COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-088/CENIPA/2023

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-UVC**
MODEL:	**EMB-202A**
DATE:	**23MAI2023**

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 23 May 2023 accident involving the EMB-202A aircraft of registration marks PT-UVC. The occurrence was typified as “[FUEL] Combustion.”

During a flight for the application of agricultural pesticides on a cotton plantation, the aircraft experienced a power loss, prompting the pilot to perform an emergency landing in an unprepared area.

The aircraft sustained substantial damage.

The pilot suffered serious injuries.

An Accredited Representative from the National Transportation Safety Board (NTSB) of the United States, the State of manufacture of the engine, was designated for participation in the investigation of this occurrence.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
AEHC	Hydrated Ethyl Alcohol Fuel - HEAF
CENIPA	Brazil's Center for the Investigation and Prevention of Aeronautical Accidents
CHE	Company Qualification Certificate
CIV	Digital Pilot-Logbook
DGPS	Differential Global Positioning System
MLTE	Multi-Engine Landplane Class Rating
MNTE	Single-Engine Landplane Class Rating
NTSB	USA's National Transportation Safety Board
OM	Maintenance Organization
PAGA	Agricultural Pilot Rating - Airplane
PCM	Commercial Pilot License - Airplane
PIC	Pilot In Command
PPR	Private Pilot License - Airplane
SIPAER	Aeronautical Accidents Investigation and Prevention System
SN	Serial Number
UTC	Coordinated Universal Time

1. FACTUAL INFORMATION.

Aircraft	**Model:** EMB-202A **Registration:** PT-UVC **Manufacturer:** EMBRAER	**Operator:** *Aero Agrícola Cambará Ltda.-ME*
Occurrence	**Date/time**: 23MAI2023 - 19:15 (UTC) **Location:** *Fazenda Karitel* **Lat.** 14°42'47"S **Long.** 045°31'27"W **Municipality – State:** *Cocos – Bahia*.	**Type(s):** [FUEL] Fuel related

1.1. History of the flight.

At approximately 19:15 UTC, the aircraft took off from an agricultural landing area at *Fazenda Karitel*, municipality of *Cocos*, State of *Bahia*, for an aerial application flight with 01 POB (pilot).

Approximately 18 minutes into the flight, during a reversal turn, the aircraft experienced a power loss, prompting the Pilot in Command (PIC) to perform an emergency landing in an unprepared field.

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

The aircraft sustained substantial damage.

The PIC suffered serious injuries.

1.2. Injuries to persons.

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

1.3. Damage to the aircraft.

The aircraft sustained substantial damage to the tail cone, main and auxiliary landing gear, wings, elevator, rudder, propeller assembly, engine mount, and fuel tanks.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

Hours Flown	
	PIC
Total	10,000:00
Total in the last 30 days	45:45
Total in the last 24 hours	03:00
In this type of aircraft	2,000:00
In this type in the last 30 days	45:45
In this type in the last 24 hours	03:00

Note: flight-hour data provided by the operator of the aircraft.

1.5.2. Personnel training.

The PIC completed his PPR course (Private Pilot - Airplane) in 1987, at the *Aeroclube de Volta Redonda*, State of *Rio de Janeiro*.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PLA License (Airline Transport Pilot - Airplane) and had valid ratings for MNTE (Single-Engine Landplane), MLTE (Multi-Engine Landplane), and PAGA (Agricultural Pilot - Airplane).

1.5.4. Qualification and flight experience.

The PIC initially worked in agricultural aviation from 2004 to 2008. Between 2008 and 2022, he operated the following aircraft models: PA31, PA42, EMB-810, and LR30. He returned to the activities of agricultural aviation in 2023, the same year in which he underwent a proficiency flight to renew his PAGA rating, with validity until April 2025.

According to information contained in his CIV (digital pilot-logbook) of the ANAC's Integrated Civil Aviation Information System (SACI), the PIC met the requirements outlined in Section 61.21, "Recent Experience," of the RBAC-61 (Brazilian Civil Aviation Regulation nº 61), which governs "Licenses, Ratings, and Certificates for Pilots."

The PIC was, therefore, qualified and experienced for this type of flight.

1.5.5. Validity of medical certificate.

The PIC held a valid CMA (Aeronautical Medical Certificate.

