COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-002/CENIPA/2019

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-RMZ**
MODEL:	**R44 II**
DATE:	**01JAN2019**

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 01 January 2019 accident with the R44 II helicopter, registration marks PR-RMZ. The occurrence was typified as “[SCF-PP] Engine failure or malfunction”.

Approximately 55 seconds after takeoff, during the climb for a scenic flight, the low-rotation horn of the aircraft's main rotor sounded, and an autorotation attempt was made in an urban area located 1.5 NM from the aerodrome.

Close to the ground, the aircraft struck the wires of a utility pole and some tree branches. When the helicopter collided with the ground, the resulting debris hit a few vehicles parked nearby.

After touching the ground, the helicopter traveled approximately 35 meters, stopping at a position that was 180° displaced relatively to the direction of its autorotation axis.

The aircraft sustained substantial damage.

The pilot and one of the passengers received minor injuries, the other passenger suffered serious injuries, and a person that was passing by was fatally injured.

For being the USA the State of manufacture of the aircraft and of the engine, the NTSB (National Transportation Safety Board) designated an accredited representative for participation in the investigation of the occurrence.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AGL	Above Ground Level
AWB	Airworthiness Bulletin
ANAC	Brazil's *National Civil Aviation Agency*
ANP	Brazilian National Agency for Petroleum, Natural Gas and Biofuels
ATSB	Australian Transport Safety Bureau
AvGas	Aviation Gasoline
CA	Certificate of Airworthiness
CASA	Australia's Civil Aviation Safety Authority
CENIPA	Brazil's *Aeronautical Accidents Investigation and Prevention Center*
CIV	Pilot Logbook
CMA	Aeronautical Medical Certificate
COA	Air Operator Certificate
DCTA	Department of Science and Aerospace Technology
EO	Operating Specifications
FAA	USA's *Federal Aviation Administration*
HMNC	Conventional Single-Engine Helicopter Class Rating
HMNT	Turbine Single-Engine Helicopter Class Rating
IAE	Institute of Aeronautics and Space
IAM	Annual Maintenance Inspection
IAS	Indicated Air Speed
InHg	Inches of Mercury
NM	Nautical Miles
NTSB	USA's *National Transportation Safety Board*
OM	Maintenance Organization
PCH	Commercial Pilot License (Helicopter)
PIC	Pilot in Command
PN	Part Number
POH	Pilot Operating Handbook
PPH	Private Pilot License (Helicopter)
RAB	Brazilian Aeronautical Registry
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
RHC	Robinson Helicopter Company
RPM	Revolutions Per Minute
SACI	Integrated Civil Aviation Information System

SAE	Aircraft Registration Category (Specialized Public Air Services)
SB	Service Bulletin
SDUB	ICAO location designator - *Gastão Madeira* State-Aerodrome, *Ubatuba*, State of *São Paulo*.
SIPAER	Brazil's *Aeronautical Accidents Investigation and Prevention System*
SN	Serial Number
TC	Type Certificate
TPP	Aircraft Registration Category (Private Air Services)
TPX	Aircraft Registration Category (Non-Regular Public Air Transport)
UTC	Universal Time Coordinated

1. FACTUAL INFORMATION.

Aircraft	**Model:** R44 II **Registration:** PR-RMZ **Manufacturer:** Robinson Helicopter	**Operator:** *Helicon Táxi Aéreo Ltda.*
Occurrence	**Date/time**: 01JAN2019 - 13:55 (UTC) **Location:** Urban area of *Ubatuba*. **Lat.** 23°27'29"S **Long.** 045°03'47"W **Municipality – State:** *Ubatuba – São Paulo.*	**Type(s):** [SCF-PP] Powerplant failure or malfunction

1.1. History of the flight.

At around 13:55 UTC, the aircraft took off from SDUB (*Gastão Madeira* State-Aerodrome, *Ubatuba*, State of *São Paulo*), in order to perform a scenic flight over the city, with a pilot and two passengers on board.

Approximately 55 seconds after takeoff, while the helicopter was still climbing, the main rotor's low RPM audible alert sounded, and the pilot attempted autorotation for an emergency landing in the urban area of *Ubatuba*.

During the final approach, the helicopter collided with the wires of a utility pole and trees located along the street. After colliding with the ground, the wreckage of the aircraft also hit vehicles parked nearby.

Figure 1 - View of PR-RMZ at the accident site.

The aircraft sustained substantial damage.

The pilot and one of the passengers suffered minor injuries. The second passenger received serious injuries, and a pedestrian was fatally injured.

1.2. Injuries to persons.

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

1.3. Damage to the aircraft.

The aircraft sustained substantial damage to its entire structure, including the rotors.

1.4. Other damage.

After the aircraft collided with power lines and trees, parts of the aircraft detached, hitting a total of ten cars, as well as the window of an apartment located on the street of the accident.

1.5. Personnel information.

1.5.1. Crew's flight experience.

	PIC
Total	352:31
Total in the last 30 days	05:22
Total in the last 24 hours	00:58
In this type of aircraft	270:00
In this type in the last 30 days	05:22
In this type in the last 24 hours	[00:58]

N.B.: data on the hours flown by the PIC obtained through records of the Integrated Civil Aviation Information System (SACI) and Pilot Logbook (CIV) of the Pilot in Command (PIC). The last record registered in his Digital CIV dated from 04 December 2018.

The data contained in the SACI revealed that the PIC had a total of 347 hours and 09 minutes of flight time. In addition, by means of the records of the operation in *Ubatuba*, it was possible to determine that the PIC had flown another 5 hours and 22 minutes on the accident aircraft.

1.5.2. Personnel training.

The PIC did his PPH course (Private Pilot – Helicopter) in 2015, at *EDAPA Escola de Aviação*, *Campinas*, State of *São Paulo*. He completed his practice training at *Voo Solo Helicópteros Escola de Pilotagem*, in *Ribeirão Preto,* State of *São Paulo.*

1.5.3. Category of licenses and validity of certificates.

The PIC held a PCH License (Commercial Pilot - Helicopter), as well as valid HMNC (Single-Engine Conventional Helicopter) and HMNT (Single-Engine Turbine Helicopter) ratings.

1.5.4. Qualification and flight experience.

The PIC started his professional pilot career, performing dual command flights in companies with the objective of gaining experience. Since two years before the day of the accident, he had been carrying out freelance flights at "*Helicopteross*", the company for which he was operating on the day of the occurrence. The owner of the referred company was also the owner of the aircraft involved in the accident. However, the company did not have an Air Operator Certificate (COA) issued by the pertinent Regulatory Agency.

The pilot did not compose the staff of the *Helicon Táxi Aéreo* company, which operated the aircraft, according to records of the Brazilian Aeronautical Registry (RAB).

At an interview, the PIC reported that he had been conducting scenic flights in the region since 27 December 2018, with an average 15 flights per day, each one with duration of about 5 minutes.

Furthermore, he informed that it was common for pilots of the "*Helicopteross*" company to carry out training flights. According to the PIC, he had completed emergency training a few days before the accident.

The PIC had qualification and experience for the flight, but was not qualified to operate in accordance with the requirements of the Brazilian Civil Aviation Regulation nº 135 (RBAC-135) - "Public Air Transport Operations with Airplanes with a Maximum Certified Passenger Seating Configuration of up to 19 Seats and Maximum Paid Cargo Capacity of up to 3,400 kg (7,500 Lb.), or Helicopter", as he did not compose the staff of the Helicon company, and had not completed the training required to operate in Non-Regular Public Air Transport - Air Taxi.

1.5.5. Validity of medical certificate.

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

1.6. Aircraft information.

The SN 13,028 aircraft, was a product manufactured by Robinson Helicopter in 2010, registered in the Multiple Category of Non-Regular Public Air Transport Registration - Air Taxi (TPX) and Specialized Public Air Service (SAE) - AA/C/F/P/R (M04).

Its CA (Certificate of Airworthiness) was valid.

The last inspection of the aircraft (type "Annual Maintenance Inspection" - *IAM*) was performed on 25 October 2018 by the OM (Maintenance Organization) *HELIHELP – Manutenção de Helicópteros* (COM N° 1209-41 ANAC), in *Ribeirão Preto*, State of *São Paulo*. The aircraft flew 50 hours and 55 minutes after such inspection.

