COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 015/CENIPA/2018

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PP-HLI**
MODEL:	**R44 II**
DATE:	**23JAN2018**

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 23JAN2018 accident with the R44 II aircraft model, registration PP-HLI. The accident was classified as “[SCF-NP] System/Component Failure or Malfunction Non-Powerplant | Structural Failure”.

While performing an aero reporting flight for a television channel, the aircraft crashed on the sea, near to Pina Beach, in Recife, PE.

The aircraft was destroyed.

The pilot and passengers suffered fatal injuries.

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

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AC	Advisory Circular
AD	Airworthiness Directive
ANAC	Brazil's National Civil Aviation Agency
ANP	National Agency of Petroleum, Natural Gas and Biofuels
APP	Approach Control
APP-RF	Approach Control Recife
APRS	Return to Service Approver
CA	Airworthiness Certificate
CB	Cumulonimbus Cloud
CENIPA	Aeronautical Accident Investigation and Prevention Center
CIV	Pilot's Flight Logbook
CMA	Aeronautical Medical Certificate
CP-FAA	Commercial Pilot - Federal Aviation Administration
CPTEC	Weather Forecast and Climate Studies Center
CTA	Supply Tank Truck
CTTU	Recife Transit and Urban Transport Autarchy
DCTA	Department of Science and Airspace Technology
DIVOP	Operational Disclosure
EDS	X-ray Energy Dispersive Spectroscopy
EUA	United States of America
FAA	Federal Aviation Administration
FCDA	Airworthiness Directive Compliance Form
HMNC	Conventional Single Engine Helicopter Rating
IAM	Annual Maintenance Inspection
ICA	Aeronautics Command Instruction
IFRH	Instrument Flight Rating - Helicopter
IPEV	Research and Flight Testing Institute
IS	Supplementary Instruction
MCQ	Quality Control Manual
METAR	Aviation Routine Weather Report
MOM	Maintenance Organization Manual
MRB	Main Rotor Blade
NSCA	Aeronautics Command System Standard
NTSB	National Transportation Safety Board (USA)
OM	Maintenance Organization
PCH	Commercial Pilot License – Helicopter
PMD	Maximum Take-Off Weight

P/N	Part Number
POH	Pilot's Operating Handbook
PPH	Private Pilot License – Helicopter
RADAR	Radio Detection And Ranging
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
REDEMET	Aeronautics Command Meteorology Network
RHC	Robinson Helicopter Company
RPM	Rotations per Minute
RS	Safety Recommendation
RT	Technical Manager
SAE	Aircraft Registration Category of Specialized Air Service
SEM	Scanning Electron Microscope
SB	Service Bulletin
SBRF	ICAO Location Designator – Guararapes International Airport - Gilberto Freyre, Recife - PE
SERIPA II	Second Regional Aeronautical Accident Investigation and Prevention Service
SGSO	Safety Management System
SIPAER	Aeronautical Accident Investigation and Prevention System
SN	Serial Number
TCU	Towering Cumulus
TLV	Life Time Limit
TWR-RF	Recife Aerodrome Control Tower - PE
UTC	Universal Time Coordinated
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** R44 II **Registration:** PP-HLI **Manufacturer:** Robinson Helicopter	**Operator:** Helisae *Serv. Aéreo Especializado* Ltd.
Occurrence	**Date/time:** 23JAN2018 - 0902 UTC **Location:** Pina Beach **Lat.** 08º05'17"S **Long.** 034º52'42"W **Municipality – State:** Recife – PE	**Type(s):** [SCF-NP] System/Component Failure or Malfunction Non-Powerplant **Subtype(s):** Structural Failure

1.1 History of the flight.

The aircraft took off from the Guararapes - Gilberto Freyre International Aerodrome (SBRF), Recife - PE, for a local flight, at about 08h48min (UTC), in order to perform aerial images of the city's metropolitan area to a television channel, with a pilot and two passengers on board.

About fifteen minutes after takeoff, observers sighted the aircraft in a downward trajectory until crashing into the sea. The collision occurred near Pina beach, located Northeast of SBRF.

The aircraft was destroyed.

The pilot and both passengers suffered fatal injuries.

Figure 1 - Location of the aircraft impact into the sea.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	1	2	-
Serious	-	-	-
Minor	-	-	-
None	-	-	-

1.3 Damage to the aircraft.

The aircraft was destroyed.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours	Pilot
Total	2,041:20
Total in the last 30 days	32:05
Total in the last 24 hours	00:00
In this type of aircraft	1,263:00
In this type in the last 30 days	10:50
In this type in the last 24 hours	00:00

N.B.: The data related to the flown hours were obtained through the Pilot's Flight Logbook records.

1.5.2 Personnel training.

The pilot took the Pilot Private Rotorcraft course, equivalent to the Private Pilot License – Helicopter (PPH) in Brazil, at the American Red Cross in Washington – DC, USA, in 2006.

He took the Commercial Pilot License – Helicopter (PCH) and Instrument Flight Rating - Helicopter (IFRH) courses at Monarch Sky Flight School, in Las Vegas - NV, USA, in 2010.

1.5.3 Category of licenses and validity of certificates.

The pilot had the Commercial Pilot - Federal Aviation Administration (CP-FAA) License.

On 30MAY2011, the ANAC validated the American License as a PCH in Brazil.

The Conventional Single Engine Helicopter Rating (HMNC) Rating, which included the R44 II model, was valid.

1.5.4 Qualification and flight experience.

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

1.5.5 Validity of medical certificate.

The pilot had valid Aeronautical Medical Certificate (CMA).

1.6 Aircraft information.

The aircraft, serial number 10026, was manufactured by Robinson Helicopter Company (RHC), in 2003 and it was registered in the Aircraft Registration Category of Specialized Air Service (SAE).

The aircraft had valid Airworthiness Certificate (CA).

The engine logbook records were updated. The airframe logbook records were not following the legislation valid at the time of the accident.

The last inspection of the aircraft, an "Annual Maintenance Inspection (IAM)" type, was carried out on 17JAN2018 by the Fênix - Manutenção e Recuperação de Aeronaves Ltd. maintenance organization, in Recife, PE, with the aircraft having flown 05 hours and 30 minutes after the inspection.

The aircraft operated for approximately seven years in the US and was exported to Brazil on 15DEC2010, according to the FAA's Export Certificate of Airworthiness.

On 08FEB2011, the helicopter was acquired by the Helisae Company, as stated in the Full Content Certificate issued by the ANAC.

At the time of the acquisition by the Helisae, the aircraft had a total of 2,392 flown hours.

R44 II Aircraft General Characteristics

The R44 II model had a main rotor and a tail rotor, both two-bladed. The helicopter was single-engine, powered by Lycoming IO-540-AE145 piston engine, S/N L-28784-48A.

The primary fuselage structure was welded steel tubing and riveted aluminum sheet. The tailcone consisted of a monocoque structure covered with aluminum skins. Fiberglass and thermoplastic materials were used in the secondary cabin structure and in some other parts of the aircraft such as fairings, ducts and doors. The landing gear that supported the structure was the skid type.

Stainless steel firewalls were installed forward and above the engine.

According to the CA, the helicopter had the capacity to carry three people.

Main Rotor System

According to Section 7 - Systems Description of the POH, Revision 10MAR2015, of the R44 model, the main rotor system consisted of two all-metal blades mounted to the hub by coning hinges. The hub was mounted to the shaft by a teeter hinge. The system had droop stops that limited the teeter hinge movement of the blades.

Main Rotor Blades (MRB)

The PP-HLI blades, P/N C016-5, had S/N 6128 and S/N 6131.

The blades were manufactured by the same helicopter manufacturer.

The S/N 6128 blade was part of lot n° 619 and the S/N 6131 blade was part of lot n° 620. Both lots had their manufacturing process started on 29OCT2008 and concluded on 19JAN2009.

No fault records or problem reports were found in the documents related to the blade manufacturing process.

The blades were purchased as new parts by the first owner/operator of the aircraft, Sky Helicopters Inc., located in the state of Texas - USA, and were installed on 15JUL2009 by the operator itself. At the time of the installation of the blades, the aircraft had a total of 2,200 flight hours.

Before its acquisition by the Brazilian operator, the PP-HLI aircraft, which had the US registration N401TV, operated with the blades S/N 6128 and S/N 6131, from 15JUL2009 to 15DEC2010, having flown a total of 192 hours in this period.

There are no records of repair services performed on the S/N 6128 and S/N 6131 blades in the aircraft logbook, neither in the period that the helicopter operated with the blades in the US, nor after the import of the aircraft by the Brazilian operator.

The S/N 6128 and S/N 6131 blades, as well as all P/N C016-5 blades, had a Life Time Limit (TLV) of 2,200 hours or 12 years of operation, whichever occurred first.

At the time of the crash, the PP-HLI blades had 1,659 hours and 10 minutes of flight and were just over nine years since their date of manufacture. The components were within the operating limits set by the manufacturer.

Each P/N C016-5 blade consisted of a honeycomb aluminum core structure. A stainless steel spar was installed at the leading edge and extended from the root to the blade tip. The blade was finished at its end (tip) by an internal structure called tip cap or tip block. The tip of the blade was protected by the tip cover, which was fixed to the tip cap by two screws.

Finally, a layer of stainless steel coated the blade above and below (upper skin and lower skin). Each skin extended from the leading edge to the trailing edge; as well as from the root to the tip of the blade, as shown in Figure 2.

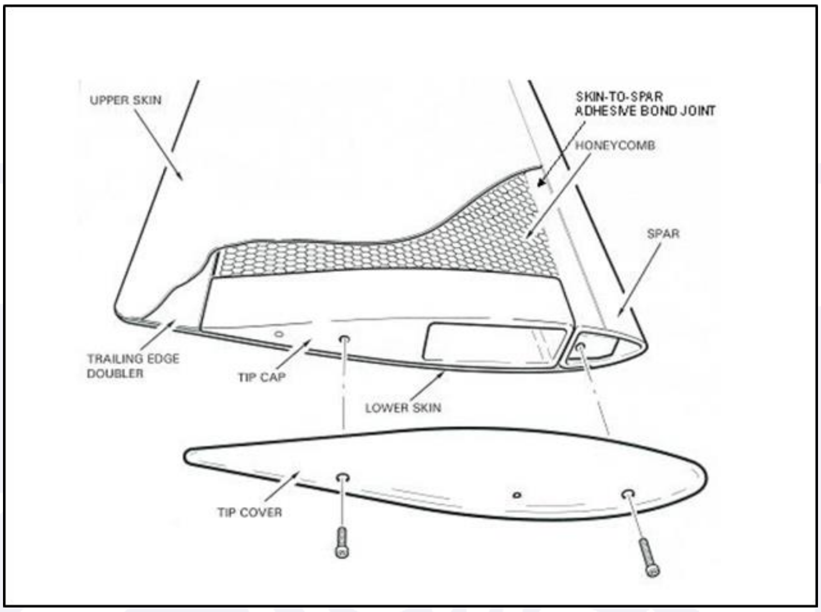

Figure 2 - R44 II main rotor blade composition.
(Source: www.robinsonheli.com).

The upper and lower skins were fixed to the upper and lower surfaces of the blade core by using adhesive material. At the leading edge of the blade, the upper and lower skins were bonded to the spar, approximately one inch aft of the leading edge, in a region called the skin-to-spar bond joint (adhesive joint for upper/lower skin/spar). In the tip of the blade region, the upper and lower skins were bonded to the tip cap. At the trailing edge of the blade, the upper and lower skins were bonded together just after the honeycomb core (Figure 3).

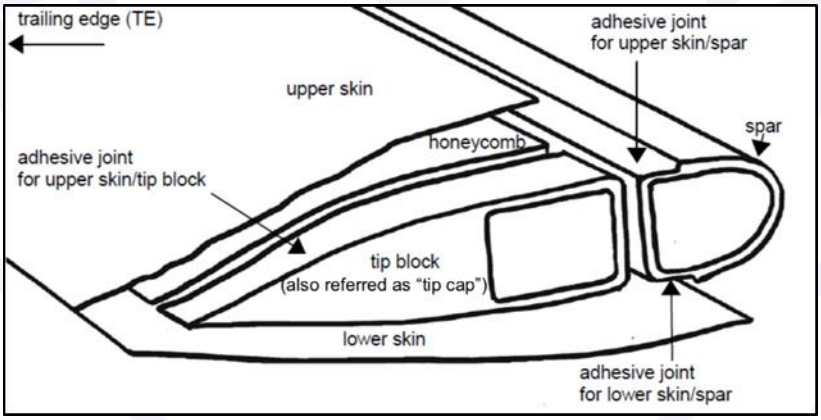

Figure 3 - Detail of skin-to-spar bond line and skin to tip cap regions.
(Source: NTSB).

The POH further specified that the spar was resistant to corrosion and erosion, emphasizing that the blades should be refinished in case of paint erosion and bare metal exposure in the skin-to-spar bond line region, bonding area near the leading edge of the blades. The manual also addressed that bond may be damaged if bond line is exposed.

The blades that equipped the R44 II models had a documentation history related to skin debonding.

This matter was first noted by the RHC on the publication of the Safety Alert of 04JAN2007, and of the Service Bulletin (SB) n° 61, 29MAR2007, which dealt with Main Rotor Blade Erosion.

On 30APR2010, the SB-72 was published, which dealt with Main Rotor Blade Bond Inspection. This bulletin was revised on 19JUL2012, when it was renamed SB-72A (Figure 4). The publication applied to the R44 helicopters equipped with blades P/N C016-2 and P/N C016-5 (model of blades that equipped the PP-HLI).

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R44 SERVICE BULLETIN SB-72A
(supersedes R44 SL-24 and R44 SB-72)

DATE: 30 April 2010 **REV A:** 19 July 2012

TO: R44 and R44 II owners, operators, and maintenance personnel

SUBJECT: Main Rotor Blade Bond Inspection

ROTORCRAFT AFFECTED: R44 helicopters with C016-2 main rotor blades, and R44 II helicopters with C016-5 main rotor blades.

TIME OF COMPLIANCE: Every four months, 100-hour inspection, or annual inspection, whichever occurs first.

BACKGROUND: Debonding of rotor blade skins can occur when the bond line is exposed due to erosion of the blade finish, or when corrosion occurs on the internal aluminum tip cap. Proper inspection and protection (refinishing) of bonded areas is required. Debonding resulting from improper inspection and maintenance could cause a catastrophic accident.

Figure 4 - SB-72A first page extract.
(Source: www.robinsonheli.com).

The SB-72A background warned about the possibility of skin debonding when bond line exposure occurred due to paint erosion or tip cap corrosion. It also stressed that the debonding could result in a catastrophic accident.

The text highlighted by the red rectangle in Figure 5, taken from the SB-72A, illustrated examples of blade failures that, if found, would mean that the blade was unairworthy, requiring component replacement.

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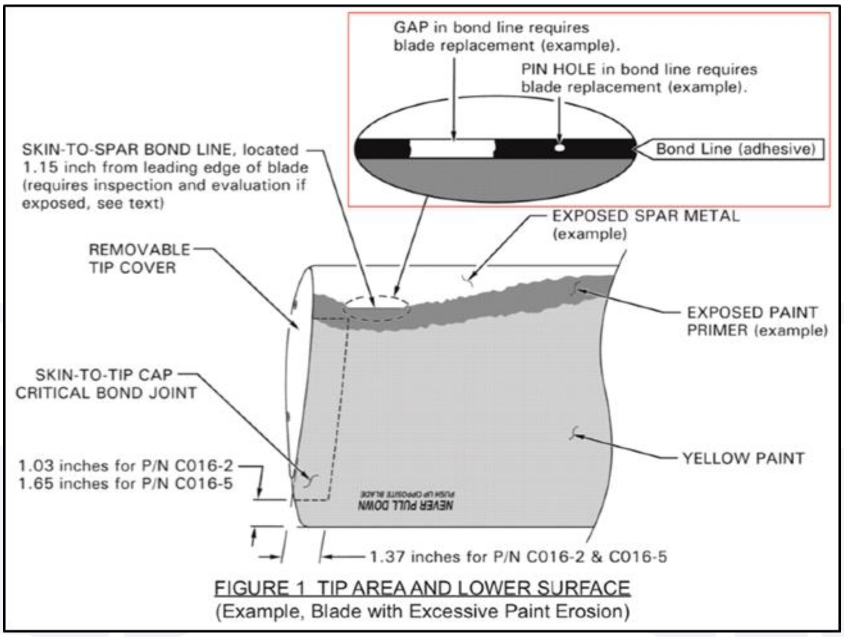


Figure 5 - Examples of failures in critical areas that would make a blade unairworthy. (Source: www.robinsonheli.com).

In the same way, from 2007 on, the FAA, the project's primary certification authority, has expressed its views on the topic through the publication of three Airworthiness Directives (AD).

The first AD 2007-26-12 was issued on 17DEC2007 and was replaced by AD 2011-12-10 on 02JUN2011 and subsequently by AD 2014-23-16 on 09JAN2015. All publications dealt with the prevention of main rotor blade failures and subsequent loss of control of the aircraft due to skin debonding.

The AD 2014-23-16 (Figure 6) applied, among others, to R44 II helicopters equipped with P/N C016-5 blades. Paragraph (b) Unsafe Condition made it clear that the FAA considered debonding of the main rotor blades to be an unsafe condition that could lead to component failure and, consequently, loss of control of the helicopter.

FAA Aviation Safety

AIRWORTHINESS DIRECTIVE

www.faa.gov/aircraft/safety/alerts/
www.gpoaccess.gov/fr/advanced.html

2014-23-16 Robinson Helicopter Company: Amendment 39-18032; Docket No. FAA-2013-0159; Directorate Identifier 2012-SW-010-AD.

(a) Applicability

This AD applies to Model R22, R22 Alpha, R22 Beta, and R22 Mariner helicopters with main rotor blade (blade), part number (P/N) A016-2 or A016-4; and Model R44 and R44 II helicopters with blade, P/N C016-2 or C-016-5, certificated in any category.

(b) Unsafe Condition

This AD defines the unsafe condition as blade skin debonding, which could result in blade failure and subsequent loss of control of the helicopter.

(c) Affected ADs

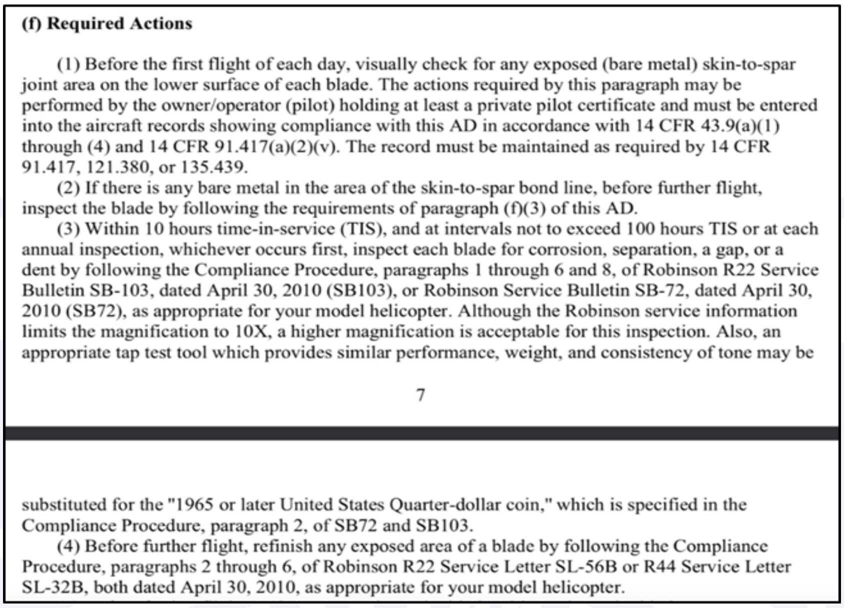
This AD supersedes AD 2011-12-10, Amendment 39-16717 (76 FR 35330, June 17, 2011); corrected March 5, 2012 (77 FR 12991).

(d) Effective Date

This AD becomes effective January 9, 2015.

Figure 6 - Extract from page 7 of the AD 2014-23-16. (Source: www.faa.gov).

Paragraph (f) of the AD 2014-23-16 described the actions required to comply with the Airworthiness Directive (Figure 7).



(f) Required Actions

(1) Before the first flight of each day, visually check for any exposed (bare metal) skin-to-spar joint area on the lower surface of each blade. The actions required by this paragraph may be performed by the owner/operator (pilot) holding at least a private pilot certificate and must be entered into the aircraft records showing compliance with this AD in accordance with 14 CFR 43.9(a)(1) through (4) and 14 CFR 91.417(a)(2)(v). The record must be maintained as required by 14 CFR 91.417, 121.380, or 135.439.

(2) If there is any bare metal in the area of the skin-to-spar bond line, before further flight, inspect the blade by following the requirements of paragraph (f)(3) of this AD.

(3) Within 10 hours time-in-service (TIS), and at intervals not to exceed 100 hours TIS or at each annual inspection, whichever occurs first, inspect each blade for corrosion, separation, a gap, or a dent by following the Compliance Procedure, paragraphs 1 through 6 and 8, of Robinson R22 Service Bulletin SB-103, dated April 30, 2010 (SB103), or Robinson Service Bulletin SB-72, dated April 30, 2010 (SB72), as appropriate for your model helicopter. Although the Robinson service information limits the magnification to 10X, a higher magnification is acceptable for this inspection. Also, an appropriate tap test tool which provides similar performance, weight, and consistency of tone may be

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substituted for the "1965 or later United States Quarter-dollar coin," which is specified in the Compliance Procedure, paragraph 2, of SB72 and SB103.

(4) Before further flight, refinish any exposed area of a blade by following the Compliance Procedure, paragraphs 2 through 6, of Robinson R22 Service Letter SL-56B or R44 Service Letter SL-32B, both dated April 30, 2010, as appropriate for your model helicopter.

Figure 7 - Extract from paragraph (f) of the AD 2014-23-16.
(Source: www.faa.gov).

Item (1) of paragraph (f) stated that the blades should be visually checked for bare metal prior to the first flight of each day. The owner/operator or the pilot should perform this visual inspection. Compliance with this action should be recorded in the aircraft records.

Item (2) of the same paragraph stated that if bare metal was found during the visual inspections referred to in item (1), the blades should be inspected in accordance with the procedures described in item (3), before the next flight.

Item (3) of paragraph (f) set out procedures that should be performed every 100 flight hours or each annual inspection, whichever comes first. This same item mentioned that the inspection should be carried out in accordance with the Compliance Procedures set out in paragraphs (1) to (6) and (8) of the SB-72A bulletin, of 19JUL2012 (Figure 8).

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1. Refer to Figures 1 and 2. Remove both main rotor blade tip covers and clean the blades. Clean and remove any corrosion from tip covers.

2. Using 10x magnification, visually inspect uncovered skin-to-tip cap bond joints. Using a 1965-or-later United States quarter-dollar coin, tap test skin-to-tip cap bond joints on both upper and lower surfaces. If corrosion, separation, or voids are detected, blade is unairworthy. A tap test tutorial video is available on our website, www.robinsonheli.com, under the Publications tab.

3. Using 10x magnification, visually inspect any exposed skin-to-spar bond line for gaps (empty space between skin and spar). Blade is unairworthy if any gap, including “pin hole(s)”, is detected in the bond line.

4. Refer to Figure 2. Mark outboard 135 inches of blade lower surface as shown to identify skin-to-spar bond joint area.

(OVER)

R44 SB-72A
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5. Verify no visible dents within the bond joint area. Blade is unairworthy if bond joint area is dented.

6. Tap test the lower skin-to-spar bond joint and verify no voids exist. Blade is unairworthy if a void is detected.

7. Refinish all exposed bare metal, including tip covers, per R44 SL-32B.

8. Install blade tip covers, ensuring cover edges are flush with blade profile.

9. Make appropriate maintenance record entries.

Figure 8 - Extract from paragraphs (1) to (9) of the SB-72A.
(Source: www.robinsonheli.com).

The SB-72A paragraph (2) mentioned a procedure called the tap test. According to the Advisory Circular 43.13-1B, Acceptable Methods, Techniques, and Practices Aircraft Inspection and Repair, published by the FAA on 08SEPT1998, the tap test consisted of a type of nondestructive test.

The test was still widely used for quick evaluation of aircraft surfaces for the presence of debonding and delamination.

The test consisted of tapping the surface to be checked and comparing the acoustic response of the tested site to the response obtained in a known good area. A flat or dead response were considered unacceptable by the test.

According to the AC 43.13-1B, the test depended on the inspector's subjective interpretation of the results (Figure 9).

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9/8/98 AC 43.13-1B

SECTION 8. TAP TESTING

5-105. GENERAL. Tap testing is widely used for a quick evaluation of any accessible aircraft surface to detect the presence of delamination or debonding.

a. The tap testing procedure consists of lightly tapping the surface of the part with a coin, light special hammer with a maximum of 2 ounces (see figure 5-22), or any other suitable object. The acoustic response is compared with that of a known good area.

b. A "flat" or "dead" response is considered unacceptable. The acoustic response of a good part can vary dramatically with changes in geometry, in which case a standard of some sort is required. The entire area of interest must be tapped. The surface should be dry and free of oil, grease, and dirt. Tap testing is limited to finding relatively shallow defects in skins with a thickness less than .080 inch. In a honeycomb structure, for example, the far side bondline cannot be evaluated, requiring two-side access for a complete inspection. This method is portable, but no records are produced. The accuracy of this test depends on the inspector's subjective interpretation of the test response; therefore, only qualified personnel should perform this test.

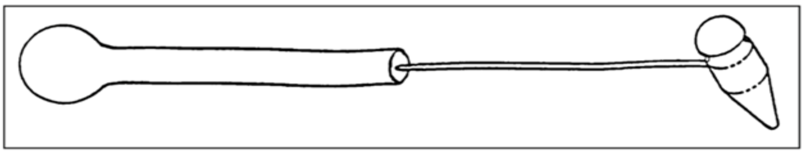

FIGURE 5-22. Sample of special tap hammer.

Figure 9 - Description of tap testing in the AC 43.13-1B, published by the FAA. (Source: www.faa.gov).

In accordance with paragraphs (ii) and (iii) from item (6) of paragraph (f) of the AD 2014-23-16, the blades of R44 (P/N C016-2 and P/N C016-5) should be replaced by new blade, models P/N C016-7, within five years from the date of publication of the AD.

Also in accordance with paragraph (iv) of the referred document, the replacement of blades was considered a terminating action to comply with the AD 2014-23-16 (Figure 10).

(6) Within 5 years of the effective date of this AD:

(i) For Model R22 series helicopters, replace blade P/N A016-2 or A016-4 with a blade, P/N A016-6.

(ii) For Model R44 series helicopters fitted with hydraulically boosted main rotor flight controls, replace blade P/N C016-2 or C016-5 with a blade, P/N C016-7.

(iii) For Model R44 series helicopters without hydraulically boosted main rotor flight controls, replace blade P/N C016-2 or C016-5 with a blade, P/N C016-7. Prior to installing a blade P/N C016-7, verify the helicopter has been modified as required by Robinson R44 Service Letter SL-37, dated June 18, 2010, Compliance Procedures, paragraphs 1. through 10.

(iv) Installing blades, P/N A016-6 or P/N C016-7, is terminating action for the inspection requirements of paragraphs (f)(1) through (f)(4) of this AD.

Figure 10 - Extract from item (6), paragraph (f) of the AD 2014-23-16. (Source: www.faa.gov).

At the date of the accident, there was no Airworthiness Directive (AD) issued by the ANAC, related to the debonding issues on the R44 blades.

However, in cases where the Civil Aviation Authority of the project State issued an AD, the ANAC regulations were issued in such a way as to fully accept the document, as shown in the excerpts of the RBAC 39, Section 39.5 and Supplementary Instruction (IS) 39-001 Rev A, in force at the time of the accident.

RBAC 39 of 02MAR2011, in its Section 39.5-I, stated that:

> **39.5-I Airworthiness Directive issued by Foreign Civil Aviation Authority**
>
> For the purposes of this regulation, the ANAC considers the Airworthiness Directive, or equivalent document, issued by the Design State Civil Aviation Authority, as an Airworthiness Directive issued by the ANAC itself. If the ANAC issues an Airworthiness Directive that conflicts with a Foreign Airworthiness Directive, the requirements of the Airworthiness Directive issued by the ANAC shall prevail.

The IS 39-001 Rev A, of 17AUG2012 provided that:

> 5. MATTER DEVELOPMENT
>
> 5.2 Foreign Airworthiness Directive

The RBAC 39 establishes that the Airworthiness Directive issued by the product Design State Civil Aviation Authority are considered to be Brazilian Airworthiness Directives and, therefore, are mandatory for all aeronautical products.

5.11 Compliance with a Service Bulletin

5.11.2 If a Service Bulletin has been incorporated by reference into a AD, the action contained therein becomes a mandatory compliance requirement, regardless of any rating provided by the manufacturer for that bulletin (mandatory, recommended, highly recommended, etc). However, no bulletin guidance prevails, contrary to the requirement of the AD. For example, if an AD requires a penetrating liquid inspection every 1,500 flight hours of an aircraft, where the description for the inspection is, by reference, in a Service Bulletin establishing such an inspection every 3,000 flight hours of the aircraft, the inspection shall then be performed every 1,500 flight hours.

In the specific case of the accident in question, the execution of the procedures of the AD 2014-23-16 was mandatory and its content incorporated SB-72A, also making it mandatory. The R44 II ADs were available on the FAA website and the aircraft manufacturer website.

The airframe logbook of the aircraft had records regarding compliance with IAM, AD and SB. By analyzing these records, it was possible to establish a timeline of maintenance activities performed after the date the aircraft received Brazilian nationality marks (24MAR2011), with the installed blades S/N 6128 and S/N 6131 (Figure 11).

PP-HLI MAINTENANCE RECORDS					
DATE	**AIRCRAFT TOTAL FLIGHT HOURS**	**INSPECTION TYPE**	**PRIMARY RECORD**	**SECONDARY RECORD**	**RESPONSIBLE MAINTENANCE ORGANIZATION**
04JUN2011	2.511,1h	100h	AD 2007-26-12	No records	Helibase
16JAN2012	2.622,5h	100h	AD 2011-12-10	AD 2011-12-10	
12MAR2012	2.658,3h	IAM / Appendix D of RBAC 43	AD 2011-12-10	AD 2011-12-10	
14JAN2013	2.824,7h	100h	AD 2011-12-10	AD 2011-12-10	
14ABR2013	2.902,7	IAM / Appendix D of RBAC 43	AD 2011-12-10	AD 2011-12-10	
21AGO2013	3.028,4h	100h/12M	AD 2011-12-10	AD 2011-12-10	
23JAN2014	3.1296h	100h/12M	AD 2011-12-10	AD 2011-12-10	
18MAR2014	3.145,2h	IAM	AD 2011-12-10	AD 2011-12-10	
15AGO2014	3.206,5h	100h/12M	No records	AD 2011-12-10	
07FEV2015	3.310,8h	100h/12M	No records	AD 2014-23-16	
27MAR2015	3.335,5h	IAM	No records	No records	Fênix
02SET2015	3.398,5h	100h/12M	No records	AD 2014-23-16	
24MAR2016	3.491,4h	IAM	No records	No records	
04MAIO2016	3.503,5h	100h/12M 300h/36M	No records	No records	
29DEZ2016	3.575,8h	100h	No records	AD 2014-23-16	Fênix
16JAN2017	3.612h	IAM	No records	No records	
30JUN2017	3.710,7h	100h/12M	No records	AD 2014-23-16	
11NOV2017	3.804,1h	100h/12M	No records	AD 2014-23-16	
17JAN2018	3.853,7h	IAM / Appendix D of RBAC 43	No records	AD 2014-23-16	

Figure 11 - Inspection Registration Table performed on the aircraft PP-HLI.

Figure 11 shows the maintenance activities to which the aircraft was submitted and which had or should have records of compliance with the AD and/or SB related to the main rotor blades.

At the 100-hour inspection held on 04JUN2011, there was no secondary record of compliance with the AD 2007-26-12.

In three occasions in which the IAM was held (27MAR2015, 24MAR2016 and 16JAN2017), there were no primary and secondary records of compliance with the AD 2014-23-16 nor the SB-72A.

On one occasion, during the 100-hour inspection conducted on 04MAY2016, there were also no primary and secondary records of compliance with the AD 2014-23-16.

