

AIRCRAFT ACCIDENT REPORT No 6/88

Air Accidents Investigation Branch

Department of Transport

**Report on the accident to
Hughes 369HS, G-GASB
at South Highton near Newhaven, Sussex
on 15 August 1987**

LONDON

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9/87	Bell 214 G-BKFN in the North Sea, 14 miles North East of Frazerburgh, Scotland, May 1986	March 1988
1/88	DH 89A Dragon-Rapide G-AGTM at Duxford Airfield, Cambridge, June 1987	March 1988
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3/88	Bell Model 222 G-META at Lippitts Hill, Loughton, Essex, May 1987	August 1988
4/88	Cessna F 172M 00-JEL in the sea, 3 miles east-north-east of Ryde, Isle of Wight, April 1987	August 1988
5/88	Sikorsky S-76A helicopter G-BHYB near Fulmar A Oil Platform in the North Sea, December 1987	November 1988
6/88	Hughes 369HS, G-GASB at South Heighton near Newhaven, Sussex, August 1987	November 1988

Department of Transport
Air Accidents Investigation Branch
Royal Aerospace Establishment
Farnborough
Hants GU14 6TD

14 September 1988

The Right Honourable Paul Channon
Secretary of State for Transport

Sir,

I have the honour to submit the report by Mr D F King, an Inspector of Accidents, on the circumstances of the accident to Hughes 369HS, which occurred at South Heighton near Newhaven, Sussex on 15 August 1987.

I have the honour to be
Sir
Your obedient servant

D A COOPER
Chief Inspector of Accidents

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GLOSSARY OF ABBREVIATIONS

AOC	Air Operators Certificate
ATC	Air Training Corps
CAA	Civil Aviation Authority
RDAF	Royal Danish Air Froce
TOT	Turbine Outlet Temperature

Air Accidents Investigation Branch

Aircraft Accident Report No 6/88 (EW/C1037)

Registered Owner and Operator: Southern Air Ltd

Aircraft Type and Model: Hughes 369HS

Nationality: British

Registration: G-GASB

Place of Accident: South Heighton near Newhaven, Sussex

Latitude 50 48 N Longitude 000 03 E

Date and Time: 15 August 1987 at 1500 hrs.

(All times in this report are UTC)

SYNOPSIS

The accident was notified to the Air Accidents Investigation Branch at 1630 hours on 15 August 1987 and the investigation commenced that afternoon. The AAIB team comprised Mr D F King (Investigator in Charge), Mr S W Moss (Engineering) and Mr D J W Mearns (Operations).

The aircraft had been chartered to carry out pleasure flights at the annual fete organised by a local charity. A number of flights had been successfully completed from the site at South Heighton and the aircraft returned to Shoreham Airport for refuelling. On returning to South Heighton four new passengers were embarked and the pilot prepared to take-off again. On application of take-off power but prior to lift-off the aircraft experienced an uncontained engine failure and settled back onto its skids.

Debris from the uncontained engine failure punctured the main fuel tank and a fire developed which eventually destroyed the aircraft. The pilot and passengers were safely evacuated before the fire consumed the helicopter.

The report concludes that the accident was caused by loosening of the tie-bolt nut clamping the first and second stage gas generator turbine wheels together which led to an uncontained failure of the first stage wheel. Debris released holed the main fuel tank and a ground fire ensued.

The nut became loose because it had not been locked on assembly.

1 Factual information

1.1 History of the flight

In June 1987 the Newhaven based Searchlight Workshops organisation telephoned Southern Air, holders of an Air Operators Certificate (AOC) and requested a quote for a pleasure flight charter on 15 August. On 24 July the organisation wrote to Southern Air to confirm the provisional booking of the helicopter and that it was booked to provide an attraction at their fund raising fete carrying as many passengers as possible on four minute pleasure flights around Newhaven.

On the day of the fete the aircraft departed Shoreham at 1228 hrs with four passengers for Site One, a small field next to the Denton Social Centre, where the fete was being held. Four new passengers were boarded and the aircraft took-off for Site Two, a field next to the A26 in the village of South Heighton. It then operated a number of flights out of this Site before returning to Shoreham at 1434 hrs for refuelling. (Appendix 1)

The aircraft departed Shoreham again at 1444 hrs with 400 lbs of fuel and returned to Site Two to embark another four passengers. Passenger movements at this site were running smoothly controlled by a ground handling team consisting of the Adjutant and three cadets from the local Air Training Corps. The helicopter engine and rotors were kept running between flights whilst passengers embarked and disembarked.

On the next take-off, probably the fifteenth, as torque was applied for lift-off and just prior to leaving the ground the pilot heard a dull thud. He looked over his right shoulder thinking that a door had been slammed shut when the engine-out audio warning sounded and the aircraft settled down on its oleos.