According to the engine logbook, the last "50-hour" inspection of the SN L-340035-48E IO-540-AE1A5 Lycoming engine was performed on 17 November 2018 by a mechanic accredited by the National Civil Aviation Agency (ANAC), in *Ribeirão Preto*, State of *São Paulo*. The aircraft flew 9 hours and 42 minutes after the said inspection.

Both the PR-RMZ and the engine had a total of 673 hours and 23 minutes on the date of the accident.

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

Also according to the engine logbook, the last inspection of the magnetos, in compliance with the Service Bulletin TCM 643B, was carried out during an inspection ("100-hour" type) on 23 April 2018, by the OM *Airtech Soluções Aeronáuticas Ltda.* (COM N° 1604-31 ANAC), in *Rio de Janeiro*, State of *Rio de Janeiro*. On the occasion, the engine had a total of 583 hours and 48 minutes of operation.

On 11 July 2017, the PN 10-600646-201, SN E091A073, type S6LSC-204T Continental magneto was subjected to overhaul by the OM *Estrela Dourada Manutenção Aeronáutica* (COM nº 1601-42 ANAC). The magneto was approved for return to service. At the time, the item had a total of 476 hours and 10 minutes.

The ignition system was equipped with two magnetos at the rear part of the engine, being one on the right-hand side and one on the left-hand side. Both magnetos were manufactured by Continental Aerospace Technologies and their types were, respectively, S6LSC-204T and S6LSC-200.

Internally, the right-hand magneto had two components known as *contact points*. One of them was responsible for generating the spark in the spark plugs, and the other one was responsible for providing the tachometer on the instrument panel and the engine governor with the engine RPM signal.

The engine governor, which received the signal from the right-hand magneto, had the function of keeping the engine RPM close to 100%. It applied corrections to the power lever *(throttle*) by means of a friction clutch that, if necessary, could be canceled by the pilot. The governor remained active between 80% and 113% of the engine RPM and could be turned on or off by means of a selector switch at the end of the right-hand-seat collective.

The governor's role was to assist in controlling the RPM under normal conditions. In the case of aggressive flight maneuvers, it might not be able to prevent overspeed or underspeed conditions.

The engine power lever was correlated to the collective control by means of mechanical links. With the governor on, when the collective pitch was increased, the throttle was opened, and when the collective was lowered, the throttle was closed. The system sought to maintain the rotor RPM between 101% and 102%.

In addition to these pieces of equipment, the aircraft had a manifold pressure indicator on its instrument panel (Figure 2).

Figure 2 - PR-RMZ engine intake pressure indicator, after the accident.

The manifold pressure had the function of informing the intake pressure of the air/fuel mixture, being controlled by means of the power lever. As the pilot accelerated the power lever, more fuel and air would be supplied to the engine, thus increasing the intake pressure measured by the instrument.

With the engine turned off, the manifold pressure should indicate the local atmospheric pressure. This instrument was usually graded in Inches of Mercury (inHg).

At full continuous power, at 30°C and at sea level, the maximum intake pressure should be approximately 24.4 inHg.

The POH (Pilot Operating Handbook) of the R44 II Robinson helicopter read that a loss of power could be related to both engine and transmission system failures and would have, as an indication, the activation of the low RPM horn when the rotation dropped to a value equal to or below 97%. An engine failure could also be indicated by a change in the helicopter's attitude, such as a nose yaw to the left, a low oil pressure light illumination, or a decrease in the engine RPM.

According to the manufacturer, if there was a loss of power, the main rotor RPM should not fall below 80%, as recovery would become impractical.

The lowering of the collective should be executed immediately by the pilot, in order to allow the reduction of the collective pitch of the main rotor to reduce the aerodynamic drag on the blades, so that the rotor remained between 97% and 108% of the RPM, without loss of rotation.

1.7. Meteorological information.

The aerodrome of SDUB did not have meteorological information services. At any rate, as observed in the footage taken by the passengers' cameras, the sky had a layer of clouds above the nearest elevations, that is, at least above 1,000 ft in height, and the visibility was more than 10 km. The temperature in the region was approximately 30°C (Figure 3).

Figure 3 - Panoramic view of *Ubatuba* moments before the accident.
Source: image extracted from the video recorded by a passenger of the PR-RMZ.

That being so, conditions were favorable for visual flights.

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

The occurrence was outside of aerodrome area.

1.11. Flight recorders.

Neither required nor installed.

1.12. Wreckage and impact information.

During the descent in autorotation, the aircraft struck the wires of a utility pole and tree branches. Close to the ground, the helicopter turned 180° opposite the approach axis, tilted to the left, and moved forward, stopping 35 meters away from the point of the first impact on the ground, judging from the marks left on the asphalt.

As the helicopter slid down the street, it collided with a second utility pole, objects, and parked vehicles, breaking up into three parts: skids and tail rotor; cabin and main rotor; and tail boom (Figure 4).

Figure 4 - View of the PR-RMZ trajectory on the ground.

One observed that the aircraft's skids hit the utility pole with their rear part (Figure 5).

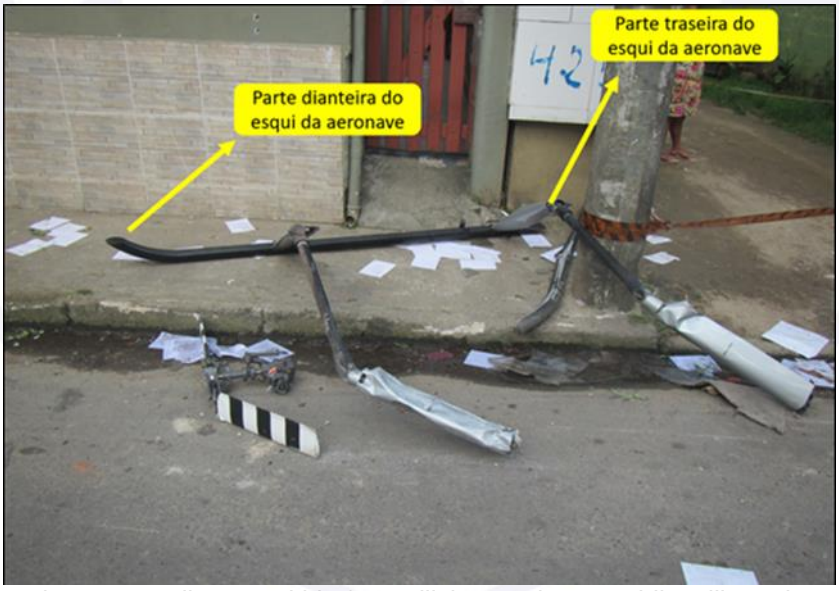


Figure 5 - Helicopter skid after collision against a public utility-pole.

On account of the linear arrangement of the wreckage, the impact marks, and the aircraft's stopping point, one concluded that the emergency landing occurred at a high speed forward.

Based on the images recorded by one of the passengers, and the fact that the main rotor blades were not fractured, but bent upwards, one inferred that the main rotor was turning at low RPM at the moment of impact (Figure 6).

Figure 6 - The red arrows show the main rotor blades bent upwards. One of the blades rotated 180° in the longitudinal axis and became inverted (upside down) in relation to the other one.

Also, a public utility-pole wire and a glass insulating-disc were found, along with the helicopter's vertical and horizontal stabilizers, at a distance of approximately 40 meters from the aircraft cabin (Figure 7 A and B).

Figure 7 - Electrical network wire (A) / Aircraft vertical and horizontal stabilizers and insulator (B).

1.13. Medical and pathological information.

1.13.1. Medical aspects.

In the 24 hours prior to the accident, the PIC had performed approximately 15 takeoffs for local scenic flights, totaling 8 hours of work, with a 2-hour rest period.

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

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

The PIC's qualification dated back from 2015. He had been carrying out freelance flights for the *"Helicopteross"* company for approximately two years. He reported that his

relationship with the co-workers, including his bosses, was healthy, and that there were no complaints regarding their support of his work.

The pilot considered himself a very composed and calm person during operations. He reported that he was enjoying a good moment of his life, emotionally stable, and without any issues that could have interfered with his performance during the occurrence.

