COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-066/CENIPA/2022

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-SHN**
MODEL:	**EMB-110P1**
DATE:	**20MAI2022**

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 Final Report pertains to the accident involving aircraft PT-SHN, model EMB-110P1, which occurred on 20 MAY 2022, typified as "[SCF-PP] Powerplant system/component failure or malfunction" and "[LOC-I] Loss of control in flight."

During descent for landing, the pilots identified that the power of the left engine would not reduce to values below 1,300 lb.ft of torque. The left engine was shut down during the final approach for landing. The aircraft subsequently lost control and impacted the ground.

The aircraft sustained substantial damage.

One pilot sustained serious injuries, and the other suffered minor injuries.

The Transportation Safety Board (TSB) from Canada, the State of Manufacture of the engine, designated an Accredited Representative for participation in the investigation of the accident.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	National Civil Aviation Agency (Brazil)
APP	Approach Control
CENIPA	Center for the Investigation and Prevention of Aeronautical Accidents
CIV	Digital Pilot-Logbook
CMA	Aeronautical Medical Certificate
COA	Air Operator Certificate
CRM	Crew Resource Management
CVA	Certificate of Airworthiness
CVR	Cockpit Voice Recorder
DECEA	Airspace Control Department
EACON	*Escola de Aviação de Congonhas* (*Congonhas* Aviation School)
EO	Operations Specifications
FCU	Fuel Control Unit
ICA	Command of Aeronautics' Instruction
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating – Airplane
LABDATA	Flight Recorders Readout and Analysis Laboratory
METAR	Routine Meteorological Aerodrome Report
MGO	General Operations Manual
MGSO	Safety Management Manual
MLTE	Multi-Engine Landplane Rating
N_g	Compressor Turbine Speed
OM	Maintenance Organization
OT	Technical Order
P_1	Fuel Pump Pressure
P_2	Measured Fuel Pressure
P_3	Compressor Discharge Pressure
PIC	Pilot in Command
PLA	Airline Transport Pilot License - Airplane
PMD	Maximum Take-Off Weight
PN	Part Number
PPR	Private Pilot License – Airplane
PrTrnOp	Operational-Training Program
P_x	P_3 Derived Pressure (internal)
P_y	P_x Derived Pressure (internal)

QAv	Aviation Kerosene
RBAC	Brazilian Civil Aviation Regulation
ROTAER	Auxiliary Air Routes Manual
SBCO	ICAO location designator – *Campo Nossa Senhora de Fátima* Aerodrome, *Canoas*, state of *Rio Grande do Sul*
SBJD	ICAO location designator – Comandante Rolim Adolfo Amaro Aerodrome, *Jundiaí*, state of *São Paulo*
SBMT	ICAO location designator – *Campo de Marte* Aerodrome, *São Paulo*, SP
SBPA	ICAO location designator – *Salgado Filho* Aerodrome, *Porto Alegre*, RS
SIC	Pilot Second in Command
SIGWX	Significant Weather Chart
SIXE	ICAO location designator – Aerodrome of *Aeroclube de Eldorado do Su*l, state of *Rio Grande do Sul*
SN	Serial Number
SPECI	Special Aerodrome Meteorological Report
TPX	Private Registration Category: Non-Scheduled Public Air Transport Service – Air Taxi
TSB	Transportation Safety Board
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VMC	Minimum Control Speed

1. FACTUAL INFORMATION.

Aircraft	**Model:** EMB-110P1 **Registration:** PT-SHN **Manufacturer:** *Embraer*.	**Operator:** *Sales Táxi Aéreo Ltda*.
Occurrence	**Date/time**: 20MAI2022 – 13:52 (UTC) **Location:** Rural area, close to km 120 of Highway BR-290 **Lat.** 30°03'25"S **Long.** 051°25'02"W **Municipality – State:** *Eldorado do Sul – Rio Grande do Sul*.	**Type(s):** [SCF-PP] Powerplant failure or malfunction [LOC-I] Loss of control - inflight

1.1. History of the flight.

At approximately 11:00 UTC, the aircraft took off from SBJD (*Comandante Rolim Adolfo Amaro* Aerodrome, *Jundiaí*, state of *São Paulo*), bound for SIXE (*Eldorado do Sul Aeroclube* Aerodrome, state of *Rio Grande do Sul*) on a cargo transportation flight, with 02 POB (pilots).

About thirty minutes prior to reaching the destination, the descent procedure was initiated. During the descent, the crew observed that the left engine torque indicator would not reduce to values below 1,300 lb.ft.

The crew continued toward the destination. On the final approach for landing, the left engine was shut down. Subsequently, the aircraft lost control and collided with the ground.

Figure 1 – View of the aircraft at the accident site.

1.2. Injuries to persons.

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

1.3. Damage to the aircraft.

The aircraft sustained substantial damage. The left wing was severed at the wing root during impact. There was damage to the hydraulic system and to the lower portion of the fuselage, the right wing, and the right engine. The fuselage section remained relatively intact, exhibiting wrinkling along the sides and significant crushing in the forward portion.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

Hours Flown		
	PIC	SIC
Total	17,101:00	1,235:00
Total in the last 30 days	61:30	70:10
Total in the last 24 hours	03:00	03:00
In this type of aircraft	1,890:00	779:00
In this type in the last 30 days	61:30	70:10
In this type in the last 24 hours	03:00	03:00

Note: Flight time data obtained from the pilots' personal log records. The digital Individual Pilot-Logbooks (CIV) were not up to date.

1.5.2. Personnel training.

The Pilot in Command (PIC) completed the Officer Aviator Training Course at the Brazilian Air Force Academy, in *Pirassununga*, SP, in 1978.

The Second in Command (SIC) completed the PPR course (Private Pilot – Airplane) at the *Congonhas* Aviation School (EACON), SP, in 2013.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PLA license (Airline Transport Pilot – Airplane). His ratings concerning the E110 type (which included the EMB-110P1 model) and IFRA (Instrument Flight – Airplane) were outside their validity period since April 2022.

The SIC held a PCM license (Commercial Pilot – Airplane) and had a valid IFRA rating. His E110 type rating had been outside its validity period since April 2022.

Although both crewmembers had their E110 type ratings outside the validity period, and the PIC had his IFRA rating outside the validity period, there was no breach of requirements. These conditions were supported by Section 61.33 – Grace period for rating renewals, of Brazilian Civil Aviation Regulation (RBAC) No. 61, Amendment No. 13, dated 01 APR 2020, which established the following provisions:

> [...]
>
> 61.33 Grace period for rating renewal
>
> (a) Provided that all applicable requirements for the renewal of a rating are met, the proficiency check associated with such renewal may be conducted during the period between 30 (thirty) days prior to the beginning of the month of expiration and 30 (thirty) days after the end of the month of expiration. Once the renewal is completed, the original expiration month shall be maintained as the base month for the new validity period.
>
> (b) Normal operation related to a rating expired for less than 30 (thirty) days is permitted.
>
> (c) Normal operation related to a rating expired for more than 30 (thirty) days is prohibited, under any circumstance.
>
> (d) Ratings renewed outside the time frame established in paragraph (a) of this section shall have their validity periods counted from the month of the pilot's approval in the proficiency check, as provided in paragraph (a) of Section 61.19.

1.5.4. Qualification and flight experience.

The digital CIV records of both crewmembers were not up to date.

According to collected information, the PIC had been operating the aircraft PT-SHN since 2021, when he was hired by the operator, and was familiar with SIXE Aerodrome as well as with the region where the runway was located.

According to reports, the SIC had been operating the aircraft PT-SHN since May 2021, when he was promoted from the position of flight coordinator to pilot by the operator.

The Journey Logbook of aircraft PT-SHN indicated that both crewmembers had conducted flights to *Eldorado do Sul* within the thirty days preceding the accident.

There were no records relative to the training of Crew Resource Management in the training notifications issued for the crewmembers.

RBAC 135, in its Section 135.330, established the following in relation to crew-resource management training:

> 135.330 Crew Resource Management (CRM) Training
>
> (a) The certificate holder must establish and maintain an approved crew resource management (CRM) training program that includes initial and recurrent training. The training program must include instruction in at least the following:
>
> [...]
>
> (b) The certificate holder may only use a person as a flight crewmember if that person has completed the initial CRM training and, every 24 months, the recurrent CRM training, in accordance with the certificate holder’s approved training program.
>
> [...]

The pilots had experience in the type of operation; however, it was not possible to verify that they were qualified to conduct the flight.

1.5.5. Validity of medical certificate.

Both pilots held valid Aeronautical Medical Certificates (CMA).

1.6. Aircraft information.

The aircraft, Serial Number (SN) 110460, was manufactured by Embraer in 1985 and was registered under the Private Registration category – Non-scheduled Public Air Transport Service – Air Taxi (TPX).

The Certificate of Airworthiness Verification (CVA) was valid.

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

The most recent aircraft inspection (“weekly” type) was performed on 17 MAY 2022 by a certified Maintenance Organization (OM) located in the municipality of *Sorocaba*, SP. At the time of the accident, the aircraft had accrued 15 hours and 36 minutes of flight time after said inspection.

The most recent comprehensive maintenance intervention on the aircraft, a “C” check, was performed on 01 OCT 2015 by a certified OM located in *Sorocaba*, SP, and the aircraft had accrued 1,179 hours and 48 minutes of flight time since that inspection.

The left engine, Part Number (PN) PT6A-34, SN PCE-57190, underwent a “minor” inspection on 20 APR 2022, performed by a certified OM located in *Sorocaba*, SP. At the time of the accident, it had accrued 137 hours and 50 minutes of flight time since that inspection.

According to Technical Order (OT) 1C95A, dated 26 DEC 1979, the model EMB-110P1 aircraft was equipped with two PT6A-34 turboprop engines, of the free turbine and reverse-flow type, manufactured by Pratt & Whitney Canada and powered by Aviation Turbine Fuel (Jet-A).

The aircraft’s fuel system comprised four integral tanks, being two tanks in each wing. The total capacity was 1,720 liters, of which 1,692 liters were usable.

Fuel was normally supplied to the engines by two main mechanical pumps (left and right). In addition to the mechanical pumps, the system had two auxiliary electric pumps (left and right), which functioned as backups in case of failure of the main pumps and were also used during engine start.

The system also incorporated a crossfeed function, consisting of a fuel line running across the fuselage, interconnecting the engine fuel-supply outlets. Upon activation of the crossfeed, both engines were supplied by the same set of tanks and fuel pump – either the main mechanical pump or the electric pump (Figure 2).

