COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-112/CENIPA/2017

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-RSP**
MODEL:	**S2R-H80**
DATE:	**06SET2017**

NOTICE

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

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

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

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

This Final Report has been made available to the ANAC and the DECEA so that the technical-scientific analyses of this investigation can be used as a source of data and information, aiming at identifying hazards and assessing risks, as set forth in the Brazilian Program for Civil Aviation Operational Safety (PSO-BR).

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

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

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

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

SYNOPSIS

This is the Final Report of the 06 September 2017 accident with the S2R-H80 aircraft, registration marks PR-RSP. The accident received the typification of “[SCF-PP] Engine failure or malfunction”.

While the aircraft was engaged on an agricultural pesticide application flight, its engine lost power, and the pilot made a forced landing on an area of plantation.

Investigators found that the engine sustained a catastrophic failure in several internal components, possibly caused by operation above the limits specified in its design.

There was substantial damage to the aircraft.

The pilot suffered no injuries.

Being the Czech Republic the State of manufacture of the aircraft’s engine, its *Air Accidents Investigation Institute* (AAII) appointed an accredited representative for participation in the investigation of the accident.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AAII	Czech Republic's Air Accidents Investigation Institute
ANAC	Brazil's National Civil Aviation Agency
ATP	Acceptance Testing Procedures
CA	Certificate of Airworthiness
CENIPA	Aeronautical Accidents Investigation and Prevention Center
CIV	Pilot Logbook
CMA	Aeronautical Medical Certificate
GEAC	General Electric Aviation Czech
ISA	International Standard Atmosphere
ITT	Inter-Turbine Temperature
MNTE	Single-Engine Land Airplane Class Rating
MVP-50T	Glass Panel Engine Monitoring System
NG	Gas-Generator Turbine Rotation
NGVR	Power Turbine Guide Vane Ring
NP	Propeller Rotation
OAT	Outside Air Temperature
OM	Maintenance Organization
PAGA	Ag Pilot Rating - Airplane
PCM	Commercial Pilot Rating - Airplane
PIC	Pilot in Command
PPR	Private Pilot License - Airplane
PT	Power Turbine
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazi8lian Aeronautical Certification Regulation
RGB	Reduction Gear Box
SERIPA III	3rd Regional Service for the Investigation and Prevention of Aeronautical Accidents
SIPAER	Aeronautical Accidents Investigation and Prevention System
SN	Serial Number
SSZK	ICAO location Designator – Aerodrome of Fazenda Água Santa, Perdizes, State of Minas Gerais
TIG	Tungsten Inert Gas
TPP	Private Air Services Registration Category
UTC	Coordinated Universal Time
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** S2R-H80 **Registration:** PR-RSP **Manufacturer:** Thrush Aircraft	**Operator:** Private
Occurrence	**Date/time**: 06SET2017 - 09:50 UTC **Location:** *Fazenda Água Santa* **Lat.** 19°18'35"S **Long.** 047°26'22"W **Municipality – State:** *Perdizes – Minas Gerais*	**Type(s):** [SCF-PP] Powerplant failure or malfunction

1.1. History of the flight.

The aircraft took off from SSZK (Aerodrome of *Fazenda Água Santa*, *Perdizes*, State of *Minas Gerais*), on an agricultural pesticide application flight, with a pilot on board.

Approximately 15 minutes into the flight, during the pesticide application over the plantation, the aircraft's engine lost power.

The pilot performed a forced landing some distance ahead.

The aircraft sustained substantial damage.

Figure 1 - Image of the aircraft at the location of the final stop.

The pilot suffered no injuries.

1.2. Injuries to persons.

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

1.3. Damage to the aircraft.

The aircraft sustained substantial damage.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

FLIGHT EXPERIENCE	
	PIC
Total	10,000:00
Total in the last 30 days	51:00
Total in the last 24 hours	01:00
In this type of aircraft	2,400:00
In this type in the last 30 days	51:00
In this type in the last 24 hours	01:00

Obs.: data on the hours flown obtained through declaration from the pilot.

1.5.2. Personnel training.

The PIC (Pilot in Command) did his PPR course (Private Pilot – Airplane) in 1986, at the *AHV Escola de Aviação Civil Ltda*, *Goiânia*, State of Goiás.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PCM license (Commercial Pilot - Airplane) and had valid ratings for MNTE (Single-Engine Land Airplane) and PAGA (Agricultural Pilot - Airplane)

1.5.4. Qualification and flight experience.

The records of his Pilot Digital Logbook (CIV) indicated that the PIC had been flying the S2R-H80 aircraft, registration marks PR-RSP, since March 2015 and that he frequently operated from SSZK.

One verified that, from January to September 2017, the PIC had approximately 620 flight hours recorded with the PR-RSP airplane.

According to a PIC's report, he had operated the following types of aircraft: Cessna C-201, Cessna C-310, EMB-720 *Minuano*, EMB-721 *Sertanejo*, EMB-201, EMB-202 *Ipanema*, Cessna 188 Ag Truck, and Piper PA-25 Pawnee, all equipped with conventional engines, and Thrush 510G and Thrush 510P, the latter ones equipped with turboprop engines.

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

1.5.5. Validity of medical certificate.

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

1.6. Aircraft information.

The SN H80-152 aircraft was a product manufactured by Thrush Aircraft in 2014, and registered in the Private Air Services Registration Category (TPP).

