

COMANDO DA AERONÁUTICA
CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE
ACIDENTES AERONÁUTICOS



FINAL REPORT
A - 120/CENIPA/2015

OCCURRENCE:	ACCIDENT
AIRCRAFT:	PT-EPD
MODEL:	EMB-721C
DATE:	30AUG2015



NOTICE

According to the Law n  7565, dated 19 December 1986, the Aeronautical Accident Investigation and Prevention System – SIPAER – is responsible for the planning, guidance, coordination and execution of the activities of investigation and prevention of aeronautical accidents.

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

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

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

This Report does not resort to any proof production procedure for the determination of civil or criminal liability, and is in accordance with Appendix 2, Annex 13 to the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree n  21713, dated 27 August 1946.

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

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

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

SYNOPSIS

This is the Final Report of the 30AUG2015 accident with the EMB-721C aircraft, registration PT-EPD. The accident was classified as “[SCF-PP] System/Component Failure or Malfunction Powerplant / Engine Failure in-Flight”.

The aircraft took off from the Ourilândia do Norte Aerodrome (SDOW) - PA, and it was considered as missed on 30AUG2015, since it did not reach its destination, the Kendjan Village - PA.

The wreckage of the airplane was located on 01SEPT2015, in a dense jungle area, at 86 NM of SDOW.

The pilot and passenger perished at the site.

The aircraft had substantial damage.

An Accredited Representative of the National Transport Safety Board (NTSB) - USA, (State where the aircraft and engine were designed) was designated for participation in the investigation.



CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS	5
1. FACTUAL INFORMATION.....	6
1.1 History of the flight.....	6
1.2 Injuries to persons.....	6
1.3 Damage to the aircraft.....	6
1.4 Other damage.....	6
1.5 Personnel information.....	6
1.5.1 Crew's flight experience.....	6
1.5.2 Personnel training.....	6
1.5.3 Category of licenses and validity of certificates.....	7
1.5.4 Qualification and flight experience.....	7
1.5.5 Validity of medical certificate.....	7
1.6 Aircraft information.....	7
1.7 Meteorological information.....	7
1.8 Aids to navigation.....	7
1.9 Communications.....	7
1.10 Aerodrome information.....	7
1.11 Flight recorders.....	7
1.12 Wreckage and impact information.....	7
1.13 Medical and pathological information.....	9
1.13.1 Medical aspects.....	9
1.13.2 Ergonomic information.....	9
1.13.3 Psychological aspects.....	9
1.14 Fire.....	9
1.15 Survival aspects.....	9
1.16 Tests and research.....	9
1.17 Organizational and management information.....	12
1.18 Operational information.....	12
1.19 Additional information.....	12
1.20 Useful or effective investigation techniques.....	14
2. ANALYSIS.....	14
3. CONCLUSIONS.....	16
3.1 Facts.....	16
3.2 Contributing factors.....	17
4. SAFETY RECOMMENDATION.....	18
5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.....	18

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
CA	Airworthiness Certificate
CASA	Australian Civil Aviation Safety Authority
CENIPA	Aeronautical Accident Investigation and Prevention Center
CG	Center of Gravity
CHETA	Air Transport Company Approval Certificate
CMA	Aeronautical Medical Certificate
DA	Airworthiness Directive
DCTA	Department of Science and Aerospace Technology
FAA	Federal Aviation Administration
IAE	Aeronautics and Space Institute
IFRA	Instrument Flight Rating - Airplane
IS	Supplementary Instruction
MNTE	Airplane Single Engine Land Rating
NM	Nautical Miles
NTSB	National Transportation Safety Board (USA)
PCM	Commercial Pilot License – Airplane
PPR	Private Pilot – Airplane category
PN	Part Number
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
RS	Safety Recommendation
SAIB	Special Airworthiness Information Bulletin
SDOW	ICAO Location Designator - Ourilândia do Norte Aerodrome - PA
SN	Serial Number
TPX	Aircraft Registration Category of Non-Regular Public Air Transport
UTC	Universal Time Coordinated

