COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 503/CENIPA/2021

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PP-BRJ**
MODEL:	**AS-350B3**
DATE:	**29DEC2012**

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 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. 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 29DEC2012 accident with the AS-350B3 aircraft model, registration PP-BRJ. The accident was classified as “[SCF-NP] System/Component Failure or Malfunction Non-Powerplant – With Flight Commands”.

During the approach to perform a rescue on the Copacabana beach shore in Rio de Janeiro - RJ, the aircraft lost rotation of the main rotor, forcing the pilot to perform an autorotation at low altitude and an emergency landing at sea.

The aircraft had substantial damage.

All occupants left unharmed.

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

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ADE	Aircraft Registration Category – Direct State Administration
ANAC	National Civil Aviation Authority
CA	Airworthiness Certificate
CBMERJ	Rio de Janeiro Military Fire Department
CENIPA	Aeronautical Accident Investigation and Prevention Center
CMA	Aeronautical Medical Certificate
DECU	Digital Electronic Control Unit
EEPROM	Electrically-Erasable Programmable Read-Only Memory
FADEC	Full Authority Digital Electronic Control
GOA	Air Operations Group
HMU	Hydro-Mechanical Metering Unit
OEE	Special Equipment Operator
OM	Maintenance Organization
PCH	Commercial Pilot License – Helicopter
PIC	Pilot in Command
PPH	Private Pilot License – Helicopter
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
SDHL	ICAO Location Designator – Lagoa Helipad, Rio de Janeiro - RJ
SERIPA III	Third Regional Aeronautical Accident Investigation and Prevention Service
UTC	Universal Time Coordinated
VEMD	Vehicle Engine Monitoring Display

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS-350B3 **Registration:** PP-BRJ **Manufacturer:** HELIBRAS	**Operator:** Rio de Janeiro Military Fire Department (CBMERJ)
Occurrence	**Date/time:** 29DEC2012 - 1800 UTC **Location:** Copacabana Beach **Lat.** 22°57'58"S **Long.** 043°10'15"W **Municipality – State:** Rio de Janeiro – RJ	**Type(s):** "[SCF-NP] System/Component Failure or Malfunction Non-Powerplant" **Subtype(s):** With Flight Commands

1.1 History of the flight.

The aircraft took off from the Lagoa Private Helipad (SDHL), Rio de Janeiro - RJ, around 1745 (UTC) to carry out a rescue operation on the Copacabana beach shore - RJ, with a Pilot in Command (PIC) and three Special Equipment Operators (OEE) on board.

After approximately 15 minutes of flight, when it was hovering over the sea, the aircraft presented a loss of engine power and power rotation of the main rotor, causing the pilot to perform an autorotation at low altitude and forced landing at sea.

The aircraft had substantial damage.

All occupants left unharmed.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft had substantial damage to its entire structure and components due to contact with seawater.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours				
	PIC	OEE1	OEE2	OEE3
Total	940:00	200:00	200:00	200:00
Total in the last 30 days	03:50	03:50	00:50	00:50
Total in the last 24 hours	00:50	00:50	00:50	00:50
In this type of aircraft	840:55	200:00	200:00	200:00
In this type in the last 30 days	03:50	03:50	00:50	00:50
In this type in the last 24 hours	00:50	00:50	00:50	00:50

N.B.: The data relating to the flown hours were obtained through the operator's records.

1.5.2 Personnel training.

The PIC took the PPH course at the São Pedro D'Aldeia Naval Aviation Base – RJ, in 2000.

1.5.3 Category of licenses and validity of certificates.

The PIC had the PCH License and had a valid H350 type aircraft Rating.

1.5.4 Qualification and flight experience.

The PIC was qualified and had experience in the kind of flight.

1.5.5 Validity of medical certificate.

The PIC and the OEEs had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 4523, was manufactured by HELIBRAS, under license, in 2008 and was registered in the ADE category.

The aircraft's CA was valid.

The airframe and engine logbook records were updated.

The last inspections of the aircraft, the “10/25 hours, 07 days, and 12 months” type, were carried out on 26DEC2012 by the Maintenance Organization (OM) *Líder Aviação*, Rio de Janeiro - RJ, with the aircraft having flown 17 hours and 10 minutes after the inspections.

The aircraft maintenance program considered the type “C” inspection (12 years) to be the largest scheduled inspection.

The last inspection of the aircraft, the “IAM” type, was carried out on 19OCT2012 by the OM *Líder Aviação*, Rio de Janeiro - RJ, with the aircraft having flown 131 hours and 50 minutes after the inspection.

On the day of the accident, the aircraft's logbook recorded a total of 1,776 hours and 40 minutes of flight time.

<u>TWIST GRIP</u>

The aircraft had an engine power control system called TWIST GRIP. Such twist grip had two positions: FLIGHT and IDLE.

The system was mechanically controlled using the twist grip and electrically activated through microswitches and relays.

When the TWIST GRIP was moved from the FLIGHT position to the IDLE position, a spring counteracted this movement. If the pilot continued turning the twist grip against the action of the spring, the TWIST GRIP would reach a bounce which, when overcome, would keep it in the IDLE position, even after the command was released.

If the pilot removed the grip from the FLIGHT position and, during the movement path, released the grip without reaching the shoulder in the IDLE position, the TWIST GRIP would automatically return to the FLIGHT position, by spring action.

Immediately after removing the TWIST GRIP from the FLIGHT position, a red light on the alarm panel would illuminate (TWT GRIP), even if it was still in transit, before reaching the IDLE position.

With the aircraft energized, the start selector in the OFF position, and the twist grip in the IDLE position, the 53Ka and 53Kb microswitches would be in the working position, that is, activated and with their internal contacts closed. As the 65K microswitch or worked with inverted contacts, in this same condition, it would not be activated, but its internal contacts would be closed, allowing grounding and the consequent lighting of the TWT GRIP light on the alarm panel (Figure 1).

