COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-587/CENIPA/2016

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-HOL**
MODEL:	**R22**
DATE:	**11JUL2012**

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 11JUL2012 accident with the R22 aircraft, registration PT-HOL. It was classified as “System/Component Failure”.

When returning for landing, about 2.7 NM from the Aerodrome, the crew lost control of the aircraft, colliding with the roof of an industrial warehouse.

The aircraft was destroyed.

The pilots perished at the accident’s site.

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

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AD	Airworthiness Directive
ANAC	National Civil Aviation Agency
APP	Approach Control
APP-SP	Approach Control – São Paulo
ATC	Air Traffic Control
AVGAS	Aviation Gasoline
CG	Center of Gravity
CMA	Aeronautical Medical Certificate
DCTA	Aeronautics’ Science and Technology Department
DECEA	Airspace Control Department
INVH	Flight Instructor Rating – Helicopter
METAR	Meteorological Aerodrome Report
NM	Nautical Miles
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board
PCH	Commercial Pilot Rating - Helicopter
PPH	Private Pilot Rating – Helicopter
RADAR	Radio Detection And Ranging
RBHA	Brazilian Regulation of Aeronautical Homologation
RPM	Rotations per minute
SERIPA	Regional Aeronautical Accident Investigation and Prevention Service
SERIPA IV	Fourth Regional Aeronautical Accident Investigation and Prevention Service
SIPAER	Aeronautical Accident Investigation and Prevention System
SRPV-SP	Regional Flight Protection Service
UTC	Universal Time Coordinated
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

<table>
<tr><td rowspan="3">Aircraft</td><td>Model: R22</td><td rowspan="3">Operator:
GO AIR / MASTER ESCOLA DE AVIAÇÃO CIVIL LTD.</td></tr>
<tr><td>Registration: PT-HOL</td></tr>
<tr><td>Manufacturer: ROBINSON HELICOPTER</td></tr>
<tr><td rowspan="4">Occurrence</td><td>Date/time: 11JUL2012 - 1317 UTC</td><td rowspan="2">Type(s):
“SYSTEM/COMPONENT FAILURE”</td></tr>
<tr><td>Location: 150, CARIJÓS ST. - ÁGUA BRANCA</td></tr>
<tr><td>Lat. 23º31’20”S Long. 046º41’19”W</td><td rowspan="2">Subtype(s):
NIL.</td></tr>
<tr><td>Municipality – State: SÃO PAULO - SP</td></tr>
</table>

1.1 History of the flight.

The aircraft took off from Campo de Marte Aerodrome - SP (SBMT), at about 09:20 am (local time), in order to conduct a Pilot Training Course flight - Helicopter (PCH). The flight was carried out in an instructional area near the Guarapiranga dam, with two pilots on board.

On return, with about 55 minutes of flight, the aircraft presented problems of performance and difficulty in directional control.

The helicopter initially crashed into the roof of an industrial warehouse, drilled the roof and crashed into the ground.

The aircraft was destroyed.

The pilots perished at the accident’s site.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft was destroyed.

1.4 Other damage.

There was damage to the roof of a warehouse used for industrial storage.

1.5 Personnel information.

1.5.1 Crew’s flight experience.

Hours Flown		
	Pilot	Student
Total	183:50	58:35
Total in the last 30 days	23:25	13:05
Total in the last 24 hours	00:45	00:45
In this type of aircraft	163:00	58:35
In this type in the last 30 days	23:25	13:05
In this type in the last 24 hours	00:45	00:45

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

1.5.2 Personnel training.

The Commander took the Private Pilot course - Helicopter (PPH) at Master Escola de Aviação Civil Ltd., in 2011.

The Student took the Private Pilot course - Helicopter (PPH) at Master Escola de Aviação Civil Ltd., in 2012.

1.5.3 Category of licenses and validity of certificates.

The pilot had the Commercial Pilot Rating – Helicopter (PCH) and had valid Technical Qualification for Robinson Helicopters R-22/ R-44 (RBHS) and INVH.

The Student had the Private Pilot Rating – Helicopter (PPH) and had valid Technical Qualification for Robinson Helicopters R-22/ R-44.

1.5.4 Qualification and flight experience.

The pilots were qualified and had experience in that kind of flight.

1.5.5 Validity of medical certificate.

The pilots had valid Aeronautical Medical Certificates (CMA).

1.6 Aircraft information.

The aircraft, serial number 2189, was manufactured by Robinson Helicopter Company, in 1992 and was registered in the category of Private Air Services - Instruction (PRI).

The Certificate of Airworthiness (CA) was valid.

The airframe, engine and rotors logbooks records were updated.

The last inspection of the aircraft, the "100 hour-type" was performed on 03JUL2012, by a certified shop in São Paulo – SP, having flown 67 hours and 12 minutes after the inspection.

The last general revision of the aircraft was performed on 17NOV2011, by a certified shop in São Paulo – SP, having flown 1411 hours and 54 minutes after the inspection.

1.7 Meteorological information.

The conditions were favorable for the visual flight.

At the time of the accident, corresponding to the observation valid for 1300 UTC, SBMT's METAR, (2.7 NM from the impact area) pointed to visibility over 10 kilometers, without cloudiness, with a calm wind. The air temperature was 22°C; 11° C above dew point temperature, with atmospheric pressure of 1016hPa. There were no cloud formations associated with instabilities, arrivals of fronts, or even post-fronts, by the forecast and wind charts.

The METAR of the previous hour, corresponding to the time of takeoff, had similar conditions, according to the bulletins below:

11UL2012 METAR SBMT 111200Z 33002KT CAVOK 20/11 Q1016=

11JUL2012 METAR SBMT 111300Z 06002KT CAVOK 22/11 Q1016=

1.8 Aids to navigation.

Nil.

1.9 Communications.

There was initial contact with the ATS bodies in SBMT, during the takeoff. During the flight in the Special Helicopter Routes (REH) of the São Paulo Terminal (TMA-SP), the aircraft should tune in and keep bilateral contact in the Aeronautical Coordination Frequency (FCA) at 127.35MHz. The PT-HOL was not in contact with ATS bodies at the time of the accident, for that reason; there was no recording of the communications on the return, at the time of the occurrence.

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 impact was on the roof of a company's warehouse that stored large rolls of industrial reels. There was tail sectioning and it remained on a lower part of the roof (Figure 1).

Figure 1 - Tail cone on the roof / post-impact position.

The rest of the aircraft (main rotor fuselage) entered the roof of the warehouse, which had a room's height of approximately 10 meters. The estimated angle of the apparatus entrance on the warehouse's roof was between 70° and 80°.

The roof was cracked in a small area. The main rotor blades had characteristic "wrinkle" damages. There were also scratches in the blades, as well as the absence of damage in the leading edges, as well as fracture of the blades near the main rotor head.

The impact of the fuselage against the ground caused structural damage. The main transmission, engine accessories, fuel tanks and the rest of the fuselage were destroyed. There was fuel leakage in the place (Figure 2).

Figure 2 - Aspect of the fuselage, after the victims removal, with detail to the damages in the blades of the main rotor, in the form of "wrinkles".

At the time of the first action team's arrival, the aircraft cabin was deformed not only by impact, but also by the action of the rescuers team, who also moved the instrument panel away from its location to try to save the victims.

The collision occurred at the geographic coordinates 23 ° 31'20 "S / 046 ° 41'19" W. There was a free terrain, ahead of the warehouse (in relation to PT-HOL trajectory), about 30m x 20m.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

There was no evidence that physiological or incapacitation considerations had affected the performance of the flight crewmembers.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The instructor was 23 years old and was acting as an INVH at the operator’s piloting school for about two months.

