COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-060/CENIPA/2014

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PP-SSP**
MODEL:	**R22 BETA**
DATE:	**23MAR2014**

NOTICE

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

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

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

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

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

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

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

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

SYNOPSIS

This is the Final Report of the 23MAR2014 accident with the R22 BETA aircraft, registration PP-SSP. It was classified as “[LOC-I] Loss of Control in Flight”.

The aircraft took off from the Ribeirão Preto Helicenter - SP (SSUE), with the purpose of performing a local flight, on the outskirts of the city.

When it flew over Bonfim Paulista - SP, there was a loss of control of the aircraft, with abrupt and vertical drop, which collided against the ground in a corn plantation area.

The aircraft was destroyed.

The pilot and the passenger had fatal injuries.

An Accredited Representative of NTSB - National Transportation Safety Board; USA (State where the aircraft was designed/manufactured), was designated for participation in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AGL	Above Ground Level
ANAC	National Civil Aviation Agency
ATS	Air Traffic Services
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CHT	Technical Qualification Certificate
CMA	Aeronautical Medical Certificate
DCTA	Aeronautics’ Science and Technology Department
FAA	Federal Aviation Administration
IAM	Annual Maintenance Inspection
INVH	Flight Instructor Rating - Helicopter
LAT	Latitude
LONG	Longitude
M.M.	Maintenance Manual
OGE	Out Ground Effect
PCH	Commercial Pilot License - Helicopter
PPH	Private Pilot License - Helicopter
PRI	Private Aircraft Registration Category - Instruction
RPM	Rotations Per Minute
RS	Safety Recommendation
SFAR	Special Federal Aviation Regulation
SSUE	ICAO location designator – Ribeirão Preto Helicenter - SP
SIPAER	Aeronautical Accident Investigation and Prevention System
TWR - RP	Ribeirão Preto Aerodrome Control Tower
UTC	Universal Time Coordinated
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** R22 BETA **Registration:** PP-SSP **Manufacturer:** *Robinson Helicopter*	**Operator:** Aces High Escola Top de Aviação Civil Ltd.
Occurrence	**Date/time:** 23MAR2014 - 1355 UTC **Location:** Bonfim Paulista - SP **Lat.** 21º15'50"S **Long.** 047º48'27"W **Municipality – State:** Ribeirão Preto - SP	**Type(s):** [LOC-I] Loss of Control in Flight **Subtype(s):** Nil.

1.1 History of the flight.

The aircraft took off from the Ribeirão Preto Helicenter - SP (SSUE), at about 1340 (UTC), in order to perform a local flight, with a pilot and a passenger on board.

After 13 minutes, there was loss of control of the aircraft over the district of Bonfim Paulista - SP, with great descent rate and violent crash against the ground.

After the collision, there was a rupture of the fuel tanks and fire blast.

The aircraft was destroyed and the two occupants suffered fatal injuries.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft was damaged throughout the structure, engine, skis, main and auxiliary rotors.

1.4 Other damage.

Nil.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown	
	Pilot
Total	7.000:00
Total in the last 30 days	00:10
Total in the last 24 hours	00:10
In this type of aircraft	800:00
In this type in the last 30 days	00:10
In this type in the last 24 hours	00:10

N.B.: The Data on the flown hours were obtained from third parties.

1.5.2 Personnel training.

The pilot took the Private Pilot Course – Helicopter (PPH), in 1999.

1.5.3 Category of licenses and validity of certificates.

The pilot had the Commercial Pilot License – Helicopter (PCH) and had valid Technical Qualification for R22 aircraft and valid INVH Rating.

1.5.4 Qualification and flight experience.

The pilot was qualified, but it was not possible to prove his recent experience.

1.5.5 Validity of medical certificate.

The pilot had valid Aeronautical Medical Certificate (CMA).

1.6 Aircraft information.

The aircraft, serial number 4613, was manufactured by Robinson Helicopter, in 2013 and it was registered in the PRI category.

The aircraft had valid Certificate of Airworthiness (CA).

The airframe and engine logbooks were inside the aircraft at the moment of the accident and caught fire.

The aircraft had approximately 22 flight hours at the time of the occurrence and had not undergone any revision.

The partial assembly of the aircraft, according to Maintenance Manual (M.M.), Cap 1,600, it was performed on 23AUG2013 by TUCSON Aviation shop, in São Paulo - SP.