Bystanders who heard the explosion could see a fire at the rear of the aircraft and fuel pouring out from underneath. They tried to warn the pilot and passengers of the danger but their gesticulations were not understood. After a few moments the Adjutant and another woman moved forward underneath the turning rotors and opened the rear passenger doors to assist the two passengers in the aft cabin to leave the aircraft.

The commander meanwhile having heard the engine-out audio warning had closed the throttle but as the aircraft was not fitted with any engine fire detection equipment he had not received any engine fire warning indications. He subsequently saw smoke, told the passengers to leave the aircraft and, after

assisting the front seat passengers, with some difficulty removed the onboard fire extinguisher from its stowage with the intention of fighting the fire when he left the aircraft. However, by the time that he had exited and was able to see the full extent of the fire he considered that the aircraft's fire extinguisher, a 1½ Kg dry powder type, was too small to be of any use. This extinguisher was subsequently discarded without being discharged.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor/none	1	4	-

1.3 Damage to aircraft

The aircraft was destroyed by fire.

1.4 Other damage

None.

1.5 Personnel information

<i>1.5.1</i>	<i>Pilot:</i>	Male, age 34
	Licence:	Commercial Pilot's Licence (H) valid until 14 June 1997 Commercial Pilot's Licence valid until 31 May 1996
	Type Ratings:	Agusta/Westland Bell 47 Series, and Hughes 369D, E, HM, and HS.
	Medical certificate:	Class 1 valid until January 1988
	Flying experience:	Total all types: 8,111 hours Total helicopters: 160 hours Total on type: 30 hours Total last 28 days: 21 hours

1.6 Aircraft information

1.6.1 General information

Manufacturer:	Hughes Tool Company Aircraft Division
Type:	Model 369HS
Airframe serial number:	110275S
Year of Manufacture:	1971
Maximum all up weight:	2,550 lbs
Certificate of Airworthiness:	Transport Category (Passenger) valid until 28 April 1990
Certificate of Registration:	Registered in the name of Southern Air Ltd.
Certificate of Maintenance:	Valid to 3,657.9 hrs or 8 September 1987 whichever occurred first
Total Airframe Hours:	3,635 approximately
Engine Manufacturer:	Allison Gas Turbine, USA
Engine Type:	Model 250-C18
Engine Serial No:	CAE 801655B
Turbine Module No:	CAT 21975P

1.6.2 Description of Allison Model 250-C18 engine (Appendix 2)

The Allison Model 250-C18 engine is a two shaft, free power turbine engine for helicopter applications. The engine is modular in construction with a centrally placed gear-box. The compressor module, mounted on the front of the gear-box, has a low pressure axial section and a high pressure centrifugal section which feed the combustion chamber at the rear of the engine through two external air ducts. From the combustion chamber the air flows in a reverse direction through two stages of turbine (gas generator turbine) which drive the compressor through an inner shaft and a further two stages (free power turbine) which drive the gear-

box through a co-axial outer shaft. The exhaust manifold is mounted directly on to the rear face of the gear-box. The two stages of the gas generator turbine are connected by a "curvic" coupling, a device comprising circumferential dogs, held in engagement by a single central tie-bolt. The curvic coupling aligns and transmits torque between the two stages of turbine.

1.6.3 Maintenance history of the engine

The Serial Number of the failed turbine module was CAT 21975P. Examination of the component history cards showed that this module had been purchased by Southern Air in March 1986 whilst fitted to engine Serial No. CAE 801766B. This engine was one of a number sold to Southern Air by a Danish dealer who had in turn purchased them from the Royal Danish Air Force (RDAF) who were disposing of them as surplus equipment.

Engine CAE 801655B, being another ex-RDAF unit, was accompanied by an Allison engine log book, which contained the component history cards, and a newly-issued Danish civilian log book which recorded compliance details of mandatory Service Bulletins and Airworthiness Directives. It was noted that the latter document bore the signature of an official in the Danish Airworthiness Authority, to the effect that establishment of the log book was approved. Danish civilian log books for other engines, including CAE 801766B, from the same source bore the signature of the Danish dealer who, whilst possessing a relevant Maintenance Engineer's licence, was not entitled to raise a new log book in this way according to the Danish authorities.

Southern Air sought Civil Aviation Authority (CAA) approval for the engines under the terms of Airworthiness Notice No. 16 (see para. 1.17.2.) which included examination of the engine log books. The CAA queried the Dealer's authority to raise the civilian log books but received an assurance *from him* that he was entitled to so act. The Danish Airworthiness Authority confirmed that the dealer was the holder of "an aircraft maintenance mechanics licence (ICAO Type II)" and was authorised to exercise the privileges of the licence on Hughes 369 aircraft with Allison 250 engines on the Danish register. However, following the accident to G-GASB, the Danish Authority has indicated that he was not authorised to raise civil log books. In addition the CAA sought an assurance from the RDAF that the engines had been operated and maintained in accordance with the Allison requirements for civil (as distinct from military) operators. Such a statement was made and the CAA accepted the engines as being fit for use.