1.6. Aircraft information.

The EMB-202A aircraft, a single-engine, low-wing, tricycle landing gear model with Serial Number (SN) 20001049, was manufactured by EMBRAER in 2008 and registered in the SAE-AG category (Special Air Services - Agricultural).

The airplane's CVA (Certificate of Airworthiness) was valid until November 25, 2023. The records of the airframe, engine, and propeller logbooks were up to date.

As of the accident date, the aircraft had accumulated 2,639 hours and 50 minutes of total flight time.

The aircraft's most recent "50-hour" inspection was completed on March 27, 2023, on the premises of *KKS Manutenção de Aeronaves* Maintenance Organization (MO) (CHE 2007-61 ANAC), located in *Formosa*, State of *Goiás*. The aircraft flew 38 hours and 10 minutes after the said inspection.

The most recent "100-hour" inspection was also performed by *KKS Manutenção de Aeronaves* on March 8, 2023. The aircraft flew 92 hours and 40 minutes after the inspection.

The aircraft was fitted with a Lycoming IO-540-K1J5 engine (SN L-33052-48E), a conventional six-cylinder, horizontally opposed, spark-ignition, air-cooled engine with fuel injection designed for Hydrous Ethyl Alcohol Fuel (AEHC). It powered a variable-pitch, three-blade metal propeller.

As of the accident date, the engine had logged 2,640 hours and 40 minutes of total operating time. Its last inspection, an overhaul, was performed when the engine had 2,634 hours and 10 minutes of operation. By the accident date, the engine had operated for 6 hours and 30 minutes after the overhaul.

The aircraft's fuel system consisted of two tanks installed within the wings, each with a capacity of 146 liters of AEHC, 132 liters of which were usable.

The aircraft's fuel quantity was measured using two mechanical liquid level gauges located on the upper wing surface, calibrated to display readings between 0 liters and 60 liters. A “zero” reading corresponded to 14 liters of unusable fuel (Figure 2).

Notably, there was no fuel quantity indicator in the aircraft's cockpit.

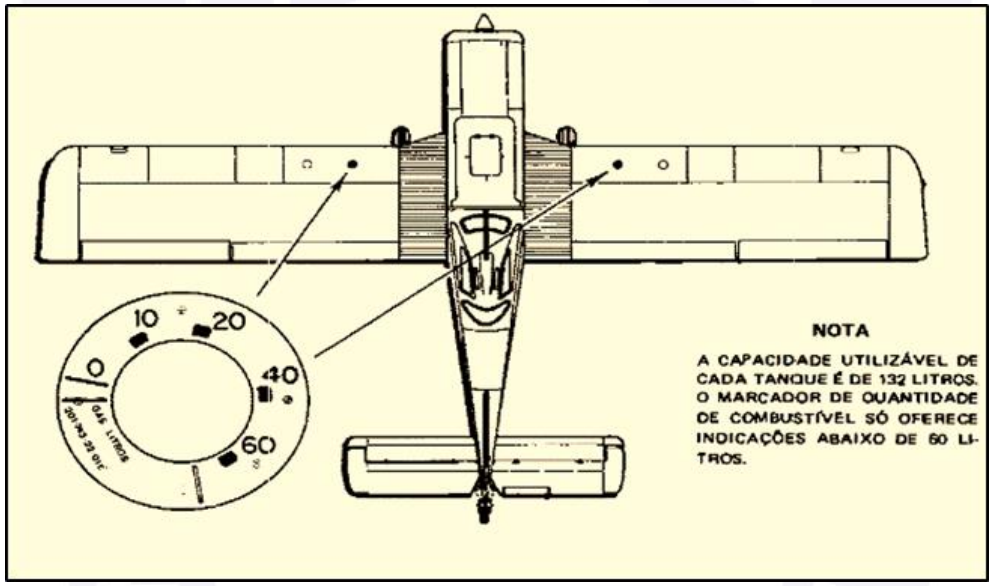

Figure 2 - Location of the fuel liquid level gauges.
Source: Adapted from the EMB-202A operations manual.

The fuel tank selector mechanism was operated via a selector located on the left side of the cockpit, near the pilot's seat. It had three positions: left tank (E), right tank (D), and closed (F), allowing the pilot to select which tank would supply fuel to the engine (“E” or “D”) or to stop fuel flow to the engine (“F”) (Figure 3).