1.7 Meteorological information.

According to the meteorological conditions of the Leite Lopes Aerodrome - SP (SBRP), distant about 6km from the place of the occurrence, there were no restrictions on visibility on the day of the flight. The wind intensity verified in the Ribeirão Preto -SP region, was around 10 knots at the time of the occurrence, without significant variations of direction.

The meteorological bulletins and SBRP forecast were as follows:

- METAR SBRP 231300Z 13011KT 9999 FEW020 SCT030 26/19 Q1017=

- METAR SBRP 231400Z 13009KT 9999 FEW030 BKN035 27/19 Q1017=

- METAR SBRP 231500Z 10010KT 9999 BKN033 28/19 Q1016=

- TAF SBRP 231000Z 2312/2412 13010KT 8000 BKN017 TX29/2318Z TN20/2409Z BECMG 2313/2315 9999 SCT035 PROB030 2318/2323 8000 TSRA BKN035 FEW045CB BECMG 2400/2402 8000 NSC PROB030 2408/2410 4000 BR RMK PGH.

1.8 Aids to navigation.

Nil.

1.9 Communications.

The transcript of the communications between the Ribeirão Preto Control Tower (TWR-RP) and the PP-SSP pilot indicated that there was no report of any problem or abnormal operation of the aircraft.

1.10 Aerodrome information.

The occurrence took place outside the Aerodrome.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The aircraft was found in a cornfield and the marks on the vegetation indicated that the impact occurred in a wide-angle approach, with a high descent rate and practically no linear displacement.

The collision of the main rotor blades against the vegetation formed a circular area around the aircraft (Figure 1).

Figure 1 - Aerial photo of the accident site.

The wreckage were concentrated, with no sign of detachment of the aircraft components in flight.

The skis were severely damaged, and even fractured and detached from the rest of the structure. The aircraft tipped over to the left side.

There was still a deflection in the main rotor blades but there was no impact marks at the leading edge, and the tail rotor blades were found to be quite twisted.

The flight commands corresponding to the passenger seat were found next to the wreckage. In this aircraft model, there was the possibility of these commands to be removed.

There was fire after the impact (Figures 2 and 3).

Figure 2 - Overview of the aircraft.

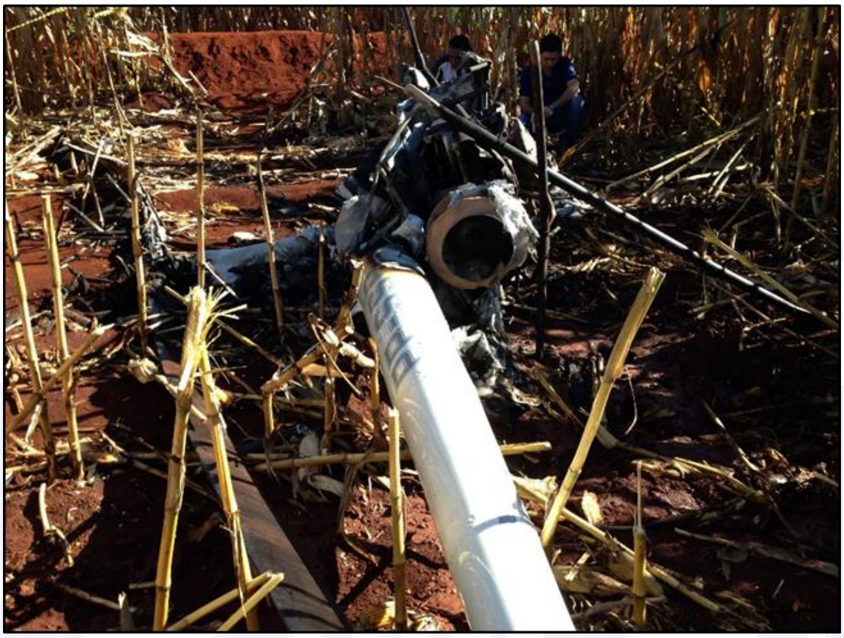


Figure 3 - View of the tail cone and cabin of the aircraft.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

There was no evidence that physiological or disability aspects affected the performance of the crewmember.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The pilot had already acted as a flight instructor and air taxi pilot. In the period before the accident, he operated in the executive aviation. According to the information obtained, in his last jobs, he acted as a private pilot hired by executives of the region.

As reported, the executives considered the pilot as a reference for being responsible and concerned about safety. Other people who had already flown with him also corroborated this perception, underscoring his professionalism.

