

AS350BA Ecureuil, G-COPT

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Category: 2.3

Aircraft Type and Registration:	AS350BA Ecureuil, G-COPT	
No & Type of Engines:	1 Turbomeca Arriel 1B turboshaft engine	
Year of Manufacture:	1988	
Date & Time (UTC):	16 May 2002 at 1100 hrs UTC	
Location:	Fairoaks Airport, Surrey	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 3
Injuries:	Crew - None	Passengers - 1 (Minor)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilots Licence	
Commander's Age:	54 years	
Commander's Flying Experience:	Approximately 380 hours (of which 100 were on type)	
	Last 90 days - approximately 5 hours	
	Last 28 days - nil hours	
	(The hours were estimated because the pilots log book was destroyed during the accident)	
Information Source:	AAIB Field Investigation	

Synopsis

After starting the engine, in accordance with the after engine start checks, the pilot depressed the hydraulic test button and rotated the cyclic control. As he did so, the collective lever jumped upwards and the pilot fought to retain control but lost. A witness saw the aircraft yaw to the left and then roll onto its right side but nobody was seriously hurt. The collective lever down-lock latch was found to be serviceable and it was concluded that either the pilot had not set it properly or the collective lever was inadvertently knocked thereby releasing the sprung latch. One safety recommendation was made to the CAA regarding the content of the after engine start checklist.

History of the flight

The pilot had planned to take three passengers on a local flight. He completed his usual walk round checks, explaining his actions to his passengers. He then ensured they were seated with their harnesses properly secured before he secured himself into the right-hand pilots seat. The pilot then carried out the normal pre-start checks and he distinctly remembered adjusting the friction on both the collective and cyclic levers. Whilst he could not specifically recall checking that the collective lever was latched down, this formed part of the normal procedure and the pilot was, therefore, sure that he did so.

The pilot started the engine, again explaining what he was doing to one of the passengers seated in the front left-hand seat. With the rotors turning, he then recalled depressing the hydraulic test button on the central console and rotating the cyclic as required during the after start checks. He remembered little after this point other than the collective lever jumping up and a vague recollection of fighting with the aircraft as it went out of control. A witness reported seeing the aircraft start and then slew to the left before rolling to the right and falling onto its side.

The pilots next recollection was lying on his right shoulder with voices shouting GET OUT. He undid his harness and together with the passengers climbed out of the aircraft through the door on the left-hand side which had been pushed open.

The airfield fire and rescue service was quickly at the scene. There was no fire and the fire fighters helped the four occupants out of the aircraft before turning off the aircraft master switch and fuel selector. As the aircraft fell onto its side, the main rotors contacted the ground and broke up sending pieces flying across the apron. One piece had sufficient energy to penetrate a nearby metal hangar. Fortunately, there were no injuries to surrounding personnel.

Hydraulic System

The AS350BA has a single hydraulic system that reduces the pilots workload by providing hydraulically assisted servo controls to actuate the flight controls. There are three servo controls and each one is equipped with a hydraulic accumulator. In the event of an hydraulic pressure failure the accumulators are designed to provide hydraulic assistance for sufficient time to enable the pilot to enter a flight configuration with acceptable control loads.

There are two after engine start hydraulic checks. Firstly, the hydraulic accumulator check verifies that the accumulators are operating and providing hydraulic assistance. Secondly, the hydraulic pressure isolation check verifies that the hydraulics can be isolated using a switch mounted on the collective.

Hydraulic accumulator check procedure

The hydraulic accumulators are tested on the ground as part of the after engine start checks. A HYD TEST button on the control console is used to test the accumulators by cutting off the main hydraulic supply but maintaining hydraulic assistance via the accumulators. The cyclic control is then moved in all axes to evaluate the control loads. If the control loads felt are light then the accumulators are working.

The test procedure as recommended by Eurocopter in their AS350BA Flight Manual is as follows:

- Check : collective pitch locked
- Cut off hydraulic pressure by actuating the test push-button
- Check that the HYD light illuminates and HORN sounds
- Move the cyclic stick 2 or 3 times along both axes separately ?10% of total travel (?2.5cm or ?1 inch), check for hydraulic assistance by absence of control load.
- Press the test pushbutton to restore hydraulic pressure
- Check that the HORN is cancelled and HYD light goes out

If the accumulators are exhausted during this test then the collective will jump up if it is not latched or held down. The sudden movement is due to the collective returning to its normal rigged position when hydraulic assistance is lost. However, two or three rotations of the cyclic stick would not normally result in a loss of hydraulic assistance unless there was a problem with the accumulators.