The aircraft's CA (Certificate of Airworthiness) was valid.

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

The last inspection of the aircraft ("100-hour" type) was carried out on 07 August 2017 by the *SOMA - Serviços Oficina e Manutenção Aeronáutica* Maintenance Organization, Primavera do Leste, Mato Grosso. The airplane flew 117 hours and 35 minutes after the referred inspection.

The SN 1410009 model H80-100 engine had been installed on the aircraft since new.

On the day of the accident, the aircraft's logbook records indicated a total of 2,088 hours and 40 minutes of flight time.

The aircraft was equipped with a digital engine data monitoring panel known as Glass Panel Engine Monitoring System (MVP-50T).

The MVP-50T's digital screen displayed data of the engine, alarm panel, as well as some information concerning the aircraft's systems, such as the electrical, hydraulic and fuel systems (Figure 2). One of the engine instruments displayed was the torque indicator.

Figure 2 - Panel of the aircraft's MVP-50T.

1.7. Meteorological information.

The meteorological conditions were consistent with visual flights.

The wind was calm, visibility was unlimited, there were no significant clouds, and the temperature was 12°C.

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

The occurrence was outside aerodrome area.

1.11. Flight recorders.

In addition to its primary function, the MVP-50T recorded and stored in its internal memory the parameters of the engine instruments and systems relating to previous flights carried out up to a limit of 500 hours of operation.

Shortly after the accident, this data was downloaded and segregated for analysis.

The MVP-50T information was analyzed at the headquarters of General Electric Aviation Czech (GEAC) in the presence of representatives from the manufacturer and the Investigative Commission.

Based on the data recorded in the MVP-50T, it was possible to generate diagrams with parameters of propeller rotation (NP), gas generating turbine rotation (NG), engine torque (TQ), Interturbine Temperature (ITT) and Outside Air Temperature (OAT).

Aiming at a better understanding of the sequence of events, the diagrams will be detailed in item 1.18. Operational information.

1.12. Wreckage and impact information.

The aircraft collided with the ground in an area of plantation, at a low angle of impact.

The first contact with the ground occurred in a straight attitude (approximately 5°), with a banking of approximately 25° to the left. After this first impact, the plane touched the ground two more times, traveling a distance of 60 m until coming to a complete stop. (Figure 3).

Figure 3 - Aircraft trajectory from the first impact to the complete stop.

The propeller had fully feathered blades, and showed no apparent damage, indicating that the impact occurred with the engine not functioning (Figure 4).

Figure 4 - Image of the aircraft propeller with the blades in the feathered position.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

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

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

NIL.

1.14. Fire.

There was no fire.

1.15. Survival aspects.

NIL.

1.16. Tests and research.

During the initial investigation, marks of oil leakage were observed on the engine cowling, around the exhaust gas pipe. The marks extended backwards, indicating that there had been an in-flight oil leakage (Figure 5).

Figure 5 - Oil marks on the engine cowling.

The engine cowling also had, on the left-hand side of its upper part, a hole made from the inside to the outside of the compartment, showing that an object had come loose that passed through this component (Figure 6).

Figure 6 - Damage with perforation on the left side of the engine cowling.

Figure 7 - Debris found inside the engine compartment.

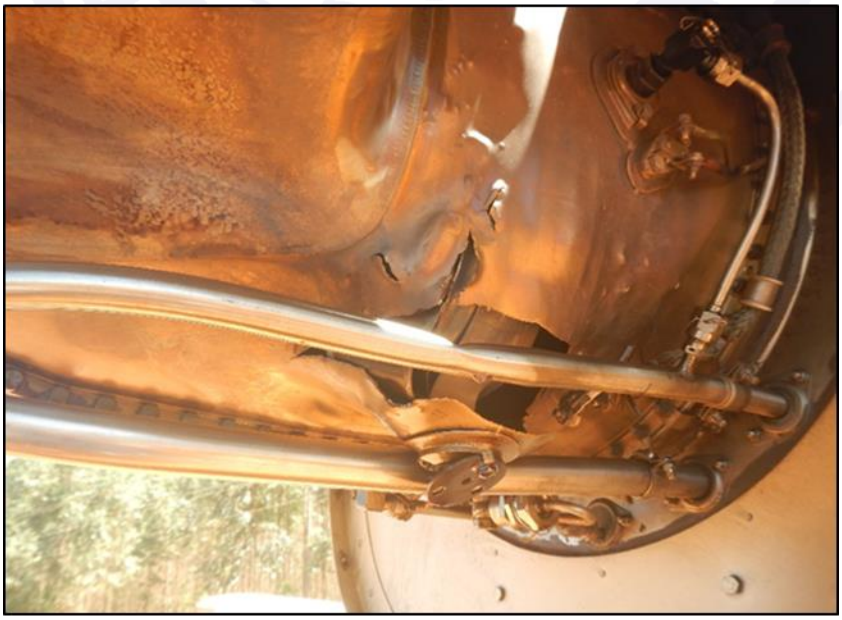

Figure 8 - Evidence of severe internal damage to the engine.

Figure 9 - Evidence of severe internal damage to the engine.

The magnetic plug of the engine's filing detection system was contaminated and had lots of metal particles (Figure 10).

Figure 10 - Magnetic plug of the engine filing detection system contaminated with metal particles.

The aircraft's engine was sent to the manufacturer's headquarters, where it underwent detailed analysis and examinations, with the aim of identifying the origin of the damage observed.