According to reports, the instructor exercised financially rewarding work before starting to fly, but left his job and disposed of some assets to pay for his PPH, PCH and INVH courses.

His practical training was held at the same school where he worked as an instructor. During the training, he always got maximum grade in the evaluation sheets. He was considered an above-average pilot with a high control of the aircraft. He stood out for his professional attitude and commitment to instructional activities.

Still according to reports, the instructor had a good interpersonal relationship with students, peers and superiors in the aviation school. Even in the off-hours, the instructor remained in the aviation school collaborating with the other instructors.

The school owner mentioned that for the purposes of assessment he used to ask future instructors to perform some risk procedures during evaluation flights. When he made the request to the instructor in question, he refused to do what was requested, demonstrating assertiveness and commitment to safety.

It was evidenced that the instructor was well adapted to his activity in the company and that he wanted better placements in the job market.

The student was well connected with his colleagues, being mentioned by some as a rather introverted person. He was an applied student and aimed to reach new levels. He aimed to, as a PCH, to begin to exercise professional activity in helicopter aviation. It was mentioned to the Investigation Commission that the learner was very studious and did the duties related to the instruction. He was in good health and did not use any medication. It was mentioned that he was not stressed or fatigued.

It was reported to investigators that the instructor of the previous flight did not notice anything abnormal in the helicopter. It was also found that the student would probably be flying and, at the time of the break, the instructor must have taken over the commands of the aircraft.

It was verified that the company sought to open channels of communication with its employees and students through an email, a blog and a suggestion box. The operator encouraged students and instructors to contact him to help diagnose faults in the company's processes or equipment.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

On 14NOV2012, the engine of the crashed helicopter was examined by technicians of the Investigation Commission, at the premises of a certified shop. A professional trained by SIPAER and belonging to the DCTA's staff accompanied the activity.

The following material was submitted to DCTA for review:

- engine with accessories;
- power transmission shaft;
- coupling yoke, clutch;
- cooling fan (or fan wheel); and
- fan coupling.

The crankcase, magnets and carburetor, among other components, could not be analyzed according to the extent of the damage found.

Specifically, the carburetor, positioned under the engine of the helicopter, suffered substantial damage because of the energy involved in the impact - fall with great vertical velocity.

The aircraft was equipped with a Lycoming engine, serial number L-17209-39A. The engine was examined and the studies comprised the cylinders, pistons, valve control, crankshaft, gears and bearings.

The exams did not identify problems related to carburizing and / or fueling of the engine. Marks were observed in the cooling fan - in the direction of the shaft rotation - as well as the integrity of the oil pump and the absence of filings in filter element.

The researches performed in the power unit concluded that the engine was normally functioning at the time of the accident, ruling out the possibility of some internal component crash.

In addition to the power unit, the rotary assembly was also analyzed. The two blades of the tail rotor were still connected on their respective axes. Some twists and dents on the leading edge of one of them were observed. The two blades of the main rotor were found almost sectioned near their respective roots. However, there were no impact marks on the leading edge of these blades. There were only scratches on the two blades, in the root-tip direction of the blade, probably explained by the blade breaking in its impact with the roof structure, in the almost vertical fall of the aircraft.

The rear axle was held next to the tail cone, which collided with the side structure of the warehouse roof. The cone deformed at an angle of 90°. It was necessary to cut the metal plates of the cone to evaluate the rear axle. It did not exhibit longitudinal helical deformations, typically produced in the part at the contact of the tail rotor in high energy or in rotation against obstacles. The yoke and flange connecting this shaft to the upper pulley, also did not shear, only deformed in the longitudinal direction of the shaft. These evidences, together with the slight damages suffered in the blades of the tail rotor, as well as the fact that they were still connected to the respective shafts, led to the belief that the rear rotor was stopped or spinning at low speed.

The front axle, located between the upper pulley and the Main Transmission Box (CTP), had a fracture at a 45° angle, close to the yoke and flange connecting the axle to the CTP (Figure 3).

Figure 3 - Detail of the crack formation in the helical direction, in the transmission shaft.

The yoke, Figure 4, apparently had adequate attachment to the shaft, and two screws and one block, accompanied by "lock-nuts", provided the adjustment. Still, in the firewall, below the fractured region of the shaft, there was a dent with a crack. The axis and the other components of the fractured region were also submitted to a technical analysis of the DCTA.

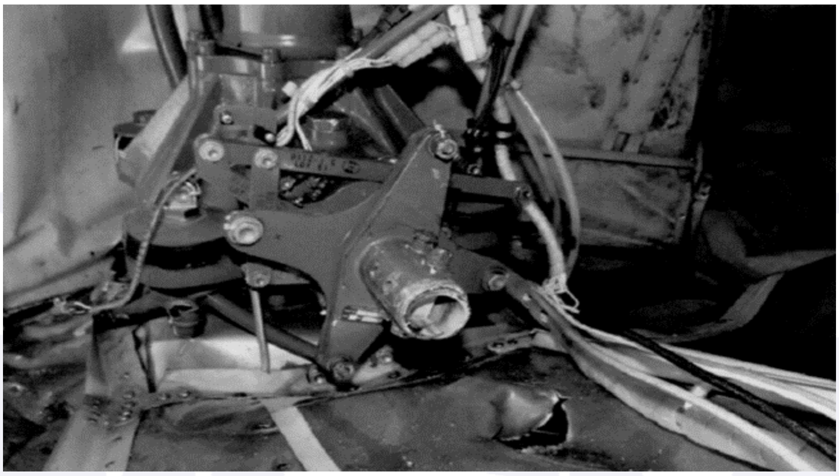


Figure 4 - Overview of the Yoke, still assembled in the gearbox.

It was observed a break in the power transmission shaft, part number - PN A166-1, due to fatigue mechanism. It started by corrosion in the transmission shaft fixing hole to the yoke, PN A907-4, by the gearbox's side.

The crack progressed helically on the axis, and as it reached the yoke's end, the catastrophic failure of the set occurred. This has caused an interruption in the transmission of power from the engine to the gearbox.

The set had been installed about 8 months before the occurrence, having flown 1,141 hours and 54 minutes since then.

Thus, as a determining event, DCTA's research report concluded that the cause of the failure found in the aircraft is related to:

> ... the fatigue breakdown of the transmission shaft. Fatigue started by corrosion in the transmission shaft fixing hole to the yoke flange by the gearbox's side. The crack progressed helically on the shaft and when it hit the region near the yoke's end, the shaft broke. This has caused loss of power transmission to the gearbox (CTP).

In addition, another DCTA report pointed out this conclusion, also based on the fact that there was no trace of applied product between the shaft and the yoke: (Figure 5)

> The performed analyzes indicated that the failure of the power transmission shaft occurred through a fatigue process initiated in one of the shaft fixing holes with the coupling to the CTP. The initiation of the process was facilitated by the occurrence of corrosion. No protection was observed on the contact surfaces between the parts to prevent corrosion.

Figure 5 - Fretting marks on the fractured power transmission shaft, with no trace of product applied for protection.