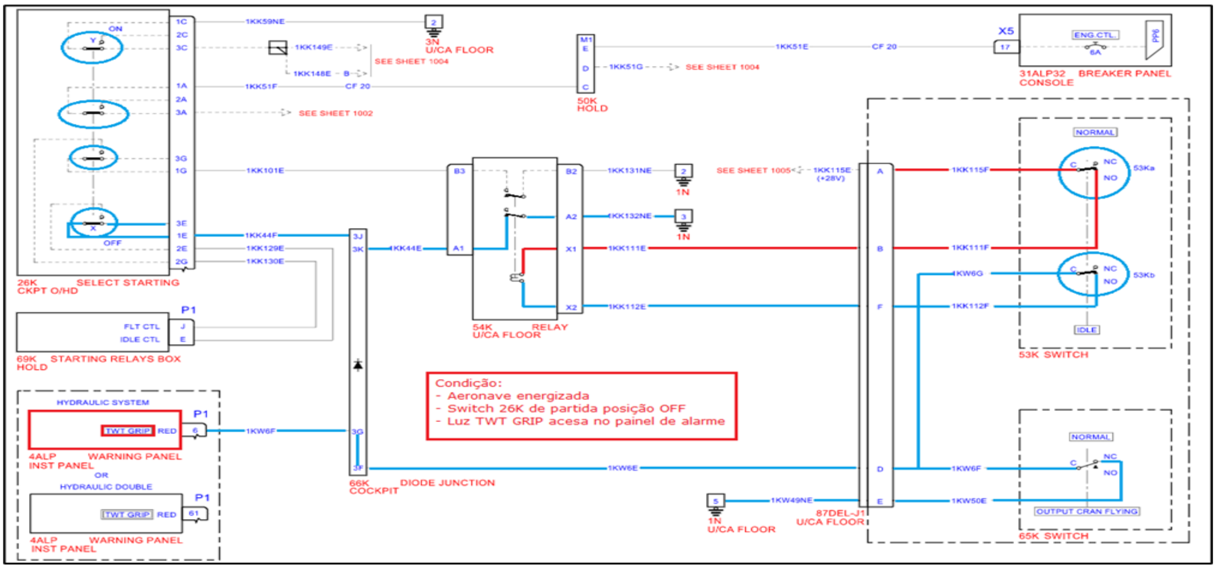


Figure 1 - TWIST GRIP electrical circuit in the following configuration: energized aircraft, start selector in OFF position and twist grip in IDLE position.

With the aircraft energized, the start selector in the ON position, and the twist grip in the IDLE position, the 53Ka and 53Kb microswitches would be in the working position, that is, activated and with their internal contacts closed. In this condition, the 53Ka microswitch would allow the passage of 28 VDC current to feed the coil at point X1 of the 54K relay while a ground signal would pass through the internal contacts of the 53Kb microswitch, allowing the coil to be grounded at point X2 of the 54K relay.

Only the activation of the two microswitches at the same time would allow powering the 54K relay circuit, giving the system a redundancy characteristic. In this same condition, the 65K microswitch would not be activated, and its internal contacts would remain closed, allowing the grounding signal to be supplied to the 53Kb microswitch and to the alarm panel for the TWT GRIP light to turn on (Figure 2).

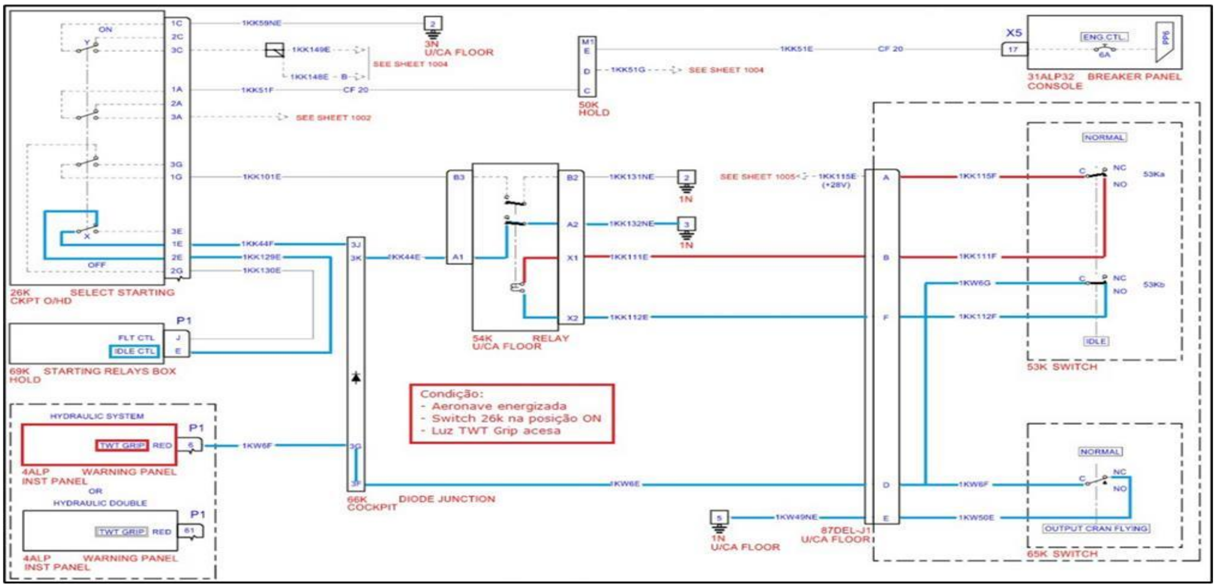


Figure 2 - TWIST GRIP electrical circuit in the following configuration: energized aircraft, start selector in ON position and twist grip in IDLE position.

The 54K relay, when activated, was responsible for sending an IDLE electrical signal to the DECU.

Electric operating logic

After mechanical activation of the twist grip to one of the positions (IDLE or FLIGHT), the TWIST GRIP's electrical system would send an electrical signal to the DECU, which, in turn, would switch the received signal into a digital signal to be sent to the HMU, so that it controls the flow of fuel supplied to the engine. Consequently, tuning the fuel delivery would allow the engine to run at matched horsepower in response to the initial TWIST GRIP trigger.

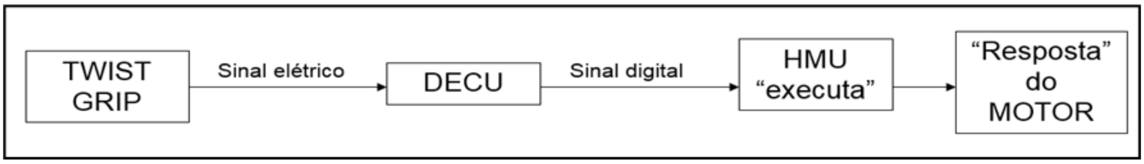
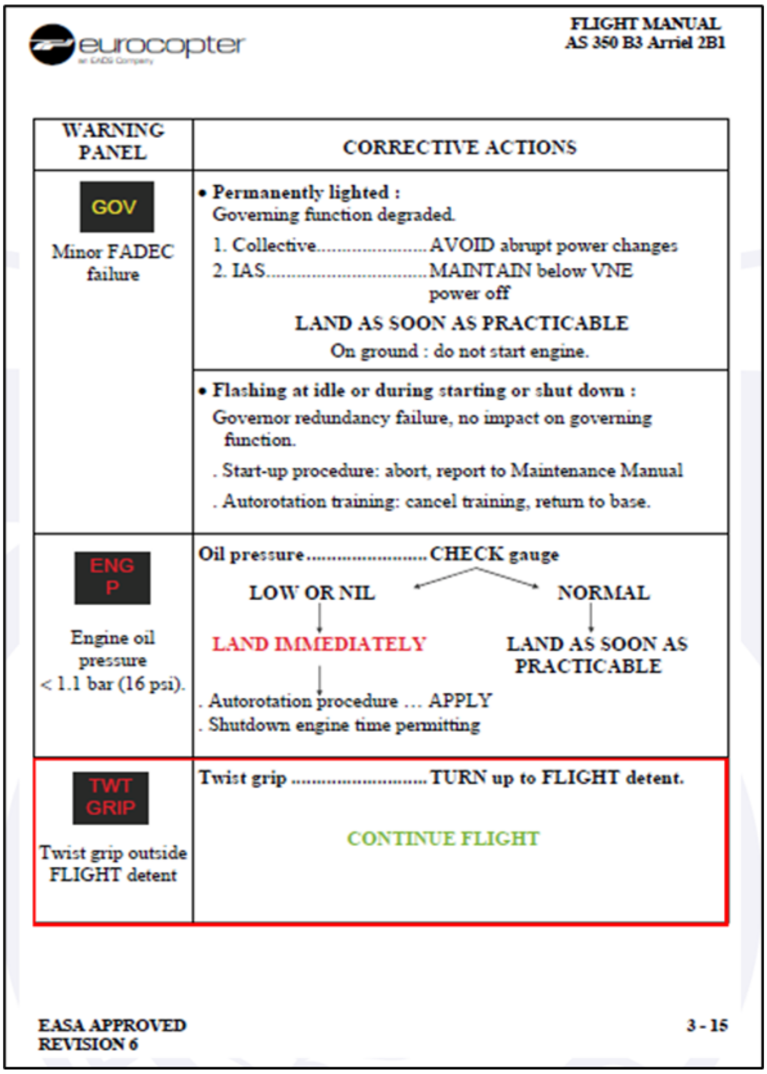