Figure 3 - Positions “D,” “E,” and “F” of the EMB-202A fuel selector.

1.7. Meteorological information.

The weather conditions were above the minimums required for the flight.

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

Not applicable.

1.11. Flight recorders.

Not required and not installed.

1.12. Wreckage and impact information.

The accident occurred approximately 3 NM from the takeoff location, in an area of typical *cerrado* vegetation.

The first part of the aircraft to contact the vegetation and the ground was the right wing. Subsequently, the aircraft spinned to the right around its vertical axis, and dragged for approximately 140 meters before coming to rest with its nose 180° offset from its direction of travel (Figure 4).

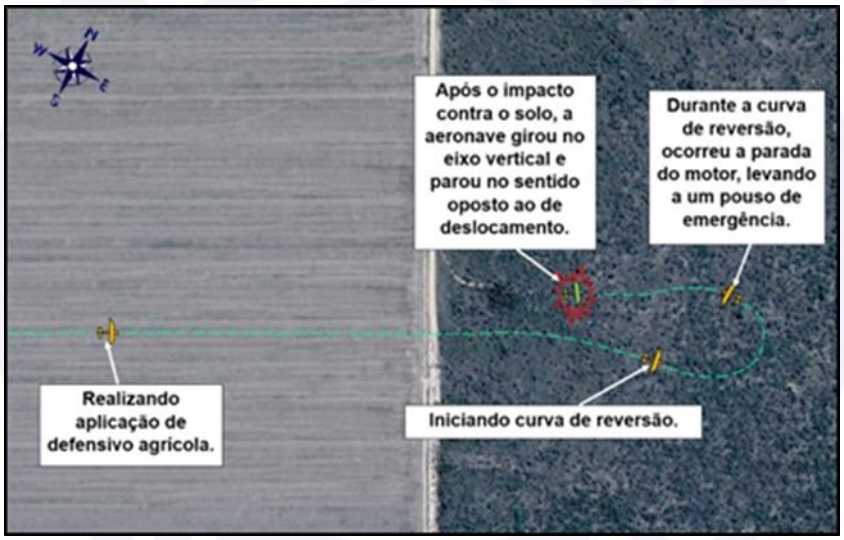

Figure 4 - Sketch of the accident site.

At the accident site, the fuel tank selector was found in the "D" position (Figure 5), and both tanks were found ruptured and empty.

Figure 5 - Fuel tank selector in the "D" position at the accident site.

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.

An agricultural pilot from *Fazenda Karitel* was dispatched to fly over the area where the PT-UVC had been performing its spraying operation, as the time elapsed between the takeoff and the expected return of the aircraft exceeded the estimated duration of this type of operation.

The crashed aircraft was located, and the PIC, who had sustained fractures in his lower right limb, was extracted from the site by a specialized work-accident response team from *Fazenda Karitel*. He was then transported by ambulance to the regional hospital.

1.16. Tests and research.

Examinations and tests were conducted on the SN L-33052-48E Lycoming engine, which powered the PT-UVC aircraft, to determine whether this component contributed to the in-flight power loss that led to the emergency landing.

During the initial inspection, the engine was cleaned, revealing no severe damage caused by the emergency landing (Figure 6).

Figure 6 - View of the SN L-33052-48E engine before and after cleaning.

The aspect of the engine components inspected and analyzed was consistent with the 6 hours and 30 minutes of flight time following the overhaul.

No abnormalities were found in the fuel system, as detailed below:

- The fuel distributor had no signs of corrosion or malfunction.
- The fuel pump was tested manually, and exhibited normal operation.
- The fuel inlet filter was clean, without any contaminating residues.
- The throttle's opening and closing movements were normal, without any abnormalities or discrepancies that could compromise fuel delivery to the engine.
- The fuel distributor showed no corrosion or other indications of malfunction (Figure 7).

