COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-099/CENIPA/2023

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-DLO**
MODEL:	**A36**
DATE:	**11JUN2023**

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 11 June 2023 accident with the model A36 aircraft, registration marks PT-DLO. The accident was typified as “[SCF-PP] Engine failure or malfunction”.

While the aircraft was in the traffic circuit for landing at SBTE (*Senador Petrônio Portella* Aerodrome, *Teresina*, State of *Piauí*), its engine sustained an in-flight failure. The aircraft performed a forced landing in an area of native vegetation of an environmental park.

There was substantial damage to the aircraft.

The pilot and the passenger received no injuries.

The United States, as the State of design and manufacture of the aircraft and its engine, appointed an Accredited Representative of the NTSB (National Transportation Safety Board) for participation in the investigation of the accident.

TABLE OF CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AC	FAA's Advisory Circular
AFM	Aircraft Flight Manual
ANAC	Brazil's National Civil Aviation Agency
AvGas	Aviation Gasoline
BKN	Cloud cover: Broken (5-7 oktas)
CENIPA	Brazil's Aeronautical Accidents Investigation and Prevention Center
CIV	Pilot Logbook
CMA	Aeronautical Medical Certificate
CVA	Certificate of Airworthiness-Verification
DECEA	Brazilian Command of Aeronautics' Department of Airspace Control
EGT	Exhaust Gas Temperature
FAA	USA's Federal Aviation Administration
IFRA	Instrument Flight Rating - Airplane
IS	Supplementary Instruction
METAR	Routine Meteorological Aerodrome Report
MNTE	Single-Engine Land Airplane Rating
NSCA	Brazilian Command of Aeronautics' System Norm
PCM	Commercial Pilot License - Airplane
PIC	Pilot in Command
PN	Part Number
POH	Pilot's Operating Handbook
PPR	Private Pilot License - Airplane
PSO-BR	Brazilian Civil Aviation Safety Program
RBAC	Brazilian Civil Aviation Regulation
SB	Service Bulletin
SBTE	ICAO location designator - *Senador Petrônio Portella* Aerodrome, *Teresina*, State of *Piauí*
SERIPA II	CENIPA's Second Regional Service for the Investigation and Prevention of Aeronautical Accidents
SIC	Second in Command
SIL	Service Information Letter
SIPAER	Aeronautical Accidents Investigation and Prevention System
SIPW	ICAO location designator - *Nossa Senhora de Fátima* Aerodrome, *Teresina*, State of *Piauí*
SL	Service Letter
SN	Serial Number
SNDC	ICAO location designator - Aerodrome of *Redenção*, State of *Pará*

TBO	Time Between Ovehauls
TPP	Private Air Services Registration Category
TSN	Time Since New
TSO	Time Since Overhaul
TWR	Aerodrome Control Tower or Aerodrome Control
UTC	Coordinated Universal Time
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** A36 **Registration:** PT-DLO **Manufacturer:** *Beechcraft Aircraft.*	**Operator:** Private.
Occurrence	**Date/time**: 11JUN2023 - 14:12 (UTC) **Location:** *Parque Ambiental Encontro dos Rios* **Lat.** 06°15'22"S **Long.** 042°27'32"W **Municipality – State:** *Teresina – Piauí.*	**Type(s):** [SCF-PP] Powerplant failure or malfunction

1.1. History of the flight.

At around 10:05 UTC, the aircraft took off from SNDC (Aerodrome of *Redenção*, State of *Piauí*), bound for SIPW (*Nossa Senhora de Fátima* Aerodrome, *Teresina*, State of *Piauí*) on a private flight with 02 POB (a pilot and a passenger).

While flying en route, the aircraft diverted to SBTE (*Senador Petrônio Portella* Aerodrome, *Teresina*, State of *Piauí*).

After the aircraft joined the traffic pattern for landing in SBTE, and was making a right-hand turn to align with the runway, its engine sustained an in-flight failure.

Upon realizing that the aircraft would not make it to the runway, the PIC (Pilot in Command) turned approximately 90º to the right, and made a forced landing in an area of native vegetation located in an environmental park.

Figure 1 - View of PT-DLO airplane at the forced landing site.

1.2. Injuries to persons.

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

1.3. Damage to the aircraft.

In addition to ruptured fuel system lines, the aircraft sustained substantial damage to its right-hand wing root and to the vertical stabilizer. There was also slight damage to the fuselage, including the soffit, as well as to the left-hand wing, horizontal stabilizer, elevator, and electrical system.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

FLIGHT EXPERIENCE	
	PIC
Total	4.200:00
Total in the last 30 days	22:00
Total in the last 24 hours	02:40
In this type of aircraft	250:00
In this type in the last 30 days	22:00
In this type in the last 24 hours	02:40

RMK: data relating to the hours flown were obtained by means of an interview with the PIC and from the records of his electronic Individual Pilot Logbook (CIV).