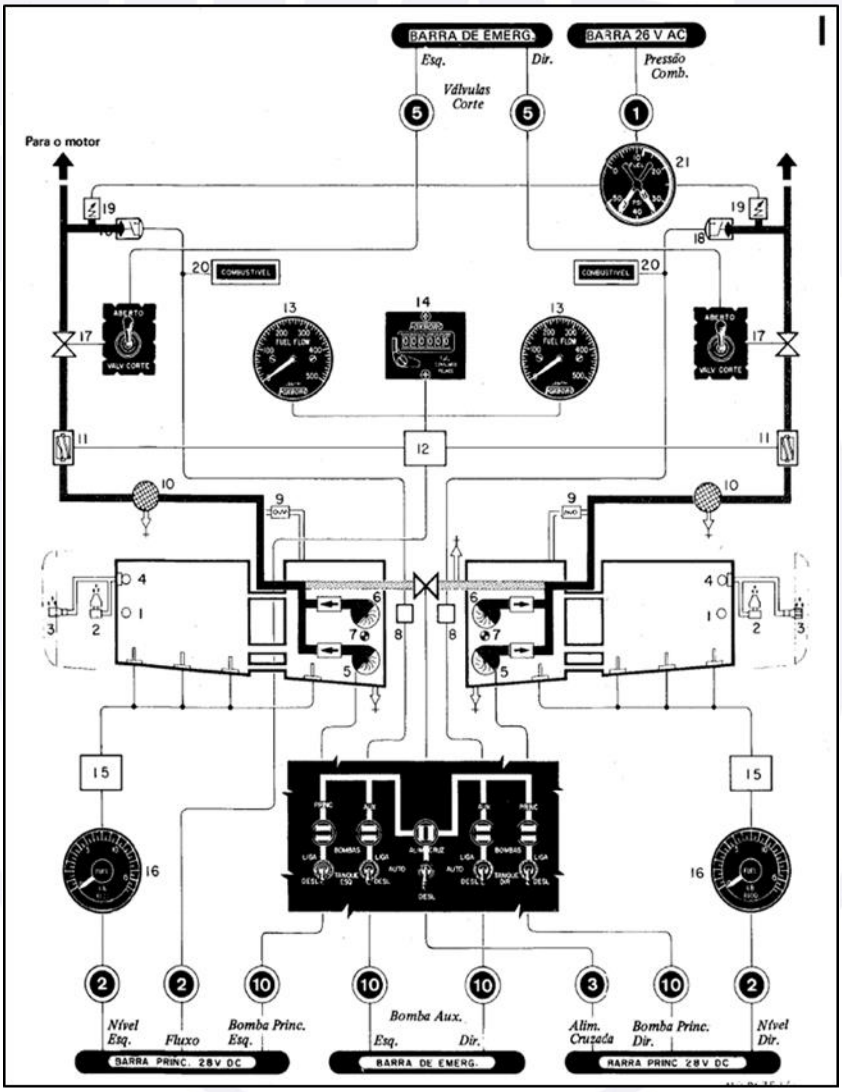

Figure 2 – Schematic diagram of the fuel system.
Source: O.T. 1C95A – Fuel System.

The fuel supply system for each engine was regulated by its respective Fuel Control Unit (FCU). The FCU was mounted on the rear flange of the fuel pump through a splined coupling, which transmitted a speed signal – proportional to the compressor turbine speed (Ng) – to the regulating section within the FCU.

Through its regulating section, the FCU determined the amount of fuel delivered to the engine combustion section, compatible with the power required at any given moment and as established by compressor speed control.

Pressurized fuel from the pump (P1) entered the FCU through the metering valve, and a bypass system regulated the inlet pressure according to operational demand. The fuel pressure immediately after the metering valve was referred to as metered fuel (P2), which then flowed to the starting control unit. The bypass valve maintained an essentially constant differential pressure (P1 minus P2) across the metering valve. Excess fuel was returned to the tank through internal passages (Figure 3).

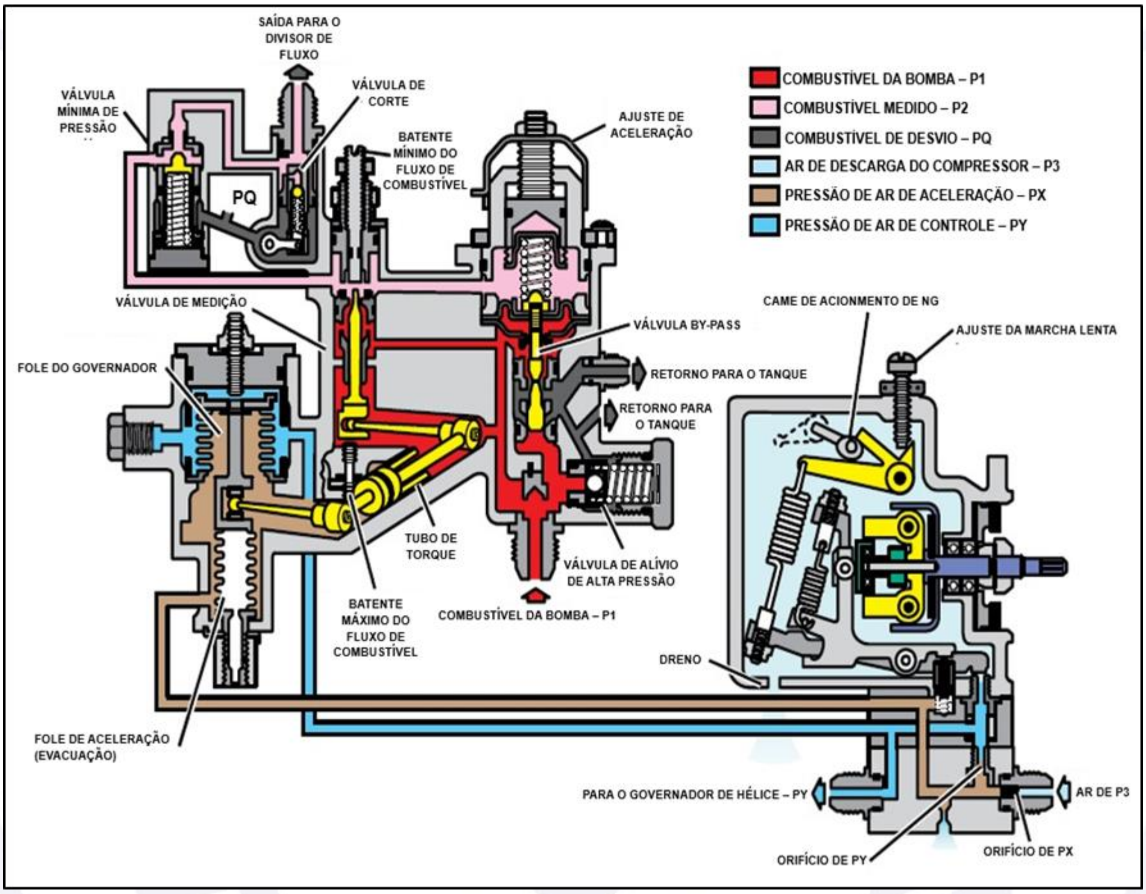

Figure 3 – Schematic diagram of the FCU.
Source: P&W PT6A – Small Series Maintenance Training Manual,
Chapter 11, Fuel Systems.

The FCU also incorporated a metering section, responsible for adjusting the quantity of fuel in order to meet the engine’s operational demands as set by the pilot and/or as required by changes in atmospheric pressure.

During normal operation, the FCU metering section was supplied by compressor discharge air (P3), from which Px and Py pressures derived. The metering section was composed of a bellows assembly consisting of an acceleration (evacuation) bellows and a governor bellows, interconnected by a common rod.

The end of the acceleration bellows was fixed to the housing, providing an absolute pressure reference. The governor bellows, in turn, functioned similarly to a diaphragm, transmitting its movement to the metering valve through a transverse shaft and associated levers.

Regarding the governor bellows, the following forces acted during its operation: Py pressure applied to its external surface; Px pressure applied to its internal surface; and the internal pressure of the acceleration bellows (evacuation), which opposed the expansion of the governor bellows. The derived pressures Px and Py varied according to changes in engine operating conditions as well as variations in inlet air temperature.

During acceleration, both pressures increased simultaneously, causing the governor bellows to contract. This movement drove the metering valve toward the open position, allowing a greater fuel flow. As Py decreased, approaching the desired Ng value (according to the power setting selected by the pilot), the bellows adjusted its expansion to reduce the metering valve opening.

When both pressures decreased simultaneously, the governor bellows expanded, moving the torque tube in the direction that reduced the metering valve opening, thus decreasing the fuel flow, because a change in Py was more effective than an equivalent change in Px. This occurred during deceleration and moved the metering valve towards the minimum-flow stop.

Any interruption to this differential variation between Px and Py prevented movement of the metering valve, causing the fuel flow – and, consequently, the engine power setting – to remain constant.

According to the pilots' statements, they had noticed that the aircraft exhibited abnormal behavior during flights, with delayed engine response to throttle inputs.

In addition, at times the aircraft was operated with a mismatch between throttle lever positions for the same selected power setting (throttles positioned at different locations on the pedestal to achieve the same torque value).

Based on this information, one verified that the maintenance department carried out the following maintenance actions on 12 MAR 2022, in accordance with Work Order (OS) No. 4465/22:

1. Adjusted the throttle control system for the LH engine to verify throttle mismatch, in accordance with Embraer Maintenance Manual P/N O.T 1C95A-2-3, Rev. 14, dated 27 JUL 2012;

2. Performed a swap of the FCUs, placing FCU P/N 3244777-2 S/N A89288 on the LH engine and FCU P/N 3244777-1 S/N A8039 on the RH engine, in accordance with Pratt & Whitney Maintenance Manual P/N 3021242, Rev. 66, dated 17 JAN 2022;

3. Performed a swap of the propeller governors, placing governor P/N 8210-025 S/N 13171750G on the LH engine and governor P/N 8210-002Y S/N 2247389AC on the RH engine, in accordance with Pratt & Whitney Maintenance Manual P/N 3021242, Rev. 66, dated 17 JAN 2022.