1. FACTUAL INFORMATION.

Aircraft	Model: EMB-721C Registration: PT-EPD Manufacturer: NEIVA	Operator: PEMA - Pereira Machado Air Taxi LTD.
Occurrence	Date/time: 30AUG2015 – Undetermined Hour Location: Outside the Aerodrome Lat. 07°22'05"S Long. 052°22'14"W Municipality – State: São Félix do Xingu – PA	Type(s): [SCF-PP] System/Component Failure or Malfunction Powerplant Subtype(s): Engine Failure in-Flight

1.1 History of the flight.

The aircraft took off from the Ourilândia do Norte Aerodrome (SDOW) - PA, to the Kendjan Village, at 1750 (UTC), in order to transport personnel, with a pilot and a passenger on board.

During the flight, engine #2 cylinder came loose, causing oil leakage and engine failure.

The aircraft was reported missing on 30AUG2015, as it did not reach its destination.

The wreckage of the plane was located on 01SEPT2015, at 86 NM from SDOW. It had bumped into trees in a dense jungle area.

The aircraft had substantial damage. The two occupants perished at the site.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft had substantial damage to the wings, fuselage and engine.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown	Pilot
Total	2.500:00
Total in the last 30 days	35:00
Total in the last 24 hours	00:40
In this type of aircraft	450:00
In this type in the last 30 days	22:12
In this type in the last 24 hours	00:40

N.B.: The data related to the flown hours were obtained through the records provided by the airline.

1.5.2 Personnel training.

The pilot took the PPR course at the Porto Nacional Aeroclub – TO, in 2010.

1.5.3 Category of licenses and validity of certificates.

The pilot had the PCM License and had valid MNTE and IFRA Ratings.

1.5.4 Qualification and flight experience.

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

1.5.5 Validity of medical certificate.

The pilot had valid CMA.

1.6 Aircraft information.

The aircraft, serial number 721103, was manufactured by the Neiva Aviation Industry, in 1977, and was registered at the TPX category.

The aircraft had valid Airworthiness Certificate (CA).

The airframe, engine and propeller logbook records were updated.

The last inspection of the aircraft, the "1.000 hours" type, was performed on 17APR2014 by the maintenance organization *Águia Aviação e Manutenção* Ltd., in Goiânia - GO, having flown 467 hours and 30 minutes after the inspection.

The last revision of the propeller was performed on 27JAN2015 by the maintenance organization GYN Prop Shop Ltd., in Goiânia - GO, having flown 244 hours and 20 minutes after the revision.

The propeller, manufactured by Hartzell, model HC-C3YR-1RF, was installed according to the Supplementary Type Certificate nº 2007S08-11.

The last revision of the engine, the "General Overhaul" type was performed on 26JAN2015 by the maintenance organization Global Parts Engines and Aeronautical Accessories, in Goiania - GO, having flown 244 hours and 20 minutes after the overhaul.

1.7 Meteorological information.

Nil.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

The occurrence took place outside the Aerodrome.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The aircraft crashed into large trees in a jungle area.

The wings were ripped apart from the fuselage at the root. They were found about 5 meters behind the fuselage. The wreckage was concentrated in the direction of the aircraft displacement, approximately at the 085° head.

The landing gear was retracted at the time of impact.

The propeller blades had characteristics of impact without power.

The fuselage was tilted 90° to the left. The aircraft nose had a deformation to the left (Figure 1). The windshield was torn off at the final impact.



Figure 1 - Final position of the fuselage.

There were no marks of the fuselage displacement on the ground.

The pilot and the passenger were found strapped to their seats by their seat belts.

The aircraft carried large quantities of groceries in the rear seats. That cargo moved forward during the collision and was concentrated at the front of the cabin.

The upper fairing of the engine detached from the aircraft and had a fracture on the left front part, area that covered cylinder # 2 (Figure 2).



Figure 2 - Top fairing of the engine.

Cylinder No. 2 was displaced from its position. There was a fracture at the top of the engine (Crankcase Assembly, according to Lycoming Aircraft Parts Catalog), near the upper stud bolts of cylinder # 2 (Figure 3). The piston rod of this cylinder was fractured on the head and was found detached from the crankshaft.