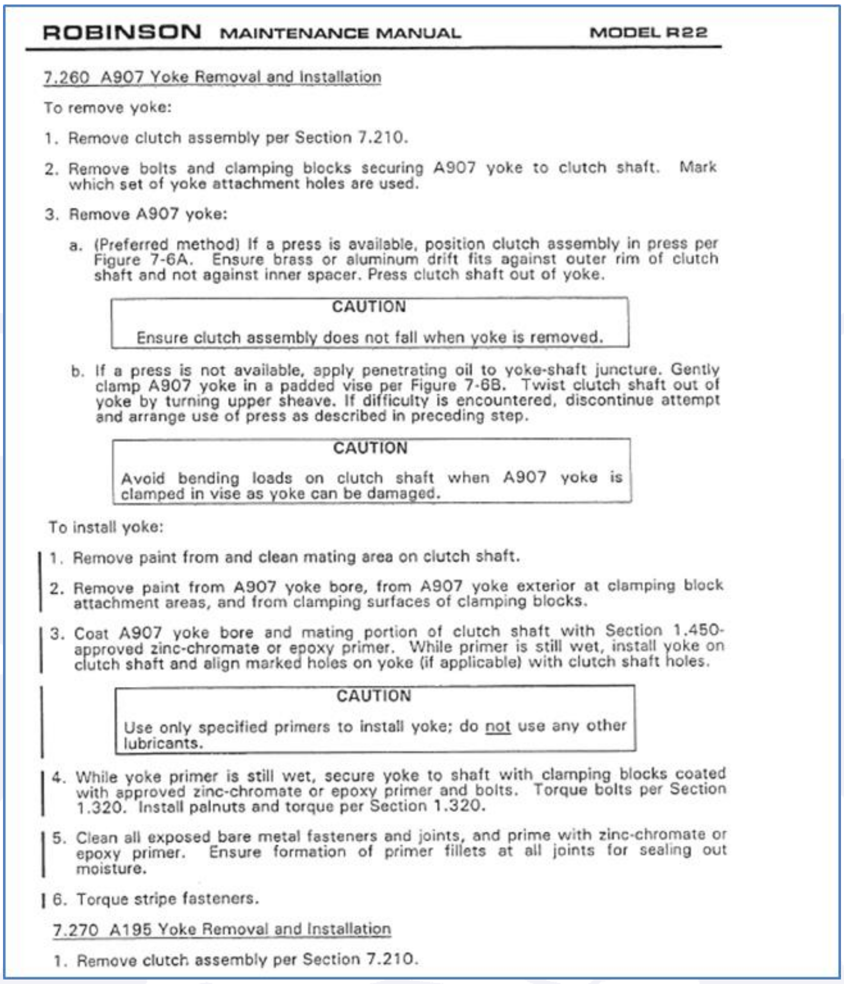
An analysis of the dynamics of the set was performed, with an interpretation of the fracture type.

There was a need for further investigations to verify some specifications of the axle material and the maintenance procedures of the power transmission shaft.

In this sense, a complementary report was elaborated with emphasis on the analysis of the fault occurred in the power transmission shaft belonging to the PT-HOL aircraft. This was for the procedure verification of removing and installing the yoke on the power transmission shaft.

During the analysis of the support blocks fixation region, after their removal, it was verified that in the interface region of the axis with the blocks there was the presence of an ink, possibly applied by the axis manufacturer. In this same region, the presence of the first one was not identified. This showed that the blocks were screwed onto the paint and not on the primer as indicated in the maintenance manual.

Verification was performed according to the instructions of the Robinson Maintenance Manual, Model R22, sec. 7.260, Change 22MAR2004. (Figure 6)



ROBINSON MAINTENANCE MANUAL MODEL R22

7.260 A907 Yoke Removal and Installation

To remove yoke:

1. Remove clutch assembly per Section 7.210.
2. Remove bolts and clamping blocks securing A907 yoke to clutch shaft. Mark which set of yoke attachment holes are used.
3. Remove A907 yoke:
   a. (Preferred method) If a press is available, position clutch assembly in press per Figure 7-6A. Ensure brass or aluminum drift fits against outer rim of clutch shaft and not against inner spacer. Press clutch shaft out of yoke.

   CAUTION

   Ensure clutch assembly does not fall when yoke is removed.

   b. If a press is not available, apply penetrating oil to yoke-shaft juncture. Gently clamp A907 yoke in a padded vise per Figure 7-6B. Twist clutch shaft out of yoke by turning upper sheave. If difficulty is encountered, discontinue attempt and arrange use of press as described in preceding step.

   CAUTION

   Avoid bending loads on clutch shaft when A907 yoke is clamped in vise as yoke can be damaged.

To install yoke:

1. Remove paint from and clean mating area on clutch shaft.
2. Remove paint from A907 yoke bore, from A907 yoke exterior at clamping block attachment areas, and from clamping surfaces of clamping blocks.
3. Coat A907 yoke bore and mating portion of clutch shaft with Section 1.450-approved zinc-chromate or epoxy primer. While primer is still wet, install yoke on clutch shaft and align marked holes on yoke (if applicable) with clutch shaft holes.

   CAUTION

   Use only specified primers to install yoke; do not use any other lubricants.

4. While yoke primer is still wet, secure yoke to shaft with clamping blocks coated with approved zinc-chromate or epoxy primer and bolts. Torque bolts per Section 1.320. Install palnuts and torque per Section 1.320.
5. Clean all exposed bare metal fasteners and joints, and prime with zinc-chromate or epoxy primer. Ensure formation of primer fillets at all joints for sealing out moisture.
6. Torque stripe fasteners.

7.270 A195 Yoke Removal and Installation

1. Remove clutch assembly per Section 7.210.

Figure 6 - Section 7.260 A907 Yoke Removal and Installation of RHC R-22 Maintenance Manual, Change 22MAR2004.

Visual examinations performed on the yoke-shaft power transmission received indicated that the manual procedures were not followed.

Figure 7 shows the set still assembled, after the fracture, indicating that item 5 of the sealing procedure of the assembly was not performed with primer.

Figure 7 - General aspect of the received power transmission yoke-shaft.

Figure 8 shows the rear view of the set indicating that there was also no sealing of the yoke-shaft with the primer.

Figure 8 - Rear view of the set: yoke - transmission shaft. It is noted that there was no sealing with primer.

Figure 9 shows the regions of fixation of the support blocks after their removal, indicating that in the region of the interface of the axis with the blocks, there was no removal of the ink from the shaft.

Figure 9 - Aspect of the regions of the axis where the external support blocks are placed. It is noted that the ink was not removed from the settling region of the blocks.

The blocks were screwed on top of the paint and not on the recommended primer. Figure 10 shows that there was no application of the primer on the contact surfaces of the support blocks. Therefore, items 1 and 4 of the installation procedure have not been performed.

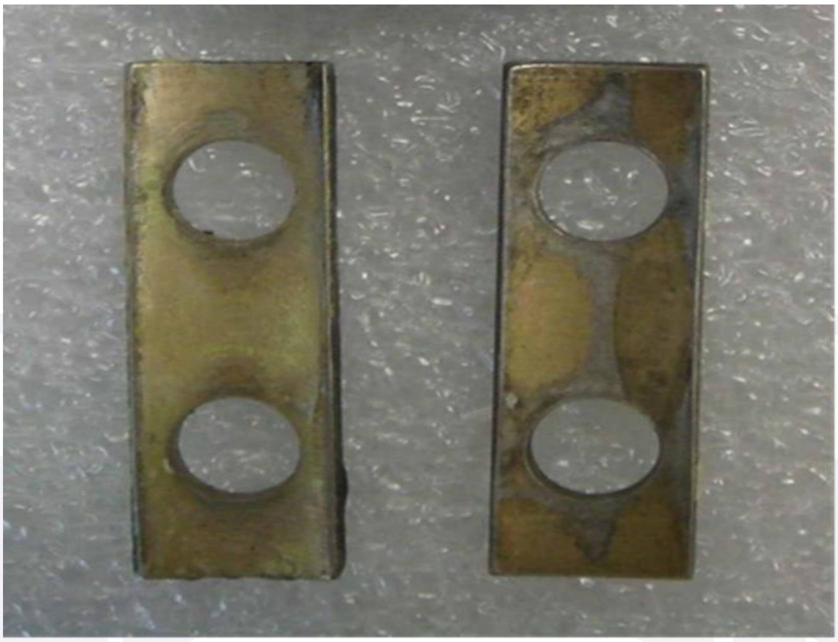


Figure 10 - Appearance of the laying regions on the shaft of the outer support blocks. It is noted that there is no presence of primer.