During the inspections carried out on 15AUG2014, 07FEB2015, 02SEPT2015, 29DEC2016, 30JUN2017, only secondary records of compliance with the AD 2011-12-10 and AD 2014-23-16 were found.

The AD execution records found on the PP-HLI aircraft logbook did not clearly show the compliance method used, as required by IS 5.003C, 17AUG2012, item 5.14, current at the time of the accident:

> 5.14 Primary Registration
>
> 5.14.1 A primary compliance record should be complete and clear, containing the compliance method used and the outcome of the action taken. For example, an AD typically requires periodic inspections, which may be a visual inspection or non-destructive testing, until a final action is incorporated, which may be described by reference in a Service Bulletin. An AD may also require a review of operating procedures of the aircraft Flight Manual. Thus, the registry should clearly present the compliance method used.

During the inspections, carried out on 11NOV2017 and 17JAN2018, the Airworthiness Directive Compliance Form (FCDA) were presented as records of compliance with AD 2014-23-16. The FCDA contained the following book wording: “Performed visual inspection”. There were no releases that evidenced tap testing on these inspections.

The FCDA is an acceptable primary record format related to the applicability analysis and compliance with an Airworthiness Directive if applicable to the aeronautical product used by the owner/operator as defined in IS 39-001A.

The FCDA had a field regarding the approval of the blades for return to service. This field should be signed by the OM Technical Manager who performed the inspection. In the FCDA regarding compliance with AD 2014-23-16, held during the IAM concluded on 17JAN2018, where it should appear the RT signature, there was the inspector’s.

1.7 Meteorological information.

The satellite images of 08h00min (UTC), the time before the accident, and 09h00min (UTC), approximate time of the event, identified areas with sharp brightness in the region between the states of Pernambuco and Alagoas. These images showed that there were Cumulonimbus (CB) clouds in that area of the Northeast coast.

In the Recife Aerodrome area and its surroundings, it was noted that there were no CB-type clouds. The SBRF area is identified by the red circles in the pictures of Figure 12.

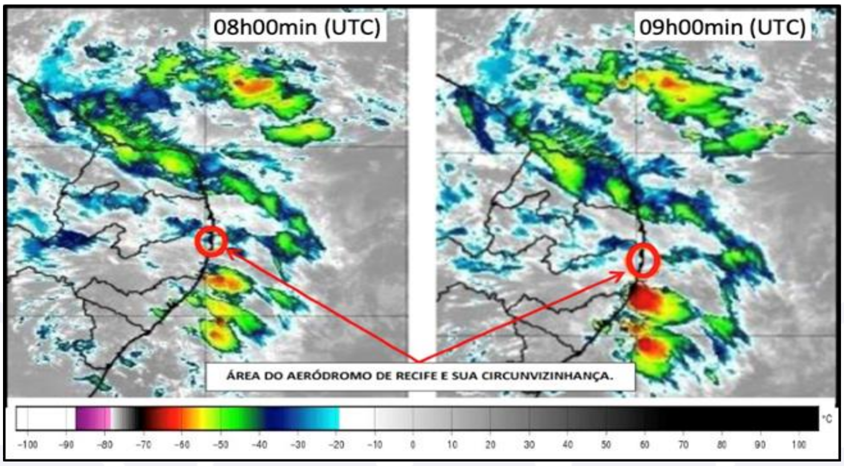

Figure 12 - Satellite images of 0800 (UTC) and 0900 (UTC).
(Source: CPTEC / INPE).

Observing the sequential behavior of the meteorological formations recorded in the images from 08h00min (UTC) and 09h00min (UTC), it was noticed that the area of greatest instability, with the presence of CB, presented predominant movement to the South, away from the neighborhood of the Recife Aerodrome and the accident area.

The meteorological radar of Maceió - AL, recorded images with zero, very slight or light precipitation potential in the Recife Aerodrome region and its surroundings (Figure 13).

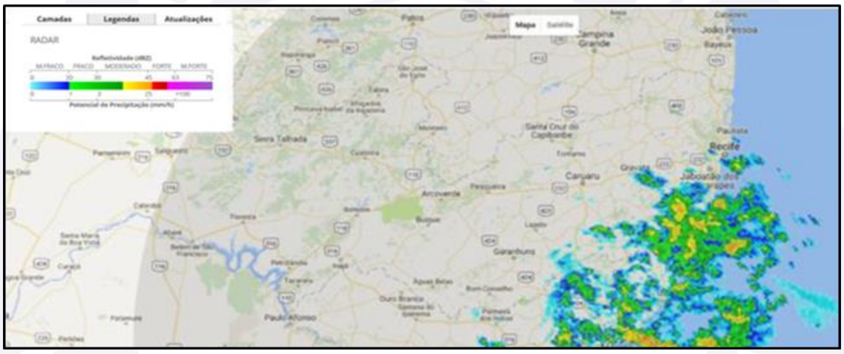

Figure 13 - Weather radar image of Maceió - AL, at 0905 (UTC).
(Source: REDEMET).

Images from the STARNET System, obtained from the STORM-T laboratory of the University of São Paulo, showed that there was no significant occurrence of lightning at Recife Aerodrome and around its surroundings during the whole day of 23JAN2018 (Figure 14).

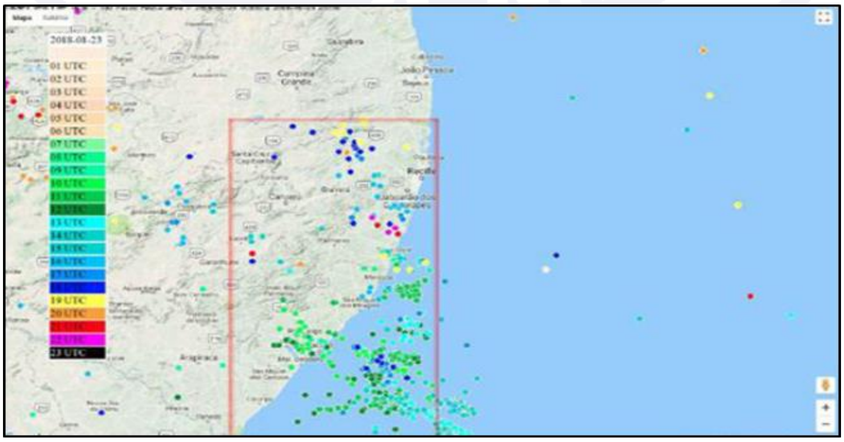

Figure 14 - Lightning map of 23JAN2018.
(Source: STARNET).

The METAR of 08h00min (UTC) and 09h00min (UTC), to the Guararapes - Gilberto Freyre Aerodrome (SBRF), provided the following information:

> METAR SBRF 230800Z 22005KT 9999 SCT040 24/23 Q1010=
>
> METAR SBRF 230900Z 31005KT 9999 VCSH SCT015 FEW020TCU BKN040 24/23 Q1010=

No severe weather phenomena were found near SBRF on the date of the accident.

All weather forecasting and surveillance information needed for flight planning was available to the pilot.

The Aeronautics Command Instruction (ICA) 100-4, which dealt with Special Air Traffic Rules and Procedures for Helicopters, in force at the time of the accident, stated that:

> **3.1.1** Within controlled airspace, the helicopter flight VFR shall be performed only when, simultaneously and continuously, the following conditions can be met:
>
> (a) maintain flight visibility conditions of 3000m or more;
>
> (b) remain at least 1500m horizontally and 500 ft. vertically from clouds or any other meteorological formation of equivalent opacity; and
>
> c) maintain ground or water reference, so that weather formations below the flight level do not obstruct more than half of the pilot's area of vision.

1.8 Aids to navigation.

Nil.

1.9 Communications.

According to the transcripts of the communication audios between the PP-HLI and the Air Traffic Control, it was found that the pilot maintained radio contact with the Recife Control Tower (TWR-RF) and the Recife Approach Control (APP-RF).

In order to support the analysis of the sequence of events leading up to the accident, some parts from the communications between the aircraft and the control services were highlighted.

At 08:47:39 (UTC), the TWR-RF asked if the PP-HLI was able to take off from Taxiway “M”, with a Northern head. Immediately, the PP-HLI requested wind conditions.

At 08:47:46 (UTC), the TWR-RF reported that the wind was coming from the 350° direction with an intensity of 06kt. Subsequently, the PP-HLI lined up and took off at the Northern head.

At 08:48:29 (UTC), the TWR-RF reported that the PP-HLI had taken off at 0848 (UTC) and that the aircraft should call the APP-RF.

At 08:48:37 (UTC), the PP-HLI informed the APP-RF that it intended to remain in the SBRF's “E” sector, over the Boa Viagem beach and kept listening to that control service. The message was confirmed by the APP-RF.

At 08:50:32 (UTC), the PP-HLI made contact with the APP-RF, informing of its intention to remain in the upright of the Recife city center. Five seconds later, the APP-RF reported that it was aware of the PP-HLI intent and requested that the aircraft remain clear of the final approach axis of the SBRF.

At 08:50:43 (UTC), the PP-HLI answered the APP-RF message, adding that it would keep listening to that control service.

At 09:10:55 (UTC), the APP-RF initiated several calls through the PP-HLI, with no response.

There was no record of any technical abnormality in the operation of communication equipment during the flight.

No emergency-related communications reported between the PP-HLI and the Air Traffic Control.

1.10 Aerodrome information.

The occurrence took place outside of the Aerodrome.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

Most of the wreckage remained concentrated in the region of Pina Beach, where the main cabin was found. The tailcone was fractured and the tail rotor assembly was found separated from the rest of the aircraft structure.

Figure 15 - Aircraft tail rotor assembly.

The aircraft crash was seen by observers, who claimed to have seen parts of the structure separating in flight.

Security cameras recorded the aircraft on a vertical trajectory with a high rate of descent.

Figure 16 shows two moments of the recording where it was possible to observe parts of the helicopter separating in flight.

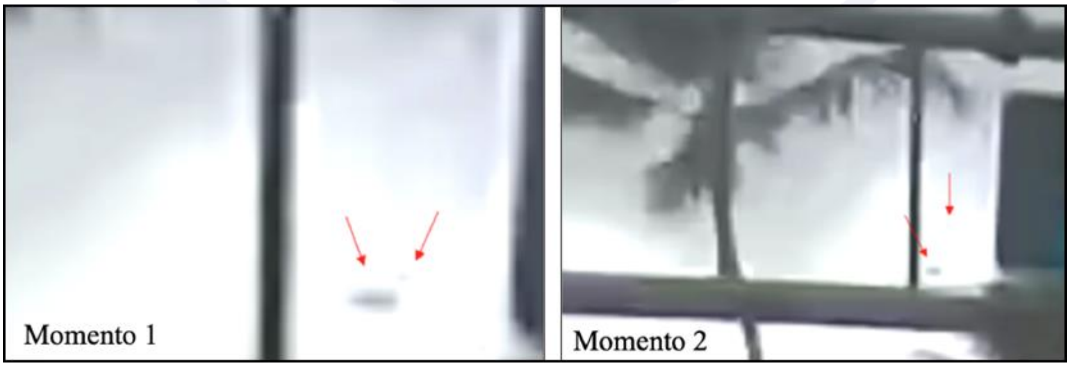

Figure 16 - Separation of helicopter parts in flight.
(Source: CTTU).

The S/N 6128 blade was found with its root still attached to the main rotor mast. This blade showed substantial damage to its structure, especially in the region farthest from the mast (Figure 17).

The S/N 6131 blade was found whole, relatively well maintained and still connected to the main rotor mast. This blade had slight upward curvature (warping) in its structure (Figure 17).

Figure 17 - Aircraft main rotor blades.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

The pilot had performed his last health inspection for CMA renewal on 13JAN2018. According to the CMA, the pilot was able to fly.

According to reports, the pilot had rested the night before the accident and had no complaints of fatigue or stress.

No evidence was found that problems of physiological nature or incapacitation could have affected the pilot´s performance.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The pilot had approximately seven years of career. According to the reports obtained, he sought to remain operationally updated and was a dedicated professional in his activities. Maintained a good interpersonal relationship in the workplace and showed cooperative attitudes with the team.

According to information provided by coworkers, the pilot was characterized by a high degree of professionalism and a high sense of responsibility.

He had worked for the aircraft owner company since November 2012 and was considered a disciplined and operationally compliant professional.

1.14 Fire.

There was no evidence of fire in-flight, nor after the impact.

1.15 Survival aspects.

The occupants of the helicopter were rescued from the sea by civilians.

The pilot and the passenger died at the crash site.

The third occupant was rescued through the Mobile Emergency Care Service and sent to the city's emergency hospital, dying nine days after the occurrence.

1.16 Tests and research.

On 15 and 16FEB2018, the wreckage of the aircraft was analyzed by investigators from the SIPAER, accompanied by technicians from the Department of Science and Airspace Technology (DCTA) and representatives of the RHC, the aircraft manufacturer (Figure 18).

Figure 18 - Layout of the aircraft wreckage.

EXAMINATION OF THE AIRCRAFT STRUCTURE

Examinations performed on the fuselage structure showed that all fractures found had an angle of approximately 45º, as well as bends and dents in the steel tubes covered by riveted aluminum sheets. These characteristics were consistent with overload fractures as a result of the impact of the aircraft into the sea (Figure 19).

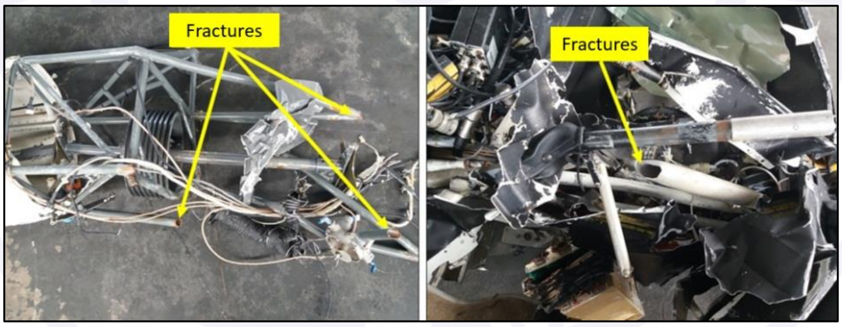

Figure 19 - Bended and fractured steel tubes.

Examinations performed on flight controls, found that there was no continuity failure in the tubes and bell-cranks part of main and tail rotors actuation controls systems. The fractures found in the flight control system components were overloaded as a result of the impact of the aircraft into the sea.

The tailcone of the helicopter had some bents, evidencing impacts of the main rotor blades against its structure. The appearance of the component as well as the characteristics of the damage found was consistent with the impact of the main rotor blades against the tail cone (Figure 20).

Figure 20 - Tailcone bents, due to impact of the main rotor blade.

The damage found in the two tail rotor blades had characteristics consistent with overload, due to the impact of the aircraft into the sea (Figure 21).

Figure 21 - Damage to the tail rotor blades highlighted by red arrows.

The examinations concluded that there were no signs of firearm projectile impact on the aircraft structure.

The examinations concluded that there was no evidence of fauna collision on the aircraft structure.

<u>FUEL EXAMINATION</u>

Tests performed on fuel samples collected from the Supply Tank Truck (CTA), which fueled the aircraft before the flight, concluded that the fuel was in accordance with specifications established by the National Agency of Petroleum, Natural Gas and Biofuels (ANP) and international agencies.

Fuel samples could not be collected from the aircraft tanks, due to leakage caused by the impact damage.

ENGINE EXAMINATION

The engine had no severe damage or malfunctions resulting from the collision of the aircraft into the sea. However, there was a significant amount of sand and seawater inside the engine and its accessories, as well as severe oxidation and corrosion due to the period the component was submerged in saline water (Figure 22).

Figure 22 - Aircraft engine overview.

All engine connecting rods were moved before disassembly and no binding or signs of lack of lubrication were observed.

Porcelain staining was observed on some engine spark plugs, consistent with the normal component operation.

It was not possible to perform functional tests on the magnetos; condenser; bearings; and the other components of the ignition and fuel supply systems, because of the large amount of sand, corrosion and oxidation found in these components due to immersion on seawater.

Bearing housings and connecting rods; the piston rod pins on the pistons; the crankshaft, and the camshaft showed normal movement and lube oil residue.

The cylinders and pistons showed no signs of detonation, poor mixing operation or lack of lubrication.

Carbonization was observed in the cylinders' valve guide. However, there were no scratches on valve rods, due to carbonization accumulation.

Comparative carbonization measurements were performed and it was found that the amount found was not sufficient to cause the valves to jam during engine operation.

Engine analysis concluded that the component had a normal operating performance at the time of the accident.

MAIN GEAR BOX (MGB) AND MAIN ROTOR MAST EXAMINATION

The MGB disassembly required specific tools, available only at the manufacturer's premises. For this reason, the exams were conducted at the RHC headquarters in Torrance, CA - USA. All procedures and examinations were followed by members of the SIPAER Investigation Team (Figure 23).

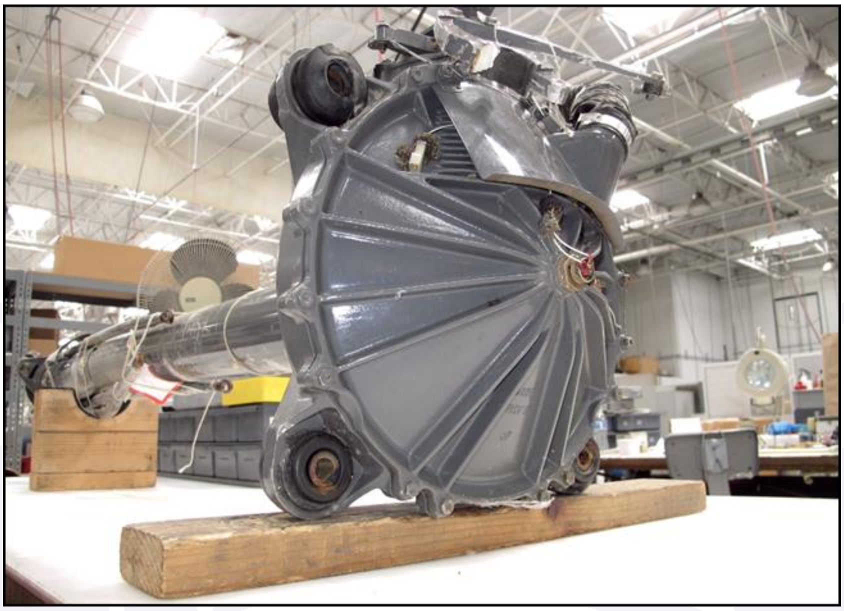

Figure 23 - General appearance of the MGB before disassembly.

Prior to the disassembly, it was found that the MGB turned by hand with no sign of binding or jamming.

The mast tube had damage to the outer structure (Figure 24).

Figure 24 - Damage to external mast fairing.

No ruptures were detected inside the mast tube.

There was a significant amount of lubricating oil inside the MGB. The oil coloration was compatible with normal system operation, with no signs of overheating or lack of lubrication.

There were no traces of metal chips on the MGB chip detector.

The MGB hydraulic pump had good internal condition and oil inside. The pump bearings rotated freely.

The MGB's internal bearings showed signs of corrosion, due to immersion in saline water.

The internal bearings of the gearboxes were spinning.

No significant damage to the MGB gears was found, although signs of corrosion were observed due to the immersion in saline water and the presence of sand inside the MGB.

The MGB exams found that the component had signs compatible with normal operation. No characteristics related to overheating, lack of lubrication, presence of metal chips, malfunctions or system jamming were found during the MGB examinations.

GOVERNOR CONTROLLER EXAMINATION (MAIN ROTOR RPM GOVERNOR)

The RPM Governor was bench-tested by the manufacturer's existing functionality standards (RHC).

All procedures and examinations were followed by members of the SIPAER Investigation Team.

The test performed on the crashed aircraft governor was the same as that performed during the general overhauls of this type of component.

The equipment was tested in nineteen parameters, was approved in sixteen and presented deviation in three.

The discrepancies found were not relevant, regarding the engine performance in controlling the aircraft Main Rotor RPM.

The tests concluded that the Governor Controller was functional at the time of the accident.

MAIN ROTOR BLADES EXAMINATION

The main rotor blades were P/N C016-5 and had S/N 6128 and S/N 6131. For maintenance control purposes, the blades were identified by a color code. The red color was assigned to the S/N 6128 blade and the blue color was assigned to the S/N 6131 blade (Figure 25).

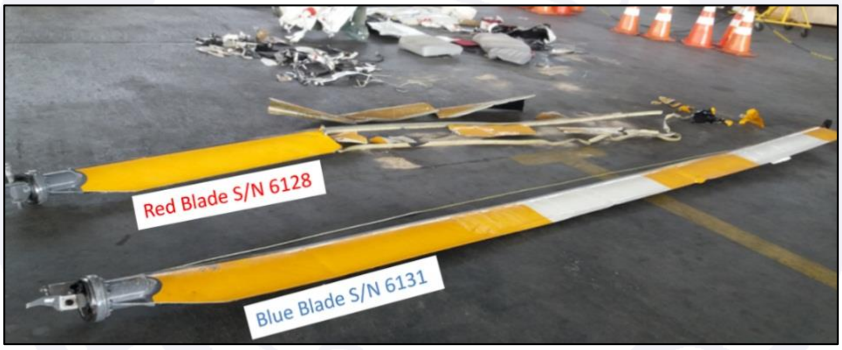

Figure 25 - General aspect of the main rotor blades.

The red blade (S/N 6128) has been found with substantial damage from the middle section to the tip region. Some parts of the middle section were not recovered. The tip of this blade was found sectioned and separated from the rest of the structure. Red blade fragments were sent for laboratory examination at the NTSB facility in Washington, DC - USA (Figure 26).

The blue blade (S/N 6131) was found with some bents along with its structure. The tip of this blade was manually sectioned by the Investigation Team and sent for laboratory examination at the NTSB facility in Washington, DC - USA (Figure 26).

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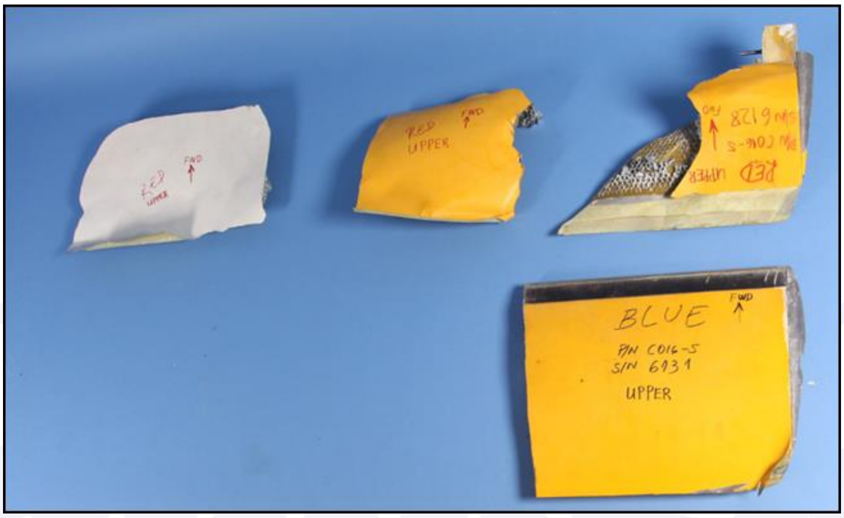

Figure 26 - Fragments of the main rotor blades sent for laboratory tests.
(Source: Adapted from NTSB).

The blades were analyzed at three different levels: visual exams, stereoscopic exams and X-ray Energy Dispersive Spectroscopy (EDS) exams by Scanning Electron Microscope (SEM). In addition, some chemical composition analyzes were performed on samples collected from both blades.

All procedures and examinations were followed by members of the SIPAER Investigation Team.

- Examination of the red blade (S/N 6128)

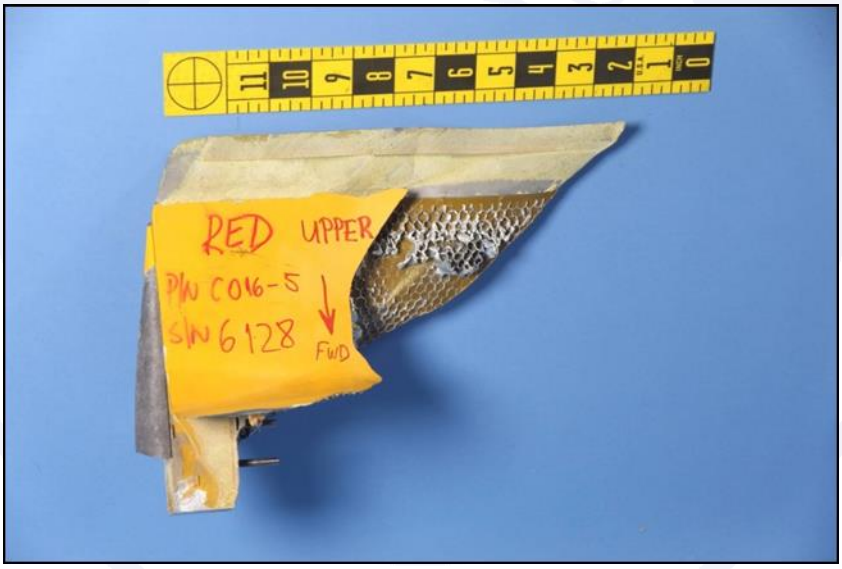

Figure 27 - Red blade fragment (S / N 6128) sent for laboratory tests.
(Source: Adapted from NTSB).

Visual examinations found that the upper skin was separated from the blade core at its forward portion, including the skin-to-spar bond line area. The forward end of the upper skin was found folded back and approximately 50% of the upper face of the tip cap was exposed. The upper skin remained attached to the aft end of the tip cap (Figure 28).

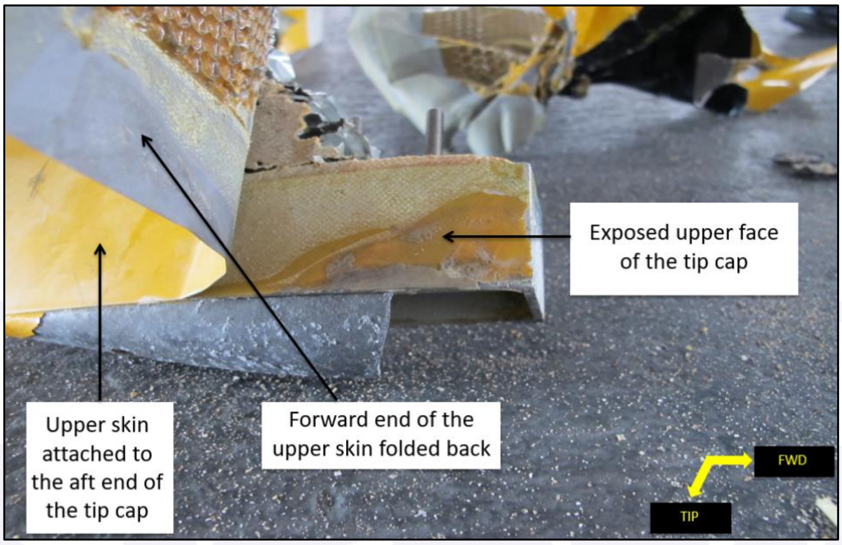

Figure 28 - Upper surface of the red blade (S/N 6128). Highlight the detachment of the front portion of the upper skin and the exposed part of the tip cap.
(Source: Adapted from NTSB).

The forward end of the lower skin was fractured and missing, exposing approximately 90% of the lower face of the tip cap. The remaining rear end portion of the lower skin was attached to the tip cap (Figure 29).

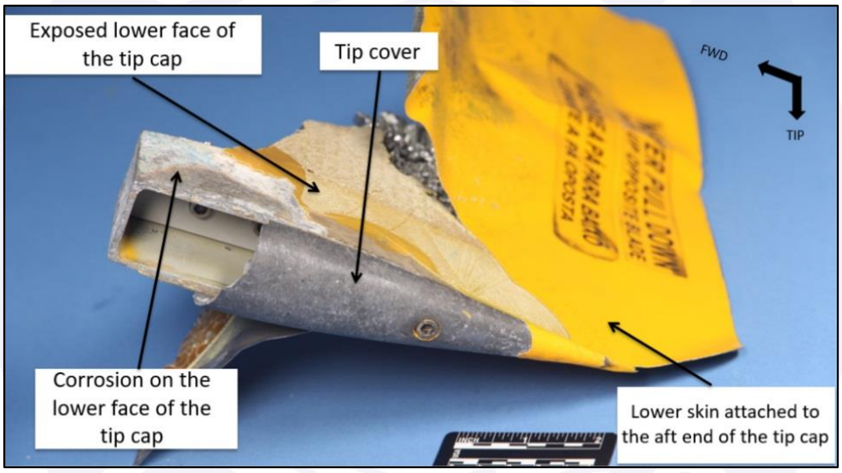

Figure 29 - Red blade lower surface (S/N 6128). Highlight for the absence of the front portion of the lower skin and the exposed portion of the tip cap.
(Source: Adapted from NTSB).

The spar (stainless steel stringer installed at the leading edge) was missing.

The rear portion of the tip cover was connected to the tip cap by the rear attachment screw, but the forward portion of the tip cover was fractured and was missing (Figure 29).

Both, the upper and lower surfaces of the tip cap showed signs of corrosion and deposition of substances of different colors. Fragments of these substances have been submitted to EDS analysis that will be commented later in this report.

It was also observed the presence of material with color and characteristics different from the original adhesive material, which was used during the manufacture of the blade. The filler material was concentrated in the outermost region of the tip cap, on the upper surface of the blade (Figure 30).

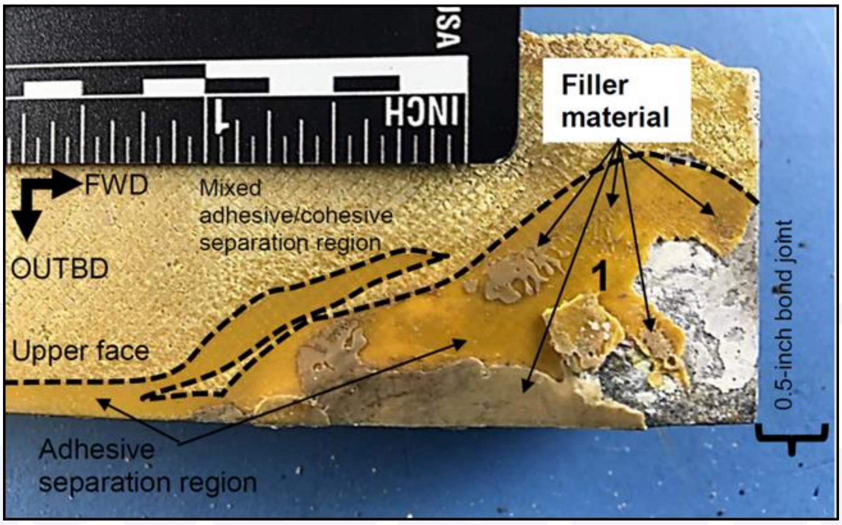

Figure 30 - Upper surface of the red blade tip cap (S / N 6128). Highlight for the presence of filler material in area “1”.
(Source: Adapted from NTSB).

The filler material was found from the outermost regions of the tip cap with propagation toward the innermost regions of the blade, which is consistent with a material that was inserted or injected from the outside.

Visual examination of the blade revealed areas of fracture in the polymer layer used for bonding the skins. These fractures showed signs of adhesive separation, cohesive separation, and mixed adhesive/cohesive separation (Figure 31).

Cohesive separation occurs when a crack propagates within the adhesive material, while adhesive separation occurs when a crack propagates at the adhesive-metal interface.

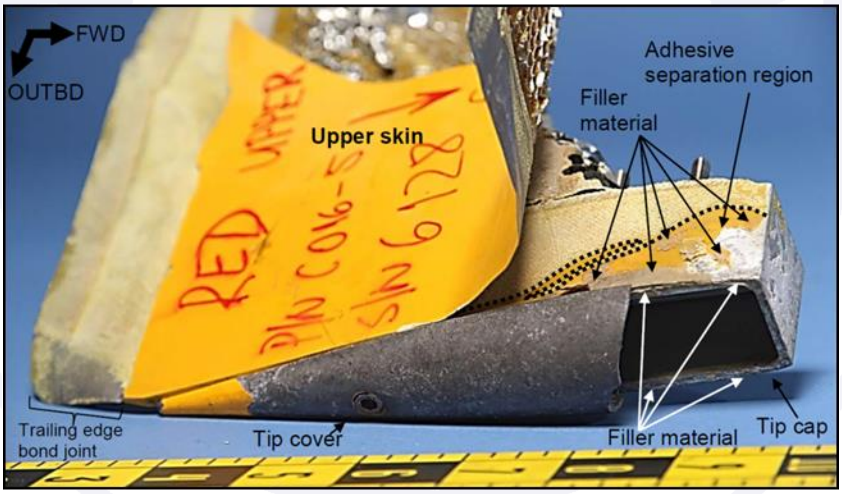

Figure 31 - Appearance of the red blade tip (S/N 6128).
(Source: NTSB).