Engine CAE 801766B ran approximately 60 hours in Southern Air service before a crack was found in the exhaust collector duct which necessitated sending the turbine module, Serial No. CAT 21975P, away to a UK-based Allison authorised

maintenance and overhaul agency. During the dismantling for this repair work, it was noted that "No 7 Bearing retaining nut found not locked - rectified". The work sheets record this, but since there was no requirement to look further into the engine, specifically the area around the No 8 bearing and turbine tie bolt, this was not done.

After completion of the repair work, the module was re-fitted to another engine, Serial No CAE 801655B, which was the one involved in this accident. At the date of fitment, 11 November 1986, the module had run a total of 1560.4 hours since new but only 174.3 hours since complete overhaul. The log books indicate that the last overhaul was performed by what is now an "Allison Authorised Model 250 Maintenance and Overhaul Agency" in Sweden. In 1979, when this work took place, they were an "Approved Service Centre" for the UK-based Agency previously mentioned. Then, as now, they possessed full CAA Approval for such work, although the overhaul was conducted on behalf of the RDAF.

Engine Serial No CAE 801655B ran a further 50 hours approximately in G-GASB until the date of the accident.

Enquiries were made through the Danish authorities regarding the history and serviceability of engine CAE 801766B and four others sold to Southern Air. The initial response was that only one of the five was serviceable - engine CAE 801655B - when it was withdrawn from use by the RDAF. The others were believed to have been unserviceable when withdrawn due to, variously, high Turbine Outlet Temperature (TOT), time expired, metal in the oil system or low power.

Certainly, the log book for CAE 801766B did not reflect the assertion that when withdrawn from use by the RDAF it was unserviceable due to high TOT. Equally so, the records for another engine operated by Southern Air, CAE 801771, purchased from the same source did not show any indication that it was life-expired as was also claimed by the RDAF after the accident to G-GASB.

The Danish civil authorities have since warned, however, that their government surplus sales were regarded purely as a means of disposing of unwanted material with no warranties offered or implied as to the serviceability of the items sold. Thus, although the records may accurately indicate the life of a component, they are no guarantee that they represent the full history of that component. Immediately upon being declared surplus it would cease to be handled, controlled or monitored in the manner required even for unserviceable but reusable items. Indeed, it would appear that the RDAF advised all purchasers in writing that they should regard the equipment as unserviceable. In this case the purchaser was the

Danish dealer. This position was not, however advised to the CAA when it was pursuing its enquiries following the Southern Air application for acceptance of the engines under Airworthiness Notice No.16 (para 1.17.2).

1.7 Meteorological information

The weather was fine and sunny and the Shoreham airport observation at 1500 hours was; surface temperature 24°C, wind velocity 220/10 kt.

1.8 Aids to navigation

Not relevant.

1.9 Communications

There was no radio communication between the aircraft and either of the two operating sites.

1.10 Operating sites

Southern Air were holders of a valid 'permission' granted by the CAA under the provisions of rule 5(1)(d)(i) of section II of the schedule to the Rules of The Air and Air Traffic Control Regulations 1985.(Appendix 3) However, they were not exercising that permission in operating from Sites One or Two as neither contained an " - - assembly - - of more than 1000 persons - -" at the time of each particular site operation. Consequently the conditions of the permission were not complied with, in particular 2(b) "the authority shall be given not less than 7 days notice in advance of every proposed use of each place to be used for the aforesaid purposes and such notification shall include an Ordnance Survey grid reference and a map or diagram of approximately six inches to the mile scale to identify the location of each place."

The accident site, Site Two, was a fenced grass field measuring approximately 100 metres x 100 metres with access via a farm gate from a main road which bounded its north eastern side. This site had been used by the operator for pleasure flying on previous occasions .

1.11 Flight recorders

The aircraft was not required to be fitted with either a flight data or a cockpit voice recorder and neither was fitted.

1.12 Wreckage and Impact Information

1.12.1 *Preliminary examination*

The helicopter lay in a field a few yards from the main A26 road running between Lewes and Newhaven. Its heading was 210° Magnetic. The tail boom had burnt through at the fuselage junction and fallen to the ground. The fuselage rested on its skids although the aft oleo structure had partially collapsed. The cabin portion had been completely destroyed by fire although enough structure remained to support the main rotor gearbox. The engine compartment doors had burnt away and the compartment was severely fire damaged. One main rotor blade was completely destroyed by fire, whilst the other three were badly heat affected. The underside of the fuselage beneath the passenger cabin was burnt away, exposing the fuel cells located beneath the floor.