Figure 3 - Block of the engine fractured at the base of cylinder # 2 and head of the fractured connecting rod.

The fuselage and vertical stabilizer of the aircraft were covered by drained engine oil.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

Not investigated.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

Nil.

1.14 Fire.

No signs of either inflight or post-impact fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

During the initial action of investigation, the following aspects were observed:

- the connecting rod of cylinder # 2 has detached from the crankshaft;
- #2 cylinder has come loose from the engine's Crankcase Assembly;
- there was a rupture of the Part Number (PN) 38-13 and 50-15 bolts, as well as of the bolts of fixing of cylinder # 2, PN 76220; and
- the upper cylinder bolts #2 and a section of the Crankcase Assembly were not located at the accident site.

Visual analysis of the connecting rod indicated pounding and fracture marks due to overload.

The piston was attached to the cylinder and it was not possible to remove it manually.

The visual analysis of cylinder #2 indicated mirror marks on its skirt, below the fixation flange, as can be seen in Figure 4.

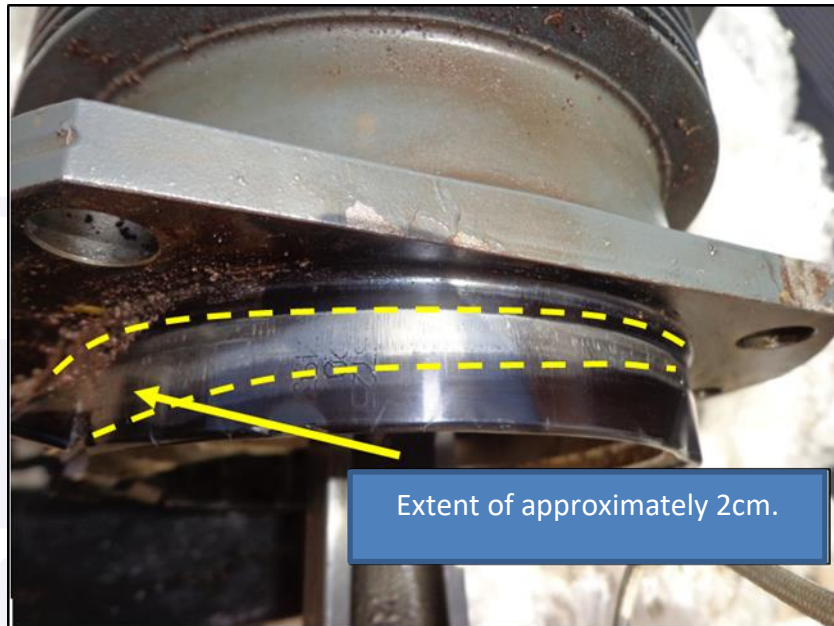


Figure 4 - Mirror markings on cylinder skirt #2.

The mirror marks, shown in Figure 4, indicated that the cylinder worked loose for a certain period, prior to the total release of all bolts.

These marks also suggested that the fracture process was initiated by the 0.5 inch, PN 50-15, front studs shown in Figure 5, as they formed an arc between the passing bolts, as shown in Figure 6.

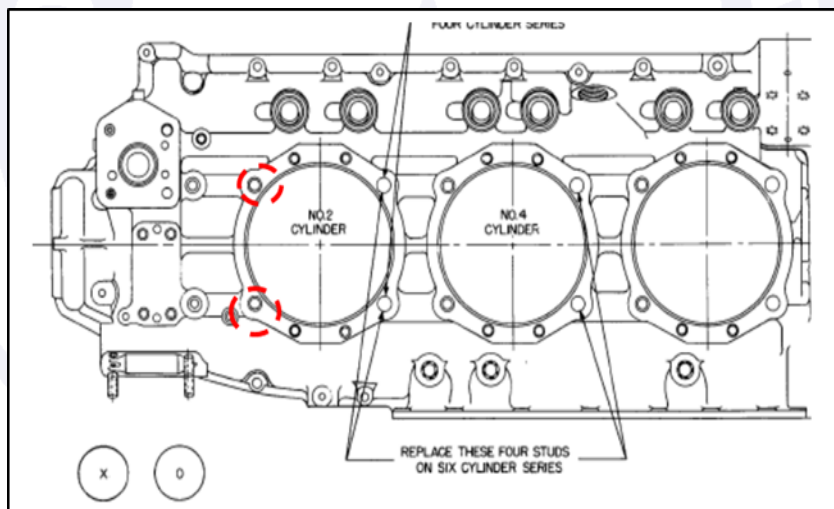


Figure 5 - 1/2" stud bolts.