It is added that, according to information, the pilot had a good interpersonal relationship and was satisfied in his professional practice. He had healthy habits and had no personal problems.

Regarding the professional practice, it was reported that he had specific training in autorotation with the manufacturer of the aircraft in question.

In spite of his busy routine of work, he did not report fatigue or exhaustion. According to the information obtained, the pilot had adequate rest the night before the flight.

The passenger was described as a person who showed an interest in aviation. He and the commander of the aircraft did not know each other, but they had a mutual friend, who suggested that the passenger looked for the pilot to follow a flight, when possible.

It should be noted that the passenger was not qualified as a pilot and therefore had no theoretical or practical training in aircraft piloting.

1.14 Fire.

There was fire in the wreckage of the aircraft, focusing on the location corresponding to the fuel tank, which spread throughout the cabin area, reaching also part of the mast and the root of the main rotor blades.

The fire occurred after the impact, due to the rupture of the fuel tank.

Figure 4 - Destruction caused by fire.

1.15 Survival aspects.

There were no survivors.

1.16 Tests and research.

The DCTA performed a series of tests on the engine / transmission set of the aircraft, and issued the following result:

> The engine had indications that it was operating normally. In the tail rotor drive shaft, it was evidenced that, at the moment of the collision against the ground, there was rotation and development of torque in the set.
>
> The torsion of the shaft, along with the coupling flange with the engine, is the strongest evidence that there was no problem with the engine and the transmission assembly. In the reduction box, there was also no anomaly that could contribute to the occurrence.

Figure 5 - Shaft / flange assembly with torsion marks and cracks at break site.

1.17 Organizational and management information.

Nil.

1.18 Operational information.

It was a panoramic flight, in which the pilot was qualified and had already acted as an instructor in the model in question, but he did not perform this function at the time of the accident, since he was operating another model of aircraft.

An estimate of the weight at the time of the occurrence, taking into account the basis weight, the fuel used in the last supply and an estimate of the weight of the occupants, indicated that it was within the limit specified by the manufacturer.

1.19 Additional information.

In addition to the pilot, a passenger, who was interested in aviation, was aboard the aircraft, but had no pilot's license.

During the investigation, it was discovered that a security camera recorded the crash of the aircraft and the video was used to help in the investigation.

Considering the indications that the impact occurred in a wide-angle approach, with a high descent rate and practically no linear displacement, it is possible that the aircraft has been subjected to a vortex stall condition.

In this way, it is necessary to clarify some relevant aspects about the condition called stall vortex, which is characterized by the unstable airflow through the rotor blades.

A helicopter in hovering flight, out of the ground effect, produces lift equal to its weight. To do so, spiral-shaped vortex rings are formed at the tips of the blades. In addition, in rapid vertical descents or with slow speed ahead, a small region appears in which the airflow is ascending, near the root of the blades. If the collective control lever is pushed down, the lift decreases and reaches a value less than the weight of the aircraft.

The helicopter starts a descent seeking balance between weight and lift. With low or moderate descent ratios, the ascending airflow decreases the angle of attack and increases lift values in the intermediate and outer sections of the blades, keeping the helicopter in a steady descent ratio. Blade-tip vortices consume engine power, but do not generate lift.

While these vortex rings are relatively small, the impact on the lift generated by the main rotor is almost null, only imposing a decrease in its efficiency. As the rate of descent increases, the angle of attack in the inner sections of the blades reaches very high values, which can lead to the stalling of that part of the rotor disk. Secondary vortex rings are formed near the root of the blades, at the intersection of the ascending airflow with induced airflow.

If the rate of descent increases, the secondary vortex rings formed will become larger and the rotor blades will be getting closer and closer to these descending vortex rings (turbulent airflow below the helicopter) until the helicopter reaches a point at which the most of the power generated by the engine will be wasted to accelerate these same vortex rings.

In practice, the helicopter would be flying within its own downwash, that is, in turbulent airflow. The inner section of the rotor disk will be stalled.

The symptoms felt by the crew are increased vibration, pitch and roll movements and increased rate of descent, even with collective application up.

The effects of the vortex reach their peak when the rate of descent reaches values approximately equal to 3/4 of the induced speed, provoking strong vibrations and uncontrolled pitch and roll oscillations, being able to lose control of the aircraft.

The induced velocity is defined as the velocity of the airflow sucked through the rotor disk. It depends on the type of the helicopter and its gross weight.