In this supplementary report, it is stated that:

> Failure to comply with items 1, 4 and 5 of the maintenance manual installation instructions facilitated the occurrence of fretting and corrosion, which led the shaft to fatigue failure.

The complementary report also presented the results regarding the verification of the level of inclusions, grain size and hardness of the fractured shaft material.

The verification was performed according to the specifications of standard AMS 6265, which indicates ASTM standards E45 (method D) for the level of inclusions, E112 for grain size and A370 for hardness.

The inclusion level verification was performed by image analysis in an area close to the fracture, and the presence of globular type D inclusions was verified above the maximum width allowed by the ASTM E45 standard, which is 13μm. Twelve inclusions of type D with widths between 13.68μm and 27.98μm were observed, as shown in Figure 11.

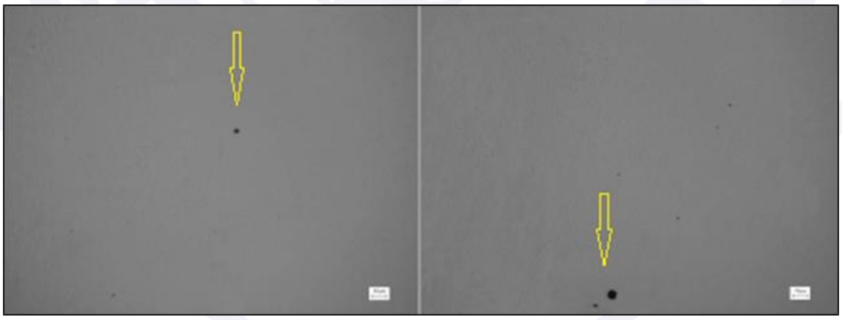


Figure 11 - Aspect of two of the observed fields, with globular inclusion with 13.68μm and 27.98μm width.

Grain size verification indicated that the material has an ASTM 7 grain size, smaller than the maximum allowable size, which is ASTM 5.

The hardness verified in the material was 37.5 ± 1.5 Rockwell C, which is between the maximum values (41 HRc) and minimum (32 HRc) values reported in AMS 6265.

Also, according to the report, the results obtained in the evaluation of the material of the shaft did not indicate that it influenced the fracture process, despite the presence of some inclusions above the maximum size indicated by the standard.

The section 7.260 A907 Yoke Removal and Installation of the RHC R-22 Maintenance Manual, Change 22MAR2004, warned to use only primers specified when installing the yoke, prohibiting the use of other lubricants. These products adhere to the contact surfaces, without allowing air or water to be present (Figure 12).

To install yoke:

1. Remove paint from and clean mating area on clutch shaft.
2. Remove paint from A907 yoke bore, from A907 yoke exterior at clamping block attachment areas, and from clamping surfaces of clamping blocks.
3. Coat A907 yoke bore and mating portion of clutch shaft with Section 1.450-approved zinc-chromate or epoxy primer. While primer is still wet, install yoke on clutch shaft and align marked holes on yoke (if applicable) with clutch shaft holes.

CAUTION

Use only specified primers to install yoke; do not use any other lubricants.

4. While yoke primer is still wet, secure yoke to shaft with clamping blocks coated with approved zinc-chromate or epoxy primer and bolts. Torque bolts per Section 1.320. Install palnuts and torque per Section 1.320.
5. Clean all exposed bare metal fasteners and joints, and prime with zinc-chromate or epoxy primer. Ensure formation of primer fillets at all joints for sealing out moisture.
6. Torque stripe fasteners.

Figure 12 - Section 7.260 A907 Yoke Removal and Installation of RHC R-22 Maintenance Manual, Change 22MAR2004.

The same section also prevised the removal of the paint, installation of the set and the subsequent coverage with a coated product, which was not correctly observed in the assembly of the set, performed in the event of a post-accident maintenance suffered in 2010.

It was also found out during a visit to the company that the maintenance shop used an epoxy, associated with an "automotive / industrial" hardener, which withstand temperatures up to 40ºC according to its technical specification. On the other hand, the aeronautical product parameters were continuous 92° C, or 148° C in intermittent heating conditions, as well as other specific characteristics such as density and flash point.

In the event of the accident, on 09AUG2012, the company submitted to the aircraft manufacturer an email questioning about the possibility of using a product similar to those prevised in the manual, obtaining the answer from the company's technical support, also by e-mail , that any primer epoxy could be used, with the exception of "Corlar" or zinc chromate. In the meantime, Du Pont's catalog contained the "Corlar" associated with the "825P26295" specification, which was listed as the third product approved for use in Section 1.450 of Maintenance Manual R-22. This made Robinson's information inconsistent (Figure 13).

ROBINSON MAINTENANCE MANUAL MODEL R22

1.450 Primers

PRODUCT	MANUFACTURER/SUPPLIER	APPLICATION
Yellow chromate epoxy 200-129M with CA116 activator and acetone reducer	WLS Coatings Los Angeles, CA	Aluminum, and steel
Green chromate epoxy 44-GN-72 with 44-GN-72 activator and water reducer	Deft, Inc. Irvine, CA	Exterior aluminum and steel components
White epoxy 825P26295 with 936S activator and 8970S reducer	DuPont Los Angeles, CA	Exterior aluminum, steel, and fiberglass components
Gray epoxy 44-GY-21 with 44-GY-21 activator and water reducer	Deft, Inc. Irvine, CA	Interior and exterior aluminum, steel, and fiberglass components
Gray epoxy CA 7501 with CA 7501B activator	Desoto Aerospace Coatings, PRC-Desoto Int., Inc. Glendale, CA	Unlimited
Light gray epoxy primer-sealer Corlar 934S with 936S (fast) or 937S (slow) activator	DuPont Los Angeles, CA	Spot treatment of sanded-bare areas. No sanding of primer required if top-coat is applied within 72 hours.
Zinc Oxide Green #A802 (Aerosol)*	Valspar Corporation Medina, OH	Limited or touch-up use only
Green zinc chromate A7-6889A* (Aerosol)	Tempo Products Medina, OH	Limited or touch-up use only

* shelf life two years

Figure 13 - Section 1450 of the Maintenance Manual R-22 with the primers planned at the time of the accident.

Three other parts also drew the attention of the Investigation Committee, in view of the damage they observed. The clutch mechanism, fractured on its half-bolt screw, pulleys with teeth and intense friction marks, and the cooling fan, separated from the engine at impact. The latter had the holes of the securing screws deformed in the direction opposite to the rotation of the crankshaft (crankshaft of the engine). Still, bluish spots near some of these holes proved that the separation occurred under high temperature.

In the light of the observed and analyzed damages, a conference was initiated between the Investigation Commission, the IAE / DCTA engineers, researchers from the National Transportation Safety Board (NTSB), US counterpart of the CENIPA, as well as engineers and researchers from the crashed model manufacturer.

The purpose of the information exchange was to understand and establish a cause and effect relationship between the damages. In short, the chain of events that resulted in the accident.

After a series of questions, the following responses were obtained: a fracture (with separation) on the shaft located between the upper pulley and the CTP in the region of the yoke and the flange would cause the engine speed to increase, due to the reduced load assigned to it.