He had been operating in the city of *Ubatuba* for 5 days, and reported that, on the day of the accident, he performed a pre-flight inspection in the hangar, and then removed the aircraft in order to wash and refuel it.

After the refueling, the passengers boarded the helicopter when the engine had already been started. According to reports, after takeoff, “at 300 feet”, there was a loss of RPM and the “low rotation horn began to sound”, which made the PIC react “automatically” for the autorotation procedure. He mentioned not remembering whether he had operated the power lever during the descent.

Finally, he added having undergone a “re-check” 30 days before the occurrence, on the same model of aircraft, having also performed, on that occasion, one hour of autorotation training before the technical proficiency exam to revalidate his rating certificate.

1.14. Fire.

There was no fire.

1.15. Survival aspects.

After being rescued, the pilot and passengers were taken to a beneficent hospital known as *Santa Casa de Ubatuba*. Subsequently, one of the passengers was taken to another hospital, located in the city of *Taubaté*, State of *São Paulo*, on account of injuries to the right eye.

A passerby, who was on the public street where the helicopter made the forced landing, died after being hit either by the helicopter or its debris.

1.16. Tests and research.

Engine Lubricating Oil and Aviation Gasoline (AvGas)

Three samples of Engine Lubricating Oil and a sample of AvGas were collected from the aircraft, and sent to the Aeronautical Propulsion Subdivision of the IAE (Institute of Aeronautics and Space), a unit subordinate to the DCTA (Department of Science and Aerospace Technology).

With regard to the Engine Lubricating Oil, physical-chemical tests of kinematic viscosity at 100°C (mm^2/s), kinematic viscosity at 40°C (mm^2/s), and Cleveland flash point (°C) were carried out, with the objective of verifying compliance with the values specified by the Society of Automotive Engineers Standard J-1899.

In the case of the AvGas, the following tests were carried out: physical-chemical appearance; corrosivity to copper (100ºC/2 hours); specific mass at 20ºC and distillation of the fuel, in order to verify compliance with the values specified by Resolution of the National Petroleum, Natural Gas and Biofuels Agency (ANP).

The results obtained in the tests demonstrated that the materials of all samples met their technical specifications and showed no signs of contamination.

Powertrain

The SN L-34035-48E, IO-540-AE1A5, Lycoming engine, which equipped the PR-RMZ, was also analyzed by the IAE, being inspected at GO AIR maintenance organization, in *São Paulo*, State of *São Paulo*, and then tested at the facilities of *Estrela Dourada* maintenance organization, headquartered in *Itápolis*, State of *São Paulo*.

During the external inspection, one observed that the engine did not sustain severe damage resulting from the crash.

Before being installed on the test bench, the engine had its dry sump replaced due to a puncture. Subsequently, the cylinders were tested for compression. To carry out this check, it was necessary to remove the lower spark plugs from the cylinders, and one observed that they had normal operating appearance and color.

In the lubrication system, one observed that, when manually turning the engine, there was oil pressure in the hose that conveyed information to the test bench panel.

The engine was started, and presented failure. The spark plugs were removed and cleaned again, as they were impregnated with lubricating oil. At the second attempt, the engine started normally. After the engine got warm, its rotation was increased to 1,800 RPM to test the magnetos.

One identified that the cable of the upper spark plug of cylinder nº 3 was partially severed as a result of the crash. It was reworked, and the engine was re-started, showing normal operation.

Thus, the result of the functional bench test revealed that the engine operated normally with power development at 2,800 RPM, without any discrepancy or abnormality being noticed.

After the test, the magnetos were removed and tested on the bench. Both of them functioned normally. However, the presence of lubricating oil residue unforseen by the manufacturer was observed in the right-hand magneto, as evidenced in Fig. 8, 9 and 10.

Figure 8 - Lubricating oil residue on the contact breaker of the right-hand magneto.

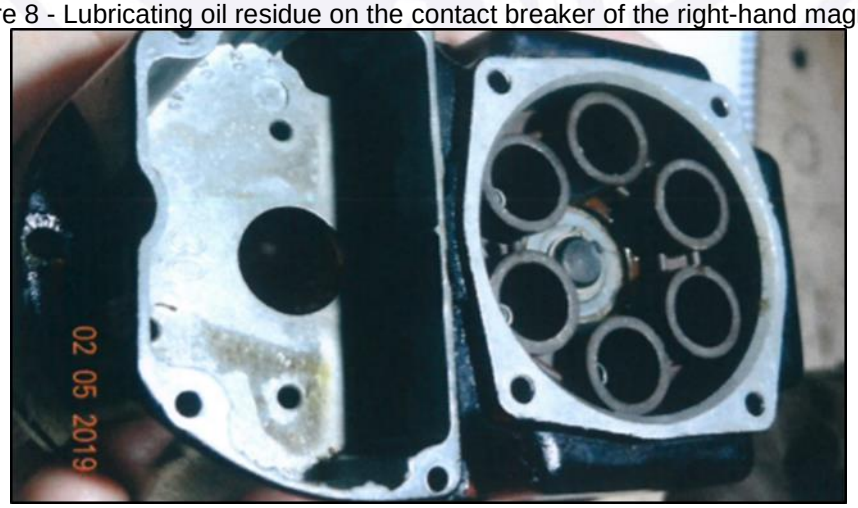


Figure 9 - Lubricating oil residue on the base of the contact breaker.

Figure 10 - Presence of lubricating oil in the rotor and right-hand magneto housing.

Magneto - SN E091A073

The component was examined at the headquarters of Robinson Helicopter Company (RHC) in Torrance, California, USA.

When analyzing the contact breaker on a microscope, multidirectional marks were found on the contact surface of the right-hand magneto.

Figure 11 - Multidirectional marks found on the contact breaker
of the right-hand magneto. Source: Robinson Helicopter Company.

In this component, it would be usual to find only unidirectional marks. The multidirectional marks suggest the possibility that some material (such as sandpaper) was used for cleaning the circuit-breaker contacts.

In addition to the marks, one also observed that there was a small smooth and shiny area, occupying approximately 20% of the contact surface. There were cavities and a narrow ledge near the edge.

There was also a small dark area between the smooth area and the center of the circuit breaker, appearing to be some sort of substance. A dark, grainy pasty substance on the inner side of the part was also found (Figure 12).

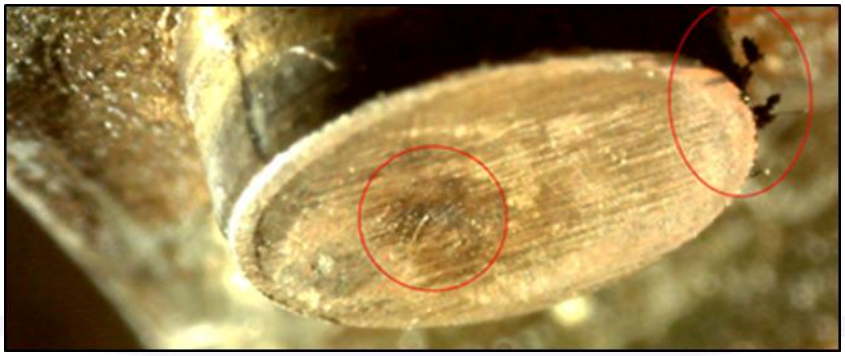


Figure 12 - SN E091A073 Magneto. Source: Robinson Helicopter Company.

In consonance with a note contained in the item 6-2.2 - Contact Assemblies of the manual of the magneto manufacturer, Continental Aerospace Technologies - S20/S200 Series High Tension Magneto - Service Support Manual (Figure 13), it was not permitted to burnish, stone or dress the contact points with emery cloth. The aforementioned note also informed that if the item "appeared damaged or unusable, the entire contact assembly was to be replaced".

NOTE: Do not attempt to burnish, stone or dress contact points. Do not clean contact points with emery cloth. If the contact assembly points appear to be unserviceable, replace the entire contact assembly.

Figure 13 – Extracted note on contact point maintenance procedure listed in the manual of the magneto manufacturer. Source: Service Support Manual.

Furthermore, the item 4 (Figure 14) of the same procedure informed that the desired surface on the contact breaker (i.e., the contact points, the area in which the electrical contact was made), should have a "dull gray, sandblasted (almost rough) or frosted appearance".

