COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-032/CENIPA/2018

OCCURRENCE:	**ACIDENTE**
AIRCRAFT:	**PT-HYW**
MODEL:	**AS350B2**
DATE:	**22FEV2018**

NOTICE

According to the Law nº 7565, dated 19 December 1986, the Aeronautical Accident Investigation and Prevention System – SIPAER – is responsible for the planning, guidance, coordination, and execution of the activities of investigation and prevention of aeronautical accidents.

The elaboration of this Final Report was conducted considering the contributing factors and hypotheses raised. The report is, therefore, a technical document which reflects the result obtained by SIPAER regarding the circumstances that contributed or may have contributed to triggering this occurrence.

The document does not focus on quantifying the degree of contribution of the distinct factors, including the individual, psychosocial or organizational variables that conditioned the human performance and interacted to create a scenario favorable to the accident.

The exclusive objective of this work is to recommend the study and the adoption of provisions of preventative nature, and the decision as to whether they should be applied belongs to the President, Director, Chief or the one corresponding to the highest level in the hierarchy of the organization to which they are being forwarded.

This Final Report has been made available to the ANAC and the DECEA so that the technical-scientific analyses of this investigation can be used as a source of data and information, aiming at identifying hazards and assessing risks, as set forth in the Brazilian Program for Civil Aviation Operational Safety (PSO-BR).

This Report does not resort to any proof production procedure for the determination of civil or criminal liability, and is in accordance with Appendix 2, Annex 13 to the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree nº 21713, dated 27 August 1946.

Thus, it is worth highlighting the importance of protecting the persons who provide information regarding an aeronautical accident. The utilization of this report for punitive purposes maculates the principle of "non-self-incrimination" derived from the "right to remain silent" sheltered by the Federal Constitution.

Consequently, the use of this report for any purpose other than that of preventing future accidents, may induce to erroneous interpretations and conclusions.

N.B.: This English version of the report has been written and published by the CENIPA with the intention of making it easier to be read by English speaking people. Considering the nuances of a foreign language, no matter how accurate this translation may be, readers are advised that the original Portuguese version is the work of reference.

SYNOPSIS

This is the Final Report of the 22Feb2018 accident with the AS350B2 aircraft, registration PT-HYW. The accident was typified as “[SCF-NP] System/component failure or malfunction and [LOC-I] Loss of control in flight".

While flying between SBBR *(Presidente Juscelino Kubitschek International* Airport, *Brasília*, Federal District), and SJMS *(Mineração Serra Grande* Helipad, *Crixás*, State of *Goiás)*, the helicopter suffered a hydraulic-system failure, and made an emergency landing on unprepared terrain.

Close to the ground on the approach for landing, the pilot lost control of the helicopter, which ended up making an abrupt landing after the main rotor blades struck the terrain.

The aircraft sustained substantial damage.

The pilot was slightly injured, but the two passengers were not hurt.

Since France is the State of aircraft manufacture, an Accredited Representative of the *Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA)* was designated for participation in the investigation

TABLE OF CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AMM	Aircraft Maintenance Manual
ANAC	Brazil's National Civil Aviation Agency
ANP	Brazilian Agency for Petroleum, Natural Gas and Biofuels
CIV	Pilot Flight Logbook
CMA	Aeronautical Medical Certificate
CTP	Main Gear Box
DCTA	Brazil's Department of Science and Aerospace Technology
FAP	Pilot Evaluation Sheet
METAR	Meteorological Aerodrome Report
HMNT	Single-Engine Turbine Helicopter Rating
OM	Maintenance Organization
PN	Part Number
PIC	Pilot in Command
PCH	Airline Transport Pilot License – Helicopter category
PPH	Private Pilot License – Helicopter category
SACI	Civil Aviation Information Integrated System
SAE	Private Registration Category – Specialized Public Air Service
SBBR	ICAO A/D designator - *Presidente Juscelino Kubitschek* Intl Airport, Brasília, Federal District
SJMS	ICAO A/D designator - *Mineração Serra Grande* Helipad, *Crixás*, State of *Goiás*
SN	Serial Number
TPX	Private Registration Category – Non-Regular Public Air Transport
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS350B2 **Registration:** PT-HYW **Manufacturer:** Eurocopter France	**Operator:** DS AIR *TÁXI AÉREO LTDA.*
Occurrence	**Date/time**: 22FEV2018 - (UTC) **Location:** Rural area in the municipality of *Santa Rita do Novo Destino*, State of *Goiás* **Lat.** 15°10'41"S. **Long.** 049°05'48"W. **Municipality – State:** *Santa Rita do Novo Destino - Goiás*	**Type(s):** [SCF-NP] System/component failure or malfunction (non-powerplant) [LOC-I] Loss of control - inflight

1.1. History of the flight.

At approximately 13:30 UTC, the aircraft took off from SBBR (*Presidente Juscelino Kubitschek* Intl Airport, *Brasília*, *Federal District*), bound for SJMS (*Mineração Serra Grande* Helipad, *Crixás*, State of *Goiás*) on a flight for transport of personnel and cargo, with a pilot and two passengers on board.

Approximately 30 minutes into the flight, the hydraulic-system emergency light on the alarm panel illuminated, triggering the corresponding sound signal.

The Pilot in Command (PIC) noticed the stiffening of the flight controls, and decided to make an emergency landing in the rural area of the municipality of *Santa Rita do Bom Destino*, State of *Goiás*.

At the end of the approach, as the helicopter was about to land, the pilot lost control of the aircraft, and the main rotor blades struck the ground. Subsequently, the helicopter skids touched the ground, and the aircraft stopped

Figure 1 - View of the PT-HYM at the crash-site.

The aircraft sustained substantial damage.

The PIC suffered slight injuries, while the passengers were not hurt.

1.2. Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	1	-	-
None	-	2	-

1.3. Damage to the aircraft.

One of the main-rotor mast support-rods was broken, the tail boom had a fracture, and there was breakage of the main and tail rotor blades, left skid and left windshield (Figure 2).

Figure 2 - Damage to the PT-HYW tail boom.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

	PIC
Total	696:10
Total in the last 30 days	30:00
Total in the last 24 hours	00:40
In this type of aircraft	Unknown
In this type in the last 30 days	30:00
In this type in the last 24 hours	00:40

Note: Information on the hours flown by the PIC was obtained from his Digital Pilot-Logbook (CIV). Complementary information was provided directly by the PIC**.**

Although the PIC reported having approximately 500 hours of flying time in the occurrence aircraft model, the numbers of his Pilot's Digital Logbook (SACI system/ ANAC) as per the day of the accident summed up to a total of 696 hours and 10 minutes of flight (505 hours and 52 minutes of which in the R22 model, and 187 hours and 36 minutes in the B105 model.

1.5.2. Personnel training.

The PIC did his PPH (Private Pilot Helicopter) course at the *Escola Nacional de Pilotagem*, *Rio de Janeiro*, in 1998,

1.5.3. Category of licenses and validity of certificates.

The PIC held a PCH license (Commercial Pilot - Helicopter category), and had a valid HMNT* rating (*Single Engine Turbine Helicopter).

1.5.4. Qualification and flight experience.

The PIC's Pilot Evaluation Sheets (FAP) were presented and had information on his Initial and Transition Trainings, as well as his Route Training of the AS350 aircraft (period between 04Apr2017 and 11Apr2017).

No records were found in the SACI system of the initial check-ride (06Apr2017, FAP 03), and of the en-route check ride (25Apr2017, FAP 14).

The last date of a flight record in the Pilot's Digital Logbook was 16Nov2016.

However, the Aircraft Logbook No. 021/PT-HYW/17 records showed that the PIC flew a total of 5 hours and 28 minutes in the PT-HYW helicopter on 20Feb2018.

The company offered an internal training annually, which included the training of emergencies. After checking the company's documentation relative to such training, the investigators verified that it included training of AS350 aircraft.

The company's Training Program prescribed four practice-training sessions, with flights of 1 hour and 15 minutes, resulting in a total of 5 hours for the initial training.

As for the PIC's training, three sessions were held on 04Apr2017. The third session consisted of a 32-minute flight not dealing with training of emergencies. On the next day, another "section 3" flight was conducted (duration: 01 hour and 28 minutes), in which the training of emergencies was accomplished as planned. All in all, the PIC's initial training lasted 5 hours and 46 minutes in total. The PIC complied with the requirements of the company's Training Program. According to his evaluation sheets, the overall performance was satisfactory.

Nonetheless, the FAP of the "section 3" flight of 05Apr2017, in the specific item related to the training of the "approach and landing with the hydraulic system cut off" emergency procedure, had the following comment:

> The procedure of landing with cutoff hydraulics was performed satisfactorily, however, such procedure should be dealt with again in the next periodic training sessions, so that an ideal condition may be reached.