Still regarding issues related to the performance of the left engine, one verified that the aircraft Journey Logbook No. 10/PT-SHN/2022 recorded the accomplishment of a test flight on 17 MAY 2022. In that flight, the following entry was made in the "remarks" field: "Powerplant with the LH engine accelerating slightly slower than the RH engine, but within tolerance." However, no records were found regarding the values observed.

FCU P/N 3244777-2, S/N A89288, underwent a general overhaul on 28 MAR 2008, in accordance with Overhaul Manual P/N 3244777, Revision 2, dated 15 DEC 1989, and as recorded in SEGVOO 003, No. 1308000052/08. The intervention was performed by a certified Maintenance Organization in *Sorocaba*, SP, and at the time of the accident, the unit had accrued 1,256 hours and 12 minutes since the overhaul.

There were no records concerning the components that had been replaced during that overhaul.

1.7. Meteorological information.

The Meteorological Aerodrome Reports (METAR) and the Special Aerodrome Meteorological Reports (SPECI) from SBPA (*Salgado Filho* Aerodrome, *Porto Alegre*, RS) located approximately 14 NM east of the accident site, provided the following information:

METAR SBPA 201200Z 26006KT 240V300 1800 0700NW R11/P2000U R29/P2000D BR BKN002 10/10 Q1022=

METAR SBPA 201300Z 26007KT 1800 R11/P2000D R29/P2000D BR BKN002 11/10 Q1023=

SPECI SBPA 201337Z 28005KT 230V330 2600 BR OVC003 11/11 Q1022=

METAR SBPA 201400Z 27006KT 240V320 4000 BR OVC003 12/11 Q1022=

SPECI SBPA 201420Z VRB03KT 5000 BR SCT003 OVC005 13/12 Q1022=

METAR SBPA 201500Z 26007KT 230V290 8000 FEW005 BKN006 13/12 Q1022=

The METAR and SPECI reports from SBCO (*Campo Nossa Senhora de Fátima* Aerodrome, *Canoas*, state of *Rio Grande do Sul*) located approximately 16 NM east of the accident site, provided the following information:

METAR SBCO 201200Z 28007KT 1800 R13/P2000 R31/P2000 BR OVC002 10/10 Q1022=

SPECI SBCO 201208Z 25006KT 0800 R13/1100 R31/2000 FG OVC002 10/10 Q1022=

METAR SBCO 201300Z 28005KT 1800 R13/P2000 R31/P2000 BR OVC002 11/11 Q1023=

METAR SBCO 201400Z 31006KT 3000 BR SCT003 BKN005 12/11 Q1022=

SPECI SBCO 201440Z 28007KT 6000 BKN006 14/11 Q1022=

METAR SBCO 201500Z 27006KT 9000 BKN008 14/12 Q1022=

A Significant Weather Chart (SIGWX) generated at 10:05 UTC, valid until 00:00 UTC, showed the absence of any type of weather formation along the entire route, likely due to the presence of a large high-pressure area extending over nearly the entire country.

Based on the collected information, one concluded that meteorological conditions were below the minimum required for conducting the flight.

The Command of Aeronautics' Instruction (ICA) 100-12, "Rules of the Air," dated 05 DEC 2018, provided in Section 5, item 5.1.3, the following conditions for conducting flights under visual flight rules:

[…]

5.1.3 Except when authorized by the ATC unit to conduct a Special VFR flight, VFR flights shall not land, take off, enter the ATZ, or join the traffic circuit of such aerodrome if:

a) the ceiling is lower than 450 m (1,500 ft); or

b) the ground visibility is lower than 5 km.

NOTE: The ceiling remains the meteorological parameter used to define the operational status of an aerodrome (whether VFR or IFR). (NR) – Ordinance No. 204/DGCEA, dated 08 November 2018.

1.8. Aids to navigation.

According to the information recorded in the Auxiliary Air Routes Manual (ROTAER), the Aerodrome of *Eldorado do Sul Aeroclube* was certified for day- and night-time operations under Visual Flight Rules.

1.9. Communications.

Approximately thirty minutes before landing, aircraft PT-SHN established contact with *Porto Alegre* Approach Control (APP-PA), reporting entry into *Porto Alegre* terminal area, informing visual references of the terrain, and requesting cancellation of the IFR flight plan in favor of a VFR flight plan.

Initially, aircraft PT-SHN was cleared to continue flying at an altitude of 5,500 ft, heading toward SIXE. About twelve minutes after the first contact, APP-PA cleared the aircraft to descend under VFR, heading toward *Eldorado do Sul*.

One minute later, APP-PA requested a change in the aircraft's trajectory, instructing PT-SHN to proceed toward *Charqueadas* position to prevent traffic conflicts. The final contact with APP-PA took place 22 minutes and 13 seconds after the aircraft entered the *Porto Alegre* terminal area, when the crew was authorized to change frequency to 135.025 MHz for landing coordination at SIXE.

1.10. Aerodrome information.

Not applicable.

1.11. Flight recorders.

The aircraft was equipped with Cockpit Voice Recorder (CVR), P/N 980-6023-001, S/N 0259.

The voice recorder was forwarded to Cenipa's LABDATA (Flight Data Recorder Readout and Analysis Laboratory), where data extraction was successfully performed.

The equipment operated normally and contained data related to the occurrence flight, having recorded approximately 30 minutes up to the moment of final impact.

Among the information obtained from the recorder, one established that the SIC was acting as Pilot Flying (PF) throughout the flight until the approach for landing at SIXE and the go-around, at which point the PIC assumed the PF role.

One also observed that the SIC expressed concern regarding the meteorological conditions, which were not quite consistent with VFR navigation, at times preventing both ground reference and horizontal visibility.

Furthermore, it was possible to infer that the crewmembers only became aware of the effects of the FCU malfunction approximately 15 minutes prior to the final impact, when they attempted to reduce power in order to decrease the aircraft's speed.

At that moment, the right engine was reduced to 1,000 lb.ft, while the left engine remained at 1,300 lb.ft. Initially, the PIC suggested that the abnormal behavior observed might merely be indication of a fault in the left engine torque system, possibly related to the low outside temperature, and believed that the situation would normalize by the time of landing.

The crew decided to increase power on the right engine and maintain both engines operating at the same regime.

At various moments during the approach, while the crew adjusted the throttle levers, the SIC mistook an aural alert for the stall warning.

Later, this alert was identified as the landing gear warning horn, triggered with the throttles retarded and placed in the idle position when the landing gear was not locked down.

Approximately 10 minutes before impact, the SIC informed the PIC that the minimum safe altitude in the area was 2,000 ft. The PIC, however, replied that he knew that the region was dedicated to rice production, and was characterized by low flat terrain.

Approximately 8 minutes before the accident, the crew reached a consensus that there was indeed an engine malfunction, and that the left engine would not reduce below 1,200 – 1,300 lb.ft, even with the throttle at idle.

Prior to configuring the aircraft for landing, the crew could not agree on the exact location of the runway, questioning where it was. Only after several minutes was visual contact achieved.

Upon sighting the aerodrome, the crew elected to join the downwind leg for runway 29, maintaining an altitude of 800 ft due to the presence of clouds.

During the first landing attempt, a go-around was initiated due to the large power asymmetry between the engines and the inability to reduce the aircraft's speed.

On the second attempt, the crewmembers agreed that the left engine would be shut down on final approach. After the shutdown, the PIC attempted to maintain aircraft control by applying rudder and maximum power on the right engine; however, the aircraft continued uncontrollably until ground impact.

Upon reviewing the recording, it was possible to perceive that the crew maintained, up to the moment of the accident, a cordial interaction and did not exhibit any behavior suggesting imposition of authority or conflict of roles between them.

1.12. Wreckage and impact information.

The wreckage site was located 1 NM from SIXE.

Based on the physical evidence at the impact site, one determined that the aircraft followed a descending left turn trajectory until colliding with the ground. The descent profile began on the runway heading of *Eldorado do Sul* Aerodrome, magnetic 290°. After the shutdown of the left engine, aircraft PT-SHN deviated from the straight-in path, entering a 245° left turn and impacting the ground on a magnetic heading of 045° (Figure 4).

Figure 4 – Information on the accident dynamics.

The site was an area used for rice cultivation, which, at the time of the occurrence, had already been harvested, leaving the terrain waterlogged.

The aircraft's first impact occurred approximately 124 meters before its final stopping point. The aircraft was banked, with the left wing lower than the right. The initial impact occurred against an earthen embankment that separated the flooded fields and served as a crossing path between them.

Upon striking the embankment, aircraft PT-SHN lost the entire structure of the left wing, which was destroyed and scattered along the impact trajectory (Figure 5).

Figure 5 – Final wreckage position with emphasis on the initial point of impact.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

There was no evidence that physiological factors or incapacitation affected the performance of the crewmembers.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

Both crewmembers were regarded as serious with respect to work-related matters, friendly, and maintaining good relationship with other company personnel.

The pilots demonstrated good interpersonal interaction and cooperative engagement inside the cockpit – an assessment corroborated during the review of the CVR audio recordings. They were reported to have had adequate physical and mental rest for the conduct of the flight.

Other investigative elements related to psychological factors are consolidated within the factual information presented in item 1.18 (Operational Information).

This approach was adopted because, in this occurrence, human and operational factors were intrinsically connected, with psychological evidence emerging organically from the operational context. Maintaining such evidence integrated with the other facts contributes to a comprehensive understanding of the accident.

1.14. Fire.

There was no fire.

1.15. Survival aspects.

NIL.

1.16. Tests and research.

In order to identify the factors that contributed to the occurrence – particularly the condition in which the left engine power became locked – both the left and right PT6A-34 powerplant assemblies (S/N PCE-57190 and PCE-57192) were subjected to analysis.

Regarding the S/N PCE-57192 engine installed on the right side of the aircraft, characteristics consistent with normal operation and low power at the time of impact were observed. In view of reports that the right engine had been operating normally, the analyses focused on identifying its operational condition.

It was found that the pneumatic system exhibited the correct torque in its connections from the propeller governor to the FCU. The P3 line also presented characteristics of normal operation.

After removal of the “C” flange, free rotation of the compressor turbine was verified, along with normal conditions of the remaining components and the accessory gearbox. Both the compressor turbine and the diaphragm exhibited wear marks associated with light friction, indicative of residual rotation or deceleration at the time of impact.

On the power turbine side, rotation via the propeller-coupling flange was not possible, and the assembly was found to be seized.

However, as no evidence of bearing failure or lack of lubrication was identified, this condition was attributed to a probable displacement of the rotating assembly during ground impact.