Figure 11, below, shows the position of the main internal components that were subject to more detailed evaluations.

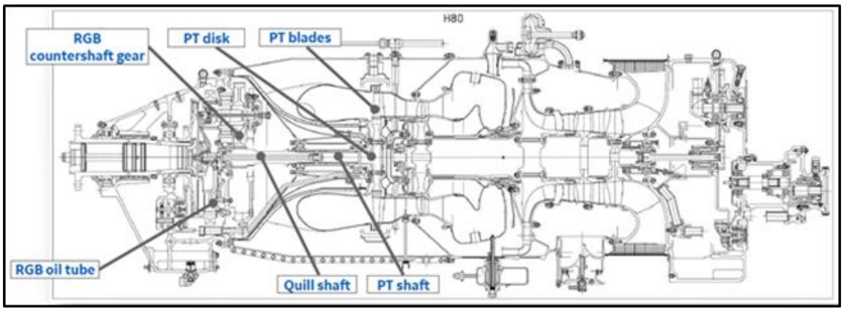

Figure 11 - Schematic drawing of the engine showing the position of the main internal components that were subject to more detailed evaluations.
Source: Investigation Report GEAC.

The engine was disassembled at the headquarters of General Electric Aviation Czech (GEAC), in Prague, Czech Republic, in the presence of representatives of the manufacturer and the Investigation Commission.

After disassembling the engine, one observed a fracture in the Reduction Gear Box (RGB) Oil Tube, which provided information to the engine torque indicator in the region of the flange, which was screwed to the pseudoplanetary stator body (Figures 12 and 13).

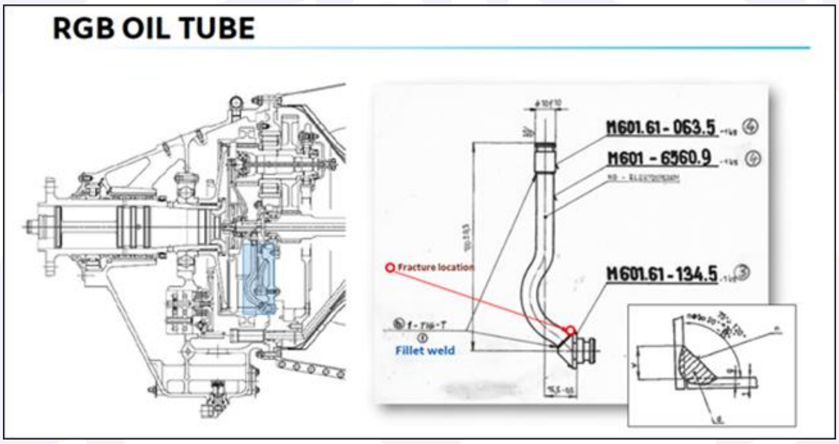

Figure 12 - Location of the RGB Oil Tube, with the point of fracture in highlight.
Source: Investigation Report GEAC.

Figure 13 - Images of the fractured RGB Oil Tube obtained at the engine disassembly. Source: Investigation Report GEAC.

By means of metallographic analysis, it was possible to identify cracks and “beachmarks”, typical characteristics of the mechanism of material failure due to fatigue. The cracks progressed along the entire length of the tube wall, allowing part of the oil to leak (Figure 14).

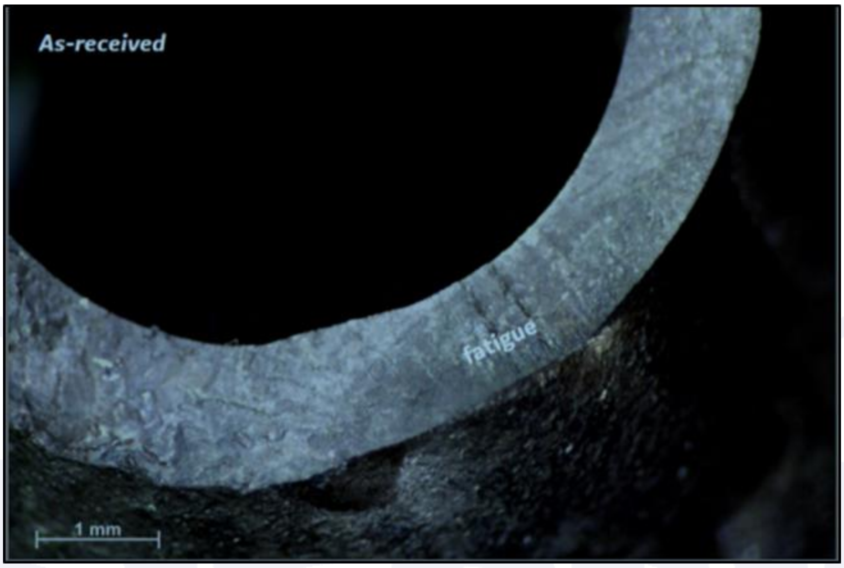

Figure 14 - Metallographic analysis image showing cracks and “beach marks”, typical characteristics of the material-failure mechanism due to fatigue.
Source: Investigation Report GEAC.

The assembly included two M601-626.9 RGB Oil Tubes. The one not damaged was sectioned for more in-depth analysis, which made it possible to identify that the Tungsten Inert Gas (TIG) weld presented characteristics different from those required, such as multiple overlapping layers, lack of penetration, and direction not corresponding to the expected axis (Figure 15).

