# COMANDO DA AERONÁUTICA

## CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

# FINAL REPORT
# A - 183/CENIPA/2013

| | |
|---|---|
| **OCCURRENCE:** | **ACCIDENT** |
| **AIRCRAFT:** | **PT-YSS** |
| **MODEL:** | **AS-350B2** |
| **DATE:** | **12OCT2013** |

# 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 taking into account 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 different 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 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. Taking into account 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 12OCT2013 accident with the AS-350B2 aircraft, registration PT-YSS. The accident was classified as "Engine Failure In-Flight".

During the emergency landing, there was the touch of the main rotor blades in the tail cone, causing the sectioning of the transmission shaft.

The aircraft suffered substantial damage.

All occupants were unharmed.

An Accredited Representative from the BEA - Bureau d'Enquêtes et d'Analyzes pour la Sécurité de l'Aviation Civile, France (State where the aircraft was designed) was designated for participation on the investigation.

## CONTENTS

## GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

| | |
|---|---|
| ANAC | (Brazil's) National Civil Aviation Agency |
| BEA | *Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile* |
| CA | Airworthiness Certificate |
| CENIPA | Aeronautical Accident Investigation and Prevention Center |
| CFIT | Controlled Flight Into Terrain |
| CHE | Certificate of Company Approval |
| CHETA | Certificate of Air Transport Company Approval |
| CIV | Pilot's Flight Logbook |
| CM | Registration Certificate |
| CMA | Aeronautical Medical Certificate |
| DCTA | Aeronautics' Science and Technology Department |
| GSL | General Service Letter |
| IAE | Aeronautics and Space Institute |
| IFR | Instrument Flight Rules |
| PCH | Commercial Pilot License - Helicopter Category |
| PN | Part Number |
| RBAC | Brazilian Civil Aviation Regulation |
| RS | Safety Recommendation |
| SAE | Aircraft Registration Category of Public Specialized Air Service |
| SB | Service Bulletin |
| SERIPA II | Second Regional Aeronautical Accident Investigation and Prevention Service |
| SIPAER | Aeronautical Accident Investigation and Prevention System |
| SNBX | ICAO location designator – Barra Aerodrome |
| SOP | Standard Operational Procedures |
| TPX | Aircraft Registration Category of Non-Regular Public Air Transport |
| TSN | Time Since New |
| UTC | Universal Time Coordinated |
| VFR | Visual Flight Rules |

## 1. FACTUAL INFORMATION.

| | | |
|---|---|---|
| **Aircraft** | **Model:** AS 350-B2<br>**Registration:** PT-YSS<br>**Manufacturer:** Eurocopter France | **Operator:**<br>Henrimar Air Taxi Ltd. |
| **Occurrence** | **Date/time:** 12OCT2013 -1840 UTC<br>**Location:** Pantanal Farm – Jupaguá District<br>**Lat.** 11°46'18"S **Long.** 044°19'02"W<br>**Municipality – State:** Cotegipe - BA | **Type(s):**<br>"Engine Failure In-Flight".<br>**Subtype(s):** |

### 1.1 History of the flight.

The aircraft took off from the Barra Aerodrome, BA (SNBX) at 1810 (UTC), in order to perform a flight of fire monitoring in the countryside of the State of Bahia, with one pilot and four passengers on board.

After 30 minutes of flying, the "ENG CHIP" warning light illuminated followed by a loud noise and by the engine flameout.

During the emergency landing, there was the touch of the main rotor blades in the tail cone, causing the sectioning of the transmission shaft.

### 1.2 Injuries to persons.

| Injuries | Crew | Passengers | Others |
|---|---|---|---|
| Fatal | - | - | - |
| Serious | - | - | - |
| Minor | - | - | - |
| None | 1 | 4 | - |

### 1.3 Damage to the aircraft.

The aircraft had damage at the main rotor assembly, at the fuselage of the tail cone, at the tail rotor drive shaft and at the lower cutter fixing bracket.

### 1.4 Other damage.

Nil.

### 1.5 Personnel information.

### 1.5.1 Crew's flight experience.

| Hours Flown | |
|---|---|
| | Pilot |
| Total | 1.700:00 |
| Total in the last 30 days | 25:00 |
| Total in the last 24 hours | 03:00 |
| In this type of aircraft | 500:00 |
| In this type in the last 30 days | 25:00 |
| In this type in the last 24 hours | 03:00 |

**N.B.:** The Data on flown hours were obtained from the pilot.

### 1.5.2 Personnel training.

The pilot took the Private Pilot course - Helicopter (PPH) at Unifly – *Escola de Aviação* Ltd, São P aulo - SP, in 2000.