Figure 4 - TWIST GRIP operating logic.

TWIST GRIP system alarm light

The AS-350B3 flight manual described (Figure 5) the lighting of the TWT GRIP alarm light, in the WARNING PANEL, exclusively as a position of the twist grip outside the FLIGHT position.


eurocopter

FLIGHT MANUAL
AS 350 B3 Arriel 2B1

WARNING PANEL	CORRECTIVE ACTIONS
GOV Minor FADEC failure	• Permanently lighted : Governing function degraded. 1. Collective.....................AVOID abrupt power changes 2. IAS..............................MAINTAIN below VNE power off LAND AS SOON AS PRACTICABLE On ground : do not start engine.
	• Flashing at idle or during starting or shut down : Governor redundancy failure, no impact on governing function. . Start-up procedure: abort, report to Maintenance Manual . Autorotation training: cancel training, return to base.
ENG P Engine oil pressure < 1.1 bar (16 psi).	Oil pressure........................CHECK gauge LOW OR NIL → LAND IMMEDIATELY → . Autorotation procedure … APPLY . Shutdown engine time permitting NORMAL → LAND AS SOON AS PRACTICABLE
TWT GRIP Twist grip outside FLIGHT detent	Twist grip ....TURN up to FLIGHT detent. CONTINUE FLIGHT

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Figure 5 - Extract from the aircraft's Flight Manual, highlighting the red light TWT GRIP and the corrective action.

Given this scenario, the manual prevised as corrective actions the twist grip replacement in the FLIGHT position and the continuation of the flight.

<u>DECU and VEMD.</u>

The DECU was a two-channel digital engine control unit that regulated the fuel, managed the engine parameters, as well as recorded in the EEPROM, installed in each channel, the failures found in the systems that interacted with it.

The VEMD was a multifunction screen installed on the instrument panel of the aircraft, with a two-channel system, each with an EEPROM memory, which recorded data relevant to the accident investigation, such as failures and limits exceeded.

<u>Emergency Floats.</u>

The purpose of this type of equipment was to prevent, for a few hours, the helicopter from sinking into the water in case it was forced to make a precautionary or forced landing due to an emergency on board, thus allowing passengers to disembark safely, without the need to carry out an emergency evacuation with the aircraft submerged. The aircraft did not have emergency floats installed.

1.7 Meteorological information.

The weather 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 out of the Aerodrome.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The impact took place at sea, on the Copacabana beach shore, Rio de Janeiro - RJ, and shortly after the landing, the aircraft submerged.

Figure 6 - Aircraft trajectory to the point of impact.

Figure 7 - Aircraft wreckage concentrated after removal from the sea.

The aircraft reached the surface of the water practically leveled with the surface of the sea and with low speed.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

No evidence was found that problems of physiological nature could have affected the flight crew performance.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

Nil.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

After the impact and submersion, the crew managed to abandon the aircraft through the main doors.

The two rescue crewmembers on board helped the pilot and one of the specialized operators, as both were not wearing life jackets.

Then, the occupants swam to the beach, being attended by people who were on the shore.

1.16 Tests and research.

Analyzes were performed on the video recording of the occurrence, examinations of the engine, components and tests on aircraft systems. The results obtained are described below.

Spectral analysis of the engine sound.

The BEA analyzed, in the laboratory, the audio of a video recorded by bathers at the moment of the aircraft's fall into the sea.

The spectral analysis revealed that the two frequencies compatible with the axial and centrifugal compressors of the engine indicated that its power was established at 71.5% of nominal NG, four seconds before landing at sea, which corresponded to a value close to that of an engine operating with the TWIST GRIP in the IDLE position.