On 06Apr2017, as noted in his FAP, the PIC passed the proficiency check ride to earn the HMNT qualification. However, no records were found related to his fulfillment of the aforementioned emergency procedure on the referred check ride.

1.5.5. Validity of medical certificate.

The PIC held a valid Aeronautical Medical Certificate (CMA).

1.6. Aircraft information.

The AS350B2 aircraft (SN AS2765, single engine turbine helicopter) was manufactured by Eurocopter France in 1994, and registered in the Private Registration Categories of Non-Regular Public Transport (TPX) and Specialized Public Air Service (SAE).

The aircraft had a valid Airworthiness Certificate.

The records of the aircraft airframe and engine logbooks were up to date.

The last inspection of the aircraft ("50 hours" type) was performed on 19Feb2018 by *Fênix* Maintenance Organization (COM 0902-61/ANAC), in the municipality of *Goiânia*, State of *Goiás*. The helicopter flew 5 hours and 30 minutes after the referred inspection.

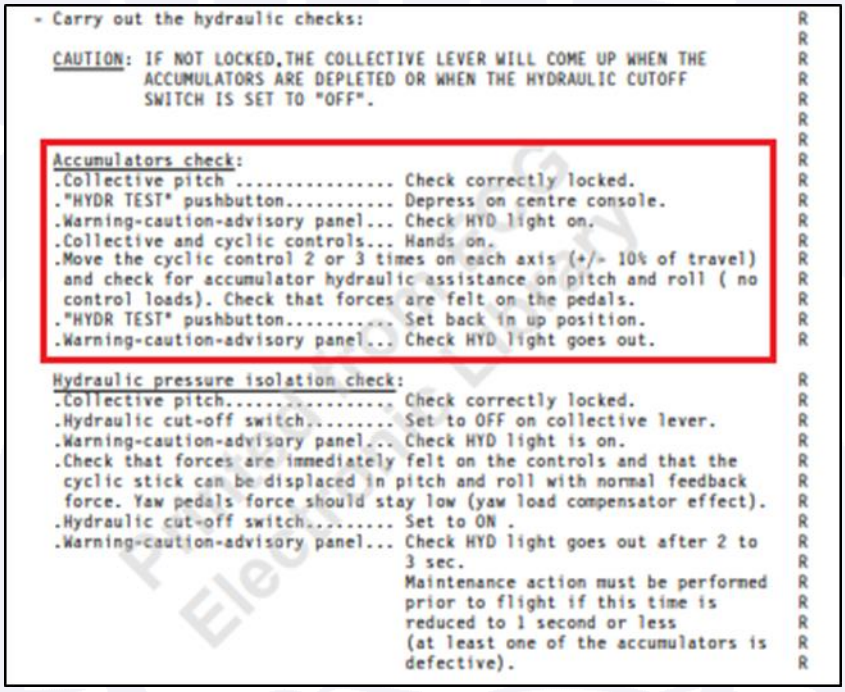
The last "100 hours/12 months" and "150 hours/3/6 months" inspections of the aircraft were performed by *Fênix* Maintenance Organization (COM 0902-61/ANAC), in the municipality of *Goiânia*, State of *Goiás*, on 22Dec 2017. The aircraft flew 30 hours and 10 minutes after those inspections. According to the Airframe Logbook 07/PTHYW/09, the inspections were performed in accordance with the MSM 05-25-00 and ALS 04-20-00.

The hydraulic system of the AS350 was the constant-hydraulic-power type, with a gear pump driven by the Main Gear Box at a constant speed by means of a pulley. There was a filter, fitted with a clogging indicator and a regulating valve with a nominal pressure of 40 bar.

The pump flow was calculated to meet, in all cases, the demand of the servo controls. In case of excess flow, the fluid was routed to the hydraulic tank through the pressure regulating valve, which would open if the pressure exceeded 40 bar.

The helicopter had a HYD TEST pushbutton on its console that made it possible to verify the correct functioning of the hydraulic system accumulators.

According to item 3 “STARTING” (Section 4, Normal Procedures, AS350B2 Flight Manual), the hydraulic test pushbutton was to be pressed only during procedures aimed at testing the hydraulic accumulators (Figure 3).



- Carry out the hydraulic checks:

CAUTION: IF NOT LOCKED,THE COLLECTIVE LEVER WILL COME UP WHEN THE ACCUMULATORS ARE DEPLETED OR WHEN THE HYDRAULIC CUTOFF SWITCH IS SET TO "OFF".

Accumulators check:

.Collective pitch	Check correctly locked.
."HYDR TEST" pushbutton.....	Depress on centre console.
.Warning-caution-advisory panel...	Check HYD light on.
.Collective and cyclic controls...	Hands on.
.Move the cyclic control 2 or 3 times on each axis (+/- 10% of travel) and check for accumulator hydraulic assistance on pitch and roll (no control loads). Check that forces are felt on the pedals.	
."HYDR TEST" pushbutton.....	Set back in up position.
.Warning-caution-advisory panel...	Check HYD light goes out.

Hydraulic pressure isolation check:

.Collective pitch.....	Check correctly locked.
.Hydraulic cut-off switch.....	Set to OFF on collective lever.
.Warning-caution-advisory panel...	Check HYD light is on.
.Check that forces are immediately felt on the controls and that the cyclic stick can be displaced in pitch and roll with normal feedback force. Yaw pedals force should stay low (yaw load compensator effect).	
.Hydraulic cut-off switch.....	Set to ON .
.Warning-caution-advisory panel...	Check HYD light goes out after 2 to 3 sec. Maintenance action must be performed prior to flight if this time is reduced to 1 second or less (at least one of the accumulators is defective).

Figure 3 - Item 3 STARTING AS350B2. Source: adapted from the AS350B2 Flight Manual.

Upon the HYD TEST pushbutton being depressed, the hydraulic test solenoid valves would open, making the fluid return to the tank, and causing an immediate drop of the hydraulic pressure (< 30 bar), illumination of the “HYD” light, and activation of the horn.

As a result of depressing the pushbutton, the operation of the cyclic/collective with hydraulic assistance was limited to the capacity of the accumulators (small reserve of energy), since there was a significant increase of the load required to move the cyclic and collective controls without hydraulic assistance. The control of the hydraulically-assisted pedal dropped to zero on account of the opening of the pedal servo solenoid (Figure 4).

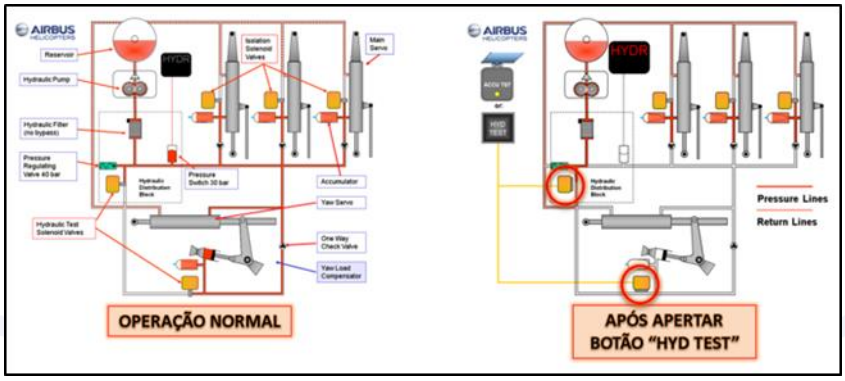
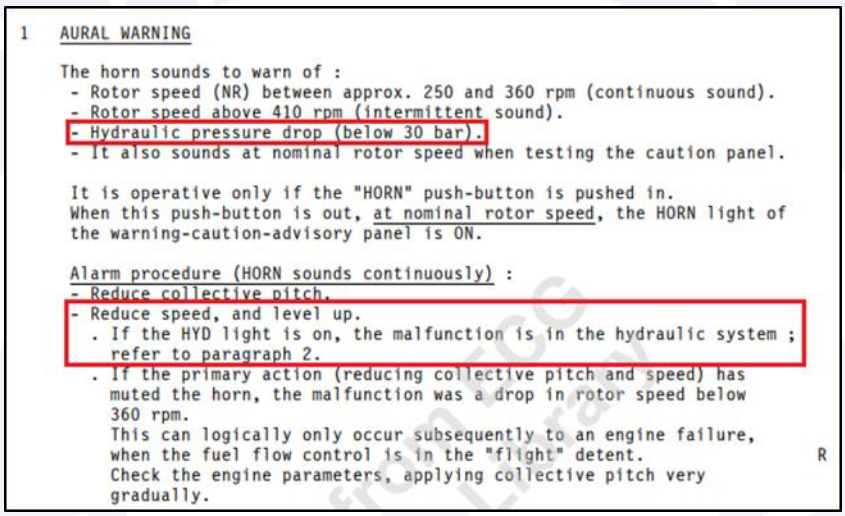


Figure 4 - Diagram of the hydraulic system in normal operation, and after activation of the HYD TEST. Source: Adapted from Airbus Helicopters' Back to the Basics presentation.