It was immediately obvious that the engine had suffered a major uncontained failure in the area of the gas producer turbine wheels. A large number of shrapnel penetrations of the remaining structure and the engine air transfer tube could be seen. The engine turbine case had separated through 360° and it could be seen that the first stage gas producer turbine wheel had completely disappeared. Two fragments of this wheel were later found near the accident site, but the majority of it was not recovered. Witnesses living in a caravan site located 400-500 metres behind the aircraft later reported that small pieces of debris, moving at very high speed and trailing vapour, had passed high over their heads at the time of the accident. Examination of the cockpit controls revealed that the engine throttle control on the pilot's collective lever was set to the ground idle position and the low pressure fuel shut-off knob was still selected to 'ON'.

1.12.2 *Off-site examination*

The helicopter was moved from the site and the engine removed for despatch to an overhaul facility for strip examination. With the removal of the engine, it was possible to see that a piece of debris had penetrated the firewall bulkhead low down on the right hand side, damaging the underside of the skid strut. It was further determined that this same piece had clipped the aft lower corner of the right-hand fuel cell and exited through the lower fuselage skin. One of the two pieces of first stage turbine wheel was recovered from the ground underneath this area. Using a straight rod, it was shown that the trajectory of this piece was in the plane of the first stage turbine wheel (Appendix 4). The size of the hole in the fuel cell was such that a considerable flow of fuel would leak from the puncture.

1.12.3 *Powerplant examination*

The engine was carefully dismantled at an overhaul facility. During strip of the gas producer turbine, removal of the oil sump nut (Appendix 2) revealed that the tie bolt retaining nut had backed completely off the tie bolt thread and had rubbed against the oil sump nut. In addition, the No 8 bearing retaining nut, which has a left-hand thread, had also backed-off roughly 2 turns. The tie bolt itself remained intact although kinked, with the first stage turbine wheel extension shaft, carrying the No 8 bearing, being the only part of the wheel remaining in the engine.

Examination of the remainder of the engine away from the heavily damaged gas producer turbine section showed no evidence of defects or abnormalities. The second stage wheel, although intact had evidence of much material lost by abrasion on the face of the curvic coupling.

1.12.4 *Examination of the tie rod nut and No 8 bearing retaining nut*

The manufacturer's Overhaul Manual for the Model 250C-18 engine states that turbine tie bolt nuts should be discarded after disassembly - i.e. once the nut locking flange has been deformed, it should not be re-used. The No 8 bearing nut may be re-used provided there is sufficient unused locking skirt remaining to lock the nut. Areas which have already been peened are usually marked with a 'nick' to indicate their location and prevent re-use.

Examination of the turbine tie bolt nut showed that the locking flange was well clear of the turbine tie bolt locking spigot and showed evidence of having been driven back by some sort of drift. There were also signs of bruising of the material of the nut as if an incorrect tool had been used to either assemble or remove it (Appendix 5).

The No 8 bearing nut had areas where the locking skirt had been used and all these areas had been 'nicked' to indicate their presence. Some of the areas showed marks of a drift being used to knock the peening away from the locking slot.

1.13 **Medical and pathological information**

Not applicable.

1.14 **Fire**

The helicopter was operating with the main fuel cells beneath the passenger compartment floor nearly full, containing about 400 lb of Jet A1. The auxiliary

tank behind the passenger seat-backs was empty. A piece of debris from the uncontained engine failure had penetrated the firewall at a point just below the right landing skid oleo unit and ruptured the extreme aft lower edge of the right fuel cell, releasing the fuel before exiting the lower fuselage skin. A fire developed on the ground beneath the aircraft and in the engine compartment eventually consuming most of the fuselage.

An amateur video of the burning aircraft taken by a passenger from an earlier flight was made available and gave valuable information. The film which runs for about 8 minutes, was taken from the left-hand side of the aircraft and started some 2 minutes after the turbine wheel had disintegrated.

The video shows the pilot leaving the otherwise empty aircraft and a small ground fire can be seen underneath. The left engine cowling is open and it shows evidence of some shrapnel damage with fire visible behind it in the engine compartment. About 1 minute later the flashing anti-collision light on top of the fuselage is seen to be still operating as the main and tail rotors come to a stop, the battery master switch remaining selected to the 'on' position.

Shortly afterwards the pilot and his passengers, the Air Training Corps team and passengers from the previous flight are seen leaving the field containing the burning aircraft to wait by the side of the main road for the emergency services.