4. Examine contact points for wear or burning. Discard and replace contact assemblies (Figure 1) (39) with points that are deeply pitted or burned. Figure 6-2 shows how a typical contact point will look when the surfaces are separated for inspection. Desired contact surfaces have a dull gray, sandblasted (almost rough) or frosted appearance, over the area where electrical contact is made, indicating the points are wearing evenly and mating properly. Replace burned, pitted, peaked or otherwise damaged contact assemblies.

Figure 14 – Contact assembly maintenance procedure. Source: Service Support Manual.

This condition indicated that the points were wearing evenly and fitting properly together. The Item 4 also clarified that the contact assemblies should be replaced if they were "burnt, pitted, peaked, or otherwise damaged".

A figure in the Manual illustrated what the condition of the contact point should be like after being removed for inspection (Figure 15).

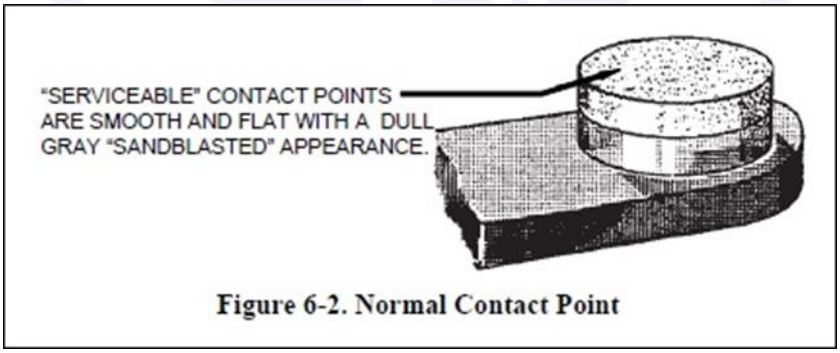


Figure 6-2. Normal Contact Point

Figure 15 - Image taken from the magnetos' manual showing what the appearance of the contact points should be after being removed for inspection.

The Figure 15 shows that contact points in good condition should have a smooth and flat surface, with a dull gray "sandblasted" appearance.

The components were tested in the laboratory for a period of three minutes, and presented satisfactory results.

In the sequence, the aircraft's manufacturer, with a drop of lubricating oil on the surface contact points, simulated the signal generated by the contact breaker. One observed that the signal degraded for several seconds and then returned to normal. During signal degradation, one noticed a decrease in voltage and a loss of frequency reading on the oscilloscope.

Tachometer - SN 6402 Rev I

The component was examined by RHC, and no damage or inconsistencies were observed.

Governor Controller - SN 3138 Rev E

The item was visually examined by RHC for any external damage and/or gaps in the sealant, and no abnormalities were found. The controller was subjected to a functional test, and no discrepancies were observed.

That said, the analysis conducted by the Aeronautical Propulsion Subdivision of the IAE, based on examinations performed at both the IAE and the RHC, led to the conclusion that the failure presented during the flight was possibly related to the degradation of the signal received by the governor controller.

In the laboratory, one identified that the contact breaker that generated the electrical signal for the governor controller presented multidirectional scratches on the pads. Such condition was not allowed because it could lead to degradation of the signal generated for the governor controller.

In tests performed by the manufacturer, one found out that, by adding a drop of oil to the contact breaker, the signal was degraded for a few seconds and then returned to normal. If the degradation occurred during the flight, at least the audible alarm would be triggered, and it could induce the pilot to take a decision not recommended for that phase of the flight.

1.17. Organizational and management information.

On 27 September 2018, in accordance with the Certificate of Entire Content contained in the Brazilian Aeronautical Registry (RAB), the operational lease was registered on the aircraft with nationality marks and registration PR-RMZ, according to a private aircraft leasing instrument, dated from 17 September 2018 and signed between the owner (lessor) and the *Helicon Táxi Aéreo Ltda.* company (lessee). Under the terms of the referred instrument, the aircraft's lease term was one year, counting from the date of registration of the pertinent document.

On the same date, the lessee requested a change in the aircraft registration category from TPP (Private Air Services Aircraft Registration Category) to TPX (Non-Regular Public Air Transport Aircraft Registration Category), and the aircraft was included in the Operational Specifications of the *Helicon* company.

Also in accordance with the aforementioned Certificate, on 02 April 2020, the operating lease was terminated between the parties, in consonance with a contract termination agreement signed on 03 September 2019.

Due to the fact that, at the time of the accident, in accordance with the Brazilian Aeronautical Registry (RAB), the aircraft was operated by the lessee company under the operating lease contract, the Investigation Commission requested the *Helicon* company to provide information on the pilot's operational background, the analysis and/or or mapping related to operational safety risk management, and authorization for the conduction of scenic flights.

The *Helicon* company informed that, although it had authorization to use the equipment contained in its Operational Specifications (EO), it was the owner of the aircraft who had operational control over the flight that resulted in the accident, and the PIC did not have an employment relationship with the *Helicon Air Taxi Ltda*. company.

According to interviews given by the PIC and passengers, the helicopter was engaged on a paid scenic flight over the city of *Ubatuba*, State of *São Paulo*. The passengers made a financial payment to the *"Helicopteross"* company, owned by the aircraft lessor at the time of the accident.

On the date of the accident, the PIC had an employment bond with the owner of the aircraft to perform scenic flights in the region, having started such services on 27 December 2018.

Still in regulatory terms, it is worth mentioning that, at the time of the accident, scenic flight activities were governed by the RBAC-135, and carrying out this type of operation on aircraft registered in the TPP category was not allowed.

Scenic flights could also be carried out in accordance with the Brazilian Aeronautical Homologation Regulation nº 141 (RBHA-141) - “Civil Aviation Schools”, under certain operational limitations.

Only in June 2020 did the Regulatory Agency published the RBAC-136 - “Certification and Operational Requirements: Panoramic Flights”, specifically regarding this type of activity.

In order to operate in accordance with the RBAC-135, in addition to possessing the Air Operator Certificate (COA) and authorization to provide paid public air transport services for passengers or cargo, the contractor had to have a training program approved by the ANAC, capable of ensuring adequate training for the accomplishment of each crewmember’s duties.

The aircraft owner's company, at the time, did not have an approved COA, did not have authorization to provide paid public air transport services for passengers or cargo, and did not have a training program approved by the ANAC.

1.18. Operational information.

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

The start-up and takeoff procedures were uneventful, with no indication of any complications.

By means of a video recording made by one of the passengers who occupied the front left seat, it was possible to observe the development of the flight from the takeoff to the collision with trees and the ground.

From the place of takeoff to the first obstacle located ahead on the takeoff axis (the aerodrome's security fence), the aircraft had approximately 85 meters of grassy area available for accelerating.

After leaving the ground, the PIC performed a 130° tail-turn to the right, accelerating up to 40 kt and, in order to start a climbing turn to the right at a height of approximately 20 ft., allowing a momentary reduction in speed down to 30 kt.

The helicopter then accelerated to about 85 kt, and adjusted the rate of climb to 500 ft/min. From the start-up until that moment, the engine and rotor RPM parameters remained stabilized in the normal operating range (Figure 16).

Figure 16 - PR-RMZ panel, without discrepancies, during the climb after takeoff.

Approximately 55 seconds after leaving the ground, at a height of approximately 350 feet, still climbing, the noise from the aircraft's rotor decreased rapidly and continuously, until the audible (HORN) and visual (ROTOR LIGHT) alarms for low main rotor rotation were triggered.

A few seconds after the horn sounded, an image of the PR-RMZ panel was recorded indicating a drop in rotation of both the engine and rotor. The condition of the “little ball” indicating a skidding to the right-hand side is an indication of reduced engine power. (Figure 17).

Figure 17 - Image captured by the passenger's camera, moments after activation of the low rotor rotation alarm.

Based on the images obtained, the time elapsed between the moment of the audible alarm and the first collision was approximately 13 seconds.

When comparing the PR-RMZ tachometer indications in flight (Figure 18A) with those of the RHC laboratory, in Torrance (Figure 18B), one sees that the rotor and engine indications initially fell to approximately 80% during the occurrence of the failure.

