COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG - 191/CENIPA/2018

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PR-AQZ**
MODEL:	**ATR-72-212A**
DATE:	**23DEC2018**

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 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 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. 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 23DEC2018 serious incident with the ATR-72-212A model, registration PR-AQZ. The serious incident was classified as “[F-NI] Fire/Smoke (Non-Impact) – Smoke in the Cockpit”.

The aircraft took off from the Guararapes - Gilberto Freyre Aerodrome (SBRF), Recife - PE, to the Zumbi dos Palmares Aerodrome (SBMO), Maceió - AL, to conduct a passenger transport flight.

As the crew descended to their destination, they identified noise and sparks in the rack behind the copilot, with the presence of smoke. The crew declared emergency and performed the checklist procedures. The landing occurred normally and the disembarkation was made at the designated parking position.

Damage has been restricted to the static inverter.

The crew and passengers were not injured.

An Accredited Representative of the National Transportation Safety Board (NTSB) - USA, (State that provided facilitations for the investigation) was designated for participation in the investigation.

An Accredited Representative of the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) - France, (State where the aircraft was designed and manufactured) was designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AC	Alternating Current
ACW	Alternating Current and Variable Frequency
ANAC	Brazil's National Civil Aviation Agency
APP	Approach Control
APP-MO	Maceió Approach Control
BTC	Bus Tie Contactor
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile
CA	Airworthiness Certificate
CB	Circuit Breaker
CENIPA	Aeronautical Accident Investigation and Prevention Center
CIV	Pilot's Flight Logbook
CMA	Aeronautical Medical Certificate
CVR	Cockpit Voice Recorder
DC	Direct Current
FDR	Flight Data Recorder
IFRA	Instrument Flight Rating - Airplane
METAR	Aviation Routine Weather Report
MLTE	Airplane Multi Engine Land Rating
PCM	Commercial Pilot License – Airplane
PLA	Airline Pilot License – Airplane
PN	Part Number
PPR	Private Pilot License – Airplane
QRH	Quick Reference Handbook
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
SIGMET	Significant Meteorological Information
SIGWX	Significant Weather
SIPAER	Aeronautical Accident Investigation and Prevention System
S/N	Serial Number
TPR	Aircraft Registration Category of Regular Public Transport
TRU	Transformer Rectifier Unit
UTC	Universal Time Coordinated
VHF	Very High Frequency
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

1. FACTUAL INFORMATION.

Aircraft	**Model:** ATR-72-212A **Registration:** PR-AQZ **Manufacturer:** Aerospatiale and Alenia	**Operator:** Azul Linhas Aéreas Brasileiras S.A
Occurrence	**Date/time:** 23DEC2018 - 0223 UTC **Location:** Out of the Aerodrome **Lat.** 09°31'02"S **Long.** 035°47'01"W **Municipality – State:** Route	**Type(s):** [F-NI] Fire/Smoke (Non-Impact) **Subtype(s):** Smoke in the Cockpit

1.1 History of the flight.

The aircraft took off from the Guararapes-Gilberto Freyre Aerodrome (SBRF), Recife - PE, to the Zumbi dos Palmares Aerodrome (SBMO), Maceió - AL, to conduct a passenger transport flight, with four crewmembers and 48 passengers on board.

During the descent to SBMO, the crew identified noise and sparks in the rack behind the copilot, with the presence of smoke.

The cabin chief informed the commander that the smoke was intense. The crew put the oxygen masks and declared emergency (MAYDAY) to the air traffic control.

The crew performed the checklist procedures and proceeded for landing at the destination Aerodrome.

The landing occurred normally and the disembarkation was made at the designated parking position.

The aircraft had minor damage.

All the occupants left unharmed.

Figure 1 - Aircraft after parking.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	4	48	-

1.3 Damage to the aircraft.

The aircraft had minor damage. Damage was restricted to static inverter.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	Pilot	Copilot
Total	3,003:44	1,865:32
Total in the last 30 days	52:00	64:00
Total in the last 24 hours	02:00	02:00
In this type of aircraft	1,622:29	1,131:20
In this type in the last 30 days	52:00	64:00
In this type in the last 24 hours	02:00	02:00

N.B.: The data related to the flown hours were obtained through the CIV records.