In relation to the warning light and aural alarm, the content of the Emergency Procedures, Section 3.3, states that the hydraulic pressure sound alarm activates whenever the hydraulic pressure drops below 30 bars. Likewise, the illumination of the HYD warning light indicates a hydraulic system malfunction. (Figure 5).



1 AURAL WARNING

The horn sounds to warn of :
- Rotor speed (NR) between approx. 250 and 360 rpm (continuous sound).
- Rotor speed above 410 rpm (intermittent sound).
- Hydraulic pressure drop (below 30 bar).
- It also sounds at nominal rotor speed when testing the caution panel.

It is operative only if the "HORN" push-button is pushed in.
When this push-button is out, at nominal rotor speed, the HORN light of the warning-caution-advisory panel is ON.

Alarm procedure (HORN sounds continuously) :
- Reduce collective pitch.
- Reduce speed, and level up.
  . If the HYD light is on, the malfunction is in the hydraulic system ; refer to paragraph 2.
  . If the primary action (reducing collective pitch and speed) has muted the horn, the malfunction was a drop in rotor speed below 360 rpm.
  This can logically only occur subsequently to an engine failure, when the fuel flow control is in the "flight" detent. R
  Check the engine parameters, applying collective pitch very gradually.

Figure 5 - Extract from item 1 of Section 3.3 - Emergency Procedures. Source: AS350B2 Flight Manual.

The aircraft had a filter-clogging indicator in its hydraulic system, which consisted of a pin (1) that would become apparent to an external observer in case of system operation with polluted hydraulic fluid (Figure 6).

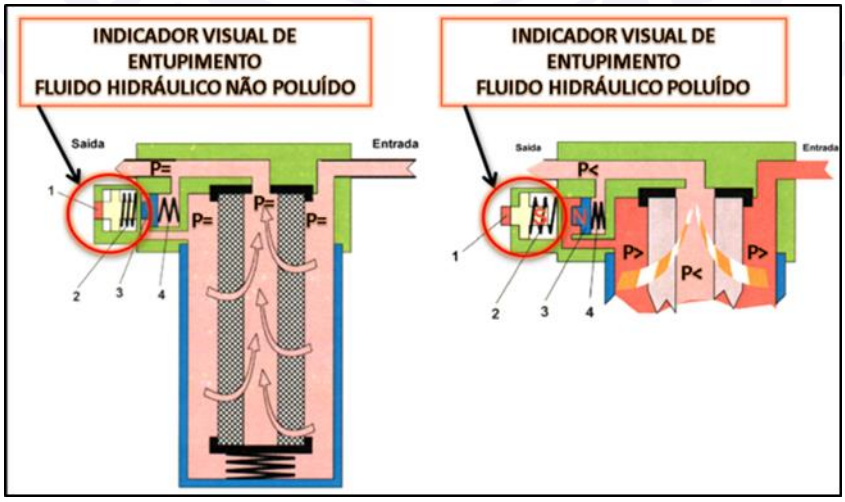


Figure 6 - Detail of the hydraulic-fluid filter-clogging indicator (apparent pin).

Observing the operation in detail, one sees that the pressure difference (ΔP) between the filter inlet and outlet is detected by the magnetic piston (3) and spring (4) assembly.

While the hydraulic fluid is clean, the (ΔP) is small. The spring (4) keeps the magnetic piston against the wall that separates it from the clogging visual indicator (1). The visual indicator (1) is attracted against the wall by the magnetic field of the piston (3), and compresses the spring (2). As the filter element clogs, the pressure at the filter inlet increases. When (ΔP) reaches 2.7 bar, the pressure pushes the piston (3), compressing the spring (4). The magnetic attraction is broken, the spring (2) pushes the visual indicator (1) and the pin of the indicator emerges to indicate filter pollution.

1.7. Meteorological information.

The prevailing weather was consistent with VFR flights.

1.8. Aids to navigation.

NIL.

1.9. Communications.

There were no technical abnormalities affecting the communication equipment during the flight.

1.10. Aerodrome information.

The accident occurred outside of aerodrome area.

1.11. Flight recorders.

Neither required nor installed

1.12. Wreckage and impact information.

The first impact occurred with the main-rotor blades both at a pitched attitude (approximately 5°) and tilted to the left. The impact caused damage to the tips of all the blades and fractured the red blade at the distances of 97 cm and 110 cm from the tip.

The second impact occurred with the aircraft leveled, touching the ground with both skids, with a short displacement to the right (20-cm mark on the terrain).

With the second impact, the control rod of the right-hand servo of the main rotor, the left-hand skid and left-hand windshield got broken, the tail boom was damaged, and the short shaft of the tail rotor transmission was fractured, causing a tear in the protective fairing of the component.

Several dented spots were observed on the fuselage resulting from the forceful vertical impact of the helicopter against the ground, although the supports of the seats were not affected.

The collective control was in the UP position, the emergency hydraulic cut-off switch was in the OPEN position, and the switch-guard was closed (normal situation in flight).

The “HYD TEST” pushbutton was in the depressed position (Figure 7).

Figure 7 - View of the depressed hydraulic-test (TESTE HIDR) pushbutton.

At the initial action of the investigation, upon checking the PT-HYW hydraulic filter clogging indicator, the investigators observed that the pin was apparent (Figure 8).

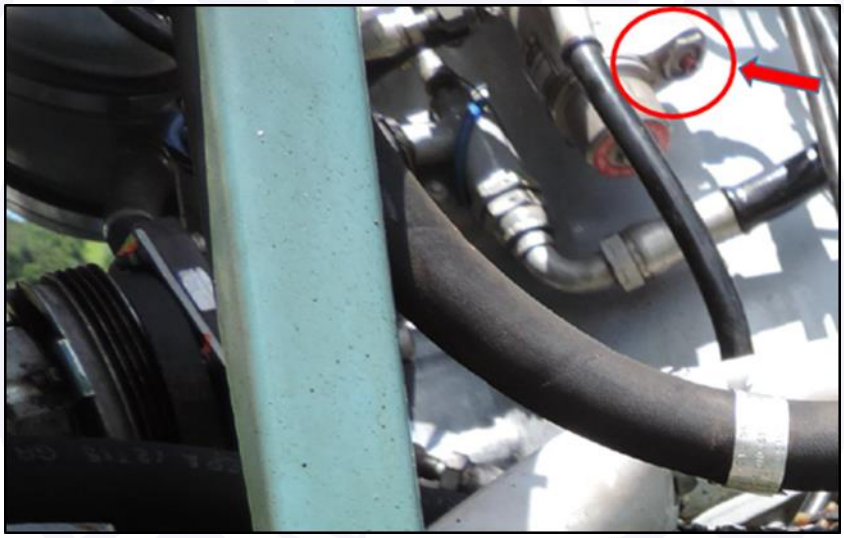


Figure 8 – Hydraulic-fluid filter clogging indicator (with apparent pin).

1.13. Medical and pathological information.

1.13.1. Medical aspects.

There was no evidence that issues of physiological nature or disability might have affected the crewmember's performance.

1.13.2. Ergonomic information.

NIL

1.13.3. Psychological aspects.

There was no evidence that issues of psychological nature or disability might have affected the crewmember's performance.

1.14. Fire.

There was no fire.

1.15. Survival aspects.

The pilot and passengers got out of the aircraft by their own means.

1.16. Tests and research.

Fuel

The test of the aviation kerosene sample collected from the PT-HYW tank revealed compliance with the ANP specifications for the evaluated characteristics.

Hydraulic fluid

The NAS 1638 norm was a standard developed in 1964 to define the classes of contamination that hydraulic fluids in aircraft components could suffer. It determined the level of contamination by counting the particles per 100 ml, in 5 size groups, as shown in Figure 9.

Número de partículas por 100 ml														
Micra	**00**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
5 à 15	125	250	500	1.000	2.000	4.000	8.000	16.000	32.000	64.000	128.000	256.000	512.000	1.024.000
15 à 25	22	44	89	178	356	712	1.425	2.850	5.700	11.400	22.800	45.600	91.200	182.400
25 à 50	4	8	16	32	63	126	253	506	1.012	2.025	4.050	8.100	16.200	182.400
50 à 100	1	2	3	6	11	22	45	90	180	360	720	1.440	2.880	5.760
Acima de 100	0	0	1	1	2	4	8	16	32	64	128	256	512	1.024

Figure 9 - NAS 1638 table.