As for the S/N PCE-57190 PT6A-34 engine installed on the left side of the aircraft, characteristics consistent with abnormal operation were observed, including an inability to regulate the fuel flow, which prevented the power adjustments commanded by the crewmembers.

Given the scenario reported regarding the behavior exhibited by the left engine, the analysis focused on the fuel supply system and the functioning of its components.

The investigation began with a comprehensive inspection of the pneumatic system supplying the FCU – from the propeller governor inlet to the FCU inlet – also including verification of the integrity of the line responsible for diverting air from the compressor’s section 3 (P_3). No discrepancies or abnormalities were found that could justify the reported behavior.

Subsequently, the fuel flow and its response to FCU control variations were examined. It was determined that the fuel flow remained unchanged despite adjustments made through the FCU.

The decision was then made to inspect the internal components of the FCU. In the governor section, the dynamic counterweights and the enrichment and fuel flow control springs were examined. The components did not exhibit blue-colored grease residue, a condition consistent with proper bearing lubrication and normal operation.

In the metering section, the torque tubes, the metering valve, the internal bushings, and the fuel flow valves leading to the fuel nozzles showed no anomalies and were in a condition compatible with normal operation.

In the pneumatic section, the Px and Py orifices were inspected and found unobstructed, a condition consistent with correct functioning in the control of fuel flow to the fuel nozzles.

Finally, the bellows component was analyzed by means of the procedure described in Component Maintenance Manual 3244777, Section 73-20-27, dated 05 MAY 2008, issued by the manufacturer Honeywell. During testing, it became evident that the component exhibited a leak (Figure 6).

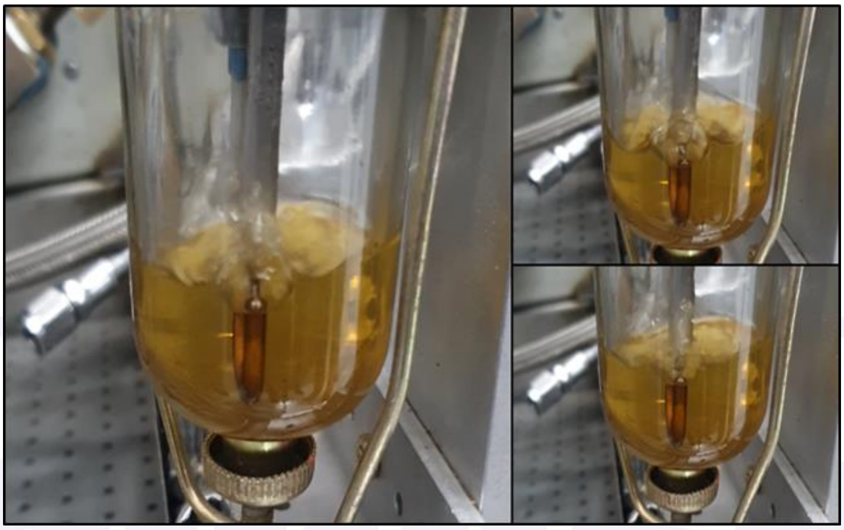

Figure 6 – Bellows test performed in accordance with the manufacturer's manual.

The identified leak was consistent with a condition in which Px and Py pressures would have equalized during aircraft operation, resulting in fuel flow commanded to the maximum – consistent with the condition reported by the crew.

In order to determine the failure mechanism, the bellows was subjected to laboratory testing. An initial visual inspection was performed, followed by a helium leak test under submersion, which detected that the failure region was located between the first and second spiral segments of the bellows (convolutions), as shown in Figure 7.

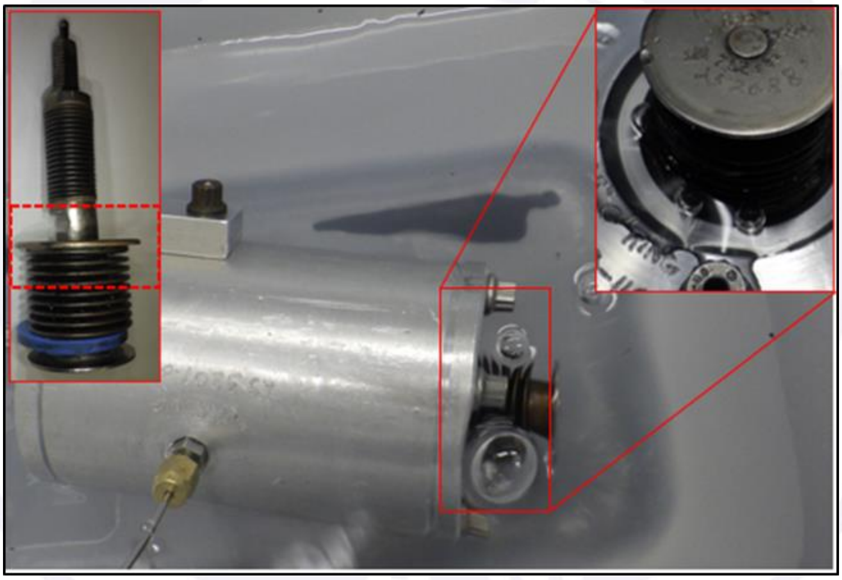

Figure 7 – Helium leak test.

After one determined the location of the leak, the component underwent computed tomography (CT scan), which identified the precise position of the leakage point (Figure 8).

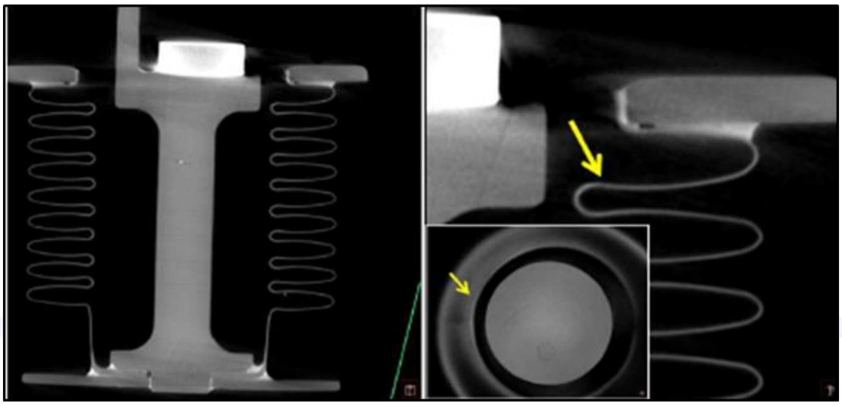

Figure 8 – Computed tomography image highlighting the crack location (in yellow).

With the exact location of the crack identified, a new visual inspection was carried out, allowing the precise extent and location of the defect to be confirmed (Figure 9).

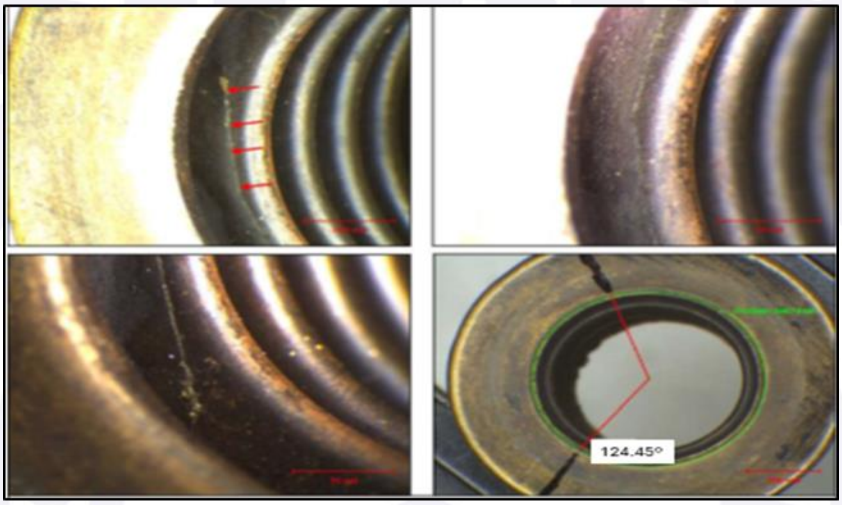

Figure 9 – Visual inspection results after CT scan.

In order to examine the fracture surfaces, the bellows was sectioned longitudinally using a rotary electric saw. Final separation of the area of interest was then performed mechanically, exposing both surfaces for scanning electron microscope analysis. During the process, a new fracture occurred at the seventh convolution.

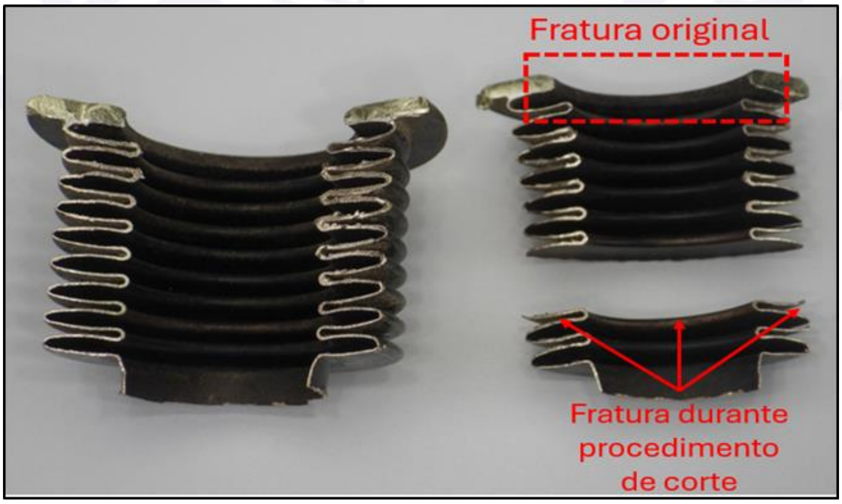

Figure 10 – Bellows after sectioning, highlighting the location of the original fracture and the new fracture that occurred during the procedure.

The examination of the new fracture that occurred during the separation process showed that its extremities exhibited characteristics of an overload fracture, caused by the manual force applied at the time of separation.

The pre-existing fracture exhibited a worn surface, on which, for the most part, the features that characterized de type of fracture had been damaged, rendering its fractographic evaluation imprecise.

A detailed examination of the entire crack length revealed, near its midsection, a region exhibiting characteristics consistent with a fatigue fracture. Radial marks (beach marks) were identified, originating from the internal diameter of the component (Figure 11).