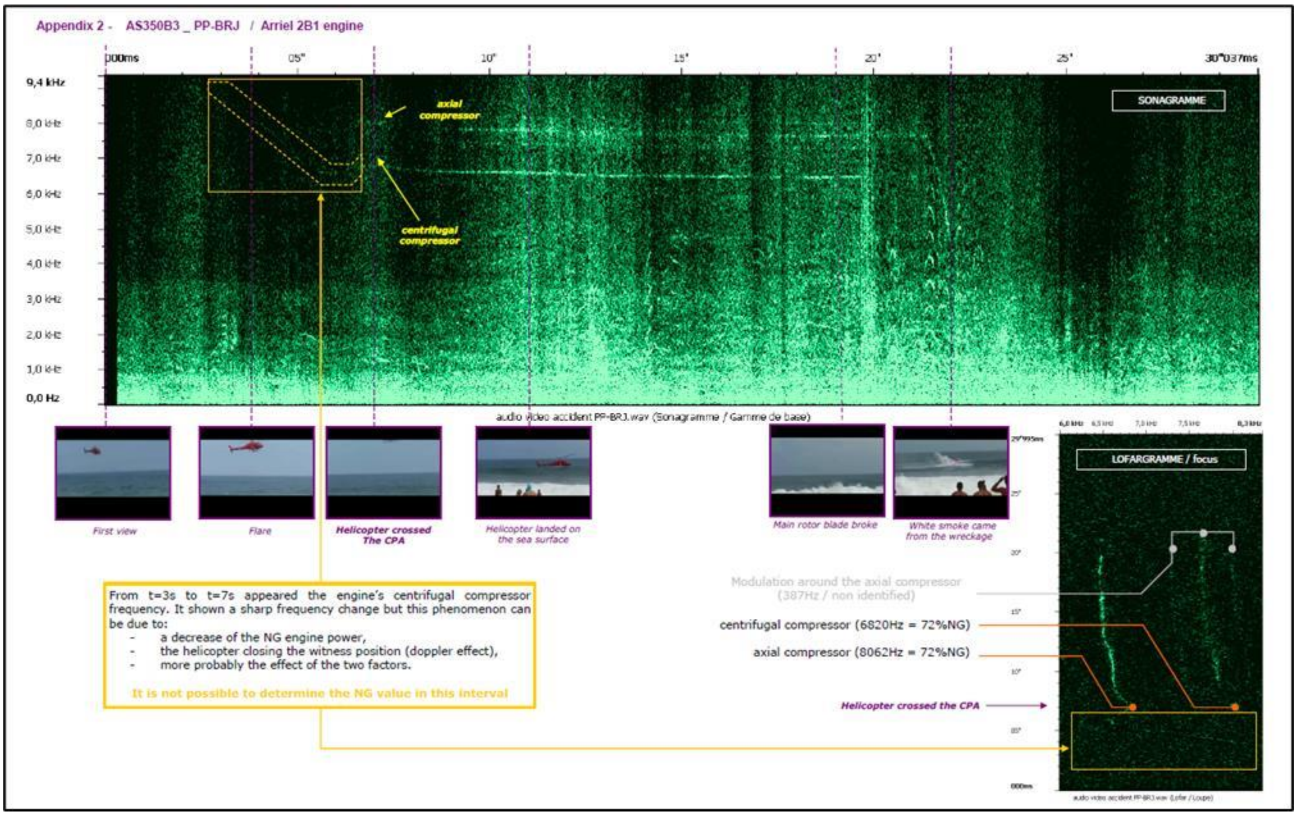

Figure 8 - Spectral analysis of the accident video audio.

It was also found that the loss of engine power occurred before the beginning of the video file, during the approach phase of the aircraft to rescue the bather at sea.

<u>Aircraft's engine.</u>

The aircraft's engine was dismantled at the headquarters of SAFRAN Turbomeca Brasil, located in Xerém - RJ, for analysis of internal and component damage, in the presence of the manufacturer's technicians and investigators from the SERIPA III.

During the disassembly, it was possible to verify that, in general, the engine was in good condition, despite the damage and crashes caused by the impact and corrosion from the action of seawater.

The result of the analysis found that there was no evidence that could explain the loss of power reported by the pilot of the aircraft.

<u>DECU and VEMD.</u>

The aircraft's DECU and VEMD were analyzed in the BEA's laboratories.

The flight data retrieved from the EEPROM memories of these devices were consistent with the event.

Analysis of the data retrieved from the VEMD and DECU showed that the first fault message on each computer was linked to a signal discrepancy in the collective command. Experience gained in analyzing this type of equipment in previous catastrophic events showed that this failure message was often encountered during aircraft impact.

Data recorded by the DECU showed that the aircraft engine was at IDLE (NG equal to 68%) at the time of the impact and the TWIST GRIP signal was equivalent to the IDLE position.

Data analysis concluded that all other discrepancies coming from different sensors occurred at the same time about 4 to 5 seconds after power reduction, and, therefore, would be consequences of the aircraft's impact with the sea.

No records of limits exceeded were found in the VEMD data.

Electrical continuity and operation of the TWIST GRIP system.

After recovering the wreckage of the aircraft, technicians from the manufacturer together with the SERIPA III investigators verified the condition of the electrical connections and the functioning of the microswitches of the TWIST GRIP command of the aircraft.

During the verification, evidence was found that the system had undergone maintenance intervention with no equivalent record.

The 53Ka microswitch wires were more flexible and had black thermo-restrictive protection. The original restrictive term, used in the manufacture of the aircraft, was transparent, presented great resistance, and was less flexible than the black one (Figure 9).

Then, electrical continuity and system operation tests were carried out due to the suspicion of internal rupture in the region of the restrictive term.

The integrity of the wires was checked using a continuity check. The connections of the 53Ka and 53Kb microswitches to the circuit were verified. The result was considered consistent with normal system operation.

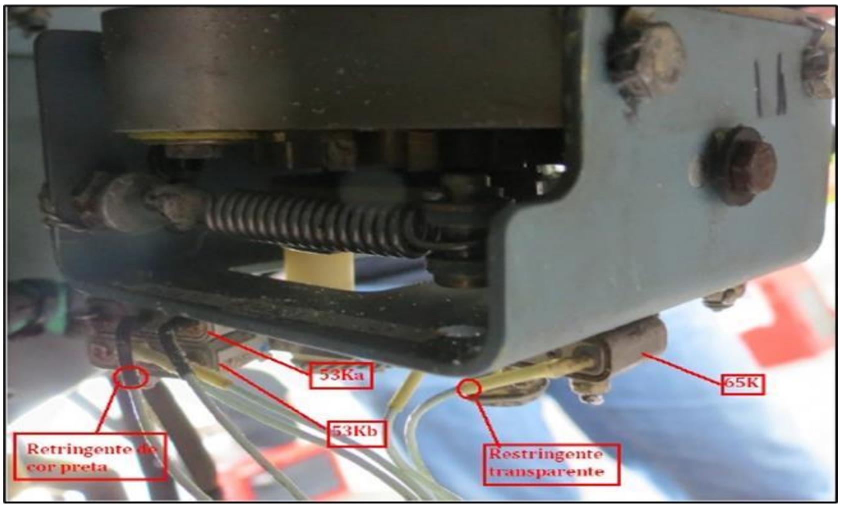

Figure 9 - Restrictive term used in the wiring of the 53Ka microswitch different from the original.

The wires close to the place where the black restrictor term was applied were moved without changing the continuity of the system. The same checks on wires with transparent thermo-restricting were performed without showing different results.

The TWIST GRIP was stuck in the flight position due to the action of salt water. However, after lubricating the mechanical part of the drive the twist grip movement was re-established.

A check of the mechanical functioning of the twist grip, as well as of the activation and correct functioning of the microswitches, was carried out by repeating several movements on the TWIST GRIP, between the FLIGHT position and the IDLE position. In all verifications, the microswitches showed normal operation.

All tests carried out on the system showed that the TWIST GRIP was working normally, as well as no anomalies were found in the microswitches and electrical wiring connections that could justify an abnormal functioning of the system.

Laboratory tests on the TWIST GRIP components.

53Ka, 53Kb, 65K, and 54K components.

The 54K relay and the microswitches named 53Ka, 53Kb, and 65K belonged to the TWIST GRIP set and were analyzed in the BEA laboratories.

An external visual inspection of the components identified, in all of them, points of corrosion in each pin connecting to the electrical circuit.

X-ray and computed tomography examinations were performed, noting the absence of visible discrepancy in the components that could compromise the functioning of the system.

Wiring.

All TWIST GRIP wirings were tested by SERIPA III investigators before being taken to BEA laboratories for further examination. At that time, they showed normal continuity.

Subsequently, the same wiring had its continuity tested in the BEA laboratories, when it presented the same result.

System functional test.

A functional test of the twist grip system was carried out in BEA's laboratories, using the electrical components of the TWIST GRIP. The objective was to expose the microswitches to salt water droplets to simulate the influence of the environment on an aircraft hovering at a low altitude over the sea.