1.5.2 Personnel training.

The pilot took the PPR course at the Jundiaí Aerodrome – SP, in 2007.

The copilot took the PPR course at the São José do Rio Preto Aerodrome – SP, in 2007.

1.5.3 Category of licenses and validity of certificates.

The pilot had the PLA License and had valid AT47 aircraft type (which included the ATR-72-212A model) and IFRA Ratings.

The copilot had the PCM License and had valid AT47 aircraft type and IFRA Ratings.

1.5.4 Qualification and flight experience.

The pilots were qualified and had experience in the kind of flight.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 1241, was manufactured by Aerospatiale and Alenia, in 2015 and it was registered in the TPR category.

The aircraft had valid Airworthiness Certificate (CA).

The aircraft maintenance records were updated.

In the ATR72 model aircraft, power generation was provided by the main battery, emergency battery, two starter generators (DC) driven by the aircraft engines, two voltage generators (ACW) and two external power sources (AC and DC).

Additionally, two static inverters, which were powered by the DC system, provided alternating electrical power (AC) at constant frequency.

The aircraft ACW electrical system could also supply the DC system through a TRU.

The electrical distribution was made through bars that fed the equipment.

Two separate buses, left and right, operated individually and could be connected in the event of a power failure through connectors called Bus Tie Contactors (BTC).

The static inverters had 500 VA of power, 115 V ±4 V and 26 V ±1 V of output voltage, 400 Hz ±5 Hz frequency and were single phase.

Both inverters were powered respectively by DC BUS 1 and DC BUS 2 bars.

Inverter #1 normally supplied the AC bus to which it was connected (AC BUS 1) and the standby bus (AC STBY BUS).

Inverter #2, under normal conditions, supplied the AC bus to which it was connected (AC BUS 2).

In the event of a inverter failure or power failure, the associated AC bus was isolated from the affected inverter and AC BUS 1 and 2 were connected to the running inverter. In the event of inverter #1 failure, AC STBY BUS would be automatically powered by inverter #2.

The inverters were identical and what make them distinct was just the position in which they were installed on the aircraft, position #1 or #2. From then on, they were understood as Inverter 1 and Inverter 2, Static Inverter 1 and Static Inverter 2.

The inverter was manufactured by AVIONIC INSTRUMENTS LLC and was designated by model 1G500-1A-2573 and Part Number (PN) 1-002-0102-2573.

The failed unit had the Serial Number KC000885 and was applied to the PR-AQZ aircraft at position #1.

The installation took place on 19DEC2018 and was removed on 23DEC2018, due to the failure that originated the event in question.

1.7 Meteorological information.

The weather conditions were favorable for the visual flight.

The METAR of SBMO brought the following information:

METAR SBMO 240200Z 07005KT 9999 SCT020 BKN070 25/22 Q1014=

METAR SBMO 240300Z 06004KT 9999 SCT020 SCT070 25/22 Q1014=

Conditions were found to be favorable for the visual flight, with visibility above 10km and few clouds at 2,000ft. The wind had intensity between 04 and 05kt.

1.8 Aids to navigation.

Nil.

1.9 Communications.

According to the transcripts of the communication audios between the PR-AQZ and the ATC, it was found that the crew maintained radio contact with the Maceió Approach Control (APP-MO) and that there was no technical abnormality of the communication equipment during the flight.

1.10 Aerodrome information.

The aircraft landed on SBMO with smoke on board.

The Aerodrome was public, ran by INFRAERO and operated under VFR and IFR, day and night.

The runway was made of asphalt, with thresholds 12/30, dimensions of 2,602m x 45m, with elevation of 387 ft.

1.11 Flight recorders.

The aircraft was equipped with a digital FDR L-3, FA2100 FDR Model (Solid State Memory), PN 2100-4045-00, S/N 879367, with a capacity of 1024 words (each word has 12 bits), thus reading 1024 x 12 every 1 second (words per second).

In addition, it was also equipped with a CVR L-3, FA2100 CVR Model (solid-state memory), PN 2100-1020-02, S/N 1013249, with two hours recording capacity, having 4 channels of 2 hours of High Quality audio.

