clearance was obtained by radio from Lyneham ATC to fly through the Special Rules Zone (SRZ) about seven minutes before the accident, and this was the last radio contact with the aircraft. At about 1230 hrs the aircraft was seen at about 200–300 feet making a gradual descent in a north-westerly direction towards some fields near Kingswood, Wotton-under-Edge, close to an escarpment at the western end of the Cotswold Hills. The engine was heard to be spluttering and misfiring. Shortly afterwards a sharp noise similar to a whip crack was heard and pieces of the aircraft were seen to fall to the ground. The aircraft rotated in a clockwise direction several times before rolling over onto its back and falling to the ground. The aircraft caught fire on impact and both pilots were killed.

1.2 Injuries to persons

<i>Injuries</i>	<i>Crew</i>	<i>Passengers</i>	<i>Others</i>
Fatal	2	—	—
Non-fatal	—	—	—
None	—	—	—

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

Slight surface damage to pasture land and a hedge.

1.5 Crew information

(a) First Pilot (male)	Aged 36
Licence:	Airline Transport Pilot's Licence (Helicopter/ Gyroplane) valid until 30 April 1975
Aircraft ratings:	Wessex 60; Bell 206A; Bell 47
Certificate of test:	15 January 1975
Certificate of test as a qualified flying instructor:	3 August 1972

Medical certificate: Class 1, valid until 30 April 1975

RTF Licence: Restricted VHF only

Flying experience:

Total hours: 3,200 hours

Hours on type: 845 hours

The pilot was an ex Royal Navy helicopter pilot, and an instructor of considerable experience. He had originally instructed the second pilot on the Bell 47G to qualify for the issue of a Private Pilot's Licence (Helicopters/Gyroplanes). Records indicate that he had last flown with the second pilot on 3 September 1974, about 6 months before the accident.

(b) Second Pilot (female) Aged 31

Licence: Private Pilot's Licence (Helicopters/Gyroplanes) valid until 1 June 1976

Aircraft ratings: Bell 47, Bell 206A and B

Certificate of test: 19 September 1974

Medical certificate: Class 3, valid until 1 June 1976

RTF Licence: Restricted VHF only

Flying experience:

Total hours: 81 hours (Pilot-in-command 29)

Hours on type: 50 hours (Pilot-in-command 10)

The Second Pilot's last recorded flight in a Bell 47 was on 19 September 1974, 6 months before the accident, when she took the flight test for the issue of a PPL(H/G). Since that time she had converted on to the Bell 206 and completed 31 hours flying on that type. During the month of March she had made 14 flights as Pilot-in-command under supervision on the Bell 206 including two on the day of the accident.

1.6 Aircraft information – Bell 47G–5A, G–BBKP

(a) Airframe

Date of manufacture: 1973

Certificate of airworthiness (C of A) General Purpose Category, valid until 9 December 1975

Most recent inspection: Check 1, 13 February 1975 at 171.55 hours

Total flying: (1) since new: 177 hours
(2) since last Check 1: 5 hours

Maximum weight authorised: 2,850 lb

Weight at time of accident	Not established
Centre of gravity limits:	3 inches forward to 4 inches aft of datum
Centre of gravity at time of accident:	Not established
Controls:	Dual
Quantity of fuel remaining at time of accident:	39 imp/gal (estimated)
(b) Engine:	Lycoming VO-435-B1A. Six cylinder horizontally opposed, normally aspirated mounted vertically and restrained at its lower end by four Lord-type mounting rods with secondary restraint provided by four cables
Date of manufacture:	1973
Total running since new:	177 hours
Total running since last C of A:	157 hours
Total running since last Check 1:	5 hours
Type of fuel:	100/130 octane

1.7 Meteorological information

An aftercast for the area where the accident occurred was prepared by the Meteorological Office and is as follows:

Wind; Surface to 1,500 feet:	050°/25-30 knots. Low level turbulence
Surface temperature:	8°C
Surface visibility:	15 kilometres
Cloud:	6/8 strato cumulus 2,000-2,500 feet
Weather:	Nil

The following warnings were in force at the time of the accident and valid until 1900 hours.

- (1) *Strong Wind* - NE wind 20 knots with occasional gusts 35 knots expected during daylight today.
- (2) *Severe Low Level Turbulence* - Moderate, locally severe, low level turbulence expected below 6,000 feet, especially in SE and over high ground of S Wales.

1.8 Aids to navigation

Not applicable

1.9 Communications

The aircraft was in contact with Lyneham ATC on the frequency 123.4 MHz between 1159 and 1223 hrs as it passed through the SRZ. On clearing the frequency the pilot intimated that he was changing to 124.6 MHz which was the frequency for London FIR (East). No calls from the aircraft were heard on this or any other frequency. The correct frequency for the London FIR (W) was 124.75 MHz.