During the lab exams, the upper skin was peeled by hand with the use of a plier. With the removal of the skin, the adhesive joints underneath the upper skin were exposed and could be examined.

Two main areas were found with the presence of adhesive separation. These areas extended from the leading edge to the trailing edge of the blade.

The areas were demarcated by a dashed line and labeled with numbers “1” and “2”. Areas “1” and “2” extended inboard from the outboard end of the tip cap (Figure 32).

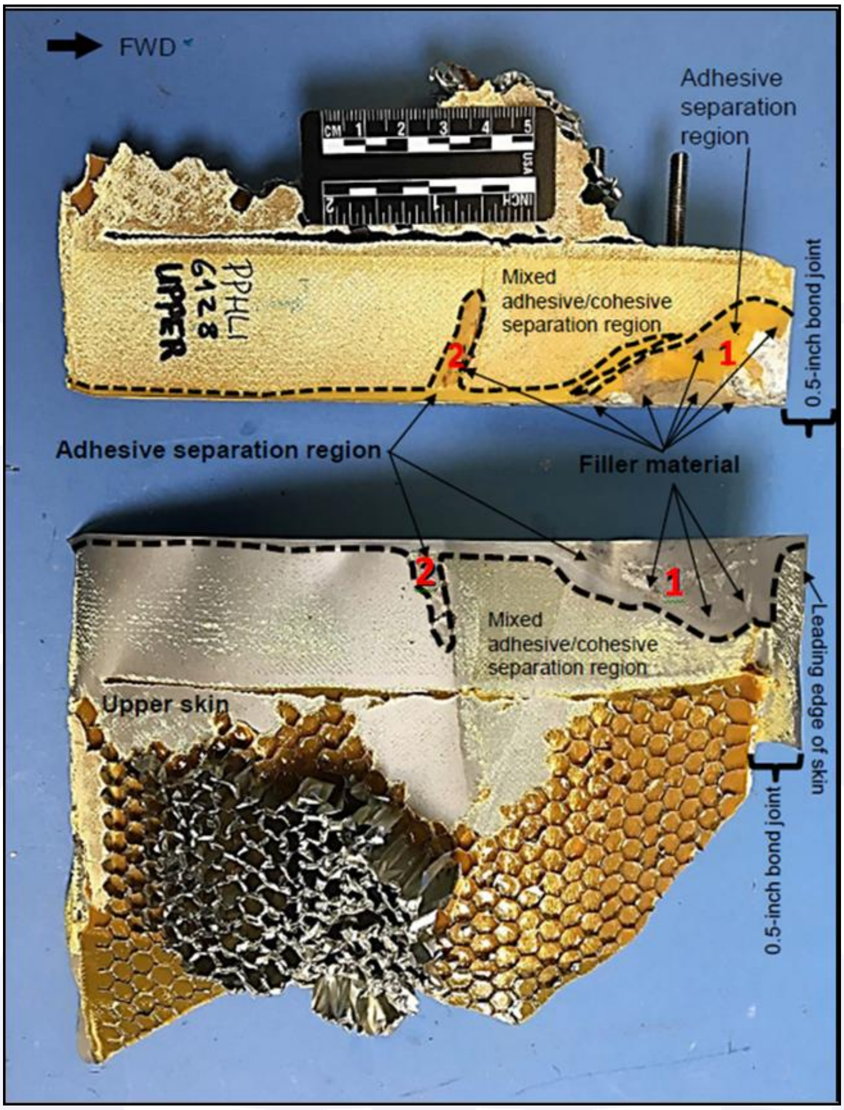

Figure 32 - Upper surface of the red blade (S/N 6128) after removal of the upper skin.
Highlight for areas "1" and "2" where adhesive separation was found.
(Source: Adapted from NTSB).

The largest area, labeled number "1", was located at the forward end of the tip cap, closest to the leading edge of the blade.

The smaller area, labeled by number "2", was located in the central portion of the tip cap, between the leading edge and the trailing edge of the blade.

Areas "1" and "2" were measured by reference to two imaginary lines: one of length and one of chord length.

Area "1" measured approximately 5.6cm (2.2in) x 2.5cm (1in). Area "2" measured approximately 0.8cm (0.3in) x 2.5cm (1in).

On the outboard end portion of the blade, a narrow longitudinally shaped area was observed, with the presence of adhesive separation extending from the leading to the trailing edge. This area included the region of the skin-to-spar bond line. The area in question is highlighted by a red ellipse in Figure 33.

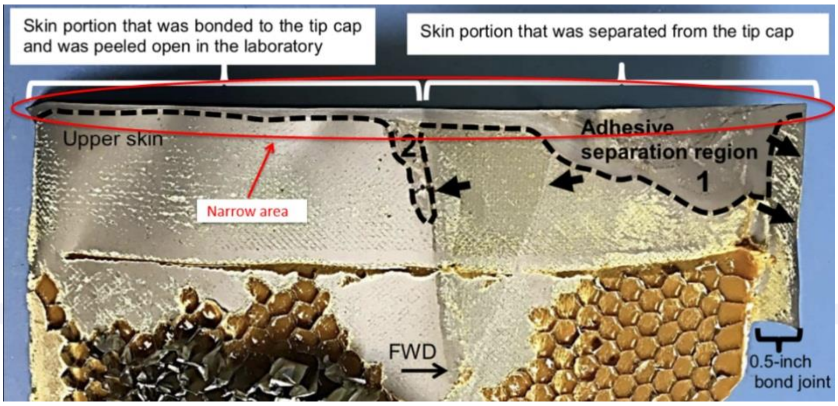

Figure 33 - Upper skin red blade (S/N 6128) after removal in the laboratory. Highlight for the narrow area in the outboard, including the skin-to-spar bond line.
(Source: Adapted from NTSB).

The fracture faces of the adhesive joint areas were examined with a bench top binocular microscope to determine the direction of fracture propagation.

The fractures intersected microscopic voids in the adhesive. The direction of fracture, for the most part, was determined by the location of a tear in the adhesive on one side of the void, with the fracture direction toward the tear from the void. The general direction of these lacerations indicated the direction of fracture propagation, illustrated by a red arrow in Figure 34.

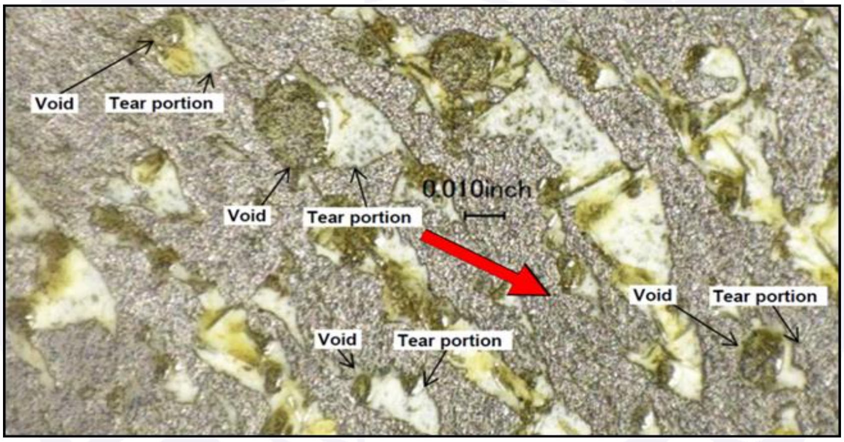

Figure 34 - General propagation direction of the adhesive fractures in the upper skin of the red blade (S/N 6128).
(Source: Adapted from NTSB).

From the bench top microscope exams, it was possible to establish the propagation direction of the adhesive fractures found in the blade (Figure 35).

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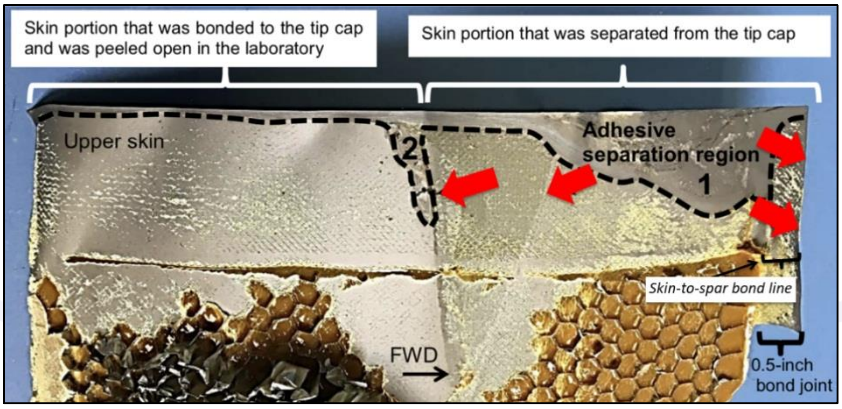

Figure 35 - Propagation of the adhesive fractures in the upper skin red blade (S/N 6128) (Source: NTSB).

Adhesive fractures found in the outboard region of the leading edge (upper right corner of Figure 35) had forward propagation away from the reference area indicated by the number "1".

In the region near the rear portion of area "1", the general direction of adhesive fracture propagation was backward, toward the trailing edge of the upper skin.

In the region slightly in front of area “2”, the general direction of adhesive fracture propagation was also backward toward the trailing edge of the upper skin.

The lower surface of the red blade presented characteristics similar to those found on the upper surface.

Regions with adhesive separation and regions with mixed adhesive/cohesive separation extending from the outermost blade (tip) to the innermost (root).

Areas marked by a dashed line indicate the region where adhesive separation was noted (Figure 36).

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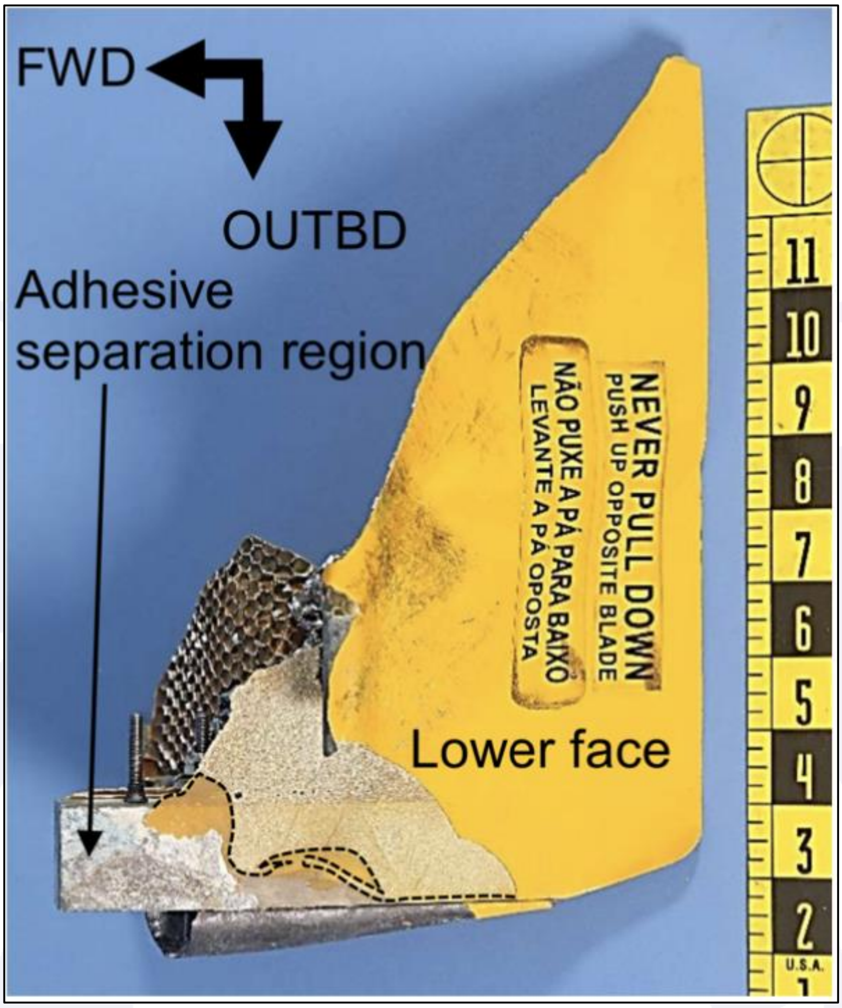

Figure 36 - General appearance of the lower surface of the red blade (S/N 6128). (Source: Adapted from NTSB).

The largest region with adhesive separation was found in the forward portion of the lower surface. In this region was also detected the presence of material with color and characteristics different from the original adhesive material used in the manufacture of the blade.

Filler material was found from the outermost regions of the tip cap with propagation toward the innermost regions of the blade, which is consistent with a material that was inserted or injected from the outside (Figure 37).

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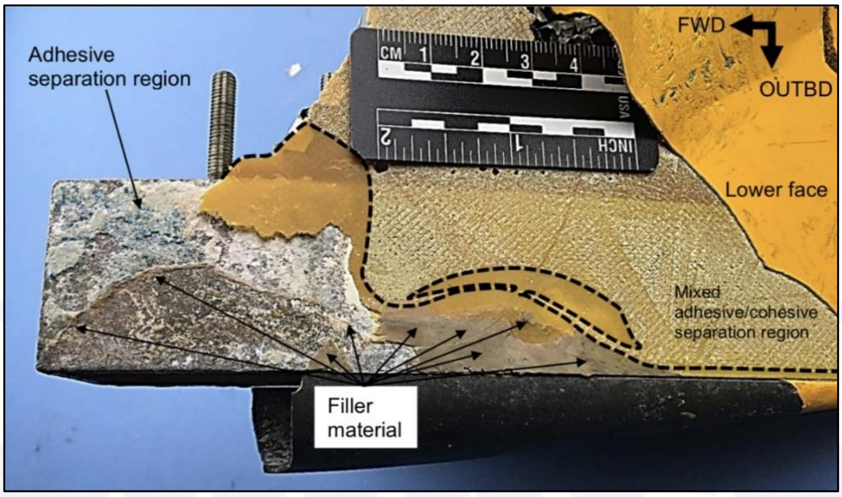

Figure 37 - Lower surface of the red blade (S/N 6128). Highlighting the demarcation of regions with adhesive separation and the presence of filler material.
(Source: Adapted from NTSB).

The size of the region with the presence of filler material and adhesive separation on the lower surface of the blade was larger compared to the size of the demarcated area "1" on the upper surface.

The lower skin was also removed with the aid of pliers. After the removal of the skin, the adhesive joints underneath the lower skin were exposed and could be examined (Figure 38).

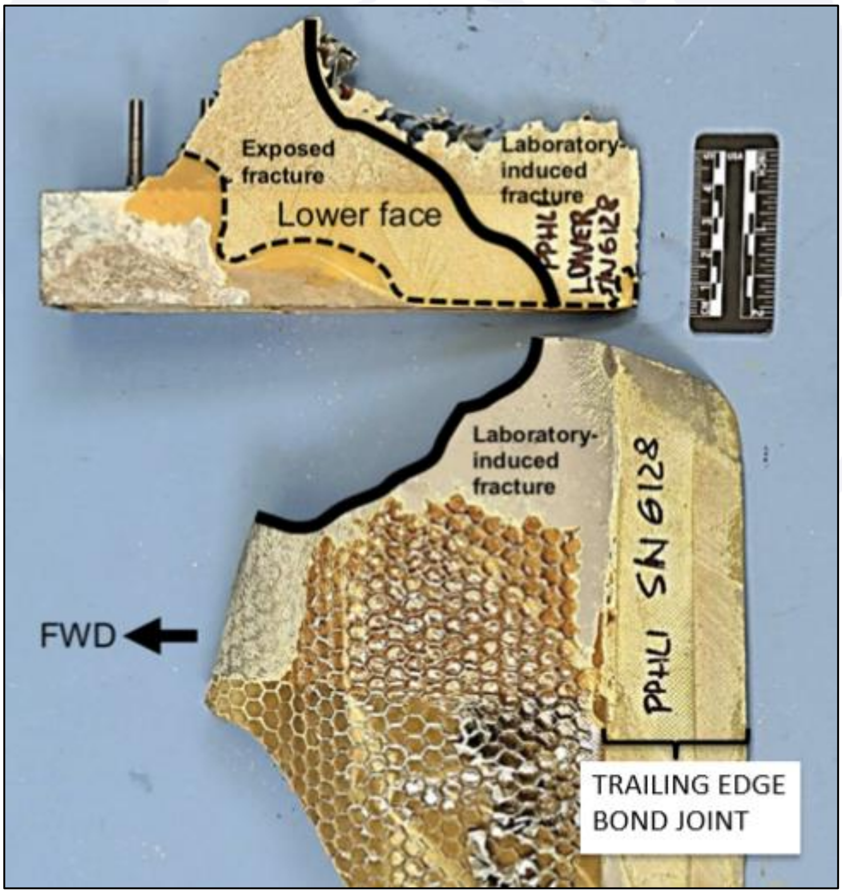

Figure 38 - Lower skin of the red blade (S/N 6128) after removal performed in the laboratory.
(Source: Adapted from NTSB).

- Examination of the blue blade (S/N 6131)

The blue blade (S/N 6131) was found with some bents along with its structure (Figure 39).

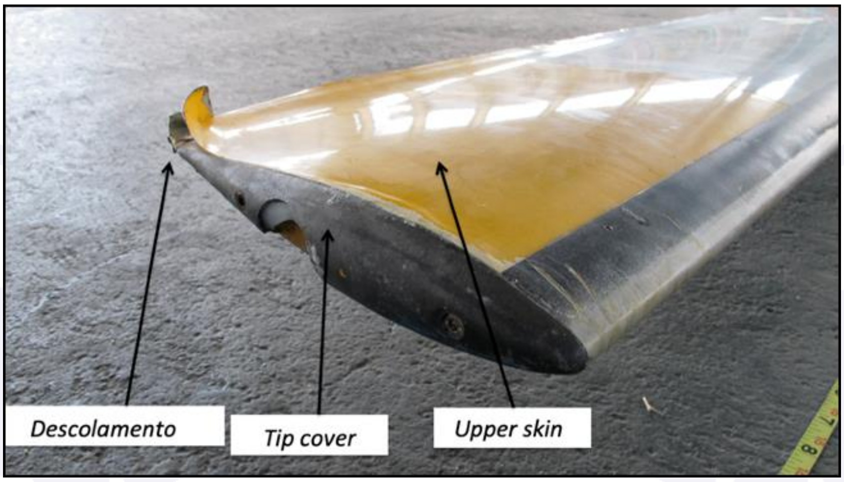

Figure 39 - General aspect of the blue blade (S/N 6131).

In the laboratory, the blade was inspected in accordance with AD 2014-23-16 and SB-72A, including the tap test.

During the visual inspection, after removing the tip cover, it was possible to observe corrosion, skin delamination and the presence of filler material in the outboard region of the tip cap (Figure 40).

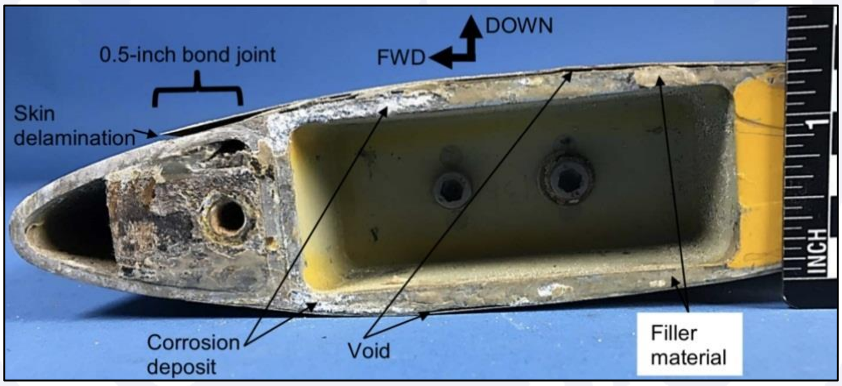

Figure 40 - Outer region of the blue blade tip cap (S/N 6131) after removal of the tip cover.
(Source: Adapted from NTSB).

The upper surface tap test found areas with signs of upper skin debonding, marked with a red line (Figure 41).

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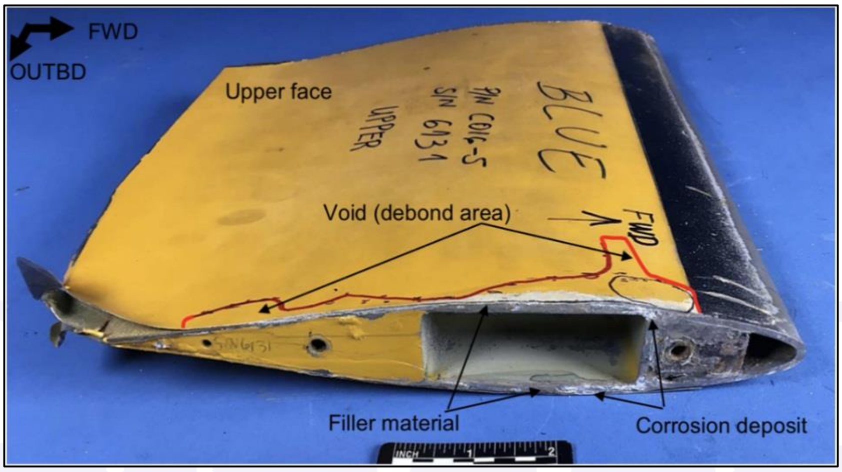

Figure 41 - Upper surface of the blue blade (S/N 6131) after the tap test. The void debond area was marked with a red line.
(Source: NTSB).

The upper skin of the blue blade was handed removed with the use of a plier. After the skin removal, the adhesive joints underneath the upper skin were exposed and could be examined.

The polymer used for blade gluing presented areas with adhesive separation more concentrated in the external region of the forward portion of the blade.

The areas where the adhesive separation was found corresponded to the areas identified with signs of debonding during the tap test (Figure 42).

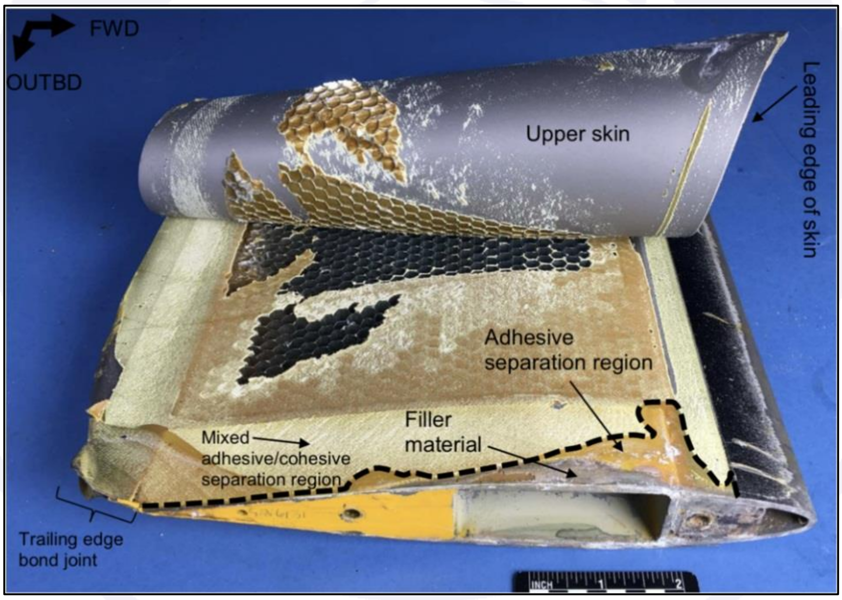

Figure 42 - Upper surface of the blue blade (S/N 6131) after removal of the upper skin.
(Source: Adapted from NTSB).

Comparing the pictures in Figure 43, it is possible to notice the similarity between the area with signs of debonding, identified by the tap test, and the area where the adhesive separations were found, after the removal of the upper skin of the blue blade (S/N 6131).

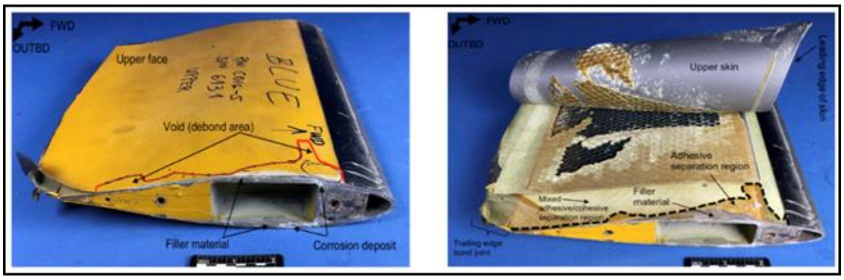

Figure 43 - Upper surface of the blue blade (S/N 6131) in two moments: Left, after the tap test; and on the right, after removing the upper skin.
(Source: Adapted from NTSB).

The area in which adhesive separation was present also contained material with color and characteristics different from the original adhesive material used in the manufacture of the blade. The filler material was concentrated in the outboard region of the central portion of the tip cap.

Similarly, the lower surface was also tap-tested. The test found areas with signs of lower skin debonding, marked with a red line, as shown in Figure 44.

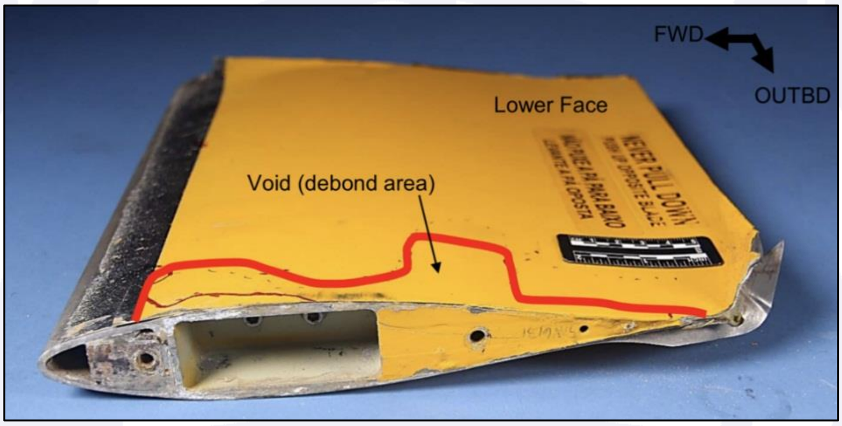

Figure 44 - Lower surface of the blue blade (S/N 6131) after the tap test. The debonding area was marked with a red line.
(Source: Adapted from NTSB).

The lower skin was also handed removed. After that, areas with adhesive separation were found, which corresponded to the regions identified with signs of debonding during the tap test.

The area where the adhesive separation was present also contained filler material (Figure 45).

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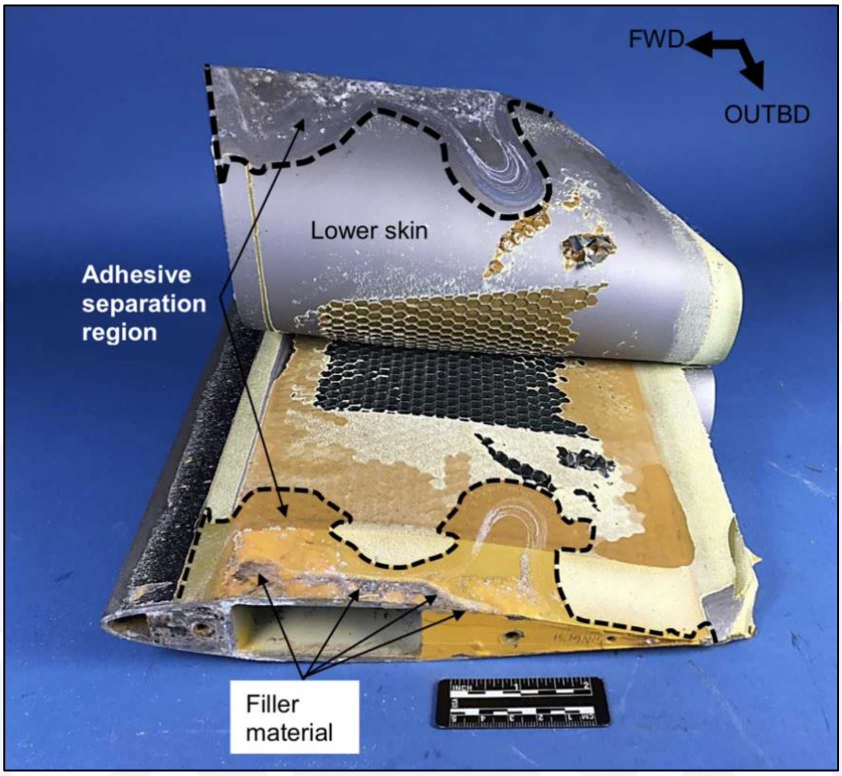

Figure 45 - Lower blue blade surface (S/N 6131) after the lower skin removal.
(Source: Adapted from NTSB).

Comparing the pictures in Figure 46, it is possible to notice the similarity between the area with signs of debonding, identified by the tap test, and the area where the adhesive separation was found after the removal of the lower skin of the blue blade (S/N 6131).

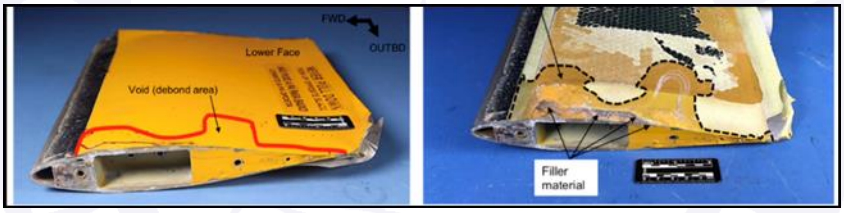

Figure 46 - Bottom surface of the blue blade (S/N 6131) in two moments: Left, after the tap test; and on the right, after removing the lower skin.
(Source: Adapted from NTSB).

- <u>Examinations of corrosions found on both blades</u>

In both, the red and blue blades, signs of corrosion were found.

Corrosion samples were collected from some points of the blades and submitted to EDS analysis.

In the red blade (S/N 6128) there were spots with the presence of corrosion of different colors. In order to identify whether the corrosions present at these points had similar or distinct characteristics, samples were collected from two different sites of the blade, one with bluish color (point 1) and the other with whitish color (point 2) (Figure 47).

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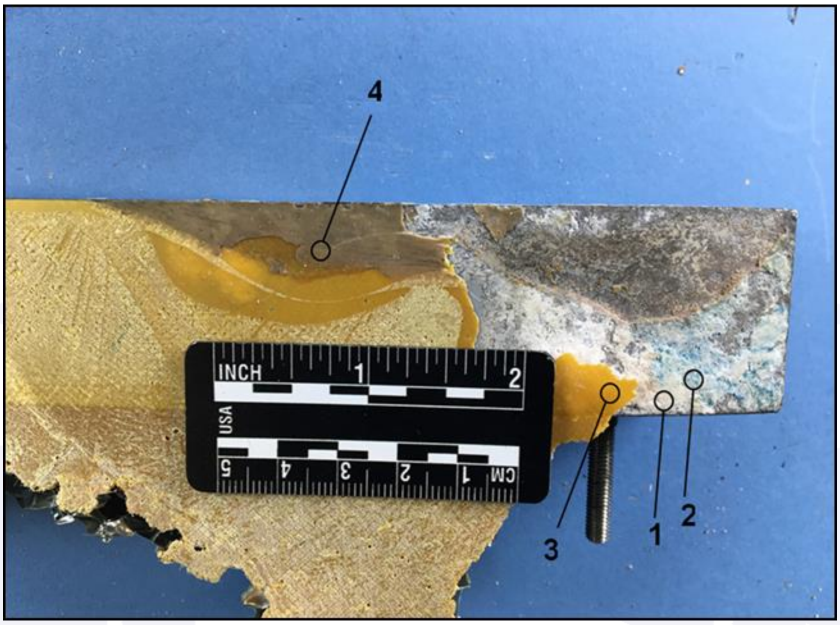

Figure 47 - Point 1 (whitish stain) and point 2 (bluish stain) from where the red blade (S/N 6128) corrosion samples were collected.
(Source: Adapted from NTSB).