In August 1996 the CAA issued a change sheet to the AS350BA flight manual which modified the above accumulator check procedure. The primary difference between the CAAs procedure and Eurocopters recommended procedure is in the duration of the movement of the cyclic stick. The CAAs procedure requires that the cyclic stick be moved in a circular manner until control loads are felt. That is, the cyclic movement should be continued until all three accumulators have been exhausted.

The test procedure as recommended by CAA Change Sheet 2 Issue 1 is as follows:

- Check that the collective pitch is locked
- Cut off the hydraulic supply by actuating the test button
- Check that the HYD caption lights up and that the KLAXON (HORN) sounds
- Level the rotor disc
- Move the cyclic stick in a circular, (two inch diameter), manner until control loads are felt. Check that at least four complete rotations can be achieved before hydraulic assistance is lost.
- Press the test push button to re-establish hydraulic pressure
- Check that the HORN is cancelled, and that the HYD caption light goes out

Because the CAA procedure requires that cyclic stick movement is continued until the accumulators have been exhausted, the collective will always jump upwards during this test if it has not been locked down.

Hydraulic pressure isolation check

The hydraulic pressure isolation check verifies that the hydraulics can be isolated in an emergency. The check is performed by shutting off all hydraulics via a switch on the collective: the cyclic stick is not moved. In this check the accumulators are bypassed and all hydraulic assistance is lost upon switch activation. This check will result in an immediate collective jump if the collective lever is not latched down. However, as the switch is located on the collective lever it is more likely that the pilots hand will be on the lever when the switch is operated. Thus he will probably be more able to prevent the lever from moving upwards if it had not been correctly latched.

Collective Down-Lock Latch

The aircraft was equipped with a metal tab to lock the collective in the down position. This tab prevents the collective from moving upwards during the hydraulic check procedures after engine start. The tab has a circular hole in it that engages a knob at the end of the collective as shown in Figures 1 and 2 (*jpg 31kb*). The latch is engaged by pushing down on the collective and using the thumb to pull the spring tab over the knob. The latch can be disengaged in two ways: pushing down on the collective and removing the latch with the thumb or by simply pushing down on the collective with sufficient force until the tab automatically springs back to the upright position as shown in Figure 2. The collective down-lock latch was examined and found to be functioning properly.

Force required to inadvertently unlatch the collective

Ground tests were carried out by the AAIB to estimate the force required to inadvertently unlatch a locked collective. The tests were carried out on the accident aircraft and on two other AS350BA aircraft. A stick force gauge was placed between the collective handle and the Inspectors hand and then downwards pressure applied until the latch automatically released. The average force required to unlatch the collective lever on the accident aircraft was 48 lb. The average force required to unlatch the collective on the other two test aircraft was 48 lb and 50 lb. It should be noted however that the design of the stick force gauge required that the Inspectors hand be placed one inch further aft than normal thus reducing the moment arm and slightly increasing the force required.

Force required to prevent sudden collective movement

A test was also carried out by the AAIB on an AS350BA aircraft to estimate the force required to prevent the collective from jumping upwards during the accumulator test procedure if the collective had not been latched down. The accumulator check was carried out in accordance with the CAA change sheet with the engine operating but with the collective lever un-latched. Approximately 12 rotations of the cyclic were carried out before the first accumulator was exhausted (noticed by a slight change in stick force). When all three accumulators were exhausted, a force of approximately 8 lb was required to restrain the collective lever.

Previous similar accident to an AS350

On 15 December 1998 there was a similar accident to an AS350 HT1 (which has the same hydraulic system as the BA model). In this accident the HYD TEST switch was switched on and the aircraft then reportedly pitched violently nose up and rolled to the right. Control was regained but the aircraft incurred some damage. The subsequent accident report stated: *Given there was no major technical failure, the only plausible explanation is that the collective lever was unlatched*

with the students subsequent control inputs either intentionally or inadvertently made, causing the aircraft to leave the ground in an uncontrolled manner. However, the military Aircrew Manual for this aircraft stated that there was no requirement to exhaust the accumulators. The military accumulator check procedure simply required that the cyclic stick be moved in a two inch diameter circle for a minimum of four cycles.