1.5.2. Personnel training.

The PIC did his PPR course (Private Pilot – Airplane) in 2004, at the *Aeroclube do Piauí*, State of *Piauí*.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PCM License (Commercial Pilot - Airplane) and valid ratings for MNTE (Single-Engine Land Airplane) and IFRA (Instrument Flight - Airplane).

1.5.4. Qualification and flight experience.

The records of his electronic CIV indicated that the pilot had been operating the model A36 aircraft, registration PT-DLO, since June 2021, and that he had flown to SNDC as a frequent destination.

The PIC reported that in the period of thirty days preceding the accident, he had performed around 10 flights to SBTE.

The PIC had qualification and experience for the type of flight.

1.5.5. Validity of medical certificate.

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

1.6. Aircraft information.

The SN E-223 aircraft was a product manufactured by Beechcraft Aircraft in 1970, and registered in the Private Air Services Registration Category (TPP).

The aircraft had a valid CVA (Certificate of Airworthiness-Verification).

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

The latest inspection of the aircraft, "CVA obtainment/50 hours" type, took place on 07 December 2022, at the premises of the *JPA Manutenção de Aeronaves* Maintenance Organization, in *Santa Rita*, State of *Paraiba*. The aircraft flew 46 hours and 10 minutes after the referred inspection.

The latest overhaul of the SN 569-817 model IO-520-BA Continental engine equipping the PT-DLO airplane took place on 07 March 2008. On the occasion, the aforementioned component had 3,855 hours and 10 minutes of operation.

On the date of the accident, which occurred 184 months and 4 days after the overhaul, the engine had a TSN (Time Since New) of 5,270 hours and 5 minutes, and a TSO (Time Since Overhaul) of 1,414 hours and 55 minutes.

According to the Continental Motors Aircraft Engine's *Service Information Letter 98-9C* (SIL 98-9C), dated 17 July 2013, the Time Between Overhauls (TBO) of the mechanical fuel pump, fuel distributor, and fuel controller equipping the aircraft engine was 1,700 hours or 12 years, whichever came first.

According to the aircraft documentation, the latest overhaul of the mechanical fuel pump took place on 16 January 2008, and the overhaul of the distributor, as well as of the fuel controller, took place on 18 January 2008, when all the components had 5,203 hours and 55 minutes, in 15 years and five months of operation (185 months).

It was not possible to identify whether a trend-monitoring method concerning the operating parameters of the engine and its accessories had been established.

In consonance with the scheme shown in Figure 2, the aircraft's fuel system consisted of the following components:

- A - rubber cell-tank on each wing with a total capacity of 100 gallons, in the standard system;
- B - a selector valve;
- C - an auxiliary electric pump;
- D - a mechanical injection pump;
- E - a fuel controller (metering control unit);
- F - a fuel distribution valve; and
- G - six injection nozzles.

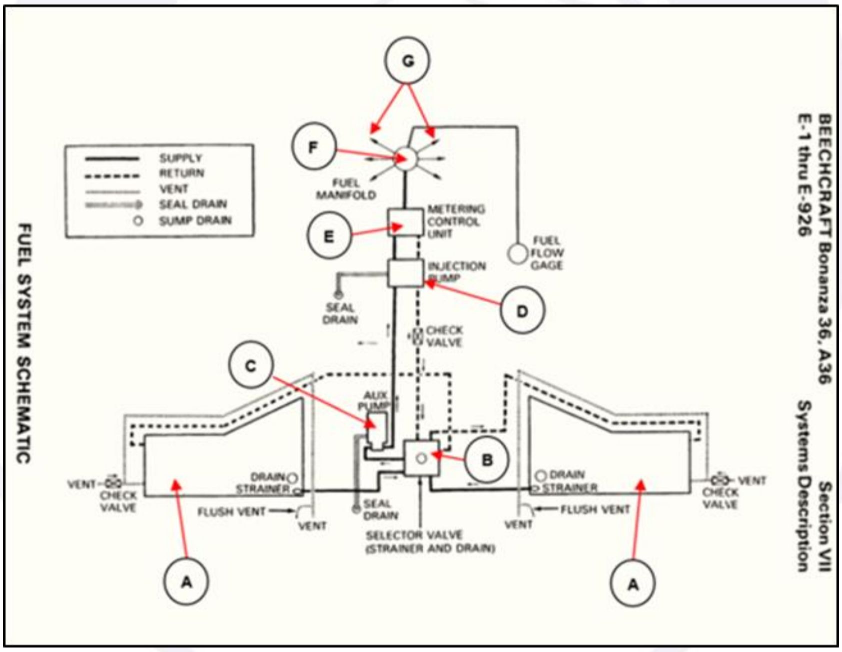

Figure 2 - Scheme of the A36 aircraft fuel system.
Source: Beechcraft Bonanza 36. A36 POH_AFM.