Due to the stresses imposed by the belts to the pulleys, the fractured end of this shaft, in this new condition, would be displaced downwards. This would explain the dent with a crack, seen in the engine's firewall.

With the shaft moved down, the upper pulley would move out of the alignment of the belts, causing them to loosen (especially the front belt). So, it was unlikely that the belts would remain in the tracks (grooves) of the pulleys. With the belts loose and out of the grooves of the pulleys, the rear shaft would no longer be connected, that is, it would not continue to mechanically receive the load of the engine. Thus, the drag produced by the tail rotor blades would also help to decelerate the rear shaft (Figure 14)

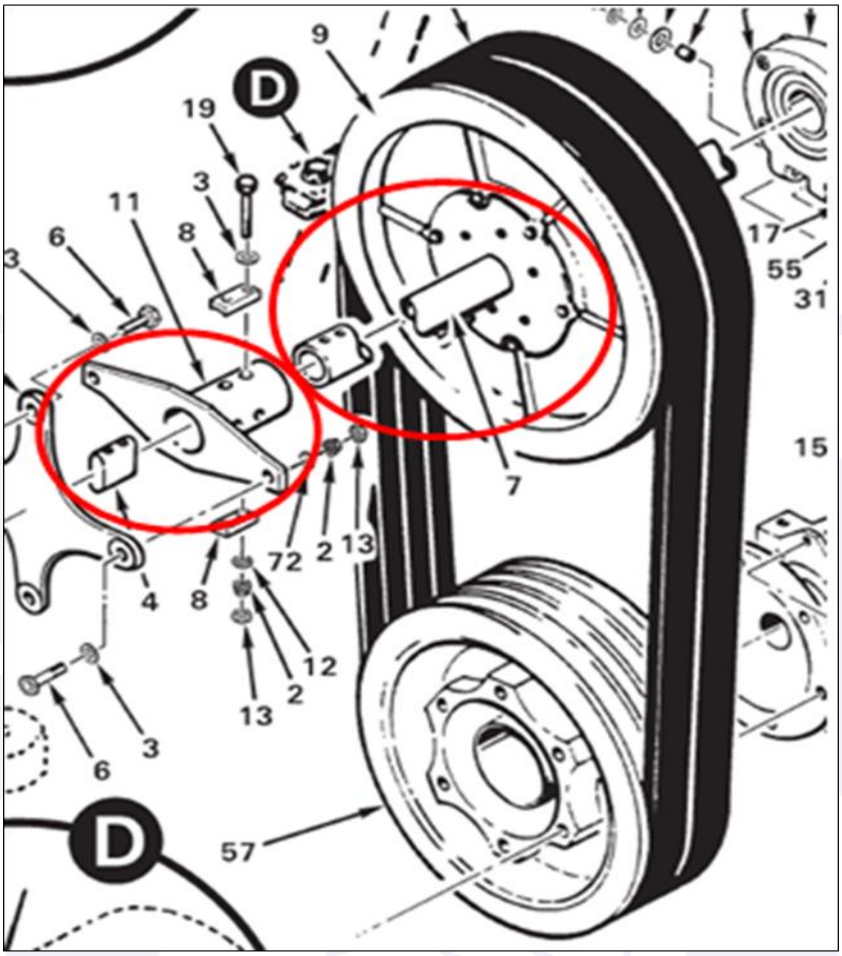


Figure 14 - Details of the Yoke (11) and Shaft-Transmission (7), in the R-22 Drive train.

The Investigation Committee received from the operator a report prepared by INMETRO / DIMCI, in which the hypothesis of epoxy residue in the set was raised, as well as the existence of discontinuities in the metallic alloy, raised by microscopy and spectroscopy. The study was based on a metallographic analysis, which determined inclusions and absences of the material, of the order of micrometers.

At a meeting of the Commission held on 27JUN2013, the possibility of adjusting between the yoke and the transmission shaft was made so that the contact between the two of them, without any clearance, would eventually remove the first one applied. The assay was performed at the operator company, with the PN shaft and yoke, and it was observed that the protective film remained in the materials, after the application.

Due to fuel spillage at the accident site, it was not possible to perform a collect on the aircraft. At the time of the accident, therefore, 18 samples were collected at the distributor of aviation gasoline, at Campo de Marte Aerodrome (in the tank, in the monitor filter and in the fuel nozzle). The analysis of such samples, carried out in the DCTA, pointed to the use of aviation gasoline that met the specifications.

1.17 Organizational and management information.

It was found that the company had twelve instructors of which four were registered. The instructor would be effective in the school of aviation staff soon, starting to have an employment relationship. The company had a history of five events - between accidents and incidents - between 2011 and 2012. However, the mood among students and instructors was favorable. The occurrence of the accident in question increased the level of situational alert.

The company submitted to the Commission a document issued to the manufacturer on 15DEC2011, in which it requested the presence of a technical representative in Brazil in order to provide maintenance technical support. However, the manufacturer did not make any technical visits to the operator.

As a result of the work carried out by the Investigation Commission with the operator, another aircraft, in maintenance service at the company, was found to have evidence of surface corrosion of the Transmission Shaft (PN A166-1) and Yoke (PN A907- 4). The documentation was sent to the company.

Regarding the Instructor's Course Manual, it was observed that the school adapted the Ministry of Aeronautics Manual (MMA) 58-16 - Flight Instructor Course Manual (INVA), 01JAN1992, in force on the date of accident. The school obtained the renewal of the authorization of the Flight Instructor course (INVH), published in ANAC Ordinance (n ° 2191 / SSO, from 17/10/2012).

Go Air became the second denomination of the Master Escola de Aviação Civil Ltd, from 2009 on

While Go Air (school) carried out the instruction activity according to the Brazilian Regulation of Aeronautical Homologation (RBHA) nº 141, Master performed aeronautical maintenance shop activity according to RBHA 145, (in force at the time). In this last activity, services were also performed for third parties. There was an inspector on the board of the company, who was Robinson's only trained technician (a course that had been offered in Brazil by the factory's representative). The company's maintenance team consisted of four aeronautical maintenance mechanics, auxiliaries, with a load of up to five R-22 overhauls per year, according to the team itself.

1.18 Operational information.

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

This was an FPR instruction flight, with take-off and landing planned for SBMT. Thus, a visual notification was completed and the most relevant exercises would be carried out in the Guarapiranga dam area (São Paulo-SP). The helicopter was making the third flight of the day, during the accident. The take-off took place at 09:20 (local time). The flight was estimated to last from 60 to 70 minutes. The instructor knew the area of the dam as well as the visual helicopter corridors within the controlled airspace of the city.

Proof of refueling showed that the aircraft had about 112 liters of aviation gasoline before takeoff. According to the manufacturer, the approximate consumption of the engine that equipped the helicopter was 7 to 10 gallons / hour, which is equivalent to an average consumption of 35 liters / hour, depending on the trinomial "atmospheric conditions / power employed / flight altitude" .

The Commission requested and obtained access to the collection of radar revisions, provided by the Regional Flight Protection Service - São Paulo (SRPV-SP).

This way, it was observed that the aircraft, when returning from the exercise area and approaching SBMT, at 13:15:56 (UTC), remained in the bow 085 °, at 3,000ft altitude (about 500ft AGL), with speed average of 84kt. The approximate bow of PT-HOL corresponded to the stretch of the visual corridor "ROTA MARTE", on the beginning of Rodovia dos Bandeirantes (Figure 15).