The diagram below (Figure 10) shows the installation that was followed, representative of the installation of the TWIST GRIP set, with the use of new microswitches and relay.

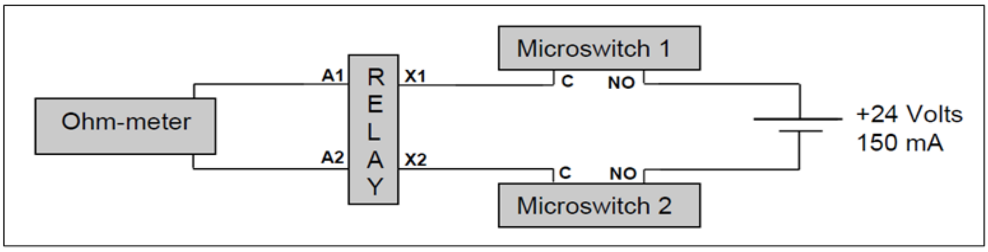

Figure 10 - Diagram of the functional test of the TWIST GRIP system performed by the BEA.

Initially, the system was tested and operated without the addition of salt water to confirm correct operation, which it did.

The nominal consumption of the 54K relay, when energized, was 60mA.

Then, drops of salt water were deposited between the pins (C and NO) and on the housing of each microswitch, when electrolysis was started and the connection could be established between C and NO in the two microswitches.

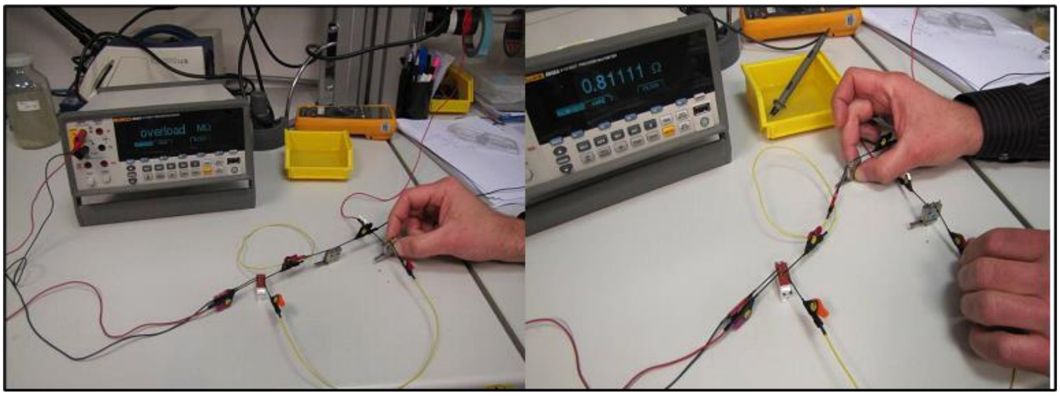

Figure 11 - Functional test of the TWIST GRIP electrical circuit using new microswitches (53Ka, 53Kb and 54K relay) and with salt water.

After the use of salt water drops and the occurrence of electrolysis, the impedance between pins C, NO, the housing decreased, and the current reached 22mA, when the 54K relay could be energized and closed.

The researchers also observed the occurrence of electrolytic corrosion in the 53Ka and 53Kb microswitches, at the time of the test, due to the oxidation of the metal and the generation of small gas bubbles in the hydrosaline solution.

Electrolytic corrosion could only occur with the passage of electric current in the presence of an electrolyte solution, that is, an electrical conductor of a liquid nature. During the test, electrolysis instantly fixed the oxygen in the water to the metal, forming an oxide, and released the hydrogen in the formation of tiny bubbles.

After drying the microswitches with air (simulating the evaporation of salt water), the 54K relay returned to the “de-energized” state with approximately 7mA. The residual current consumption was between 5 and 6mA.

Using fresh water, the results could not be reproduced.

One of the new microswitches was replaced by the 53Ka microswitch removed from the crashed aircraft's TWIST GRIP assembly. The same result was obtained by energizing the 54K relay.

All microswitches (53Ka, 53Kb, and 65K) of the crashed aircraft had electrolytic corrosion points.

1.17 Organizational and management information.

As for the organizational aspects, reports point to a deficiency in the registration and, consequently, in the follow-up of breakdowns and aircraft maintenance.

Situations similar to the one that occurred and culminated in the accident were experienced on previous flights (turning on the TWT GRIP light). However, the absence of records made it impossible to carry out frequency and severity analyses, compromising the mapping of the risks involved.

It was also found that the resolution of the aforementioned breakdowns was not recorded in maintenance books and logbooks, nor shared, aiming at raising awareness and raising the alert level of the other crewmembers.

There is no evidence of records made in Service Orders, nor of the opening of a process of Difficulty in Service, in view of maintenance interventions carried out without registration.

1.18 Operational information.

The aircraft performed a rescue flight on the coast of Rio de Janeiro. It had taken off from SDHL with a pilot and three crew on board, one being a operational crewmember and two lifeguards.

The aircraft was within the weight and balance limits specified by the manufacturer, and the weather conditions were favorable for the visual flight.

The crew had already carried out several rescues that day. However, this was considered normal.

The aircraft approached the Copacabana beach shore towards the rescue point, where it would hover to allow the two lifeguards on board to jump from the aircraft to rescue the swimmer at risk of drowning.

According to the crewmembers, until the beginning of the hover, the flight took place without any abnormalities.

During the hover, the pilot noticed that the TWT GRIP alarm light came ON on the alarm panel, at the same moment he noticed a sudden drop in engine power and the rotation of the aircraft's main rotor.

Through the analysis of a video recorded at the location, it was possible to perceive the increase in the “cone effect” in the main rotor from the moment when there was a loss of engine power and rotation of the main rotor until the landing in the water (Figures 12).

Figure 12 - Moment of landing of the aircraft at sea, highlighting the increase in the “cone effect” in the main rotor.

The first lifeguard who would jump over the sea and who was already on the ski of the aircraft said that, at that same moment, he heard an abnormal noise, and according to his report, he realized, according to his experience in this type of flight, that something strange was happening. He decided to return to the cabin and take cover, as the aircraft was already about to land at sea.

The pilot of the aircraft stated that realizing that he was experiencing a drop in power and rotation, he had no alternative other than performing an autorotation in hover, within the ground effect, over the water.

Neither the pilot-in-command nor the operational crewmember used life jackets. After the forced ditching, the lifeguards, who were on board the aircraft, helped these crewmembers in the emergency evacuation. Then it sank and was fully submerged.

With the rescue of the aircraft, it was possible to notice that the collective control was in the fully pulled position (Figure 13) and that the TWIST GRIP was in the FLIGHT position (Figure 14).

Figure 13 - Image of the cabin, shortly after removing the aircraft from the sea, highlighting the collective control in the fully pulled position.