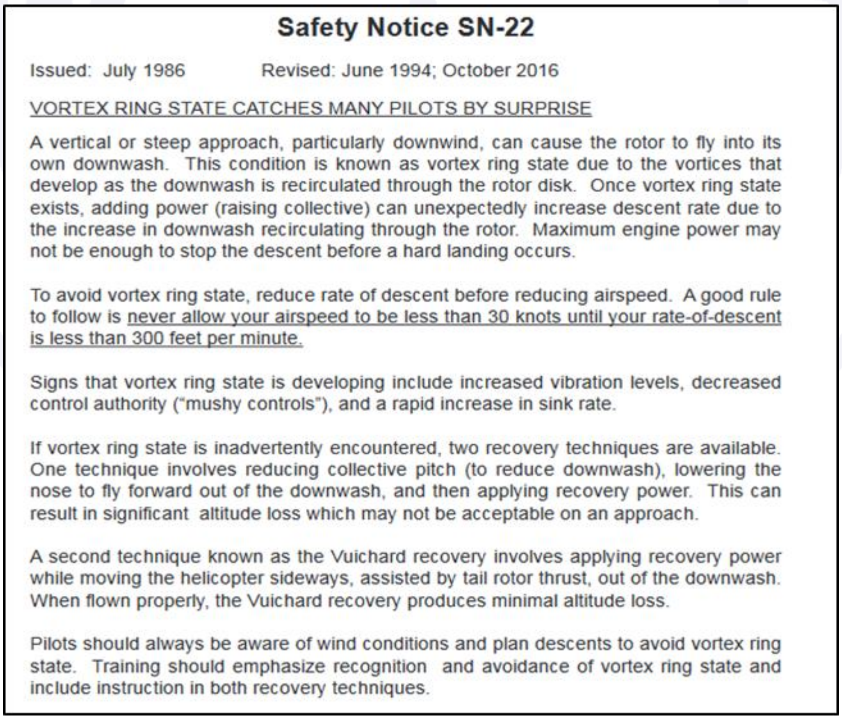
Large-angle, high-altitude, and tailwind approaches are factors that contribute to this type of occurrence. In addition to these, other factors contribute to the stall vortex: aircraft slipstream turbulence of the leader aircraft in takeoff during formation flights; tail wind in operations with external load; attempt of hovering flight out of the ground effect, above the Out Ground Effect (OGE) hovering ceiling and keeping the hovered Out Ground Effect without effectively controlling the altitude.

Some helicopter pilot schools conduct training in Settling with Power, a term used by operators to describe the flight condition in which the helicopter "sinks" even with the full power applied equivalent to the aircraft engine-powered stall. The technique of recovery taught is to reduce the collective pitch and take the cyclic ahead to increase the speed and to leave the region of turbulent airflow.

If there is enough altitude, the aircraft can also enter in autorotation. It is noted that, in general, students tend to start the recovery by acting on the collective control upwards, in order to try to decrease the rate of descent before taking the cyclical ahead. This tendency is even greater when the helicopter is near the ground.

It is important to know that these attitudes on the part of the pilot will cause the effect opposite to that one he expected, because it will increase the stalled area in the internal section of the rotor disk, increasing the aircraft's rate of descent too.

In this perspective, the helicopter manufacturer Robinson Helicopter Company issued the Safety Notice SN-22, revised in October 2016, which dealt with stall vortex:


Safety Notice SN-22

Issued: July 1986 Revised: June 1994; October 2016

VORTEX RING STATE CATCHES MANY PILOTS BY SURPRISE

A vertical or steep approach, particularly downwind, can cause the rotor to fly into its own downwash. This condition is known as vortex ring state due to the vortices that develop as the downwash is recirculated through the rotor disk. Once vortex ring state exists, adding power (raising collective) can unexpectedly increase descent rate due to the increase in downwash recirculating through the rotor. Maximum engine power may not be enough to stop the descent before a hard landing occurs.

To avoid vortex ring state, reduce rate of descent before reducing airspeed. A good rule to follow is never allow your airspeed to be less than 30 knots until your rate-of-descent is less than 300 feet per minute.

Signs that vortex ring state is developing include increased vibration levels, decreased control authority ("mushy controls"), and a rapid increase in sink rate.

If vortex ring state is inadvertently encountered, two recovery techniques are available. One technique involves reducing collective pitch (to reduce downwash), lowering the nose to fly forward out of the downwash, and then applying recovery power. This can result in significant altitude loss which may not be acceptable on an approach.