1.15 Survival aspects

The local Air Training Corps (No. 1218 Newhaven) had been requested by the fete organisers to provide a team to help control the passengers as they arrived at the South Heighton site for their pleasure flights. The team which consisted of the Adjutant and three teenage cadets had previously been briefed on helicopter safety precautions by their commanding officer. Their task was to check that the passenger's ticket number was appropriate for the flight, to escort them to the helicopter and to strap them into their seats. Before leaving the aircraft the cadets ensured that the passenger doors were correctly closed and locked and when appropriate a 'thumbs up' signal was given to the pilot to signify that the area around the aircraft was clear.

When the engine failed the explosion was clearly heard and the fire seen by all the bystanders, who immediately waved to the passengers to get out. The passengers and particularly the pilot, who was wearing noise cancelling headphones, did not hear the explosion as anything more than a thud and were initially unaware of the fire.

The Adjutant, and a young woman from the previous flight, immediately ran in under the turning rotors opened the left and right rear doors respectively and helped the rear seat passengers to leave the aircraft. The woman who opened the right rear door reports that she had some difficulty in unlocking the door and that the heat of the fire was apparent on her legs before she was finally able to open it. She also observed that the young boy sitting by the window was unable to unfasten his seat belt unaided and was assisted by the person sitting beside him. The commander and two front seat passengers evacuated without difficulty.

The Adjutant meanwhile returned to her car which was parked in the same field and using the Air Training Corps equipment radioed back to the fete at Site One and requested the emergency services. The Air Training Corps team then cleared everyone from the field and awaited the arrival of the fire service.

It was later observed that the 'TO OPEN' caption below each external door handle and the associated small black arrow pointing downwards in the direction of required movement were positioned such that anyone placing their hand on the handle immediately obscured both.

1.16 Tests and research

None.

1.17 Additional information

1.17.1 Site requirements for pleasure flying

The Southern Air Operations Manual contained detailed requirements to be met when organising public transport pleasure flights among which were:-

3. Fire, Rescue and Medical Services

- (i) The Operations Manager shall make known to the appropriate local fire and ambulance service details of the proposed operation, giving particulars of the site location and of access routes suitable for use by their appliances as soon as it is reasonably practicable.
- (ii) Suitable means for calling emergency services shall be provided at the site, together with written instructions on action to be taken in emergency and contact names and telephone numbers.

- (iii) The company will provide fire rescue and medical equipment in accordance with the Schedule. Such equipment must be available and ready for immediate use.

5. Carriage of Equipment, the Schedule.

The Emergency Services and Equipment:

(i) Fire Fighting and Rescue Equipment

The following shall be provided and available for instant use.

- (a) A suitable vehicle capable of carrying the personnel and rescue and fire fighting equipment.
- (b) 2 x 11 kg dry chemical extinguishers.
- (c) Suitable tools for the release and rescue of persons involved in light helicopter accidents. These shall include:

- 1 x axe, aircraft type
- 1 x bolt cropper 24 inch
- 1 x crowbar 3 foot 6 inch
- 1 x harness knife with sheath
- 1 x flame resistant blanket

- (d) Protective clothing for personnel to include:

- 2 x helmets with visors
- 2 x pairs flame resistant gloves

(ii) Medical Equipment

A sufficient quantity of medical first aid equipment shall be provided including the following:-

Dressings	Quantity
Designated BPC9	6
Designated BPC12	6
Triangular Bandages	6

Equipment

Foil Blankets	6
Scissors	1 pair
Stretchers	1

NOTE: The above dressings and equipment should be packed in protective transparent material.

(iii) Personnel

Not less than two persons shall be available for rescue and fire fighting duties. They must possess adequate knowledge of the door, window and harness release mechanisms on the helicopter being used. They shall also be proficient in the operation and application of the fire extinguishers provided and capable of effectively using the first aid equipment. Personnel may be employed on other duties on the site provided this does not prevent them responding immediately to an accident.

(iv) General

In respect of paragraphs (i), (ii) and (iii) these requirements may be met by the attendance on site of the local authority fire services and a recognised first aid team and ambulance, *ie* St Johns Ambulance Brigade or Red Cross. Should the applicant wish to take advantage of this arrangement a letter of agreement will be necessary from the appropriate organisation. In all other cases the equipment as specified shall be made available on the site.

No evidence was found that any of these CAA approved requirements were in fact met.

1.17.2

Extract from CAA Airworthiness Notice No 16

(relating to engines, propellers and equipment obtained from sources not under the airworthiness control of the CAA).

"1.3 It shall be established that there is no reason to suppose that the item may have become unserviceable as a result of operational abuse, maintenance or unsuitable storage. (See also Airworthiness Notice No 18).