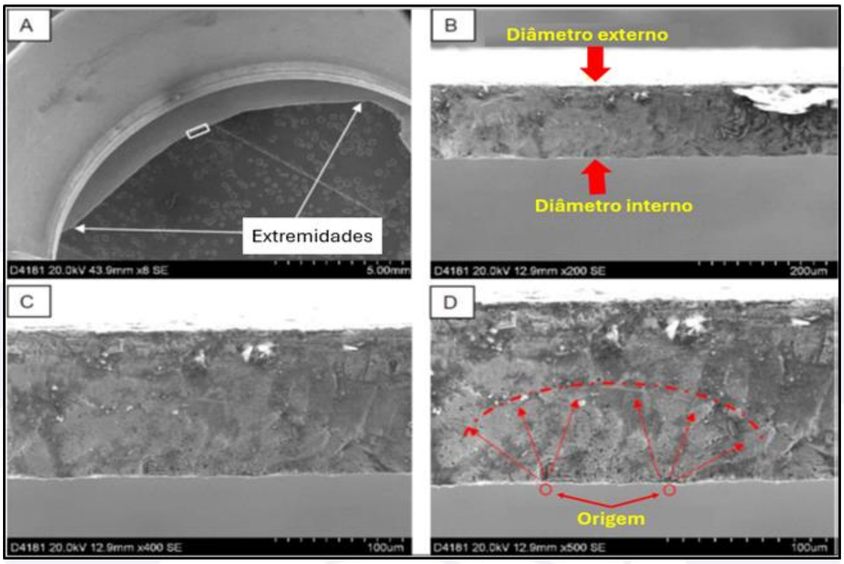

Figure 11 – Analyzed area exhibiting characteristics of fatigue failure.

Due to the degraded condition of the crack surface, likely caused by friction between the two faces after the occurrence of the fracture, it was not possible to determine the extent of the fatigue-affected area, preventing a qualitative assessment of the nucleation and propagation mechanisms involved in the formation of the discontinuity.

The fracture that occurred during the cutting procedure was also examined using a scanning electron microscope. This surface contained radial marks indicative of fatigue failure, in addition to those already identified as overload-related.

However, it was likewise not possible to determine which specific factors contributed to the development of that fatigue process.

The bellows was a component that, for inspection and overhaul purposes, was to be reviewed or replaced only when found to be in a potentially unsafe or unusable condition, such as due to wear, operational failure, improper performance, intermittent operation, or the impossibility of normal maintenance repair.

1.17. Organizational and management information.

The aircraft operator was a company certified to provide air taxi services in accordance with the requirements set forth in RBAC 135 – “Public air transport operations with airplanes having a maximum certified passenger seating configuration of up to 19 seats and a maximum payload capacity of up to 3,400 kg (7,500 lb), or helicopters,” Amendment 11, dated 15 MAR 2021, which was in effect at the time of the accident.

From an organizational standpoint, it was noted that the company had a family-based structure, in which members of the board of directors were related to one another.

The company's administrative and operational headquarters, as well as its main operating base, were located at SBMT (*Campo de Marte* Aerodrome, *São Paulo*, SP). The company held an Air Operator Certificate (COA), issued on 27 MAR 2017.

According to the Operational Specification (EO), Revision 17, dated 22 FEB 2022, the operator was authorized by ANAC to conduct non-scheduled domestic operations for passenger and cargo transportation using its aircraft fleet.

With regard to new hires, the selection process began with job postings and résumé submissions. Candidates underwent several stages, including interviews and psychological evaluations conducted by an outsourced psychological service, as well as technical interviews and theoretical and practical training. At times, applicants were referred by employees already working for the company.

The operator's General Operations Manual (MGO) was at Revision 3, approved on 05 FEB 2021. In Section 3.3.1, it established the following:

> Prior to assigning the crew, the responsible person shall verify whether the crewmembers have conducted a recent operation within the last 90 days. In addition to the other requirements – such as having completed the Company's training program, holding a valid technical qualification certificate (CHT), a valid aeronautical medical certificate (CMA), a valid IFR rating, and, for international flights, ICAO level 4 at a minimum.

In Section 4.1.1, "Qualifications for Captains," the MGO stated the following:

> The criteria for performing captain duties within the Company are:
>
> Hold at least a Commercial Pilot (PC) license for class-rated aircraft and an Airline Transport Pilot (PLA) license for type-rated aircraft, with the appropriate category and class ratings and, when required, a type rating for the aircraft;
>
> Have a minimum of 1,200 total flight hours, including 500 hours en route, 100 hours at night, and a valid IFR rating with at least 75 hours of actual IFR flight time;
>
> Have completed the company's ground and flight training program for the aircraft and for the onboard function to be performed.
>
> In addition, crewmembers designated as captains shall meet the following minimum acceptable requirements:
>
> 4.1.1.1 Minimum Acceptable Requirements:
>
> Embraer EMB-110P1: PLA.

In Section 7, the MGO established the criteria for conducting flights involving cargo and materials with special characteristics.

The flight performed by aircraft PT-SHN on the date of the accident had a cargo manifest and weight and balance record, as required under Section 8.7.

In its Section 10, 'Aircraft Logbook,' the General Operations Manual (MGO), in item 10.1.2, 'Recording of Aircraft Technical Status,' established the following:

> In the event of a system malfunction, the flight crew shall record the occurrence in Part II of the logbook. If the malfunction is covered by the MEL and therefore allows the aircraft to be dispatched, the malfunction shall be transcribed to the Deferred Corrective Action (ACR) list.

In this context, it was observed that, in the ninety days preceding the occurrence, only on 09 MAR 2022, on page 04 of Aircraft Logbook No. 09/PT-SHN/2022, there was a record made by the same crew reporting that the power levers were misaligned, with the lever corresponding to the left engine positioned one 'ball' ahead of that corresponding to the right engine.

In its Section 11.16, 'Procedure for Determining Operating Minima,' the MGO stated the following:

Upon arrival at the destination location, if meteorological conditions are degraded, that is, below the minimum established by the air navigation authority, the commander shall divert the flight to the alternate aerodrome.

Under no circumstances shall *Sales* allow its crew to attempt a landing when the aerodrome is below the permitted minimum; therefore, there shall be no 'press-on-itis' or forced continuation.

The MGO established in Section 12, "Emergencies," the following:

12.1.1 Duties and obligations in an emergency

Pilot in Command duties:

- Inform or brief the passengers that the aircraft is in an emergency;

- Perform the emergency checklist in coordination with the copilot;

Copilot duties:

- Follow the emergency procedure;

- Assist first with passenger evacuation;

- Remove obstacles to allow passenger movement, open doors, and transfer occupants to a safe location;

- Count on the Pilot's support and may designate one or more passengers to assist, if applicable.

Complete procedure per crewmember:

Copilot:

- Brief passengers before an emergency landing;

- Assist in the egress of the captain and incapacitated passengers.

Pilot in Command:

- Select the most suitable location for landing;

- Establish contact with ATC, reporting the emergency landing;

- After the emergency landing, remove survival equipment from the aircraft;

- Abandon the aircraft and assist passengers, if necessary.

Regarding organizational and management aspects, it was verified that the Safety Management Manual (MGSO), Revision 04, dated 04 AUG 2021, had been approved by the Brazilian Civil Aviation Authority (ANAC). It was identified that the MGSO did not include aircraft PT-SHN, an EMB-110P1 model aircraft, within the fleet listing. The aircraft model was later included in the Operational Specifications on 30 AUG 2021, by means of Revision 13, published under ANAC process No. 00066.002391/2021-75.

With respect to the operator's Operational Training Program (PrTrnOp), Revision 04, dated 10 FEB 2021, it was verified that it defined, among other topics, the initial training to be completed by pilots after hiring, including theoretical evaluation, practical evaluation, and general aviation subjects such as CRM, jungle and sea survival, and the handling of dangerous goods.

Concerning the training provided, it was observed that the crewmembers did not present records demonstrating the completion of their CRM training.

As for recurrent training prescribed in the PrTrnOp and conducted by the crewmembers involved in the accident, it was found that the PIC completed his ground training on 28 APR 2022, performed his flight training on 20 APR 2022, and was scheduled to undergo the proficiency check to revalidate his type and IFRA ratings in May 2022.

Similarly, the SIC completed his ground training on 28 APR 2022, performed his flight training on 20 APR 2022, and was scheduled to undergo the proficiency check to revalidate his type rating in May 2022.

RBAC 135, Amendment 11, in its Section 135.323, “Training program: general,” item (b), provided the following:

> (b) If a crewmember is required to complete recurrent training under this Subpart in a given calendar month and completes it in the previous or subsequent calendar month, ANAC will consider that the training was completed in the month in which it was due.
>
> (1) A crewmember may perform his duties during the 1-month calendar grace period after the end of the calendar month in which the recurrent training is due.

After analyzing the manuals submitted, it was determined that this documentation complied with Sections 135.341, 135.343, 135.345, 135.347, and 135.531 of RBAC 135, all of which address the conduct of initial and recurrent training for pilots.

The company also had a Maintenance Program for the EMB-110P1 aircraft, Revision 00, dated 01 MAR 2021.

The document analyzed had been prepared by the company and met the requirements described in Section 135.411(a)(2) of RBAC 135, Amendment 10, which established that: “aircraft whose type has been certificated for a passenger configuration, excluding any pilot seats, of 10 seats or more must be maintained in accordance with a maintenance program in compliance with 135.412, 135.413, 135.415, 135.417, and 135.423 through 135.443.”

The Maintenance Program referred to the different maintenance manuals, both for the Embraer aircraft and for the Pratt & Whitney Canada engines.

In its final considerations, it stated the following regarding the philosophy for controlling the service life of aeronautical items:

> *Sales* will adopt the service-life control philosophy for items characterized as Hard Time, On Condition, and Condition Monitoring as suggested by the aircraft, engine, and propeller manufacturers.

Aircraft maintenance was carried out either by a Maintenance Organization located in *Sorocaba*, state of *São Paulo*, or at the company’s own headquarters, as needed and in accordance with applicable requirements.

According to reports, at the end of each flight the pilots informed the Director of Maintenance of any unscheduled maintenance needs identified. Based on the information gathered, the crewmembers did not have access to all maintenance actions performed on the aircraft, which were managed by the Director of Maintenance.

According to information provided by the personnel responsible for aircraft PT-SHN maintenance, only those interventions requested by the company’s Director of Maintenance, by means of a work order, would be carried out.