A second technique known as the Vuichard recovery involves applying recovery power while moving the helicopter sideways, assisted by tail rotor thrust, out of the downwash. When flown properly, the Vuichard recovery produces minimal altitude loss.

Pilots should always be aware of wind conditions and plan descents to avoid vortex ring state. Training should emphasize recognition and avoidance of vortex ring state and include instruction in both recovery techniques.

Figure 6 - Excerpt from Safety Notice SN-22.

Lírio, T. A. Guia Técnico de Investigação de Acidentes Aeronáuticos com Helicópteros para Investigadores do SIPAER. 2012. 118f. Dissertação (Mestrado Profissional em Segurança de Aviação e Aeronavegabilidade Continuada) – Instituto Tecnológico de Aeronáutica, São José dos Campos, São Paulo. 2012.

For initial training or maneuvers demonstration, the Robinson Helicopter Company issued Safety Notice SN-20, revised in June 1994, as follows:

Safety Notice SN-20

Issued: Sep 85 Rev: Jun 94

BEWARE OF DEMONSTRATION OR INITIAL TRAINING FLIGHTS

A disproportionate number of fatal and non-fatal accidents occur during demonstration or initial training flights. The accidents occur because individuals other than the pilot are allowed to manipulate the controls without being properly prepared or indoctrinated.

If a student begins to lose control of the aircraft, an experienced flight instructor can easily regain control provided the student does not make any large or abrupt control movements. If, however, the student becomes momentarily confused and makes a sudden large control input in the wrong direction, even the most experienced instructor may not be able to recover control. Instructors are usually prepared to handle the situation where the student loses control and does nothing, but they are seldom prepared for the student who loses control and does the wrong thing.

Before allowing someone to touch the controls of the aircraft, they must be thoroughly indoctrinated concerning the extreme sensitivity of the controls in a light helicopter. They must be firmly instructed to never make a large or sudden movement with the controls. And, the pilot-in-command must be prepared to instantly grip the controls should the student start to make a wrong move.

Figure 7 - Excerpt from Safety Notice SN-20.

Pilots have to watch out for vortex or vortex phenomena. Descent vertically, or with steep ramp angles, require slow descent speed.

It is important to note that by choosing one or both of the techniques listed above; a large loss of altitude will be required. However, the gain of velocity ahead usually results in a lower altitude loss than the autorotation entry, which is always the most appropriate option for the recovery of this condition.

As the rate of descent in a vortex stall can be very high, 6,000ft / min in some cases depending on the model, the autorotation can generate an uncontrollable rotation runaway due to various aerodynamic factors.

As long as the vortex stall condition exists, any application of power will aggravate the situation by stalling the blades more and increasing the sinking ratio.

The following situations may lead to the development of vortex stall and should therefore be avoided:

a) DESCENTS WITH APPLIED POWER, LOW SPEED AND HIGH RATE: the necessary rate of descent for the advent of this condition differs between the various types of helicopter, though it is generally higher than 500ft / min with little or no speed ahead. This situation is aggravated and becomes more dangerous with the heavy helicopter on a hot day due to the greater need of power to keep the hovering flight.

b) b) TAIL WIND MANEUVERS AND APPROACHES: In general, maneuvers with tailwinds will always be critical, especially approaches. In such approaches, the turbulent airflow, which would be left behind in a normal approach, would be thrown back toward the helicopter, causing the aircraft to enter in its own downwash, causing the vortex stall.

c) c) RAPID STOPS: When a helicopter makes an aggressive flare at an abrupt stop, with the rotor disk tilted backward, the horizontal airflow comes from the bottom of the rotor disk, due to the direction of the displacement and to the attitude of the aircraft itself. If a descent ratio is initiated in this situation, the airflow displacement verticalizes even more and the aircraft enters once more into the downwash zone itself.

d) d) RECOVERY OF AUTOROTATION DURING TRAINING: The recovery of an autorotation in which there is the application of power before the leveling of the aircraft, during flare, is similar to the situation of the rapid stop on the line mentioned above. It is important to consider that this would not happen in a real situation of autorotation (with the engines cut), because, due to the lack of power, with the application of collective, it would not induce the airflow in the direction of the aircraft displacement.

Robinson issued the Safety Notice SN-24 in 1994, which warned about the occurrence of fatal accidents due to the rotor stall caused by low RPM, briefly described in Figures 8 and 9.