Although the collection points had different colors, the exams found out that the composition of the collected material was similar, showing that the corrosion in points “1” and “2” was of the same type (Figures 48 and 49).

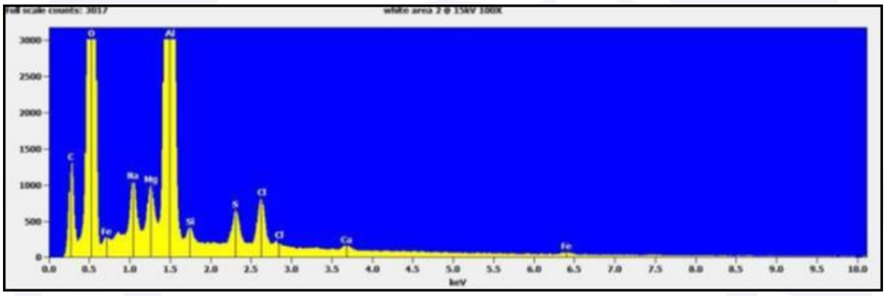

Figure 48 - Chemical composition of the sample collected in point 1.

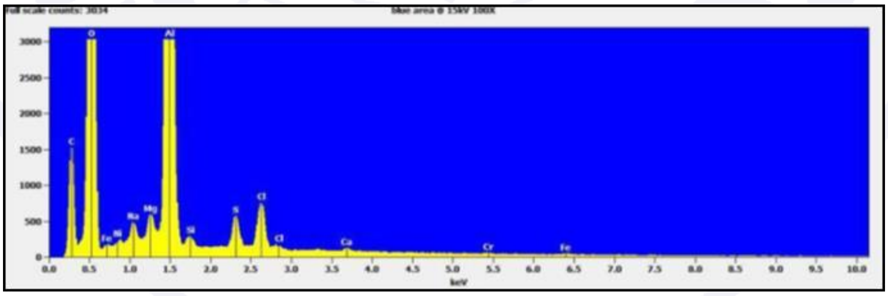

Figure 49 - Chemical composition of the sample collected in point 2.

The EDS examinations identified oxygen (O) and aluminum (Al) as the main elements present in the samples. The presence of these components indicated that there was corrosion of the base metal (aluminum) of the blade. The results were compatible with the presence of aluminum oxide from the corrosion found in the tip cap.

The other elements found in a smaller scale were identified as: carbon (C), iron (Fe), sodium (Na), magnesium (Mg), silicon (Si), sulfur (S), chlorine (Cl) and calcium (Ca).

In the blue blade, regions with bulging were found under the original polymer layer used by the manufacturer to bond the blade. A cut in the polymer layer was made to access the white material underneath the bulging regions. A thin layer of white material was also found above the original polymer (Figure 50).

Samples of both materials were collected and submitted to EDS analysis.

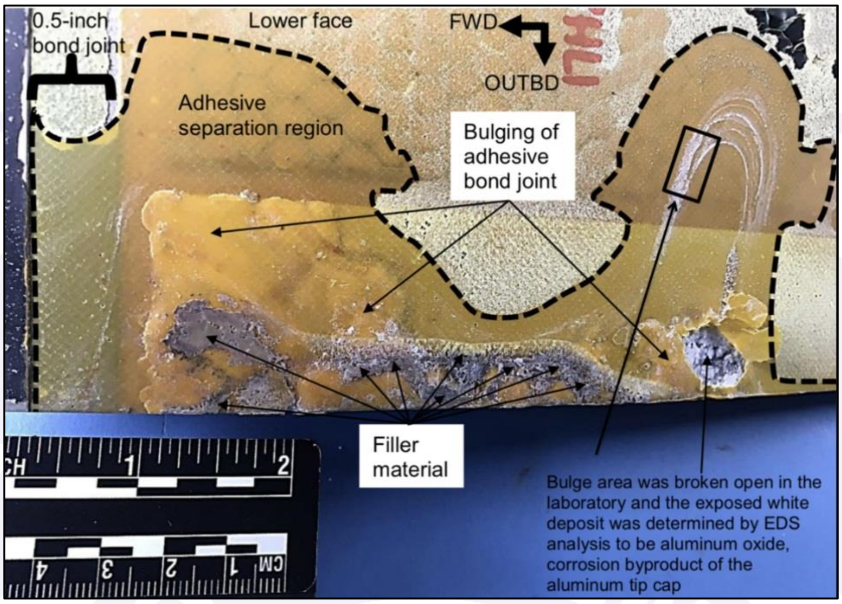

Figure 50 - Points where the samples were collected in the blue blade (S/N 6131). (Source: Adapted from NTSB).

The EDS analysis of the material collected above the polymer layer (highlighted in the black rectangle of Figure 50) identified higher sodium (Na), chlorine (Cl) and peaks of lower intensity of calcium (Ca), potassium (K), sulfur (S), silicon (Si), aluminum (Al), magnesium (Mg), oxygen (O) and carbon (C). Larger scale substances found (sodium and chlorine) are common in saline environments.

The EDS analysis of the material collected below the polymer layer identified higher intensity peaks of aluminum (Al) and oxygen (O). The presence of these components indicated that there was corrosion of the base metal (aluminum) of the blade. The results were compatible with the presence of aluminum oxide from the corrosion found in tip cap.

- <u>Examination of the filler material</u>

A sample of the adhesive smooth side polymer layer and a sample of the filler material were collected and examined.

The samples, identified in Figure 51 by circles C1 and C2, were collected from the lower surface of the red blade tip cap (S/N 6128).

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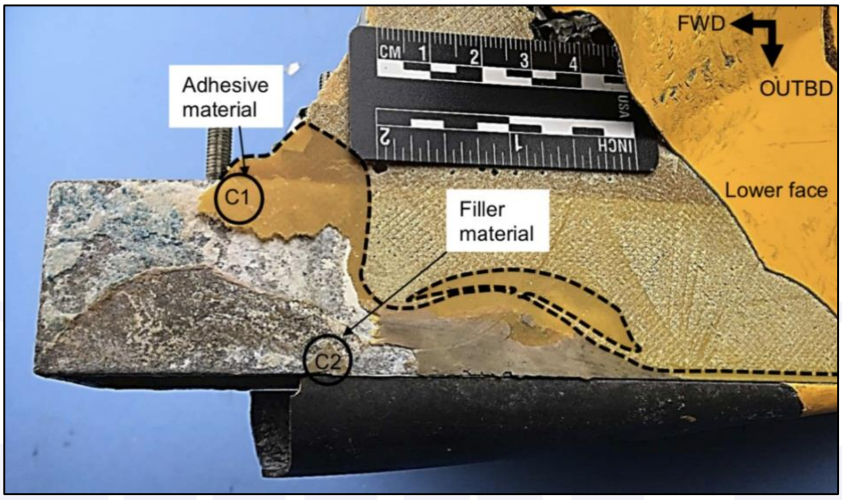

Figure 51 - Lower surface of the red blade indicating the areas from where samples C1 and the filler material found during the investigation were collected (C2). (Source: Adapted from NTSB).

Examination of the samples was performed using a Fourier Transform Infrared (FTIR) spectrometer with a diamond Attenuated Total Reflectance (ATR) accessory, in accordance with the American Society for Testing Materials (ASTM) E1252-98 standards.

The spectrum examination of the original material (C1 - adhesive smooth side) identified absorbance peaks consistent with an epoxy resin derivative, which were compatible with the original material information provided by the manufacturer (RHC).

The spectrum of the filler material (C2 - filler smooth side) examination was similar to the spectrum of the original material, indicating that the filler material was also an epoxy resin derivative. However, the absorbance peaks observed in the C2 sample examination did not have the intensity and definition as the same absorbance peaks observed in the spectrum of the original material (Figure 52).

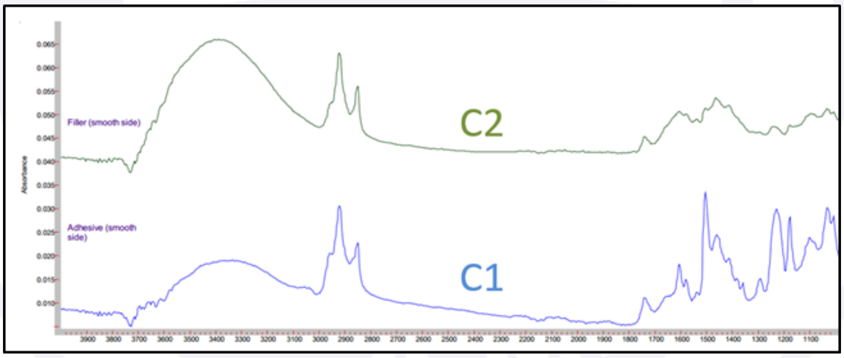

Figure 52 - FTIR spectrum of samples collected at C1 and C2. (Source: Adapted from NTSB).

This difference between the absorbance peaks may have occurred for several reasons, including contamination, water intrusion and lack of curing.

AERODYNAMIC RESEARCH

In order to determine the aerodynamic effects associated with an inflight debonding of the main rotor blade skin, a study was conducted by the Research and Flight Testing Institute (IPEV).

The research evaluated the aerodynamic consequences in two scenarios:

a) upper skin debonding in the leading edge of one of the blades; and

b) upper skin debonding in the trailing edge of one of the blades.

The researches were based on the aerodynamics classical theory and rotor dynamics theory. No experimental or computational exams were performed.

The available video was poor in quality and recorded only the accident flight's final phase when the aircraft was already out of control. For these reasons, the images were not considered in this research.

The R44 main rotor system has a rotational speed of 408 RPM.

The blades were rectangular, with a symmetrical profile, with a constant geometric washout torsion of six degrees (- 6) along the blade span.

Typically, the lift distribution along the blade span of a helicopter is shown along the red dotted line in Figure 53.

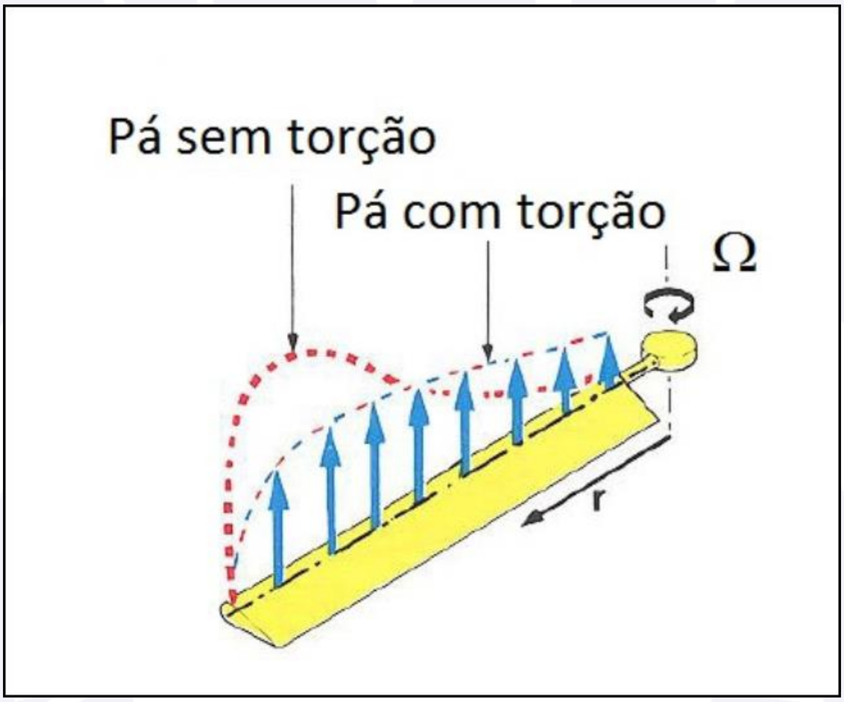

Figure 53 - Lift distribution along the blade wingspan.
(Source: IPEV).

In geometrically torsioned blades, such as the R44 blades, this torsion tends to reduce the aerodynamic load in the tip region when compared to a non-torsioned blade.

According to the IPEV studies:

> “The values of the distributed lift forces will be a function of the blade position in a rotor revolution, as the helicopter moves in relation to the air mass, but there will always be a tendency for higher values near the blade tip. Thus, regions near the blade tip are important in the aerodynamic balance of the rotor system.”

The upper skin debonding scenario at the leading edge (scenario “a”) is represented in Figure 54.

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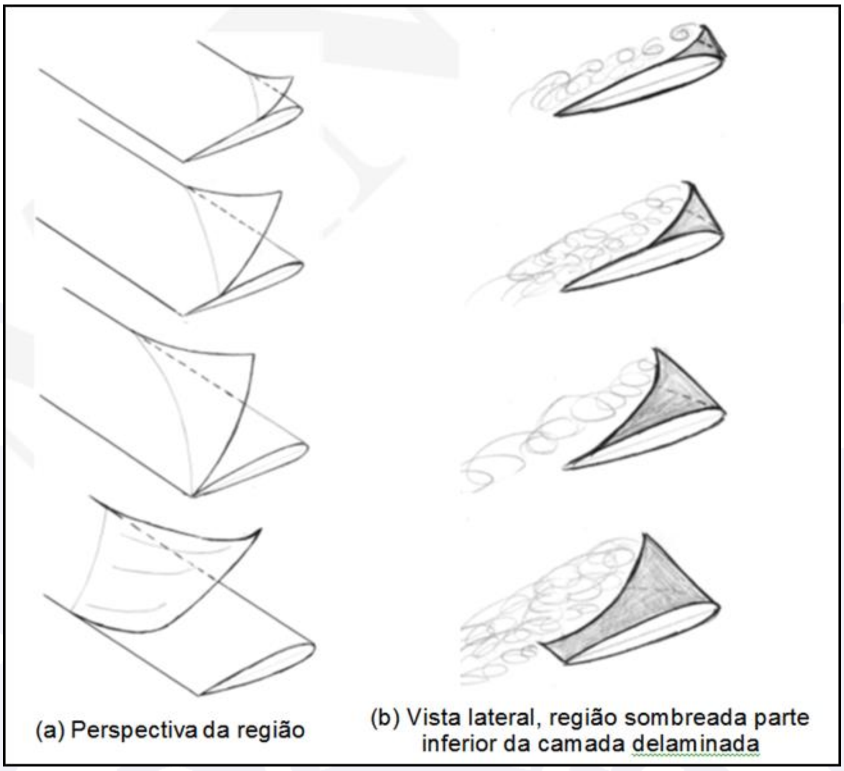

Figure 54 - Influence of the upper skin debonding on the airflow of a blade in flight.
(Source: IPEV).

The Figure illustrates the evolution of a debonding (delamination) started at the leading edge of the blade tip.

The left column of Figure 54 illustrates the evolution of the upper skin debonding in a blade during flight. The right column demonstrates airflow behavior as it passes through the debonded area. The shaded region refers to the surface below the region where the upper skin debonding is occurring.

It is important to emphasize that an upper skin debonding at the leading edge would tend to be increased by the airflow generated during the blade revolution.

Figure 54 shows that even when the debonded area of the upper skin is small, the change in airflow is considerable. Initially, the disturbance in the airflow is restricted to a small region at the tip of the blade. As the debonded area of the upper skin increases, so does the disturbing region of airflow along the blade.

These changes in the upper surface and the airflow has an influence on the aerodynamic characteristics and, consequently, increase the drag and the pitching moment of the blade.

According to the IPEV's research:

> "... if the skin debonding of one of the blades occurs on the upper surface of the leading edge of the blade tip, it may induce the stall of the profiles located near the blade tip, which region is classically responsible for greater lift generation on the blade. "

Regarding the upper skin debonding scenario on the trailing edge (scenario "b"), the IPEV research has shown that:

> "... the debonding starting at the trailing edge has less probability of being increased due to aerodynamic effects and airflow during the main rotor blades revolution. However, if such an event occurred there would not stall, but generate high drag and pitching moment. "

According to the IPEV, in both scenarios the upper skin debonding would represent a decrease in the ability of the blade to generate lift compared to a blade with non-debonded skin:

> "In both cases considered, with skin debonding and consequence aerodynamic issues along the blade, the lift and the effective wingspan decreases, and therefore the CLα also decreases in comparison to a "normal" blade (without delamination). In other words, compared to a "normal" blade, for the same variation in angle of attack there would be a smaller lift increment for the blade with skin debonding. "

The decrease in the ability to generate lift influences the blade aerodynamic flapping behavior.

> "The dynamic response of the blade to this aerodynamic lift change will be in terms of flapping, that is, in terms of vertical blade motion (movement in which the blade rises and/or falls during a main rotor revolution).
>
> The flapping is a movement of the helicopter rotor blade that occurs naturally in any flight condition even if the pilot holds the controls steady, and is generated by the aerodynamic bending moment along the blade. [...]
>
> [...] the greatest amplitudes of this vertical movement occur at the tip of the blade, being accentuated by the elastic modes of the blade (due to the flexibility of the blades). "

When a helicopter is flying forward, the advancing blade will generate higher lift values than the retreating blade. This dissymmetry of lift can cause aircraft control issues.

In this context, the flapping motion of the blades is relevant. Through the freedom of the vertical oscillation, the dissymmetry of lift between the advancing blade and the retreating blade is attenuated.

Teetering rotors, such as the R44, have specific characteristics related to the flapping movement of blades, as explained by the IPEV:

> "In the specific case of a teetering rotor such as the R44 aircraft with the flapping hinge centered on the mast, the resulting system is resonant, that is, the natural frequency of the flapping motion (Ωn) is equal to the rotational frequency of the rotor (Ω). As a result, the main rotor naturally operates under conditions of greater flapping motion amplitudes, attenuated by lift variation. "

In rotating systems such as helicopter rotors, balancing is a critical matter. Helicopter rotor blades are statically and dynamically balanced to reduce vibration associated with the system and allow operation within a safety margin defined by the manufacturer.

In addition to balancing, tracking is also very important in helicopter rotors. This is an adjustment in the blade rotation plan.

Both balancing and tracking of the main rotor assembly would be affected in the event of upper skin debonding on an R44 blade, according to research:

> "Thus, regardless the upper skin debonding has occurred from the leading edge or the trailing edge, there will be a general increase in the amplitude of the main rotor flapping motion. This causes an increase in the amplitude of the response in the blade flapping to fixed controls, that is, without pilot inputs, and consequently loss of balance and tracking of the rotor assembly, raising the vibration of 1Ω passed to the fuselage (nominal main rotor rpm). In this case, the undamaged blade is also expected to raise the oscillation in flapping, as in the teetering rotors the blades are interconnected and the system dynamics work together.
>
> This effect will be more significant and may even be an abruptly response in flapping, to the event of the skin debonding at the upper surface of the leading edge due to the blade tip stall and also in its central portion, (there won't be the generation of lift ∆L to attenuate the flapping motion). "

Teetering rotors, such as the R44, have specific characteristics related to the behavior of the fuselage relative to the rotor disk (imaginary disk formed by the moving main rotor blades), as explained by the IPEV:

> "… another effect to be considered on the dynamics of the teetering rotor-equipped aircraft is that the fuselage does not keep up with the inclination of the disc. This way, the helicopter fuselage (Figure 55) will not accompany any kind of response of the rotor in flapping derived, for example, from the skin debonding of the blade. "

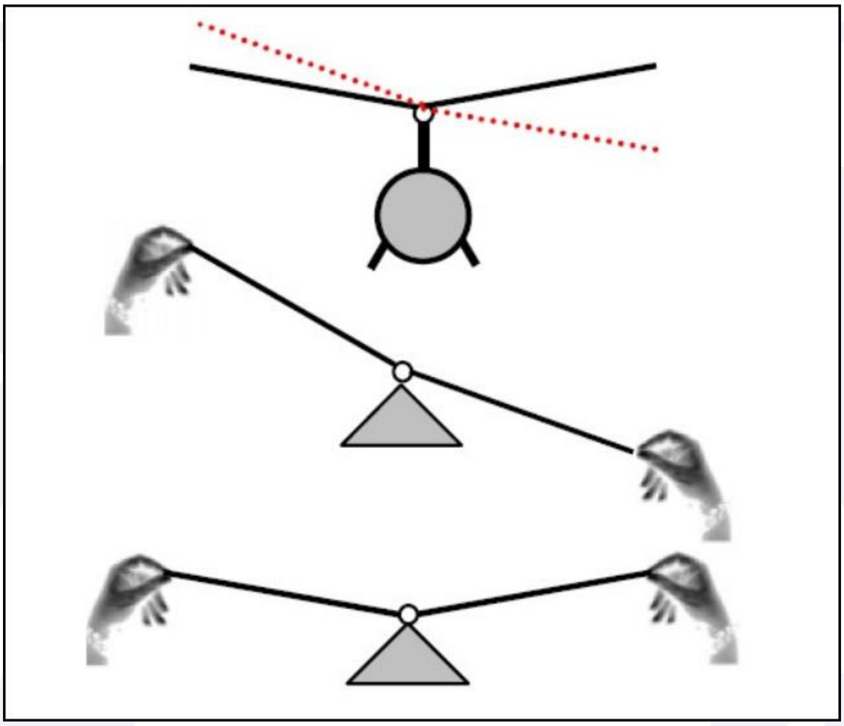

Figure 55 - Representation of the disc movement of a teetering rotor in relation to the helicopter fuselage.
(Source: IPEV).

Taking into account the helicopter dimensions contained in the manufacturer's manual, it was possible to calculate which flapping angle values could cause a contact between the main rotor blades and the tailcone, according to the IPEV research:

> "... a flapping angle greater than approximately -16 ° from the plan of the R44 rotor head could already cause the tip of the blade to touch the tailcone, considering the blade as rigid and taking into account that the fuselage does not follow the inclination of the rotor disc. With the flexibility of the blade, this angle could be even smaller. This order of magnitude could be obtained during excessive flapping oscillations. "

In this context, the IPEV research concluded that in both scenarios ("a" and "b"), an upper skin debonding would have the following consequences on the main rotor behavior:

- decreased ability of the blade to generate lift;

- increased amplitude of the blade flapping motion;

- changes in balancing and tracking of the main rotor; and

- increased system vibration.

According to the IPEV, these consequences could reach the point of exceeding the minimum separation limits between the main rotor and the fuselage of the aircraft and could cause a contact between the main rotor blades and the tailcone (tailcone strike).

Although possible in both scenarios, the possibility of a contact between the main rotor blades and the tailcone could be considered higher in the scenario "a" (leading edge debonding) than in the scenario "b" (trailing edge debonding).

1.17 Organizational and management information.

<u>About the Operator</u>

Helisae Helicopters of the Northeast was a helicopter charter company, with the authorization granted by ANAC to operate in the SAE segment, in the activities of aero-advertising, aero-inspection, aero-reporting, and aero-photography.

At the time of the crash, the company's fleet consisted of three Robinson helicopters, two R44 II models and one R66 model.

<u>About the Maintenance Organization that Performed the Latest Inspections on the Aircraft</u>

The Maintenance Organization (OM) *Fênix Manutenção e Recuperação de Aeronaves* Ltd. had its base in Goiânia, GO, and was certified by the ANAC. The Organization´s Operative Specification (EO) had included the following Robinson models: R22, R22 Alpha, R22 Beta, R22 Mariner, R44, R44 II, and R66.

In the past, the OM had a secondary base of operations in Recife, PE, which had been suspended at its request on 24MAY2016, according to information provided by the ANAC.

After the suspension of the secondary base in 2016, the technicians who had worked in that base continued to perform aircraft maintenance services, including the PP-HLI, in the “out of the headquarters” mode.

In order to perform these services, the organizational processes established by the OM defined procedures from the receipt to the delivery of the aircraft to the operator, including aspects such as the handling of aircraft documentation, for the purpose of its approval/return to service by the Technical Manager (RT).

The OM maintained a number of mechanics seconded in Recife, PE, to perform maintenance services away from the headquarters. It was found that these mechanics had training and qualification, established by the ANAC, to perform all functions, including that of mechanic assistant. These professionals were also qualified to perform maintenance services on that helicopter model.

However, only the records referring to the initial training were presented by the OM, not showing the recurrent training records, as foreseen in RBAC 145-EMD01, of 06MAR2014, in force at the time of the accident:

> 145.163 Training Requirements
>
> (a) Each certified maintenance organization must have an ANAC approved personnel training program consisting of initial and recurrent training. To comply with this requirement, each applicant for a maintenance organization certificate must submit the training program for the ANAC approval, as required by paragraph 145.51 (a) (7) of this RBAC.
>
> (b) The training program must ensure that each person assigned to perform maintenance, preventive or alteration maintenance, and inspection and registration functions is able to perform the assigned tasks.
>
> (c) Each certified maintenance organization must document, in a format acceptable to the ANAC, the individual training of personnel required by paragraph (a) of this section. These training records must be retained for at least five (5) years after the termination of the contract.

The OM defined its internal processes through the Maintenance Organization Manual (MOM) and the Quality Control Manual (MCQ). These manuals described the organizational processes to be followed, from receipt to delivery of the aircraft to the operator.

The MOM, in Section 7, which dealt with SERVICES CARRIED OUT IN ANOTHER LOCATION, among other aspects, established the criteria and outlined the procedures for performing off-site maintenance services, such as necessary tools, facilities, technical personnel, publications and handling the aircraft documentation for return to service.

Item 7.3 of the MOM established that, once the services were finished, the aircraft documentation would go to the shop headquarters in Goiânia, GO, in order to the approval/return to service of the aircraft by the RT.

Section 43.11 of RBAC 43 provided that the aircraft approval for return to service should be carried out by the RT or someone designated by it. The documentation submitted by the OM did not include the appointment of a company professional assigned to the tasks of the RT.

However, according to the information obtained, one of the OM owners, who also served as Chief Maintenance Inspector, signed the aircraft inspection sheets as Approval for Return to Service (APRS), as well as mentoring another mechanic (company employee in Recife) to sign when he, himself did not sign. It is noteworthy that neither professional had formal OM designation to approve the aircraft return to service, which function, in that OM, was exclusive to the RT.

This owner had effectively actuated in different levels of authority inside the company, executing tasks related to the lower levels of actuation, passing through the management level, and reaching the direction level.

1.18 Operational information.

The aircraft took off at 08h48min (UTC) to perform aero-reporting flight, transmitting images to a television station.

At the time of the crash, the pilot was occupying the right front seat, a second occupant was in the rear seat, who operated the image transmission equipment, and a third occupant on the left front seat were on board.

There were no flight controls installed on the left front seat.

The Maximum Takeoff Weight (PMD) of the aircraft was 1,134kg. It was estimated that at the time of the crash the helicopter weight was 1,065kg.

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

The day before the accident, the aircraft was refueled three times, respectively, with 64, 62 and 30 liters of aviation gasoline. The last refueling occurred at 18h27min (local).

At the time of takeoff, the aircraft had 165 liters of fuel in the tanks, a total of three hours of flight endurance.

It was a flight over Recife with expected duration of two hours.

The aircraft remained over the Pina Beach neighborhood, maintaining visual references to the ground at approximately 500ft above ground level. There was radar coverage in the area overflown by the aircraft.

The latest images generated by the helicopter camera were recorded by the TV station. Records showed that significant helicopter vibration occurred and, shortly after the vibration, images were interrupted.

1.19 Additional information.

<u>DEFINITION OF SERVICE BULLETINS (SB) AND AIRWORTHINESS DIRECTIVES (AD)</u>

According to the IS 145.109-001C of 16JUN2017, Service Bulletin and Airworthiness Directive had the following definitions:

4. DEFINITIONS

4.3 Service Bulletin - SB: Document issued by the type design holder or manufacturer of the aeronautical product (aircraft, engine, propeller, equipment and component) for the purpose of correcting failure or malfunction of this product or to introduce modifications and/or improvements, or aiming at the implementation of maintenance action or preventive maintenance additive to those prevised in the aeronautical product maintenance program;

4.6 Airworthiness Directive - AD: document issued by the ANAC, aimed at eliminating an unsafe condition existing in an aeronautical product, likely to exist or develop in other products of the same type design. Compliance is mandatory and often requires compliance with a SB in a specified manner. The guidelines issued by the various AACs are also considered Brazilian and here are applicable if these AACs are responsible for the product type design operating in Brazil…;

Note: The acronym AAC refers to the Civil Aviation Authority.

AD AND SB COMPLIANCE CONTROL

Regarding the AD compliance control, IS 39-001 Rev A of 17AUG2012 provided that:

5. DEVELOPMENT OF THE MATTER

5.12 Compliance control of AD

5.12.1 All ADs applicable to aircraft, engines, propellers and any other aeronautical equipment shall have compliance records registered, even if a certain AD does not apply to a particular aeronautical product. In this case, it should appear as *Not Applicable*, justifying the reason. For instance, an AD may apply to a particular product but does not include certain serial numbers.

5.12.2 Effective control of ADs is mandatory. The lack of control or maintenance records proving compliance with an AD will result in an unairworthy condition, and the Airworthiness Certificate (CA) will be suspended. As stated in RBHA 91, owners or operators are primarily responsible for the conservation of their products in airworthy conditions. Compliance with this item is considered an indispensable condition in the demonstration to the ANAC that this responsibility is effectively exercised.

5.13 AD Compliance Records

5.13.2 In accordance with section 91.403 (a) of RBHA 91, every owner or operator of an aircraft is primarily responsible for the maintenance of that aircraft under airworthy conditions. In this case, if applicable, the owner should consult an Aeronautical Product Maintenance Organization, certified under RBHA 145 requirements, which has his aircraft listed in its Operational Specifications to verify the applicability of an AD.

5.14 Primary Record

5.14.1 A primary record shall be complete and clear, containing the method of compliance used and the outcome of the action taken. For instance, an AD normally requires periodic inspections, which may be a visual inspection or through non-destructive testing, until a terminating action is incorporated, which may be described in a Service Bulletin. An AD may also require a review of operating procedures of the Aircraft Flight Manual. Thus, the record shall clearly present the method of compliance used.

5.14.2 The compliance form FCDA is an acceptable format that can be used as the primary record of compliance of an AD. However, if the FCDA is not used, the records must contain at least the information contained in the FCDA; this is usually applicable for RBAC 135 or 121 operators since its approved Manuals provides a systemic records procedures considered acceptable by ANAC.

5.14.3 An Aeronautical Product Maintenance Organization providing services for a 121 or a 135 company shall keep a copy of the compliance record (a primary record) as stated in this section for each AD related to each service accomplished. For operations conducted under RBHA 91 regulations, such record includes analysis of each AD.

5.15 Secondary Record

5.15.1 A secondary record can be made using a spreadsheet or AD status map. This map should be drawn up and/or updated when certifying an IAM, or when conducting a major inspection (check - C, for example), or when performing an AD. The AD control map is a system that allows a quick query as to the status of an AD compliance on an aircraft, engine, propeller or component, and is only valid if coupled with a primary record. Such a spreadsheet or map does not replace a primary record.

Regarding the control of aircraft maintenance records, RBHA 91, of 20MAR2003, stated that:

91.405-REQUIRED MAINTENANCE

Each owner or operator of an aircraft:

(a) shall have such aircraft inspected as prevised in Subpart E of this Regulation and shall, between mandatory inspections, except as provided in paragraph (c) of this section, repair any discrepancies that may arise as provided in RBHA 43;

(b) ensure that maintenance personnel have made the appropriate notes in the aircraft maintenance records, indicating that it has been approved for return to service;

(c) ensure that any instrument or inoperative equipment, under paragraph 91.213 (d) (2) permissions, will be repaired, replaced, removed or inspected at the next required inspection; and

(d) when listing discrepancies, including inoperative instruments and equipment, it shall be ensured that a placard has been installed as required by section 43.11 of RBHA 43.

The mechanics working in Recife were interviewed regarding the understanding of the procedures contained in the AD 2014-23-16 and the techniques for performing the tap test.

Professionals demonstrated understanding that performing only the visual inspection on blades met the full compliance with AD 2014-23-16, during both daily and scheduled inspections.

Regarding the techniques for performing the tap test, the mechanics reported that the test was performed according to the instructions established by the aircraft manufacturer.

PREVIOUS ACCIDENTS

Characteristics related to the dynamics of the accident involving the PP-HLI aircraft were similar to previous occurrences involving aircraft manufactured by RHC (models R22 and R44/R44 II) in other countries.

Some of these occurrences were objects of study by the NTSB in the USA. In 2008, the NTSB published a document (Safety Recommendation, A-08-25 through - 29, 09JUN2008) which contained an analysis of three accidents involving model R44 aircraft.