1.7. Meteorological information.

The routine Meteorological Aerodrome Report (METAR) of SBTE (*Teresina* Aerodrome), located at a distance of 01 NM from the accident site, contained the following information:

METAR SBTE 111400Z 16006KT 9999 BKN030 30/32 Q1014

One observed that the conditions were above the minimums for the flight, with visibility above 10 km and with broken clouds at an altitude of 3,000 ft. The wind direction was 160° at six kt.

1.8. Aids to navigation.

All navigation and landing aids were operating normally during the approach of the aircraft.

1.9. Communications.

From the audio transcripts of the communication between the PT-DLO aircraft and the control agencies, it was possible to verify that the PIC maintained radio contact with TWR-TE (*Teresina* Aerodrome Control Tower), and that there were no technical abnormalities in the communication equipment during the flight.

In order to support the analysis of the sequence of events that preceded the forced landing of the aircraft, the Investigation Committee highlighted some of the radio transmissions that may help to understand the dynamic of the accident.

The time reference used is UTC (Coordinated Universal Time).

At 14:03:09, the PT-DLO airplane made the first radio call to TWR-TE.

At 14:03:13, TWR-TE requested PT-DLO to report joining the downwind leg by the right, in the whiskey sector of SBTE, for landing on the runway 20.

At 14:03:21, the PT-DLO read back the message received from TWR-TE, informing that they would report joining the downwind leg by the right, for landing on runway 20.

At 14:06:47, the PT-DLO informed TWR-TE that they were joining the downwind leg of runway 20 by the right, and were abeam TWR-TE.

At 14:07:01, TWR-TE reported that the PT-DLO was in sight, and cleared the aircraft to land, wind direction 160 degrees at five kt.

At 14:07:10, the PT-DLO read back the message, stating that they were aware of the message transmitted by TWR-TE.

At 14:10:04, the PT-DLO transmitted a Mayday message.

At 14:10:10, TWR-TE made a call requesting confirmation of the PT-DLO message.

At 14:10:14, the PT-DLO confirmed the Mayday message to TWR-TE.

At 14:11:17, TWR-TE made another call to the PT-DLO.

At 14:30:29, TWR-TE made the last call, asking whether the PT-DLO was listening to that control unit.

1.10. Aerodrome information.

NIL.

1.11. Flight recorders.

Neither required nor fitted.

1.12. Wreckage and impact information.

The forced landing was made at a distance of approximately 1,900 m short of the SBTE runway 20 threshold, in a sector located to the right of the runway 20 axis (Figure 3).

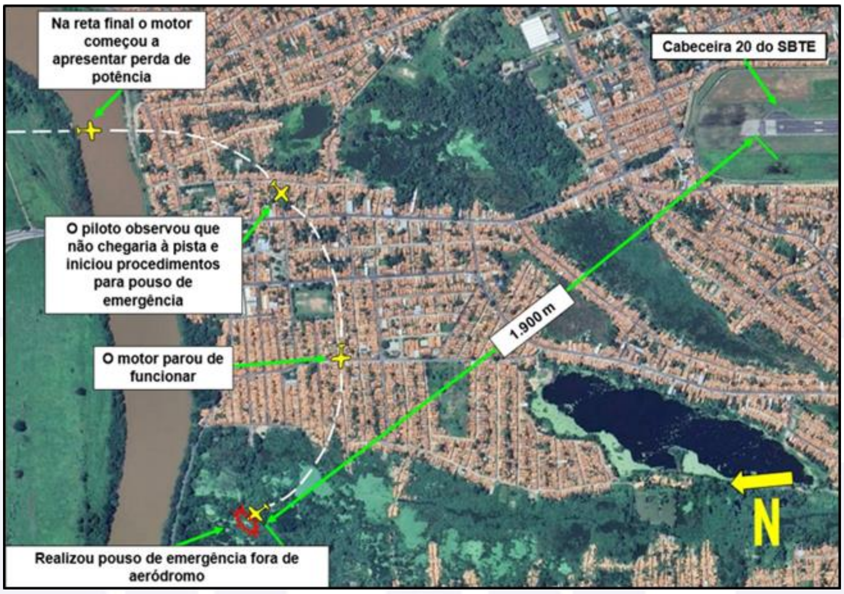

Figure 3 - PT-DLO trajectory toward the accident site.
Source: adapted from Google Earth.

The aircraft landed in a low-traffic area of the Environmental Park *Encontro dos Rios*, located in the neighborhood of *Poti Velho*, *Teresina*, State of *Piauí*.

According to physical evidence at the site of occurrence, in the final moments of the flight, the aircraft collided with bushes typical of the region. The bushes had an average height of 6 m, measured from the ground to the top.

The forced landing occurred on the edge of a flooded area, at an approximate distance of 12 m from the affected bushes. The aircraft came to a stop at the magnetic direction of 007°.