Figure 15 - Image obtained during the metallographic examination of the sectioned tube, highlighting welding characteristics different from those required.
Source: Investigation Report GEAC.

The planetary gear of the 1st RGB reduction stage was found damaged. The analyses identified typical characteristics of material failure due to fatigue followed by overload in thirty teeth (Figures 16 to 18).

The examinations identified that the fatigue could have been caused by the fact that the engine had operated with power above the limit established in the certification (*overtorque*).

Figure 16 - Damaged planetary gears.
Source: Investigation Report GEAC.

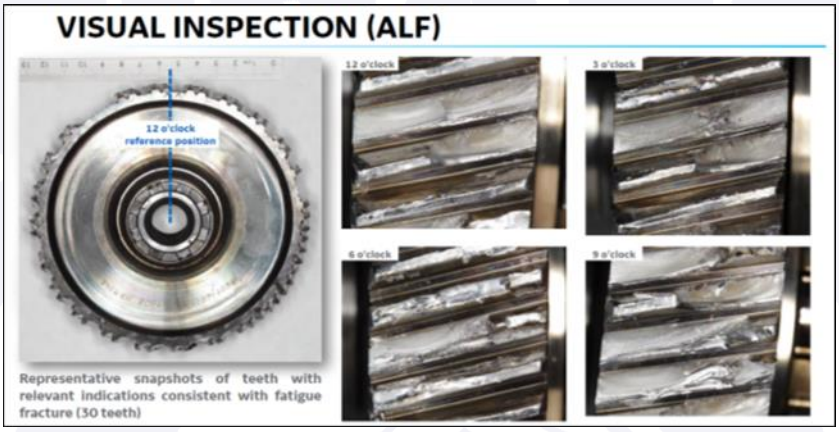

Figure 17 - View of the RGB gear showing fractured teeth.
Source: Investigation Report GEAC.

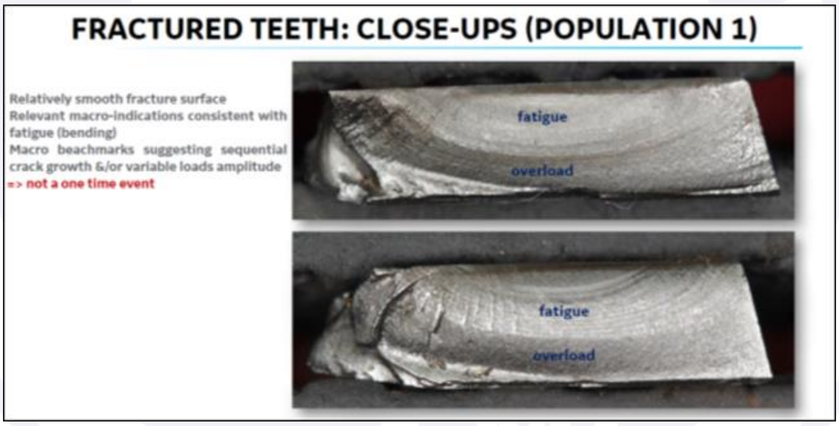

Figure 18 - Stereoscopic image of one of the gear teeth showing characteristics of material failure due to fatigue and overload.
Source: Investigation Report GEAC.

The observed “beach marks” (Figure 18) demonstrated that there was a sequential increase in the amplitude of the cracks and that the structure was subjected to efforts of varying intensity, not being a single event.

The rotor of the Power Turbine (PT) sustained severe damage and lost all of its blades (Figure 19).

Figure 19 - PT Image. Source: Investigation Report GEAC.

Examination of the region of separation of the blades showed features consistent with overload fractures (Figure 20).

Figure 20 - Image showing the fracture region on a PT blade.
Source: Investigation Report GEAC.

The Power Turbine Guide Vane Ring (NGVR) also showed severe damage resulting from impact against the PT (Figure 21).

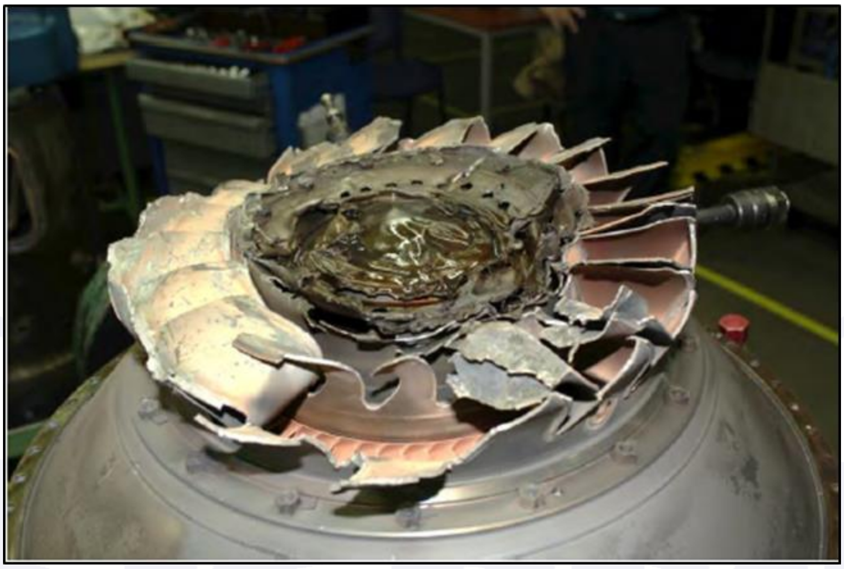

Figure 21 - Image showing the damage to the NGVR.
Source: Investigation Report GEAC.