Technicians from the NTSB Materials Laboratory examined the main rotor blades of the helicopters involved in these accidents. The exams found evidence of skin debonding, resulting in the inflight component failure.

The debonding found on the crashed helicopter´s blades had characteristics very similar to each other (Figure 56).

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DATE AND PLACE	MODEL	BLADE P/N	BLADES TIME IN SERVICE
Dominican Republic 11OUT2006	R44	C016-2	1.800h
• Fracture in the main rotor blade extended through the majority of the adhesive bond joints. • Fracture face of skin-to-spar adhesive bond joints showed adhesive failure at the leading edges of the skin and corresponding surface of the spar; the remaining areas of the bond joints showed mixed cohesive and adhesive fracture features with a high percentage of adhesive failure, an indication that the bond strength had deteriorated after the blade was manufactured. • Adhesive fractures propagated from the general area at the tip of the blade.			
Fiji Island 05DEZ2006	R44	C016-2	1.083h
• Extensive separations at the adhesive bond joints. • Origin of the adhesive bond fracture undetermined because fracture features emanated mostly from the tip area of the blade, which was not recovered. However, major portions of the fractures at the adhesive bond joints emanated from the leading edges of the skin. • The fracture features in the adhesive bond joints were markedly similar to those in the Dominican Republic event.			
Australia 15MAR2007	R44	C016-2	597h
• Leading edge of the lower skin at the tip was peeled back about 2.5 inches. • Peel damage extended about 17 inches inboard from the tip. • Lower skin in the area of the skin-to-spar bond joint showed evidence of paint erosion that exposed the bondline to the environment. • Exposed fracture face of the lower skin at the adhesive bond joint between the skin and spar showed randomly mixed adhesive and cohesive failure fracture features with several isolated areas at the leading edge of the skins showing adhesive fracture, an indication that the bond strength had degraded, causing separation of the lower skin. • The fracture features in the adhesive bond joints were markedly similar to those in the Dominican Republic and Fiji events.			

Figure 56 - Table of accidents involving model R44 aircraft.
(Source: Adapted from the NTSB Safety Recommendation A-08-25 through - 29).

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DOCUMENTS PUBLISHED AFTER THE ACCIDENT INVOLVING PP-HLI

On 23FEB2018, Robinson Helicopter Company issued a Safety Alert for the R22, R44 operators.

ROBINSON
HELICOPTER COMPANY
2901 Airport Drive, Torrance, California 90505 Phone (310) 539-0508 Fax (310) 539-5198

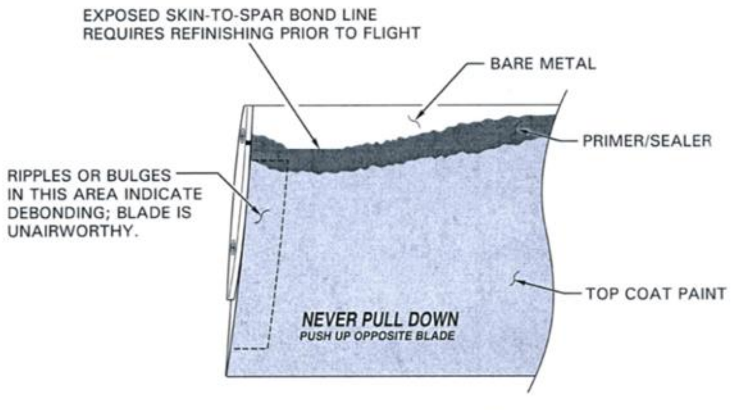
R22 & R44 SAFETY ALERT

Issued: 23 February 2018

A016-4, C016-2, & C016-5 MAIN ROTOR BLADES

RHC has received additional reports of improper inspection or poor maintenance resulting in skin debonding on earlier-design main rotor blades with stainless steel skins. Debonding can occur when the bond line at the spar is exposed due to erosion of the blade finish, or when corrosion occurs on the internal aluminum tip cap. R22 Service Bulletin SB-103A and R44 Service Bulletin SB-72A require the blades to be inspected by a mechanic at least every four months. FAA AD 2014-23-16 requires the pilot, before the first flight of each day, to visually check for any exposed (bare metal) skin-to-spar joint area on the lower surface of each blade. Pilots should also check for ripples or bulges on the outboard end of the blade skin, which would indicate corrosion damage and debonding between the skin and tip cap (see figure below). Failure to inspect and maintain the blades properly, particularly in harsh or corrosive environments, can allow erosion or corrosion to develop to the point that skin debonding occurs, potentially leading to a fatal accident. Do not fly with damaged blades!

AD 2014-23-16 also requires that all A016-4, C016-2, and C016-5 main rotor blades be taken out of service by 9 January 2020. RHC will offer a special discounted price for A016-6 and C016-7 blades to operators who choose to replace their blades earlier. Contact RHC Customer Support for additional information.



MAIN ROTOR BLADE LOWER SURFACE

Figure 57 - Safety Alert published by the RHC on 23FEB2018.
(Source: www.robinsonheli.com).

The published document stressed the importance of the procedures set out in the AD 2014-23-16 for P/N A016-4 (R22), P/N C016-2 (R44) and P/N C016-5 (R44) main rotor blades.

The Safety Alert also pointed out that the failure to follow these procedures could result in fatal accidents.

Finally, the manufacturer reminded the operators that these blades should be taken out of service by 09JAN2020.

In order to increase the perception of pilots, mechanics, and operators of the R22 and R44/R44 II aircraft in Brazil, the CENIPA published a DIVOP on 07MAR2018.

The DIVOP 02/2018 reaffirmed the need to comply entirely the procedures of the AD 2014-23-16, as well as the need to comply with the Safety Alert issued by the manufacturer, as indispensable actions for ensure safety of the operations in R22 and R44/R44II equipped with blades P/N A016-4; P/N C016-2 and P/N C016-5 in Brazil.

On 15MAY2018, the CENIPA published the DIVOP 003/2018. The document provided additional explanations of the situation and recommended that operators of models R22 and R44 perform visual inspections on the lower and upper surfaces of the main rotor blades prior to the first flight of each day, regardless of the blade P/N installed in your aircraft.

On 03MAY2018, the RHC published another Safety Alert, revised on 08JUN2018. At that time, the manufacturer reported that it had received several reports that R22 and R44 debonded main rotor blades were being repaired in Brazil.

The document pointed out that blades with skin debonding issues were not repairable and should be immediately removed from service. He also stressed that this practice could result in a fatal accident (Figure 58).

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HELICOPTER COMPANY

2901 Airport Drive, Torrance, California 90505 Phone (310) 539-0508 Fax (310) 539-5198

R22 & R44 SAFETY ALERT

Issued: 03 May 2018 Revised: 08 June 2018

UNAUTHORIZED REPAIRS ON MAIN ROTOR BLADES IN BRAZIL

Robinson Helicopter Company has received several reports and allegations from Brazil of R22 and R44 main rotor blades with debonded skins being "repaired" in the field and returned to service. **Debonded or "repaired" main rotor blades can lead to a fatal accident.** Any A016-4, C016-2, or C016-5 blade with a debonded skin is not field repairable and must not be returned to service. Any main rotor blade which has been previously "repaired" is unairworthy and must be immediately removed from service.

Owners, operators, and maintenance personnel who have or suspect they may have unairworthy blades should contact Peter Hallqvist (ts3@robinsonheli.com) with Robinson Technical Support immediately for verification and assistance in getting replacement blades.

Refer to R22 Service Letter SL-79 and/or R44 Service Letter SL-65.

R22 & R44 ALERTA DE SEGURANÇA

REPAROS PROIBIDOS E NÃO AUTORIZADOS NAS PÁS DO ROTOR PRINCIPAL ESTÃO SENDO FEITOS NO BRASIL

A Robinson Helicopter Company recebeu vários relatos do Brasil de pás do rotor principal do R22 e do R44 com descolamento que estão sendo reparadas e retornadas para vôo. **Pás do rotor principal com descolamento e com reparos proibidos e não autorizados podem levar a um acidente fatal.**

Quaisquer Pás fabricadas pela Robinson Helicopter Company incluindo as de P/Ns A016-4, C016-2 ou C016-5 com sinais de descolamento, NÃO SÃO REPARÁVEIS e devem ser imediatamente tiradas de serviço.

Qualquer pá do rotor principal que tenha sofrido reparo não autorizado não são aeronavegáveis e devem urgentemente serem removidas da aeronave.

Proprietários, operadores, e empresas de manutenção que saibam ou suspeitem de pás não aeronavegáveis devem contatar Peter Hallqvist (ts3@robinsonheli.com), do Suporte Técnico da Robinson Helicopter Company, imediatamente para verificação e assistência para adquirir a substituição das pás do rotor principal.

Usar como referência o Service Letter do R22 SL-79 e/ou Service Letter do R44 SL-65.

Figure 58 - Safety Alert published by RHC on 08JUN2018.
(Source: www.robinsonheli.com).

SURVEY WITH OPERATORS, PILOTS, AND MECHANICS

In order to assess whether helicopter operators, pilots, and mechanics of models R22 and R44 were aware of the existence of the AD 2014-23-16, a survey was conducted that addressed, among others, the following:

- At what point did the aircraft they operated were submitted to the inspections established by the AD 2014-23-16?

A total of 123 pilots and 26 maintainers of R22, R44 answered the survey.

Among the maintainers, 16.7% (red slice on the graphic) answered that aircraft maintained by them were submitted to AD inspections following the issuance of the 23FEB2018 Safety Alert (Figure 59).

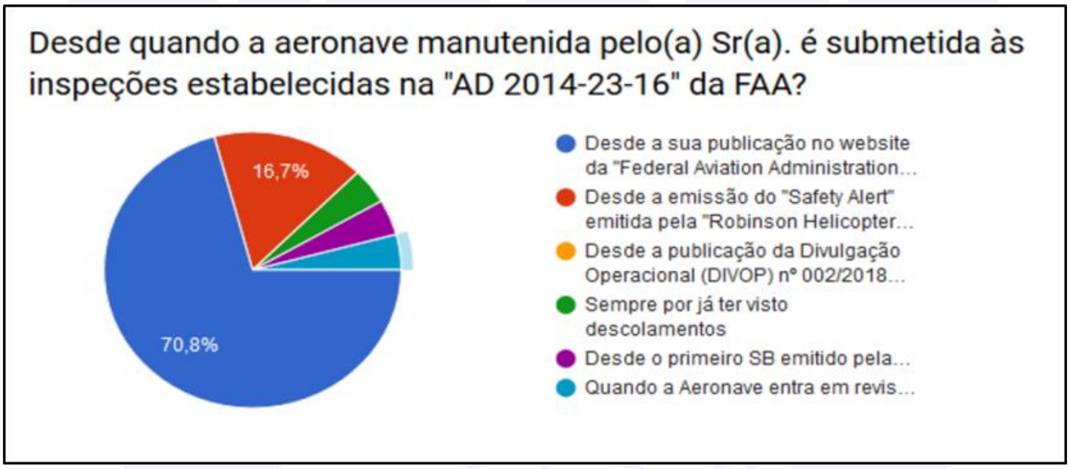


Figure 59 - Survey conducted with R22 and R44 maintainers.

Among the pilots, 35.8% (red slice on the graphic) answered that the aircraft they operated were submitted to the inspections contained in the AD following the issuance of the 23FEB2018 Safety Alert.

Another 15.4% of the interviewed pilots answered that the aircraft they operated began to be submitted to the inspections contained in the AD after the issuance of the DIVOP published by the CENIPA, on 07MAR2018 (Figure 60).

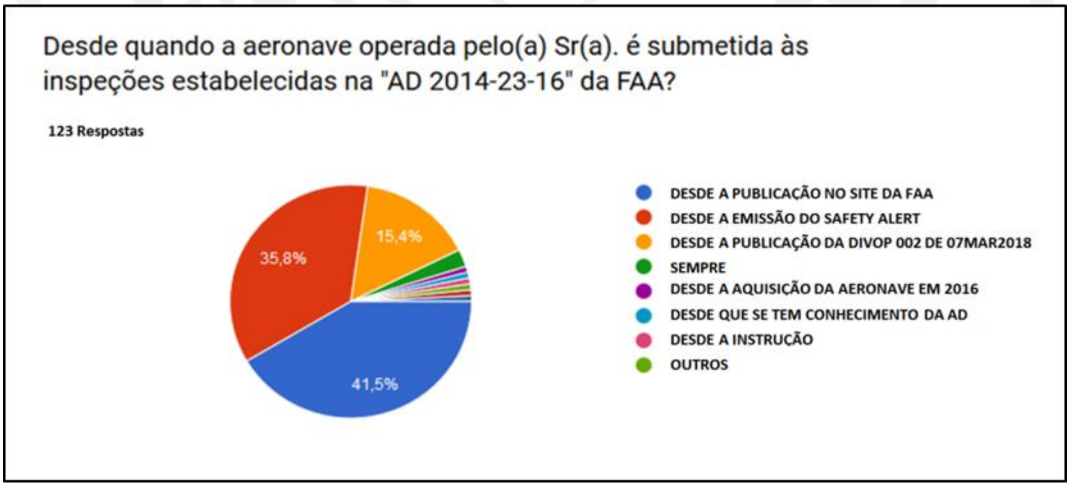


Figure 60 - Survey conducted with R22 and R44 pilots.

SERVICE DIFFICULTY REPORTS

The RBAC 145-EMD01 of 06MAR2014, valid at the time of the accident, stated in paragraph 145.221 that the Maintenance Organizations should report to the ANAC certain events, as excerpted:

> **SUBPART E - OPERATING RULES**
>
> **145.221 Service Difficulty Reports**
>
> (a) Each certified maintenance organization shall report to the ANAC and the type design holder, supplemental type design or approved aeronautical product Certification, any serious event of failure, malfunction, defect and other events defined by the ANAC within 96 (ninety-six) hours after its discovery. The report must be made in a format acceptable by the ANAC.

SUPPLEMENTARY INSTRUCTION 145-009B

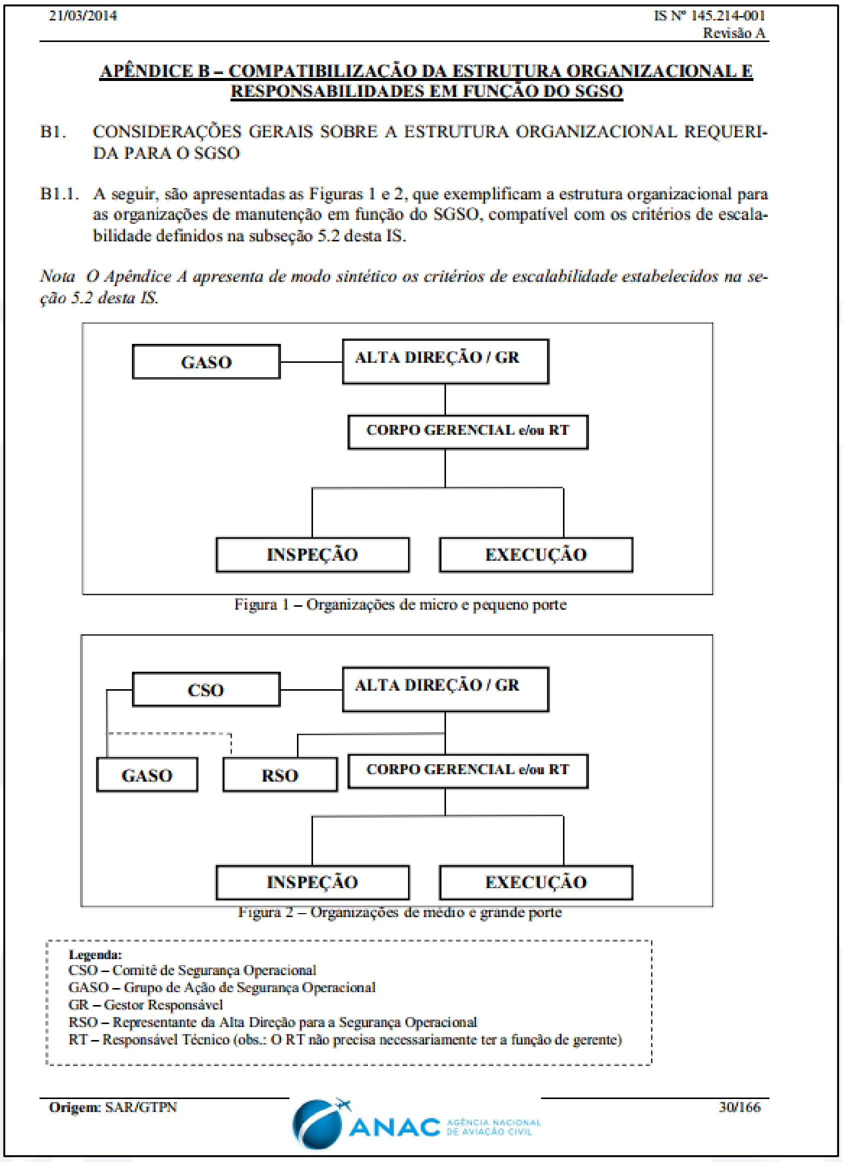
Regarding the work performed out of its headquarters, the IS 145-009B, among other aspects, stated that:

> 5.5.5 **Work Performed in Another Location**
>
> 5.5.5.1 ...
>
> 5.5.5.2 **Circumstances for the concession:** work performed in another location is a concession. It allows an OM to perform works in another location, other than the one that has been certified (also called headquarters or main base) under the following conditions: due to a special circumstance (an opportunity and temporary service and in certain emergencies), and the applicant (when it is necessary to repeatedly perform such work in other locations, during certain time intervals).
>
> 5.5.5.3 ...
>
> 5.5.5.4 **Long-term or Repetitive Services:** An authorization to perform services outside of your locality is always granted on an exceptional and temporary basis. Even so, the ANAC may grant authorizations of up to 6 months and may be extended for another 6 months.

SUPPLEMENTARY INSTRUCTION 145.214-001A

The IS 145.214-001A, which dealt with the Safety Management System (SGSO) in Aeronautical Product Maintenance Organizations, in item 5.6.1.3 (Element 1.3 - Designation of key operational safety personnel) stated that:

> (a) It is the responsibility of the key operational safety personnel, formally designated by the Responsible Manager, to define the planning and high-level coordination of the activities necessary for the implementation, maintenance and performance of the SGSO.
>
> (b) The SGSO structure designed and operationalized by the key operational safety personnel shall be consistent with the organizations' scalability criteria as defined in subsection 5.2 of this IS. The implementation and operationalization of this structure depends on the prior and formal decision of the organization regarding the following aspects:
>
> I - identification of the Manager Responsible for operational safety, as established in sub-paragraph “b” of sub-paragraph 5.6.1.2 of this IS;
>
> II - designation of the RSO, according to the hierarchical structure of the organization, as established in Appendices A and B of this IS; and
>
> III - constitution and performance of the Operational Safety Committee - CSO and the Operational Safety Action Group - GASO according to the criteria and recommendations set in Appendices A and B of this IS.
>
> c) The RSO shall have the required decision-making authority that in any way impacts the performance of the SGSO. It should report directly to the Responsible Manager as well as report to the latter one on operational safety and the SGSO issues.



21/03/2014 IS Nº 145.214-001
Revisão A

APÊNDICE B – COMPATIBILIZAÇÃO DA ESTRUTURA ORGANIZACIONAL E RESPONSABILIDADES EM FUNÇÃO DO SGSO

B1. CONSIDERAÇÕES GERAIS SOBRE A ESTRUTURA ORGANIZACIONAL REQUERIDA PARA O SGSO

B1.1. A seguir, são apresentadas as Figuras 1 e 2, que exemplificam a estrutura organizacional para as organizações de manutenção em função do SGSO, compatível com os critérios de escalabilidade definidos na subseção 5.2 desta IS.

Nota O Apêndice A apresenta de modo sintético os critérios de escalabilidade estabelecidos na seção 5.2 desta IS.

Figura 1 – Organizações de micro e pequeno porte

Figura 2 – Organizações de médio e grande porte

Legenda:
CSO – Comitê de Segurança Operacional
GASO – Grupo de Ação de Segurança Operacional
GR – Gestor Responsável
RSO – Representante da Alta Direção para a Segurança Operacional
RT – Responsável Técnico (obs.: O RT não precisa necessariamente ter a função de gerente)

Origem: SAR/GTPN ANAC AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL 30/166

Figure 61 - Appendix “B” of the IS 145.214-001A.
(Source: ANAC).

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was an aero-reporting flight to a TV channel.

The R44 II model was a single-engine helicopter capable of carrying three people (one crewmember and two passengers). The helicopter was equipped with a main rotor and a tail rotor, both two-bladed.

The helicopter´s main rotor blades had a Life Time Limit (TLV) of 2,200 hours or 12 years of operation, whichever occurred first.

The PP-HLI aircraft was manufactured in 2003 and operated for approximately seven years in the USA before being exported to Brazil.

In 2009, while still operating in the USA, the aircraft reached 2,200 flight hours of operation. Although not representing a limit for the helicopter, this amount of flight hours made up the TLV for the main rotor blades. This meant that upon reaching this mark, the blades should be replaced.

Thus, the USA operator arranged for the replacement of the blades that equipped the helicopter with two new blades P/N C016-5, S/N 6128 and S/N 6131. The new blades were purchased directly from the manufacturer (RHC) and there were no fault records or problem reports in the manufacturing process documentation.

The aircraft was exported to Brazil on 15DEC2010 and was acquired by the Brazilian operator on 08FEB2011.

At the time of ownership transfer, the helicopter had a total of 2,392 flight hours and the blades S/N 6128 and S/N 6131 had a total of 192 flight hours. The aircraft remained under the property of the same Brazilian operator from 08FEB2011 until the date of the accident.

In Brazil, the aircraft was registered in the Specialized Air Services Category - S00 (SAE multiple category).

According to the maintenance records, the engine logbook was up to date. However, the records of the airframe logbook were not following the legislation valid at the time of the accident.

The Airworthiness Certificate was valid and the last “IAM” type inspection was concluded on 17JAN2018, with the aircraft flying 5 hours and 30 minutes after this inspection.

At the time of the crash, the helicopter had a total of 3,859 hours and 10 minutes flown since new.

There are no records of repair services on the S/N 6128 and S/N 6131 blades in the aircraft documentation, both in the period in which it operated with those blades in the USA and in the period in which it operated in Brazil.

At the time of the accident, the PP-HLI blades had 1,659 hours and 10 minutes flown and were just over nine years since their date of manufacture. These values were less than the operating limit values (2,200 hours or 12 years). Therefore, no TLV limits set by the manufacturer for these components have been extrapolated.

The aircraft took off from the SBRF Aerodrome for an aero-reporting flight over the city of Recife, PE, with a pilot, a camera operator and a passenger on board.

There was bilateral contact between the helicopter and the air traffic control in the region.

The aircraft was approximately 500ft above ground level, over the Pina Beach, when people saw it on a vertical flight path until it crashed into the sea. At this moment, the onboard recording equipment recorded a vibration, and the recording was interrupted.

Security cameras recorded the final moments of the flight. The analysis of the video concluded that parts of the helicopter detached in flight and that the aircraft developed a vertical trajectory with a high rate of descent.

Analyzes of the prevailing weather conditions at the SBRF Aerodrome indicated that the ceiling was around 4,000ft high and the horizontal visibility was above 10,000m with rain in the vicinities of the Aerodrome and TCU clouds.

These ceiling and visibility values were higher than the meteorological minimums established for helicopter VFR operation, according to the ICA 100-4, valid at the time of the accident.

All the weather information was available to the pilot for flight planning.

The analyzes concluded that there was no significant severe weather capable of contributing to the accident.

No evidence of failure, fatigue or impact from firearm were found on the aircraft structure.

Exams ruled out the possibility of collision with fauna.

Exams, tests, and surveys were conducted on the wreckage of the aircraft to determine if its systems and components were functioning properly at the time of occurrence.

Regarding flight controls, the examinations found out that there was no continuity fault in the tubes and bellcranks that integrated the main and tail rotor control systems.

Engine tests showed that all internal components were intact, with no sign of inflight failure or malfunction.

The results of fuel samples analysis showed that fuel characteristics were within the limits established by the ANP and international agencies for aviation gasoline.

MGB exams found out that all internal components showed signs compatible with normal operation. No characteristics related to overheating, lack of lubrication, presence of metal chips, malfunctions or system jamming were found.

The tests conducted on the Governor Controller did not find relevant discrepancies regarding component performance in controlling the main rotor RPM. The tests concluded that the equipment was functional at the time of the accident.

The main rotor blades exams were performed at three different levels: visual exams, stereoscopic exams and X-ray Energy Dispersive Spectroscopy (EDS) exams by Scanning Electron Microscope (SEM). Some chemical composition analyses were also performed.

To understand the results of the tests conducted on the blades, it is necessary to know the general characteristics related to the structure of the components.

The R44 II main rotor blade structure was composed of an aluminum honeycomb core and two stainless steel skins (upper and lower skins).

A spar, also made of stainless steel, was installed on the leading edge. The tip of the blade was finished by an internal aluminum structure called tip cap and the whole end was protected by a cover, also of aluminum, called tip cover.

The various components of the blade were bonded by a polymer used as an adhesive material. In other words, the different parts that made up the blade structure were bonded together during the manufacturing process. The unique piece that was not bonded was the tip cover, which was attached to the tip cap by two screws.

The front sections of the upper and lower skins were bonded to the spar in a region known as a skin-to-spar bond joint. This region had dimensions of approximately 1.3 cm (0.5 in).

At the trailing edge of the blade, the upper and lower skins were bonded together just behind the honeycomb core (Figure 62).

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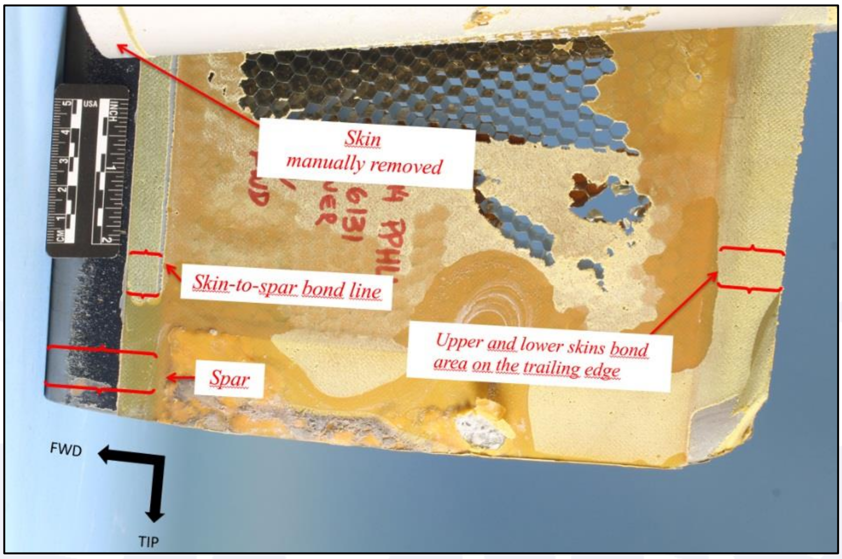

Figure 62 - Blue blade (S/N 6131) lower surface. Highlighted the areas where the skin was bonded to the spar (leading edge) and where the skins were bonded to each other (trailing edge).
(Source: Adapted from the NTSB).

The red blade tip (S/N 6128) was found sectioned and separated from the rest of the helicopter wreckage. Visual examinations performed at the tip of the red blade found the following (Figures 27, 28 and 29):

- areas with signs of debonding of the skins on the upper and lower surfaces;
- the forward area of the upper skin folded back;
- a detachment of the spar, which was not found near the blade tip; and
- fracture in the middle portion of the tip cover.

These characteristics indicated that the red blade had an inflight failure.

Despite some damage and deformation, the blue blade (S/N 6131) was found entirely and in better conditions than the red blade. These characteristics indicated that the blue blade did not have an inflight failure (Figure 25).

For that reason, the blue blade was chosen to be inspected following the AD 2014-23-16 standards. During the inspection, a tap test was performed that identified areas with signs of skin debonding.

After the tap test, the blue blade skins were manually removed. Examination of the inner parts of the blue blade found that in the externally demarcated areas during the tap test, there was internal debonding of the blade skin (Figure 43).

Confirmation demonstrated the effectiveness of the tap test in detecting debonded areas by acoustic responses of the tested surface (Figures 41 to 46).

After the removal of the skins, the blades were examined for corrosion. Some samples of the corrosion found on the upper and lower surfaces of both blades were collected.

The EDS analyses identified the collected samples as aluminum oxide, a product originated from the tip caps manufacturing material itself.

Corrosion was present above and below the original polymer layer, as seen in Figures 47 and 50. The presence of corrosion below the adhesive layer compromised the skin adherence to the spar and contributed to the red blade inflight failure.

It was also observed the presence of material with color and characteristics different from the original adhesive material used in the manufacture of the blade. The foreign material was found in both blades, both on the upper and lower surfaces. The substance had signs of propagation toward the inner regions of the blades, indicating that it had been inserted, or injected, from the outside. Spectrometric analyses concluded that the chemical product found was an epoxy resin derivative (Figure 51).

However, the absorbance peaks observed in the foreign material examination did not have the same intensity and definition as found in the original polymer. This showed that they were different materials with different chemical compositions. The difference between the absorbance peaks may have been caused, among other factors, by the presence of humidity (Figure 52).

The same type of corrosion found under the original polymer layer was also found under the foreign material layer. This fact demonstrated that this substance was inserted after the beginning of the corrosion process in the blades. It also revealed that the application of the foreign product did not interrupt the corrosive process that was in progress.

In both blades, all regions that had this foreign product had adhesive fractures (debonding). In other words, adhesive fractures are flaws in the interface between the adhesive material and the metal, characterized by debonding.

Therefore, it was concluded that the presence of filler material compromised the adhesion of the skin to the spar and contributed to the red blade failure in flight.

Part of the upper skin of the red blade (S/N 6128) was found debonded and folded back. This region of the blade was analyzed using a microscope to determine the direction of the propagation of adhesive fractures (Figure 63).

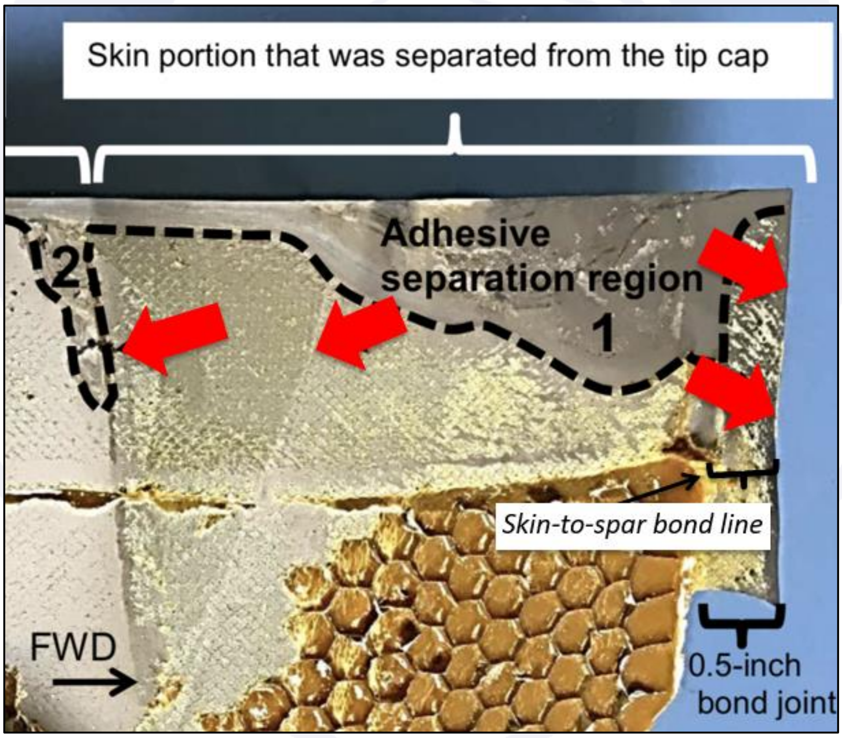

Figure 63 - Direction of the propagation of adhesive fractures in the upper skin region that was found debonded and folded backwards.
(Source: Adapted from the NTSB).

It was noted that the adhesive fractures in the skin-to-spar bond line region had forward propagation, toward the leading edge of the blade (red arrows in the upper right corner of Figure 63). However, fractures located in the central region of the skin (red arrows in the upper left corner of Figure 63) had a backward propagation, toward the trailing edge of the blade.