The observed damage suggested that the aircraft was at a low horizontal speed at the time of the impact.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

NIL.

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.

The SN 569-817 model IO-520-BA Continental engine equipping the PT-DLO (an A36 Beechcraft airplane) was removed for investigation (Figure 4).

Figure 4 - Top view of the engine.

The engine was tested and analyzed at the facilities of *Oficina Nacional - Manutenção de Aeronaves Ltda*. in *Teresina*, *Piauí*, under the supervision of SIPAER investigators.

The exams were as follows:

- <u>Engine</u>:

The condition of the propellers without bends, that is, without plastic deformation typical of impact with power development, showed that the engine was not rotating at the time of the impact against the ground.

The engine had restrictions to rotation due to the breakage of the alternator, which occurred at the impact with the ground. In spite of the accident, the internal parts of the engine showed no apparent physical damage.

The gears, shafts, and the whole interior of the engine were clean and lubricated, showing no signs of abnormalities.

The alternator and the components of the fuel system were sent for bench testing in a specialized workshop, which worked under the supervision of SIPAER investigators.

- <u>Alternator</u>:

The alternator had visible external damage. The functioning of this component was considered satisfactory during a bench test. The observed damage resulted from the impact of the aircraft against the terrain.

- <u>Mechanical fuel pump</u>:

The PN 638154-2 and SN 2677RA mechanical fuel pump underwent bench testing.

During the test, the pump exhibited a fuel leak through the drain (Figure 5). This evidence was then associated with the impossibility of the item reaching the acceptable pressure and fuel flow parameters listed in the test form of the item's overhaul manual (*Overhaul and Parts Catalog for Fuel Injection Systems-X30593A*).

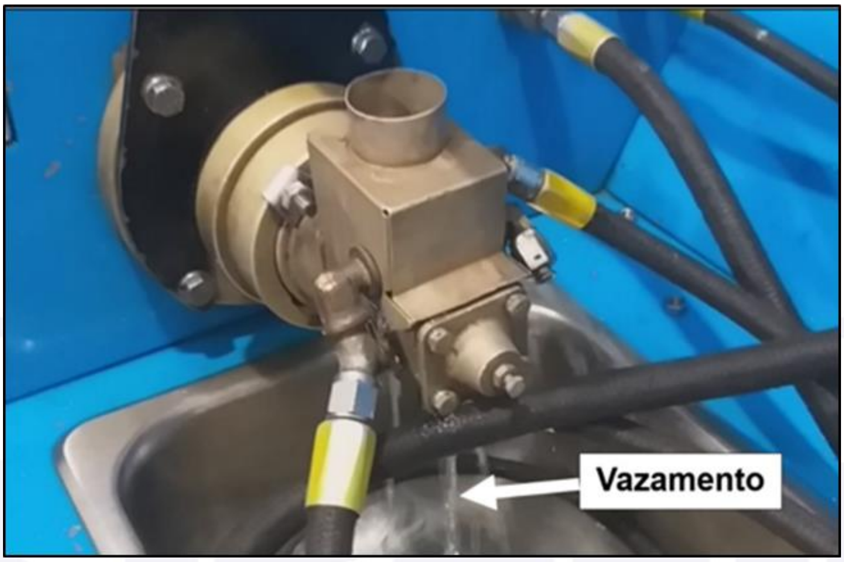

Figure 5 - Leak in the mechanical fuel pump.

During the disassembly, a deformity was found in the retaining seal of the eccentric housing (*seal adapter* PN - 646198*),* which caused pressure to leak with the consequent reduction of the fuel flow pressure (Figure 6).

Figure 6 - Retaining seal showing deformities.

- <u>Fuel controller</u>:

The PN 629904-2 / SN G118303A fuel controller exhibited a leak on the power and mixture arm shaft (Figure 7) and, therefore, it was not possible to reach the parameters established in the test form contained in the X30593A Manual.

Figure 7 - Leak in the fuel controller power-arm shaft.

After the disassembly, deformations were detected in the internal sealing O-ring of the power-arm shaft PN 630979 (Figure 8).

Figure 8 - Aspect of the power-arm shaft O-ring.

- <u>Fuel distributor</u>:

The PN 631351-5 / SN L01753BC fuel distributor showed satisfactory fuel flow in the six distribution outlets for feeding the injection nozzles and, therefore, there was no evidence of internal obstruction, either in the valve or in its fuel supply lines.

- <u>Injection nozzles</u>:

During the bench tests, the six PN 655234A11 injection nozzles did not present any restrictions or obstructions to the fuel flow.

After the exams and tests described above, one found that the engine failure was associated with a leak in the mechanical pump and fuel controller.

Thus, in the investigation of the engine and fuel system of the PT-DLO aircraft, one found that when the engine power decreased due to a leak in the pump and servo injector, there was loss of power due lack of fuel flow to the cylinders, resulting in the in-flight engine shutdown.