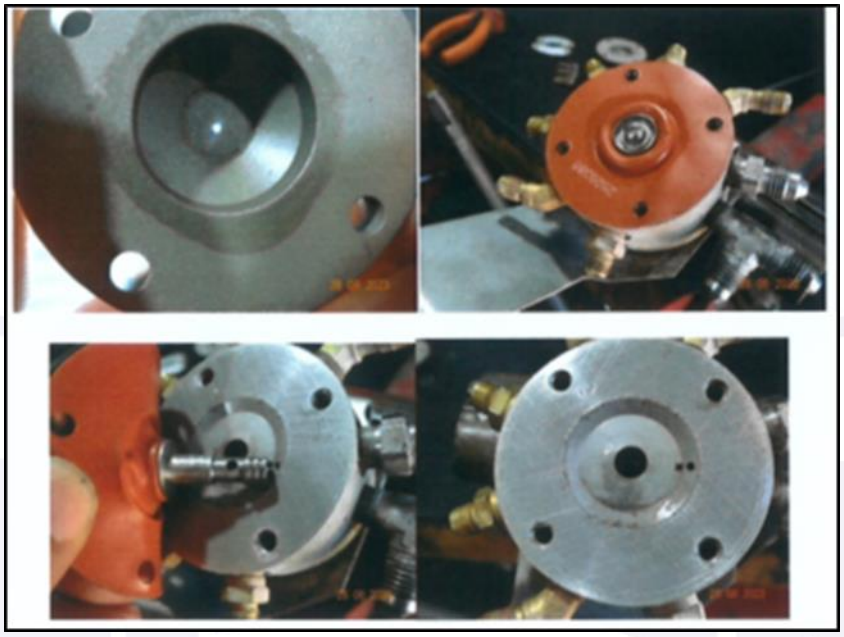

Figure 7 - View of the fuel distributor.

- The cylinder injectors were unobstructed (Figure 8).

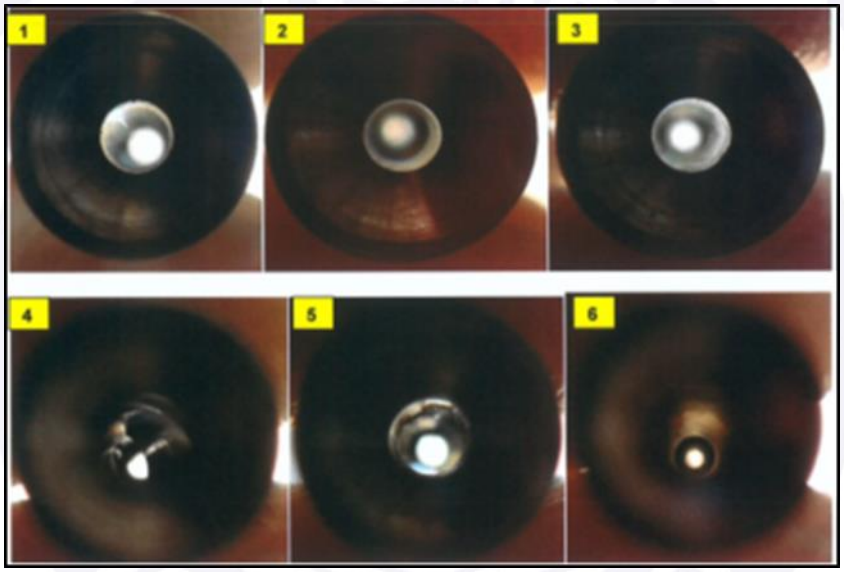

Figure 8 - General view of the cylinder fuel injectors, free of obstructions.

- The other components of the fuel system functioned normally during functional testing.

As for the ignition system, the magnetos were tested manually, and showed no operational issues. The spark plugs exhibited signs of normal operation.

All internal engine components requiring lubrication appeared to function normally.

No abnormalities or discrepancies were found in the cylinders, connecting rods, crankshafts, or valve controls that could cause malfunction or engine failure.

The disassembly and analysis of the engine revealed no evidence of malfunction, nor were any factors identified that could have caused engine failure or shutdown.

Therefore, the disassembly and analysis of the engine revealed no evidence of malfunction, nor were any factors identified that could have caused engine failure or shutdown.

1.17. Organizational and management information.

The operator of the PT-UVC airplane was a company certified to provide aerial agricultural services in accordance with the requirements established in the RBAC-137, Amendment 04, which governs “Certification and Operational Requirements: Agricultural Aviation Operations.”

The company operated five aircraft, being two EMB-201A and three EMB-202A models.

The PIC’s employment bond with the operator began on May 5, 2023.

According to Operational Specifications (EO) Revision nº 2, dated November 12, 2020, the operator was authorized by ANAC to conduct the following types of agricultural aviation operations: liquid application, solid application, firefighting, and water stocking.