- (a) It may be possible to make this judgement from a knowledge of the previous users. Where an appropriate arrangement exists between the CAA and the responsible authority of a foreign country, a statement certifying serviceability issued by an organisation appropriately authorised by that authority will be acceptable. Failing this, reference shall be made to the CAA which will make a decision taking into account such information as may be available from the responsible authority, the constructor and the previous operator.
- (b) Where adequate assurance cannot be obtained under the methods of (a), the item shall be dismantled sufficiently (taking into account any recommendations issued by the constructor) to enable a judgement to be reached based on the revealed condition. If necessary, rectification action shall be taken before the item is regarded as complying with this paragraph 1.3."

2. Analysis

2.1. The commander's response

The general noise level of the helicopter at take-off power and his headset masked the true sound of the turbine explosion from the commander, causing him initially to think that a door had been slammed shut. Furthermore the subsequent waving and gesticulating from the bystanders who had seen the fire start was not understood.

In the absence of any engine fire detection equipment the commander was faced with a confusing situation which manifested itself as an engine run down with audio warning for no apparent reason. In this difficult situation he became aware of smoke, closed the throttle and told the passengers to leave the aircraft. The Hughes Flight Manual carried on the aircraft did not contain a drill such as an Engine Fire Drill or an Engine Start Fire Drill which would have helped the commander to focus his actions in the emergency. As the engine and rotor blades slowed down he prepared to leave the aircraft and with some difficulty removed the onboard fire extinguisher. However, by the time he had evacuated the aircraft he assessed that the fire was too large to be influenced by the onboard extinguisher and, without discharging it, discarded it.

In the event although he did not close the throttle below the 'ground idle' position, operate the fuel cut-off or switch off the battery master switch the outcome was probably not affected.

2.2 The Engine Failure

There are several possible causes of an uncontained failure of a turbine wheel, including overspeed, material defects or overtemperature effects. Only two fragments of the first stage turbine wheel from the engine were recovered and it is therefore not possible to state categorically that the material was free of defects despite the fact that no evidence of such was found on the two pieces.

Metallurgical examination of the two fragments did not reveal any signs of significant overtemperature, sufficient to have led to failure of the wheel, having occurred.

The condition of the curvic coupling on the second stage turbine wheel, however, showed there had been significant differential rotation between it and the first stage wheel which would, of course, not occur in normal circumstances. Notwithstanding the fact that the engine rotates at very high r.p.m. in normal

operation, the amount of energy imparted to the wheel fragments was very great, as witnessed by the apparent distance they were thrown after failure, leading to the suggestion that the wheel was subject to an overspeed condition.

Disconnection of the Curvic Coupling would lead to such an overspeed, since the torque generated by the first stage turbine wheel is transmitted to the compressor through the second stage wheel via the coupling. If it became disconnected, rapid overspeed of the first stage wheel would inevitably follow.

Such a disconnection could only occur through a loss of integrity of the tie bolt connection either by fracture of the tie-bolt itself, as occurred in a Model 250-C20 engine (see AAIB report 8/82), or a loss of clamping torque on the turbine tie bolt nut.

In the case of G-GASB, the turbine tie bolt remained intact but the nut had clearly become completely undone and it must therefore be concluded that this was the reason for failure of first stage turbine wheel.

There are a number of reasons to believe that the nut had not been locked on last assembly:

- (a) Nuts which have been forced against their locking collar to undo them (the normal method of dismantling) remain tight on the tie rod spigot if attempts are made to re-assemble. There was considerable clearance present on the subject nut, which bore evidence of a drift being used to drive back the locking collar.
- (b) Number 8 bearing retaining nut and, apparently, number 7 bearing retaining nut were also not locked, the latter being detected during the last workshop visit by the turbine module.
- (c) Throughout the considerable history of this type of engine there do not appear to have been any cases of a properly locked turbine tie bolt nut coming undone.

The component history card for turbine module CAT 21975P showed that the last shop visit by the module for overhaul was in February 1979 in Sweden. It would then appear that it returned there in August 1979 for "modification". The log book for engine CAE 801766B, which had been fitted with turbine module CAT 21975P, shows an entry for April 1980 indicating that the compressor was "inspected" and the turbine was "repaired". Inquiries with the Swedish company concerned failed to provide information on this workshop visit, although they were able to provide worksheets covering the previous visits. These were in

order and, whilst it could be argued that their work practices may have changed in the 7 years since they last saw that particular module, their current procedures were beyond reproach as one would expect given the nature of their business. In particular, they follow the Allison guidelines regarding non re-use of turbine tie bolt nuts and possessed the correct tools to lock and torque tighten them.

This latter point is of particular significance because of the damage observed on the nut which appeared to indicate that it had either been undone or re-tightened using an incorrect tool. They also advised that they never undo a locked tie rod nut by driving back the collar with a drift - they simply turn the nut using the correct tool against the locking.