1.17. Organizational and management information.

NIL.

1.18. Operational information.

The flight between SNDC and SBTE was conducted at flight level 075 (FL075). According to the VFR flight plan initially filed, the destination was SIPW. The decision to divert to the alternate aerodrome (SBTE) was made in flight.

The PIC had experience on the route, and considered that the weather conditions throughout the flight were compatible with the proposed type of flight.

Before taking off from SNDC, the aircraft had its fuel tanks filled with 205 liters of Aviation Gasoline (AvGas). After the refueling, the aircraft had 314 liters of fuel, which meant an endurance of approximately 5 hours and 15 minutes of flight.

The aircraft weight at takeoff was 1,625 kg. At the time of the forced landing, the weight was approximately 1,460 kg.

During the checks conducted on the ground before takeoff, as well as during his observation of the in-flight instrument readings, the PIC considered that the engine's operating parameters were normal.

The engine failure started with a gradual loss of power until the engine shut down, when the power lever was reduced, and the aircraft was turning to the right to align with the final approach segment.

Upon realizing that the aircraft would not make it to SBTE runway 20 threshold, the pilot made a turn of approximately 90º to the right of the axis of the final approach and made a forced landing in an area of native vegetation of an environmental park, at a distance of approximately 1,900 m from the referred runway threshold.

The actions carried out by the PIC were in accordance with the provisions of the A36 POH (Pilot's Operating Handbook), Section III - *Emergency Procedures* - *Landing Without Power*.

The aircraft was within the prescribed weight and balance limits.

1.19. Additional information.

Service Information Letter 98-9C (SIL 98-9C)

By means of the Continental *Motors Aircraft Engine*'s SIL98-9C of 17 July 2013, which dealt with the limits between overhauls, the manufacturer highlighted, among other aspects, the following ones in relation to the continued airworthiness of the engine:

- with the engine being operated regularly or even being kept in storage, internal components such as gaskets and elastomeric seals (synthetic and natural rubber) might deteriorate over time;
- the corrosion resulting from environmental factors might occur naturally in the internal and external components of the engine. Such process might affect the continued airworthiness of the engine and its accessories;
- overhaul of the engine or its replacement, within a maximum period of 12 years from the date of entry into service, or within the accumulation of operating hours defined for the engine model in question;
- the quality of parts, accessories, and labor utilized during routine maintenance, major overhaul and general overhaul had a direct effect on the lifespan of the

engine. Additionally, the maintenance and condition of engine-related components, including (but not limited to) the propeller, propeller governor, vacuum pump, gear-driven alternator, brackets, baffles, instrumentation, and controls also had a direct effect on the durability of the engine;

- TBOs were based on the engine being maintained in accordance with instructions relating to continued airworthiness and accepted by the *Federal Aviation Administration* (FAA); and
- such instructions should be specified in the engine maintenance manual, as well as in the respective Service Bulletins (SB), with the engines being operated within the limitations specified in the Continental Engine Operator's Manual and the Pilots' Operating Manual (*Aircraft Flight Manual* - AFM).

Regarding the TBO of the model IO-520-BA engine, the aforementioned SIL recommended 1,700 hours of operation or 12 years since the latest overhaul, whichever came first. Engine-mounted components and accessories required service at the same hourly and calendar intervals as the engine, unless otherwise specified by the manufacturer of the component or accessory.

<u>Supplementary Instruction (IS) No. 91.409-001 - “Aircraft Maintenance, Recommended Time Between Overhauls”</u>

With respect to compliance with the TBO of engines equipping aircraft operating under the rules of the Brazilian Civil Aviation Regulation nº 91 (RBAC-91), *General Requirements for Operation of Civil Aircraft*, in force on the date of the accident, the ANAC’s *IS 91.409-001*, Revision B, among other aspects, established the following guidelines:

> [...]
>
> 5.1 Regulatory aspects
>
> 5.1.1 The minimum required level of maintenance and safety of an aeronautical product or article is guaranteed by compliance with normal maintenance procedures within the deadlines established by the manufacturers (daily, pre-flight, 25-, 50-, 100-hour checks, etc.).
>
> Note - the owner/operator is responsible for ensuring the aircraft’s minimum safety conditions. This means that s/he is responsible for ensuring an assessment capable of verifying that there are no indications of decreased performance of the aircraft, engine, propeller, or equipment (parts, accessories, instruments, and other components). If this decrease in performance is to be corrected, the recommended overhaul becomes necessary.
>
> [...]
>
> 5.1.8 Airworthiness Directives and operational regulations may also impose mandatory instructions for continued airworthiness.
>
> 5.1.9 TBO’s periods or deadlines are generally presented in Service Bulletins (SB), Service Letters (SL), Service Information Letters (SIL), and similar documents. Even if manufacturers indicate TBO’s periods or deadlines as mandatory in these documents, they are considered mandatory only when approved by the aeronautical authority.
>
> [...]
>
> 5.2 Technical aspects of the overhaul
>
> 5.2.1 Once it is understood that the deadline for the overhaul is a recommendation, the question that arises is, “if the recommended deadline is reached, does an engine, propeller or equipment (part, accessory, instrument and other components) need to be removed from service and sent for overhaul?”
>
> 5.2.2 This is an issue of great relevance, for example, in the case of engines. The owner/operator of an aircraft operating in accordance with the rules of the RBAC-91 may have an engine reaching, for example, the calendar period of 12 (twelve) years - referring to the calendar period in some conventional engines - and not yet have