**1.5.3 Category of licenses and validity of certificates.**

The pilot had the license of Commercial Pilot - Helicopter (PCH) and had valid aircraft technical qualification in AS50.

**1.5.4 Qualification and flight experience.**

The pilot was qualified and had experience on this kind of flight.

**1.5.5 Validity of medical certificate.**

The pilot had valid Aeronautical Medical Certificate (CMA).

**1.6 Aircraft information.**

The aircraft, serial number AS-2964, was manufactured by Eurocopter France in 1997 and was registered in the categories of Non-Regular Public Transport (TPX) and Specialized Air Service (SAE).

The aircraft had valid Airworthiness Certificate (CA).

The airframe and engine logbooks records were up-to-date.

The last inspection of the aircraft, the "10 hours or 7 days" type was done on 11OCT2013 by the Henrimar Air Taxi shop, in Salvador, BA. The aircraft flew 3 hours and 30 minutes after the inspection.

The last revision of the aircraft, the "5,400 hours" type, was performed on 27JAN2010 by the WM *Helicópteros Imigrantes* shop, in Diadema, SP. The aircraft flew 1,823 hours and 48 minutes after the inspection.

On 05SEPT2013, a 100h / 300h / 400h / 500h inspection was performed on the aircraft engine (Time Since New - TSN: 2,994 hours and 10 minutes) by Flyone *Serviço Aéreo Especializado Comércio e Serviços LTDA.*

On 25SEPT2013, a "7d / 15d / 30h / 50h" inspection was performed on the aircraft engine (TSN: 3,028 hours and 20 minutes) by Henrimar Air Taxi.

On 07OCT2013, a "200h" inspection was performed on the aircraft engine (TSN: 3,063 hours and 10 minutes), as well as the oil flow check in the gas generator rear bearing, by Flyone *Serviço Aéreo Especializado Comércio e Serviços LTDA.*

**1.7 Meteorological information.**

The conditions were favorable for the visual flight.

**1.8 Aids to navigation.**

Nil.

**1.9 Communications.**

Nil.

**1.10 Aerodrome information.**

The occurrence took place outside the Aerodrome.

**1.11 Flight recorders.**

Neither required nor installed.

**1.12 Wreckage and impact information.**

After the engine flameout, the pilot performed the procedures for "Landing without Power" provided in the aircraft's Flight Manual.

During the autorotation procedure, on the imminence of the landing, the pilot encountered an obstacle (termite nest), forcing him to change the approach ramp. Changing the approach ramp from the initially chosen place led the helicopter to touch the ground 29 meters ahead (Figure 1).

Figure 1 - View of the obstacle in relation to the landing place of the aircraft.

In the last meters of the ground run, the aircraft presented a strong tendency to flip upside down, to the point of damaging the "cutter" located in the lower front part of the aircraft (Figure 2)

Figure 2 - Damage to the lower cutter of the aircraft.

This dynamics was counteracted by the pilot's performance through the cyclic command. Thereafter, there was the touch of the main rotor blades in the tail cone, causing the sectioning of the transmission shaft (Figure 3).


Figure 3 - View of damage in the tail boom of the aircraft.

**1.13 Medical and pathological information.**

**1.13.1 Medical aspects.**

The pilot reported that he had been operating in the area of the accident for three days. During this period, he inspected the area in which he was going to work, trained personnel in embarking and disembarking of the aircraft, among other activities with passengers, and operated in the tracing of areas with fire outbreaks.

The verification of the working conditions of the pilot allowed visualizing that he operated under overloaded conditions.

**1.13.2 Ergonomic information.**

Nil.

**1.13.3 Psychological aspects.**

The pilot was working for some businessmen in the state of Bahia when he received, almost a year ago, an invitation to operate with the air taxi company. The company started a service of air monitoring of fires for the State.

The pilot reported that he obeyed the routes or directions of displacement commanded by the fire brigade officer of the Bahia State Fire Brigade, who was aboard the aircraft at the time of the accident. He coordinated all pre-flight, inter-flight and post-flight activities.

When he realized the emergency situation he was in, he checked the performance parameters of the aircraft and then turned his attention only to the landing procedure.

He reported that the short time he had since the “ENG CHIP” warning light illuminated until landing, he was analyzing an obstacle-free location and could not notice that the aircraft would touch the ground with so high speed, almost provoking the aircraft to tip on its nose.

**1.14 Fire.**

There was no evidence of fire in flight or after impact.

**1.15 Survival aspects.**

Nil.

## 1.16 Tests and research.

The engine of the crashed aircraft had 3,077 hours and 20 minutes of total flight at the time of the occurrence.