It must therefore be concluded that it was unlikely to have been the Swedish overhaul agency who apparently failed to lock three vital nuts in the turbine module. The general impression created was that the module had been tampered with on a very casual basis possibly by someone who did not realise that it would, sometime in the future, be returned to service without strip examination.

2.3 Airworthiness Notice No. 16

As can be seen from paragraph 1.17.2, Southern Air had to demonstrate to the CAA that, in addition to all the normal requirements regarding overhaul and scrap life information, the engines they purchased from Denmark were serviceable, assuming that they wished to commence operating them without strip inspection or overhaul. Whilst it was reasonable to assume that the log books were correct regarding the history of the engines in-service with the RDAF, it is evident that they were stored for some 5 years before being sold to the Danish dealer. The statement obtained from the RDAF regarding the operation and maintenance of the engines was no assurance of their serviceability state but may have been construed as such. In retrospect it is regrettable that such a specific assurance was not sought, since it appears that the RDAF would have been unlikely to have committed themselves, given the nature of their surplus equipment sales and this should have alerted Southern Air and the CAA to the possibility that it was not a straightforward transfer of components in a current, serviceable condition as was indicated by the log books.

Information recently obtained from the RDAF on the condition of some of the engines sold to Southern Air via the Danish dealer was certainly not consistent with entries made in the technical records held by Southernair. In the particular case of an engine Serial No. CAE801771, which the RDAF has since said was withdrawn from use "unserviceable due to high TOT and engine time-expired", Southern Air were able to produce apparently unquestionable documentation to

show that it had been overhauled shortly before its withdrawal from use by the RDAF.

The apparent inconsistency between the records and the recent statements of the RDAF serves to highlight the inadvisability of placing reliance upon technical documentation accompanying surplus equipment from this source, at least. It may also apply to other ex-military equipment. It should be noted, however, that the RDAF had notified purchasers that their surplus equipment should be regarded as unserviceable. It would appear that this advice was not passed on to either Southern Air or the CAA by the Danish dealer. It could be argued that the practice of disposing of equipment together with its technical documentation on these terms is open to misrepresentation and it would have been better to have endorsed the log books themselves if it was intended to declare that the equipment was unserviceable as sold. The issuance of apparently invalid Danish civil log books, whether deliberately or due to misunderstanding, also contributed to the misleading impression of the serviceability state of the engines.

2.4. Passenger Handling and Evacuation

On arrival at the site for their flights passengers were escorted to the aircraft and helped to strap in by the cadets from the ground handling party. There was therefore no possibility of a full passenger briefing before the flight nor time available to read the passenger briefing card on the aircraft before departure. Furthermore, as the passengers were assisted in fastening their safety belts it is not surprising that one young person had to be helped to release his belt when the emergency occurred.

The actions of the Adjutant, and a young woman from the previous flight, in rushing forward underneath the rotating blades to open the passenger doors and start the evacuation was praiseworthy. Eyewitness and video evidence of the aircraft on fire suggests that their efforts ensured that the passenger evacuation was completed successfully.

Had the evacuation been delayed for any reason the lack of fire fighting equipment and personnel could have been critical.

2.5 Fire fighting

The only equipment available at Site Two to fight the fire was the 1.5 Kg dry powder extinguisher carried in the helicopter. The commander assessed that it would be of no use against such a fire and it was not used.

There were no means of contacting the local emergency services direct and the alarm was raised by the ATC Adjutant via a radio link to Site One. The local services had not been briefed about the helicopter operations and there had been no preplanning for an attendance at the site. Their arrival was too late to save the aircraft.

The availability of two 11 kg dry chemical extinguishers at the site as specified in the Operations Manual should have enabled trained personnel to save the aircraft.

2.6 Selection, equipping and notification of Sites

The purpose of the flights qualified them to be classified as public transport, pleasure flights requiring the operator to conduct the charter in compliance with the terms and conditions of his AOC.

Southern Air were holders of a current 'permission', granted by the CAA, to "- fly closer than 3000 feet , but not less than 1000 feet over - - - more than 1000 persons." However, as the operations never involved taking advantage of the terms of the 'permission' the conditions were not met, nor were they required to be. This meant that the CAA were not notified of the intention to operate from Sites One or Two. Had they been notified maps of the proposed sites would have been vetted by the Authority for suitability and a 'spot check' on the operation a possibility. Such situations could frequently arise denying the CAA an opportunity to monitor the operators conduct of off airfield operations.

The Southern Air Operations Manual contains clear guidance on the requirements to be met for pleasure flight operations from off airfield sites. This includes criteria to be met regarding the size and positioning of the site and in particular the Schedule contains detailed requirements to be met with regard to the provision of fire fighting, rescue equipment and personnel.