The Quill-Shaft also showed severe damage. The teeth on the edge that connected to the RGB sustained severe mechanical damage and the shaft got bent. (Figure 22).

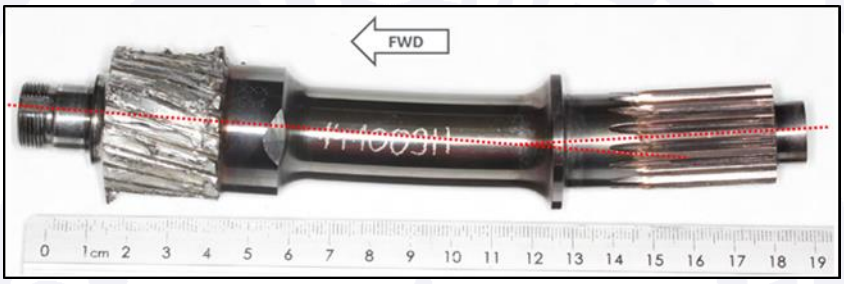

Figure 22 - Image showing damage to the Quill-Shaft.
Source: Investigation Report GEAC.

1.17. Organizational and management information.

NIL.

1.18. Operational information.

It was an agricultural pesticide application flight conducted under the requirements established by the Brazilian Civil Aviation Regulation nº 137 (RBAC-137), Amendment 00, dealing with "Certification and Operational Requirements: Aeroagricultural Operations".

The aircraft was within the weight and balance limits specified by the manufacturer. At the time of the accident, the weight of the airplane was 2,647 kg, including 482 kg of fuel.

The *Section 4 - "Performance"* of the Airplane Manual contained, among others, diagrams of torque limits as a function of altitude and temperature.

Considering that the temperature on the day of the accident was 12°C and that the altitude was 1,060 m (approximately 3,500 ft), one calculated that the ambient temperature was approximately ISA + 4°C.

Therefore, by means of the diagram on page 53 of the aforementioned manual, one verified that the available torque would be 2,020 ft-lbs, the maximum value allowed for the engine, which corresponded to 100% under the conditions present during the flight in which this accident occurred. (Figures 23 and 24).

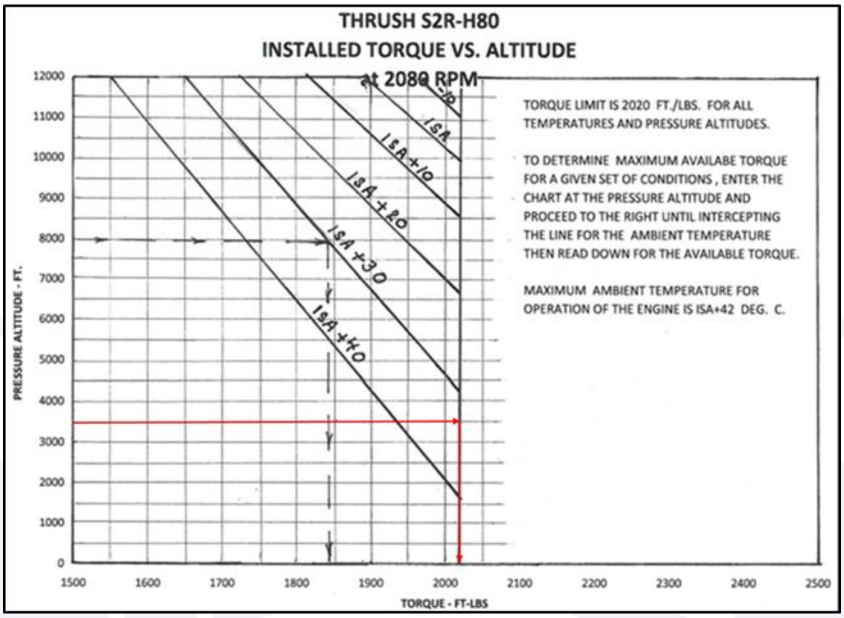

Figure 23 - Diagram of the engine available torque limit as a function of ISA temperature and altitude of the location.

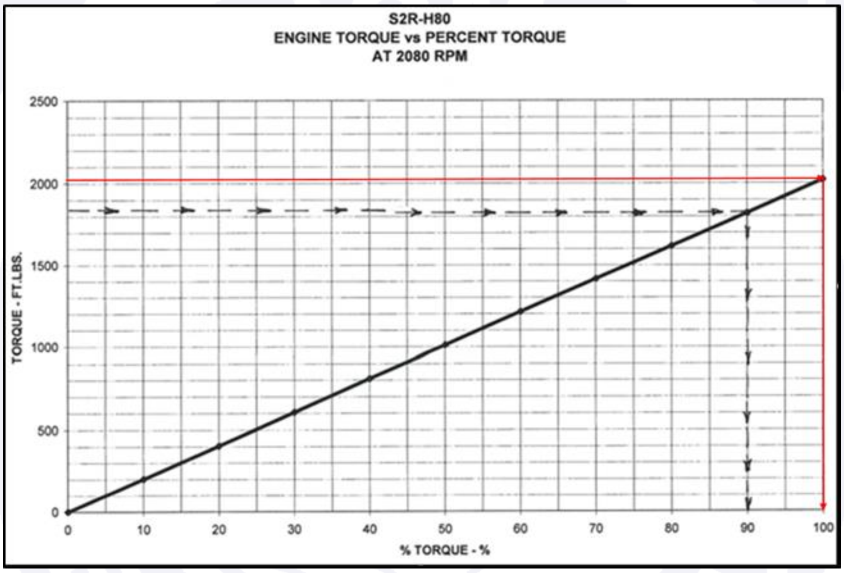

Figure 24 - Torque measurement unit conversion chart from ft-lbs to percentage.