This engine was transported to the Turbomeca Company, being submitted to the analysis by professionals of this company, with the accompaniment of the representatives of the Aeronautics and Space Institute (IAE) of the Aeronautics' Science and Technology Department (DCTA), of the Second Regional Aeronautical Accident Investigation and Prevention Service (SERIPA II), HELIBRAS and the aircraft operator.

The purpose of this analysis was to identify the contribution of the engine operation to the accident and the following discrepancies were observed:

a) The rotating assemblies of modules 2 and 3 were locked, there being a large amount of particles at the outlet of the oil pump (Figure 4) and in the filter elements of the engine lubrication system.

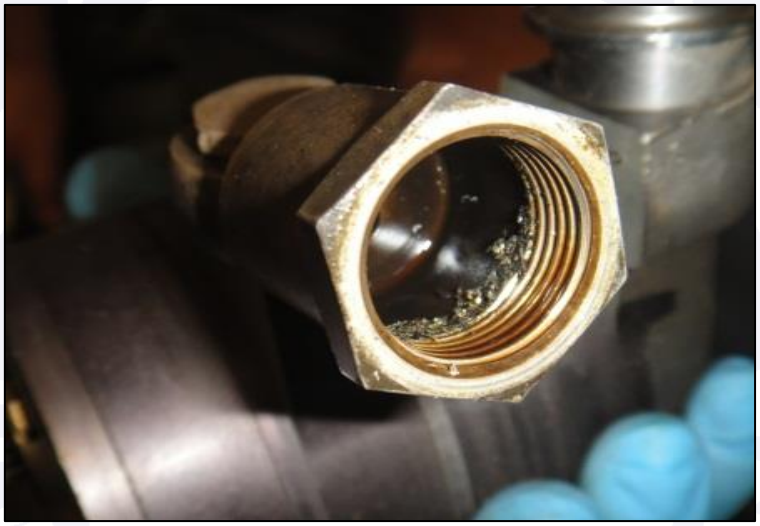

Figure 4 - Appearance of the engine oil pump outlet.

b) There were marks of intense friction between the axial compression stage and its casing (Figure 5).

Figure 5 - Friction marks between the blades and the axial compressor casing.

c) Seven out of thirteen axial compressor blades presented wear from 3.5 mm to 4 mm at the leading edges (Figure 6).

Figure 6 - Wear on the leading edges of the axial compressor blades.

d) The centrifugal compression stage exhibited damage due to the intense friction between the blades and the impeller casing (Figure 7).

Figure 7 - Damage to the impeller of the centrifugal compressor.

e) There was a large amount of *laterite* (residual deposits hardened from the decomposition of rocks and surface soil materials) adhered to the inner wall of the hollow shaft of module 3. Only the *laterite* detached from the component accumulated a mass of 8.42 grams (Figure 8).

Figure 8 - *Laterite* detached from the inner wall of the hollow shaft of module 3.

f) There were friction marks between the first and second stages of the compressor and the second stage stator (Figure 9).

Figure 9 - Friction marks in the turbine rotor.

g) The housing region of the gas generator rear bearing was bluish in color, indicating signs of overheating (Figure 10).

Figure 10 - Indication of overheating in the gas generator rear bearing.

h) The rollers of the gas generator rear bearing were fused in the outer bearing track (Figure 11).

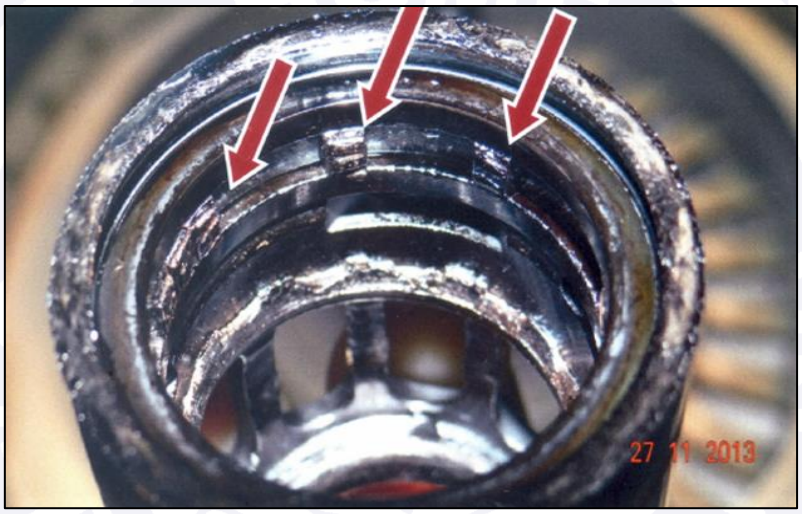


Figure 11 - Fused roller in the gas generator rear-bearing track.

i) There was the rupture of the locking ring of the gas generator rear bearing, whose fragments were found in the engine lubrication system (Figures 12 and 13).