1.18. Operational information.

This was a cargo transportation flight departing from SBJD and destined for SIXE, operated in accordance with the requirements established by RBAC 135.

The intended route, as filed in a “Y” flight plan, provided for departure from SBJD to SIXE. The IFR portion of the flight was cancelled after entering *Porto Alegre* Approach Control airspace, and the flight was subsequently conducted under VFR until near the destination.

During the approach, the crewmembers made it clear that the meteorological conditions were not suitable for visual flights, as evidenced by CVR audio recordings. This concern was reinforced during the traffic pattern, where the SIC reported that the cloud base was approximately 800 ft above ground level.

The aircraft’s basic operating weight was 3,530 kg, and it was refueled with 1,227 kg of QAv-1 fuel. Adding the crew weight of 164 kg, 20 kg of pilot baggage, and 700 kg of cargo, the total weight amounted to 5,641 kg – below the aircraft's Maximum Takeoff Weight (MTOW) of 5,670 kg.

According to OT 1C95B (110P1) -1, Section 5, Performance, the following data were to be considered for flight planning: climb fuel consumption (72 kg) and climb duration of twelve minutes; cruise fuel consumption (286 kg per hour); and descent fuel consumption (136 kg) with a descent duration of twenty minutes.

Considering a flight time of approximately 2 hours and 50 minutes, it was estimated that the aircraft had consumed 875 kg of fuel up to the time of the accident, and therefore had an approximate weight of 4,766 kg at impact.

The aircraft was within weight and balance limits.

After identifying the abnormal operating condition of the left engine, the crew elected to continue to their destination and attempt a landing in that configuration. SBPA (*Salgado Filho* Airport) was located approximately 14 NM from SIXE.

Regarding the decision to continue with the landing, RBAC 135 established the following requirements:

> 135.69 Operational restrictions or suspension: continuation of a flight in an emergency
>
> (a) During operations under this Regulation, if a certificate holder or a pilot in command becomes aware of conditions – including aerodrome and runway conditions – that pose a hazard to safe operations, the certificate holder or the pilot in command, as applicable, must restrict or suspend operations, as necessary, until such conditions are corrected.
>
> (b) A pilot in command may allow a flight to proceed to an aerodrome where he intends to land under the conditions referred to in paragraph (a) of this section only if, in that pilot's opinion, there is a reasonable probability that those conditions considered hazardous to safe operations may be corrected by the estimated time of arrival, or if no other safe course of action exists. In the latter case, continuation of the flight toward the aerodrome constitutes an emergency in accordance with Section 135.19 of this Regulation.

During the approach, it was possible to identify, through the CVR recordings, that the meteorological conditions impaired the pilots' ability to conduct the arrival properly, as described below:

- PIC – asks the SIC about the runway location.
- SIC – informs the PIC that he has the runway in sight and, in his perception, they were at low altitude and the runway was to the PIC's left.
- PIC – states to the SIC that he has visual contact.
- SIC – informs the PIC that he will join the downwind leg for runway 29.
- SIC – comments to the PIC that the ceiling is low.
- PIC – agrees with the SIC.
- SIC – informs the PIC that they are at 800 ft.

The first attempt to perform the landing was unsuccessful, and the PIC elected to execute a go-around before touchdown. During this procedure, the following exchanges were recorded:

- PIC – comments to the SIC that the torque is very high.
- SIC – tells the PIC that the flight will end at that location.
- PIC – instructs the SIC to reduce both engines.

- SIC – informs the PIC that the power levers are fully retarded and that he will apply reverse thrust once the aircraft is on the ground.
- PIC – instructs the SIC not to land and tells him to increase power.
- SIC – asks the PIC if they are to go around.
- PIC – confirms to the SIC with a “yes”.
- PIC – instructs the SIC to increase power and retract the flaps.

After the go-around, the PIC assumed the Pilot Flying (PF) role and decided to enter the traffic pattern again for another landing attempt.

The CVR recordings revealed that the dialogue between the crewmembers continued to exhibit moments of low assertiveness and a lack of clear coordination regarding the next steps to be performed prior to landing:

- SIC – asks the PIC if the torque is decreasing.
- PIC – replies to the SIC that the torque is not decreasing.
- SIC – tells the PIC that they will have to shut down the engine over the runway.
- PIC – shows the SIC the position of the slip indicator.
- SIC – agrees with the PIC.
- SIC – asks the PIC whether the turn is to the left.
- PIC – asks the SIC if he has retracted the flaps.
- SIC – replies that the aircraft is “clean.”
- PIC – comments to the SIC that the ceiling is low.
- SIC – comments to the PIC about the conditions, questions how they should proceed, and asks the PIC if the engine shutdown will be performed over the runway.
- PIC – asks the SIC to wait.
- PIC – requests flaps 25 from the SIC.
- SIC – asks the PIC what plan to follow.
- PIC – replies to the SIC that there is no plan.
- SIC – asks the PIC if there really is no plan.
- PIC – tells the SIC: “Reduce, feather, and shut down.” Then asks the SIC to wait.
- SIC – replies: “Okay.” Then asks the PIC to inform him on final for the shutdown.
- PIC – agrees with the SIC.
- SIC – replies: “Okay.”
- PIC – comments to the SIC that the ceiling is worsening, then corrects himself and says: “800 is fine,” and states that they will perform a long final.
- SIC – replies: “Okay.”
- PIC – comments to the SIC: “If it doesn’t reduce, I can’t stop.”
- PIC – requests flaps 50.
- SIC – replies: “Flap fifty,” and comments: “The horn won’t stop,” and “I’m pressing the button and it won’t stop.”
- PIC – requests landing gear down and comments: “Now it will stop.”

- PIC – requests flaps 75.
- SIC – repeats: “Seventy-five.”
- PIC – requests full flap.
- SIC – replies: “Full flap down.”
- SIC – informs the PIC: “Gear down, offset for landing,” and comments: “Over the runway… near the threshold reduce, feather, and shut down.”
- PIC – comments to the SIC that the engine is not dropping below 1,400 and requests power reduction.
- SIC – asks the PIC: “Feather?”
- PIC – confirms to the SIC: “Feather.”
- SIC – tells the PIC to trim the aircraft.
- PIC – instructs the SIC to shut down the left engine.
- SIC – asks the PIC: “Shut it down?”
- PIC – replies that he can shut down the left engine.

From the moment the engine was shut down, the aircraft developed a descending left-turn tendency, which the pilots were unable to counteract through power management on the right engine and flight-control inputs. The aircraft completed a 245° turn before colliding with the ground.

Regarding emergency procedures, OT 1C95B (110P1)-1, Revision 21, dated 01 DEC 2010, “Flight Manual – Airplane – EMB-110P1 BANDEIRANTE”, provided the following guidance for the emergencies “Engine failure or fire in flight” and “Engine shutdown”:

ENGINE FAILURE OR FIRE IN FLIGHT

Directional control – Maintain

Autopilot – Disengage (See Section 9)

Airspeed – Maintain above VMC

Power lever – Advance until the first of the following limits is reached: T5, Torque, or Ng

Affected engine – Identify and apply the Engine Shutdown procedure

Landing gear and flaps – As required. Retraction of landing gear and flaps is an important factor in reducing drag and should be carried out as soon as possible

Air-conditioning – VENT or OFF

Trim – As required

Power lever and airspeed – As required. Adjust power and airspeed according to performance needs (see Section 5)

NOTE

Use of rudder trim will reduce the pedal force required, and a 5° bank toward the operative engine will reduce the necessary rudder deflection. A sudden reduction of power from one engine will cause an immediate yaw and bank toward the inoperative side, requiring corrective rudder (pedal on the operative-engine side) and aileron input to maintain directional control. Loss of power will be confirmed by a drop in T5 and torque indications. Extended single-engine operation causes lateral imbalance, since only fuel from the operative side is consumed. Use crossfeed to allow fuel consumption from the inoperative side to eliminate this imbalance.

ENGINE SHUTDOWN

Fire warning horn – Silence (if applicable)

Propeller synchrophaser – OFF

The right-engine propeller will not fully feather via propeller-lever command if the synchrophaser is ON.

Power lever – MIN

Propeller lever – FEATHER

NOTE

Manually feather even if automatic feathering actuates.

Fuel lever – CUTOFF

Affected engine fuel shutoff valves – CLOSED

If fire warning is present, perform the steps below. Otherwise, proceed directly to Generator.

Wait 8 seconds after actuating the fuel shutoff valve. If the fire light remains illuminated:

Fire extinguisher – Discharge (if applicable)

Light “V” – Check illuminated (if applicable)

Generator – OFF

Load on operative generator – Verify within limits; reduce electrical load if necessary (see para. 3.7.39(A) “Generator failure”)

Fuel pumps (main and auxiliary) on affected side – OFF

The OT 1C95B (110P1)-1 also provided information regarding the landing procedure with only one engine operating:

SINGLE-ENGINE LANDING AND GO-AROUND

See Figure 3.1

A. BEFORE LANDING

Altimeters – Set QNH and crosscheck

Flaps – 25%

Propeller lever – MAX RPM

Hydraulic boost pump – ON

Hydraulic pressure – Check

Airspeed – Maintain 10 kt above threshold speed for 25% flaps

Landing gear – DOWN (when practical)

B. FINAL APPROACH

Flaps – Maintain 25%. Extend beyond 25% only when landing is assured and if required by runway length

Airspeed – Maintain threshold speed for selected flap configuration

After touchdown, reverse thrust and braking are at pilot’s discretion. When using reverse on the operative engine, directional control is maintained with nosewheel steering.