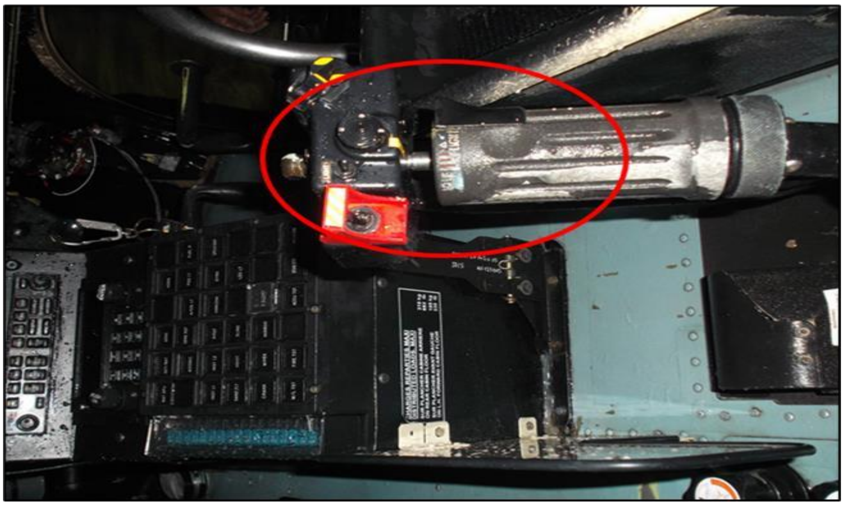

Figure 14 - Image of the cabin, shortly after removing the aircraft from the sea, highlighting the TWIST GRIP in the FLIGHT position.

1.19 Additional information.

Previous events.

The Investigation Team conducted interviews with crewmembers of the CBMERJ's GOA. During the collection of reports, there was great concern about the events of the TWT GRIP light being turned ON, on this aircraft.

It was possible to verify that, in some flights prior to the accident, the TWT GRIP light came on without loss of rotation, including an event on the day before the accident. On these occasions, the crews opted to land the aircraft as quickly as possible. Afterward, the system returned to normal operation.

Furthermore, it was also reported that the TWT GRIP light came on, which made it impossible to reduce the engine speed from FLIGHT to IDLE, with the aircraft grounded moments before the engine was shutdown. The shutdown occurred with the TWIST GRIP in FLIGHT and the aircraft underwent maintenance intervention. However, no records about this intervention were found in the aircraft's logbooks.

There was also, on at least one occasion, the total loss of radio communication while carrying out the mission. The contracted maintenance company carried out interventions to identify the causes of the breakdown and it was found that this fact occurred due to the high presence of moisture in the electrical contacts.

Two-channel FADEC system microswitch box.

The aircraft, model AS-350 in the B3 version, with a two-channel FADEC system, had a microswitch box sealed against water, under the aircraft floor, on the left side, and at the end of the collective command.

The microswitch box had acrylic protection, secured with screws. Right at the fixing points of the screws, there was no seal.

In addition, the opening and closing latch of the lower fairing was located in a slot exactly aligned with the microswitch box, more precisely, with one of the fixing screws (Figures 15 to 17).

During operation over the sea, the back of the aircraft received a lot of moisture, due to the flow of air from the main rotor over the water and, consequently, the suspension of water particles on the aircraft, mainly on its underside.

Figure 15 - Bottom fairing latch crack (photo of a helicopter of the same model).

Figure 16 - Alignment of the lower fairing latch crack with the acrylic housing of the TWIST GRIP microswitches (photo of a helicopter of the same model).

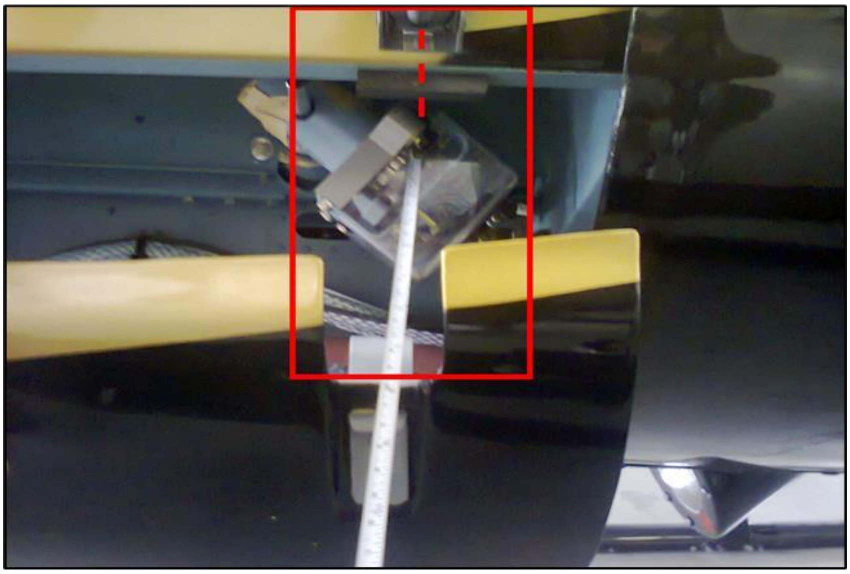

Figure 17 - Alignment of the lower fairing latch crack with one of the TWIST GRIP microswitches' acrylic box mounting screws (photo of helicopter of the same model).

In the comments made on this Final Report, Airbus Helicopters recognized that the 53ka, 53kb, and 65k microswitches were not in a completely sealed environment, besides being located near an opening.

For this reason, the microswitches could be affected under certain conditions by small drops of salt water, with the aircraft being operated close to the surface of the sea in rescue operations.

Nevertheless, the manufacturer emphasized the importance of protecting the cabin floor against sea water during rescue operations in which people are retrieved from the water, since the infiltration may lead to corrosion.

The manufacturer also pointed out that there are certain kinds of device indicated (e.g. drip trays) for the protection of the cabin floor and prevention of such dripping. One did not verify whether or not the aircraft was equipped with such device).

Air operations over an expanse of water.

The RBHA 91 - "General Rules of Operation for Civil Aircraft" in force at the time of the accident, did not previse the mandatory use of a life jacket (or other approved means of flotation) for each occupant of a helicopter that would perform a flight over water, nor the need for this helicopter, if it was single-engine, to have floats or flotation equipment of an inflatable type by command of the cabin.

Section 90.351 of Subpart Z (air operations over expanses of water) of the RBAC 90 - “Requirements for Special Public Aviation Operations” in force since 12APR2019, began to establish the mandatory use of life jackets worn by the crew of a helicopter in flight over an expanse of water where it was not possible, due to height and distance, to land in a suitable location on the coast.

The regulation also defined, in the same section, letter “f”, complementary requirements for air operations carried out over expanses of water at a distance greater than 100 NM or 30 minutes from the nearest coast/bank, having as reference the normal cruising speed of the aircraft, highlighting, in these cases, the mandatory use of a multi-engine aircraft equipped with floats or “hull” type fuselage approved by the ANAC.