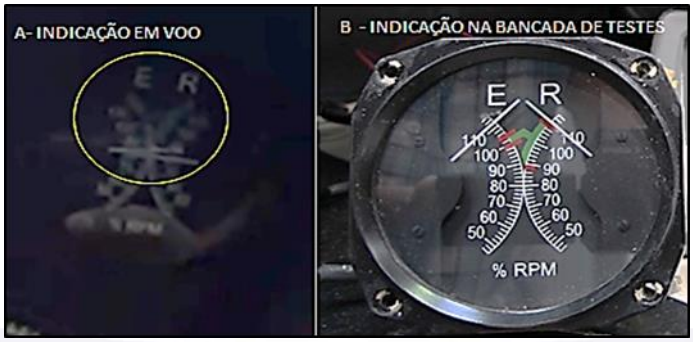


Figure 18 (A and B) - Comparison between the PR-RMZ tachometer indications.

Upon hearing the audible alarm, the pilot lowered the collective and applied the cyclic forward in order to lower the aircraft's nose, increasing its Indicated Airspeed (IAS) to 97 kt.

During the descent, the main rotor RPM indication stabilized at 80%, the engine RPM varied abruptly between 80% and 116% (the maximum upper stop of the tachometer), as shown in Figure 19.

The main rotor's low RPM caution light remained illuminated during most of the descent, before turning off and then on again in the final segment of the flight.

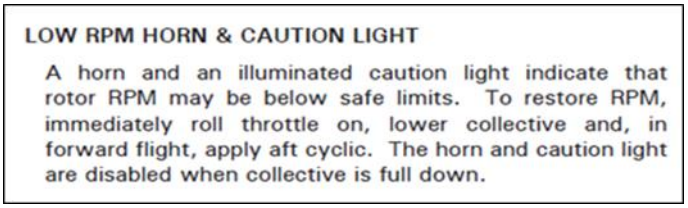
The sequence of images presented in Figure 19, obtained by means of the passenger's camera, recorded, in sequence, the oscillations of both the rotor and engine RPM, the condition of the RPM light, and the manifold pressure indication in the moments before the accident.

Figure 19 - Variation in engine RPM, while the rotor remains constant at 80%, and low RPM light “cycling”.

The images in Figure 19 were obtained in the time interval recorded in the upper quadrant of each frame, demonstrating the high oscillations in the engine RPM indication in that short period of time. The time elapsed from the moment of the audible alarm until the first collision was 13 seconds.

The POH of the Model R44 II Robinson helicopter, Section 7, *Systems Description*, warned that the activation of the light (CAUTION LIGHT) and the activation of the low RPM horn (LOW RPM HORN) indicated that the rotor rotation was equal to or less than 97%.

The POH, Section 3 - *Emergency Procedures*, specified the recommended actions in the event of caution light illumination and the low rotor RPM horn activation (Figure 20).


LOW RPM HORN & CAUTION LIGHT

A horn and an illuminated caution light indicate that rotor RPM may be below safe limits. To restore RPM, immediately roll throttle on, lower collective and, in forward flight, apply aft cyclic. The horn and caution light are disabled when collective is full down.

Figure 20 - LOW RPM HORN & CAUTION LIGHT emergency procedure.

For the condition in question, the emergency procedure in the case of activation of the main rotor RPM alarm below the safety limit of 97% RPM (*LOW RPM HORN & CAUTION LIGHT*), advised that the pilot should restore the RPM of the rotor by opening the power lever (*throttle on*), lowering the collective immediately in the case of forward flight, and applying cyclic backwards. With the collective lowered, both the caution light and horn alarms would be deactivated.

The POH (Section 2 – Limitations) specified the following limits for the rotor Tachometer indication:

Lower red line - 90%

Green arc - 90 to 108%

Upper red line - 108%

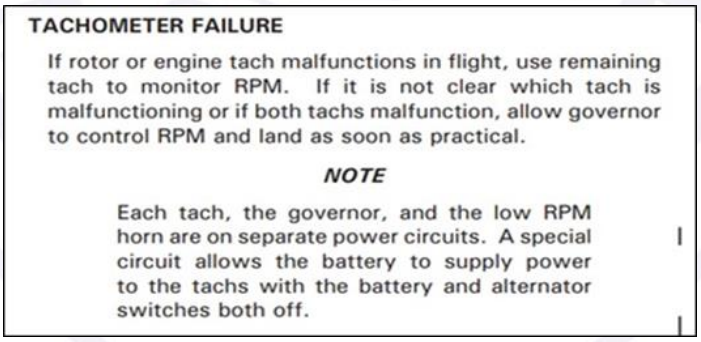
As for the engine, the limits were as follows:

Lower red line - 101%

Green arc - 101 to 102%

Upper red line - 102%

In case of Tachometer Failure, the POH (Section 3 - Emergency Procedures) advised that the pilot should use, as a reference, the remaining tachometer to monitor the RPM. If the failure occurred in both tachometers, or if the pilot was unable to identify the faulty tachometer, he should allow the governor to control the RPM, and perform a landing as soon as practicable (Figure 21).


TACHOMETER FAILURE

If rotor or engine tach malfunctions in flight, use remaining tach to monitor RPM. If it is not clear which tach is malfunctioning or if both tachs malfunction, allow governor to control RPM and land as soon as practical.

NOTE

Each tach, the governor, and the low RPM horn are on separate power circuits. A special circuit allows the battery to supply power to the tachs with the battery and alternator switches both off.

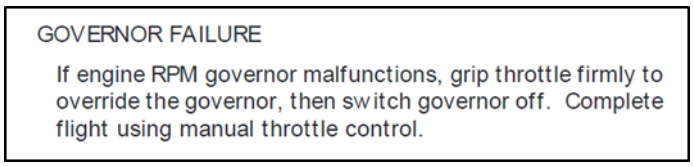
Figure 21 - TACHOMETER FAILURE emergency procedure.

The POH (Section 4 - Normal Procedures) informed the governor would remain inactive with engine rotations below 80%, regardless of the position of the respective switch:

NOTE

Governor is inactive below 80% engine RPM regardless of governor switch position.

Regarding the Governor Failure, the POH (Section 3, Emergency Procedures) had a prescription for turning off the governor switch, so that the flight could be completed through manual control of the power lever (Figure 22).

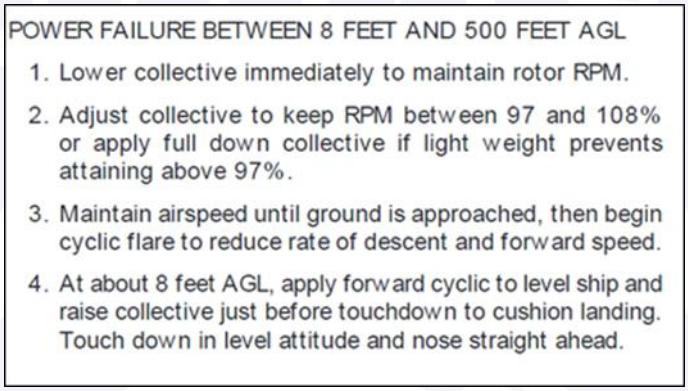

GOVERNOR FAILURE

If engine RPM governor malfunctions, grip throttle firmly to override the governor, then switch governor off. Complete flight using manual throttle control.

Figure 22 - GOVERNOR FAILURE emergency procedure.

As seen in Figure 16, the governor's alarm light was off, an indication that it was illuminated during the flight in question. Therefore, in accordance with the Section 7 (Systems Description, Warning And Caution Lights), the governor alarm light (*governor-off light*) would only illuminate if the respective switch was turned off.

According to POH (Section 3 - Emergency Procedures), for the Engine Failure procedure between 8 ft and 500 ft AGL, the pilot should comply with the procedures listed in Figure 23, as follows:


POWER FAILURE BETWEEN 8 FEET AND 500 FEET AGL

1. Lower collective immediately to maintain rotor RPM.
2. Adjust collective to keep RPM between 97 and 108% or apply full down collective if light weight prevents attaining above 97%.
3. Maintain airspeed until ground is approached, then begin cyclic flare to reduce rate of descent and forward speed.
4. At about 8 feet AGL, apply forward cyclic to level ship and raise collective just before touchdown to cushion landing. Touch down in level attitude and nose straight ahead.