Figure 12 - Broken locking ring.

Figure 13 - Fragment of the locking ring found in the engine lubrication system.

j) The teeth of the curved coupling of module 3 had vibration marks (Figure 14).

Figure 14 - Evidence of the occurrence of vibration in the teeth of the curved coupling of the hollow shaft of module 3.

The above evidence obtained through IAE / DCTA examinations, tests and research resulted in the report of the analysis of damaged material, which includes the following:

DISCUSSION OF RESULTS - In the disassembly and analysis performed on the *Arrie*l 1D1 engine, n / s 9457, of the Eurocopter AS-350 B2 model, *Esquilo*, registration PT-YSS, evidence was found that the engine was under excessive wear in the axial stage of compression. This may have allowed the engine to run above normal operating temperature, due to loss of compressor efficiency. The observed wear indicates that the aircraft operated in an aggressive environment.

The operation in this environment provided the formation of *laterite* inside the hollow shaft of the engine. The probable detachment of part of this *laterite* from the hollow shaft wall may have caused the unbalance of the rotating assembly of module 3, which damaged the gas generator rear bearing of the engine, causing the engine flameout during the flight on 12OCT2013.

It is stated in the report that only the laterite mass detached from the inner part of the hollow axis of the gas generator rear bearing totaled 8.42 grams. This loose mass has exceeded the laterite limit that could have been deposited on the shaft, as established by the engine manufacturer, according to the description of "B" on page 4 of Mandatory Service Bulletin A292 72 0230, version C, on 29FEB2012.

The DCTA report further notes that Service Bulletin A292 72 0230, issued in 1998, alerted operators to the possible consequences of *laterite* deposition on the inner wall of

the hollow shaft of the gas generator rear bearing, causing unbalance of the rotating assembly of the generating section of gas. It could lead to deterioration of the gas generator rear bearing, as well as the engine flameout.

The identification of the indications of the superheating of the gas generator rear bearing (bluish color), by the technicians of the DCTA, led to the deepening of the research by the SIPAER researchers, leading to the confirmation that there was no such evidence in the peripheral components of that bearing.

In relation to gas generator rear bearing, the measurement of the wear of the axial compressor blades of the engine and the traceability of the compliance of the Service Bulletin A292 72 0230, version C, of 29FEB2012, according to the maintenance records published in the logbook and in the logbook of the aircraft engine , the following services were performed:

- On 21JAN2012 (TSN: 2,319 hours and 40 minutes), an inspection of 750h / 2years was performed, with engine oil replacement and gas generator rear bearing oil flow check.

- On 17AUG2012 (TSN: 2,501 hours and 25 minutes), the engine was subjected to overhaul. On that occasion, Service Bulletin A292 72 0230, published on 29 FEB2012, was fulfilled. 1.5 mm was found as the maximum value for wear on the axial compressor blades, and six grams (6 g) of laterite adhered to the internal wall of the hollow shaft of the module 3.

- On 14SEPT2012 (TSN: 2,501 hours and 25 minutes), the engine was installed in the aircraft, being subjected to the rear point vibration check, performance check and engine downtime.

- On 19FEB2013 (TSN: 2,793 hours and 10 minutes), a 7d / 15h / 100h / 150h / 300h inspection was performed, with oil spectrometric analysis and gas generator rear bearing oil flow check.

- On 02MAY2013 (TSN: 2,883 hours and 25 minutes), a 7d / 15h / 100h inspection was performed, with oil spectrometric analysis and gas generator rear bearing oil flow check.

- On 23MAY2013 (TSN: 2,889 hours and 10 minutes), a 7d / 15h inspection was performed, with the application of Airworthiness Directive 2012-0071.

- On 05SEPT2013 (TSN: 2,994 hours and 10 minutes), an inspection of 100h / 300h / 400h / 500h was carried out by Flyone *Serviço Aéreo Especializado Comércio e Serviços LTDA*. At the time, engine and rear point vibration checks were performed, which presented parameters within the recommended by the engine maintenance manual. It was also performed the measurement of the wear on the axial compressor blades, and the most compromised vane had a wear of 2.64mm.

- On 25SEPT2013 (TSN: 3,028 hours and 20 minutes), inspection of 7d / 15h / 30h / 50h was performed by *Henrimar* Air Taxi.

- On 07OCT2013 (TSN: 3,063 hours and 10 minutes), a 200 hour inspection and oil flow check of the gas generator rear bearing were performed by Flyone *Serviço Aéreo Especializado Comércio e Serviços LTDA*.