On the date of the accident, the Air Operator Certificate (COA) nº 2014-12-6IJJ-06-01/ANAC, issued on January 24, 2023, was valid.

The company had implemented a Safety Management System (SMS) by means of an MGSO (Safety Management Manual) approved by the ANAC.

In this context, the MGSO served as the primary document guiding operational safety activities. It contained the safety policy and objectives, individual responsibilities, and procedures related to the operation and maintenance of the SMS.

In this respect, it was noted that the ANAC conducted a follow-up audit of the company on November 24, 2020, to verify its technical and operational capacity in compliance with the RBAC-137.

For that purpose, the audit included a routine of data collection and document verification process, covering both pre-requested and on-site materials.

On the occasion, the ANAC identified 11 non-conformities, which were officially communicated to the company on December 14, 2020.

In response, the company (*Aero Agrícola Cambará Ltda.*) developed a Corrective Action Plan (PAC) to address the observed non-conformities. The plan was accepted and deemed satisfactory by the ANAC, which closed the audit process.

The referred follow-up audit was conducted after the accident involving the PT-UGO aircraft on June 12, 2020. The Final Report of the accident was published on February 12, 2021.

As a result of the investigation, three Safety Recommendations were issued, the first of which, addressed to the ANAC, pertained to managerial supervision:

> A-074/CENIPA/2020 - 01
>
> Coordinate with *Aero Agrícola Cambará Ltda.* to verify the effectiveness of managerial supervision mechanisms for aerial agricultural activities, particularly regarding hazard identification and risk management processes.

In response, on June 28, 2021, the ANAC stated that:

> Regarding the first recommendation, the relevant sector of the ANAC reported that *Aero Agrícola Cambará*, aiming to enhance the safety of its activities, updated its methods as documented in the revised MGSO submitted to the ANAC. Additionally, the operator stated that those involved in identifying hazards to operational safety would use the following tools: operational safety audits, hazard reports, investigation authority safety reports, data analysis (e.g., from logbooks), and reports on accidents, incidents, or safety events.

Thus, regarding operational safety management, SIPAER professionals found no systematic procedures for assigning responsibilities to pilots or ground support staff concerning fuel refueling procedures during aerial agricultural operations.

Furthermore, interviews with company personnel revealed that pilots did not consistently perform visual fuel checks before each agricultural operation due to the routine nature of flights, which were conducted between sunrise and sunset, with similar altitude and speed profiles, and lasting an average of 25 minutes.

It was also observed that pilots often delegated the task of visually checking the fuel quantity in the tanks to ground support personnel.

1.18. Operational information.

The PT-UVC operation was conducted under the rules of RBAC-137 - "Certification and Operational Requirements: Agricultural Aviation Operations."

On the day of the occurrence, the PIC arrived at *Fazenda Karitel* at approximately 17:30 UTC and then proceeded to the landing area of the agricultural unit to prepare the aircraft for two pesticide application flights over distinct cotton plantation areas.

For planning purposes, the PIC estimated the aircraft's fuel consumption at 100 liters of AEHC per flight hour, consistent with the aircraft's operations manual.

According to accounts, the meteorological conditions were favorable for visual flights. There was no significant cloud cover or visibility restrictions, and the temperature was around 25°C.

The PIC noted that he typically used the fuel selector in the "E" position for agricultural operations. However, he stated that on May 23, 2023, he had informed the ground support personnel that he would use only the right-wing fuel tank for both flights that day due to logistical refueling considerations.

After completing the preparation of the airplane, takeoff took place at 17:44 UTC with the fuel selector in the "D" position. The PIC returned to the location of departure at 18:45 UTC after completing the first flight of the day for pesticide application.

The PIC reported that during that flight, he decided to switch the fuel selector from the "D" position to the "E" position during the return leg from the application site for a better management of the aircraft's fuel endurance, as the spraying time and the distance between the plantation and the landing area were greater than usual.

He also emphasized having performed the landing and engine shutdown with the fuel selector in the "E" position, without observing any abnormalities in the aircraft's performance.

The PIC recalled remaining seated in the cockpit during the preparation of the aircraft for the next flight, which primarily involved reprogramming the Differential Global Positioning System (DGPS), refueling the right-wing fuel tank, and filling the hopper.