Figure 23 - Engine Failure Procedure between 8 ft and 500 ft AGL.

In general, the procedure prescribed that the collective was to be lowered immediately and adjusted so that the RPM could be sustained between 97% and 108%, maintaining the speed until the flare was executed, at which point the rate of descent and speed would be reduced. With approximately 8 ft AGL, the cyclic control would be moved forward, concomitantly with application of the collective, so that the landing could be made in a level attitude and in a smoothened manner.

According to the POH (Section 4 - Normal Procedures), the recommended IAS for the autorotation procedure would be between 60 and 70 kt.

In addition to the facts mentioned above, based on the images, it was evident that the manifold pressure dropped excessively during the attempt to perform the autorotation procedure, remaining between 8 and 9 inHg, a value corresponding to operation of the engine at IDLE (Figure 24).

Figure 24 - Indication of the intake pressure of the PR-RMZ engine.

The position of the “ball” to the right indicates a left yaw of the helicopter, corresponding to a reduction in power.

In the description of the failure, no action by the pilot on the power lever (*throttle*) was mentioned.

According to information provided by the manufacturer, if a degradation of the right-hand magneto signal occurred in flight, the loss of power would not be so relevant as to significantly reduce engine RPM or intake pressure, such as the one that occurred in the case of the PR- RMZ.

With the exception of the illumination of the low rotor RPM caution light, no drop in engine oil pressure or illumination od the low engine oil pressure light in the alternator were observed in the images, something that would be expected in the event of engine failure in flight (Figure 25).

Figure 25 - Video recording of the cabin made during the emergency.

Likewise, the engine's intake pressure, as shown in Figure 25, indicated that the engine was developing power at idle.

With the engine not operating, the intake pressure would correspond to the local atmospheric pressure, that is, something between 27 and 30 inHg, as can be seen in Figure 26, which captured the image of the panel of an R 44I helicopter during a situation of engine failure in flight.

Figure 26 - Image of an engine failure in flight, involving another R 44 helicopter.

Other aspects observed in the Figure 26 attest to an engine shutdown condition in flight, such as illumination of the low oil pressure lights, low alternator voltage, and engine tachometer indicating 0%.

An instantaneous failure is not common, occurring in case of complete interruption of ignition or lack of fuel.

In most cases, engine failures occur gradually, preceded by certain signs, such as: drop in intake pressure, drop in RPM, drop in oil pressure, excessive increase in cylinder head temperature, vibration, oil leak, abnormal RPM variation, and presence of fire or smoke.

1.19. Additional information.

- *Safety Notice 10 - Fatal Accidents Caused By Low RPM Rotor Stall*

In October 1982, the RHC issued the Safety Notice-10 (Fatal Accidents Caused By Low RPM Rotor Stall), available at the link: https://robinsonheli.com/robinson-safety-notices/.

The document described that the primary cause of fatalities in accidents involving light helicopters would be the failure to maintain the RPM of the rotor. To prevent that, every pilot should have their reflexes conditioned so that they instantly add power to the engine and lower the collective to maintain the rotor RPM in any emergency condition.

Even when descending towards rough terrain, trees, wires, or water, the pilot should remain with the collective lowered to maintain the RPM until the last moment just before impact. In such condition, the helicopter could sustain substantial damage, but the chances of survival would be high.

The engine power available is directly proportional to the RPM. If the RPM dropped 10%, there would be 10% less power. If the pilot not only failed to lower the collective, but instead pulled the collective to prevent the helicopter from sinking, the rotor would “stall” almost immediately, worsening the situation being experienced.

Thus, the document concluded that the cause of the drop in rotor RPM did not matter. The pilot should lower the collective to regain rotation before looking into the real problem.

This action should be a conditioned reflex. In forward flight, bringing the cyclic back could also help recover rotor RPM.

- Australian Transport Safety Bureau (ATSB)

The ATSB published an alert about a 15 June 2018 event, in which there was a failure in the RPM governor of the R44 engine (available at the link: https://www.atsb.gov.au/publications/occurrence-briefs/2018/aviation /ab-2018-082).

According to the ATSB records, during the flight, at an altitude of 1,000 feet, the rotor speed began to decrease and the low rotor RPM horn sounded. On the occasion, the pilot applied the low rotor RPM recovery technique, which consisted of lowering the collective to increase acceleration. The aircraft descended to 800 feet, before climbing back to 1,000 feet.

According to the description of the incident, as the pilot was not sure of the cause of the drop in RPM, he chose to manually control the engine's RPM, overriding the governor. However, the governor was not disconnected, as instructed by the POH, Section 3, Emergency Procedures, Governor Failure.

In the normal course of the operation, before the failure, the pilot had already identified two possible forced landing areas and, while seeking to solve the failure experienced, he directed the helicopter to an area free of obstacles. He also alerted air traffic agencies and other aircraft flying nearby about the problem, and declared an urgency situation. In this condition, the pilot correctly decided not to enter autorotation but land controlling the RPM manually.

The aircraft's magnetos had undergone a 500-hour inspection immediately before the flight. Engineering analysis after the incident flight identified a problem with the magnetos, related to the rotation reading, which caused the governor to receive information about an RPM higher than the actual one, which caused the governor to act by reducing the engine RPM and, consequently, the RPM of the rotor system.

In this case, the ATSB decided to present a brief description of the event, without opening a formal investigation, in order to allow the industry to become aware of possible safety issues and take the necessary safety actions.

In addition, on 04 February 2022, during the procedures related to the investigation of the occurrence with the PR-RMZ, in view of a few reports sent to both the ATSB and the Civil Aviation Safety Authority (CASA) of Australia, reporting that the governor failed to control the Engine RPM Under Normal Conditions, the Australian Investigative Authority, has recommended all pilots, operators and maintainers of Robinson R22 and R44 helicopters purchased after 15 January 2020, to monitor for intermittent or abnormal engine RPM governor operations that may lead to engine overspeed or underspeed conditions.

Therefore, the ATSB, in addition to encouraging all pilots, operators and maintainers of R22 and R44 helicopters to continue to report such cases via the appropriate channels, recommends that everyone familiarize themselves with the Airworthiness Bulletin (AWB) 67-006 Issue 5, Robinson R22/R44 Governor Control Anomalies, dated 28 July 2022.

- AWB 67-006 - Issue 5 - Robinson R22/R44 Governor Control Anomalies

This AWB (of a non-mandatory nature) was issued in view of the various reports informing that the governor failed to control the engine RPM under normal conditions, leading to a condition of overspeed or underspeed of the engine and, consequently, of the rotor, demanding the pilot to override the governor's operation by manually controlling the rotation by means of the throttle, so that the flight could be completed in such condition.

In normal operation, the RPM governor detects the engine rotation and makes the necessary adjustments to maintain a constant engine rotation and, consequently, that of the rotor during flight, preventing both overspeed and loss of rotation.

According to the AWB, pilots are encouraged to be careful not to unintentionally override the governor and to monitor the operation of the component during flight.

The helicopter manufacturer, Robinson Helicopter Company, is currently investigating the circumstances of the failures to identify causal factors and solutions.

The Issue nº 5 in question expanded the recommended actions, including removing the C143 engine speed sensor for cleaning to ensure signal integrity.

On the occasion, Robinson Helicopter Company, as the Type Certificate (TC) holder, was investigating these reports to identify the contributing factors and the respective solutions to be adopted. The Federal Aviation Administration (FAA), in turn, as the issuer of Robinson Helicópteros' TC, was notified and was also participating in the investigation.

- Robinson Flight Training Guide - Straight-In Autorotation With Power Recovery.

"From level flight, at 70-75 kt / 500-700 feet AGL, and flying upwind, lower the collective fully, smoothly but firmly, and without reducing the throttle. Coordinate the collective movement with the right pedal, and adjust the cyclic to maintain an attitude that guarantees a speed of 70 kt. The engine and rotor RPM indicators will generally split, establishing a descent in autorotation. If the indicators do not split, reduce the lever a little. Cross-check attitude, trim, rotor rotation and speed. With two occupants on board, a slight increase in RPM is expected, requiring a small input in the collective."

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

It was a paid scenic flight over the city of *Ubatuba*, State of *São Paulo*, with a pilot and two passengers on board.