There was no traceability of compliance with Service Bulletin A292 72 0230, published on 16OCT1998, and its updates as of 29FEB2012, regarding the measurement of wear on the axial compressor blades and the cleaning of the rotating assembly of the gas generating section, on occasion of the last inspection of 200h.

**1.17 Organizational and management information.**

The operating company started its activities in 1995, operating in the Air Taxi and Specialized Air Service segments.

The Second Regional Management of the National Civil Aviation Agency (ANAC) issued the first Certificate of Air Transport Company Approval (CHETA) in May 2006.

At the time of the accident, it was included in the ANAC records that the company operated through Decision No. 244, of 16JUN2009, valid until 30JUN2014.

The head office of the company was located in the municipality of *Lauro de Freitas*, BA. The helicopters Robinson R44, Esquilo AS-350B2 and Bell Jet Ranger 206 composed its fleet. It was homologated by ANAC to perform maintenance on aircraft in 2012, receiving CHE Certificate 2006-05-2CIS-11-01 / GER2.

The pilot's greatest professional experience was in passenger transport operations. Therefore, he had to undergo a training and adaptation phase in the kind of operation that he would perform for the company, regarding the monitoring of fire outbreaks. According to the pilot, however, the period spent by the company on this training could have been longer, given the nature of the operation.

Still according to the pilot, although the training received followed the basic program provided by the company, this training did not cover the reproduction of the SAE type operational activities that he would develop. In addition, he also reported that he did not have access to the Standard Operating Procedures (SOP) established by the company for the type of SAE operation performed.

Although requested by the Investigation Commission, the company did not submit the SOPs for verification.

The flight that culminated in the accident was part of a three-day operation in the region of *Jupaguá*, BA, to monitor fire outbreaks. For this specific operation, two days of familiarization training were conducted with the Fire Brigade Group of the State of *Bahia*, which would also be involved in the operation.

**1.18 Operational information.**

The flight that culminated in the accident was part of an operation to monitor fires in the countryside of the State of Bahia.

The aircraft was flying for 30 minutes, at 2,000ft altitude and 100kt speed, when the amber "ENG CHIP" warning light illuminated.

Approximately three minutes after it, there was a loud noise and the engine flameout, causing the pilot to adopt the procedures for the emergency landing.

The Aircraft Flight Manual established that, in the event of an "ENG CHIP" light, landing should occur as soon as possible.

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

**1.19 Additional information.**

The aircraft involved in the event was equipped with the *ARRIEL* 1D1 engine, which consisted of five modules independent from one another, consisting of a power shaft and accessory box, axial compressor, gas generator, power turbine (or free turbine) and reduction box, as shown below:

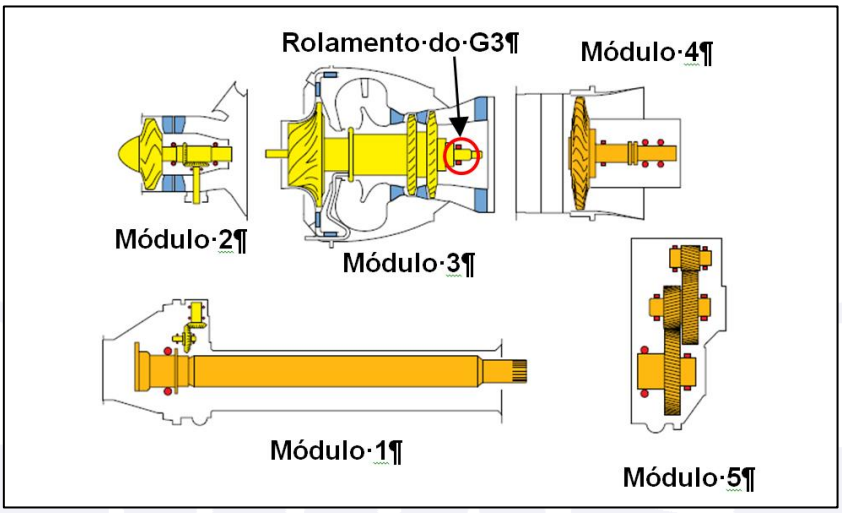


Figure 15 - Arriel 1D1 engine module layout.

- Module 1 - Power shaft and accessory box;
- Module 2 - Axial compressor;
- Module 3 - Gas generator;
- Module 4 - Power turbine (or free turbine), and
- Module 5 - Reduction box.

According to chapter 05-20-02-200-801-A01, page 2, of the aircraft's engine maintenance manual, edited on 30OCT2012, inspections focusing on the impacts and distortions on the blades of the rotating components of module 2 were expected to occur at each inspection of 15 hours or 7 days.