The Report nº 026/18 of the Hydraulic Fluid Pollution Test performed by HELIBRAS informed a Class > 12 result for the samples of both the hydraulic lines and hydraulic reservoir. The samples showed pollution by particles - Class C NAS 1638 - (Particles ≥ 5µ) (Figure 10).

IDENTIFICAÇÃO DA AMOSTRA

Aeronave	Tipo	S/N	TSN (horas)	Sistema Hidráulico	F.H tipo
PT-HYW	AS350B2	2720	4.558	Mono	MIL H 5606

Data da coleta: 24/02/18 – Origem: **Linhas hidráulicas** Responsável: [redacted]

RESULTADOS

POLUIÇÃO POR PARTÍCULAS - CLASSE (C) NAS 1638 - (PARTÍCULAS ≥ 5 µ)			POLUIÇÃO POR LAMA (PARTÍCULAS < 5 µ)
DIMENSÕES EXTREMAS DAS PARTÍCULAS (µ)	EXIGIDO (Máximo) Classe 10	OBTIDO Classe > 12	ÍNDICE COLORIMÉTRICO (I)
5 a 15	25600	36800	ANOTAR
15 a 25	45600	33200	
25 a 50	8100	10500	500
50 a 100	1440	4720	
Acima de 100	256	2820	
Documento aplicável: IH 0030			Data do ensaio: 02/04/18

OBSERVAÇÕES

Sexto Serviço Regional de Investigação e Prevenção de Acidentes Aeronáuticos.
Anexo do ofício n. 07/ASQ/73 de 19/03/18.
Classificação da ocorrência: Acidente
Solicitante: [redacted]

Contagem aproximativa, devido ao elevado número de partículas.
Partículas ≥ 25 µ (fator 10x)
Partículas < 25 µ (fator 100x)
Gama de partículas que definiu a classe de poluição: acima de 100 µ.

Figure 10 - Extract from the Report of the Hydraulic Fluid Pollution Test of the hydraulic lines. Source: HELIBRAS.

IDENTIFICAÇÃO DA AMOSTRA

Aeronave	Tipo	S/N	TSN (horas)	Sistema Hidráulico	F.H tipo
PT-HYW	AS350B2	2720	4.558	Mono	MIL H 5606

Data da coleta: 24/02/18 – Origem: **Reservatório hidráulico** Responsável: [redacted]

RESULTADOS

POLUIÇÃO POR PARTÍCULAS - CLASSE (C) NAS 1638 - (PARTÍCULAS ≥ 5 µ)			POLUIÇÃO POR LAMA (PARTÍCULAS < 5 µ)
DIMENSÕES EXTREMAS DAS PARTÍCULAS (µ)	EXIGIDO (Máximo) Classe 10	OBTIDO Classe > 12	ÍNDICE COLORIMÉTRICO (I)
5 a 15	25600	35200	ANOTAR
15 a 25	45600	28000	
25 a 50	8100	7300	500
50 a 100	1440	2810	
Acima de 100	256	1220	
Documento aplicável: IH 0030			Data do ensaio: 02/04/18

OBSERVAÇÕES

Sexto Serviço Regional de Investigação e Prevenção de Acidentes Aeronáuticos.
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Classificação da ocorrência: Acidente
Solicitante: [redacted]

Contagem aproximativa, devido ao elevado número de partículas.
Partículas ≥ 25 µ (fator 10x)
Partículas < 25 µ (fator 100x)
Gama de partículas que definiu a classe de poluição: acima de 100 µ.

Figure 11 - Extract from the Pollution Test Report of the hydraulic reservoir.
Source: HELIBRAS.

The analysis performed by HELIBRAS specified that approximate counts ha been made, on account of the high number of particles greater than 25µ. A note was included in the report stating that the range of particles defining the Class of pollution was greater than 100µ.

Hydraulic system

The verification of the main rotor servos, rear servo control, electro valves, and accumulators attested that those assemblies were in good condition, and operating normally at the time of the accident. Further tests were performed using another hydraulic pump, which had a normal operating condition, since the PT-HYW pump did not provide system pressurization.

The hydraulic pump shaft (P/N A5026780), which received the torque and transferred it to the pump's internal gears, showed wear on the notches (splines), as was verified from the comparison between the pump that equipped the PT-HYW and the pump in normal operating condition (Figures 12 and 13).

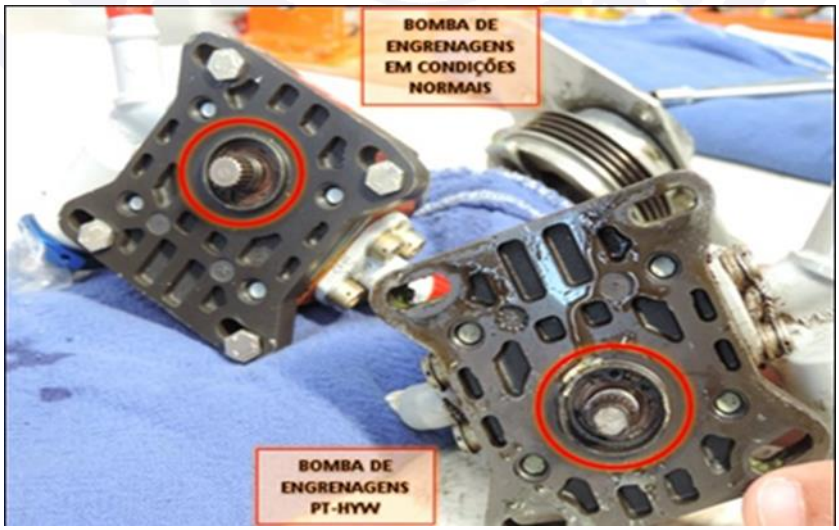


Figure 12 - Hydraulic Gear-Pumps and respective shafts.

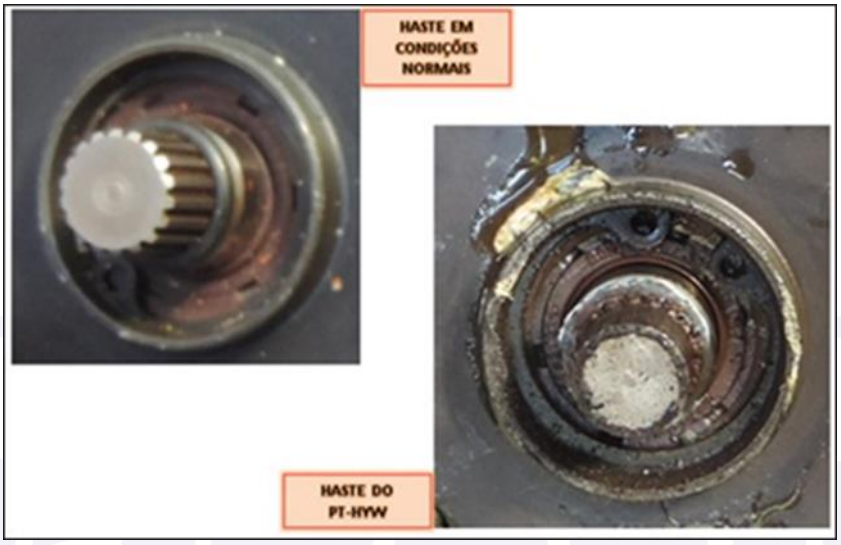


Figure 13 - Detail of the Gear Pump shafts.

With regard to the maintenance procedures, the Airbus Aircraft Maintenance Manual (AMM) 63-11-00,3-2, 2016.06.27 - Page 1, pointed out that the lubrication of the item Drive *Splines of the Belt-Driven Hydraulic Pump MGB/ Engine Coupling* was to be done, in the case of B2 models, in accordance with the work-cards of the "150 hours/12 months" and "600 hours/24 months" inspections, by means of the cards MSM 05-21-00(B2)/MSM 05-22-00(B2) (Figure 14).

Greasing - Drive splines of the belt-driven hydraulic pump MGB / Engine Coupling

Additional information from O.R.I.O.N.	
Work card referenced in the MSM	
MSM 05-21-00 (B2)	150 FH // 12 M
MSM 05-21-00 (B3)	150 FH // 12 M
MSM 05-22-00 (B2)	600 FH // 24 M
MSM 05-22-00 (B3)	600 FH // 24 M

Figure 14 - Lubrication of the item *Drive Splines of the Belt-Driven Hydraulic Pump MGB/Engine Coupling*. Source: AMM 63-11-00, 3-2, page 1, Airbus.

In the sequence, the AMM 63-11-00, 3-2, 2016.06.27, page 2, described the preliminary steps and procedures that were to be performed (Figure 15).