Anecdotal evidence suggests that similar events have occurred to other civilian AS350 aircraft. It is likely that on these other occasions the pilots were able to regain control and in the absence of an accident, they did not submit a formal occurrence report.

Discussion

From the evidence available it appears that the collective jumped upwards during the hydraulic accumulator check. The resultant collective movement was sufficient to produce enough lift to unload the skids and may have been sufficient to cause lift-off. The pilot then faced the task of having unexpectedly to take control of the rotorcraft without any hydraulic assistance. Unable to regain control in sufficient time the helicopter came to rest on its side.

The collective down-lock latch was examined and there was no evidence to suggest that the latch could have failed due to the collective jump. It is possible that during the checks leading up to the accumulator check, the collective was inadvertently knocked and un-latched. However, as the force required to un-latch the collective was in the order of 48 lb (based on post-accident measurements) this seems unlikely. It is, therefore, more probable that the collective had not been correctly latched prior to the accumulator check. The latching tab is black and stands against a black background and so its position is not highly visible.

The pilot could not recall how many times he rotated the cyclic stick during the accumulator check but he was following the procedure in the CAA change sheet and so it is likely that he rotated the cyclic sufficiently to exhaust the accumulators which resulted in the collective jump.

Discussions with some AS350BA flight instructors revealed that they instruct their students to place a hand on the collective during the hydraulic accumulator test to guard against a potential collective jump. The pilot of the accident aircraft recalled having his hand near the collective but did not recall actually holding the collective during the check.

Risk of losing control

Pilots operating the AS350 should take extreme care in ensuring that the collective is latched down before initiating either the hydraulic accumulator check or the hydraulic pressure isolation check. In particular, there is a significant risk of losing control during the accumulator check if the collective lever has been left unlatched and it is not guarded by the pilots left hand whilst the cyclic is moved. Moreover, if there is an existing accumulator problem, the collective could tend to rise immediately on selection of HYD TEST when the pilots left hand would still be on the test switch, not on the collective grip. Therefore, the first action during the hydraulic checks must be to latch the collective lever and confirm that it is positively locked down.

Recommended safety action

The risk associated with an unlatched collective lever during the after-start checks could be much reduced if the requirement to exhaust the accumulators during their functional check was omitted

from the test procedure. The aircraft manufacturers original test procedure only required two to three rotations of the cyclic stick and did not require exhaustion of the accumulators. Moreover, the military accumulator check procedure does not require the accumulators to be exhausted. Consequently, during the investigation it was recommended to the CAA that they should review the rationale in Change Sheet 2 Issue 1 which requires the accumulators to be exhausted.

Safety Recommendation 2003-07

The Civil Aviation Authority should review Change Sheet 2 Issue 1 to the AS350BA Rotorcraft Flight Manual (Revised Hydraulic Accumulator Test) that requires the hydraulic accumulators to be exhausted during the pre-takeoff accumulator test.

Safety action taken

On 23 December 2002 the Civil Aviation Authority stated that they had investigated the reasons for the inclusion of the Change Sheet into the AS 350 Flight Manual.

The revisions were made to detect a possible dormant fault in the hydraulic accumulators. This dormant fault could prevent there being sufficient energy in the accumulators to enable control of the helicopter to be maintained (in the event of an hydraulic pump failure) whilst recovering to a speed at which the control loads are manageable. The CAA position on the helicopter manufacturers pre-flight check was that it did not adequately establish that there was sufficient energy in the accumulators. The Change Sheet was raised to require the checking of the accumulators to exhaustion (a minimum of four circular movements of the cyclic stick should be possible before exhaustion was reached). Only later did it become apparent that by following the Change Sheet procedure, the collective lever could jump upwards if it was not correctly locked down.

The Authority conducted a review of the CAA Change Sheet Rationale and has concluded that the Change Sheet should (in an amended form) be retained. The amendments to the Change Sheet are:

- The instruction to Check that the collective lever is locked will be emphasised by bold text.

- Before the instruction to move the cyclic in a circular manner, the instruction *Guard the collective* will be introduced.

- The instruction to move the cyclic stick will be changed to Move the cyclic stick in a circular (2 inch diameter) manner for 4 complete revolutions. Check that hydraulic assistance is maintained by the absence of control loads.

- A note will be added after instruction above: It is not necessary to continue the test until the accumulators are exhausted

The Authority also stated that the continued airworthiness aspects of the collective lever latch would be reviewed.