In chapter 05-20-03-200-801-A01, page 12, of the mentioned maintenance manual, the engine manufacturer establishes as 400 hours the periodicity for the measurement of wear on the leading edge of the axial compressor blades, when the operation of the aircraft occurred in a dusty environment. It was stated on page 208 of the maintenance manual that the maximum wear limit on the leading edge of the axial compressor blades was 3 mm.

For the measurement of wear on the leading edge of the axial compressor blades, the aircraft engine manufacturer's manual mentioned the need to use the erosion tool - PN 131G004.

The aircraft maintainer did not have such a tool. When this was necessary, the tool was requested from third parties.

For the purpose of the inspections to be performed in the gas generator rear bearing, this manual defined that it was submitted to oil flow verification and oil spectrometric analysis every 150 hours. When the aircraft operated in a dusty atmosphere, these procedures should be accompanied by vibration analysis, every 400 hours and when the operation occurred outside of this environment, every 750h.

Service Letter No. 1825/98 / *ARRIEL* / 41, from 26MAR1998, dealt with the *laterite* deposit on the hollow shaft of module 3 for *ARRIEL* 1 engines operating in a dusty atmosphere. The publication referred to compliance with the gas generator rear bearing hollow cleaning program based on the erosion of the axial compressor blades of the engine, as established by the Service Bulletin (SB - Service Bulletin) A292 72 0230 and by the AD F-1990 -064 R1.

The mentioned technical publication also mentioned that the operation in dusty atmosphere was one in which the visibility was sensibly compromised during landings, take-offs and flights performed at low altitude in dry (sandy or dusty) areas.

The General Service Letter (GSL) No. 2731/09 defined a sandy atmosphere as an environment in which landings and takeoffs were carried out under the effect of soil effect on unprepared landing strips, sandy areas, desert areas or similar environments, in any height, with significant concentration of sand or dust suspended in the air.

In addition to GSL 2731/09, SB A292 72 0230, version C, of 29FEB2012, regarded dusty atmosphere as any that contained dust such as *laterite*, sand, crop spray products and volcanic dust, which were generally found in the vicinity of forest, construction works with cement and volcanic areas.

Some operating indications in this type of environment:

- reduced visibility due to particles suspended in the air;

- erosion of the axial compressor, main or tail rotor;

- excessive obstruction or clogging of the drain filter of the pneumatic valve control system;

- dust deposition on aircraft parked outside hangars that accumulate in a short period of time;

- meteorological alert transmissions especially for particles in the air such as volcanic ash, sandstorm etc.

According to the aforementioned Service Bulletin, if the pilot's visibility was not reduced during the operation of the aircraft, it would not be operating in a dusty atmosphere. However, the technical publication referred to the need of establishing contact with the Engine Service Engineer, seeking technical support to determine the type of environment in which the aircraft was operating or had operated.

Service Bulletin No. A292 72 0230, version C, from 29FEB2012, established the frequency for cleaning the rotating assembly of the gas generating section in order to limit the *laterite* deposit to 8 grams (8g) on the inner wall of the hollow axis of module 3, due to the operation in dusty atmosphere. This procedure was aimed at avoiding the unbalance of the rotating assembly of that section, which in turn, could cause damage to the gas generator rear bearing, with the possibility of locking the rotating assembly of that module and, consequently, the engine flameout.

The SB A292 72 0230, version C, from 29FEB2012, also established the limit of 1 mm for every 1,000 hours or less than 3 mm in any situation. Its purpose is to determine the type of operating environment (dusty atmosphere or not), as well as the criteria for determining the limit of the first cleaning performance and the cleaning frequency of the gas generating rotating assembly.

**1.20 Useful or effective investigation techniques.**

Nil.

## 2. ANALYSIS.

The aircraft was performing a fire outbreak monitoring flight in the countryside of the State of *Bahia*, when the “ENG CHIP” warning light illuminated, followed by a strong noise and the engine flameout.

After the “ENG CHIP” warning light illuminated, the pilot performed the procedures for "Landing without Power", provided for in the Flight Manual of the aircraft.

The short time elapsed between the “ENG CHIP” light illumination and the engine flameout surprised the pilot who immediately started the procedures for the autorotation.

At the end of the autorotation procedure, at the imminence of the landing, the pilot performed a maneuver to clear an obstacle, which in turn changed the approach ramp to the place initially chosen, leading the helicopter to touch the ground 29 meters ahead.

In the last meters of the ground race, the aircraft tended to flip upside down, being this dynamics counteracted by the pilot's performance through the cyclic command. Then, there was the touch of the blades of the main rotor in the tail boom, causing the sectioning of the corresponding transmission axis.