At the time, there was an operating lease agreement on the aircraft (nationality marks and registration number PR-RMZ) signed between the owner (lessor) and the *Helicon Táxi Aéreo Ltda* company (lessee).

However, in accordance with the Operating Specifications (EO), even though the *Helicon* company had authorization to use the equipment, according to information collected, it was the owner of the aircraft who had operational control over the accident flight in question.

Regardless of the situation verified, and in accordance with the aircraft's Certificate of Entire Content on the date of the accident, the PR-RMZ was listed as being operated by the *Helicon Táxi Aéreo Ltda.* company. Likewise, the said company was an operator as far as the RAB was concerned, from 27 September 2018 to 02 April 2020, with responsibility for the operation of the referred helicopter. Therefore, the aircraft should be operated in accordance with the requirements of the RBAC-135 when performing Non-Regular Public Air Transport services.

According to verification, the PIC was hired by the aircraft owner to conduct scenic flights in the region, having started such services on 27 December 2018. In this condition, the operation should have been carried out in accordance with the requirements of the RBAC-135, and the PIC should have done the training required in the referred regulation.

The investigation commission verified that the start-up and takeoff procedures were uneventful, without indication of any complications.

With the helicopter approximately 55 seconds into the flight, at an altitude of about 350 ft. AGL and still climbing, the noise of its rotor decreased quickly and continuously, until the audible (HORN) and visual (ROTOR LIGHT) alarms for low engine-rotation were triggered. The activation of the alarms indicated that the RPM of the rotor was below the safety limit of 97%.

The video recording made by the passenger who occupied the front left seat revealed that the rotor and engine indications dropped initially to approximately 80%. These indications led the PIC to infer that he was experiencing a loss of power in flight.

In this regard, in accordance with the manufacturer, if a loss of power occurred, the main rotor RPM should not fall below 80%, as recovery would become impractical.

The POH of the R44 II Robinson helicopter read that a loss of power could be due to a failure of either the engine or transmission system, and had, as a piece of evidence, the activation of the low RPM horn, when the rotation equaled to or fell below 97%.

Thus, in the event of a possible loss of power, in order to allow the reduction of the collective pitch of the main rotor to decrease the aerodynamic drag on the blades, and the rotor to remain between 97% and 108% of RPM, thus preventing loss of rotation, the collective was to be lowered immediately.

In this sense, one verified that the PIC lowered the collective and started the autorotation procedure for an emergency landing on a street in the city of *Ubatuba*.

However, it was found that the IAS increased to 97 kt and that the main rotor RPM indication stabilized at 80%. Furthermore, it was found that the main rotor's low RPM caution light remained on during most of the descent, and only turned off and on again during the final segment of the flight.

Still in relation to an instantaneous engine failure in flight, such failure could also be corroborated by a change in the aircraft's attitude, a yaw of the nose to the left, illumination of the low oil pressure light, or a decrease of the engine RPM.

In the event in question, the signs indicating a possible loss of power were related to the decrease in the engine rotation and the drop in the manifold pressure indication. The position of the “ball” to the right, as observed moments after the rotor RPM alarm sounded, indicated a yaw of the helicopter to the left, corresponding to a reduction in power.

That said, one cannot rule out the possibility that the pilot may have acted on the lever to manually reduce power when the collective was lowered. Therefore, in the occurrence in question, one observed no other signs of engine failure, such as: drop in engine oil pressure, illumination of low engine oil pressure lights, low alternator voltage, and indication of 0% of the engine tachometer.

The images captured during the flight in a short period of time (after the alarms were triggered) revealed large fluctuations of the engine RPM, between 80% and 116% (maximum upper limit of the tachometer). The POH specified that, under normal conditions, the engine rotation should be between 101% and 102%, and informed that the governor would remain inactive with engine rotations below 80%.

One observed that the PIC unfortunately experienced an emergency condition, in which some pieces of information were presented that indicated a probable engine failure in flight, for which the expected procedure at the height of 350 ft AGL, would be to lower the collective immediately, and adjust it so that the rotor RPM remained between 97% and 108%, maintaining the speed until the flare was executed, at which point the rate of descent and speed would be reduced to smoothen the impact against the ground.

According to reports from the PIC, the indications of a drop in engine and rotor rotation led him to adopt the procedures prescribed for an engine failure in flight.

Due to the linear arrangement of the wreckage, the impact marks, and the aircraft's resting spot, it was possible to conclude that the emergency landing occurred at a high forward speed.

Based on the images recorded by the passenger and the fact that the main rotor blades were not fractured, but bent upwards, one inferred a low RPM of the main rotor at the moment of impact.

During the investigation process, the SN L-34035-48E IO-540-AE1A5 Lycoming engine, which equipped the PR-RMZ, was analyzed by the IAE's Aeronautical Propulsion Subdivision. The result of the bench test revealed that the engine operation was normal with power development at 2,800 RPM, without any discrepancy or abnormality being noticed.

In the sequence, the magnetos were removed and tested on the bench. Both showed normal functioning. However, one observed the presence of lubricating oil residue inside the right-hand magneto.

When analyzing the magnetos, one found that inside the right-hand magneto there was lubricating oil on the contact points of its contact breaker (responsible for transmitting the electrical signal to the governor controller and panel tachometer).

For that reason, the component was sent to the RHC headquarters in Torrance, California, where multidirectional marks were detected on the contact point of the contact breaker of the right-hand magneto. In such component, it would be usual to find only unidirectional marks. The multidirectional marks suggest the possibility that some material (such as sandpaper) was used for cleaning the contact points, thus revealing an inappropriate maintenance procedure.

However, it was not possible to establish either the date on or location at which the item would have been supposedly subjected to the possible sanding, given that the aircraft flew with no recorded problems around 90 hours after the last inspection of the magnetos, besides flying 197 hours after its last overhaul.

The magnetos were tested in the laboratory for a period of three minutes, and the results obtained were satisfactory.

Subsequently, the signal generated by the contact breaker was simulated with a drop of lubricating oil on the surface contact points, and one found that the signal degraded for several seconds and then returned to normal. During signal degradation, one noticed a decrease in voltage and a loss of frequency reading on the oscilloscope.

Therefore, based on the examinations conducted, the analysis performed by the Aeronautical Propulsion Subdivision of the IAE concluded that the failure presented during the flight was possibly related to the degradation of the signal received by the governor controller.

This means that a degradation of the signal generated for the governor controller would compromise the engine RPM indication and the governor's performance itself, since both were powered by the same source.

This would result in the governor acting inadvertently to increase or reduce power, which would also have an impact on the rotation of the main rotor. As its actuation range varied between 80% and 116%, the engine governor may have operated to stabilize the RPM based on erratic information coming from the governor controller.

It is important to clarify that the governor's function was to assist in controlling the RPM under normal conditions, and that it may not be able to prevent overspeed or underspeed conditions.

Therefore, it is possible that, with the sudden variation in the engine RPM indication, the governor, upon receiving a false indication, acted in an attempt to correct the possible

abnormality, consequently causing a reduction in the main rotor RPM to less than 97%. This value below 97% caused the horn to activate and the LOW RPM caution light to illuminate.

As the helicopter was still ascending, flying with a power regime compatible with the climb phase, the drop in rotor RPM was rapid and substantial, reaching 80%, as visually confirmed by means of the rotor tachometer.

These indications, in turn, induced the PIC to perform the “Engine Failure between 8 ft and 500 ft AGL” procedure, as previously explained.

However, and taking into account that there was no failure of the engine itself, nor of the tachometers, the recommended procedure to be adopted for the failure in question would initially be the one provided for in the POH (Section 3 - Emergency Procedures) for the case of LOW RPM HORN & CAUTION LIGHT.

For the condition in question, the pilot should restore the rotor RPM by opening the power lever (*throttle on*), lowering the collective immediately, and reducing the speed to the ideal speed in relation to the autorotation procedure. With the collective lowered, both the caution light and horn alarms would be deactivated.

In that respect, the Safety Notice 10 (*Fatal Accidents Caused By Low RPM Rotor Stall*) also stated that, regardless of the reason for the drop in rotor RPM, the pilot should lower the collective to recover rotation before looking into the problem. This should constitute a conditioned reflex. Furthermore, the document reported that, in forward flight, bringing the cyclic back could also help recover rotor RPM.