He also mentioned that, due to his lack of familiarity with operating the DGPS, he spent more time than expected for entering the parameters related to the change in the operational area, adjustments to the pesticide application flow rate, and increasing the dimensions of the terrain swaths to be sprayed.

The PIC added having asked the ground support person to perform the following tasks:

- Refuel the right-wing tank to reach 60 liters of usable fuel;
- Fill the hopper with 400 kg of pesticide;
- Check the usable fuel quantity in the left-wing tank; and
- Perform an external inspection of the aircraft.

The EMB-202 operations manual, Rev. 37, dated September 12, 2018, Section 4, Page 4-5, Item 5, contained the following instructions regarding the pre-flight external inspection:

[...]

a. Fuel Filler Cap – Check for proper refueling and closure.

b. Fuel Quantity Indicator – Check fuel quantity (emphasis added).

c. Wing Root Fairing – Check for safety and general condition.

d. Landing Gear – Check general condition.

e. Tire – Check general condition and proper inflation.

f. Fuel Tank Drain – Use a sampling jar and drain a small quantity of fuel (before the first flight of the day and after each refueling) to eliminate any presence of water and sediment at the bottom of the tank.

g. Drain Pitot Lines (drains inside the inner leading edge).

The ground support person stated that after following the PIC's instructions, the aircraft was fueled for the second flight of the day as follows:

- left-wing tank: 30 liters of usable AEHC;
- right-wing tank: 60 liters of usable AEHC;
- hopper: 400 kg of pesticide.

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

Once the preparations were completed, the PIC reported that he performed the engine start procedures and took off with the fuel selector in the "E" position to conduct a flight with an expected duration of 25 minutes.

The aircraft's operations manual, Section 4, Page 4-7, Item 21, outlined the following routine engine start procedures:

4-21. ENGINE START

1. Fuel selector valve – Verify it is set to the fullest tank (emphasis added).

2. Propeller control lever – MAX RPM.

3. Master switch (BAT) – switch on (INT or EXT).

4. ALTERN switch – switch off.

5. Throttle – Advance approximately 1/6 of its travel.

6. Auxiliary electric pump – Turn on.

7. Mixture control lever – Move to RICH until fuel flow indicates approximately 5 gallons per hour.

8. Mixture control lever – Return to CUT-OFF.

9. Auxiliary electric pump – Turn off.

10. Ignition switch (MAG) – Set to START. Once the engine starts, let the selector return to BOTH.

11. Mixture control lever – Gradually advance to achieve smooth engine operation.

The PIC recalled that after approximately 18 minutes of flight, after performing a “spraying run,” he pulled up the aircraft to reposition for another run in the opposite direction. When initiating the “reversal turn,” the engine “stalled,” and the propeller stopped rotating.

The PIC further stated that at approximately 150 ft. above ground level, he leveled the wings, switched the fuel selector to the "D" position to attempt an engine restart, but shortly later, the aircraft collided with the *cerrado* vegetation.

The pesticide load in the hopper was not jettisoned.

Relatively to emergency procedures for forced landings without engine power, the operations manual provided the following guidance:

3-16-2 FORCED LANDING WITHOUT ENGINE POWER

In the event of total engine failure, establish a glide at 85 mph (90 mph with 1,800 kg) with flaps retracted.

If the failure is sudden and time permits, attempt to restart the engine and check the following:

1. Fuel supply – Verify the fuel selector valve position and fuel quantity indication. Test with the auxiliary fuel pump pressure.

Turn it off if the engine runs irregularly and/or if the pressure fluctuates (line rupture).

2. Magnetos – Test operation on a single magneto.

If all attempts to restart the engine are unsuccessful and a forced landing is imminent, select the most suitable area for landing and take the following actions:

1. Hopper load – JETTISON (emphasis added).

2. Seatbelt and shoulder harness – Adjust and verify locking.

3. Mixture control lever –CUT-OFF.

4. Fuel selector valve – CLOSED (F).

5. Switch off all switches except the master switch (BAT) and the alternator switch.

6. Approach at 80 mph (85 mph with 1,800 kg).

7. Use flaps as necessary.

8. Switch off the master switch (BAT) and alternator switch on final approach.

9. Perform a three-point landing.

10. Use maximum braking during the initial landing roll.

1.19. Additional information.

NIL.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

The flight involved the application of agricultural pesticides over a cotton plantation, with only the pilot on board.