The extent of the aircraft damage initially refers to improper execution of the autorotation procedures. However, the need to perform a maneuver in the short final, due to the presence of obstacle, modified the dynamics of the facts, leading the pilot to manage the most critical phase of the flight with little room for maneuver.

Although the company considers the pilot to be experienced for the SAE type operation, it is known that the operational context characteristics also influence the performance of the crew member. The fire outbreak monitoring flight tends to occur in different external environments in relation to the passenger-only flights, which the pilot was already accustomed to doing.

In these scenarios, the risks and dangers to be managed under abnormal conditions of operation become other, requiring the pilot different levels of analysis and situational awareness.

In the case in hand, the pilot informed that the training received by the company did not cover the in-flight reproduction of SAE-type operational activities, besides not having access to the SOPs established by the company for this type of operation.

Although the pilot was able to perform emergency procedures such as autorotation, it was not possible to rule out the hypothesis that the insufficient training for the type of flight that he performed at the time of the accident had compromised an adequate response to the risks and obstacles characteristic of the external environment on which the pilot was flying, thus interfering with the choice of location and the time of reaction to the landing.

In addition, SOPs configure normative systems that support and guide crew performance, and their knowledge is critical to the proper compliance of the operational standards required for each type of operation.

The fact that the company did not give notice of this specific regulation to the type of operation that the pilot performed at the time of the accident, although it probably did not compromise the management of the emergency, indicated the existence of fragilities in its organizational processes.

As for the analysis performed on the aircraft engine, a wear of 3.5 mm to 4 mm at the leading edge was evident in seven of the thirteen blades of the axial compression stage, thus, above the limit (3 mm) established by the engine manufacturer.

Taking into account the measurement of the wear on the leading edge of the axial compressor blades, on 17AUG2012, the date of the general engine overhaul (TSN 2501 hours and 25 minutes, measured wear of 1,5mm) and the date of the inspections of 100h / 300h / 400h / 500h, performed by the Flyone *Serviço Aéreo Especializado Comércio e Serviços LTDA*. On 05SEPT2013 (TSN: 2994 hours and 10 minutes, measured wear of 2.64mm), a wear increment of up to 1,14mm was observed in the axial compressor blades, in 492 hours and 50 minutes of engine use.

At the time of the accident, when the engine accumulated a total of 576 hours post-overhaul and 83 hours and 10 minutes of 100h / 300h / 400h / 500h post revision, the wear

observed on the leading edge of the axial compressor of the engine had an increase of about 2.5 mm, since the aforementioned general revision and an increase of 1.36mm since the 100h / 300h / 400h / 500h revision.

The extrapolations of the wear of the axial compressor blades of the engine signaled that the aircraft operated in an environment characterized as a dusty atmosphere and that, in order to monitor such wear, the type of environment in which the aircraft operated was not taken into account, as well as the frequency with which the cleaning of the rotating assembly of module 3 should be performed, considering that established in SB A292 72 0230, version C, 29FEB2012.

The *laterite* that remained adhered to the inner wall of the hollow shaft of module 3 was not measured. However, only the amount of laterite released from that component accumulated a mass of 8.42 grams, thus exceeding the 8g limit established by the aircraft engine manufacturer.

The above-described scenario shows that the detachment of part of the *laterite* that was adhered to the inner wall of the hollow shaft caused the unbalance of the rotating assembly of module 3. The resulting vibration of this module caused damage to the gas generator rear bearing and, consequently, the engine flameout.

Although the periodic inspections in the logbook and the engine book of the aircraft were up to date, the excessive wear observed on the axial compressor blades, as well as the presence of a large amount of *laterite* deposited on the hollow shaft of the gas generator rear bearing, pointed for a deficiency in the supervision in the management of maintenance. It culminated in the inadequate compliance with the maintenance program established by the aircraft engine manufacturer in accordance with SB A292 72 0230, version C, 29 FEB2012.