Examinations corroborated that the peeling off of the red blade upper skin (S/N 6128) occurred in flight.

The peeling off began at the leading edge of the blade, more precisely in the skin-to-spar bond line area. The relative wind incident at the leading edge, due to the blade inflight revolution, lifted up the front portion of the upper skin, causing the peeling off of approximately 50% of the skin toward the trailing edge of the blade. (Figure 64).

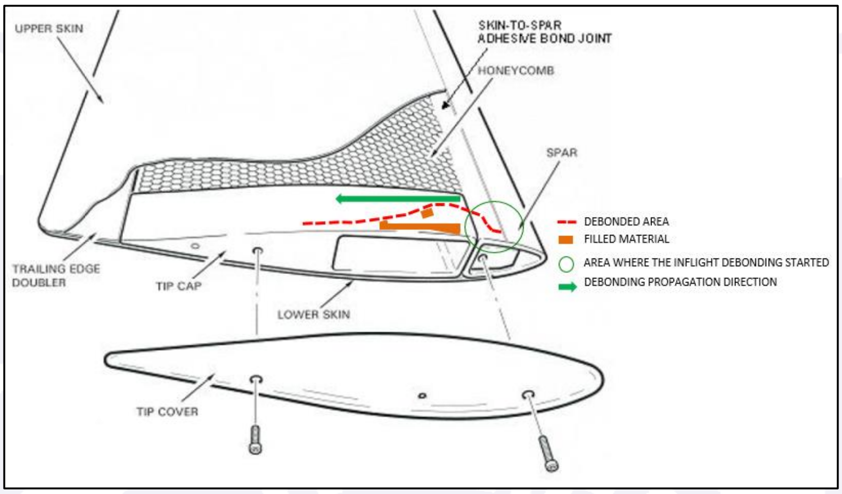

Figure 64 - Schematic representation of the in-flight take-off dynamics of the red blade (S/N 6128).
(Source: Adapted from www.robinsonheli.com).

According to aerodynamic studies conducted by the IPEV, the inflight upper skin peeling off generated the following consequences on the red blade:

- decreased ability of the blade to generate lift;

- increased amplitude of the blade flapping motion;

- changes in balancing and tracking of the main rotor; and

- increased system vibration.

These associated consequences generated a vertical flapping motion that exceeded the separation limits between the main rotor blades and the tailcone, causing the collision between the parts. The tailcone strike by the main rotor blades damaged the structure and caused the entire inflight tail rotor assembly separation from the rest of the aircraft.

At the moment of the collision between the parts, the red blade had its tip fractured, reason why this part was found distant from aircraft wreckage.

The images from the helicopter camera, which recorded high vertical vibration of the aircraft at the time of the crash; the images taken by security cameras, which recorded inflight separation of aircraft parts; the marks found on the tailcone and main rotor blades, which revealed contact between the parts; and the characteristics of the damage found in the tail rotor blades, which indicated slow rotational energy at the moment of impact, corroborated to the accident dynamics.

The R44 blades had a skin debonding failure history as a contributing factor in at least three accidents prior to the occurrence of PP-HLI. As a result of these findings, some prevention and control measures were recommended by the RHC (Service Bulletins) and determined by the FAA (Airworthiness Directives).

Visual and maintenance inspections were added to the main rotor blade operating routine through Service Bulletins and Airworthiness Directives to allow debonding areas to be detected before a catastrophic failure occurs.

The finding that there was an adhesive material different from the original on both blades (S/N 6128 and S/N 6131) suggested that, at some point in the operative life of these components, prior to the accident flight, areas with signs of debonding were detected and that, in an attempt to correct these faults, a filler material was applied. This application of filler material was consistent with an unapproved repair.

According to SB-72A and AD 2014-23-16, blades with debonding in this region were considered unairworthy. In other words, blades in this situation should be removed and their use was unacceptable.

Acceptance limits for skin-to-spar bond line debonding were very tight. According to SB-72A paragraph (3) (Figure 8), even small faults such as pin holes would leave the blade in unairworthy condition.

For debonding in these critical areas, the blades could not be repaired. The only solution in these cases was to replace the blade, as highlighted in the red rectangle in Figure 5 (SB-72A), which gives examples of faults that, if found, would turn the blade unairworthy.

There were no records of repairs related to blade debonding, either in the period of flight in the USA or in the period of operation in Brazil. The maintenance professionals interviewed reported not being aware of any such repairs performed on the aircraft.

Therefore, it was not possible to specify in which country, time, place and circumstances the application of the filler material found in the PP-HLI blades took part. No failure records or problem reports were found in the documents related to the blade manufacturing process. In addition, the foreign material had a different chemical composition from the material used by the RHC during the blade manufacturing process. Thus, a blade that had been subjected to the application of this material would not be approved by the manufacturer's quality control.

The PP-HLI maintenance records regarding the compliance with AD 2014-23-16 revealed that the records were not following the parameters established in the legislation in force at the time of the accident. The maintenance record issues were related to the OM and the aircraft Operator as well, as existing legislation (IS 39-001 and RBHA 91) assigned both responsibilities associated with this type of record.

Among other factors, the aircraft documentation did not include adequate detailing of primary maintenance records, mainly regarding the AD 2014-23-16 procedures, contrary to the instructions contained in paragraph 5.14 of IS 39-001 Rev A, from 17AUG2012.

According to the aforementioned IS, the AD compliance records should clearly state the method used. However, the recordings in the PP-HLI airframe logbook regarding compliance with the AD 2014-23-16 attested only to the visual inspection of the blades. There was no reference in the notes to the tap test as one of the methods used to perform this AD.

However, professionals working at the OM demonstrated understanding that performing the visual inspection on the blades would fully met the compliance with AD 2014-23-16 procedures. This understanding was not compatible with the level of detail of the maintenance procedures in the AD, which required tap testing every 100h or IAM, whichever occurred first.

Misunderstanding of the AD content may be related to the absence of recurring training for mechanics, where these professionals could receive updated knowledge of maintenance practices required for effective compliance with the AD 2014-23-16, and thus, in this way, they would improve the skills and knowledge necessary to perform a suitable, qualified and safe work.

The last “IAM” type inspection of the aircraft was completed on 17JAN2018, six days before the crash. During this annual inspection, the AD 2014-23-16 protocols should be performed, including a tap test.

In an interview, the mechanics who performed the last IAM reported that they completed the tap test during the AD 2014-23-16 compliance procedures. However, this procedure was not recorded in the aircraft airframe logbook as required by IS 39-001 Rev A of 17AUG2012. For this reason, it was not possible to attest the effective compliance with the AD procedures.

The results of the blue blade tap test conducted in the NTSB laboratory showed that if the tests were performed using the proper techniques, the signs of debonding present in both blades would probably be detected during routine programmed inspections.

On the other hand, it is not possible to discard that the presence of filler material in the blades could have compromised the interpretation of the tap test results, in case of this test was performed during the last Annual Maintenance Inspection.

A survey was applied to R22 and R44 operators, pilots and mechanics to assess whether these professionals were aware of the existence of the AD 2014-23-16.

The survey results attested that 16.7% of the interviewed maintainers responded that the aircraft they maintained were submitted to the AD inspections after the 23FEB2018 Safety Alert (Figure 59). In other words, these maintainers only heard about the AD after the accident involving the PP-HLI aircraft.

This aspect evidenced that ANAC R22/R44 accredited shop maintainers, supposedly, were unaware of the AD procedures, considered critical for the safety of these aircraft operations. This scenario constituted a high-risk factor for the project operation in Brazil.

Among pilots, 35.8% responded that the aircraft they operated were submitted to the AD inspections after the 23FEB2018 Safety Alert was issued and 15.4% answered that the aircraft they operated began to be submitted to the AD inspections after the issuance of the DIVOP, published by the CENIPA on 07MAR2018 (Figure 60). This means that 51.2% of the interviewed pilots said they had become familiar with the AD procedures only after the accident involving the PP-HLI.

This finding reinforced the existence of a latent risk condition for the operation of the project in Brazil since the AD also established procedures for pilots, which were fundamental in monitoring the airworthiness conditions of the blades. Through visual inspections prior to the first flight of each day, pilots should monitor the airworthiness conditions of the main rotor blades for exposed metal and signs of debonding.

Besides the issues related to the AD compliance records in the airframe logbook, was also identified the absence of the RT signature in the fields intended to approve the aircraft return to service after inspections. Possibly, issues related to the AD compliance records and the absence of RT signatures were related to management oversight failures within the responsible maintenance organization during off-site services.

The succession of out of headquarters inspections for more than 12 months characterized a systematization (continuous and uninterrupted) in compliance with the aircraft maintenance program, contrary to the IS 145-009B.

The fact that one of the OM professionals belongs to senior management, as one of the owners, and also accumulates the role of chief inspector, led to the possibility of conflict in the operational safety management process.

The duties performed by this professional were structured at different levels of authority, in which the position of chief inspector was in line with authority lower than the managerial level of the OM, which included the level of operational safety management, according to the model established in item 5.6.1.3 of the IS 145.214-001A.

In addition, there may also have been a conflict of roles arising from the different responsibilities assigned to each role performed by the same person. Thus, in this scenario, the actions and decisions issued by the chief inspector may have been freely accepted or not subjected to some kind of oversight at the OM.

Section 145.221 of the RBAC 145 provided that OMs should report to the ANAC situations of difficulties in service. These reports provide to Civil Aviation Authorities a better view of the real airworthiness conditions of projects.

During the interviews, some maintainers reported that it was not a recurrent OM practice to report to the ANAC the service difficulties concerning the R44 project.

This context compromised the proper follow-up of the theme by the ANAC and, consequently, by the FAA, the project's primary certification authority.

3. CONCLUSIONS.

3.1 Facts.

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

b) the pilot had valid HMNC Rating;

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

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

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

f) the airframe logbook records were not following the legislation valid at the date of the accident;

g) on 15JUL2009, the main rotor blades that equipped the helicopter were replaced by two new blades P/N C016-5 (S/N 6128 and S/N 6131) due to life limit;

h) the helicopter operated in the USA until December 2010, with the new blades installed;

i) on 08FEB2011, the helicopter was acquired by the Brazilian operator;

j) at the time of the accident, the blades had flown 1,659 hours and 10 minutes, being over 9 years since its date of manufacture;

k) blade TLV limits were not extrapolated;

l) there are no records of blades repair services in the aircraft documentation;

m) the aircraft took off from the SBRF Aerodrome for an aero-reporting flight;

n) observers saw the aircraft in a downward trajectory until colliding into the sea;

o) the onboard recording equipment recorded a vibration, and the recording was interrupted;

p) no severe weather phenomenon was found capable of contributing to the accident;

q) red blade examinations (S/N 6128) found that the component had an inflight failure;

r) the presence of corrosion below the adhesive layer contributed to the red blade (S/N 6128) inflight failure;

s) the presence of filler adhesive material contributed to the red blade (S/N 6128) inflight failure;

t) the foreign material had a different chemical composition from the material used by the RHC during the blade manufacturing process;

u) the presence of the filler material was consistent with an unapproved repair on the blades;

v) it was not possible to specify in which circumstances the application of filler material found on the blades took place;

w) the debonding began at the leading edge of the red blade (S/N 6128) in the skin-to-spar bond line area;

x) the relative wind incident on the red blade (S/N 6128) caused a peeling off of 50% of the forward portion of the upper skin;

y) there was a collision between the main rotor blades and the tailcone;

z) the tailcone has been fractured;

aa) there was loss of control in flight and the aircraft crashed into the sea;

bb) blue blade examinations (S/N 6131) found that the component had debonded areas, but did not fail in flight;

cc) from 17DEC2007, Airworthiness Directives were issued dealing with the prevention of main rotor blade failures and subsequent loss of control of the aircraft, due to skin debonding;

dd) AD 2014-23-16 incorporated SB-72A, making it mandatory;

ee) both AD and SB mentioned tap testing as a method of complying with maintenance procedures;

ff) AD 2014-23-16 compliance records on the airframe logbook were not following IS 39-001 Rev A standards;

gg) laboratory tests on the blue blade (S/N 6131) demonstrated the effectiveness of the tap test in recognizing skin debonding;

hh) the aircraft was destroyed; and

ii) all occupants of the aircraft died as a result of the accident.

3.2 Contributing factors.

- **Aircraft maintenance – a contributor.**

The presence of unapproved filler material found on both blades, both on the upper and lower surfaces, with signs of propagation towards the innermost regions indicated that this product was inserted or injected from the outside inwards, consistent with an unapproved repair.

The presence of corrosion found below the original polymer layer and below the unapproved filler material layer showed that the substance was inserted at a date after the beginning of the corrosion process.

Debonding was found in all regions that had this filler material, in both blades.

This aircraft was traded more than once, and it was the property of different owners since it was new. Consequently, it had performed maintenance services in various Maintenance Organizations. There was no record of blade repair in the aircraft maintenance records. Therefore, it was not possible to specify in which country, time, place, and circumstances the filler material found in the blades was applied.

According to Brazilian Aviation Regulations the owners or operators were primarily responsible for the airworthiness of the products they operate (IS 39-001 Rev A, item 5.12.2). In addition, they must ensure that maintenance personnel has performed appropriate notes in the aircraft maintenance records logbooks (RBHA 91, item 91.405, letter “b”).

- **Managerial oversight – a contributor.**

The succession of inspections carried out away from headquarters, for a period exceeding 12 months, in disagreement with the provisions of the IS 145-009B, compromised the establishment of the correct follow-up of the work, thus impairing the proper compliance with the AD 2014-23 -16 and the correct record in the airframe logbook as to the methods effectively used during the inspections of referred guideline.

- **Organizational processes – a contributor.**

The OM practices involving non-compliance with current legislation, such as the IS 145-009B and the RBAC 145 - section 145.221, denoted the existence of organizational procedures that compromised the safety of the R44 operation.

In addition, the recurring lack of reports on service difficulties in relation to the R44 project, specifically involving the main rotor blades, represented a failure in the OM's communication processes with the ANAC, which compromised the monitoring of the real airworthiness conditions of the project in Brazil and by the FAA, the primary certification authority.

- **Training – undetermined.**

The absence of recurring training for mechanics may have contributed to a misunderstanding of the maintenance procedures specified in the AD 2014-23-16 and, consequently, resulted in inadequate compliance with these procedures, with the required level of detail.

- **Work organization – undetermined.**

The accumulation of duties at different hierarchical levels by the same professional, as well as the conflict of roles resulting from this situation, may have impacted the operational safety management process, so that the actions and decisions issued by the chief inspector may have had free acceptance or not have been subjected to some kind of supervision in the OM.

4. SAFETY RECOMMENDATION.

A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident. In addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies.

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

Recommendations issued at the publication of this report:

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

A-015/CENIPA/2018 - 01 **Issued on 10/29/2020**

Work with *Fênix Recuperação e Manutenção de Aeronaves* Ltd., in order to ensure that the maintenance organization produces the documents for return to service of the aircraft in accordance with the MOM adopted by the company, and also ensure that deadlines and repetitions of out of headquarters inspections take place as required by the IS 145-009B.

A-015/CENIPA/2018 - 02 Issued on 10/29/2020

Work with *Fênix Recuperação e Manutenção de Aeronaves* Ltd. to ensure that the company performs the main rotor blade inspections of aircraft manufactured by Robinson Helicopter Company, models R22, R44 and their variations, in accordance with the provisions of the Maintenance Manuals of these projects.

A-015/CENIPA/2018 - 03 Issued on 10/29/2020

Work with pilots, operators, and maintainers of aircraft manufactured by Robinson Helicopter Company, models R22, R44, and their variations, to ensure that these regulated entities comply in an acceptable manner with the processes set in the technical publications of these aircraft.

A-015/CENIPA/2018 - 04 Issued on 10/29/2020

Work with *Fênix Recuperação e Manutenção de Aeronaves* Ltd., to make sure that maintenance organization improves its Management Supervision mechanisms in the technical and administrative areas, especially regarding the maintenance services performed out of the headquarters of the aircraft manufactured by Robinson Helicopter Company, models R22, R44, and their variations.

A-015/CENIPA/2018 - 05 Issued on 10/29/2020

Work with *Fênix Recuperação e Manutenção de Aeronaves* Ltd., in order to re-evaluate the adequacy of the SGSO and the compliance with the MGSO adopted by that maintenance organization, following the IS 145.214-001B protocols.

A-015/CENIPA/2018 - 06 Issued on 10/29/2020

Work with approved Maintenance Organizations to perform maintenance services on the main rotor blades of aircraft manufactured by Robinson Helicopter Company, model R22, R44, and their variations, so that these companies effectively comply with the provisions of section 145.221 of RBAC 145 – Service Difficulty Reports.

A-015/CENIPA/2018 - 07 Issued on 10/29/2020

Work with *Fênix Recuperação e Manutenção de Aeronaves* Ltd., so that maintenance organization assures the mechanics who perform in it, initial and recurrent training that make them able to perform the assigned tasks, and that such training is documented in an acceptable format, according to section 145.163 of RBAC 145.

A-015/CENIPA/2018 - 08 Issued on 10/29/2020

Act with *Helisae Serv. Aéreo Especializado* Ltd., to make sure that the company improves its administrative and operational mechanisms of receiving, registering and verifying the maintenance services performed on the aircraft operated by it, as a way to prevent aeronautical occurrences.

A-015/CENIPA/2018 - 09 **Issued on 10/29/2020**

Disseminate the lessons learned from this investigation to alert pilots, operators and maintainers of R22, R44, and their variations on the importance of keeping up to date with the Technical Publications issued by the RHC, FAA and ANAC, notably, as regards the issuance of the SB and AD.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

Issuance of the DIVOP 002/2018, of 07MAR2018, and the DIVOP 003/2018, of 15MAY2018.

On 03FEB2020, ANAC published an Alert for all Robinson Helicopters Operators and certified Maintenance Organizations highlighting that the due date for accomplishing AD 2014-23-16, issued by FAA, was 09JAN2020.

The aforementioned Alert had an informational aspect since ADs were mandatory according to Brazilian Aviation Regulations in force at the time of the issuance of this Final Report.

On Octuber 29th, 2020.

ANNEX A - AD 2014-23-16

[Federal Register Volume 79, Number 234 (Friday, December 5, 2014)]
[Rules and Regulations]
[Pages 72132-72135]
From the Federal Register Online via the Government Printing Office [www.gpo.gov]
[FR Doc No: 2014-28478]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 39

[Docket No. FAA-2013-0159; Directorate Identifier 2012-SW-010-AD; Amendment 39-18032; AD 2014-23-16]

RIN 2120-AA64

Airworthiness Directives; Robinson Helicopter Company Helicopters

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: We are superseding Airworthiness Directive (AD) 2011-12-10 for Robinson Helicopter Company (Robinson) Model R22, R22 Alpha, R22 Beta, R22 Mariner, R44, and R44 II helicopters with certain main rotor blades (blade) installed. AD 2011-12-10 required inspecting each blade at the skin-to-spar line for debonding, corrosion, a separation, a gap, or a dent and replacing any damaged blade with an airworthy blade. This new AD also requires a terminating action for those inspection requirements. These actions are intended to detect debonding of the blade skin, which could result in blade failure and subsequent loss of control of the helicopter, and to correct the unsafe condition by replacing the main rotor blades with new blades that do not require the AD inspection.

DATES: This AD is effective January 9, 2015.

The Director of the Federal Register approved the incorporation by reference of certain publications listed in this AD as of January 9, 2015.

The Director of the Federal Register approved the incorporation by reference of certain other publications listed in this AD as of July 5, 2011 (76 FR 35330, June 17, 2011); corrected March 5, 2012 (77 FR 12991).

ADDRESSES: For service information identified in this AD, contact Robinson Helicopter Company, 2901 Airport Drive, Torrance, CA 90505; telephone (310) 539-0508; fax (310) 539-5198; or at http://www.robinsonheli.com/servelib.htm. You may review a copy of the referenced service information at the FAA, Office of the Regional Counsel, Southwest Region, 2601 Meacham Blvd., Room 663, Fort Worth Texas, 76137.

Examining the AD Docket

You may examine the AD docket on the Internet at http://www.regulations.gov or in person at the Docket Operations Office between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. The AD docket contains this AD, any incorporated-by-reference service information, the economic evaluation, any comments received, and other information. The street address for the Docket Operations Office (phone: 800-647-5527) is U.S. Department of Transportation, Docket Operations Office, M-30, West Building Ground Floor, Room W12-140, 1200 New Jersey Avenue SE., Washington, DC 20590.

FOR FURTHER INFORMATION CONTACT: Fred Guerin, Aviation Safety Engineer, Los Angeles Aircraft Certification Office, Transport Airplane Directorate, FAA, 3960 Paramount Blvd., Lakewood, CA 90712; telephone (562) 627-5232; email fred.guerin@faa.gov.

SUPPLEMENTARY INFORMATION:

Discussion

On February 25, 2013, at 78 FR 12648, the Federal Register published our notice of proposed rulemaking (NPRM), which proposed to amend 14 CFR part 39 to supersede AD 2011-12-10, Amendment 39-16717 (76 FR 35330, June 17, 2011), corrected March 5, 2012 (77 FR 12991), that applied to Robinson Model R22, R22 Alpha, R22 Beta, and R22 Mariner helicopters with blade, part number (P/N) A016-4; and Model R44 and R44 II helicopters with blade, P/N C016-2 or C-016-5, installed. AD 2011-12-10 required a pilot check of the blade skin-to-spar joint area for any bare metal before the first flight of each day. AD 2011-12-10 also required repetitively inspecting each blade for corrosion, separation, a gap, or a dent, refinishing any bare metal before further flight, and replacing any damaged blade with an airworthy blade. AD 2011-12-10 was prompted by a fatal accident due to blade delamination.

At the time we issued AD 2011-12-10, Robinson had developed replacement blades on the R22 and R44 model helicopters. AD 2011-12-10 was issued as a Final rule; request for comment; however, the amount of time permitted to replace the blades required allowing the public an opportunity to comment. Thus, the NPRM proposed to retain the pilot check, recurring inspection, and blade refinishing requirements of AD 2011-12-10. An owner/operator (pilot) may perform the visual check required by paragraph (f)(1) of this AD and must enter compliance with that paragraph into the helicopter maintenance records in accordance with 14 CFR 43.9(a)(1) through (4) and 91.417(a)(2)(v). A pilot may perform this check because it involves only looking at a visible area of the blades and can be performed equally well by a pilot or a mechanic. This check is an exception to our standard maintenance regulations. The NPRM also proposed to add a part-numbered blade to its applicability for R22 model helicopters. Lastly, the NPRM proposed to require, within five years of the effective date, replacing both main rotor blades with the new part-numbered aluminum blades, which would constitute terminating action of the recurring inspection requirements. These actions are intended to detect and prevent debonding of the blade skin, which could result in blade failure and subsequent loss of control of the helicopter.

Comments

After our NPRM (78 FR 12648, February 25, 2013) was published, we received comments from 15 commenters and have given due consideration to each one. We have identified five unique issues and addressed those issues as follows.

Requests

Ten operators requested that we withdraw the NPRM and allow continued repetitive inspections of the blades for all affected models, as there is insufficient data justifying the termination of the requirement for repetitive inspections and for replacing the main rotor blades with new blades that do not require the AD inspection. One commenter noted that there have been no blade failures since the procedures of AD 2011-12-10 have been implemented, and therefore the NPRM increases the financial burden to an operator without increasing safety. Another commenter requested that more data be obtained regarding the effect of the operating environment and the inspection accordingly modified. Two commenters stated that a salt air environment caused the debonding due to corrosion. Some commenters state that inspections and routine maintenance, if done correctly, will ensure continued operational safety.

We do not agree. Blade debonding continues to occur in service. The cause of the debonding was determined to be erosion on unpainted blade tip bond lines which allows the bond to weaken and the skin to pull up. The erosion is mechanical and occurs in any environment regardless of salt or moisture in the air. This unsafe condition is sufficient to mandate inspections due to the catastrophic consequences if the blade becomes delaminated. However, airworthiness cannot be assured long-term by reliance on continued repetitive inspections. Although there have been no fatalities since we issued AD 2011-12-10, Robinson continues to report instances of blade delamination found during maintenance checks. Because blades continue to have debond issues, and as using a safety-by-inspection approach for a critical component has been shown to have an inherent amount of risk, it is in the interest of safety to reduce the retirement of the blades from 12 years from the blade manufacturing date to an earlier date.

Five operators requested that we remove the requirement for replacing the blades for the R44 Astro models, because these models are not equipped with hydraulic assisted controls and the new blades cannot be installed on these models unless the helicopter is converted to hydraulic assisted controls, a costly conversion which is not necessary for safe flight. These commenters further stated that the conversion is not only an additional expense but also can only be performed at the Robinson factory. One commenter believed the new blades are compatible with the non-hydraulic airframe and requested we require that Robinson test the new blades on the non-hydraulic R44 Astro airframe, so that the new blades can be installed on the R44 Astro without also having to convert the helicopter. The commenters also stated that Robinson then reserves the right to upgrade any component on the helicopter to their latest revision even though there is no AD or SB stating the Robinson required change, and this Robinson requirement results in additional cost increase. One commenter requested that we justify this requirement for the R44 Astro helicopters by identifying the number of reports of blade delamination on R44 Astros and explain the safety improvement resulting from converting a helicopter to hydraulic assisted controls. Finally, the commenters also stated that requiring replacement of the blades (and thus, conversion) for R44 Astro helicopters significantly reduces the resale value of these helicopters.

We do not agree. The R44 Astro is subject to the same unsafe condition as the other R22 and R44 helicopter models. The purpose of this AD is not to require converting a helicopter to hydraulic assisted controls; the purpose is to correct this unsafe condition on the blades. Robinson's decision whether to test the new blades with the non-hydraulic R44 Astro helicopter is a business decision, and the FAA does not have the authority to mandate a different decision. Similarly, Robinson's decision to discontinue blades designed for the non-hydraulic equipped helicopters is a business decision that the FAA does not have the authority to change. Because the blades for the non-hydraulic equipped R44 Astro helicopters are calendar life limited to 12 years and will no longer be produced, and as the manufacturer has not pursued FAA approval for installation of the new blades on the non-hydraulic R44 Astro, the owners of the Astro helicopter will need to install hydraulic assisted flight controls after 12 years regardless of the AD requirements. The FAA acknowledges that the expense and downtime to accomplish the blade replacement is greater for the R44 helicopters that are not equipped with hydraulic assisted controls. However, this greater cost due to an absence of hydraulic controls, while unfortunate, does not change the blade safety issue or the need to require replacement of the blades prior to their retirement life.

Four operators stated that the FAA has not considered the cost of this AD on operators and requested that Robinson be responsible for the cost of the new blades. One commenter also requested that Robinson be responsible for the cost of converting the R44 Astro to hydraulic assisted flight controls, as this will be required for that model when the new blades are installed.

We do not agree. While we acknowledge that the costs associated with the actions of this AD are not minimal, we have determined that these costs are reasonable given the unsafe condition. As far as request for Robinson to bear these costs, the FAA does not have the authority to require a manufacturer to bear the cost of a repair.

One commenter requested that we require blade replacement at the 2,200 hour overhaul or 12 years instead of the 5-year compliance time. The commenter stated that as Robinson started the production of new blades about 3 years ago, the 5-year replacement period would require some owners to replace the blades long before reaching the 12-year inspection, and this financial cost was not taken into account with the proposed rule.

We do not agree. We determined a replacement period of five years from the date of the AD by using a quantitative and qualitative risk assessment methodology. The risk of blade skin debonding results in a loss of control of the helicopter and is beyond acceptable risk guidelines when allowing the blades to continue in service indefinitely. Although the risk assessment indicates that immediate action is required to correct the unsafe condition, this risk is partially mitigated by the improved inspection techniques, making it acceptable to allow a five year period of time for blades to be replaced. The added cost to retire the blades has been anticipated in the financial burden justification of this AD. The FAA acknowledges that in some situations the cost to the operator may be in excess of the cost of the replacement blades, but we have determined that the costs associated with the actions of this AD are reasonable given the safety issue.

Lastly, one commenter did not make a request but stated that bare metal can be seen on areas of the helicopter and that the helicopter manufacturer provides poor corrosion protection on the helicopter. The commenter explained that metal-to-metal contact causes the corrosion that occurs on the blades.

We disagree. Metal-to-metal contact may be a mechanism that is causing the corrosion in the rotor blade tip cap to skin interface, but it has not been shown to be a mechanism for skin debonding in the area of the blade that has been found in the fleet. Skin debonding is the unsafe condition the actions in this AD are correcting.

FAA's Determination

We have reviewed the relevant information, considered the comments received, and determined that an unsafe condition exists and is likely to exist or develop on other products of these same type designs and that air safety and the public interest require adopting the AD requirements as proposed, except we are allowing compliance with the revised service information as an optional action. We have also made clarifications in the economic analysis to reflect the correct cost of required parts and labor for R-44 helicopters without hydraulically boosted flight controls installed. The total estimated cost for these model helicopters has not changed. These changes are consistent with the intent of the proposals in the NPRM (78 FR 12648, February 25, 2013) and will not increase the economic burden on any operator nor increase the scope of the AD.

Related Service Information

We have reviewed the following Robinson service information:

- Letter titled "Additional Information Regarding Main Rotor Blade Skin Debonding," dated May 25, 2007, discussing blade skin debonding;

- Rotorcraft Flight Manual (RFM) changes to the Normal Procedures Section 4 and Systems Description Section 7, revised April 20, 2007, for each applicable model helicopter containing a "caution" about skin-to-spar bond line erosion;
- One Service Letter with two different Nos.: R22 SL-56B and R44 SL-32B, both revised April 30, 2010, specifying proper inspection and protection (refinishing) of bonded areas; and
- Service Bulletins SB-103 for the Model R22 and SB-72 for the Model R44, both dated April 30, 2010, and SB-103A and SB-72A, both dated July 19, 2012, specifying proper inspection and protection (refinishing) of bonded areas for certain affected blades.
- R44 Service Letter SL-37, dated June 18, 2010, specifying the required modifications for a carbureted R-44 to install P/N C016-7 blades.

Costs of Compliance

We estimate that this AD affects 1,290 Model R22 helicopters and 1,353 Model R44 helicopters, for a total of 2,643 helicopters of U.S. Registry. At an average labor rate of $85 per hour, we estimate that operators will incur the following costs in order to comply with this AD:

- Time to perform the before flight check each day is negligible.
- Inspecting both blades will require about three work hours, for a total cost per helicopter of $255 and a total cost to the U.S. operator fleet of $673,965.
- Replacing both blades on a Model R22 helicopter will require about 20 work hours, and required parts will cost $29,808, for a total cost per helicopter of $31,508 and a total cost to the U.S. R22 operator fleet of $40,645,320 over a 5-year period.
- Replacing both blades on a Model R44 helicopter with hydraulically boosted flight controls installed (approximately 1,053 helicopters) will require about 20 work hours, and required parts will cost $43,783, for a total cost per helicopter of $45,483 and a total cost to the U.S. R44 operator fleet of $47,893,599 over a 5-year period.
- Replacing both blades on a Model R44 helicopter without hydraulically boosted flight controls installed (approximately 300 helicopters) will require modifying the aircraft with hydraulic flight controls, and adding the P/N C016-7 blades and the required airframe provisions at a cost of 100 work-hours for a total labor cost of $8,500. Parts will cost $103,747 for a total cost per helicopters of $112,247, and a cost to U.S. operators of $33,674,100 over 5 years.

Authority for This Rulemaking

Title 49 of the United States Code specifies the FAA's authority to issue rules on aviation safety. Subtitle I, section 106, describes the authority of the FAA Administrator. Subtitle VII: Aviation Programs, describes in more detail the scope of the Agency's authority.

We are issuing this rulemaking under the authority described in Subtitle VII, Part A, Subpart III, Section 44701: "General requirements." Under that section, Congress charges the FAA with promoting safe flight of civil aircraft in air commerce by prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce. This regulation is within the scope of that authority because it addresses an unsafe condition that is likely to exist or develop on products identified in this rulemaking action.

Regulatory Findings

This AD will not have federalism implications under Executive Order 13132. This AD will not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.

For the reasons discussed above, I certify that this AD:

(1) Is not a "significant regulatory action" under Executive Order 12866;

(2) Is not a "significant rule" under DOT Regulatory Policies and Procedures (44 FR 11034, February 26, 1979);

(3) Will not affect intrastate aviation in Alaska to the extent that it justifies making a regulatory distinction; and

(4) Will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act.