F. Procedure

i NOTE

If any old grease is found, or if there is any doubt when greasing the splines, refer to the work card for Inspection criteria - Drive splines of the belt-driven hydraulic pump (AMM 63-11-00,6-3).

1. Grease the splines of the hydraulic pump shaft and the splines of the coupling sleeve (AMM 29-11-01,4-1).
2. Install the hydraulic pump (AMM 29-11-01,4-1).

End of Document

Figure 15 - Procedure prescribed in the AMM 350 B2B3.
Source: AMM 63-11-00,3-2, 2016.06.27, Page 2, Airbus.

In this sense, the letter F (Procedure) determined the following:

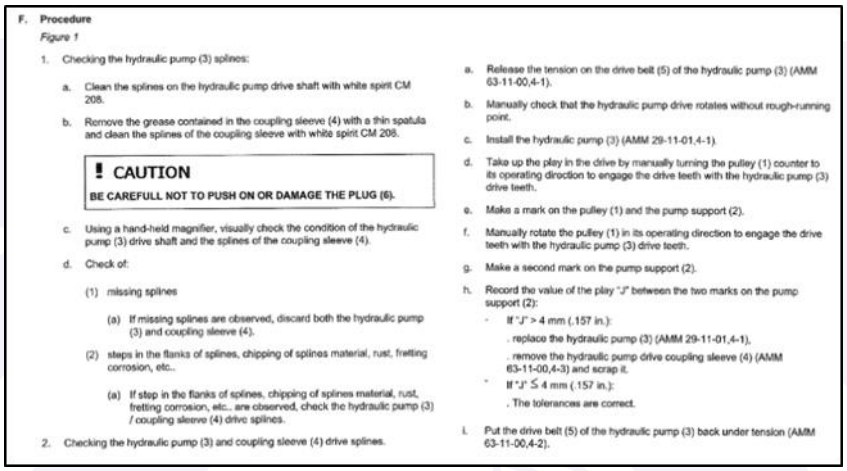
NOTE

If any old grease is found, or if there is any doubt when greasing the splines, refer to the work card for inspection criteria – *Drive splines of the belt-driven hydraulic pump* (AMM 63-11-00, 6-3).

1. Grease the splines of the hydraulic pump shaft and the splines of the coupling sleeve (AMM 29-11-01-4-1).

2. Install the hydraulic pump (AMM 29-11-01, 4-1).

Figure 16 shows the extract of the procedures to be adopted in compliance with the inspection of the *Drive splines of the belt-driven hydraulic pump* (Airbus AMM 63-11-00, 6-3, 2013.11.05 - Page 2-3).



F. Procedure

Figure 1

1. Checking the hydraulic pump (3) splines:
   a. Clean the splines on the hydraulic pump drive shaft with white spirit CM 208.
   b. Remove the grease contained in the coupling sleeve (4) with a thin spatula and clean the splines of the coupling sleeve with white spirit CM 208.

   ! CAUTION
   BE CAREFULL NOT TO PUSH ON OR DAMAGE THE PLUG (6).

   c. Using a hand-held magnifier, visually check the condition of the hydraulic pump (3) drive shaft and the splines of the coupling sleeve (4).
   d. Check of:
      (1) missing splines
         (a) If missing splines are observed, discard both the hydraulic pump (3) and coupling sleeve (4).
      (2) steps in the flanks of splines, chipping of splines material, rust, fretting corrosion, etc..
         (a) If step in the flanks of splines, chipping of splines material, rust, fretting corrosion, etc.. are observed, check the hydraulic pump (3) / coupling sleeve (4) drive splines.
2. Checking the hydraulic pump (3) and coupling sleeve (4) drive splines.
   a. Release the tension on the drive belt (5) of the hydraulic pump (3) (AMM 63-11-00,4-1).
   b. Manually check that the hydraulic pump drive rotates without rough-running point.
   c. Install the hydraulic pump (3) (AMM 29-11-01,4-1).
   d. Take up the play in the drive by manually turning the pulley (1) counter to its operating direction to engage the drive teeth with the hydraulic pump (3) drive teeth.
   e. Make a mark on the pulley (1) and the pump support (2).
   f. Manually rotate the pulley (1) in its operating direction to engage the drive teeth with the hydraulic pump (3) drive teeth.
   g. Make a second mark on the pump support (2).
   h. Record the value of the play "J" between the two marks on the pump support (2):
      - If "J" > 4 mm (.157 in.):
        . replace the hydraulic pump (3) (AMM 29-11-01,4-1),
        . remove the hydraulic pump drive coupling sleeve (4) (AMM 63-11-00,4-3) and scrap it.
      - If "J" ≤ 4 mm (.157 in.):
        . The tolerances are correct.
   i. Put the drive belt (5) of the hydraulic pump (3) back under tension (AMM 63-11-00,4-2).

Figure 16 - Extract from the inspection of the *Drive splines of the belt-driven hydraulic pump* (Airbus AMM 63-11-00, 6-3, 2013.11.05, Page 2-3).

O *AMM 63-11-00, 6-3* described the criteria for inspection of the splines of the hydraulic pump and pulley:

F. Procedure

1. Checking the hydraulic pump (3) splines:

   a. Clean the splines on the hydraulic pump drive with white spirit CM 208;

   b. Remove the grease contained in the coupling sleeve (4) with a thin spatula and clean the splines of the coupling sleeve with white spirit CM 208;

   ! CAUTION

   Be careful not to push on or damage the plug (6).

   c. Using a hand-held magnifier, visually check the condition of the hydraulic pump (3) and the splines of the coupling sleeve (4);

   d. Check of:

(1) Missing splines;

   (a) If missing splines are observed, discard both the hydraulic pump (3) and the coupling sleeve (4).

(2) Steps in the flanks of splines, chipping of splines material, rust, corrosion, etc.;

   If steps in the flanks of spines, chipping of splines material, rust, fretting corrosion etc. are observed, check the hydraulic pump (3) and coupling sleeve (4) drive splines.

2. Checking the hydraulic pump (3) and the coupling sleeve (4) drive splines…

Figure 17 shows the numbers corresponding to the items marked in the extract from the inspection of the *Drive splines of the belt-driven hydraulic pump*.

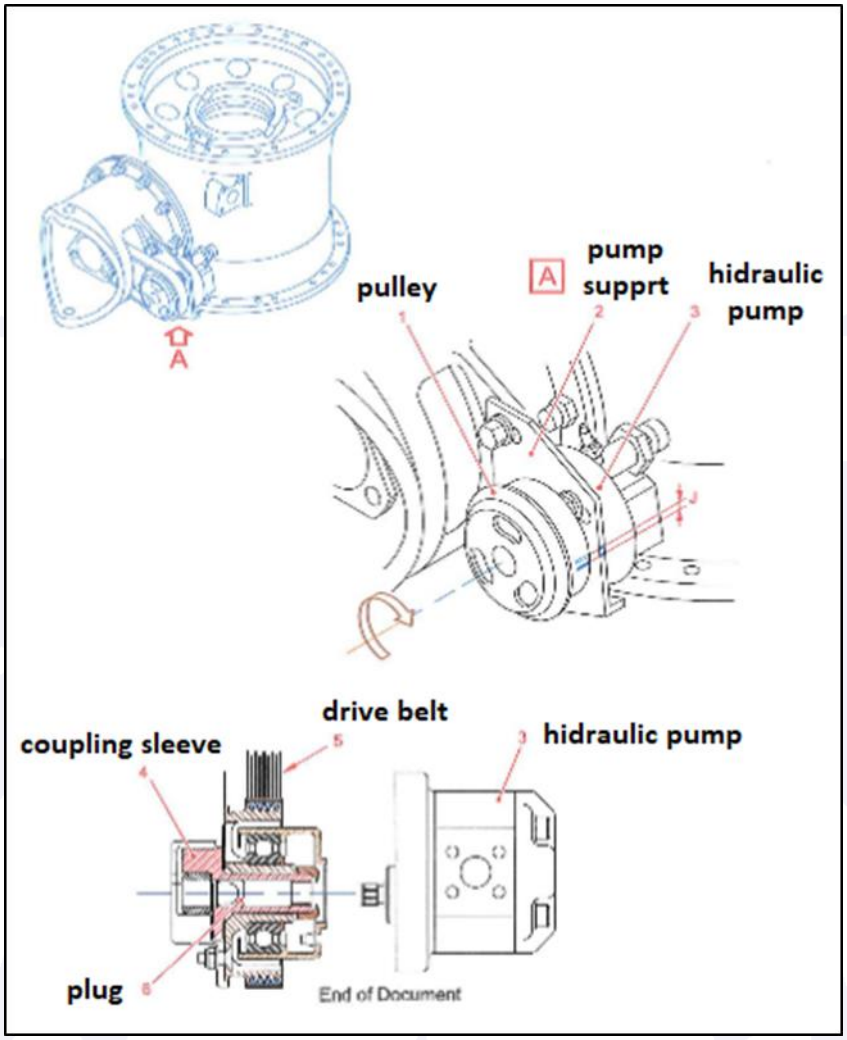


Figure 17 - Inspection Criteria - Hydraulic Pump Spline Belt Drive.
Source: Adapted Airbus AMM 63-11-00, 6-3, 2013.11.05, page 4.