## 3. CONCLUSIONS.

### 3.1 Facts.

a) The pilot had valid Aeronautical Medical Certificate (CMA).

b) the pilot had valid Technical Qualification Certificate (CHT).

c) the pilot was qualified and had experience in that type of flight;

d) the aircraft had valid Airworthiness Certificate (CA).

e) the aircraft was within the weight and balance parameters;

f) the airframe, rotors and engine logbooks records were up-to-date.

g) the aircraft was performing a fire outbreak monitoring flight;.

h) during the flight, the “ENG CHIP” warning light illuminated followed by a strong noise and the engine flameout;

i) during the emergency landing, there was the touch of the main rotor blades in the tail cone, causing the sectioning of the transmission shaft;

j) seven out of thirteen blades of the axial compressor showed wear above that admitted by the engine manufacturer;

k) the *laterite* found in the inner part of the hollow shaft of the module 3 had mass above the amount allowed by the engine manufacturer;

l) the periodic inspections in the logbook and the engine book of the aircraft were up to date;

m) between the last general overhaul performed on the aircraft engine and the time of the accident, there was an extrapolation of the wear limits on the leading edges of the axial compressor blades;

n) the engine maintenance program of the aircraft was not obeyed adequately, as regards compliance with SB A292 72 0230, version C, from 29FEB2012;

o) the aircraft had substantial damage; and

p) all the occupants were unharmed.

**3.2 Contributing factors.**

- **Aircraft maintenance – a contributor.**

The inadequate monitoring of the wear of the leading edges of the axial compressors and the presence of a large amount of laterite in the hollow shaft of the gas generator rear bearing characterized the failure to comply with the maintenance program of the aircraft.

- **Organizational processes – undetermined.**

The fact that the company did not inform the SOPs established for the type of operation performed to the pilot indicated the existence of weaknesses in the organizational processes of the company that may have influenced the pilot's decision-making.

- **Support systems – undetermined.**

The lack of access to the specific regulations that would guide the pilot for this type of operation may have hampered his operational performance in the face of emergency.

- **Managerial oversight – a contributor.**

The inadequate compliance with Service Bulletin A292 72 0230, version C, from 29FEB2012, characterized the presence of a deficient management supervision within the technical scope.

## 4. SAFETY RECOMMENDATION.

***A measure of preventative/corrective nature issued by a SIPAER Investigation Authority or by a SIPAER-Link within respective area of jurisdiction, aimed at eliminating or mitigating the risk brought about by either a latent condition or an active failure. It results from the investigation of an aeronautical occurrence or from a preventative action, and shall never be used for purposes of blame presumption or apportion of civil, criminal, or administrative liability.***

***In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of the air activity operational 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".***

**Recommendations issued at the publication of this report:**

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

**A-183/CENIPA/2013 - 01** **Issued on 09/24/2018**

Act with Henrimar Air Taxi in order to ensure compliance with SB A292 72 0230, Version C, from 29FEB2012, aiming at the execution of the engine maintenance program for the *Arriel* 1 and series, based on the definition of the types of environments in which the operations of their aircraft occur.

**A-183/CENIPA/2013 - 02** **Issued on 09/24/2018**

Act with Henrimar Air Taxi shop, in order to ensure and, for the purpose of executing the engines maintenance program for the *Arriel* 1 and series, to comply with the procedures established by SB A292 72 0230, version C, from 29FEB2012, regarding the monitoring of the wear of the axial compressor blades and the presence of *laterite* deposited on the hollow shaft of the gas generator rear bearing.

**A-183/CENIPA/2013 - 03** **Issued on 09/24/2018**

Act with Henrimar Air Taxi shop, in order to make sure that the use of the erosion tool PN-TM0131G004, occurs in accordance with the provisions of letters (a) and (a) - I of RBAC 145.109.

**A-183/CENIPA/2013 - 04** **Issued on 09/24/2018**

Act with Henrimar Air Taxi shop, in order to ensure proper Management Supervision, in the technical field, with a focus on the execution of the engines maintenance program for the *Arriel* 1 and series, especially with respect to compliance of SB A292 72 0230, version C, from 29FEB2012.

**A-183/CENIPA/2013 - 05** **Issued on 09/24/2018**

Act with Flyone *Serviço Aéreo Especializado Comércio e Serviços LTDA.* shop, in order to ensure compliance with the engines maintenance program for the *Arriel* 1 and series, notably with the procedures established by SB A292 72 0230, version C, from 29FEB2012, for monitoring the wear of the compressor vane and the presence of *laterite* deposited on the hollow shaft of the gas generator rear bearing.

**A-183/CENIPA/2013 - 06** **Issued on 09/24/2018**

Act with Flyone *Serviço Aéreo Especializado Comércio e Serviços LTDA.* shop, in order to ensure that the use of erosion tool PN-TM0131G004 occurs in accordance with the provisions of letters (a) and (a) -I of RBAC 145.109.

**A-183/CENIPA/2013 - 07** **Issued on 09/24/2018**

Act with Flyone *Serviço Aéreo Especializado Comércio e Serviços LTDA.* shop, in order to ensure adequate management supervision in the technical field, focusing on the compliance with the engines maintenance program for the *Arriel* 1 and series, notably with regard to compliance with SB A292 72 0230, version C, from 29FEB2012.

## 5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On September 24th, 2018.