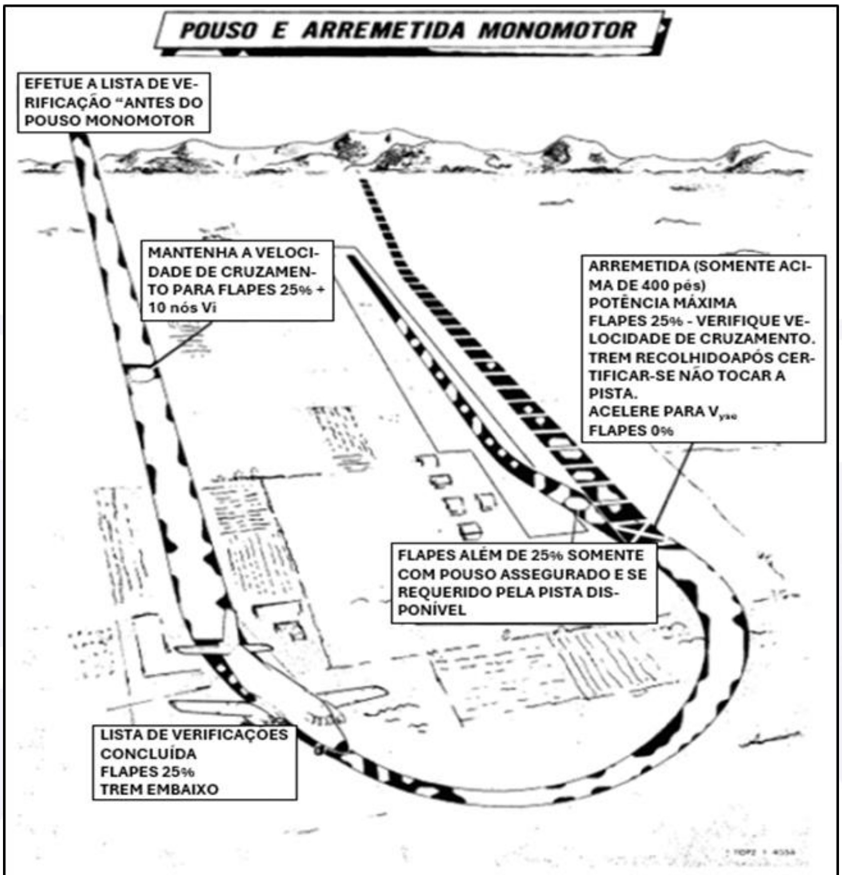

Figura 3.1

The OT 1C95B (110P1)-1 also defined the Minimum Control Speed (V_{MC}) as the speed below which flight-control effectiveness is insufficient:

> VMC – MINIMUM CONTROL SPEED: 84 kt IAS (83 kt for C95M – SC series)
>
> MINIMUM CONTROL SPEED WITH PROPELLER NOT FEATHERED: 94 kt IAS (93 kt for C95M – SC series)
>
> RECOVERING AIRCRAFT CONTROL BELOW VMC
>
> If power loss occurs at an airspeed below VMC, reduce power on the operative engine as necessary to improve directional control, pitch down to gain speed, feather and shut down the inoperative engine. Once control is regained, increase power on the operative engine as required.

The destination aerodrome had no emergency response plan and no fire-fighting services available for aeronautical accident scenarios.

1.19. Additional information.

After reconstructing the events leading to the occurrence and reviewing the communications exchanged between aircraft PT-SHN and Air Traffic Services, it was concluded that no urgency or emergency was declared at any point during the sequence of events that culminated in the accident.

ICA 100-12, "Rules of the Air", issued by the Department of Airspace Control (DECEA), provided the following guidance in item 3 – Applicability of the Rules of the Air, subitem 3.6 – Aircraft in Emergency:

> 3 APPLICABILITY OF THE RULES OF THE AIR
>
> 3.6 AIRCRAFT IN EMERGENCY
>
> An aircraft in emergency, whether in distress or urgency, shall use, by means of radiotelephony, the corresponding message (signal) prescribed in Annex A and in MCA 100-16 (Air Traffic Phraseology).
>
> Distress and urgency conditions were defined as:

a) Distress: a condition in which the aircraft is threatened by serious and/or imminent danger and requires immediate assistance.

NOTE: Distress also refers to an emergency in which an aeronautical accident is unavoidable or has already occurred.

b) Urgency: a condition involving the safety of the aircraft or of any person on board, but which does not require immediate assistance.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

This was a cargo flight departing from SBJD and destined for SIXE, conducted under the requirements established by RBAC 135. As planned, the flight was to be conducted under IFR from the departure aerodrome and under VFR at the destination aerodrome.

Although the pilots had experience in this type of operation, it was not possible to attest that they were qualified to conduct the flight.

Both pilots had previous experience in flights of this nature, including landings at that location. Furthermore, the PIC’s many years of experience created a condition conducive to the development of overconfidence. Such a condition had the potential to reduce critical judgment, leading to improvisation or noncompliance with procedures and operational guidance.

The arrival into SIXE was conducted under VFR, after the crew canceled the IFR flight plan during the first call upon entering the *Porto Alegre* terminal area. However, a review of the METARs from SBCO and SBPA revealed that those aerodromes were reporting restricted horizontal visibility between 1,800 m and 2,600 m and a ceiling of 500 ft.

From the CVR transcripts, one identified that this was a concern for the SIC during the arrival. He alerted the PIC about the aircraft’s navigational altitude being below the sector minimum altitude, in an attempt to keep the aircraft in visual contact with the ground.

Thus, although meteorological conditions did not directly contribute to the accident, they impaired the flight crew’s ability to organize and project the available information and apply it to the operation. This reduction in situational awareness directly affected the pilots’ capacity to perceive, analyze, and act appropriately, resulting in ineffective decision-making during the critical portion of the emergency management and including operation contrary to ICA 100-12.

Communications with Air Traffic Control up to landing clearance were deemed adequate. The *Porto Alegre* Approach Control unit was not informed of the urgency condition that later developed, nor was there any attempt to divert the landing to SBPA, which offered better ground support conditions.

After reviewing the CVR recordings, it was determined that the crewmembers did not initially associate the engine behavior with a possible malfunction. This recognition occurred only eight minutes prior to impact, when they attempted to reduce power on the left engine by moving the power lever to the idle position, but the torque did not decrease below 1,300 lb.ft.

During the identification of the malfunction, difficulties were noted in organizing and articulating ideas and facts in a rational and coherent manner. The pilots also used colloquial expressions, vague responses such as “okay”, and showed confusion regarding the commands being issued.

Following the go-around from the first landing attempt, it became evident that the crew did not allocate adequate time to manage the situation. This was corroborated by the exchange in which the SIC asked what the plan of action was, to which the PIC replied that there was no plan.

This condition characterized inefficient use of available human resources for aircraft operation, demonstrating confusion in communication between the crewmembers.

It is further noteworthy that, from the arrival at *Eldorado do Sul* Aerodrome through the subsequent traffic patterns, no conversation was captured in the recording indicating that the pilots performed the emergency checklist for the aircraft, evidencing noncompliance with operational procedures.

The impact sequence began on final approach, when the crew opted to shut down the left engine. From that moment, the aircraft developed a descending left-turn tendency that could not be countered with power management on the right engine and flight-control inputs. The aircraft completed a 245° turn before colliding with the ground.

Both engines were analyzed to determine whether their performance contributed to the occurrence. The right engine showed characteristics consistent with normal operation at low power. The examinations revealed free rotation of the compressor turbine and normal conditions in other accessory gearbox components. Light friction marks were identified, indicative of residual rotation or deceleration at impact.

With respect to the left engine, the analysis indicated characteristics consistent with normal operation; however, there was an inability to modulate the fuel flow. It was determined that the fuel flow metered by the FCU remained unchanged regardless of the movement of the cam and its control shaft.

After examining all components and operational characteristics of the FCU, a leak was identified in the bellows, originating from a crack located between the first two convolutions of the component. Subsequent examinations identified features consistent with a fatigue failure process, including radial marks originating from the inner diameter of the component.

Regarding the findings from the bellows examination, it was concluded that the crack allowed an indirect equalization between the pressure in the internal and external sections of the component.

Each surface of the component was exposed to a different pressure derived from compressor discharge air (P3). The pressure acting on the internal side was Px, while the external side was exposed to Py.

Through the pressure differential between Px and Py, the bellows – integrated into the governor bellows assembly – functioned as a diaphragm, contracting or expanding and transmitting its movement to the metering valve via the transverse shaft. By establishing communication between the derived pressures, the differential between Px and Py was nullified.

It is likely that this condition developed during cruise flight, when the bellows would have been contracted in order to maintain the fuel flow and sustain engine power at approximately 1,300 lb.ft for level flight.

The bellows exhibiting the crack was part of FCU PN 3244777-2, SN A89288, installed on the SN PCE-57190 PT6A-34 engine. Both components were considered to have undergone maintenance interventions in accordance with manufacturer requirements to ensure proper operation.

The FCU had accrued 1,256 hours and 12 minutes since its last overhaul, which was scheduled at 4,000-hour intervals. During this intervention, the bellows was subjected to the procedure described in Component Maintenance Manual 3244777, Section 73-20-27, dated 05 MAY 2008, issued by Honeywell.

Therefore, it was not possible to determine whether inadequate operational parameter settings or preventive maintenance actions could have prevented the malfunction.

The component was subject to a monitoring process that did not allow the identification of an imminent failure condition. Thus, its replacement would occur only if a defect or deficiency was detected during FCU overhaul.

The test performed on the bellows would be capable of identifying leaks that were already present; however, it would not assess the component's structural condition or its ability to withstand operational loads throughout the hours of use leading up to the next overhaul. As a result, it is possible that the bellows already exhibited a condition that limited its durability at the time of maintenance, but the applied test was not capable of detecting it.

Furthermore, one considered that the hypothesis that maintenance personnel might have contributed to the problem due to inadequacies in preventive and/or corrective services performed on the aircraft. This hypothesis was reinforced by pilot reports indicating that the aircraft had previously exhibited abnormal engine response lag relative to power lever selection.

In response to these reports, the company's maintenance director instructed the inversion of the FCUs between the right and left engines. The condition reported by the crew was consistent with that encountered during the accident flight. An initial crack of smaller extent could have allowed a reduced rate of equalization between Px and Py.

Such a condition would eventually produce the same effects observed on the day of the accident, albeit with less intensity. The mismatch between the power levers and the delayed response from the FCU would constitute an early indication of the problem later encountered.

It is noteworthy that the aircraft model involved in the accident was not included in the company's MGSO. The absence of the EMB-110P1 in that document contrasted with the publication of the Maintenance Program, Revision 00, dated 01 MAR 2021. This discrepancy revealed inadequate oversight by the organization's management.

The company also had an Operational Training Program (PrTrnOp), dated 10 FEB 2021, which defined the training required for crewmembers and already included the EMB-110P1 model. It was established that neither pilot had records of CRM training, in violation of Section 135.330 of RBAC 135.

Although periodic training was still within the grace period allowed by ANAC, it had not been completed with the required proficiency check, which could have revealed inadequate performance and insufficient readiness for emergency operations.

Therefore, one inferred that there was inadequate managerial oversight regarding pilot training activities and monitoring of their qualifications.