The investigation found out that the PIC did not use the aircraft's performance charts before starting the operation. He made use of the different colors (green, yellow and red) of the MVP-50T's digital arcs as a reference during operation, because, in his understanding, the engine could be operated within the green range regardless of the temperature and altitude of the location.

As a matter of fact, the instruments' digital arcs (green, yellow and red) presented fixed values, based on engine bench-tests and on the International Standard Atmosphere (ISA) conditions at sea level. Therefore, they did not automatically translate the real limitation of each parameter depending on the temperature and altitude at which the operation was being conducted.

According to the manufacturer, during the Acceptance Testing Procedures (ATP), the SN 141009 engine presented the following results:

- maximum torque associated with 100% NG in standard atmosphere (15°C at sea level) between 110% and 120%;
- ITT 695°C; and

- Power of 597 KW.

The data recorded in the MVP-50T's internal memory indicated that there were two flights on the day of the accident.

The produced diagram based on the aircraft's engine parameters during the takeoff and cruise phases of the first flight showed that, at takeoff, although the NG was at 100%, the torque remained at 94%, a value that the engine manufacturer deemed too low. Relatively to this parameter, the records based on the ATP results indicated that the maximum torque associated with 100% NG at 15°C OAT should be between 110% and 120%.

Furthermore, the ITT reached 705°C, while in the ATP the engine remained at 695°C at maximum power.

According to calculations, in that phase of the flight (takeoff), the power developed was 700 KW, in contrast to the 597 KW of the design.

Based on the results obtained, the manufacturer's representatives concluded that the engine was being operated in an overtorque condition (Figure 25).

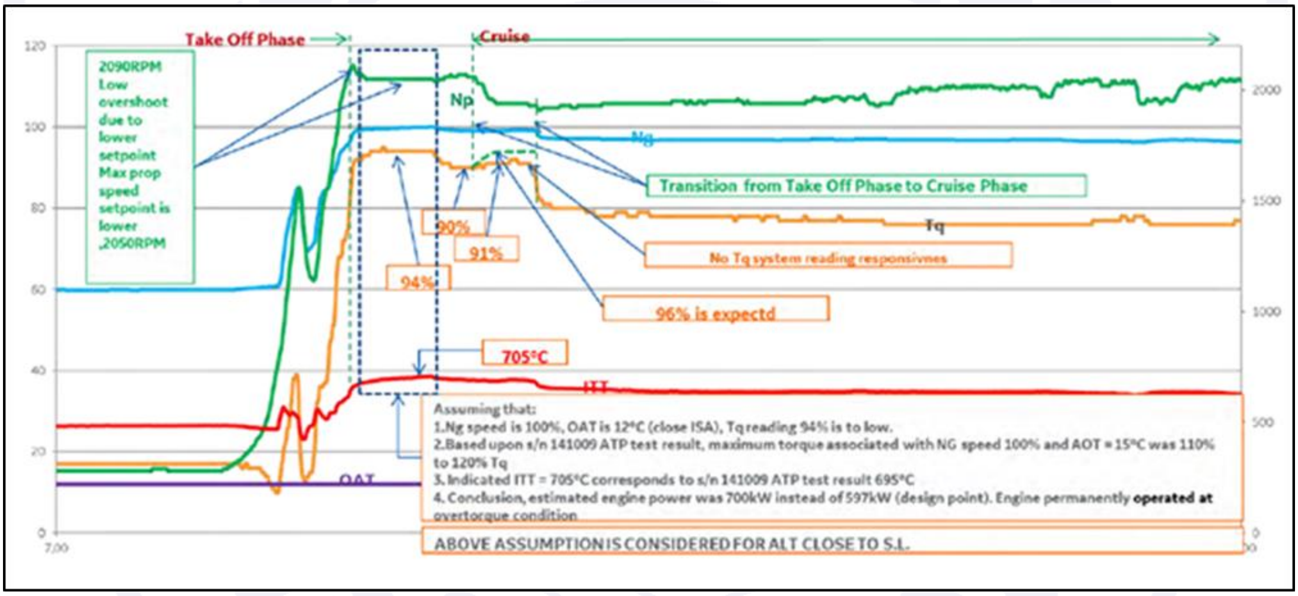

Figure 25 - Diagram showing the aircraft engine parameters during the takeoff and cruise phases of the first flight. Source: Investigation Report GEAC.

Near the end of the first flight, one observed a drop in value and total loss of torque indication without the corresponding change in the parameters of the NG, NP, and ITT.

In the sequence, all parameters decreased. That was the moment at which the landing to replenish the aircraft with the product occurred, without shutting down the engine (Figure 26).

Figure 26 - Diagram of aircraft engine parameters in the first complete flight.
Source: Investigation Report GEAC.

The moment at which the torque indication “zeroed out” was recorded in an image obtained with a cell phone by the PIC (Figure 27).

Figure 27 - Image recorded by the PIC showing the torque indication on the MVP-50T screen.