accumulated the total operating hours recommended for its removal for overhauling. In this case, one can choose either to comply with the manufacturer's recommendation for an overhaul within the calendar period, or conduct the overhaul only when necessary, considering an operational assessment performed in accordance with the manufacturer's instructions, thus being able to exceed the calendar time of 12 (twelve) years and even the accumulated period of operating hours mentioned above. Therefore, once any of the recommended limits has been exceeded, if the aircraft still appears to be safe and performing well (ascertained from an assessment of the general condition according to the manufacturer's instructions), operational continuity is a possibility.

Note - daily, pre-flight, 25-, 50-, 100-hour, annual inspections, etc., cannot be postponed or extended as if it were the case with the recommended TBO. It is even by means of such inspections that safety and performance can result in measurable data to support the decision not to follow the recommended TBO. Additionally, discrepancies that may appear between inspections must be corrected, in accordance with the RBAC 91.405

5.3 How to recognize the obligatoriness of an overhaul:

5.3.1 To identify whether the execution of the overhaul within the deadline proposed by the manufacturer is considered mandatory by the ANAC, one must verify whether the TBO deadline is described in the Airworthiness Limitations section, or even if this deadline was determined through an Airworthiness' Guideline. Otherwise, this period is considered by the ANAC only as a manufacturer's recommendation, as long as the aircraft is operating in accordance with the RBAC-91.

5.3.2 Note that in current ANAC regulations, in practical terms, the postponement of the overhaul is acceptable (keeping the monitoring conditions already mentioned in the note to section 5) and, at some point, the overhaul may have to be performed.

5.3.3 It is worth highlighting that there are manufacturers that classify some Service Bulletins (SB), Service Letters (SL), Service Information Letters (SIL) and similar documents as mandatory, although they are not part of the Airworthiness Limitations section nor are referenced by an Airworthiness Directive. In these cases, from the ANAC's standpoint, the deadlines mentioned in these overhaul documents are simply considered as a manufacturer's recommendation.

[...]

APPENDIX C - FREQUENTLY ASKED QUESTIONS RELATED TO TBOs

[...]

C.3 Is the TBO optional for any aircraft operating in Brazil if it is not included in the airworthiness limitations?

No. Compliance with the TBO recommended by manufacturers is optional for aircraft under paragraph 91.409(i) of the RBAC-91. The RBAC-121 and 135, as they involve public passenger air-transport companies, require compliance with the maintenance program recommended by the manufacturer.

C.4 According to the criteria of this IS, will the overhaul of a conventional engine never be carried out?

No. The operation of an engine causes wear and tear, and, at some point, the engine will have to be overhauled. The overhaul may be carried out within the TBO established by the manufacturer or within another time interval, but it must be carried out whenever the engine conditions have deteriorated to the point of requiring correction, or when the TBO is reached in situations where it is mandatory as mentioned in the answer to the question.

C.5 How can one tell whether the engine's condition has deteriorated?

Either when the engine is outside the normal operating parameters prescribed by the manufacturer or when this is identified through monitoring. One may perform monitoring using the methods recommended by the manufacturer. The FAA’s AC 20-105 and 120-113 may also be used.

C.6 What if the operator chooses not to monitor the engine’s condition?

If the engine conditions are not monitored, the ANAC strongly recommends the conduction of an overhaul either within the TBO recommended by the manufacturer or when the engine conditions deteriorate, whichever occurs first.

Advisory Circular (AC) 20-105B

This AC, issued by the FAA on 15 June 1998, dealing with trend monitoring to prevent accidents related to loss of power in reciprocating (piston) engines, reads the following:

[...]

5. TREND MONITORING PROGRAM.

a. Trend monitoring is a data collection system in which periodically a select number of engine readings/indications are recorded, analyzed, and from such data analysis, an airworthiness decision is made. The purpose of a trend-monitoring program is to predict a failure mode before it happens. A trend-monitoring program for reciprocating engines should address at least three engine areas for monitoring. They are:

(1) Area #1 ...

[...]

(2) Area #2

[...]