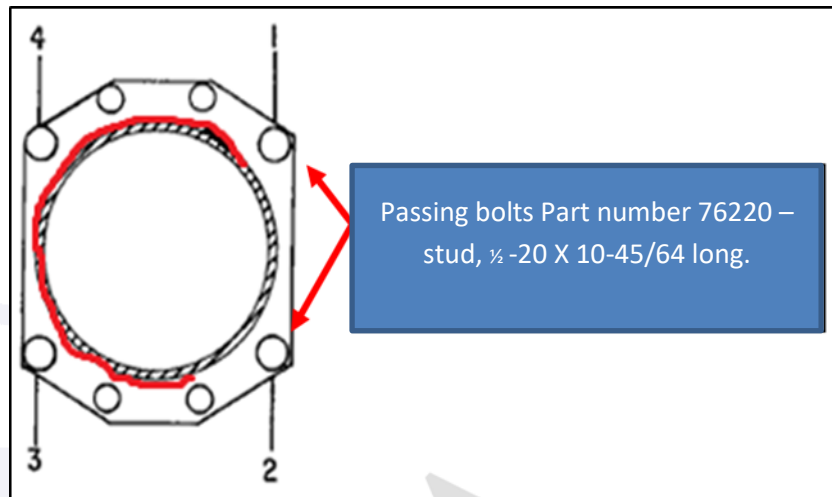


Figure 6 - Illustration of the area where the mirror marks were found in the cylinder skirt #2.

The cylinder #2 was sent to the DCTA's IAE.

According to the technical report drawn up by the IAE, the marks on the cylinder skirt, below the fixing flange, were in fact an indication that it worked loose on its fixing base.

It was not possible to identify the fault mechanism that caused the fractures in the stud bolts and passing ones.

The connecting rod fracture was considered a consequence of the cylinder having worked loose and misaligned.

Analysis of engine maintenance documentation indicated that the Crankcase Assembly PN 11F20022-D3, installed in the latest revision, was not the one for the Lycoming engine model IO-540-K1G5D. This component was suitable for Lycoming TIO, LTIO-540 and series engines (turbocharged engines).

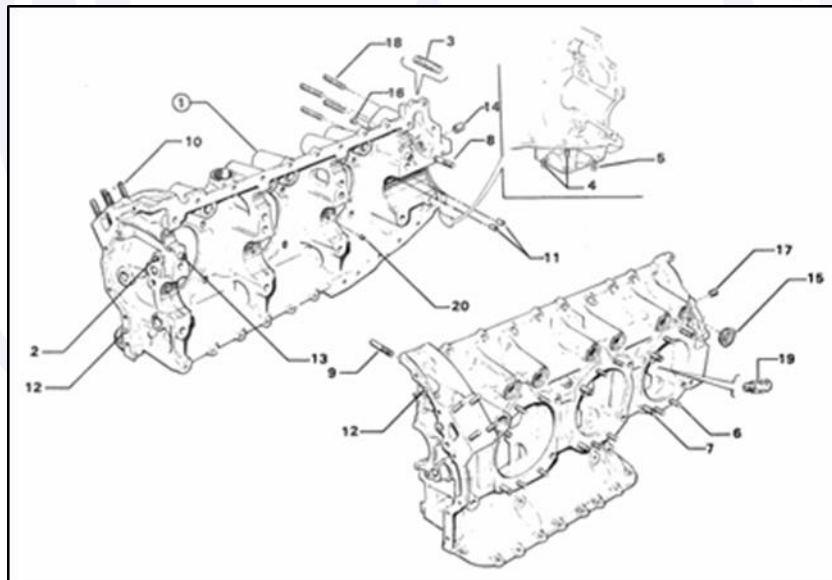


Figure 7 - Image of the Crankcase Assembly TIO, LTIO-540 Series extracted from Parts Catalog.