The two flights performed by the PIC on the day of the accident originated from the agricultural aircraft landing area at *Fazenda Karitel*, located approximately 3 NM away from the crops to be sprayed.

At the time of the occurrence, the meteorological conditions were favorable for the proposed flight.

The PIC would typically use the fuel selector in the "E" position, corresponding to the left tank, for agricultural operations.

However, on the day of the accident, he decided to select the right-wing fuel tank due to refueling logistics.

Thus, the aircraft performed the first flight of the day with the fuel selector in the "D" position. However, the PIC switched the selector to the "E" position at the beginning of the return leg from the application area to optimize the aircraft's fuel endurance.

The PIC landed the aircraft and shut down the engine with the fuel selector in the "E" position.

During the preparations for the departure leading to the accident, the ground support person, following the PIC's instructions, refueled the right tank of the aircraft to 60 liters of

usable fuel, with the left tank remaining with the 30 liters of usable fuel from the previous flight.

As a result, the aircraft took off with a total of 90 liters of usable AEHC fuel, sufficient for 54 minutes of fuel endurance, for flight with a planned duration of 25 minutes.

The hopper was loaded with 400 kg of agricultural pesticide.

The PIC admitted not having worked the pre-flight checklist items recommended by the manufacturer, including the visual verification of fuel quantity in the tanks, as he was preoccupied with programming the DGPS, with which he had limited experience.

Interviews with members of the company staff revealed that pilots did not routinely perform visual fuel checks before each agricultural operation, as these flights were the usual ones, conducted between sunrise and sunset, with similar altitude and speed profiles, and lasting approximately 25 minutes. Such informal practices likely created an environment incompatible with flight safety.

Flight planning was conducted during the refueling process, moments before takeoff, likely contributing to a lessening in the pilot's attention to checklist procedures.

The PIC reported that, after preparations were completed, he started the engine and took off with the fuel selector in the "E" position.

In the operational area, approximately 18 minutes into the flight, as the PIC initiated a "reversal turn" for repositioning, the engine lost power due to fuel exhaustion in the left tank.

The PIC then switched the fuel selector to the "D" position to attempt an engine restart. However, because of the low altitude, he was forced to execute an emergency landing in the *cerrado* vegetation.

The pesticide load in the hopper was not jettisoned.

Examination of the PT-UVC's engine revealed no evidence of malfunction or factors that could have caused the engine failure in flight.

It is possible that the PIC carried out the aircraft inspections instinctively, without consulting the checklist. Failure to adhere to safety procedures may have contributed to the accident, as a thorough execution of the checklist could have allowed the incorrect fuel selector position to be identified and corrected in time.

Furthermore, the operations manual recommended starting the engine with the fuel selector set to the tank with the higher load, which in this case was the right-hand one.

Such an aspect may have contributed to the accident, as at the time of the failure, if the fuel selector had been set to the "D" position since engine start, that tank would have had sufficient endurance to continue the flight safely. Considering that after flying 18 minutes, the aircraft would have consumed approximately 30 liters of AEHC.

Based on the fuel consumption data provided by the manufacturer, as well as on the information made available by the PIC, it is possible to affirm that the 30 liters of usable fuel in the left tank were consumed during the flight, despite the existence of 60 liters of usable fuel remaining in the right tank.

The absence of a fuel quantity indicator in the cockpit underscored the need for effective flight time management to properly select the fuel tank.

In this context, one verified that the PIC maintained the fuel selector in the "E" position from takeoff until the moment at which the engine shut down. However, it remains unclear whether he skipped the checklist item to select the fullest tank, or whether he left the selector in the "E" position due to habitual use of that configuration, indicative of prior conditioning that led to inadequate performance.

It is worth noting that, although the PIC was qualified and certified for this type of flight and had prior experience as an agricultural pilot, he had only resumed this activity less than a month before, after a 15-year period without conducting pesticide application flights.

This situation suggests that the pilot's experience, combined with habits acquired over time, may have led him to rely on intuition rather than technical flight parameter information to support his decision-making regarding fuel tank selection.

Regarding flight management, one concluded that the PIC faced challenges in performing the emergency landing procedures outlined in the operations manual for engine-out scenarios. The failure to jettison the hopper's load after the unsuccessful engine restart attempt supports this observation. However, the PIC's observed performance may have been influenced by the engine failure occurring at low altitude.