(3) Area #3. Accessories including the magnetos, harness, spark plugs, exhaust, generator, or alternator drive belts, generator or alternator, carburetor/fuel injection unit and vacuum or pressure pump, are easily removable for inspection and testing and usually give the pilot an indication of their operating condition by instrumentation and gauges in the cockpit.

[...]

b. A generic trend-monitoring program is found in Appendix 1 and 2. Appendix 1 is a sample data form that the mechanic and pilot will fill out. Appendix 2 is a sample tracking sheet in which all tracked items collected on the data form are listed together in sequence for easier comparison and analysis. The actual analysis of the airworthiness items should be accomplished by comparing the readings obtained and noting the trend as measured against the manufacturer's recommended reading. For example, if the engine manufacturer recommended a cruise oil pressure of 55 to 60 psi and the indicated reading in cruise was 48 psi the mechanic should check oil viscosity, oil quantity, oil relief valve setting, oil filter, bearing wear, indications of blow by/leaks, and the accuracy of the oil pressure gauge. The mechanic can also cross check with the results of the oil analysis, cylinder head temperatures, oil temperatures, spark plug condition, and cylinder compression readings.

NOTE: A trend-monitoring program is only as good as the information that it collects and analyzes. Before incorporating an engine trend monitoring program, the owner/operator should ensure that the following aircraft's instruments and gauges have been tested for accuracy; RPM gauge, oil pressure, oil temperature, cylinder head temperature, Exhaust Gas Temperature (EGT), fuel gauges, and manifold gauge, if applicable.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

It was a private flight between SNDC (*Redenção*, State of *Pará)* and SBTE (*Teresina*, State of *Piauí)*. An in-flight engine failure occurred when the aircraft was on the final approach for landing on the runway 20 of SBTE.

Upon realizing that the aircraft would not make it to the runway, the PIC made a right turn of approximately 90º and performed the *Landing Emergencies/Landing Without Power* procedures prescribed in the A36 airplane Pilot's Operating Handbook. Eventually, the aircraft made a forced landing in an area of native vegetation located in an environmental park (aka *Parque Ambiental Encontro dos Rios*).

Due to the observed failure, the IO-520-BA Continental engine (SN 569-817), which equipped the Beechcraft A36 aircraft (registration marks PT-DLO) was analyzed, based on the research focused on the engine and fuel system components.

The analysis of the engine revealed that the gears, shafts, and the whole engine interior were clean and lubricated, showing no evidence of abnormalities. The internal parts had no apparent physical damage.

The exams and tests showed that the engine failure was associated with a leak in the mechanical pump and fuel controller.

That said, one observed that the loss of engine power (following the reduction of the power lever) occurred due to the failure of the components mentioned above, which caused a reduction of the fuel flow/pressure in the feeding process to maintain the engine combustion flame.

Since the electric pump is located in the fuel system in a position preceding the fuel controller and the mechanical pump, even if the referred electric pump was active, it would possibly not prevent the engine failure from occurring.

During the bench inspection of the components that presented the functional failure (namely the mechanical pump and the fuel controller), one identified that there was wear on the seal shaft of the mechanical fuel pump and deformations in the internal sealing O-ring of the fuel controller' shaft.

In this circumstance, the Investigation Committee sought to establish the traceability of the maintenance services carried out on the engine components that showed discrepancies during the tests.

It is important highlighting that, on the date of the accident, the aircraft's engine had 1,414 hours and 55 minutes in 184 months and 4 days after the latest overhaul.

Through the SIL 98-9C, the engine manufacturer recommended considering a TBO of 1,700 hours or 144 months, whichever came first. The same criteria was to be observed for the purpose of the engine accessories' overhaul.

In this regard, from the aircraft's documentation, one verified that, on the date of the accident, in addition to the aircraft's engine, the mechanical pump, the distributor, and the fuel controller had 1,414 hours and 55 minutes in just over 184 months after the latest overhaul.

Since the engine and the aforementioned accessories met the overhaul deadlines established by the manufacturers, one sought to verify the conditions that could prolong their respective TBOs.

Initially, it was identified that, for purposes of determining the time limits between overhauls and ensuring the continued airworthiness of the engine in question, the *SIL 98-9C* issued by Continental Motors Aircraft Engine on 17 July 2013 specified, among other aspects, that internal components such as gaskets and seals made of synthetic or natural rubber should be inspected, since they could deteriorate over time, independently of the engine being operated on a regular basis or kept in storage.

The referred *SIL* considered that corrosion resulting from environmental factors could occur naturally in the internal and external components of the engine, and that such process could affect the continued airworthiness of the engine and its accessories.

In this regard, the SIL recommended the overhaul of the engine or its replacement at a maximum of twelve years from the date of entry into service or upon accumulation of the operating hours defined for the specific engine model.