1.10 Aerodrome and ground facilities

Not applicable.

1.11 Flight recorder

Not required and not fitted.

1.12 Wreckage

The helicopter had come to rest on its left side some 150 yards south of the B4058 (Charfield) and B4062 (Kingswood) road junction. Both main and tail rotors were still attached to the aircraft, but showed little evidence of rotation at ground-impact.

The helicopter had left a trail of wreckage which extended some 5/8 mile in a south-south-westerly direction and consisted mainly of cockpit canopy fragments, but also included parts from the left side of the elevator assembly, flight manual pages and various personal effects.

Detailed examination of the wreckage established the following:

- (i) A marked impression of a setscrew-head was found on the leading edge of one of the main rotor blades, 18 inches from its tip. This impression was found to correspond with damage to the end-plate weight on the left side of the elevator assembly, where the upper forward setscrew-head had been sheared-off. Evidence of a main rotor strike was also found on one large section of cockpit canopy, which closely matched contact marks on this main rotor blade.
- (ii) The mast-nut, dynamic flap restraint (DFR) assembly and forward section of the tail rotor drive shaft could not be located in the main wreckage. An extensive search using a metal detector was made, but only the mast-nut and associated tab-washer were found, some 70 feet from the main wreckage.
- (iii) The mast had been bent through some 30° about a point between the stabiliser bar and damper frame. There had been a single contact between the stabiliser bar and damper frame, distorting the latter. Laboratory examination revealed no signs of 'reversal' associated with this bend in the mast.
- (iv) Evidence of heavy bedding was found on the gimbal ring which indicated that the DFR assembly had been opposing severe main rotor flapping loads in flight and as a result had gradually been displaced upwards together with the mast-nut. The main rotor yoke had been contacting the mast due to the excessive flapping and the main rotor blade grips had damaged the stabiliser bar pivot bearings due to similar contact.
- (v) All failures found in the control systems were consistent with the effects of ground impact and the subsequent ground fire. The hydraulic system 'power/manual' switch was found in the gated 'power-on' position.

- (vi) All four Lord-type lower mount rods which secured the engine to the frame had been overstressed at their twin-lug attachments to the sump 'collar' mounting. Conical distortion was present on all four (normally flat) stop-washers which indicated excessive multi-directional displacement of the base of the engine before failure of the mounts occurred. In addition the two aft safety cables, which provide a temporary emergency restraint when the lower mounts fail, had failed in tension and the two forward safety cables had pulled out of their engine attachment plates.
- (vii) Strip examination of the engine, a Lycoming VO435-B1A Serial No. 3743-3, revealed marked heat discolouration of the connecting rods and gudgeon pins from the three right bank cylinders, which was not present in the cylinders on the left bank. Hardness surveys carried out after sectioning the three right bank pistons showed that marked softening of the pistons had occurred, particularly the centre-area of the piston-crowns. A hardness survey of the upper left piston was also carried out for comparison purposes. In addition, thermal discolouration 'print' evidence was found in four of the cylinders which indicated that on two occasions when the engine had been stopped the pistons had been in an overheated condition. There was partial erasing of this effect due to subsequent running of the engine. No evidence of seizure was present.
- (viii) Examination of the engine oil and cooling systems showed no evidence of pre-crash malfunction and in particular the cooling shroud press-stud attachments appeared to have been satisfactory. All six induction pipes were securely attached to their respective cylinders and had charred remnants of their rubber-hose attachments to the induction box. The latter had completely fused.
- (ix) Strip examination showed the main gearbox to be satisfactory as regards the mechanical condition of the centrifugal clutch, freewheel unit, both planet reduction gears and power off-takes. The freewheel unit had however been affected by ground fire heat soakage such that the roller 'air-cushions' had melted and re-solidified in one area, effectively jamming the unit.
- (x) The engine throttle control level gears at the base of the left collective lever, which had bent through some 90° on ground impact, were found at the 'full throttle' position. The remainder of the cockpit instruments afforded little information due to ground fire damage. Of the three lap-belts, only two buckles were found and these were fully fastened.

1.13 Medical and pathological information

A full post-mortem and toxicological examination was carried out on both occupants of the aircraft. No medical cause was found to account for the accident and death in both cases was due to multiple gross injuries.

1.14 Fire

Fire broke out in the wreckage shortly after impact. The local fire service which arrived soon after the accident extinguished the flames, but not before extensive fire damage had been sustained by most parts of the wreckage.

1.15 Survival aspects

The accident was non-survivable.

1.16 Tests and research

Nil.