The Part Number of the Crankcase Assembly planned for the Lycoming IO-540-K1G5D engine would be the 11F24020-D1-S.

The process through which this modification was authorized and implemented was not presented to Investigators.

According to the owner of the aircraft, this item was used. Its source and maintenance history could not be traced.

According to available records, it was subjected to a non-destructive penetrant test in December 2014 and considered approved for return to service.

That component was delivered to the maintenance organization responsible for the engine overhaul already with the 0.5 inch, PN 50-15 stud bolts installed.

The torque wrenches used in the engine overhaul were calibrated at the time of the service execution.

1.17 Organizational and management information.

PEMA Air Taxi started its activities in July 2001. Its first Air Transport Company Approval Certificate (CHETA) was issued in 2003.

The company's base was in the Municipal Airport of Ourilândia do Norte - PA. It was authorized to carry passengers, cargo and aeromedical, on demand.

The fleet consisted of six aircraft of several models, two of which were identical to the crashed model.

The company had a total of nine pilots. Its in-flight proficiency assessments were conducted by the Operations Director, who was an accredited examiner of the National Civil Aviation Agency (ANAC).

The injured pilot had no other function in the company.

PEMA also had authorization to conduct inspections up to the "50 hour" level on its aircraft. The other services were carried out by maintenance organizations certified by the regulatory agency.

1.18 Operational information.

According to information collected, the flight was intended to transport a passenger and cargo from SDOW to Kendjan Village - PA, returning to the original Aerodrome.

The distance between the Municipal Aerodrome of Ourilândia do Norte and Kendjan Village was of 150 NM.

The Kendjan Village runway was not approved / registered.

The aircraft was fuelled to carry out the round trips.

According to the company's operating specifications, the crashed aircraft was not authorized to carry cargo.

It was not possible to determine whether the aircraft was within the limits of weight and center of gravity (CG) specified by the manufacturer, since the cargo manifest was not presented to Investigators.

1.19 Additional information.

On 24MAR2014, the Federal Aviation Administration (FAA) issued the Special Airworthiness Information Bulletin - SAIB (Special Airworthiness Information Bulletin) number NE-14-13, alerting owners, operators and Lycoming engine maintainers about the possibility of failure of the passing bolts and stud bolts fixing cylinder.

According to this document, the FAA had received reports from the aviation authority of another country identifying failures in mounting bolts of the Lycoming engine cylinders, due to the absence of a cadmium-shielding bath.

One of these reports concerned a No.2 cylinder that separated from the Crankcase Assembly after the mounting bolts failed. Laboratory analyzes determined that one of the four stud bolts had a high-cycle fatigue fracture.

This fracture started from a single point, corresponding to a corrosion pit at the base of the thread. There was no evidence of cadmium coating where the corrosion pit developed.

In a survey of the National Transportation Safety Board (NTSB) databases, there were records of seven bolt failures in Lycoming engines and two in Continental engines, from January 2000 to June 2013.

These failures were attributed to bolt fatigue, caused predominantly by insufficient torque and / or inadequate installation. Corrosion resistance was not mentioned as a cause of failure.

One report stated that three #3 cylinder stud bolts were fractured due to fatigue. In addition, the fracture of the various stud bolts by fatigue resulted in cylinder clearance.

Some maintainers reported having seen flaws in the prisoners, but they did not point to corrosion as the cause of the problem.