Site Two at South Highton where the accident occurred was adequate for pleasure flight purposes however no equipment for fire fighting or rescue was provided by the operator nor were adequately trained personnel on the scene. Although a small party of ATC cadets was present their task was simply to organise passenger movements on and off the aircraft.

The intention to operate the helicopter from both Sites One and Two was not notified to the local authority emergency services as required by the Operations manual. Consequently had rescue been necessary the difficulties caused by a lack of equipment and personnel on site might have been compounded by a less than optimum response from the local services.

3

Conclusions

(a) Findings

- (i) The pilot was properly licenced and adequately experienced to conduct the flight.
- (ii) No Engine Fire Drill was detailed in the aircraft Flight Manual.
- (iii) The pilot, in the absence of an appropriate drill did not close the throttle below 'ground idle', operate the fuel cut-off or switch off the battery master switch. However, these omissions probably did not affect the outcome.
- (iv) The helicopter had been maintained in accordance with an approved maintenance schedule and the Certificates of Airworthiness, Maintenance and Registration were valid at the time of the accident.
- (v) The helicopter was destroyed by fire following an uncontained failure of the first stage gas generator turbine wheel, a fragment of the wheel rupturing the right main fuel tank cell, releasing fuel which ignited beneath it.
- (vi) The uncontained engine failure was caused by an overspeed of the first stage turbine wheel due to a disconnection of the curvic coupling between it and the second stage turbine wheel.
- (vii) Disconnection of the curvic coupling occurred because the turbine tie bolt nut became loose resulting in a loss of clamping force between the two turbine wheels.
- (viii) The tie-bolt nut became loose because it had not been locked during its last assembly. The Nos 7 and 8 engine bearing nuts had also not been locked.
- (ix) The person or organisation responsible for failing to lock the turbine tie bolt and engine bearing nuts could not be identified.
- (x) The RDAF, the original operator of this and certain other engines and modules imported into the United Kingdom has advised that they can accept no responsibility for the serviceability of such engines and that some were known to be in an unserviceable condition when disposed of by them. Such information was not evident in the technical documentation passed to Southern Air. The RDAF would, however, appear to have advised the dealer who initially purchased the engines that he should regard them as unserviceable.

(xi) The Civil Aviation Authority granted Airworthiness acceptance of the subject turbine module and other engines under the terms of Airworthiness Notice No 16. However, in seeking to establish that the engines were serviceable, in addition to being within laid-down life limitations, the Civil Aviation Authority did not make enquiries directly of the RDAF or the Danish Airworthiness Authorities to verify the information and assurance provided by Southern Air's supplier.

(xii) In the case of all but one, the ex-RDAF engines sold to Southern Air had Danish civil log books which had been issued by an unauthorised person and they had not been approved by the Danish Airworthiness Authority.

(xiii) The operator did not comply with the requirements of his Operations Manual in conducting this public transport charter, in particular with respect to the provision of Rescue and Fire Fighting Personnel and equipment.

(xiv) The operator failed to provide the required ground handling party and consequently a team of inexperienced young cadets were assisting members of the public to embark and disembark the aircraft operating beneath the turning main rotors and in close proximity to the tail rotor.

(xv) There was no preflight briefing of the passengers in particular they were not briefed on the use of seat belts or on the actions in case of an emergency.

(xvi) The positioning of the instructions for operating the external door handles were such that anyone placing their hand on the handle immediately obscured them from view.

(b) Cause

The accident was caused by loosening of the turbine tie bolt nut clamping the first and second stage gas generator turbine wheels together which led to an uncontained failure of the first stage wheel. Debris released holed the main fuel tank and a ground fire ensued.

The nut became loose because it had not been locked on assembly.

Safety Recommendations

It is recommended that:-

- (1) The Civil Aviation Authority should determine how many complete engines and modules have been imported into the United Kingdom from the same source as the failed module CAT 21975P and action should be taken to ensure that the intent of Airworthiness Notice No 16 is met for these components..
- (2) The Civil Aviation Authority should review its procedures for approving major aircraft components from ex-military or other sources where the vendor is non-accountable to civilian authorities.
- (3) An Engine Fire Drill and Engines Start Fire Drill should be incorporated in the aircraft Flight Manual.
- (4) The Civil Aviation Authority should be notified of all pleasure flights from unlicensed sites enabling them to implement a procedure to more closely monitor compliance with the terms and conditions of an Air Operators Certificate when an operator is engaged on such pleasure flights.
- (5) The Civil Aviation Authority should review the requirements for all emergency equipment, including exits, to ensure that operating instructions remain visible during equipment use.
- (6) The Civil Aviation Authority should introduce more effective requirements for the protection of essential helicopter systems and structure following an uncontained engine failure if the engine manufacturer is unable to guarantee containment.

D F KING

Inspector of Accidents

Air Accidents Investigation Branch
Department of Transport

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