RBAC 90 - REQUIREMENTS FOR SPECIAL PUBLIC AVIATION OPERATIONS

SUBPART Z - AIR OPERATIONS OVER EXPANSE OF WATER

90,351 General requirements

(a) For this Regulation, an air operation over expanses of water is considered to be one carried out at a distance and height where:

(1) in gliding flight or autorotational regime, it will not be possible to perform a forced landing at a suitable location on the coast or the nearest bank; or

(2) if an emergency occurs during the take-off or landing phases, an emergency water landing (ditching) is unavoidable.

[...]

(c) Notwithstanding the provisions of paragraph (f) of this section, air operations over expanses of water shall be carried out, as a priority, by multi-engine aircraft.

[...]

(e) General requirements for air operations over expanses of water are:

(1) The aircraft shall be provided with a life jacket or personal flotation device, equipped with a whistle and a location light, for all crewmembers, persons with function on board, and passengers on board. The following provisions apply:

[...]

(i) for helicopter operations, crewmembers and persons with functions on board must wear a lifejacket or personal flotation device throughout the flight;

[...]

(f) Complementary requirements for air operations carried out over expanses of water at a distance greater than 100 NM or 30 minutes from the nearest coast/shore, having as reference the normal cruising speed of the aircraft:

[...]

(3) use multi-engine aircraft;

(4) use a helicopter equipped with floats or fuselage type “hull” approved by the ANAC.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a rescue flight on the coast of Rio de Janeiro - RJ.

During the hover, the pilot noticed that the TWT GRIP light came ON, on the alarm panel at the same time he noticed a sudden drop in engine power and the rotation of the aircraft's main rotor, that is, the TWT GRIP light came ON, and it indicated a situation of TWT GRIP in IDLE, or at least out of the FLIGHT position, since transitory positions would be enough for the light to turn on.

On the other hand, a simple partial movement or bump on the TWT GRIP would not be enough to keep the light on. Therefore, a continuous and intentional rotational mechanical command would be necessary, removing the TWT GRIP from the FLIGHT position, because when the TWT GRIP was removed from this position and moved to the IDLE position, a spring would counteract this movement, until it reached a rebound, which at the being overpowered would keep the TWT GRIP in the IDLE position, even after the command is released.

However, with the rescue of the aircraft, it was possible to notice that the collective control was in the fully pulled position and that the TWIST GRIP was in the FLIGHT position.

Considering the rotational mechanical functioning characteristics of the TWT GRIP, which would make movement impossible due to the impact, and the fact that the SERIPA III investigators were the first to access the aircraft after the rescue, it is possible to affirm that the TWIST GRIP was in the FLIGHT position during the event, despite the pilot's assertion that the TWT GRIP light on the alarm panel came on, followed by a sudden drop in engine power and the aircraft's main rotor rotation.

Given this, the BEA analyzed in the laboratory the audio of a video recorded by bathers at the moment of the aircraft's fall into the sea. The conclusion of the spectral analysis revealed that the two frequencies compatible with the axial and centrifugal compressors of the engine indicated that the power was established at 71.5% of nominal NG, four seconds before landing at sea. This value corresponded to a value close to that of an engine operating at idle, or with the TWIST GRIP in the IDLE position.

Additionally, the aircraft engine was analyzed at the manufacturer's headquarters. The result of the analysis found that there was no evidence that could explain the loss of power reported by the pilot of the aircraft.

Considering that all the microswitches of the accident aircraft had points of electrolytic corrosion, it was possible to conclude that the microswitch box of the TWIST GRIP system of the aircraft, located under the floor, suffered the action of salt water, during the operation over the sea, facilitating the closing the circuit of the 53Ka, 53Kb, and 65K microswitches, thus sending an IDLE electrical signal to the DECU, and turning on the TWT GRIP light to the alarm panel, regardless of the position of the TWT GRIP.

On the other hand, as the microswitch box, in this aircraft model (B3 version, with a two-channel FADEC system) was sealed and located inside the lower fairing, such an action would not be possible inside. However, despite the acrylic protection being sealed, it was fixed with screws, where there was no seal.

It was also found that the opening and closing latch of the lower fairing was located in a crack exactly aligned with one of the fixing screws of the microswitch box. Droplets of salt water in suspension, deposited on the surface of the aircraft, especially those deposited on the left door, flowed downwards, until they found the crack of the lower fairing lock, entering the compartment when they began to drip on the fixing screw, without sealing, of the acrylic box.

Assuming that the three microswitches (53Ka, 53Kb, and 65K) were in perfect working order, the IDLE command and the TWT GRIP light would depend on the activation of the 53Ka and 53Kb microswitches, as well as the 65K microswitch, where the grounding point for the 54K relay, via the 53Kb microswitch, and for the TWT GRIP light to turn on.

Therefore, the action of salt water on the microswitches may have occurred in the previous events, when the TWT GRIP light was turned on in flight, without any loss of power. However, it is not possible to say whether there was an influence of salt water on another microswitch, 53Ka or 53Kb, together with the microswitch 65K, or if it was only the latter that suffered the action of salt water, being the only one necessary to allow the alarm light to turn on, since there was no IDLE command.

According to the reports, this anomaly was temporary, and the system returned to normal operation after some time, probably after the evaporation of salt water between the pins and the housing of the affected microswitches, exactly as per the results of the TWIST GRIP electrical system functional test performed at the BEA, when the 54K relay returned to the “not energized” state, after drying the microswitches with air (simulating the evaporation of salt water).

On the other hand, considering the results of the tests carried out at the BEA and the electrolytic corrosion points on the microswitches of the accident aircraft, it is possible to conclude that, in the accident flight, the three microswitches (53Ka, 53Kb, and 65K) suffered the action of salt water and had their contacts closed, as it was necessary to activate both the 53Ka and 53Kb microswitches, in addition to grounding the 65K microswitch, to allow the electrical signal from IDLE to the DECU.

It was not possible to specify the order in which the microswitches were acted upon by the salt water and closed, except the last one, precisely the 65K microswitch, which allowed the TWT GRIP light to come on and ground, thus completing the essential conditions for the inadvertent IDLE command.

It is noteworthy that, despite the redundancy of the system, since only when the two microswitches 53Ka and 53Kb were activated, together with the ground provided by the microswitch 65K, there was the electrical signal from IDLE to the DECU, this loss of redundancy was not reported to the pilot.

On the accident flight, with the 53Ka and 53Kb microswitches under the action of salt water and with their contacts closed, the alarm light did not come ON, thus allowing the flight to proceed without the redundancy foreseen for the TWIST GRIP system.

The corrective action for turning on the TWT GRIP light in flight consisted of rotating the TWIST GRIP to the FLIGHT position. Thus, it was considered that the procedure did not effectively address a sequence of actions after positioning or checking the TWIST GRIP in the FLIGHT position and keeping the alarm light on, that is, the persistence of the breakdown, predicting actions in the checking of the engine parameters, landing immediately or as soon as possible, performing autorotation, among others.

The lack of specific procedures regarding the lighting of the TWT GRIP light in flight, with the TWT GRIP in the FLIGHT position, may have excluded the possibility of the pilot making a safe landing, due to the possibility of inadvertent IDLE command.