An incorrect interpretation of alarms and indications presented by the aircraft during the approach was also observed, characterizing an inadequate assessment of key operational parameters, despite the crew being certified to operate the aircraft.

Additionally, the absence of CRM training may have exacerbated deficiencies related to cockpit coordination, degrading communication between the pilots who, during the emergency management phase, exchanged information in a manner that was not sufficiently effective.

Regarding the operation, once the crew realized that the left engine was malfunctioning, they decided to proceed with the landing at SIXE, an aerodrome without an emergency plan or firefighting services.

The arrival to *Eldorado do Sul* Aerodrome was highly demanding, particularly due to meteorological conditions that impaired visual acquisition of the runway. In response to this situation, the PIC chose to fly below the minimum sector altitude – approximately 800 ft above ground level – despite warnings from the SIC, who was flying the aircraft at that moment.

Initially, the SIC, in coordination with the PIC, opted to conduct an approach to Runway 29 with both engines operating. However, the procedure was aborted due to the high power maintained on the left engine. During this interval, the phraseology used and the cockpit coordination displayed by the pilots revealed confusion and low assertiveness at times.

After the go-around, the PIC assumed control of the aircraft and decided to fly another traffic pattern and attempt a second landing. The CVR recordings revealed that communication between the crewmembers continued to display low assertiveness and lacked a clear sequence regarding the actions to be taken prior to landing.

The use of nonstandard phraseology led the SIC to misunderstand the commands issued by the PIC, which, during a critical phase of flight, demonstrated a continuation of the communication failures already evident during earlier portions of the approach.

For the second traffic pattern, the time available for decision-making was limited to that between the go-around and the aircraft's turn onto the downwind leg. At no point in the recordings did the crewmembers run the emergency checklist, thereby depriving themselves of information on how to properly carry out the shutdown of the left engine.

In addition to the emergency procedures, consulting the procedures contained in the Flight Manual would have allowed the crew to make a better assessment of the single-engine approach.

Observance of these procedures would have prevented the aircraft from being fully configured for landing before the engine shutdown. The actions taken by the pilots reflected overconfidence in their knowledge of aircraft operation and resulted in disregard of prescribed procedures.

Configuring the aircraft for landing before shutting down the left engine placed aircraft PT-SHN in a condition of high drag, impairing its ability to maintain forward momentum. This led to a rapid decrease in airspeed immediately after the malfunctioning engine was shut down.

It was determined that, at that point, the aircraft descended below the minimum control speed defined in the Flight Manual, leading to loss of control.

According to the Manual, recovery from loss of control below minimum control speed requires reducing power on the operative engine and pitching down to regain sufficient airspeed for restored control authority.

The engine shutdown performed on final approach did not provide sufficient altitude to execute the required recovery actions. Additionally, CVR transcripts indicated that, when control was lost, the PIC applied maximum power on the right engine.

This input may have further aggravated the loss of control, causing the aircraft to roll and yaw to the left, descending until ground impact.

The decision to conduct an emergency landing at an aerodrome lacking the capability to support such an operation reflected inadequate judgment and represented a latent failure in the crew's decision-making process.

One therefore concluded that the malfunction of the left engine on aircraft PT-SHN originated from a fracture in the bellows component of the left engine's FCU, which caused an inability to modulate the fuel flow and engine power to be maintained at approximately 1,300 lb.ft.

Additionally, cockpit coordination between the crewmembers was ineffective, leading to the decision to shut down the left engine during the approach without reference to the emergency checklist or the procedures and operating concepts contained in the Flight Manual.

Finally, with the landing gear extended and flaps set to 100%, the aircraft decelerated to speeds below those required to maintain effective flight-control authority.

This condition resulted in the loss of control of aircraft PT-SHN at an altitude too low to permit recovery, rendering the accident irreversible.

3. CONCLUSIONS.

3.1. Findings.

a) the pilots held valid CMAs (Aeronautical Medical Certificates);

b) the PIC's IFRA rating (Instrument Flight – Airplane) was not current, and both pilots' E110 type ratings had expired in April 2022; however, such condition was allowed under Section 61.33 of RBAC 61;

c) the SIC held a valid IFRA rating;

d) the pilots had experience in this type of flight, but it was not possible to attest that they were qualified to conduct it;

e) the aircraft had a valid CVA (Certificate of Airworthiness);

f) the aircraft was within weight and balance limits;

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

h) meteorological conditions were below the minima required for the intended flight;

i) communications with ATC units were adequate;

j) during the flight, the SIC expressed concern about meteorological conditions being below those required for VFR;

k) near the destination, the pilots identified that power on the left engine did not decrease below 1,300 lb.ft;

l) tests and exams performed on the right engine indicated characteristics consistent with normal operation at low power at the time of impact;

m) tests and exams performed on the left engine indicated characteristics consistent with abnormal operation, characterized by inability to regulate fuel flow, which prevented power adjustment;

n) during the investigation, the bellows component that integrates the FCU was found distressed;

o) laboratory analysis of the bellows revealed a fracture with evidence of fatigue failure;

p) the engine power lock at 1,300 lb.ft was associated with the equalization of the pressures acting on the FCU, Px and Py, which came into contact through the crack;

q) with respect to the company's MGO, it was determined that the crew did not comply with established procedures for flight operations and meteorological minima when proceeding to the destination aerodrome;

r) no records of CRM training were found for the pilots;

s) no urgency/emergency condition was declared to Air Traffic Control regarding aircraft PT-SHN;

t) the pilots attempted to land at SIXE twice;

u) the pilots elected to shut down the left engine on final approach during the second landing attempt;

v) the procedures for engine failure in flight or engine shutdown were not reviewed before the shutdown was executed;

w) after shutting down the left engine, the aircraft entered an uncontrolled descending left turn that the pilots were unable to counteract;

x) the aircraft collided with an embankment and subsequently skidded across a rice field;

y) the aircraft sustained substantial damage; and

z) the PIC suffered serious injuries, and the SIC sustained minor injuries.

3.2. Contributing factors.

- **Attitude – a contributor.**

Familiarity with the destination aerodrome, developed through recent experience, along with experience in this type of operation, generated a complacent attitude toward safety procedures and excessive confidence in the pilots' ability to handle the situation. These attitudes led to inadequate adherence to the procedures required in the presence of an engine malfunction.

Additionally, the decision to continue the flight and landing under VFR, despite adverse meteorological conditions, reflected difficulty in reacting appropriately to external stimuli affecting the operation, resulting in inadequate behaviors and compromising flight safety.

- **Training and Qualification – undetermined.**

There were no records indicating that the pilots had completed CRM training, as required by Section 135.330 of RBAC 135. Furthermore, it is possible that the lack of completion of periodic flight training before the accident contributed to inadequate performance and insufficient proficiency in the context of the emergency operation and management.

- **Communication – a contributor.**

During the management of the emergency, the crew demonstrated difficulty organizing and expressing information rationally and coherently. The PIC's unclear and low-assertiveness verbalizations hindered the SIC's ability to properly interpret and act upon the instructions.

This situation worsened during the go-around after the first landing attempt, when the PIC repeatedly issued commands using non-standard phraseology, delaying actions on the part of the SIC.

Throughout the second traffic circuit, information exchange between the pilots was insufficient to establish an orderly definition of the commands and actions to be executed before shutting down the left engine on final approach.

- **Adverse meteorological conditions – undetermined.**

Meteorological conditions below the minima for VFR and for landing at SIXE may have affected aircraft performance and induced the pilots to conduct engine-malfunction procedures at low altitude to maintain ground reference, reducing the safety margin during the ensuing loss of control.

- **Crew Resource Management – a contributor.**

Human resources available for the operation were inefficiently employed, with inadequate management of each crewmember's actions and a failure to consult emergency checklists.

The confusion observed on the CVR indicated that, once assuming control of the aircraft, the PIC struggled to provide clear direction to the SIC during critical flight phases, particularly during the landing attempt and the subsequent left-engine shutdown on final.

At no point did the crew engage in dialogue aimed at analyzing the situation, interpreting available information, or consulting checklists to support decision-making.

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

CVR transcripts showed that, when control was lost, the PIC applied maximum power on the right engine. Under those circumstances, the action performed by the crew may have aggravated the aircraft’s loss-of-control condition, which resulted in a left descending turn that continued until ground impact.

- **Piloting judgment – a contributor.**

There was inadequate assessment of aircraft operational parameters prior to shutting down the left engine. This misjudgment led the crew to perform the shutdown on final approach, at low altitude and with the aircraft fully configured for landing – conditions under which sustained flight was no longer possible. Additionally, shutting down the engine during final approach prevented recovery of control in the new single-engine flight condition due to insufficient altitude.

- **Aircraft maintenance – undetermined.**

The possibility of maintenance personnel involvement could not be ruled out, due to inadequacies in the corrective or preventive actions taken regarding discrepancies recorded in the Aircraft Logbook by the same crew days prior to the accident.

At that time, a mismatch between the power-lever positions had been noted. It was considered that this condition may have been associated with the onset of FCU malfunction, through an incipient fracture in the bellows.

- **Decision-making process – a contributor.**

Evidence collected during the investigation suggests difficulty in perceiving, analyzing, and appropriately responding to the situation, resulting in hasty decision-making and inadequate use of available time to implement a safe course of action.

During arrival at SIXE, inadequate evaluations and/or indecision were identified regarding measures to mitigate the emergency in question. By choosing to land at SIXE, the pilots did not comply with the meteorological minima prescribed for that operation, reducing the safety margin when shutting down the malfunctioning engine – an action that led to loss of control.

Misinterpretation and insufficient analysis led to an underestimation of the seriousness of the situation, resulting in the decision to shut down the engine during final approach at an aerodrome lacking emergency response capability, without notifying air traffic services of the aircraft’s emergency condition.

- **Managerial oversight – undetermined.**

One deemed plausible that there was inadequate oversight by the organization’s management regarding pilot training activities and monitoring of qualifications.

Additionally, in response to reports of discrepancies, the aircraft maintenance manager may not have adequately addressed abnormal behaviors exhibited by the aircraft – such as the power-lever mismatch – prior to the accident.

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 ANAC (Brazil's National Civil Aviation Agency), it is recommended:

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Coordinate with *Sales Táxi Aéreo Ltda*. to ensure the company's compliance with its Training Program, particularly regarding CRM training, as required by Section 135.330 of RBAC 135, for all personnel involved in its aeronautical activities.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On December 29th, 2025.