For removal of the hydraulic pump, the applicable document is the Airbus AMM AS350 B2B3 29-11-01, 4-1 (Removal/Installation - Belt-driven hydraulic Pump), by means of the following procedures:

2. Installation of the hydraulic pump

a. Build-up the hydraulic pump (3) if necessary (AMM 29-11-01, 4-2).

NOTE

If bases (2) and (4) are removed, Install new seals (20) and (21). Install protective strainer (6) (DETAIL C), cleaned and blown dry beforehand ((AMM 29-00-00, 3-2) at suction base (2).

b. before installation (*Figure 2*), make sure that:

- pump (3) rotate smoothly and without friction point;

- pulley support (13) is not bent, distored.

c. Check presence of the plug (17) at the bottom of the coupling sleeve (15) visually or with a thin spatula;

! CAUTION

SHOULD IT BE MISSING, INSTALL A PLUG (17), BY REMOVING THE DRIVING FLANGE (19) (AMM 63-11-00, 4-3).

d. Repack the coupling sleeve (15) internal cavity (3) with fresh grease CM116.

(Manual: PREMOD 079561: grease hydraulic pump splines and new O-ring with grease CM 116

Verification of the flight controls confirmed that they were in good condition and operating correctly at the time of the accident, although without the hydraulic system on account of hydraulic pump failure.

In a visit of the maintenance organization facilities, investigators discovered recently-used grease cans with expired validity.

The CM116 grease was an Airbus Helicopter denomination for the NATO CODE G-355 grease, denominated by its NYCO manufacturer as NYCO grease GN06, the same grease that was to be used in the maintenance of the PT-HYW.

The grease validity date of the grease was 30Jun2017, i.e. about 8 months after the expiry date (Figure 18).

Figure 18 - Evidence of use of expired product

1.17. Organizational and management information.

The operator had six pilots in Brazil, and the PT-HYW pilot was the only one based at the headquarters in Brasília, Federal District. The helicopter fleet consisted of AS350 Squirrels.

Scheduled aircraft maintenance was executed by an outsourced company, with the maintenance team traveling from Rio de Janeiro or Goiás during predetermined periods; unscheduled maintenance was the responsibility of mechanics formally hired by the company, who resided in Brasília.

According to reports, there was trust between the pilots and the maintenance team in relation to the work done by the outsourced company and by the company's own mechanics.

The workload was seen as medium, with an average of three flights per week. Summoning would take place one day in advance, and was not usually earlier than that for security reasons, on account of the high added value of the transported cargo.

The pilots usually reported work two hours before the takeoff to organize the flight and the catering issues. The maximum working day, calculated from the commuting from home until the return, was about 12 hours.

There were no complaints of fatigue, and the working conditions were deemed as good. There were no problems regarding the flow of information, support systems, equipment and infrastructure available.

Some reports pointed to a fragile safety-culture related to non-compliance with aircraft-refueling procedures, the traffic and parking of vehicles in the operational area and, sometimes, the haste of passengers to take off.

There were also reports of a dumping ground in the vicinity of the operational area, presence of F.O.D. and large numbers of birds.

1.18. Operational information.

The aircraft was within the weight and balance limits specified by the manufacturer.

According to the PIC, on the day of the occurrence, the mechanic responsible for the pre-flight informed that everything was in order with the helicopter.

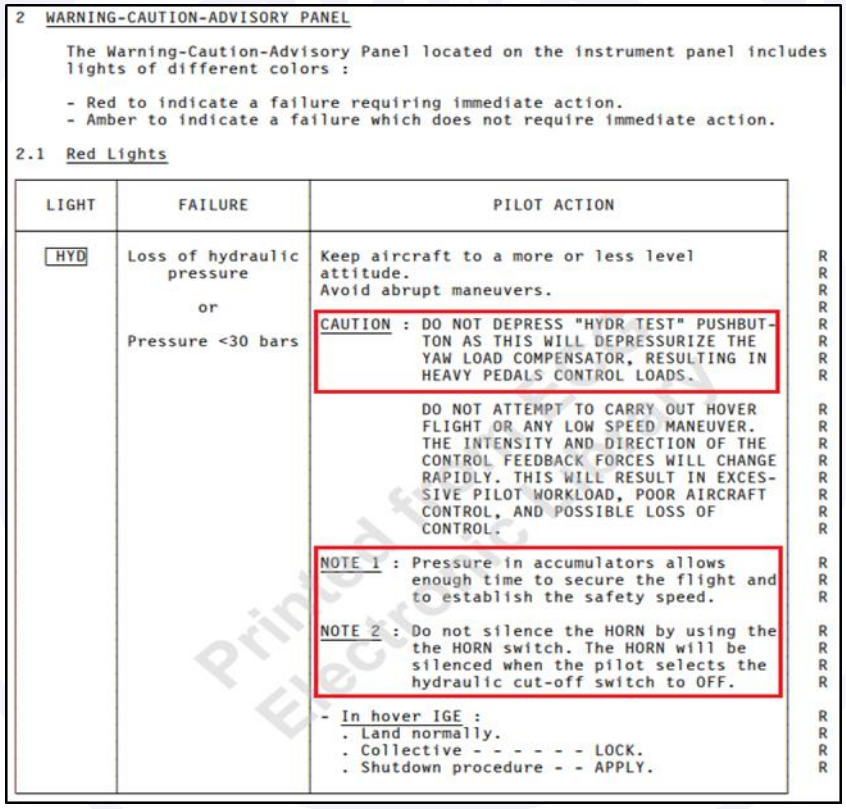
After the takeoff, the en-route phase of the flight was uneventful, with the weather consistent with VFR until the outskirts of Santa Rita do Novo Destino, when the “Hydraulic” light illuminated and the corresponding aural alarm sounded.

The illumination of the red light, in this case, was an indication of failure in the hydraulic system, caused by loss of pressure or a pressure-drop below 30 bars.

Therefore, taking immediate action was necessary, as described in item 2.1 Red lights of paragraph 2 Warning Caution - Advisory Panel.

As an initial action, one had to avoid both attitude changing and the adoption of abrupt maneuvers. The procedure prescribed that the “HYDR TEST” pushbutton ought not to be pressed, otherwise it would cause a high load on the pedals, due to the depressurization of the yaw load compensator.

The pressure stored in the accumulators would allow a safe flight and speed stabilization (Figure 19).



2 WARNING-CAUTION-ADVISORY PANEL

The Warning-Caution-Advisory Panel located on the instrument panel includes lights of different colors :

- Red to indicate a failure requiring immediate action.
- Amber to indicate a failure which does not require immediate action.

2.1 Red Lights

LIGHT	FAILURE	PILOT ACTION
HYD	Loss of hydraulic pressure or Pressure <30 bars	Keep aircraft to a more or less level attitude. Avoid abrupt maneuvers. CAUTION : DO NOT DEPRESS "HYDR TEST" PUSHBUTTON AS THIS WILL DEPRESSURIZE THE YAW LOAD COMPENSATOR, RESULTING IN HEAVY PEDALS CONTROL LOADS. DO NOT ATTEMPT TO CARRY OUT HOVER FLIGHT OR ANY LOW SPEED MANEUVER. THE INTENSITY AND DIRECTION OF THE CONTROL FEEDBACK FORCES WILL CHANGE RAPIDLY. THIS WILL RESULT IN EXCESSIVE PILOT WORKLOAD, POOR AIRCRAFT CONTROL, AND POSSIBLE LOSS OF CONTROL. NOTE 1 : Pressure in accumulators allows enough time to secure the flight and to establish the safety speed. NOTE 2 : Do not silence the HORN by using the the HORN switch. The HORN will be silenced when the pilot selects the hydraulic cut-off switch to OFF. - In hover IGE : . Land normally. . Collective - - - - - - LOCK. . Shutdown procedure - - APPLY.

Figure 19 - Item 2.1 Red lights of paragraph 2 Warning Caution - Advisory Panel.
Source: Flight Manual AS 350 B2.

In the sequence, as per the above procedure, the pilot was required to smoothly adjust the aircraft speed to a value between 40 kt and 60 kt (a safety speed in the event of hydraulic failure). After stabilizing at that speed, with the probable stiffening of the cyclic/collective controls (due to the discharge of the accumulators), the next step was to activate the hydraulic cut-off switch (collective HYD switch), which controls the opening of the electro-valves, thus nullifying the residual pressure and counter-pressure on both sides of the servo-control piston (reducing the efforts required to move the servo-controls), as shown in Figure 20.