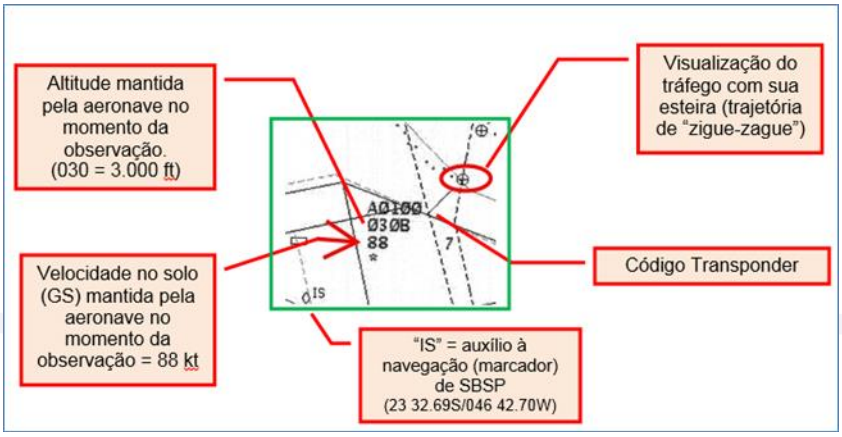


Figure 15 - Frame of 13h16min56s (UTC).

From 13h16min56s (UTC), a change in trajectory (bow variation for both sides) was observed, associated to the significant drop in speed, as indicated in the radar-revision charts. Such changes of flight parameters lasted 25 seconds until the loss of the return-radar. (Figures 16 and 17).

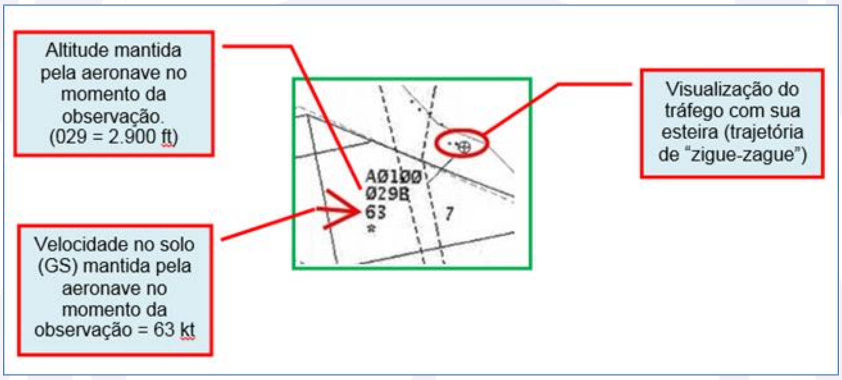


Figure 17 - Frame of 13h17min16s (UTC).

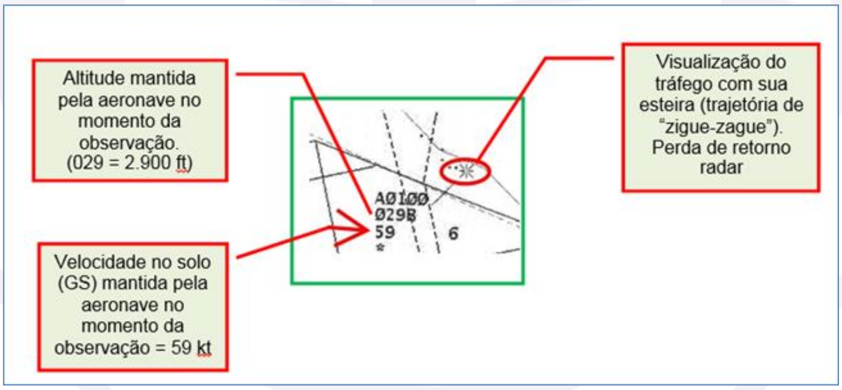


Figure 17 - Frame of 13h17min21s (UTC). Note the loss of radar "plot" (asterisk), indicating altitude loss with practically no horizontal displacement in relation to the previous frame.

These changes in the bow and speed are evidence that the aircraft has been subjected to a sudden loss of power due to failure in the drive system, since the engine was functioning correctly, as it can be inferred from observing the Emergency Procedures of the R -22:

> POWER FAILURE - GENERAL
>
> A power failure may be caused by either an engine or drive system failure and will usually be indicated by the low RPM horn. An engine failure may be indicated by a change in noise level, nose left yaw, an oil pressure light, or decreasing engine RPM. A drive system failure may be indicated by an unusual noise or vibration,

> nose right or left yaw, or decreasing rotor RPM while engine RPM is increasing. In case of power failure, immediately lower collective to enter autorotation.
>
> CAUTION
>
> Aft cyclic is required when collective is lowered at high speed.

With the loss of power, caused by the fracture of the drive shaft, the rotation of the main rotor decreased. To reverse such a situation, the pilot, according to Emergency Procedures of the R-22, should lower the collective immediately and, in the case of a cruise, bring the cyclic backward, in order to reduce the speed to 65kt.

> 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.

According to the Flight Training and Pilot`s Operating Handbook of the manufacturer, the helicopter required, in eventual emergencies related to the rotation of the main rotor, to maintain a translational speed of at least 65 kt, in order to safely initiate a real autorotation maneuver.

The R-22 model was characterized by the main rotor of low inertia, that is, extremely susceptible to the loss of rotation, if the collective control was not lowered immediately, when observed the rotation of the main rotor.

If the pilot had not adjusted the collective to maintain the rotation between 97% and 110%, as the Robinson R22 Series, Section 3, Emergency Procedures, or had allowed it to decay excessively, the controllability of the helicopter would become extremely compromised.

> 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 110% or apply full down collective if lightweight 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.

Likewise, any elevation of the collective control, inadvertently performed during the approach path to the point chosen for landing in autorotation would increase the pitch of the main rotor. It would result in loss of rotation and loss of the ability to generate support in the flare (the flare would mark the moment of transition from approximation at considerable vertical velocity to ground-controlled touch).

The approach bow to the landing site was estimated by the Investigation Commission in 085º. Such a consideration was based on the information gathered from the collection of radar revisions (Figure 17), as well as interviews with witnesses at the scene.

Figure 18 - Sketch of the approximate trajectory of the aircraft.

The helicopter collided the tail cone, practically at its root, against the side structure of the roof of a large warehouse of steel reels. The metal structure of the roof in this building did not support the weight of the rest of the device. Considering the direction of approach, there was a yard for car maneuvers after the warehouse, free of obstacles (Figure 18).

Figure 19 - Aspect of the roof of the warehouse, being visible the part without cover, where the fuselage of the PT-HOL entered.

Evidence found in the main rotor and tail rotor as well as the damage suffered by the roof of the shed indicated that the rotors were with low rotation and the aircraft with little displacement ahead, that is, reduced speed.

The same aircraft had suffered an accident on 04NOV2010, and a general review was carried out after this date, which, among other services, included the installation of a new shaft-yoke assembly, according to the invoice for import of the manufacturer's material and service order, presented during the investigation.

1.19 Additional information.

The Commission had access to R-22 accidents reports in Australia, similar to that one with PT-HOL, namely: VH-HFP in 1992, VH-UXF in 2003 and VH-HXU in 2005. In all occurrences, there was failure in the transmission shaft, loss of connection of the "yoke" assembly under study, lack of use of specific product or even the use of non-suitable product in the contact area as a contributing factor, in two of these three occurrences (Figure 20).