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Safety Notice SN-24

Issued: Sep 86 Rev: Jun 94

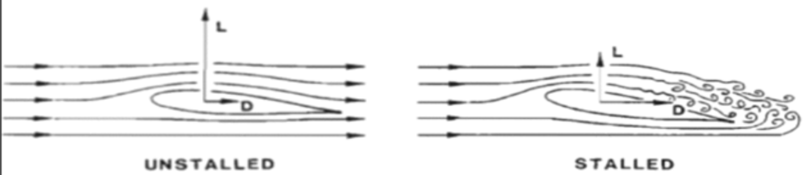
LOW RPM ROTOR STALL CAN BE FATAL

Rotor stall due to low RPM causes a very high percentage of helicopter accidents, both fatal and non-fatal. Frequently misunderstood, rotor stall is not to be confused with retreating tip stall which occurs only at high forward speeds when stall occurs over a small portion of the retreating blade tip. Retreating tip stall causes vibration and control problems, but the rotor is still very capable of providing sufficient lift to support the weight of the helicopter.

Rotor stall, on the other hand, can occur at any airspeed and when it does, the rotor stops producing the lift required to support the helicopter and the aircraft literally falls out of the sky. Fortunately, rotor stall accidents most often occur close to the ground during takeoff or landing and the helicopter falls only four or five feet. The helicopter is wrecked but the occupants survive. However, rotor stall also occurs at higher altitudes and when it happens at heights above 40 or 50 feet AGL it is most likely to be fatal.

Rotor stall is very similar to the stall of an airplane wing at low airspeeds. As the airspeed of an airplane gets lower, the nose-up angle, or angle-of-attack, of the wing must be higher for the wing to produce the lift required to support the weight of the airplane. At a critical angle (about 15 degrees), the airflow over the wing will separate and stall, causing a sudden loss of lift and a very large increase in drag. The airplane pilot recovers by lowering the nose of the airplane to reduce the wing angle-of-attack below stall and adds power to recover the lost airspeed.

The same thing happens during rotor stall with a helicopter except it occurs due to low rotor RPM instead of low airspeed. As the RPM of the rotor gets lower, the angle-of-attack of the rotor blades must be higher to generate the lift required to support the weight of the helicopter. Even if the collective is not raised by the pilot to provide the higher blade angle, the helicopter will start to descend until the



Wing or rotor blade unstalled and stalled.

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Figure 8 - Excerpt from the Safety Notice SN-24, first page.

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-24 (continued)

upward movement of air to the rotor provides the necessary increase in blade angle-of-attack. As with the airplane wing, the blade airfoil will stall at a critical angle, resulting in a sudden loss of lift and a large increase in drag. The increased drag on the blades acts like a huge rotor brake causing the rotor RPM to rapidly decrease, further increasing the rotor stall. As the helicopter begins to fall, the upward rushing air continues to increase the angle-of-attack on the slowly rotating blades, making recovery virtually impossible, even with full down collective.

When the rotor stalls, it does not do so symmetrically because any forward airspeed of the helicopter will produce a higher airflow on the advancing blade than on the retreating blade. This causes the retreating blade to stall first, allowing it to dive as it goes aft while the advancing blade is still climbing as it goes forward. The resulting low aft blade and high forward blade become a rapid aft tilting of the rotor disc sometimes referred to as "rotor blow-back". Also, as the helicopter begins to fall, the upward flow of air under the tail surfaces tends to pitch the aircraft nose-down. These two effects, combined with aft cyclic by the pilot attempting to keep the nose from dropping, will frequently allow the rotor blades to blow back and chop off the tailboom as the stalled helicopter falls. Due to the magnitude of the forces involved and the flexibility of rotor blades, rotor teeter stops will not prevent the boom chop. The resulting boom chop, however, is academic, as the aircraft and its occupants are already doomed by the stalled rotor before the chop occurs.

Figure 9 - Excerpt from Safety Notice SN-24, second page.

During aviation accident investigations, US flight safety officials concluded that apparently qualified pilots might not be properly prepared to safely operate R22 and R44 helicopters under certain flight conditions.

This way, in addition to the Federal Aviation Regulation (FAR) Part 61, the FAA developed the Special Federal Aviation Regulation N.73 (SFAR 73), which was designed to establish training criteria and experience requirements for all people who sought to operate or act as pilot-in-command on the Robinson helicopters models R22 or R44.