Notwithstanding, one verified that the general overhaul of the engine within the period proposed by the manufacturer was not mandatory. The reason was that the documentation guiding compliance with the aircraft's Maintenance Program did not include Service Bulletins (SB), *Service Letters* (SL), *Service Information Letters* (SIL), or other similar documents listed in the Airworthiness Limitations' section, and that were referenced as mandatory by an Airworthiness Directive.

Thus, from the perspective of the requirements for Continued Airworthiness established by the ANAC, the engine overhaul deadlines mentioned in such documents were considered as a recommendation from the manufacturer.

Also, considering that the 144-month calendar period for the engine overhaul had expired, and that the engine had not yet accumulated the total recommended operating hours for the overhaul, the investigation committee deduced that, in accordance with the ANAC's IS nº 91.409-001, Revision B, item 5.2.2 (*Aircraft Maintenance and Recommended Time between Overhauls*), the aircraft operator chose to conduct the referred overhaul only in case it became necessary.

However, based on the documents presented by the aircraft operator, one was not able to determine whether, under such circumstances, the engine had been subject to any method of monitoring parameter trends (*trend monitoring*) recommended by the manufacturer, in order to allow assessment of the general operating condition of the engine in question.

Similarly, it was not possible to identify the existence of any trend monitoring protocols capable of evaluating the evolution of the operating parameters of the engine accessories affected by failure (mechanical pump and fuel controller), something which would enable one to prevent accidents resulting from loss of power of the piston engine, as established by Revision B of the ANAC's IS nº 91.409-001.

In view of the aspects raised, it was possible to infer that faithful compliance with a trend-monitoring program could contribute to preventing a failure or malfunction such as the one observed in the engine accessories.

In this sense, maintenance workshops should serve as the final barrier to ensure that the extension of the interval between overhauls be associated with the adoption of trend monitoring program focused on the engine and its accessories for aircraft operating under the rules of the RBAC-91, taking into account the recommendations issued by the manufacturers with regard to the subject.

3. CONCLUSIONS.

3.1. Findings.

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

b) the PIC held valid ratings for MNTE (Single-Engine Land Airplane) and IFRA (Instrument Flight - Airplane);

c) the PIC was qualified for and had experience in the type of flight;

d) the aircraft had a valid CVA (Airworthiness-Verification Certificate);

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

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

g) meteorological conditions were above the minimums for the flight;

h) after the aircraft joined the traffic circuit for landing at SBTE, and was aligning with the final approach segment with a right-hand turn, its engine sustained in-flight failure;

i) the aircraft made a forced landing in an area of native vegetation of an environmental park;

j) the functional tests on engine accessories showed leakage in the mechanical pump and in the fuel controller;

k) there was wear on the fuel pump seal shaft and deformations on the internal sealing O-ring of the fuel controller shaft;

l) on the date of the accident, the aircraft engine had 1,414 hours and 55 minutes, as well as 184 months and 4 days after the latest overhaul;

m) the engine manufacturer, through the SIL 98-9C, recommended that a TBO of 1,700 hours or 144 months be considered, whichever occurred first;

n) the same criteria was to be observed for the purpose of the engine accessories' TBO;

o) on the date of the accident, the mechanical pump, distributor, and fuel controller had 1,414 hours and 55 minutes in just over 184 months after the latest overhaul;

p) the aircraft engine and its accessories had exceeded the deadline for the overhaul;

q) the Continental Motors Aircraft Engine's SIL 98-9C, dated 17 July 2013, recommended overhauling the engine or replacing it within a maximum period of 12 years, from the date of entry into service, or within the defined accumulation of operating hours for the engine model in question;

r) conduction of the engine overhaul within the deadline proposed by the manufacturer was not mandatory;

s) according to the ANAC's standpoint, the deadlines relating to the overhaul of the aircraft engine were considered as a manufacturer's recommendation;

t) no type of trend monitoring was identified for the engine accessories that sustained failure (mechanical pump and fuel controller);

u) the aircraft sustained substantial damage; and

v) the PIC and the passenger suffered no injuries.

3.2. Contributing factors.

Aircraft maintenance – a contributor.

The absence of a trend-monitoring program impaired that adequate assessment of the general conditions of the engine and its accessories could have prevented the occurrence of the failure that affected the fuel system components in flight.

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-099/CENIPA/2023 - 01 **Issued on 09/16/2024**

Disseminate the lessons learned from the present investigation during events and actions promoting aviation safety, with the purpose of alerting operators, pilots, and maintainers of aircraft operating under the rules of the RBAC-91, about the need for strict adherence to the IS 91.409-01, in its latest revision. The focus is on the adoption of a trend-monitoring program that promotes the proper evaluation of the general conditions of the engine and its accessories aimed at extending their respective TBOs.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

The aircraft operator and the pilot involved in the accident were advised on the need to adopt a trend-monitoring program for the engine and its accessories, in accordance with the National Civil Aviation Agency's IS 91.409-001, Revision B.

On September 16th, 2024.