1.17 Additional information

Nil.

1.18 New investigation techniques

Nil.

When the aircraft was observed to be at a low level and the engine was running, it was still well short of the runway. The aircraft was seen to be banking to the left in view of the engine's position. It was only by chance that it was observed with the evidence of a stall in the engine. It was not until a partial loss of power had occurred and that the pilot had to attempt a go-around that the engine was found to be inoperative. The investigation is currently being conducted with the aim of identifying the cause of the engine failure. The investigation is currently being conducted with the aim of identifying the cause of the engine failure. The investigation is currently being conducted with the aim of identifying the cause of the engine failure.

The nature of the damage to the remaining rods and bolts suggests strongly that they failed when the rotor became unbalanced. The main reason for this is that the rotor is a high speed rotating assembly and any imbalance will cause it to vibrate. This vibration will cause the rods and bolts to become loose and eventually fail. The investigation is currently being conducted with the aim of identifying the cause of the engine failure.

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2. Analysis

When the aircraft was observed to be at a low level and descending gradually towards some fields, it was still well short of its destination. The descent was therefore presumably unintended and, in view of the eye witnesses' reports that the engine was misfiring, together with the evidence of overheating in the cylinders, it can only be concluded that a partial loss of power had occurred and that the pilot had no choice but to attempt a precautionary landing. The loss of control which occurred during the latter stages of the descent was undoubtedly associated with the onset of severe instability of the main rotor resulting in blade strikes on the air-frame. Though there was severe turbulence at low level, there is no evidence from past experience that this would have caused rotor instability provided that the rotor system was correctly balanced and aligned. There is no evidence that the rotor of G-BBKP was other than correctly aligned before flight. The significant fact that emerged from the examination of the main rotor blade that struck the elevator is that the point of contact on the blade was not where contact would have occurred had the blade simply flapped, albeit to an unusual extent, but was some 4½ inches from that point. Furthermore the angle of this blade contact with the elevator was approximately 12° greater than that possible with a correctly aligned rotor mast. From this, it is concluded that immediately prior to the blade strikes on the airframe, the rotor mast itself had moved out of alignment forward and to the left. Though the mast was found to be bent, there are clear indications that this was the result of impact with the ground. The misalignment of the mast in flight must therefore have occurred for other reasons and in this connection the evidence of multi-directional displacement of the base of the engine is significant. There is evidence that the failure of the four restraining rods, which normally locate the engine vertically, was due to over-stressing. Also the two aft safety cables forming the secondary restraint had failed in tension, whilst the two forward cables had been pulled out of their engine attachment plates. With the loss of all restraint, the base of the engine would have been free to move well outside the designed limits and thus would have caused the rotor mast and in turn, the rotor disc to have become misaligned. Also, at the same time, the forward floating section of the tail rotor drive shaft would have become disconnected, thus depriving the pilot of directional control.

The nature of the damage to the restraining rods and cables suggests strongly that they failed when the rotor became severely unstable. Though no positive reason for this instability could be established, the most likely explanation is a loss of rotor rpm. In this connection, the state of the engine becomes significant as the defects that were found could well have resulted in a fall in rpm with associated rough running. Normally the pilot should have been able to maintain rotor rpm by lowering the collective lever as engine rpm was lost. However there is no evidence that this action was taken.

3. Conclusions

(a) *Findings*

- (i) The first pilot was properly licensed and experienced on type. The second pilot was also properly licensed, but was inexperienced on type.
- (ii) The aircraft had been maintained in accordance with an approved maintenance schedule.
- (iii) The engine had been running in an overheated condition, though the cause of this could not be established. The condition of the engine could have resulted in a loss of power and rough running.
- (iv) The pilot attempted to make a precautionary landing whilst *en route* to his destination.
- (v) During the latter part of the descent and whilst at a low altitude the main rotor developed severe instability which was probably due to a loss of rotor rpm.
- (vi) The rotor instability resulted in control of the aircraft being lost.
- (vii) Both the primary and secondary engine restraints failed whilst the aircraft was in flight. This failure could have been due to rotor instability.
- (viii) The failure of the engine restraint allowed the base of the engine to move out of alignment sufficient to cause the forward end of the tail rotor shaft to become disconnected. The movement of the engine tilted the rotor mast sufficiently to cause the main rotor blades to strike parts of the air-frame.

(b) *Cause*

The accident was caused by the main rotor blades striking the air-frame following the onset of severe rotor instability. The instability was probably caused by a loss of rotor rpm in association with a loss of engine power due to overheating of the starboard bank of cylinders.

P J Bardon
Inspector of Accidents

Accidents Investigation Branch
Department of Trade

December 1976