According to the FAA, after the adoption of SFAR 73, there was a considerable reduction in the number of accidents involving aircraft of this model, and the benefits from the application of SFAR 73 exceeded the costs of its implementation.

SFAR 73 specified the training, assessment and check requirements for Robinson R22 and R44 helicopters mentioning, among others, the following topics: Energy Management; Low Rotor RPM and Blade Stall and Rotor RPM Drop.

In Brazil, the National Civil Aviation Agency (ANAC) issued IS 61-006, Revision B, in June 2016, which included initial endorsement requirements for pilots and instructors of aircraft R22 and R44, according to the themes described above.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a panoramic flight with a passenger on board.

The pilot was duly qualified to operate that equipment and had already acted as instructor in the model in question. However, it was not possible to prove his recent experience or operational maintenance in this model, since, at the time of the accident he also operated other aircraft.

The passenger was interested in aviation, but he was not a pilot. Due to this interest, he sought the Commander to accompany that flight, as indicated by a friend in common.

Thus, until the date of the occurrence, they did not know each other, being that the first flight that they realized together.

Since no factors relating to the meteorological and technical conditions of the aircraft that could have contributed to the occurrence were identified, the Investigation Committee focused its analysis on the operational and behavioral issue of the occupants.

Taking into account the approach profile, with great angle and high descent rate presented by the aircraft at the final moments of the flight, there is a possibility that it may have entered in a situation known as a vortex stall.

In this sense, three hypotheses were raised:

a) flight commands would have been transferred to the passenger and there was no timely action in order to avoid loss of control of the aircraft due to a vortex stall condition;

b) performing a hovering flight out of the solo effect; or

c) demonstration of autorotation and inadvertent entry into a vortex stall situation, with loss of control of the aircraft.

In relation to the first hypothesis, it was considered the experience and technical proficiency to act on the aircraft commands.

Although he had experience, the pilot did not act as an instructor in the period before the occurrence, as well as he operated other aircraft models.

The pilot had arranged to receive the passenger on that flight, after being indicated by a mutual friend they had. However, it was not possible to determine the purpose of the flight or how the interaction between pilot and passenger occurred.

Considering that the pilot had already acted as an instructor and that the passenger was interested in the aviation area, it was hypothesized that such interest might have influenced the behavior of the pilot during the flight.

Thus, it was considered that the relationship established between them had led the pilot to allow the passenger to operate on the aircraft's controls, even without prior theoretical or practical training to do so, in order to provide him with the opportunity to take better advantage of that experience.

Therefore, the pilot, based on his considerable flight experience in helicopters, would have passed the flight command to the passenger and would not have been able to act in a timely manner at the controls, being surprised by the inadvertent entry into a vortex stall situation.

To get out of this situation, the recovery technique would consist of reducing the collective and taking the cyclic ahead, to increase the speed and to leave the region of turbulent air. If there was enough altitude, the aircraft could also enter into autorotation.

In general, less experienced pilots would tend to start the recovery by acting on the collective control upwards, in order to try to decrease the rate of descent before taking the cyclic ahead. This tendency would be even greater if the helicopter were close to the ground.

It is important to emphasize that these attitudes would cause the opposite effect to the expected one, because they would increase the stalled area in the internal section of the rotor disc, also increasing the rate of descent of the aircraft.

Considering that the aircraft was close to the maximum permissible weight, additional care in anticipating the use of the engine and in the application of the controls would be necessary to enable the exit of the vortex stall situation.

In this sense, considering that the pilot did not perform, at the time of the occurrence, the function of flight instructor and that he was not regularly flying this model of aircraft, it is possible to suppose that his psychomotor reactions did not correspond to the demand required for the accomplishment of the maneuver.

Without timely and effective intervention by the pilot, improper application of commands by the passenger would have led the aircraft to a vortex stall and loss of control.

As for the second hypothesis, it is possible that the pilot performed a hovering out of the solo effect. In this case, temperature, weight and wind conditions may have led to a situation where the power of the aircraft would not have been sufficient to keep the flight level, contributing to a loss of control, even if the controls had remained with the pilot during the entire flight.

In a similar way to the first hypothesis raised, in this situation there would have been a decrease in the RPM and consequent rotor stall, since the dynamics of the fall did not correspond to an attempt of landing or autorotation, but to an aircraft out of control.

Stall by RPM drop is briefly described in item 1.19 Additional information and Safety Notice SN-24 (Figure 9).