2.1 Red Lights (cont'd)

LIGHT	FAILURE	PILOT ACTION	
		- In flight : Smoothly,	R
		. Collective/Cyclic- - - SET IAS within 40	R
		to 60 kt (hydraulic	R
		failure safety	R
		speed).	R
		. Collective HYD switch- OFF.	R
		Pilot has to exert forces :	R
		- On collective to increase or decrease	R
		power around no force feedback point.	R
		- On forward and left cyclic.	R
		LAND AS SOON AS POSSIBLE	R
		NOTE : Speed may be increased as necessary	R
		but controls loads will increase with	R
		speed.	R
		- Approach and landing :	R
		. Over a clear and flat area, make a flat	R
		final approach, nose into wind.	R
		. Perform a no-hover/slow run-on landing	R
		around 10 knots.	R
		. Do not hover or taxi without hydraulic	R
		pressure assistance.	R
		- After landing :	R
		. Collective - - - - - - - LOCK.	R
		. Shutdown procedure- - - - APPLY.	R

Figure 20 - Cont'd. Item 2.1 Red lights of paragraph 2 Warning Caution - Advisory Panel.
Source: Flight Manual AS 350 B2.

For the approach, when close to the ground, the recommended procedure for the pilot would be to make use of the ability of the pedals in still providing hydraulic assistance, while looking for a flat, free area (approachable upwind) to perform a run landing at a speed close to 10 kt, without taxiing or performing a hover flight. After landing, the collective was to be lowered, and the engine shutdown procedure performed.

Hovering or taxiing without hydraulic-system assistance was not a recommended procedure.

Therefore, in case the HYD light illuminated, the hydraulic pressure cut-off was to be executed via the HYD cut-off switch of the collective (Figure 21).

Figure 21 - PT-HYW Collective HYD switch (*in highlight*).

With the hydraulic cut-off activated, the horn would stop sounding. Pedal control with hydraulic assistance was limited to the capacity of the accumulator (small reserve of energy), resulting in an increase in the load required to control both the collective and the cyclic (Figure 22).

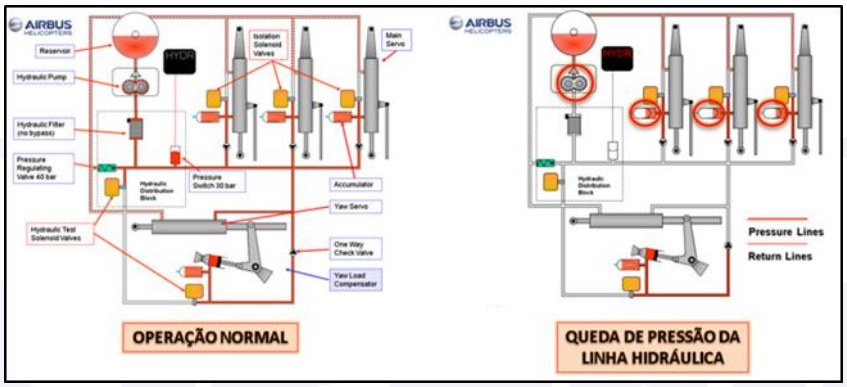


Figure 22 - Diagram of the hydraulic system in normal operation and after a drop in hydraulic line pressure. Source: Adapted from Airbus Helicopters' Back to the Basics presentation.

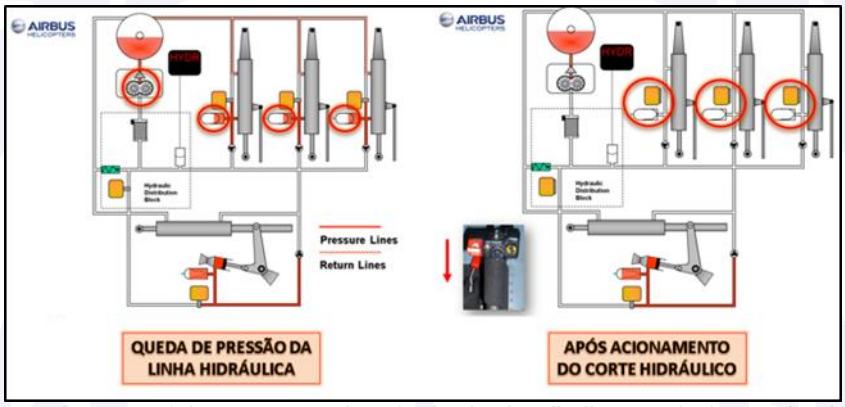


Figure 23 - Diagram of the pressure drop in the hydraulic line, and after activation of the hydraulic cut-off. Source: Adapted from Airbus Helicopters' Back to the Basics presentation.

According to the PIC, after warning the passengers, he reduced the speed to less than 60 kt, and proceeded to the area he considered ideal for landing.

The PIC pointed out that, in 5 seconds time, the controls stiffened, and he activated “the accumulators” on the console panel, and “contracted” the pedals.

The PIC informed that, upon noticing that the HYDR light illuminated, he cut off the hydraulic system by means of the hydraulic-test pushbutton of the central console button-panel, instead of using the HYD switch of the collective handle, as can be seen in Figure 24, in a photo taken moments after the occurrence.

Figure 24 - Final position of the center-console button-panel, and the PT-HYW hydraulic cut-off switch.

The pedals are responsible for the helicopter's ability to rotate around its vertical axis since they modify the traction on the tail rotor by controlling the angle of attack of the tail rotor blades.

On approaches for hovering or run-landings, the helicopter is initially flying in non-whirly air until reaching a speed between 16 and 12 kt, when it enters disturbed air and loses its translational lift.

At this point, the pilot must act on the pedals to modify the traction on the tail rotor, compensating for the increase in power.

According to the PIC, the forces acting on the aircraft close to the ground were “enormous”, and a great deal of strength was necessary to control the cyclic, collective and pedals”.

Next to the ground, the pilot lost control of the aircraft, which made a strong unexpected yaw to the left. As a result, one of the main rotor blades hit the ground, and the PT-HYW ended up making an uncontrolled landing.

1.19. Additional information.

NIL.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

Tratava-se de um voo de transporte de passageiros e de carga entre SBBR e SJMS. The aircraft was flying between SBBR and SJMS, transporting passengers and cargo.

Approximately 30 minutes into the flight, the hydraulic system emergency light (HYD) on the alarm panel came on, triggering the respective sound alarm. The PIC noticed the stiffening of the flight controls, and decided to make an emergency landing in the rural area of the municipality of Santa Rita do Bom Destino, GO.

The red light illuminated, indicating a failure in the Hydraulic System, caused by either a loss of pressure or a pressure-drop below 30 bars.

The PIC, upon noticing that the HYD light illuminated, performed the hydraulic cut-off by means of the hydraulic-test pushbutton, located in the central console panel, instead of collective HYD switch, located in the collective handle, as per item 2.1 Red lights (Cont. 'd) of paragraph 2 Warning Caution - Advisory Panel.

According to item 3 STARTING, Section 4, Normal Procedures, of the AS350B2 Flight Manual, the hydraulic-test pushbutton was only to be depressed in hydraulic-accumulator test procedures.

Thus, when performing the emergency procedure by cutting off the hydraulic system via the wrong control, the PIC completely lost the hydraulic actuation of the pedals, on account of the depressurization of the yaw load compensator.

According to the PIC's own report, the strength required to control the cyclic, collective and pedals was enormous, demanding a lot of effort. Close to the ground, he lost control of the helicopter, which made a sudden strong unexpected yaw to the left.

In this regard, it is important to point out that the pedals are responsible for the helicopter's ability to rotate around the vertical axis through the change of traction on the tail rotor resulting from controlling the angle of attack of the tail rotor blades. With the resulting increasing load the PIC was not able to apply sufficient load on the pedal to change the traction on the tail rotor, which would compensate for the torque increase during the approach for landing.

Thus, since effective control of the helicopter was lost, one of the main rotor blades struck the ground in a pitched attitude of approximately 5° and with inclination to the left. Subsequently, there was a second impact in which both skids hit the ground at a level attitude without significant lateral displacement.

According to the AS 350 B2 Flight Manual, if the prescribed procedures were adopted, the pressure stored in the accumulators would allow for a safe flight and speed stabilization.

In the case at hand, the pilot was expected to adjust the aircraft speed between 40 and 60 kt (safety speed in case of hydraulic failure) and, after stabilizing at that speed, already with the probable stiffening of the cyclic/collective controls (discharge of the accumulators), the pilot had to activate the collective HYD switch in the collective handle.