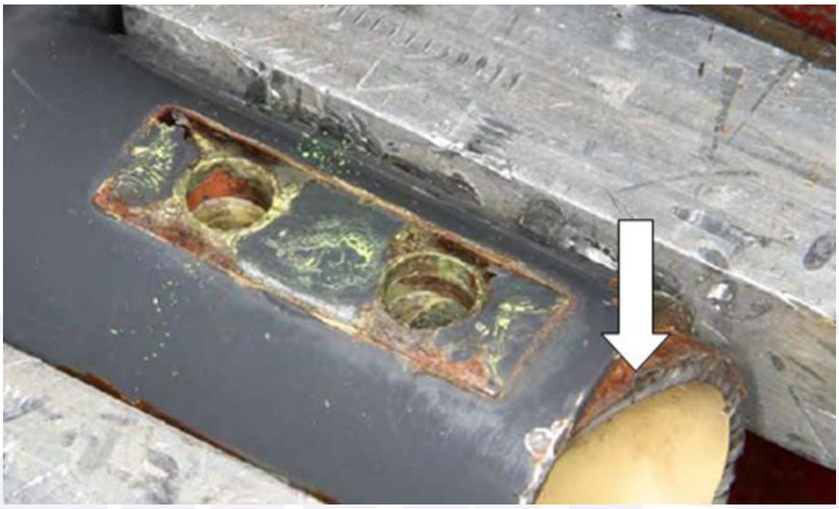


Figure 20 - Detail of Yoke and Transmission Shaft PN of R-22 VH-UXF, with helical fracture mechanism, where no predicted product was applied between the items, as well as their assembly with original painting. Source: Report 200304074, Australian Government - Civil Aviation Safety Authority.

The Australian Civil Aviation Safety Authority (CASA) issued the AD / R22 / 51 airworthiness directives, in NOV2005 and AD / R44 / 019, in JAN2004, respectively, instructing mandatory inspection in the Robinson R-22 and Robinson R-44 fleets in the country, referring to the yoke / shaft-clutch. They were later canceled after the fleet inspection.

The emission of AD / R22 / 51, below, is related to the fact that accidents involving R-22 aircraft were related to the evidence of fatigue found in the transmission axis fracture caused by the use of non-approved material and failure to assemble the set.

> That investigation has disclosed evidence of fatigue in a fractured main rotor clutch drive shaft. The failed shaft had been assembled with the yoke painted in the area of the yoke to shaft assembly bolts and a non-approved jointing compound was found in the area of the joint mating surfaces. A combination of the two discrepancies probably resulted in a loss of assembly torque and movement of the joint in service.

CASA had also issued an AWB 02-021 airworthiness certificate, entitled "Use of Sealants", on 15MAR2007, warning of improper use of unspecified products.

In at least one of the Australian occurrences, the non-removed outer painting of the yoke was also considered as a contributing factor for the loss of tension of the set fastening screws.

Table 1, below, summarizes in the foreign occurrences the evidences indicated in the reports of the authority of investigation of the accidents:

	Evidências encontradas	
Marcas / data	Uso do *primer-epoxi*, na área de contato *shaft-yoke*	Deficiente fixação do conjunto, por perda de torque na fixação parafusos/bloco
VH-HFP / 1992	Sem produto	Presente
VH-UXF/ 2003	Produto não conforme	Presente
VH-HXU / 2005	Produto conforme	Presente

Table 1 - Evidence found in occurrences in Australia.

The section 7.260 A907 Yoke Removal and Installation of the RHC R-22 Maintenance Manual, Change 22MAR2004, alerts only to the use of specified primers when installing the yoke, preventing the use of other lubricants (Figure 12).

CAUTION

Use only specified primers to install yoke; do not use any other lubricants.

It was possible to survey the hours operated by each set, since general review, in two of the Australian occurrences, namely:

- VH-HXU: 776:36 hours;

-VH-UXF: 886:12 hours.

The flying hours of this set at PT-HOL, since last overhaul, were 1,141: 54, with the Time Between Overhaul (TBO) of the set being 2,200 hours.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The student was normally fulfilling his instruction for training as a PCH, not being observed notes in the evaluation sheets that deviate from the expected levels of learning. In the same way, the instructor, who had been in the school for a short time, was considered an applied crewmember. The flight performance of the crew was therefore considered normal.

Both the instructor and the student knew their mission. They were returning to school in straight and leveled flight, flying over the city of São Paulo, when the problem happened.

With the information collected, it was not possible to highlight psychological aspects that could have contributed to the occurrence in question.

Regarding radar observation, it points to a change in flight parameters that is consistent with the control difficulty experienced by the PT-HOL pilots. The changes of the bow and speed, in the final instants of flight, denote the loss of control; being notorious that the mechanical failure occurred in the final minute of visualization in APP-SP.

The mechanical failure caused by the transmission shaft rupture was characterized, among other things, by nose twisting, increased engine speed and decreased rotor rotation. When it lost power, caused by the fracture of the transmission shaft, the rotation of the main rotor decreased. To reverse such a situation, the pilot, according to Emergency Procedures of the R-22, should lower the collective immediately and, in case of a cruise flight, bring the cyclic backward, in order to reduce the speed to 65kt.

If the pilot did not lower the collective immediately to recover the RPM from the rotor and maintain it between 97% (minimum) and 110% to perform the 65kt autorotation, the situation may have been irreversible, considering that the aircraft kept 500ft of altitude.

Pilots should have attempted to perform an autorotation, as prevised in the Robinson R22 Series, Section 3, Emergency Procedures, without, however, being able to keep rotor rotation (97% minimum), 65kt speed and the consequent ideal trajectory to reach a free area, near the warehouse.

Consequently, there was a collision against the rigid lateral structure of the roof, which caused the tail cone to rupture. The tail rotor had no rotational energy during the sectioning of the tail cone. The entrance of the aircraft, already without the tail boom, caused a crack in the roof, since the blades in the surface did not support the fuselage weight of the R-22.

The blades wrinkling (associated with longitudinal scratches), as well as integrity of the leading edges and fractures near the root were related as evidence of poor rotation of the main rotor.

The evidence found in the main rotor and tail rotor, as well as the damage suffered by the roof of the warehouse indicated that the rotors were with low speed and the aircraft with little displacement ahead, that is, reduced speed.

The fracture in the half-bolt threaded screw of the clutch mechanism, as well as the teeth and marks of intense friction in the pulleys were probably the result of the imbalance created in the rotating assembly. The warped orifices of the cooling fan and its bluish stains also showed the normal operation of the engine.

In this regard, the DCTA investigation report stated that:

> ... Internally the engine had evidence that it was operational and no discrepancies were found that could compromise or cause failure or malfunction.

To do so, all cylinders, pistons, valve control, crankshaft, internal gears and bearing brass were examined. Evidence of power development could also be observed in the engine-cooling fan. The fretting marks left by the fan when it came off the engine indicate that the engine was spinning.

> Fatigue started by corrosion in the transmission shaft-fixing hole to the yoke, by the gearbox's side. The crack progressed helically on the shaft and when it hit the region near the Yoke's end, the shaft broke. This has caused loss of power transmission to the gearbox (CTP).

The occurrence of corrosion was associated, according to the supplementary report, with failures to comply with the instructions contained in the "Robinson Maintenance Manual, Model R22", sec. 7,260, dated 22MAR2004 (Figure 6).

> Failure to comply with items 1, 4 and 5 of the maintenance manual installation instructions facilitated the occurrence of "fretting" and corrosion, which led to failure of the shaft due to fatigue.

The most likely hypothesis is that such failure would have been caused by the non-use of adequate product throughout the contact area (or even application of non-conforming input during general overhaul).

Failure to comply with the instructions prevised in Section 7.260 A907 Yoke Removal and Installation of RHC R-22 Maintenance Manual, Change MAR2004, with the placement of the screws and torque on the ink, facilitated the occurrence of fretting and corrosion, which led to fatigue failure.