This hypothesis was supported by the fact that although the pilot had a recognized flight experience, including in the crashed aircraft, it was not possible to prove his recent experience or operational maintenance in this model.

In the case of the third hypothesis, considering that the aircraft was close to the maximum permissible weight, additional care in anticipating the use of the engine and the application of the controls would be necessary to enable the success of an autorotation maneuver.

In this case, the recovery with the application of power before leveling the aircraft and with an aggressive flare would cause the rotor to remain in the zone of downwash.

It is important to consider that this would not happen in a real situation of autorotation (with the engine cut off), because due to the lack of power, with the application of collective, it would not induce the airflow in the direction of the aircraft displacement.

Thus, the poor use of the controls could have caused a rotor stall, without enough time for the pilot to intervene in order to correct the error, as quoted.

This fact would be enhanced if the Commander had transferred the commands to the passenger who, besides not having a pilot's license, would not be subjected to effective monitoring by the instructor.

This situation had already been addressed by Robinson Helicopter through the Safety Notice SN-20, Figure 7, which warned about the high incidence of accidents during a demonstration or in the initial phase of training new pilots.

The SN-20 warned that the instructor should take over the controls and regain control of the aircraft when evidence of loss of control by the students was evident.

However, this hypothesis tends to be less likely, since the high rate of descent presented at the time of the occurrence was not common for the aircraft model, being difficult to be compatible with normal flight, even in an auto-rotation condition, which would reinforce the hypotheses explained above.

In addition, the Investigation Committee found that there was a Special Federal Aviation Regulation N.73 (SFAR 73) issued by the FAA which, among other items, established special training parameters and experience requirements for all people seeking to operate or act as pilot-in-command in the Robinson helicopters models R22 or R44, meeting this way, the hypotheses formulated in this Final Report.

In this sense, the National Civil Aviation Agency (ANAC) issued IS 61-006, Revision B, in June 2016, which included initial endorsement requirements for pilots and instructors of aircraft R22 and R44, according to the themes described above in this SFAR.

3. CONCLUSIONS.

3.1 Facts.

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

b) the pilot had valid Technical Qualification for R22 aircraft and INVH;

c) it was not possible to prove the recent experience of the Commander in that type of aircraft;

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

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

f) it was not possible to verify whether the airframe and engine logbook registries were updated, since they were destroyed in the fire;

g) the aircraft took off from SSUE, with the purpose of performing a local flight, in the outskirts of the city of Ribeirão Preto - SP;

h) there was a loss of control in flight and the aircraft crashed near the district of Bonfim Paulista - SP;

i) the technical report indicated that the aircraft and its systems did not show signs of failure before the occurrence;

j) the aircraft described a trajectory with a large angle of descent and a high sinking rate;

k) the aircraft was destroyed; and

l) the two occupants perished in the accident.

3.2 Contributing factors.

- **Handling of aircraft flight controls - undetermined.**

Given that there was no contribution from the technical conditions of the aircraft or from the meteorological conditions and, according to the dynamics of the accident, it is possible that an inadequate performance in the flight commands caused the aircraft to lose control in flight, which could not be reversed.

Such a situation would have led the aircraft to a vortex stall, since the rate of descent would have been very large, and there was practically no displacement ahead.

- **Training - undetermined.**

It is possible that the psychomotor reactions required from the pilot to perform the necessary maneuvers for the recovery of the aircraft in stall condition have been affected by the lack of recent experience and maintenance of the operational proficiency in the model, which could not be proven throughout the investigation.

- **Interpersonal relationship – undetermined.**

Although it was not possible to identify the purpose of the flight, the presence of the passenger was justified by his interest in aviation.

Experience as an instructor, combined with the passenger's interest in aviation, may have induced the pilot to allow the passenger to operate on the aircraft's controls. In this context, incorrect actuation in flight commands could lead the aircraft to loss of control due to a vortex stall.

4. SAFETY RECOMMENDATION.

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

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

Recommendations issued at the publication of this report:

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

A-060/CENIPA/2014 - 01 **Issued on 09/04/2018**

Give wide dissemination of the lessons learned from this Investigation, with emphasis on IS 61-006, Revision B, in June 2016, mainly in Training Centers and *Aeroclubes*.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

The ANAC issued IS 61-006, Revision B, in June 2016, which included initial endorsement requirements for pilots and instructors of aircraft R22 and R44, according to the topics described in SFAR 73.

On September 4th, 2018.