The aircraft remained on the ground approximately four minutes to replenish the agricultural pesticide compartment and, upon completing the procedure, took off for the second flight, which was conducted without information of torque.

In the diagram showing the data from the end of the first flight to the second flight until the moment of engine failure, one verified that the second flight began without indication of torque and that, at takeoff, there was a slight excess of the propeller RPM, since the limit was 2,157 RPM, and it reached 2,160 RPM.

The flight continued until the occurrence of the catastrophic engine failure, with feathering of the propeller and loss of all parameters after the collision with the ground. The temporary increase in NG may have been the result of the pilot's attempt to restart the engine after the failure (Figure 28).

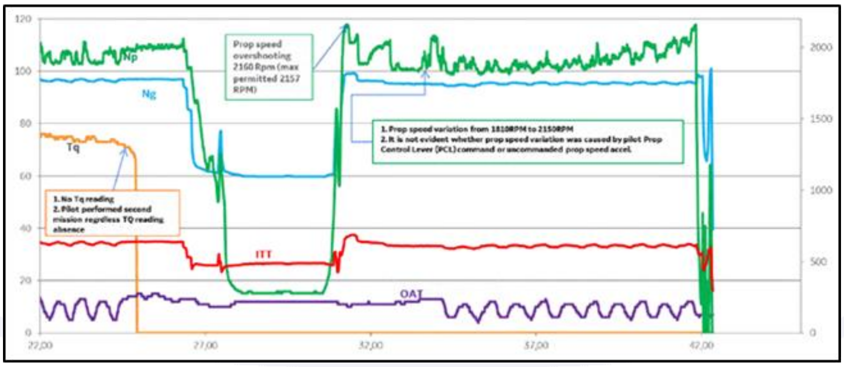

Figure 28 - Diagram showing data from the end of the first flight and data of the second flight until the moment of engine failure.
Source: Investigation Report GEAC.

1.19. Additional information.

With respect to the instrument requirements for the flight being conducted, the Brazilian Aeronautical Homologation Regulation nº 91 (RBHA-91), dealing with "General Operating Rules for Civil Aircraft", in force at the time of the accident, in its Subpart C - "Equipment, Instrument and Certificate Requirements", section 91.205 - "Instrument and Equipment Requirements - Motorized Civil Aircraft Holding a Standard Airworthiness Certificate", established the following:

> SUBPART C - REQUIREMENTS CONCERNING EQUIPMENT, INSTRUMENTS, AND CERTIFICATES
>
> 91.205 - REQUIREMENTS CONCERNING INSTRUMENTS AND EQUIPMENT. MOTORIZED CIVIL AIRCRAFT HOLDING A STANDARD AIRWORTHINESS CERTIFICATE
>
> (a) General. Except as provided in paragraphs (c)(4) and (e) of this section, no person is allowed to operate a powered civil aircraft holding a standard airworthiness certificate in any of the operations described in paragraphs (b) through (g) of this section, unless such aircraft contains the equipment and instruments required by the same paragraphs (or equivalent ones approved by the ANAC) for that type of operation, and the referred pieces of equipment and instruments are in operable condition.
>
> (b) Daytime VFR flights. In order for one to fly VFR during day-time, the following equipment and instruments are required:
>
> [...]
>
> (9) a torque indicator and a gas temperature indicator for each engine and turbine, as applicable;

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

It was an agricultural pesticide-application flight conducted by a licensed and qualified pilot under the requirements established by the RBAC-137.

The exams and tests revealed that the loss of torque-adjustment information that occurred at the end of the first flight of the day was due to the rupture of the RGB Oil Tube.

Considering that the analyses demonstrated that the referred fracture was caused by a fatigue process beginning with cracks that progressed until crossing the tube wall, allowing oil to leak, it is likely that such failure was already interfering with the torque indications even before the rupture of the pipe, due to the resulting loss of pressure.

An indication that this was occurring was pointed out by the manufacturer's technicians who, upon observing the diagram that showed the aircraft's engine parameters during the takeoff and cruise phases of the first flight, considered a torque of 94% to be too low for an NG of 100% at the altitude and temperature at which the flight was being conducted.

Upon mentioning that, in the ATP, the maximum torque associated with 100% NG at 15°C OAT would be between 110% and 120%, the manufacturer suggested that, as it was being operated at a temperature close to that of the standard atmosphere (ISA + 4°C), the engine was delivering torques in the same range observed in that acceptance test and, therefore, was operating in an overtorque condition, since the maximum value for the conditions prevailing during the flight in question was 100%.

This hypothesis is corroborated by the fact in that phase of the flight the power developed by the engine was calculated to be 700 KW, in contrast with the 597 KW of the design.

Furthermore, the fact that the analyses of the planetary gear of the first stage of the RGB identified characteristics typical of material failure due to fatigue followed by overload on its teeth, also directed the conclusions towards continued operation with power above the certification limits.

In such scenario, the damage found at the end of the Quill-Shaft that connected to the RGB, the bending observed in the said shaft, the loss of blades from the Power Turbine (PT) with overload characteristics, and the severe damage resulting from the impact against the PT rotor observed in the Power Turbine Guide Vane Ring (NGVR), indicated that the engine continued to run after the failure of the planetary gear teeth of the 1st RGB reduction stage, and collapsed due to the unbalance that followed.