Both flight data and cabin voice recorders registered the occurrence data.

1.12 Wreckage and impact information.

There was no impact.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

No evidence was found that problems of physiological nature could have affected the flight crew performance.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The commander had been in aviation for eight years. As reported, throughout his career, he had not experienced this kind of emergency in flight.

According to the information obtained, the crewmembers were on standby service and had been called to take over that flight. In addition to the commander, the copilot, two flight attendants and 48 passengers were on the aircraft.

As reported, the aircraft took off normally, presenting the problem after approximately thirty minutes of flight.

The commander reported that he heard a noise in the cockpit and, looking back, observed a light for a moment, which he described as sparks in the aircraft. A moment later, he noticed a strong smell of smoke that made him suspect the possibility of a short circuit. According to the flight attendants' report, it was also possible to smell a strong smoke in the passenger cabin.

At this point, both flight attendants were in the rear galley of the aircraft and were alert to identify a possible fire signal. They also began checking the aircraft by verifying the restrooms and luggage compartments.

Facing this situation, they made contact with the pilots. The commander reported that the aircraft had a short circuit in the cockpit and requested them to be alert and await landing directions.

The commander also made contact with the control tower, informing that there was a problem with the aircraft and what procedures he would adopt to make the landing. As reported, it was not necessary to make an emergency landing.

According to the information obtained, there was no automatic activation of the oxygen masks for the passengers. However, the pilots used the masks available in the cockpit.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

The KC000885 S/N inverter, which was installed on the aircraft in position #1, was removed from the aircraft and transported to a manufacturer's own overhaul and service center.

The CENIPA technicians took part in the partial disassembly, of the internal examination and component analysis. The work was performed by the AVIONIC INSTRUMENTS LLC technicians and accompanied by the BEA Accredited Representative.

Representatives of the aircraft manufacturer AEROSPATIALE AND ALENIA followed up on all procedures and provided additional information.

The inverter was partially disassembled according to the sequence established in its respective production protocol and the components were tested and analyzed as they were accessed.

Figure 2 - Static Inverter immediately after the opening of the enclosure.

Non-destructive X-ray tests were performed on the capacitors, C602, C603, C604, C605, C311 and the printed circuit board (EMI PCB) itself, where the C60x series capacitors were installed. For comparison, X-ray was also performed on a new C311 capacitor.

Capacitor C601 was excessively damaged and it was not possible to test it by X-ray, nor to verify the other functional characteristics. No physical damage was found on the other tested capacitors or on the board.

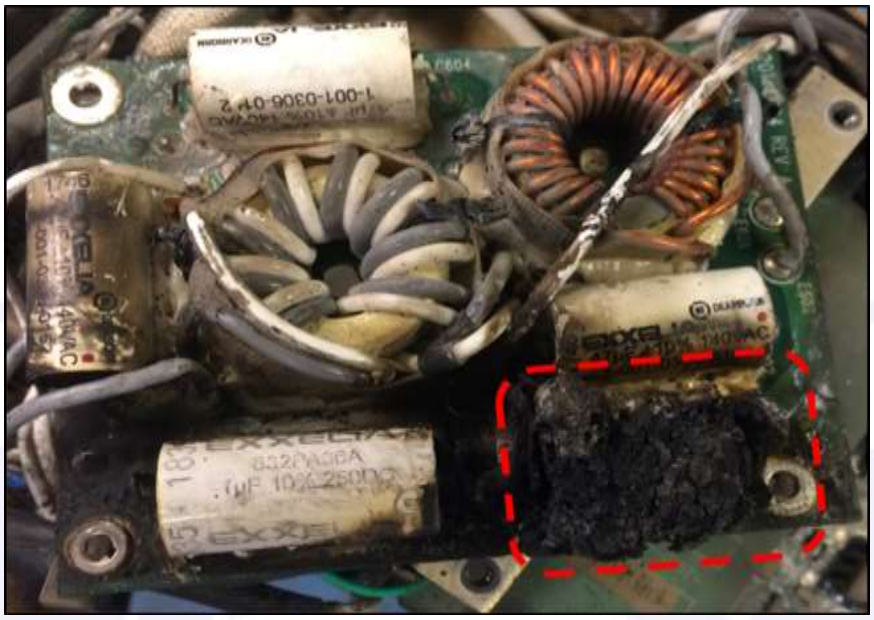

Figure 3 - Detail printed circuit board for severely damaged capacitor C601.