However, even if there was a specific procedure for the situation experienced (turning on the TWT GRIP light with loss of power), there was no alternative, other than performing an autorotation while hovering over the water.

After landing at sea, the crewmembers waited for the aircraft to submerge before evacuating through the main doors, as it was not equipped with emergency floats.

The fact that the pilot and crew were not wearing life jackets or other approved personal flotation devices increased risk exposure.

Subpart K of RBHA 91, in force at the time of the accident, did not previse the mandatory use of life jackets for the occupants of a helicopter that was to fly over an expanse of water, nor did the need for a single-engine helicopter have flotation equipment.

The ANAC established, in the RBAC 90, section 90.351 of Subpart Z, in force since 12APR2019, and applicable to Public Aviation special operations, the mandatory use of life jackets (or other approved means of flotation) by the crewmembers of a helicopter in flight over an expanse of water where it is not possible, due to height and distance, to land in a suitable location on the coast. Precisely the case of the PP-BRJ, which hovered at a low altitude.

On the other hand, the same Regulation did not establish mandatory relation to the installation of emergency floats, except in cases of air operations carried out over expanses of water at a distance greater than 100 NM or 30 minutes from the nearest coast/bank, having as a reference to the normal cruising speed of the aircraft. In these cases, the aircraft should be multi-engine and equipped with floats or a “hull” type fuselage approved by the ANAC.

Despite this, considering that this type of flight over the sea and at low altitude was frequent and a routine, it could be inferred that there was inadequate management supervision by the organization because even if there was no obligation, risk management could conclude that there was no acceptable operation without the use of life jackets by the occupants of a helicopter.

It is worth mentioning that the lifeguards who were on board the aircraft helped the crew after the emergency evacuation, preventing the consequences of the accident from being even worse.

3. CONCLUSIONS.

3.1 Facts.

a) the pilot and the OEE had valid CMAs;

b) the pilot had a valid H350 aircraft type rating (which included the AS-350B3 model);

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

d) the aircraft had a valid CA;

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

f) the airframe and engine logbook records were updated;

g) the weather conditions were favorable for the flight;

h) when hovering over the sea, the aircraft presented a loss of power and rotation of the main rotor;

i) the pilot performed an autorotation and forced landing at sea;

j) the aircraft was not equipped with emergency floats;

k) after the impact, the crew performed the emergency evacuation with the aircraft submerged;

l) the crewmembers did not use life jackets;

m) after the evacuation, the crewmembers were assisted by the lifeguards who were on board the aircraft;

n) the analysis of the aircraft's engine found that there was no evidence that could explain the loss of power reported by the aircraft's pilot;

o) data recorded by the DECU showed that the aircraft engine was at IDLE (NG equal to 68%) at the time of the impact;

p) in the TWIST GRIP mechanical operation checks, the microswitches showed normal operation;

q) no anomalies were found in the microswitches and electrical connections that could justify an abnormal functioning of the system;

r) all microswitches had electrolytic corrosion points;

s) a functional test of the TWIST GRIP revealed that the exposure of the microswitches to salt water initiated electrolysis and the consequent energization of the 54K relay;

t) the fixing points of the screws of the microswitch box were not sealed against water;

u) on flights prior to the accident, the TWT GRIP light came on, without loss of rotation;

v) an event was reported prior to the accident of total loss of radio communication, during a mission carried out, caused by high presence of humidity in the electrical contacts;

w) no records about interventions were found in the aircraft maintenance logs for these reports of breakdowns;

x) it was found that the resolution of the breakdowns was not recorded in maintenance logs and logbooks, nor shared with the other crewmembers;

y) the aircraft had substantial damage; and

z) all occupants left unharmed.

3.2 Contributing factors.

- **Organizational culture – a contributor.**

The organization's informality in monitoring breakdowns, and maintenance interventions, as well as the treatment of relevant information, in the face of previous events similar to the accident, made it impossible to carry out analyzes of frequency and severity, among other measures that could have avoided the occurrence.

- **Aircraft maintenance – undetermined.**

The absence of records about the maintenance interventions carried out on the aircraft after the events before the accident made it impossible to perform research and problem-solving measures, compromising the mapping of the risks involved and the elementary actions that could have avoided the occurrence.

- **Design – undetermined.**

The location of the opening and closing latch crack of the lower fairing, in line with the microswitch box of the aircraft's TWIST GRIP system, along with the lack of sealing at the acrylic box attachment points, allowed saltwater ingress and act in its microswitches, during operation over the sea, which may have caused contact closure between the pins and the housing of the 53Ka, 53Kb and 65K microswitches, thus sending an IDLE electrical signal to the DECU, regardless of the position of the TWIST GRIP.

- **Managerial oversight – a contributor.**

The absence of registration made it impossible to carry out frequency and severity analyses, and openings of Difficulty in the Service process, among other research and problem-solving measures. This compromised the mapping of the risks involved and made it impossible to take elementary actions that could have avoided the accident and evidenced the participation of management supervision in the occurrence.

4. SAFETY RECOMMENDATION.

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 addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies.

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-503/CENIPA/2014 - 01 **Issued on 09/22/2023**

Work with the helicopter type certificate holder, to analyze the relevance of reviewing the procedures to be adopted by the crew in situations of lighting and maintaining the TWT GRIP alarm light on in flight, even after having positioned or verified that the TWIST GRIP is in the FLIGHT position.

A-503/CENIPA/2014 - 02 **Issued on 09/22/2023**

Disclose to the GOA/CBMERJ the lessons learned in this event for that operator to improve its risk management system and certify that measures have been adopted to ensure proper and formal treatment regarding the monitoring of breakdowns and maintenance interventions.

A-503/CENIPA/2014 - 03 **Issued on 09/22/2023**

Analyze whether the hazard identification and risk assessment and control processes provided for in the GOA/CBMERJ's MGSO establish measures that ensure risk mitigation in cases of operations over the sea, in aircraft that do not have flotation systems.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

The following corrective actions were taken by the aircraft manufacturer:

- the circuit logic of the TWT GRIP system and the electrical connections of its microswitches were modified, mitigating the possibility of inadvertent loss of engine power due to the TWIST GRIP system;

- improvement was implemented in the insulation and sealing of the microswitch terminals, including the application of varnish; and

- the maintenance program was modified regarding the functional checks of the system and the periodic verification of the seal.

- Airbus provided a new set of 53ka, 53kb and 65k microswitches protected against corrosion from the environment (MOD 074782). These microswitches will be the subject of a new mandatory ASB for installation.

The RBAC 90, in force since 12APR2019, began to establish the mandatory use of a lifejacket worn by the crewmembers of a helicopter in flight over an expanse of water where it is not possible, due to the height and distance, to land in a place suitable from the coast.

This regulation also defined complementary requirements for air operations carried out over expanses of water at a distance greater than 100 NM or 30 minutes from the nearest coast/shore, having as a reference the normal cruise speed of the aircraft, highlighting, in these cases, the mandatory use of a multi-engine aircraft equipped with floats or “hull” type fuselage approved by the ANAC.

On September 22th, de 2023.