There was a questioning to eleven North American maintainers about their experiences with cylinder bolts and the instructions for revision contained in the Lycoming manual. Everyone agreed that they were adequate. Even so, SAIB NE-14-13 included the following recommendations:

- "1. Inspect stud bolts and cylinder bolts for corrosion and lack of cadmium bath.
2. Follow the cylinder installation instructions in the Lycoming revision manual or the Lycoming Service Instruction No. 1029D (already included in the engine revision manual).
3. Use Lycoming special tools, or its equivalent, to tighten the cylinder nuts.
4. When using the special keys to tighten the cylinder nuts, make sure that the keys do not come into contact with the cylinder or other parts of the engine. Contact of the wrench may result in a correct torque indication by the torque wrench, although the effective torque applied to the nut and the fixation force are less than necessary.
6. When accessible, inspect the main bearing surfaces for frictional wear. Lycoming reported that no friction wear is allowed."

It should be noted that the recommendations of the SAIB were not mandatory and no Airworthiness Directive (DA) had been issued related to this matter.

Likewise, the Australian Civil Aviation Safety Authority (CASA) issued an Airworthiness Bulletin AWB No. 85-015 on 19APR2013, alerting about failures in Crankcases, in the region of bolts of cylinders, caused by welding repairs.

The search for related occurrences of engine failure in flight, due to the breakage of stud bolts and / or passing ones, investigated in Brazil, returned the following data:

Matricula	Data	Localidade
PT-GNV	20FEV2013	Guapiaçu/SP
PT-UDH	23JAN2012	Tasso Fragoso/MA
PT-GXV	04AGO2008	Boca da Mata/AL

Figure 8 - Search for related occurrences.

The Brazilian Aeronautical Certification Regulation (RBHA) nº 91, Amendment 91-12, of 30DEC2005, that dealt with the General Rules of Operation for Civil Aircraft, established, in section 91.102, letter (d):

"91.102 - GENERAL RULES

[...]

(d) Except as provided in paragraph 91.325 of this regulation, no person may use an Aerodrome unless it is registered and approved for the type of aircraft involved and for the proposed operation.

[...]

The same RBHA No. 91 also established, in section 91.403:

"91.403 - GENERAL

[...]

(b) No person may perform maintenance, preventive maintenance, repairs or modifications other than as set forth in this subpart and other applicable regulations, including RBHA 43.

[...] "

The Brazilian Civil Aviation Regulation (RBAC) No. 43, in section 43.9, dealt with the content, form and layout of maintenance, preventive maintenance, reconstruction and alteration records:

"(a) Annotations in the maintenance record. Each person performing maintenance, preventive maintenance, rebuilding, or altering an item shall, except as provided in paragraphs (b) and (c) of this section, make a note in the maintenance record of that equipment with the following content:

- (1) a description (or reference to data acceptable to ANAC) of the work performed;
- (2) the completion date of the service performed;
- (3) the name of the person who performed the service, if that person is different from the person specified in paragraph (a) (4) of this section; and
- (4) the signature and license number of the person who approved it, if the service was satisfactorily completed in the article. The signature constitutes approval for return to the service only as to the service performed. (Redaction given by Resolution No. 348 of December 2, 2014)

[...] "

Supplementary Instruction (IS) nº 43.9-002A, of 26 APR2012, which dealt with the use and fulfillment of the Certificate of Authorized Release (Airworthiness Approval Label), foresee:

"[...]

5.2.2 Use of the label

5.2.2.1 In order to comply with the requirements of section 43.9 of RBAC 43, the Authorized Release Certificate - Form F-100-01 (Airworthiness Approval Label), the model of which is included in Appendix A of this IS, shall be used as a means of compliance with the primary maintenance record, aiming at the approval for the return to service of aircraft engines, propellers and articles after maintenance, preventive maintenance, reconditioning, modification or repair.

[...] "

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a passenger and cargo transport flight, which originated in SDOW and was destined for the not certified / registered runway of Kendjan Village, located in the municipality of São Félix do Xingu - PA.

The distribution of the wreckage in a linear way at the 085° head, which was the opposite head of the intended course, indicated that the pilot could be attempting to return to the base. The area where the accident occurred was covered by dense jungle vegetation and there was not a nearby place that would allow a safely forced landing.

The proximity of the fuselage to the point of the first impact indicated that the aircraft had a strong deceleration when colliding with the trees and reached the ground with low horizontal speed.