Capacitors C602, C603, C604, C605, C311 and the board have been tested for their operating characteristics and evidence of failure could not be identified.

It was found that the component that gave rise to the sparking reported by the pilots and the smoke that took over the cockpit was the capacitor C601 that was installed on a printed circuit board of the referred inverter.

An overheating occurred which resulted in the capacitor partially melting followed by the production of large amounts of smoke.

No signals were found at the input and output voltage terminals of the inverter that could compromise the connection pins that could indicate excess of voltage or current.

It was not possible to identify what was the present factor that led to overheating and subsequent capacitor melting.

1.17 Organizational and management information.

Nil.

1.18 Operational information.

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

The cruise flight was conducted at level 160 (FL160) and, after beginning the descent to the destination aerodrome, while crossing the FL125, the crew identified noise and sparks from the electrical cabinet behind the copilot.

After the noises and sparks, a large amount of smoke entered the cockpit, as reported by the pilots.

Flight attendants reported that there was also smoke in the passengers' cabin and that they were able to keep the people on board the aircraft calm.

The only alarm that was present during the event was that of SMOKE.

The cockpit crewmembers wore masks and, in the face of heavy smoke, proceeded to perform the emergency procedures prevised in the QRH. Actions performed according to flight recorder data are highlighted in green, as shown in Figure 4.

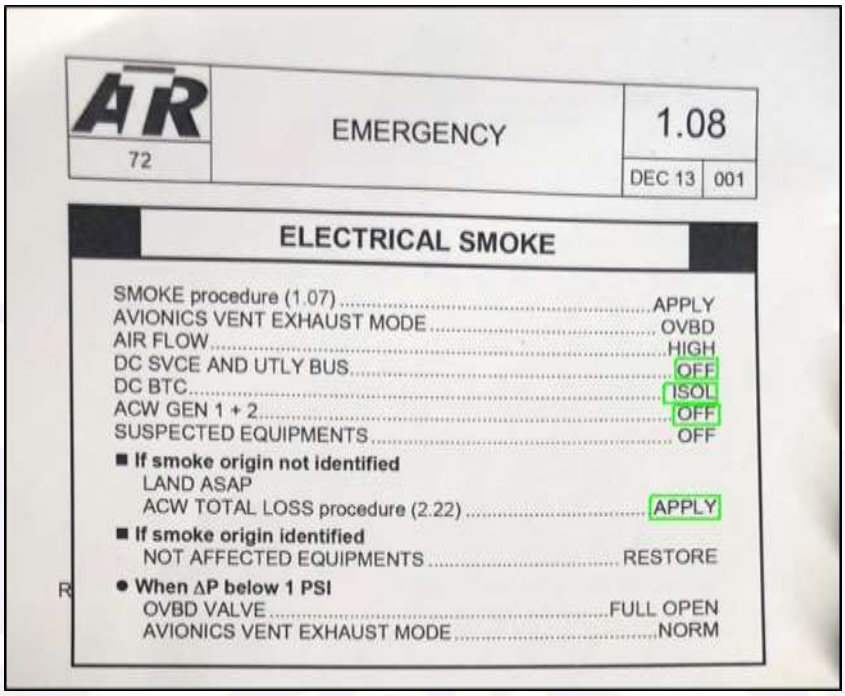

Figure 4 - QRH emergency procedures for ELECTRICAL SMOKE.

Facing the emergency when crossing FL125, the crewmembers accelerated their descent and declared MAYDAY. The aircraft was single approach traffic in SBMO, approaching with priority.

At 0223 (UTC), the SMOKE alarm was activated. From the beginning of the emergency until landing, the flight time was of ten minutes.

The crew reported that there was no loss of any aircraft system. They also found that no Circuit Breaker (CB) had disarmed.