Although the ANAC conducted an on-site audit of the operator's SMS, which was deemed satisfactory on March 7, 2022, it was possible to affirm that the company's risk management process failed to detect the hazards present and, consequently, did not implement the necessary mitigating actions regarding the refueling procedures in agricultural operations.

A fuel quantity check by the PIC could have increased his situational awareness, ensuring selection of the tank with the higher fuel load. Thus, the lack of standardized supervisory procedures for aircraft refueling by the operator may have contributed to the accident, as insufficient barriers were in place to mitigate human error during the task.

3. CONCLUSIONS.

3.1. Findings.

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

b) the pilot held valid ratings for MNTE (Single-Engine Landplane), MLTE (Multi-Engine Landplane), and PAGA (Agricultural Pilot - Airplane);

c) the PIC was qualified and experienced for this type of flight;

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

e) the aircraft was within weight and balance limits;

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

g) the meteorological conditions exceeded the minimum requirements for the flight.

h) the aircraft took off from the agricultural landing area at *Fazenda Karitel* for a local aerial application flight;

i) after performing a reversal turn, the aircraft experienced a power loss, prompting the pilot to execute an emergency landing in an unprepared area;

j) before the landing, the pilot did not jettison the agricultural pesticide load;

k) the analyses revealed that the engine failure was caused by fuel starvation;

l) examination of the engine showed no evidence of malfunction;

m) the aircraft sustained substantial damage; and

n) the PIC sustained serious injuries.

3.2. Contributing factors.

- Attitude – undetermined.

It is possible that the PIC performed aircraft checks automatically, without consulting the checklist. This disregard for safety procedures may have contributed to the accident, as

proper adherence to the checklist could have allowed the incorrect position of the fuel selector to be identified and corrected in a timely manner.

- **Work-group culture – undetermined.**

Interviews with company personnel revealed that pilots did not routinely perform visual fuel checks before each agricultural operation due to the routine nature of the flights. This aspect may have contributed to the accident.

- **Memory – undetermined.**

It could not be determined whether the PIC omitted the checklist item requiring the selection of the fullest fuel tank (the right tank) before engine start or left the selector in the "E" position due to habitual use of that configuration. This suggests prior conditioning, which may have led to inadequate performance.

- **Flight planning – a contributor.**

The PIC's inadequate actions during flight preparation, while programming the DGPS during refueling shortly before takeoff, reduced his attention to checklist items. This contributed to his failure to verify the fuel quantity in the tanks and to select the tank with the higher fuel load before starting the engine.

- **Support systems – undetermined.**

The fuel refueling procedures outlined in the SMS of *Aero Agrícola Cambará Ltda*. may not have met the minimum operational safety standards to establish barriers to prevent fuel starvation occurrences.

- **Managerial oversight – undetermined.**

It is possible that the company's risk management process, within the scope of its SMS, failed to identify the potential hazards and did not implement necessary mitigation actions regarding refueling procedures for agricultural operations. This suggests inadequate supervision of activities of execution in the operational field.

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):

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Disseminate the lessons learned from this investigation to aerial application operators, with the aim of assisting in the process of risk management and identification of hazards, fostering the adoption of the necessary mitigating actions regarding refueling procedures during aerial agricultural operations.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

The company updated its operational procedures so that pilots and ground crews now verify the fuel quantity in both tanks before each flight, in addition to maintaining an up-to-date refueling report, aiming to prevent fuel exhaustion during aerial agricultural operations.

On June 13, 2023, the ANAC approved Amendment nº 05 to the RBAC-137, and revoked item III of Article 43 and item VI of Article 46 of the Specific Operational Safety Program (PSOE-ANAC), which was approved by Resolution nº 352, dated February 10, 2015, and required the implementation of SMS (Safety Management System) in aerial application companies.

With this revocation, RBAC 137 established, in Section 137.215, the following requirement regarding risk management, which came into effect on October 2, 2023:

> 137.215 Risk Management
>
> (a) The aerial application operator is responsible for managing operational risk, identifying hazards, and implementing the necessary mitigation measures.

Around the same time, ANAC published the "Best Practices Guide for Aerial Agricultural Operations", with the aim of promoting a safety culture among all those involved in the operation, fostering a continuous process of awareness, professionalism, and adherence to regulations and best practices.

On May 14th, 2025.