Based on the absence of marks on the ventral part of the fuselage and the deformation of the nose to the left, it was concluded that the aircraft collided with the ground with a 90° tilt to the left and remained in that position.

The cargo, which was transported inside the passenger cabin, moved during impact and was concentrated at the front of the cabin.

Cylinder #2 dislocated from its position, the piston rod of that cylinder fractured and disconnected from the crankshaft, a fracture at the top of the crankcase assembly, as well as the fuselage and vertical stabilizer covered by oil, indicated that there was a large leak during the flight, which led to the conclusion that a catastrophic engine failure occurred before the first impact.

Damage to the upper fairing of the engine was probably caused by the detachment of parts of the Crankcase Assembly, and / or the cylinder, and / or the connecting rod.

The inability to analyze some components, such as the stud bolts that were lost after the collision, prevented the precise determination of the causes of this collapse.

One of the hypotheses is that the stud bolts of cylinder # 2 have fractured and allowed it to move, causing the piston to work misaligned. The mirroring marks on the cylinder skirt, which indicated that it had moved repeatedly out of the intended position, corroborated this thesis.

According to the information contained in SAIB NE-14-13, issued by the FAA, the fatigue failure of the stud bolts could have two possible causes:

- insufficient torque and / or improper installation; or
- corrosion of the stud bolts.

Since the maintenance organization responsible for the engine overhaul received the Crankcase Assembly with the 0.5-inch stud bolts already installed, it was not possible to assess the quality of the services performed at that facility.

In addition, the absence of these bolts made it impossible to verify the existence of an ongoing corrosion process.

Nevertheless, it is possible that the maintenance personnel responsible for assembling the cylinder have applied inadequate parameters and / or procedures, which would characterize the maintenance of the aircraft as a contributing factor to the occurrence.

In the same way, if there was a corrosion process in progress in these bolts, its non-detection would point, again, failures related to the maintenance process of the aircraft.

In this perspective, either by the execution of inadequate procedures, or by failures in the detection of unsafe conditions, these hypotheses signaled the possibility that, in that

context, there were no effective organizational processes to identify and correct flaws that could compromise flight safety.

Another possibility is that the release of the stud bolts has been caused by a break in the Crankcase Assembly of the engine in the region where they were attached.

This possibility was raised based on the reports of occurrences of failures, triggered in welding repairs in the region of fixation of these bolts, in Lycoming and Continental engines, objects of AWB nº 85-015, of CASA.

Although the records available showed that the Crankcase Assembly was subjected to a non-destructive penetrating test in December 2014, and considered approved for return to service, since it was not possible to trace the origin and maintenance history of the component, the verification of the performance of this kind of repair has become impractical.

On the other hand, it is also possible that a failure of the studs or a fracture in the crankcase has occurred as a consequence of the installation of an item not prevised for that engine.

The Part Number of the Crankcase Assembly planned for the Lycoming IO-540-K1G5D engine was the 11F24020-D1-S, and the one found was part number 11F20022-D3, suitable for installation on TIO / LTIO-540 engines and series (turbocharged engines).

That being considered, this was a change to the approved type design for the engine, classified as a major modification, for both the engine and the aircraft. Such modification required approval by the civil aviation authority of the country responsible for the registration of the aircraft, in this case the National Civil Aviation Agency (ANAC).

RBHA No. 91, in its section 91.403 (b), also defined the need to comply with RBAC No. 43 when performing maintenance, preventive maintenance, repairs and modifications.

The primary maintenance registry for maintenance, preventive maintenance, reconditioning, modification or repair, as provided for in RBAC No. 43, should be carried out in accordance with provided for in IS 43.9-002A, using the form SEGVOO 003.

Since the process by which this modification was authorized and implemented was not presented to the Investigators, it was considered that it constituted a violation of the regulations mentioned in the previous paragraphs.

In this way, the installation of a Crankcase Assembly incompatible with the engine of the airplane characterized an inadequacy of the performed maintenance services, which may have contributed to the accident.

In addition, the fact that this misplaced installation was not identified, recorded and corrected denoted a failure in management oversight by the maintenance organization that reviewed the engine, which may have contributed to the occurrence in question.