On the aircraft electric synoptic page, the crew identified the message INVERTER FAULT.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a 48-passengers transport flight between SBRF and SBMO. The crew was on standby service and was called to accomplish this step.

Takeoff, climb and leveling procedures occurred without any abnormality, and at the beginning of the descent, the crew noticed a noise and sparks in the rack behind the copilot, followed by the presence of smoke.

According to reports, the smoke was intense and consequently increased the workload of all crewmembers. Such a situation could have been worse considering that the crew had not previously experienced it.

Nevertheless, the crew performed the procedures recommended for emergency.

They used oxygen masks, increased the rate of descent, declared emergency, fulfilled the tasks described in the aircraft QRH and went to the nearest airfield, which coincidentally was the destination's.

Since it was only traffic to SBMO, the control had no difficulty to prioritize the approach of the aircraft that was in emergency.

During the descent, even after the presence of smoke in the passenger cabin, the flight attendants were able to keep the passengers inside the aircraft calm.

The landing was accomplished without additional problems and the disembarkation was made at the position designated for parking.

During the research and the searches for the smoke source, which took the cabin, it was observed that the damage was restricted to the inverter installed in the #1 position.

This finding corroborated the information observed in the electrical synoptic page of the aircraft in which the crew identified the message INVERTER FAULT.

Considering the evidence, the inverter was partially dismantled, according to the sequence established in its respective production protocol and it was found that the C601 capacitor, which was installed on a printed circuit board of the inverter #1 was the component that gave rise to sparks and smoke reported by the pilots.

The capacitor state (Figure 3) allowed deducting that there was an overheating, with partial melting, followed by the large amount of smoke production.

Capacitors failures, with more emphasis on those involving overheating, are usually due to high currents and voltages.

Considering the tests performed, the data found during the #1 inverter disassembly and interactions with representatives of design and manufacturing sectors, it was considered that the possible cause of the C601 capacitor failure was related to the absorption of a transient high current.

Despite the examinations, tests and research carried out in the #1 inverter, it was not possible to identify what might have caused the transient current.

The identified scenario would have caused overheating enough to degrade the existing dielectric layers within the C601 capacitor structure.

Transient absorption could be related to an excessive level of the Equivalent Series Resistance (ESR) characteristic of the referred capacitor or the high level of transient current, or a combination of these two phenomena.

Due to the event characteristics, a possible understanding is that the failure was related to the capacitor specification, with the quality of its production to meet the specifications, or with other transients occurring in the inverter (planned or not) resulting from the combination of other characteristics (known or unknown) of the other elements that set the inverter.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilots had valid AT47 aircraft type (which included the ATR-72-212A model) and IFRA Ratings;

c) the pilots were qualified and had experience in the kind of flight;

d) the aircraft had valid Airworthiness Certificate (CA);

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

f) the aircraft maintenance records were updated;

g) the weather conditions were favorable for the visual flight;

h) during the decent procedure, smoke appeared in the cockpit and in the passengers' cabin;

i) the crewmembers wore oxygen masks;

j) the crew performed the tasks recommended in the QRH;

k) it was identified that capacitor C601 was the source of smoke in the cabin;

l) the aircraft had minor damage; and

m) the occupants of the aircraft left unharmed.

3.2 Contributing factors.

- **Manufacturing – undetermined.**

It is possible that the overheating and subsequent melting of capacitor C601 was related to the quality of the material or processes used in its production, in order to meet the design specifications, or related to the printed circuit board installation procedure on the inverter.

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):

IG-191/CENIPA/2018 - 01 **Issued on 29/05/2020**

Act together with the inverter manufacturer AVIONIC INSTRUMENTS LLC, and the aircraft manufacturer AEROSPATIALE AND ALENIA to check for other occurrences of the same nature, in order to improve the quality of the static inverter, 1G500-1A-2573 model.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

Due to the possibility that the failed C601 capacitor is from a batch of material with the date code of 1835 which may have out of range ESR characteristics, Original Equipment Manufacturer (OEM) took the following corrective action:

A square wave test have been implemented to the test protocol to help ensure capacitor robustness. A retrofit campaign has been launched for all units equipped with capacitor from this batch.

On May 29th, 2020.