From the images, it was possible to see that the pilot lowered the collective and applied the cyclic forward in order to lower the aircraft's nose, increasing its indicated airspeed (IAS) to 97 kt, contrary to the actions recommended for the failure in question.

In any event, due to the low altitude of the aircraft at the time of the failure (approximately 350 ft AGL), the PIC had just a few seconds to identify and analyze the problem, and carry out an appropriate corrective action in view of the situation presented. According to the images, the time elapsed between the moment of the audible alarm and the first collision was 13 seconds.

After the audible alarm was activated, one observed that the pilot applied the forward cyclic, gaining around 10 kt of speed. This increase in speed increased the helicopter’s rate of descent, a condition that compromised the recovery of rotor rotation and contributed to a reduction of the time interval before the collision with obstacles on the ground.

According to the POH (Section 4 - Normal Procedures), the recommended IAS for the autorotation procedure would be between 60 and 70 kt, in order to glide with a lower rate of descent. If the PIC had used such speed, he would have had more time to deal with the emergency.

With the aircraft approaching the treetops, it was possible to observe an increase in the helicopter's pitch-up angle, but not enough to provide an effective speed reduction for the flare.

Due to the use of a speed of 97 kt in the autorotation and the ineffectiveness of the flare, the impact against the obstacles occurred at high speed.

Another situation observed in the images was the drop of the intake pressure to 8 InHg, a value corresponding to engine at idle. Other aspects were the indications of the engine instruments which did not vary, and the low engine oil pressure caution light which did not illuminate.

In this sense, one inferred the possibility that, when lowering the collective, the PIC may have closed the power lever, albeit unintentionally and unconsciously, taking the engine to idle speed. However, it was not possible to confirm such hypothesis, since, during the

interview, the pilot reported that he did not remember whether or not he had moved that lever.

3. CONCLUSIONS.

3.1. Findings.

a) the pilot held a valid CMA (Aeronautical Medical Certificate);

b) the pilot held a valid HMNC license (Conventional Single-Engine Helicopter);

c) the PIC had experience, but was not qualified to operate aircraft in accordance with the requirements of the RBAC-135;

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

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

f) the airframe and engine logbooks were up to date;

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

h) approximately 55 seconds after the helicopter left the ground, at a height of about 350 feet, and still climbing, the audible (HORN) and visual (ROTOR LIGHT) alarm was activated due to low RPM of the main rotor;

i) the PIC performed the autorotation procedure;

j) there was a drop in rotation of both the engine and the rotor to approximately 80%;

k) it became evident that the intake pressure dropped excessively during this procedure, remaining between 8 and 9 InHg;

l) close to the ground, the helicopter collided with wires of a utility pole, trees and then with vehicles parked nearby;

m) the emergency landing occurred at a high forward speed;

n) during the bench test, the engine showed normal operation with development of power at 2,800 RPM, without any discrepancy or abnormality being noticed;

o) the presence of lubricating oil residue was observed inside the right-hand magneto;

p) at the microscopic analysis, multidirectional marks were found in the contact of the contact breaker of right-hand magneto;

q) during tests of the right-hand magneto carried out in the laboratory, one found that the presence of oil on the contact breakers caused interference in the transmitted signal;

r) the last inspection of the magnetos, for compliance with the Service Bulletin TCM 643B was performed during a “100 hour” type inspection on 23 April 2018;

s) the manufacturer of the aircraft simulated the signal generated by the contact breaker with a drop of lubricating oil on the surface contact points. It was found that the signal degraded for several seconds before returning to normal;

t) during signal degradation, one noticed a decrease in voltage and loss of frequency reading on the oscilloscope;

u) the aircraft sustained substantial damage; and

v) the pilot and a passenger received minor injuries, the other passenger suffered serious injuries, and a pedestrian that was passing by was fatally injured.

3.2. Contributing factors.

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

There was no appropriate application of the autorotation technique during the procedure, as the PIC allowed the helicopter speed to increase to 97 kt., which resulted in the collision against obstacles at a high forward speed.

- **Piloting judgment – a contributor.**

One observed that the PIC experienced an emergency condition, in which the information presented indicated a possible engine failure in flight.

The indications of a decrease in the engine and rotor rotation led the pilot to adopt the procedures expected for an engine failure in flight. However, and considering that there was no engine failure actually, nor failure of the tachometers, the procedure, initially recommended for the failure in question, would be the one prescribed for the LOW RPM HORN & CAUTION LIGHT emergency, in which the PIC was to restore the Rotor RPM by opening the power lever (*throttle on*), lowering the collective right away, and reducing the speed to the ideal value in relation to the autorotation procedure.

- **Aircraft maintenance – undetermined.**

By means of a microscopic analysis, one found that the contact points of the contact breaker of the right-hand magneto had irregularities, multidirectional scratches and uneven coloring on their surface of contact. The multidirectional marks suggest the possibility that some sort of material (such as sandpaper) was used for cleaning the contact points of the contact breaker, thus revealing the application of an inappropriate maintenance procedure.

At the analysis of the magnetos, one observed that inside the right-hand magneto there was lubricating oil on the contact points of the contact breaker. Such item is responsible for transmitting the electrical signal to the governor controller and panel tachometer.

During tests, the manufacturer of the aircraft simulated the signal transmitted by the contact breaker after the addition of a drop of lubricating oil on its surface. In this simulation, one verified that the signal was degraded for many seconds before returning to normal. Such condition may have occurred in flight, causing the governor to malfunction.

- **Perception – a contributor.**

Although the decision to initiate autorotation was motivated by the illumination of the LOW RPM light and activation of the rotor's low RPM horn, there were no sudden changes in the aircraft's attitude, nor illumination of the lights for low engine oil pressure, low alternator voltage, and 0% indication on the engine tachometer. Such facts were not noticed by the crewmember, who was fixated on the idea that the aircraft had lost power, even though there had been no other piece of evidence for that.

- **Decision-making process – a contributor.**

Due to the low altitude at which the aircraft was flying at the time of the failure, approximately 350 ft. AGL, the PIC had just a few seconds to identify and analyze the problem, and perform an appropriate corrective action in view of the situation presented. The time elapsed from the moment of the audible alarm until the first collision was 13 seconds. This induced the pilot to make the inappropriate decision of executing an autorotation, instead of trying to recover the rotor RPM by means of the LOW RPM HORN & CAUTION LIGHT emergency procedure.

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-002/CENIPA/2019 - 01 **Issued on 12/29/2023**

Work with the Maintenance Organizations *Airtech Soluções Aeronáuticas Ltda.* (COM No. 1604-31) and *Estrela Dourada Manutenção Aeronáutica* (COM No. 1601-42), with the aim of verifying the adequacy of the procedures performed, notably with regard to periodic inspections and overhauls carried out on Continental magnetos type S6LSC-204T , PN 10-600646-201.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

According to information provided by the manufacturer, the new models of the R22 and R44 production no longer use the signals emitted from the right-hand magneto contact points to send the RPM signal to the governor, although the signal is still used to indicate the engine parameters to the tachometer.

The signal for the governor on aircraft manufactured at the time of the publication of this report was generated by a magnetic pickup mounted on the magneto housing, providing an independent source for the signal. The new magnetic pickup would no longer be affected by oil contamination and would provide a more reliable signal to the aircraft.

On 28 July 2022, the Civil Aviation Safety Authority of Australia issued the Airworthiness Bulletin 67-006 Issue 5, Robinson R22/R44 Governor Control Anomalies, of a non-mandatory nature, which recommended the removal of the C143 engine speed sensor for cleaning, in order to guarantee signal integrity.

At the time of the issuance of the document, the airworthiness concern described in the Airworthiness Bulletin was not considered an unsafe condition that would justify the publication of an Airworthiness Directive.

On 22 July 2019, by means of the Ordinance nº 2,231/SPO, the ANAC precautionarily suspended the Air Operator Certificate (COA) of the *Helicon Táxi Aéreo Ltda*. company.

On 18 August 2022, by means of the Ordinance nº 8,887/SPO, the ANAC revoked the COA of the *Helicon Táxi Aéreo Ltda*. company.

On December 29th, 2023 .