We prepared an economic evaluation of the estimated costs to comply with this AD and placed it in the AD docket.

List of Subjects in 14 CFR Part 39

Air transportation, Aircraft, Aviation safety, Incorporation by reference, Safety.

Adoption of the Amendment

Accordingly, under the authority delegated to me by the Administrator, the FAA amends 14 CFR part 39 as follows:

PART 39–AIRWORTHINESS DIRECTIVES

1. The authority citation for part 39 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701.

§ 39.13 [Amended]

2. The FAA amends § 39.13 by removing Airworthiness Directive (AD) 2011-12-10, Amendment 39-16717 (76 FR 35330, June 17, 2011); corrected March 5, 2012 (77 FR 12991), and adding the following new AD:

FAA
Aviation Safety

AIRWORTHINESS DIRECTIVE

www.faa.gov/aircraft/safety/alerts/
www.gpoaccess.gov/fr/advanced.html

2014-23-16 Robinson Helicopter Company: Amendment 39-18032; Docket No. FAA-2013-0159; Directorate Identifier 2012-SW-010-AD.

(a) Applicability

This AD applies to Model R22, R22 Alpha, R22 Beta, and R22 Mariner helicopters with main rotor blade (blade), part number (P/N) A016-2 or A016-4; and Model R44 and R44 II helicopters with blade, P/N C016-2 or C-016-5, certificated in any category.

(b) Unsafe Condition

This AD defines the unsafe condition as blade skin debonding, which could result in blade failure and subsequent loss of control of the helicopter.

(c) Affected ADs

This AD supersedes AD 2011-12-10, Amendment 39-16717 (76 FR 35330, June 17, 2011); corrected March 5, 2012 (77 FR 12991).

(d) Effective Date

This AD becomes effective January 9, 2015.

(e) Compliance

You are responsible for performing each action required by this AD within the specified compliance time unless it has already been accomplished prior to that time.

(f) Required Actions

(1) Before the first flight of each day, visually check for any exposed (bare metal) skin-to-spar joint area on the lower surface of each blade. The actions required by this paragraph may be performed by the owner/operator (pilot) holding at least a private pilot certificate and must be entered into the aircraft records showing compliance with this AD in accordance with 14 CFR 43.9(a)(1) through (4) and 14 CFR 91.417(a)(2)(v). The record must be maintained as required by 14 CFR 91.417, 121.380, or 135.439.

(2) If there is any bare metal in the area of the skin-to-spar bond line, before further flight, inspect the blade by following the requirements of paragraph (f)(3) of this AD.

(3) Within 10 hours time-in-service (TIS), and at intervals not to exceed 100 hours TIS or at each annual inspection, whichever occurs first, inspect each blade for corrosion, separation, a gap, or a dent by following the Compliance Procedure, paragraphs 1 through 6 and 8, of Robinson R22 Service Bulletin SB-103, dated April 30, 2010 (SB103), or Robinson Service Bulletin SB-72, dated April 30, 2010 (SB72), as appropriate for your model helicopter. Although the Robinson service information limits the magnification to 10X, a higher magnification is acceptable for this inspection. Also, an appropriate tap test tool which provides similar performance, weight, and consistency of tone may be

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substituted for the "1965 or later United States Quarter-dollar coin," which is specified in the Compliance Procedure, paragraph 2, of SB72 and SB103.

(4) Before further flight, refinish any exposed area of a blade by following the Compliance Procedure, paragraphs 2 through 6, of Robinson R22 Service Letter SL-56B or R44 Service Letter SL-32B, both dated April 30, 2010, as appropriate for your model helicopter.

(5) Before further flight, replace any unairworthy blade with an airworthy blade.

(6) Within 5 years of the effective date of this AD:

(i) For Model R22 series helicopters, replace blade P/N A016-2 or A016-4 with a blade, P/N A016-6.

(ii) For Model R44 series helicopters fitted with hydraulically boosted main rotor flight controls, replace blade P/N C016-2 or C016-5 with a blade, P/N C016-7.

(iii) For Model R44 series helicopters without hydraulically boosted main rotor flight controls, replace blade P/N C016-2 or C016-5 with a blade, P/N C016-7. Prior to installing a blade P/N C016-7, verify the helicopter has been modified as required by Robinson R44 Service Letter SL-37, dated June 18, 2010, Compliance Procedures, paragraphs 1. through 10.

(iv) Installing blades, P/N A016-6 or P/N C016-7, is terminating action for the inspection requirements of paragraphs (f)(1) through (f)(4) of this AD.

(7) As an option for complying with paragraph (f)(3) of this AD, you may perform a blade inspection by following the corresponding provisions of SB-103A or SB-72A, both dated July 19, 2012, as appropriate for your model helicopter.

(g) Special Flight Permits

Special flight permits will not be issued.

(h) Alternative Methods of Compliance (AMOCs)

(1) The Manager, Los Angeles Aircraft Certification Office, FAA, may approve AMOCs for this AD. Send your proposal to: Fred Guerin, Aviation Safety Engineer, Los Angeles Aircraft Certification Office, Transport Airplane Directorate, FAA, 3960 Paramount Blvd., Lakewood, CA 90712; telephone (562) 627-5232; email fred.guerin@faa.gov.

(2) For operations conducted under a 14 CFR part 119 operating certificate or under 14 CFR part 91, subpart K, we suggest that you notify your principal inspector, or lacking a principal inspector, the manager of the local flight standards district office or certificate holding district office before operating any aircraft complying with this AD through an AMOC.

(3) AMOCs approved for AD 2011-12-10 (76 FR 35330, June 17, 2011); corrected March 5, 2012 (77 FR 12991), are approved as AMOCs for the corresponding requirements in paragraph (f) of this AD.

(i) Additional Information

The Robinson letter titled "Additional Information Regarding Main Rotor Blade Skin Debonding," dated May 25, 2007, which is not incorporated by reference, contains additional information about the subject of this AD. For service information identified in this AD, contact Robinson Helicopter Company, 2901 Airport Drive, Torrance, CA 90505; telephone (310) 539-0508; fax (310) 539-5198; or at http://www.robinsonheli.com/servelib.htm. You may review a copy of this information at the FAA, Office of the Regional Counsel, Southwest Region, 2601 Meacham Blvd., Room 663, Fort Worth, Texas 76137.

(j) Subject

Joint Aircraft Service Component (JASC) Code: 6210: Main Rotor Blades.

(k) Material Incorporated by Reference

(1) The Director of the Federal Register approved the incorporation by reference (IBR) of the service information listed in this paragraph under 5 U.S.C. 552(a) and 1 CFR part 51.

(2) You must use this service information as applicable to do the actions required by this AD, unless the AD specifies otherwise.

(3) The following service information was approved for IBR on January 9, 2015.

(i) Robinson R44 Service Letter SL-37, dated June 18, 2010.

(ii) Reserved.

(4) The following service information was previously approved for IBR on July 5, 2011 (76 FR 35330, June 17, 2011); corrected March 5, 2012 (77 FR 12991).

(i) Robinson R22 Service Bulletin SB-103, dated April 30, 2010.

(ii) Robinson R44 Service Bulletin SB-72, dated April 30, 2010.

(iii) Robinson R22 Service Letter SL-56B, dated April 30, 2010.

(iv) Robinson R44 Service Letter SL-32B, dated April 30, 2010.

(5) For Robinson service information identified in this AD, contact Robinson Helicopter Company, 2901 Airport Drive, Torrance, CA 90505; telephone (310) 539-0508; fax (310) 539-5198; or at http://www.robinsonheli.com/servelib.htm.

(6) You may view this service information at FAA, Office of the Regional Counsel, Southwest Region, 2601 Meacham Blvd., Room 663, Fort Worth, Texas 76137. For information on the availability of this material at the FAA, call (817) 222-5110.

(7) You may view this service information that is incorporated by reference at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call (202) 741-6030, or go to: http://www.archives.gov/federal-register/cfr/ibr-locations.html.

Issued in Fort Worth, Texas, on November 4, 2014.

Lance T. Gant,
Acting Directorate Manager, Rotorcraft Directorate,
Aircraft Certification Service.

ANNEX B - SB 72A

ROBINSON
HELICOPTER COMPANY
2901 Airport Drive, Torrance, California 90505 Phone (310) 539-0508 Fax (310) 539-5198

Page 1 of 3

R44 SERVICE BULLETIN SB-72A
(supersedes R44 SL-24 and R44 SB-72)

DATE: 30 April 2010 **REV A:** 19 July 2012

TO: R44 and R44 II owners, operators, and maintenance personnel

SUBJECT: Main Rotor Blade Bond Inspection

ROTORCRAFT AFFECTED: R44 helicopters with C016-2 main rotor blades, and R44 II helicopters with C016-5 main rotor blades.

TIME OF COMPLIANCE: Every four months, 100-hour inspection, or annual inspection, whichever occurs first.

BACKGROUND: Debonding of rotor blade skins can occur when the bond line is exposed due to erosion of the blade finish, or when corrosion occurs on the internal aluminum tip cap. Proper inspection and protection (refinishing) of bonded areas is required. Debonding resulting from improper inspection and maintenance could cause a catastrophic accident.

COMPLIANCE PROCEDURE:

NOTE
To facilitate inspection, blade may be teetered down, collective fully raised, and cyclic stick positioned to apply maximum up pitch.

1. Refer to Figures 1 and 2. Remove both main rotor blade tip covers and clean the blades. Clean and remove any corrosion from tip covers.

2. Using 10x magnification, visually inspect uncovered skin-to-tip cap bond joints. Using a 1965-or-later United States quarter-dollar coin, tap test skin-to-tip cap bond joints on both upper and lower surfaces. If corrosion, separation, or voids are detected, blade is unairworthy. A tap test tutorial video is available on our website, www.robinsonheli.com, under the Publications tab.

3. Using 10x magnification, visually inspect any exposed skin-to-spar bond line for gaps (empty space between skin and spar). Blade is unairworthy if any gap, including "pin hole(s)", is detected in the bond line.

4. Refer to Figure 2. Mark outboard 135 inches of blade lower surface as shown to identify skin-to-spar bond joint area.

(OVER)

5. Verify no visible dents within the bond joint area. Blade is unairworthy if bond joint area is dented.

6. Tap test the lower skin-to-spar bond joint and verify no voids exist. Blade is unairworthy if a void is detected.

7. Refinish all exposed bare metal, including tip covers, per R44 SL-32B.

8. Install blade tip covers, ensuring cover edges are flush with blade profile.

9. Make appropriate maintenance record entries.

Approximate Cost:

Parts: $5 for KI-200 Kit.
KI-200 Kit includes:
1 ea MT332-44 tool
1 ea SAN30001 Sharpie® marker

Labor: Less than 1 man-hour.

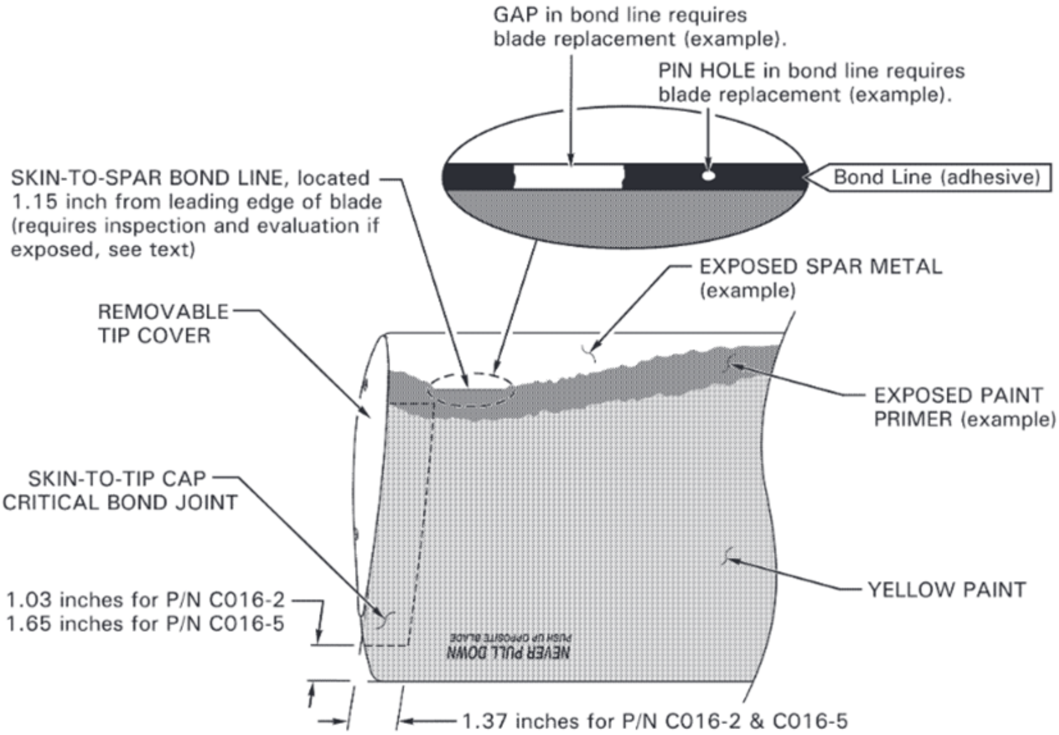

FIGURE 1 TIP AREA AND LOWER SURFACE
(Example, Blade with Excessive Paint Erosion)

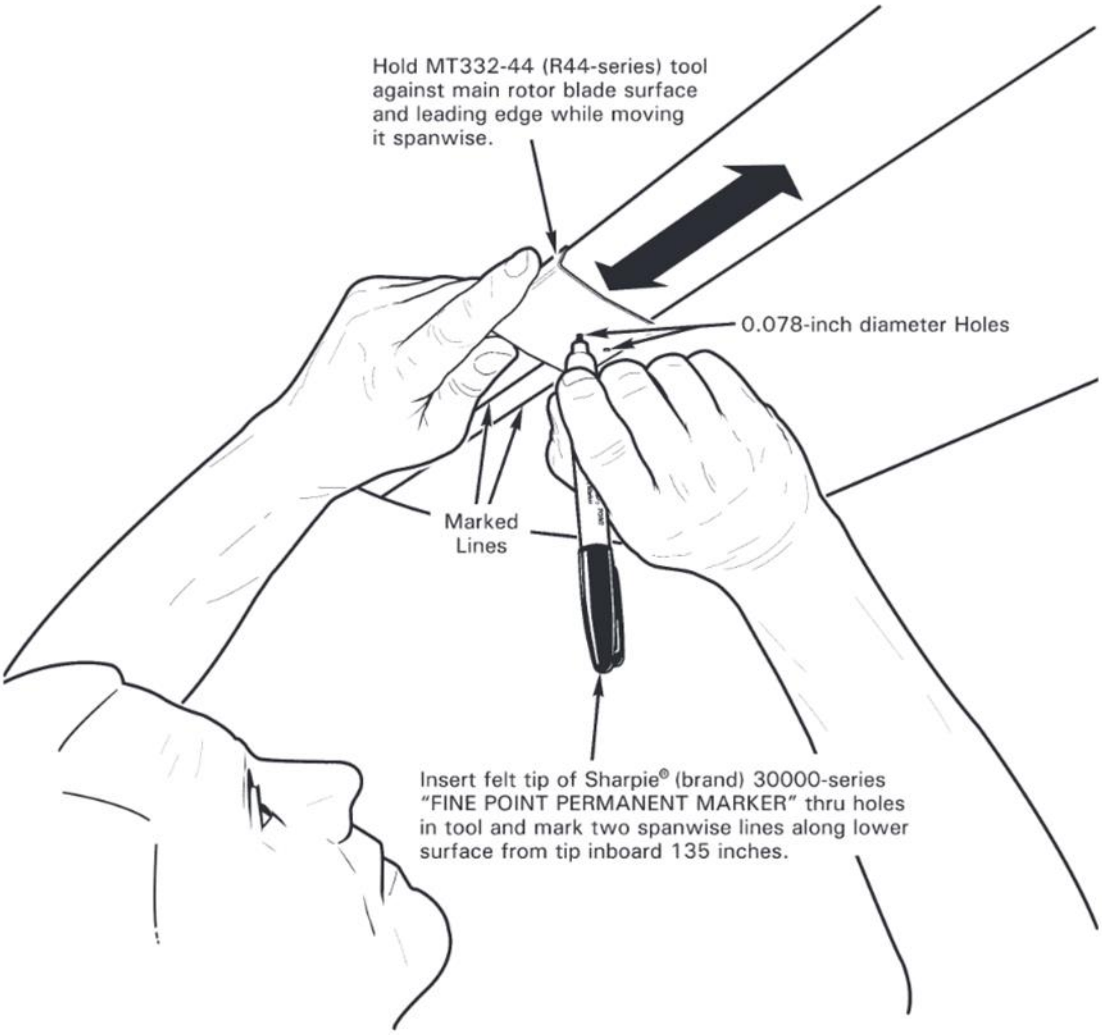

FIGURE 2 MARKING LOWER SKIN-TO-SPAR BOND JOINT AREA

THE DESIGN ENGINEERING ASPECTS OF THIS BULLETIN HAVE BEEN SHOWN TO COMPLY WITH APPLICABLE FEDERAL AVIATION REGULATIONS AND ARE FAA APPROVED.

ANNEX C - DIVOP N° 002/2018

DIVULGAÇÃO OPERACIONAL (DIVOP)	Nº 002/2018
CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS	DATA 07/03/2018

O único objetivo das investigações realizadas pelo Sistema de Investigação e Prevenção de Acidentes Aeronáuticos (SIPAER) é a prevenção de futuros acidentes aeronáuticos. De acordo com o Anexo 13 da Organização de Aviação Civil Internacional – OACI, da qual o Brasil é país signatário, o propósito desta atividade não é determinar culpa ou responsabilidade. Esta Divulgação Operacional, cuja conclusão baseia-se em fatos ou hipóteses, ou na combinação de ambos, objetiva exclusivamente a prevenção de acidentes aeronáuticos. O uso desta divulgação para qualquer outro propósito poderá induzir a interpretações errôneas e trazer efeitos adversos ao SIPAER.

ROBINSON 22 (R22) e ROBINSON 44 (R44)	RESPONSÁVEL: CENIPA

ASSUNTO: INSPEÇÃO NAS PÁS DO ROTOR PRINCIPAL DE HELICÓPTEROS MODELOS R22 E R44

HISTÓRICO

Na manhã do dia 23 JAN 2018, o helicóptero modelo R44 II, matrícula PP-HLI, decolou do aeródromo do Recife (SBRF) para realização de um voo com um piloto e dois passageiros a bordo.

Cerca de quatorze minutos após a decolagem, a aeronave foi avistada em uma trajetória descendente até colidir contra o mar, no setor Nordeste do aeródromo.

A aeronave ficou completamente destruída.

Todos os ocupantes sofreram lesões fatais.

O CENIPA ainda está investigando os fatores contribuintes presentes no referido acidente.

ANÁLISE

Os relatos de observadores, bem como imagens registradas por algumas câmeras de segurança mostraram que a aeronave PP-HLI percorreu uma trajetória descendente, praticamente na vertical, com elevada razão de descida, em voo aparentemente sem controle até o impacto contra a água do mar.

Página 1 de 5

Essas características relacionadas à dinâmica do acidente guardam similaridades com ocorrências anteriores envolvendo aeronaves ROBINSON modelo R22 e R44, ao redor do mundo.

Algumas dessas ocorrências foram objeto de estudo por parte do *National Transportation Safety Board* (NTSB), órgão congênere ao CENIPA nos Estados Unidos (USA). Em 2008, o NTSB publicou um documento (*Safefy Recommendation,* A-08-25 *through* - 29, de 09 JUN 2008) no qual constava uma análise de três acidentes aeronáuticos que envolveram aeronaves modelo R44.

As pás do rotor principal dos helicópteros envolvidos nesses acidentes foram examinadas por técnicos do Laboratório de Materiais do NTSB. Os exames encontraram sinais de descolamento (separação) da camada externa da pá do rotor principal (*skin*), as quais levaram a consequente falha do componente em voo.

As pás do rotor principal dos helicópteros modelos R22 e R44 são compostas por um *skin* de aço inoxidável, um núcleo do tipo *honeycomb* composto por alumínio e um *spar* de aço inoxidável.

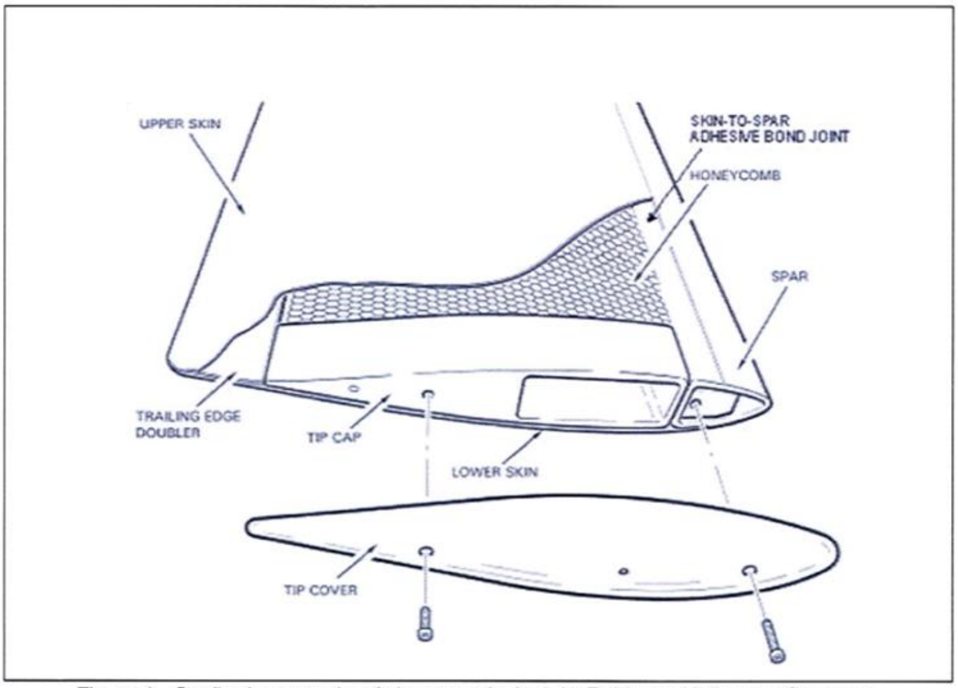

Figura 1 - Seção da ponta da pá do rotor principal da *Robinson Helicopter Company*.

Os descolamentos encontrados nas pás dos helicópteros acidentados possuíam características bastante similares entre si, conforme demonstrado na tabela a seguir:

Página 2 de 5

Local e Data	Modelo	P/N das pás	Tipo *skin* / *spar*	Tempo de operação em horas de voo
República Dominicana 11 OUT 2006	R44	C016-2	Aço Inoxidável	1.800h

- Descolamento na maior parte das juntas adesivas das pás do rotor principal.
- Descolamento na junta adesiva entre o *skin* e o *spar*, na região do bordo de ataque das pás. As áreas remanescentes apresentavam descolamentos com alta porcentagem de falha adesiva, indicando que a fixação (colagem) dos materiais se deteriorou desde a fabricação das pás.
- Os descolamentos foram, em geral, propagados a partir das pontas das pás.

Local e Data	Modelo	P/N das pás	Tipo *skin* / *spar*	Tempo de operação em horas de voo
Ilhas Fiji 05 DEZ 2006	R44	C016-2	Aço Inoxidável	1.083h

- Separação extensa nas juntas adesivas.
- Origem indeterminada dos descolamentos, em virtude de os mesmos comumente se originarem da ponta da pá, parte essa que não foi encontrada. No entanto, as maiores porções dos descolamentos nas juntas adesivas emanaram do bordo de ataque dos *skin*.
- Os descolamentos encontrados nas juntas adesivas das pás do helicóptero envolvido neste acidente eram similares aos encontrados no acidente ocorrido na República Dominicana.

Local e Data	Modelo	P/N das pás	Tipo *skin* / *spar*	Tempo de operação em horas de voo
Austrália 15 MAR 2007	R44	C016-2	Aço Inoxidável	597h

- Bordo de ataque do *skin* inferior estava descolado aproximadamente 2,5 polegadas na ponta da pá.
- O descolamento se estendeu por aproximadamente 17 polegadas para dentro da ponta da pá.
- Descolamentos nas juntas adesivas da parte inferior da pá entre o *skin* e o *spar*. Diversas áreas isoladas no bordo de ataque dos *skins* mostrando descolamentos adesivos, indicação de que a fixação (colagem) dos materiais se deteriorou, causando a separação da parte inferior do *skin*.
- Os descolamentos encontrados nas juntas adesivas das pás do helicóptero envolvido neste acidente eram similares aos descolamentos encontrados nos acidentes ocorridos na República Dominicana e nas Ilhas Fiji.

Tabela 1 – Tipos de descolamentos encontrados nas pás de helicópteros acidentados.

Página 3 de 5

Em todos os casos analisados, o descolamento nas pás do rotor principal ocorreu antes do Tempo Limite de Vida (TLV) do componente (2.200 horas de voo ou 12 anos de operação).

Como forma de mitigar a condição de perigo encontrada, a *Federal Aviation Administration* (FAA), órgão congênere à ANAC nos USA e responsável pela certificação primária do projeto R44, emitiu uma *Airworthiness Directives* (AD 2007-26-12) que estabelecia procedimentos diários visando identificar falhas nas pás do rotor principal, por descolamento da camada externa (*skin*). Este documento informava que descolamentos nas pás do rotor principal poderiam ter como consequência a perda de controle do helicóptero. A AD 2007-26-12 estabelecia, ainda, um prazo para a substituição das referidas pás.

Em um segundo momento, a AD 2007-26-12 foi substituída pela AD 2011-12-10, que prorrogava o prazo de uso das pás do rotor principal.

Posteriormente, a AD 2011-12-10 foi substituída pela AD 2014-23-16 (efetivada em 9 JAN 2015), que por sua vez passou a adotar uma ação terminal para esses requisitos de inspeção, substituindo, dentro de um prazo determinado, as pás do rotor principal por pás novas (P/N C016-7 para os R44; e P/N A016-6 para os R22) que não exigem a realização das inspeções diárias.

Dentre outros aspectos, a AD 2014-23-16 manteve os procedimentos a serem adotados pelos operadores/pilotos, diariamente, antes do primeiro voo do dia, visando identificar danos que comprometam a aeronavegabilidade das pás do rotor principal (R44 com P/N C016-2 ou P/N C016-5; e R22 com P/N A016-2 OU A016-4) bem como a escrituração desses procedimentos em registros apropriados. A AD 2014-23-16 estabeleceu, ainda, períodos determinados de inspeção e parâmetros e procedimentos a serem adotados antes da realização de voos subsequentes, quando as pás apresentassem partes metálicas expostas (*bare metal*).

A respeito de Diretriz de Aeronavegabilidade emitida por Autoridade de Aviação Civil estrangeira (FAA), o Regulamento Brasileiro da Aviação Civil n° 39 (RBAC 39.5-I) considera a Diretriz de Aeronavegabilidade, ou documento equivalente, emitido por Autoridade de Aviação Civil do Estado de Projeto, como uma Diretriz de Aeronavegabilidade emitida pela própria ANAC. Nesse sentido, o documento emitido pela FAA tem validade integral no âmbito da aviação civil brasileira.

No dia 23 FEV 2018, a *Robinson Helicopter Company* emitiu um alerta de segurança (*Safety Alert*) no qual o fabricante ressalta a importância dos operadores cumprirem o estabelecido na AD 2014-23-16 para as pás de rotor principal com P/N A016-4 (R22); C016-2 (R44) e C016-5 (R44). O *Safety Alert* ressalta, ainda, que o não cumprimento desses procedimentos pode ter como consequência acidentes fatais. Por fim, o documento relembra os operadores que essas pás **deverão ser retiradas de operação em 09 JAN 2020**.

Os trabalhos de investigação relacionados ao acidente envolvendo a aeronave PP-HLI, ocorrido em 23 JAN 2018, ainda estão em andamento. Portanto, o conteúdo da presente DIVOP não é conclusivo em relação à investigação do acidente aeronáutico em tela. Entretanto, os fatos conhecidos até o momento possuem alguma similaridade com os acidentes analisados pelo NTSB, ocorridos na República Dominicana, Ilhas Fiji e Austrália.

As pás que equipavam a aeronave PP-HLI possuíam P/N C016-5 e, portanto, eram afetadas pela AD 2014-23-16. As pás acidentadas ainda serão submetidas a exames laboratoriais a fim de identificar se houve descolamento similar ao observado nos acidentes anteriores descritos nesta DIVOP.

Com o objetivo de elevar a percepção de pilotos, de mecânicos e de operadores dos helicópteros modelos R22 e R44 no Brasil, o CENIPA **ratifica** que o cumprimento da AD 2014-23-16, na sua integralidade, bem como a fiel observância ao disposto no *Safety Alert* emitido pelo fabricante são imprescindíveis para a segurança das operações dos projetos R22 e R44 equipados com pás P/N C016-2 e P/N C016-5.

AÇÕES RECOMENDADAS

À Agencia Nacional de Aviação Civil (ANAC), recomenda-se:

- Dar ampla divulgação do conteúdo desta DIVOP aos operadores, pilotos e mantenedores dos helicópteros ROBINSON modelos R22 e R44.

Aos operadores, pilotos e mantenedores dos helicópteros ROBINSON modelos R22 e R44, recomenda-se:

- Cumprir fielmente o disposto na *Airworthiness Directives* 2014-23-16, observando, notadamente, o que se refere às inspeções a serem realizadas antes de cada voo.

- Cumprir fielmente o disposto no *Safety Alert*, de 23 FEV 2018, emitido pela *Robinson Helicopter Company*, fabricante da aeronave.

DIVULGAÇÃO

- Agência Nacional de Aviação Civil (ANAC)

- Operadores, pilotos e mantenedores de helicópteros Robinson modelos R22 e R44

APROVO:

Brigadeiro do Ar FREDERICO ALBERTO MARCONDES FELIPE
Chefe do Centro de Investigação e Prevenção de Acidentes Aeronáuticos

ANNEX D - DIVOP N° 003/2018

DIVULGAÇÃO OPERACIONAL (DIVOP)	Nº 03/2018
CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS	DATA 15/05/2018

A Divulgação Operacional (DIVOP) é uma ferramenta utilizada para a comunicação de assuntos de interesse da prevenção de acidentes, visando tão e somente à segurança de voo. Parte do Princípio SIPAER de que todo acidente pode ser evitado e de que o amplo conhecimento de fatos ocorridos se reveste de grande importância.

Em nenhuma hipótese, a DIVOP substitui o Relatório Final, o qual consiste na conclusão oficial do SIPAER relativa a investigação de uma ocorrência aeronáutica. O uso desta divulgação para qualquer outro propósito que não seja a prevenção de acidentes e incidentes aeronáuticos poderá induzir a interpretações errôneas e trazer efeitos adversos ao SIPAER.

ROBINSON 22 (R22) e *ROBINSON* 44 (R44/R44II)	RESPONSÁVEL: CENIPA

ASSUNTO: INSPEÇÃO NAS PÁS DO ROTOR PRINCIPAL DE HELICÓPTEROS MODELOS R22 E R44/R44II

PREFÁCIO

O CENIPA tem observado o aumento de reportes relatando que, durante a realização de inspeções em pás do rotor principal de helicópteros modelos R22 e R44/R44II, pilotos e mecânicos estão constatando o descolamento e/ou indício de descolamento das *blade skin* (camada mais externa da superfície das pás) das superfícies superiores (*upper skin*) e inferiores (*lower skin*), em aeronaves equipadas com pás P/N A016-2 (R22); P/N A016-4 (R22); P/N C016-3 (R44/R44II); P/N C016-5 (R44/R44II); e P/N C016-7 (R44/R44II).

DESENVOLVIMENTO

A possibilidade de descolamento de superfícies nas pás do rotor principal de aeronaves *Robinson*, modelos R22 e R44/R44II, tem sido observada pela *Robinson Helicopter Company* (RHC), fabricante das aeronaves, desde o ano de 2010. Em 30ABR2010, a RHC publicou dois *Service Bulletins* (SB) relativos ao tema: o SB-103 (aplicável ao R22); e o SB-72 (aplicável ao R44/R44II). Posteriormente, em 19JUL2012, a RHC publicou uma revisão dos dois SB, os quais substituíram os anteriormente publicados e passaram a adotar a denominação SB-103A e SB-72A.