The prescribed approach was to be executed onto a flat area, heading upwind, making use of the residual capacity of the hydraulic system to provide control. With the aircraft getting close to the ground, the speed was to be reduced to 10 kt., with no taxiing or hovering, on account of lack of hydraulic pressure.

Thus, upon verification that the PIC did not adopt the prescribed procedures, the committee inferred the presence of inefficiency in the company's process of qualification and training aimed at the improvement of the PIC’s knowledge and skills, leading him to present inadequate performance and ineffective results in the context of operations.

The Pilot Evaluation Sheet relative to the “Section 3” flight of 05Apr2017 had the following comment on the training of the item “approach and landing with hydraulic system cut off” emergency procedure:

The landing procedure with cut off hydraulics was performed satisfactorily; however, it should be gone over in the next periodical training, with the purpose of reaching an ideal condition.

In total, the initial training summed up to 5 hours and 46 minutes. As it was his first rating in a single turbine helicopter, it is likely that his practice training did not achieve the objective. The fact that the PIC proceeded with the instruction, without a proper response being given to the comment related to his latest training flight with the hydraulic system cut

off, revealed a possible inadequate managerial oversight of the training activities in the operational sphere.

In such context, it is possible to infer that there was a quantitative and/or qualitative deficiency in the process of training previously received by the PIC of this occurrence, since he was not able to respond properly at the emergency, precisely in the aspect he had difficulties to deal with during the training (landing with the hydraulic system cut off).

In relation to tests and research, the Hydraulic Fluid Pollution Test Report nº 026/18, performed by HELIBRAS, obtained a Class > 12 result in the samples of both the hydraulic lines and the hydraulic reservoir. The samples showed pollution by particles - Class C NAS 1638 - (Particles ≥ 5µ).

The HELIBRAS analysis specified that approximate particle counts were performed, and that the range defining the Pollution Class was greater than 100µ.

The results indicated that the hydraulic system of the PT-HYW aircraft was contaminated. Such fact was also confirmed by the indication of clogging of the hydraulic filter by the pin that became apparent in the presence of contamination in the hydraulic fluid.

Exams of the main rotor servo controls, rear servo control, solenoid valves and accumulators attested that the assemblies were in good condition and operating normally at the time of the accident.

The P/N A5026780 hydraulic pump notches (splines), which received the torque of motion transference from the pulley to the hydraulic pump were completely worn.

Therefore, one cannot rule out the possibility that the wear on the notches (splines) of the hydraulic pump rod may have resulted from at least one of the following: misalignment of the connecting shaft, bearing malfunction, looseness in pump attachment, a tension value different from the one prescribed for the connecting pulley, or poor lubrication. The mentioned problems may be the result of an inappropriate previous maintenance procedure, either due to inadequate services performed on the aircraft or due to misinterpretation of the relevant documents.

However, it was not possible to determine the timing, since, according to the Cell Logbook 07/PTHYW/09, the last inspections of the aircraft (types “100 hours/12 months” and “150 hours/3/6 months”, were executed in accordance with the MSM 05-25-00 and ALS 04-20-00.

Airbus AMM 63-11-00,3-2, 2016.06.27 - Page 1, pointed out that the lubrication of the item Drive Splines of the Belt-Driven Hydraulic Pump MGB/Engine Coupling should occur, for the AS350 B2 models, in accordance with the work cards of the “150 hours/12 months” and “600 hours/24 months” inspections, by means of the cards MSM 05-21-00(B2)/MSM 05-22-00(B2).

Despite the fact that, in a visit of the Maintenance Organization facilities, cans of grease with expired validity were found to have been used recently, it was not possible to relate such non-compliance with inadequate lubrication of the component.

In any case, the wear of the notches (splines) compromised the operation of the hydraulic pump, interrupting the supply of hydraulic fluid to the system, making the pressure drop below 30 bars, leading to illumination of the “HYD” light, and activation of the horn.

The contamination of the hydraulic fluid probably initiated on account of malfunction of the pump, which also showed wear in its internal moving parts.

Thus, the malfunctioning of the hydraulic system was aggravated by the fact that the PIC depressed the “HYDR TEST” pushbutton. Such action resulted in high load on the pedals, due to the depressurization of the yaw load compensator, causing loss of the pedal control, which contributed to the loss of helicopter control close to the ground.

3. CONCLUSIONS.

3.1. Findings.

a) the PIC had a valid Aeronautical Medical Certificate (CMA);

b) the PIC had a valid Single Engine Turbine Helicopter Class (HMNT) qualification;

c) the aircraft had a valid Certificate of Airworthiness (CA);

d) the aircraft was within the weight and balance limits;

e) the records of the airframe and engine logbooks were up to date;

f) the 07/PTHYW/09 airframe logbook records contained the information that latest inspections of the aircraft (types “100 hours/12 months” and “150 hours/3/6 months”) were performed in accordance with the MSM 05-25-00 and ALS 04-20-00;

g) the hydraulic-fluid filter-clogging indicator was easily visible, indicating hydraulic fluid contamination;

h) the hydraulic pump shaft had signs of wear on the notches (splines);

i) according to Airbus AMM 63-11-00,3-2, 2016.06.27 - Page 1, the lubrication of the item Drive Splines of the Belt-Driven Hydraulic Pump MGB/Engine Coupling in B2 helicopters was to be done in accordance with the work cards of the “150 hours/12 months” and “600 hours/24 months” inspections, by means of the cards MSM 05-21-00(B2)/MSM 05-22-00(B2);

j) the meteorological conditions were consistent with the type of flight;

k) the PIC performed the training prescribed in the company's Training Program;

l) in the pilot evaluation sheet related to the hydraulic system cut-off landing, there was the following note: “the landing procedure with hydraulic system cut off should be gone over in the next periodical training sessions, with the purpose of achieving an ideal condition”;

m) with the aircraft approximately 30 minutes into the flight, the hydraulic system warning light (HYD) of the alarm panel illuminated;

n) the PIC made the cut-off by means of the HYDR TEST button of the central console button panel, instead of using the HYD switch located in the collective handle;

o) the PIC lost all the hydraulic actuation of the pedals, which would be provided by the accumulators;

p) next to the ground, the pilot lost control of the helicopter;

q) without effective control of the helicopter, one of the main rotor blades struck the ground;

r) the aircraft sustained substantial damage;

s) the PIC received slight injuries;

t) the passengers were not injured.

3.2. Contributing factors.

- **Training – undetermined.**

There was possibly lack of efficiency in the company's qualification and training process aimed at upgrading the PIC’s knowledge and skills, which may have led to his inappropriate performance and to the ineffective results obtained in the context of operation.

- **Handling of aircraft flight controls – a contributor.**

The PIC, on account of a failure in the hydraulic cut-off procedure, lost control of the aircraft next to the ground, causing the main rotor to strike the terrain before the skids touched down.

- **Instruction – undetermined.**

The probable deficiency in the quantitative and/or qualitative aspect relative to the training of emergencies meant that the PIC was not given full knowledge and use of the correct techniques for the best performance of the aircraft in the different possibilities of failure, especially those related to the hydraulic system.

- **Piloting judgment – a contributor.**

According to the dynamics of the accident, the PIC tried to make a punctual landing, without assistance of the hydraulic system, instead of performing a running landing at a speed close to 10 kt, without taxiing or performing a hovering flight.

- **Aircraft maintenance – undetermined.**

One cannot rule out the possibility that the wear on the notches (splines) of the hydraulic pump shaft resulted from inappropriate previous maintenance procedures, either on account of inadequate services performed on the aircraft or due to poor interpretation of the relevant documents.

- **Decision-making process – undetermined.**

The investigation committee identified that the PIC had difficulty analyzing and choosing from the available options for a suitable landing site, probably on account of the stress resulting from the nature of the aircraft failure, which may have led him to exercise inappropriate judgment.

- **Managerial oversight – undetermined.**

The fact that the PIC continued with his training program, even without response being given to a previous recommendation of a new assessment of his performance on a flight with hydraulic system cut-off, may be related to inadequate managerial oversight of the training activities in the operational sphere.

4. SAFETY RECOMMENDATIONS

A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident.

In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of safety, and shall be treated as established in the NSCA 3-13 "Protocols for the Investigation of Civil Aviation Aeronautical Occurrences conducted by the Brazilian State".

To Brazil's National Civil Aviation Agency (ANAC):

A-032/CENIPA/2018 - 01 Issued on 08/15/2023

Analyze the pertinence of working with DS AIR *TÁXI AÉREO LTDA*., so that the company's Training Program can be reviewed for possible inclusion of crew performance monitoring, with the objective of improving all the pilots' training results that are logged in their evaluation sheets, re-assessing their eventual progress, or even proposing new training options.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

NIL

On August 15th, 2023.