3. CONCLUSIONS.

3.1 Facts.

- a) the pilot had valid Aeronautical Medical Certificate (CMA);
- b) the pilot had valid MNTE and IFRA Ratings;
- c) the pilot was qualified and had experience in that kind of flight;
- d) the aircraft had valid Airworthiness Certificate (CA);
- e) it was not possible to determine if the aircraft was within the limits of weight and balance;

- f) the airframe, engines and propeller logbook records were updated;
- g) weather conditions were favorable for the flight;
- h) the aircraft has taken off for a not approved / registered runway;
- i) the aircraft was not authorized to carry cargo;
- j) the aircraft crashed into trees and had its wings ripped from the fuselage;
- k) there were oil marks on the fuselage and vertical stabilizer;
- l) during the initial action, cylinder #2 was found to be loose from the Crankcase Assembly;
- m) there were mirror marks on the cylinder skirt, below the attachment flange, indicating that it has repeatedly worked out of position;
- n) the upper stud bolts of cylinder #2 were not found, as well as their securing section in the Crankcase Assembly;
- o) the Crankcase Assembly installed on the airplane had a Part Number different from that provided in the engine manufacturer's maintenance manuals;
- p) this modification constituted a violation of the relevant requirements of RBHA 91 and RBAC 43;
- q) the aircraft had substantial damage; and
- r) the pilot and passenger perished at the site of the accident.

3.2 Contributing factors.

- Aircraft maintenance – undetermined.

It is possible that the maintenance personnel, responsible for assembling cylinder #2 have applied inadequate parameters and / or procedures, which would characterize aircraft maintenance as a contributing factor to the occurrence.

Likewise, if there was a corrosion process going on in these bolts, its non-detection would again point out to the participation of maintenance personnel in the accident.

In addition, the installation of a Crankcase Assembly, incompatible with the airplane engine, characterized an inadequate service performed by the maintenance personnel that probably contributed to the accident.

- Organizational processes – undetermined.

It is possible that the existing organizational processes have not been sufficiently effective to allow the identification of conditions that could compromise flight safety, which may have affected the quality of the maintenance services and favored the occurrence of the accident.

- Managerial oversight – undetermined.

It is possible that a failure of the studs or a fracture in the Crankcase has occurred as a result of the installation of a Crankcase Assembly not indicated for the engine that equipped the airplane.

The fact that this misplaced installation was not identified, recorded and corrected denoted a managerial oversight failure by the maintenance organization that reviewed the engine, which may have contributed to the occurrence in question.

In this case, the application of an unforeseen component to the crashed aircraft would denote a failure of management oversight by the maintenance organization that reviewed the engine.

- **Other - Violation – undetermined.**

The installation of a Crankcase Assembly that is incompatible with the engine of the airplane, without the process by which such modification would have been authorized and implemented, characterized a violation of the regulations mentioned in the previous paragraphs and could thus have contributed to the occurrence.

4. SAFETY RECOMMENDATION.

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

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

Recommendations issued at the publication of this report:

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

A-120/CENIPA/2015 - 01

Issued on 04/08/2019

Act together with PEMA - Pereira Machado Air Taxi LTD., in order that those operators improve their administrative and operational mechanisms of reception, book keeping and verification of the maintenance services performed on their aircraft, as a way to prevent aeronautical occurrences.

A-120/CENIPA/2015 - 02

Issued on 04/08/2019

Act together with PEMA - Pereira Machado Air Taxi LTD., in order to alert the operator about the risks arising from operating on uncertified or unregistered runways, which, in addition to violating Art. 30 of the Brazilian Aeronautical Code, brings serious safety risks.

A-120/CENIPA/2015 - 03

Issued on 04/08/2019

Act in conjunction with ICON G (formerly Global Parts Aeronautical Engines and Accessories - COM N ° 0703-01 / ANAC), in order to that organization demonstrate it possesses and applies all the resources necessary for the adequate provision of maintenance services on the EMB- 721C, in accordance with the legislation in force, the applicable technical manuals and the Company Capabilities List.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On April 08th, 2019.