Thus, based on the investigation elements gathered, one concluded that the loss of engine power, which led the aircraft to make a forced landing, was caused by a catastrophic failure of internal components of the engine on account of operation beyond the limits prescribed in its certification.

With respect to the fracture of the Reduction Gear Box (RGB) Oil Tube, the non-conformities identified in the TIG weld, which presented characteristics different from those required, such as multiple overlapping layers, lack of penetration, and direction outside the expected axis, indicated the participation of manufacturing process of the component, since the cracks, which progressed until crossing the tube wall and caused the component to rupture, began close to this region of the flange that was screwed to the pseudoplanetary stator body.

It is possible that the natural vibration of the engine, exacerbated by operation at power regimes above those permitted, accelerated the propagation of the crack that resulted in the fracture of the RGB Oil Tube.

In that context, it was also possible to identify that the latent condition, characterized by fatigue in the RGB Oil Tube, could have been detected during normal engine-performance checks.

Analyzing the information provided by the PIC on his previous experience, one found that before he started operating the PR-RSP in March 2015 his experience was predominantly in flying aircraft equipped with conventional engines.

Thus, the fact that the PIC used the different colors (green, yellow and red) of the MVP-50T's digital arcs as a reference during flights, as in his understanding the turboprop engine could be operated within the green range regardless of temperature and altitude of the location, indicated that, during his adaptation to the aircraft, the training process received may not have provided him with the full knowledge and technical conditions necessary to operate the PR-RSP, which would have resulted in the operation of the aircraft's engine in power regimes above specified limits.

In consequence, it is possible that the PIC did not realize the need to use the torque limit diagrams available in the aircraft manual before starting the operation of an airplane equipped with a turboprop engine and, for this reason, considered the green, yellow, and red digital arcs of the instruments as bands applicable to any temperature and altitude conditions.

However, the failure to use the diagrams available in the aircraft manual to determine the engine torque limits usable in each particular situation compromised the quality of the work of preparation for flights, which contributed to the catastrophic failure of the aircraft's engine.

On the other hand, the torque indication was essential information for controlling the power regime of a turboprop engine and, for this reason, the instrument that provided this information was specifically mentioned as required for flight operation under Visual Rules (VFR) in section 91.205 of RBHA 91. It should be noted that the exceedance of the torque limits was a determining factor in the catastrophic failure of the PR-RSP engine.

3. CONCLUSIONS.

3.1. Findings.

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

b) the PIC held a PCM license (Commercial Pilot - Airplane) and valid ratings for MNTE (Single-Engine Land Airplane) and PAGA (Agricultural Pilot – Airplane);

c) the PIC had qualification and experience for the type of flight;

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

e) the records of the airframe, engine, and propeller logbooks were up to date;

f) meteorological conditions were consistent with visual flights;

g) near the end of the first flight, there was total loss of torque indication without the corresponding change in the NG, NP, and ITT parameters;

h) the takeoff for the second flight of the day was conducted without torque information;

i) approximately 15 minutes into the flight, there was loss of power, and the PIC made a forced landing on the plantation;

j) during the initial action of the investigation, marks of oil leakage were observed on the engine cowling, around the exhaust gas pipe, which extended backwards;

k) the engine cowling had, on the left side of its upper part, a hole made from the inside to the outside of the compartment, showing that an object had come loose that had passed through the component;

l) after removal of the cowling, one was able to identify evidence of severe damage to the engine and the presence of a lot of debris inside the engine compartment;

m) at the disassembly of the engine, a fracture was observed in the Reduction Gear Box (RGB) Oil Tube that provided information for the torque indicator;

n) the planetary gear of the first RGB reduction stage was found damaged and had fractured teeth;

o) the Power Turbine rotor had severe damage and lost all of its blades;

p) the Quill-Shaft sustained severe damage to its end connecting to the RGB, to the point of getting bent;

q) the aircraft sustained substantial damage; and

r) the pilot was uninjured.

3.2. Contributing factors.

Attitude – a contributor.

The continuation of the flight after the loss of information from the torque indicator characterized the adoption of inappropriate postures, such as complacency and improvisation.

Manufacturing – a contributor.

The non-conformities identified in the TIG weld of the Reduction Gear Box (RGB) Oil Tube, which presented characteristics different from the ones required, such as multiple overlapping layers, lack of penetration, and direction outside the expected axis, indicated the participation of the manufacturing process of this component, since the cracks that progressed until crossing the tube wall and caused the component to rupture began close to this region of the flange, which was screwed to the pseudoplanetary stator body.

Instruction – undetermined.

It is possible that, on account of quantitative and/or qualitative deficiencies in the training process received during his adaptation to the aircraft, the pilot did not receive the full knowledge and technical conditions necessary to identify the importance of using the torque limit charts available in the aircraft manual before starting operation with the PR-RSP.

Flight planning – a contributor.

Failure to use the diagrams available in the aircraft manual to determine the engine torque limits usable in each particular situation compromised the quality of the work of preparation for flights, contributing to the catastrophic failure of the aircraft's engine.

4. SAFETY RECOMMENDATIONS

A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident.

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

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

A-112/CENIPA/2017 - 01 **Issued on 03/13/2024**

Analyze the appropriateness and practicality of working with the primary certifier of the aeronautical product, so that the entity in question analyzes the procedures relative to the manufacturing of RGB Oil Tubes applied to model H80-100 engines, in order to identify possible non-conformities in the process of manufacture of the referred components.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On March 13th, 2024.