A *Federal Aviation Administration* (FAA), órgão americano congênere da ANAC, passou a tratar sobre o tema no ano de 2011, quando publicou, inicialmente, a *Airworthiness Directive* (AD) 2011-12-10, em 05MAR2012. Posteriormente, a FAA publicou a AD 2014-23-16, efetivada em 09JAN2015, documento que substituiu a AD publicada em 2012.

Em 23FEV2018, a RHC publicou um *Safety Alert* tratando do mesmo tema e reforçando a necessidade de inspeções de rotina nas pás do rotor principal das aeronaves R22 e R44/R44II. O

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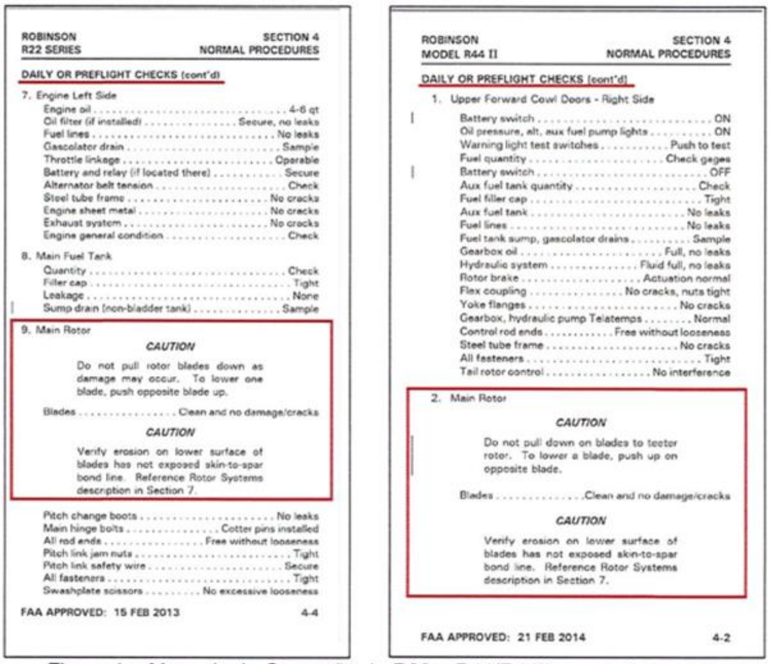
Safety Alert fazia referência aos documentos anteriormente publicados pela RHC e pela FAA.

O CENIPA, por sua vez, passou a tratar do tema em 07MAR2018, oportunidade em que publicou a DIVOP n° 02/2018. Neste documento, o Centro ressaltou a importância de operadores e organizações de manutenção cumprirem, integralmente, o disposto na AD 2014-23-16, bem como observarem o conteúdo do *Safety Alert* emitido pela RHC.

Recentemente, em 03MAI2018, a RHC publicou novo *Safety Alert*, relatando ter recebido reportes sobre a realização de reparos não autorizados em pás de rotor principal de R22 e R44/R44II. O documento ressalta que pás do R22 (P/N A016-4); e do R44/R44II (P/N C016-2 e P/N C016-5), que apresentem sinais de descolamento não são reparáveis e devem ser retiradas de serviço imediatamente.

Ressalta-se que os Manuais de Operação das aeronaves R22 (Seção 4, Item 9) e R44/R44II (Seção 4, Item 2), estabelecem procedimentos de inspeções diárias ou pré-voo nas pás do rotor principal, independentemente do *Part Number*, a serem executadas pelos pilotos. As versões dos manuais do R22 e R44/R44II foram aprovadas pela FAA em 15FEV2013 e 21FEV2014, respectivamente.


ROBINSON
R22 SERIES

SECTION 4
NORMAL PROCEDURES

DAILY OR PREFLIGHT CHECKS (cont'd)

7. Engine Left Side
   - Engine oil .... 4-6 qt
   - Oil filter (if installed) .... Secure, no leaks
   - Fuel lines .... No leaks
   - Gascolator drain .... Sample
   - Throttle linkage .... Operable
   - Battery and relay (if located there) .... Secure
   - Alternator belt tension .... Check
   - Steel tube frame .... No cracks
   - Engine sheet metal .... No cracks
   - Exhaust system .... No cracks
   - Engine general condition .... Check

8. Main Fuel Tank
   - Quantity .... Check
   - Filler cap .... Tight
   - Leakage .... None
   - Sump drain (non-bladder tank) .... Sample

9. Main Rotor

CAUTION

Do not pull rotor blades down as damage may occur. To lower one blade, push opposite blade up.

Blades .... Clean and no damage/cracks

CAUTION

Verify erosion on lower surface of blades has not exposed skin-to-spar bond line. Reference Rotor Systems description in Section 7.

- Pitch change boots .... No leaks
- Main hinge bolts .... Cotter pins installed
- All rod ends .... Free without looseness
- Pitch link jam nuts .... Tight
- Pitch link safety wire .... Secure
- All fasteners .... Tight
- Swashplate scissors .... No excessive looseness

FAA APPROVED: 15 FEB 2013 4-4

ROBINSON
MODEL R44 II

SECTION 4
NORMAL PROCEDURES

DAILY OR PREFLIGHT CHECKS (cont'd)

1. Upper Forward Cowl Doors - Right Side
   - Battery switch .... ON
   - Oil pressure, alt, aux fuel pump lights .... ON
   - Warning light test switches .... Push to test
   - Fuel quantity .... Check gages
   - Battery switch .... OFF
   - Aux fuel tank quantity .... Check
   - Fuel filler cap .... Tight
   - Aux fuel tank .... No leaks
   - Fuel lines .... No leaks
   - Fuel tank sump, gascolator drains .... Sample
   - Gearbox oil .... Full, no leaks
   - Hydraulic system .... Fluid full, no leaks
   - Rotor brake .... Actuation normal
   - Flex coupling .... No cracks, nuts tight
   - Yoke flanges .... No cracks
   - Gearbox, hydraulic pump Telatemps .... Normal
   - Control rod ends .... Free without looseness
   - Steel tube frame .... No cracks
   - All fasteners .... Tight
   - Tail rotor control .... No interference

2. Main Rotor

CAUTION

Do not pull down on blades to teeter rotor. To lower a blade, push up on opposite blade.

Blades .... Clean and no damage/cracks

CAUTION

Verify erosion on lower surface of blades has not exposed skin-to-spar bond line. Reference Rotor Systems description in Section 7.

FAA APPROVED: 21 FEB 2014 4-2

Figura 1 – Manuais de Operação do R22 e R44/R44II, respectivamente.

De maneira semelhante, os Manuais de Manutenção das aeronaves R22 (Seção 2.410, Item 13) e R44/R44II (Seção 2.410, Item 12), disponíveis à época, estabeleciam procedimentos de inspeções periódicas nas pás do rotor principal, independentemente do *Part Number*. Tais procedimentos deveriam ser executados pelos mecânicos, sobretudo, nas Inspeções Anuais de Manutenção (IAM) e nas inspeções periódicas de 100 horas (Figura 2). As versões dos Manuais de Manutenção do R22 e R44/R44II remetiam aos meses de março de 2016 e junho de 2014, respectivamente.

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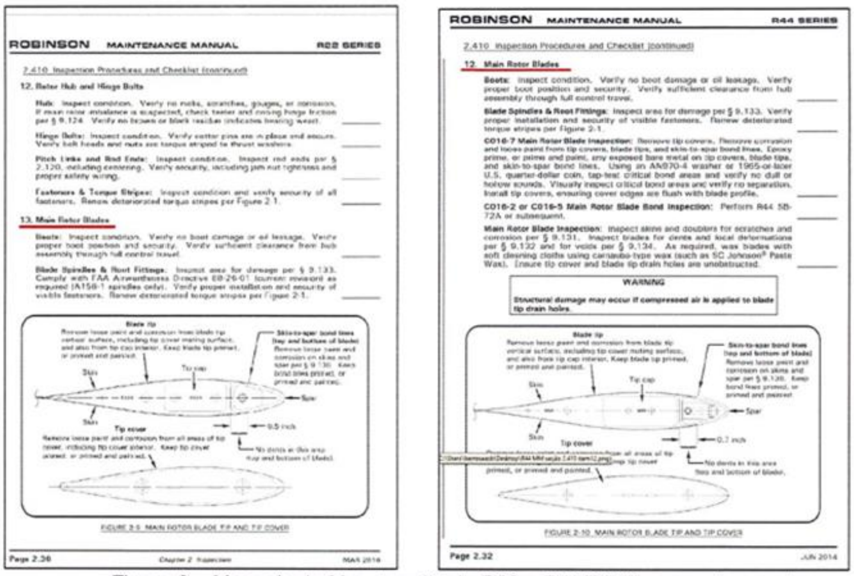

Figura 2 – Manuais de Manutenção do R22 e R44/R44II, respectivamente.

A AD 2014-23-16 adicionou procedimentos específicos referentes às pás do R22 (P/N A016-2 e P/N A016-4) e do R44/R44II (P/N C016-2 e P/N C016-5). Vale ressaltar que a AD foi publicada em função da identificação de uma condição insegura (*unsafe condition*) relacionada ao descolamento da *blade skin* das pás, conforme estabelece o parágrafo (b) da referida Diretiva.

FAA
Aviation Safety

AIRWORTHINESS DIRECTIVE

www.faa.gov/aircraft/safety/alerts/
www.gpoaccess.gov/fr/advanced.html

2014-23-16 Robinson Helicopter Company: Amendment 39-18032; Docket No. FAA-2013-0159; Directorate Identifier 2012-SW-010-AD.

(a) Applicability

This AD applies to Model R22, R22 Alpha, R22 Beta, and R22 Mariner helicopters with main rotor blade (blade), part number (P/N) A016-2 or A016-4; and Model R44 and R44 II helicopters with blade, P/N C016-2 or C-016-5, certificated in any category.

(b) Unsafe Condition

This AD defines the unsafe condition as blade skin debonding, which could result in blade failure and subsequent loss of control of the helicopter.

(c) Affected ADs

This AD supersedes AD 2011-12-10, Amendment 39-16717 (76 FR 35330, June 17, 2011); corrected March 5, 2012 (77 FR 12991).

(d) Effective Date

This AD becomes effective January 9, 2015.

Figura 3 – AD 2014-23-16, emitida pela FAA e efetivada em 09JAN2015.

Como parte de uma atividade de prevenção, técnicos do SIPAER, juntamente com pilotos e mecânicos de aeronaves R22 e R44/R44II, inspecionaram alguns helicópteros em operação no

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Brasil. As inspeções seguiram as instruções contidas na AD 2014-23-16 da FAA e no *Safety Alert* da RHC.

As inspeções realizadas revelaram a presença de descolamento, e/ou indício de descolamento, da *blade skin* nas áreas consideradas críticas, tanto nas superfícies inferiores (*lower skin*), quanto nas superfícies superiores (*upper skin*), de algumas pás de aeronaves R22 e R44/R44II, consideradas disponíveis para o voo pelos operadores.

As instruções contidas na AD 2014-23-16 e no *Safety Alert* da RHC contemplavam inspeções, que deveriam ser realizadas nas superfícies INFERIORES (*lower skin*) das pás do rotor principal, antes do primeiro voo de cada dia. Entretanto, as documentações não contemplavam a realização de inspeções idênticas nas correspondentes superfícies SUPERIORES (*upper skin*) das pás.

Apenas se fossem encontradas partes com metal exposto na área do *skin-to-spar* da pá, a AD direcionava as ações para a realização do SB103A e o SB72A. Os SB 103A e 72A eram os únicos documentos que faziam menção para inspeção das superfícies superiores das pás. Entretanto, as inspeções constantes dos SB deveriam ser realizadas apenas a cada quatro meses, durante as inspeções periódicas de 100 horas, durante a IAM, ou em caso de verificação de metal exposto por ocasião do cumprimento da AD 2014-23-16.

Algumas das pás inspecionadas durante a atividade conduzida pelos técnicos do SIPAER apresentaram problemas na superfície superior. Dessa forma, considerou-se que a ausência de metal exposto na superfície inferior das pás não exclui a possibilidade de que a superfície superior apresente sinais de descolamento. Porém, com as provisões atuais da AD 2014-23-16, a superfície superior somente seria verificada caso a superfície inferior apresentasse metal exposto ou sinais de descolamento.

Diante do exposto, considerou-se que a AD 2014-23-16; o *Safety Alert*; os Manuais de Manutenção; e os Manuais de Operação das aeronaves R22 e R44/R44II não são adequadamente claros quanto aos procedimentos a serem realizados pelos mecânicos, no que diz respeito à inspeção da superfície superior (*upper skin*) das pás.

Ademais, o texto da AD 2014-23-16 tratava como AÇÃO TERMINAL para a correção das falhas identificadas nas pás do R22 (P/N A016-2 e P/N A016-4) e do R44/R44II (P/N C016-2 e P/N C016-5) a substituição pelos novos modelos de pás P/N A016-6 para R22; e P/N C016-7 para R44/R44II.

> *Installing blades, P/N A016-6 or P/N C016-7, is terminating action for the inspection requirements of paragraphs (f)(1) trough (f)(4).*

Em outras palavras, segundo a AD 2014-23-16, a substituição das pás pelos novos modelos solucionaria o problema e as inspeções diárias deixariam de ser necessárias, uma vez que o documento não estabelecia procedimentos de inspeção diária nas pás P/N A016-6 (R22), tampouco nas pás P/N C016-7 (R44/R44II).

Entretanto, as verificações realizadas no Brasil constataram sinais de corrosão com descolamento em uma pá P/N C016-7, que equipava uma aeronave R44/R44II e que, em tese, não deveria apresentar problemas dessa natureza. A referida pá apresentava sinais de descolamento tanto na superfície inferior quanto na superfície superior, conforme ilustram as Figuras 4 e 5.

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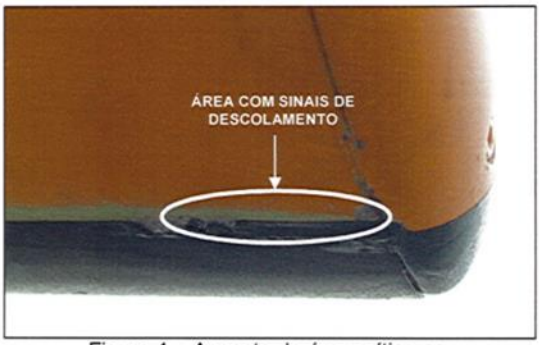

Figura 4 – Aspecto da área crítica na superfície inferior (*lower skin*) da pá P/N C016-7.

Figura 5 – Aspecto da área crítica na superfície superior (*upper skin*) da pá P/N C016-7.

A pá P/N C016-7 inspecionada também apresentou as seguintes anormalidades:

- desnível das superfícies (Figura 6), indicando deterioração da fixação (colagem) das diferentes partes do *skin*;

- descolamento nas juntas adesivas nas superfícies superior (*upper skin*) e inferior (*lower skin*), entre o *skin*, o *skin-to-spar* e o *cap cover*; e

- descolamento da *blade skin* em diversas áreas isoladas do bordo de ataque.

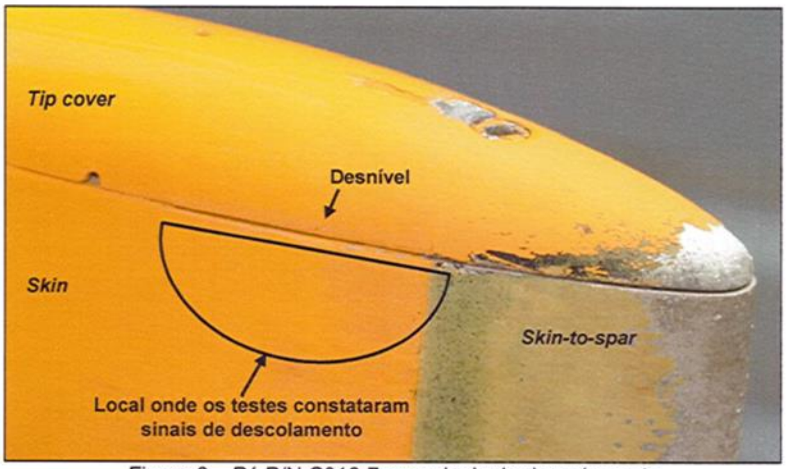

Figura 6 – Pá P/N C016-7 com sinais de descolamento.

As inspeções realizadas pelos técnicos do SIPAER, em conjunto com os operadores de R22 e R44/R44II, confirmaram que é possível a identificação visual, por parte dos pilotos, do descolamento ou indício de descolamento da *blade skin* das pás do rotor principal durante o cumprimento dos procedimentos estabelecidos na AD 2014-23-16 e nos Manuais das aeronaves. Em caso de dúvida dos pilotos, torna-se determinante a atuação de um mecânico na complementação da inspeção e

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confirmação, ou não, da condição de descolamento.

A atividade revelou sinais de descolamento da *blade skin* em algumas pás de rotor principal que anteriormente haviam sido consideradas, pelos operadores, como disponíveis para o voo. Tal fato denotou um indicativo de possível rebaixamento da "Consciência Situacional" de pilotos e mecânicos de R22 e R44/R44II, relacionado à compreensão do próprio cenário encontrado (estado de conservação das pás); e/ou ao conteúdo das instruções constantes da AD 2014-23-16 e dos Manuais de Operação / Manutenção das aeronaves R22 e R44/R44II.

De acordo com o último *Safety Alert* publicado pela RHC, existem reportes de pás com sinais de descolamento sendo reparadas inapropriadamente. Vale ressaltar que o SB103A e o SB72A tratam as pás que possuam sinais de descolamento como pás não aeronavegáveis, ou seja, indisponíveis para o voo.

Diante deste cenário, o surgimento prematuro dos problemas observados nas pás do rotor principal, dentre outros aspectos, pode estar relacionado com os serviços de manutenção realizados nos componentes. O estado geral das pás de rotor principal inspecionadas remete à necessidade de se observar, fielmente, o que dispõem os Manuais de Manutenção das aeronaves R22 e R44/R44II, mormente nas seções 9.140 – *Repair of Main Rotor Blades*; 9.141 – *Trimming*; e 9.142 – *Painting,* para efeito da realização dos referidos serviços de manutenção.

O CENIPA iniciou tratativas, junto à *Federal Aviation Administration* (FAA) e a *Robinson Helicopter Company* (RHC), para que seja realizada uma revisão das documentações técnicas que versam sobre o tema, em razão das condições encontradas.

AÇÕES RECOMENDADAS

À Agencia Nacional de Aviação Civil (ANAC), recomenda-se:

Dar ampla divulgação do conteúdo desta DIVOP aos operadores, pilotos e organizações de manutenção dos helicópteros *Robinson*, modelos R22 e R44/R44II.

Aos operadores e pilotos dos helicópteros Robinson, modelo R22, equipados com pás do rotor principal P/N A016-2; P/N A016-4; e P/N A016-6**, recomenda-se:**

Inspecionar a superfície superior (*upper skin*) das pás do rotor principal, buscando identificar descolamento ou indício de descolamento, trincas e/ou presença de corrosão em áreas críticas e não críticas da *blade skin*, em adição ao disposto no Manual de Operação das aeronaves *Robinson*, modelos R22 (Seção 4, Item 9), e na *Airworthiness Directives* 2014-23-16, notadamente, no que se refere às inspeções a serem realizadas diariamente, antes do primeiro voo do dia.

Aos operadores e mantenedores dos helicópteros Robinson, modelo R22, equipados com pás do rotor principal P/N A016-2; P/N A016-4; e P/N A016-6**, recomenda-se:**

Inspecionar a superfície superior (*upper skin*) das pás do rotor principal, buscando identificar descolamento ou indício de descolamento, trincas e/ou presença de corrosão em áreas críticas e não críticas da *blade skin*, em adição ao disposto no Manual de Manutenção das aeronaves *Robinson*, modelos R22 (Seção 2. 410, Item 13) e na *Airworthiness Directives* 2014-23-16, notadamente, no que se refere às inspeções periódicas (IAM/100 horas), e/ou quando provocados pelos pilotos em decorrência de constatações nas inspeções pré-voo.

Aos operadores e pilotos dos helicópteros Robinson, modelo R44/R44II, equipados com pás do rotor principal P/N C016-2; P/N C016-5; e P/N C016-7**, recomenda-se:**

Inspecionar a superfície superior (*upperskin*) das pás do rotor principal, buscando identificar descolamento ou indício de descolamento; trincas; e/ou presença de corrosão em áreas críticas e não críticas da *bladeskin*, em adição ao disposto no Manual de Operação das aeronaves *Robinson*, modelos R44/R44II (Seção 4, Item 2), e na *AirworthinessDirectives* 2014-23-16, notadamente, no que se refere às inspeções a serem realizadas diariamente, antes do primeiro voo do dia.

Aos operadores e mantenedores dos helicópteros Robinson, modelo R44/R44II, equipados com pás do rotor principal P/N C016-2; P/N C016-5; e P/N C016-7**, recomenda-se:**

Inspecionar a superfície superior (*upperskin*) das pás do rotor principal, buscando identificar descolamento ou indício de descolamento; trincas; e/ou presença de corrosão em áreas críticas e não críticas da *bladeskin*, em adição ao disposto no Manual de Manutenção das aeronaves *Robinson*, modelos R44/R44II (Seção 2.410, Item 12) e na *AirworthinessDirectives* 2014-23-16, notadamente, no que se refere às inspeções periódicas (IAM/100 horas), e/ou quando provocados pelos pilotos em decorrência de constatações nas inspeções pré-voo.

Aos pilotos e mecânicos de helicópteros Robinson, modelos R22 e R44/R44II, recomenda-se:

Dedicar, durante as inspeções, especial atenção a qualquer tipo de desnível das superfícies superiores e inferiores das pás do rotor principal (Figura 6), notadamente nas junções entre a *skin*, *tip cover* e *skin-to-spar*.

DIVULGAÇÃO

-Agência Nacional de Aviação Civil (ANAC); e
- Operadores, pilotos e mantenedores de helicópteros *Robinson*, modelos R22 e R44/R44II.

APROVO:

Brigadeiro do Ar FREDERICO ALBERTO MARCONDES FELIPE
Chefe do Centro de Investigação e Prevenção de Acidentes Aeronáuticos

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ANNEX A – COMMENTS BY THE STATES PARTICIPATING IN THE INVESTIGATION

In compliance with the provisions of the Chapter 6, item 6.3, of the Annex 13 to the Convention on International Civil Aviation, the States participating in this investigation had the opportunity to make their comments concerning the content of this final report.

Through the National Transportation Safety Board, the United States of America forwarded the document ERA18WA066, containing comments from the aircraft manufacturer's Robinson Helicopter Company (RHC).

All comments deemed pertinent have been included in the body of this report. The following are comments that have not been incorporated or have been partially incorporated.

COMMENT 20

Text to be corrected (Chapter 2, Page 60, Line 2)

…from the original adhesive material used in the manufacture of the blade.

Text proposed by the NTSB

…from the original adhesive material used in the manufacture of the blade consistent with an unapproved repair by an unknown individual.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

This matter is addressed along the Final Report Analysis Chapter. The idea is to build a chronological understanding of the sequence of events. In the CENIPA point of view this information is clear and comprehensible in the Analysis and Conclusion parts of this report, as shown in the text on page 61, lines 1 to 5.

COMMENT 21

Text to be corrected (Chapter 2, Page 60, Line 5)

…or injected, from the outside.

Text proposed by the NTSB

…or injected, from the outside consistent with an unapproved repair by an unknown individual.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

This matter is addressed along the Final Report Analysis Chapter. The idea is to build a chronological understanding of the sequence of events. In the CENIPA point of view this information is clear and comprehensible in the Analysis and Conclusion parts of this report, as shown in the text on page 61, lines 1 to 5.

COMMENT 22

Text to be corrected (Chapter 2, Page 61, Line 3-9)

Examinations corroborated that the debonding of the red blade upper skin (S/N 6128) occurred in flight.

The debonding began at the leading edge of the blade, more precisely in the skin-to spar bond line area. The relative wind incident at the leading edge, due to the blade inflight revolution, lifted up the front portion of the debonded upper skin, causing the peeling off of approximately 50% of the skin toward the trailing edge of the blade (Figure 64).

<u>Text proposed by the NTSB</u>

Examinations corroborated that the debonding of the red blade skins (S/N 6128) occurred prior to the accident flight and led to the skin peeling in flight.

The peeling of the lower skin began at the leading edge of the blade, more precisely in the skin-to-spar bond line area. The relative wind incident at the leading edge, due to the blade inflight revolution, lifted up the front portion of the debonded skin, causing the peeling of the skin, back toward the trailing edge of the blade (Figure 64).

<u>Argumentation by the NTSB</u>

The description should not lead the reader to believe that the skin suddenly debonded and separated from the spar. It may not need as much detail as listed below, but should explain the progression, hence the suggested revisions above.

For investigators clarification, an explanation of progression of skin separation:

- Erosion of the paint surface exposes the bond lines to moisture (in this case, mostly between the tip cap and skin).
- Moisture deteriorates the adhesive.
- Adhesive begins to debond from the metals.
- The aluminum tip cap is exposed to the moisture and begins to corrode.
- Corrosion builds up and becomes a wedge (bulging) between the tip cap and skin allowing more moisture and more corrosion to creep deeper into the blade. This is evident by the beach marks of corrosion in the adhesive (figure 45). The injecting of additional adhesive likely enhanced the wedge effect.
- Once the bond joints debonded significantly and the skin was wedged away from the spar, the relative wind also became a wedge between the skin and spar and between the skin and end cap, peeling the skin back.

Although we do not have the lower skin and/or spar to verify it, evidence shows, that the lower skin was the first to peel away, exposing the honeycomb to the relative wind which exposed the inside of the upper skin to forced air through the honeycomb area which pushed the upper skin away from the spar and end cap and into the wind, peeling it back also. This is seen in the propagation direction of the adhesive fractures at the leading edge of the upper skin (forward, not backward) along with the fact that it is a cohesive separation in that area (figure 63). It was not entirely debonded prior to the peeling.

The deteriorated adhesive and corrosion was much worst on the lower skin-to-end cap area as seen on both the red and blue blades. Figure 40 is a good example of the skin separation at the skin-to-spar bond joint on the lower surface of the blue blade. The red blade likely looked very similar (or worse) just prior to it peeling back. Figure 45 shows a much larger portion of the lower skin-to-spar bond joint had debonded as compared to the upper skin-to-spar bond joint (figure 42).

Previous cases which did not have any other damage have all been the lower skin peeling back resulting in excessive vibration, but still controllable enough to land. The EPEV study is still applicable and explains how it likely became catastrophic once the upper skin peeled away.

CENIPA's Opinion

Partially incorporated.

CENIPA's Argumentation

The term "debonding" has been replaced by the term "peeling off" (separation) to make it clear that the paragraph refers to the separation of the skin from the core of the blade.

With respect to the comment that the blade had a debonding on a date prior to the accident's flight, this statement was highlighted in the text in line 7, on page 62, namely: "The finding that there was an adhesive material different from the original on both blades (S/N 6128 and S/N 6131) suggested that, at some point in the operational life of these components, before the accident flight, areas with signs of debonding were detected and that, in an attempt to correct these failures, a filling material was applied".

Regarding the comments addressed to the lower skin, the proposal was not accepted considering that the parts were not recovered and, therefore, could not be analyzed.

Since the lower skin and spar of the red blade were not found and, therefore, could not be analyzed, the investigation cannot verify the dynamics suggested in the comment.

Likewise, in the previous occurrences reported in the comment, in which separations of the lower skin were found without further damage to the blade, there was sufficient control to land the aircraft, despite excessive vibration. Thus, in the opinion of the investigators, this dynamic was not consistent with that observed in the accident flight.

COMMENT 23

Text to be corrected (Chapter 2, Page 61, Figure 64)

Figure 64 - Schematic representation of the in-flight take-off dynamics of the red blade (S/N 6128).

Text proposed by the NTSB

Modify to show lower skin.

Green circle description should read "Area where the inflight peeling started" and should encircle the entire width of the end cap.

Green Arrow description should read "Peeling propagation direction.

CENIPA's Opinion

Partially incorporated.

CENIPA's Argumentation

Regarding the comment that suggests that the representation of the debonding dynamics should point to the lower skin instead of the upper skin, the proposition was not accepted, as explained in the argument to Comment 22.

Regarding the comment that proposes that the description of the green circle should be "Area where the separation in flight started" and should involve the entire width of the tip cap, the term "debonding" was replaced by "peeling off".

COMMENT 25

Text to be corrected (Chapter 2, Page 62, Lines 1-2)

…were determined by the FAA and implemented by the RHC.

Text proposed by the NTSB

…were determined by the RHC and implemented by both the RHC and the FAA.

CENIPA's Opinion

Partially incorporated.

CENIPA's Argumentation

Since SBs are only mandatory through an AD that includes them, the investigation understood that the RHC recommended procedures that became mandatory only after the FAA issued an AD. The text was changed to: "As a result of these findings, some prevention and control measures have been determined by the FAA and implemented by the RHC".

COMMENT 27

Text to be corrected (Chapter 2, Page 61, Lines 15-16)

The maintenance professionals interviewed reported not being aware of any such repairs performed on the aircraft.

Text proposed by the NTSB

A signed statement was submitted by a maintenance professional who visually inspected the blades prior to the last annual inspection and informed the operator that the blades were unairworthy. I see no reference to this.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

This comment does not apply to the accident of this RF, but to an accident with another R44 aircraft, registration PP-WVR.

COMMENT 32

Text to be corrected (Chapter 3, Page 65, Lines 29-30)

v) it was not possible to specify in which country, time, place and circumstances the application of filler material found on the blades took place;

Text proposed by the NTSB

While we do not know who injected the filler into the blade or when, it likely happened shortly before the accident flight. This statement should be modified as it implies the possibility that the filler material may have been injected into the blades prior to leaving the United States. The filler material in question is not used at the RHC factory, and its presence would not have allowed the blades to get through the factory Quality Assurance system.

There is no reason to suggest, or evidence that the filler injection occurred during its first 192 hours of operation in a non-coastal environment while it was in the United States.

Laboratory examination revealed the existence of corrosion on the metal surfaces on each side of the filler material, indicating the filler material was injected after the skin had debonded from the end cap and was already corroded. The filler material did not adhere to the skin or the end cap, it simply filled the void and became a wedge, forcing the skin away from the end cap and allowing more moisture to enter into the void, which accelerated the debonding of the original adhesive.

It is not possible for the main rotor blades to have been in service for several years and multiple flight hours after injection of the filler material without the discovery of a void during one of the many 100-hour inspections and seven annual inspections. It is likely that the filler material was injected after the last 100-hour inspection (11NOV2017 @3804hrs) and before the last annual inspection (17JAN2018 @3853hrs), less than 3 months and 50 hours prior to the accident.

The only other instances of a filler material being used to perform an unapproved repair of a void in a blade, that we are aware of, have all been in Brazil (ref PP-WVR & PR-VVE).

CENIPA's Opinion

Partially incorporated.

CENIPA's Argumentation

The text has been changed to: "it was not possible to specify in which circumstances the application of filler material found on the blades took place".

COMMENT 33

Text to be corrected (Chapter 3, Page 63, Lines 31-34)

t) the debonding began at the leading edge of the red blade (S/N 6128) in the skin-to spar bond line area;

u) the relative wind incident on the red blade (S/N 6128) caused a peeling off of 50% of the forward portion of the upper skin;

Text proposed by the NTSB

Reference comment above for page 60, Line 1-6.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

Regarding the comments addressed to the lower skin, the proposition was not accepted considering that the parts were not recovered and, therefore, could not be analyzed.

Since the lower skin and spar of the red blade were not found and, therefore, could not be analyzed, the investigation cannot verify the dynamics suggested in the comment.

Likewise, in the previous occurrences reported in the comment, in which separations of the lower skin were found without further damage to the blade, there was sufficient control to land the aircraft, despite excessive vibration. Thus, in the opinion of the investigators, this dynamic was not consistent with that observed in the accident flight.

COMMENT 41

Text to be corrected (Chapter 3, Page 67, Lines 34-35)

…of the aircraft manufactured by Robinson Helicopter 8 Company, models R22, R44, and their variations...

Text proposed by the NTSB

This recommendation should apply to all aircraft, not just Robinson products.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

The Safety Recommendation is specific to the case of Robinson operating in Brazil. It cannot be assumed that other projects and maintenance organizations need guidance of this nature.