The presence of fretting, combined with the lack of protection by primer-epoxy, allowed the generalized corrosion of the contact surfaces of the shaft and the coupling. This situation was enhanced in the region of the hole by the very rotation energy imposed by the shaft, along with the thousand hours flown in this condition, which caused the fracture to evolve helically.

Figure 7 shows the set still assembled, after the fracture, indicating that item 5 of the sealing procedure of the assembly was not performed with primer (white). Figure 8 shows the rear view of the set, indicating that there was also no sealing of the yoke-shaft with the primer.

Figure 9 shows the regions of attachment of the support blocks after removal, indicating that in the region of the interface of the axis with the blocks there was no removal of the ink from the shaft. The blocks were screwed on top of the paint and not on the recommended primer. Figure 10 shows that there was no application of the primer on the contact surfaces of the support blocks.

The initiation of the failure was facilitated by the occurrence of corrosion in the region of the fixation hole. A similar situation was found in at least two occurrences abroad, in different amounts of operating hours.

The application of specific primer, as prevised by the manufacturer, in this region, would have the reason of avoiding the presence of air or moisture, which favor oxidation. The hypothesis that some primer or ink has been applied, even if of unauthorized use, may have occurred.

It was also noticed, on the issue of communication between the Brazilian operator and a technical representative of the company, an information published unofficially (by e-mail), which dealt with a change in the planned publication. As well as the fact that two inconsistent technical data have been passed by the manufacturer, that is, the permission to use "any product", and the exactly prohibition of a product prevised in the manual.

The lack of trace of the product in the analysis of materials conducted in the DCTA did not necessarily denote a lack of product, since a small film on the material might have been degraded by corrosive and / or fretting processes. The spectroscopy carried out at INMETRO determined traces that could be the primer.

The findings of INMETRO disregarded that:

- inclusions may be expected in the raw material used, based on the manufacturing standard followed, and

- the DCTA report pointed to the corrosion initiated in the hole as a factor that led to helical evolution and catastrophic failure.

It is worth noting that the fracture mechanism in question, with the friction of the parts, is of internal character, and its determination / inspection is not possible until it reaches a critical level, when structural failure occurs.

The complementary report also presented the results regarding the verification of the level of inclusions, grain size and hardness of the fractured shaft material.

The results obtained in the evaluation of the raw material of the shaft, later performed in the DCTA, did not indicate that it influenced the fracture process:

> the results obtained in the evaluation of the material of the shaft did not indicate that it influenced the fracture process, despite the presence of some inclusions above the maximum size indicated by the standard.

Thus, aircraft maintenance services were considered periodic, but inadequate from the point of view of the PN A166-1 with the PN A907-4 yoke, both of the power transmission set of the power unit where the catastrophic failure occurred.

3. CONCLUSIONS.

3.1 Facts.

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

b) the pilots had valid CHT - Technical Qualifications;

c) the pilots were qualified and experienced in that kind of flight;

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

e) the aircraft was within the weight and balance parameters specified by the manufacturer;

f) the airframe, engine and rotors logbooks records were updated;

g) meteorological conditions were of clear sky and calm wind, favorable for the visual flight;

h) there was no evidence that physiological or disability considerations had affected the flight performance of the crew members;

i) the aircraft took off from the Campo de Marte Aerodrome to the training area at the margin of the Guarapiranga dam, for a stage of about 1 hour and 10 minutes of flight;

j) on the return to SBMT, with about 55 minutes of flight, the crew experienced power loss and difficulty in directional control, at an approximate altitude of 500ft AGL;

k) there was the collision of the helicopter against the roof of a warehouse, occurring the sectioning of the tail cone. The fuselage entered the warehouse, colliding against the ground;

l) no discrepancies were found that could compromise or cause engine failure or malfunction;

m) evidence was found that the engine developed power normally, there being no previous problem of carburation and / or fueling;

n) the power transmission shaft, Part Number A166-1, was broken by fatigue mechanism, started by corrosion in the transmission shaft fixing hole to the yoke, PN A907-4, by the gearbox's side;

o) aircraft maintenance services were considered to be periodic, but inadequate from the point of view of the PN A166-1 with the PN A907-4 yoke, both of the power unit set, where the catastrophic failure occurred;

p) failure to comply with items 1, 4 and 5 of the maintenance manual installation instructions facilitated the occurrence of fretting and corrosion, which led to failure of the shaft due to fatigue;

q) the aircraft was completely destroyed; and

r) the two occupants suffered fatal injuries.

3.2 Contributing factors.

- Handling of aircraft flight controls – undetermined.

Due to the deteriorated controllability condition at low altitude caused by a substantial loss of rotation of the main rotor, it is possible that the pilot did not have a command condition that would allow free ground near the warehouse in the degraded flight condition.

- Piloting judgment – undetermined.

An inadequate pilot assessment of the ideal landing site may have contributed to the catastrophic outcome of the accident.

- Maintenance – a contributor.

Maintenance services related to the coupling of the PN A166-1 shaft with the PN A907-4 yoke (both of the power unit assembly of the aircraft) were considered inadequate and contributed to the catastrophic outcome of the accident.

- Managerial oversight – a contributor.

The performance of the technical inspector was not enough to identify maintenance procedures in disagreement with the aircraft maintenance manual.

The communications of the operator with the manufacturer's technical representative, Robinson Helicopter Company, occurred in a way that conflicting data were processed with the technical publications.

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 prior to the publication of this report:

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

A-287/CENIPA/2012 - 01 **Issued on 15/12/2012**

Adopt control actions with Go Air (Master Esc de Pilotagem Hel Ltda), aiming at the immediate replacement of non-aeronautical products by those expected in the maintenance manuals. As well as their application, according to the parameters prevised by Robinson Helicopter Company and its manufacturers, such as temperature, curing time and others, in particular with regard to the primers prevised in item 1450 of the R-22 Maintenance Manual.

A-288/CENIPA/2012 - 02 **Issued on 15/08/2012**

Disclose to the other operators of R-22 and R-44 the importance of using the manufacturer-prevised primers for flight safety.

Recommendations issued at the publication of this report:

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

A-587/CENIPA/2016 - 01 **Issued on 17/05/2018**

Implement enforcement measures to ensure that the general overhaul shops on cells and large components of the R-22 and R-44 helicopters are properly employing the products specified by the manufacturers, particularly ink removal and application of primers used in junctions, notably between PN A166-1 and PN A907-4

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

- Between 12JUL2012 and 08AUG2012, the Investigation Committee carried out guidance on the control of technical directives and on the use of product specified in standards;

- A meeting was held with part of the school's crew, about emergency procedures and performance calculations;

- On 06AUG2012, a lecture was given by the Commission's psychologist at the company, presenting the methodology "Post-Traumatic Stress Disorder", applied to operations and maintenance personnel;

- On 09AUG2012, the operator was issued documents on the risks of the application of non-aeronautical product;

- On 14NOV2012, due to the verification, three months after issuance of RSV (A) 287/2012 of CENIPA, that the operator had not yet received ANAC's inspection, this need was reiterated by Fax No. R-22 / SA / 2906 - SERIPA IV; and

- On 05DEC2011, the operator was notified of a third-party aircraft found by the Commission in that hangar and in maintenance service regarding evidence of surface corrosion of the Transmission Shaft - PN A166-1 and Yoke PN A907 -4. At the same time, the operator was instructed to keep technical contact with the manufacturer in order to clarify any points of difficult interpretation of the maintenance manuals.

On May 17th, 2018.