COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG-544/CENIPA/2015

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PR-OAF**
MODEL:	**F28MK0100**
DATE:	**21JAN2012**

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 item 3.1, 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 21 January 2012 serious incident involving the F28MK0100 aircraft, registration PR-OAF. The incident was classified as “in-flight fire”.

The aircraft took off from SBBR, and while passing FL200 in the climb to the cruise level, fire started in its windshield heating system.

The crew fought the fire and returned to SBBR, where the aircraft made a safe emergency landing.

The aircraft sustained light damage, restricted to the right hand side part of the windshield and windshield heating system.

None of the crewmembers and passengers was injured.

An accredited representative of the Dutch Safety Board (DSB) - Netherlands, State of design, was designated for participation in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AC	Advisory Circular
ACC-BR	Brasília Area Control Center
ANAC	Brazil's National Civil Aviation Agency
AOM	Aircraft Operating Manual
APP	Approach/Departure Control
APU	Auxiliary Power Unit
ATS	Air Traffic Services
CB	Circuit Breaker
CENIPA	Aeronautical Accident Investigation and Prevention Center
CVR	Cockpit Voice Recorder
DCTA	Aerospace Science and Technology Department
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
FL	Flight Level
FMS	Flight Management System
MFDS	Multi Function Display System
NDB	Non-Directional Beacon
NTSB	National Transportation Safety Board
PCM	Commercial Pilot (airplane category)
PLA	Airline Transport Pilot
PMD	Maximum Take-Off Weight
PN	Part Number
PPR	Private Pilot (airplane category)
QRH	Quick Reference Handbook
RAB	Brazilian Aeronautical Registry
SBBR	ICAO location designator - Brasília Airport
SBJP	ICAO location designator - João Pessoa Airport
SN	Serial Number
SOP	Standard Operating Procedures
TPR	Aircraft registration category - Regular Public Air Services
TWY	Taxiway
UTC	Universal Time Coordinated
V_{MO}	Maximum Operating Speed

1. FACTUAL INFORMATION.

Aircraft	**Model:** F28MK0100 **Registration:** PR-OAF **Manufacturer:** FOKKER	**Operator:** Avianca - *Oceanair Linhas Aéreas S.A*
Occurrence	**Date/time:** 21JAN2012 / 14:50 UTC **Location:** SBBR **Lat.** 15º52'09"S **Long.** 047º55'15"W **Municipality – State:** Brasília - DF	**Type(s):** In-flight Fire

1.1 History of the flight.

At 14:30 UTC, the aircraft took off from Brasilia International Airport (SBBR) on a passenger transport flight destined for Castro Pinto Airport (SBJP) in the municipality of João Pessoa, State of Paraíba. 5 crewmembers and 91 passengers were aboard the aircraft.

As the aircraft was climbing and passing flight level 200 (FL200), fire and thick smoke coming from the WINDOW HEAT2 were observed in the cockpit.

The crew donned oxygen masks and smoke-goggles right away, performed the pertinent prescribed procedures, declared emergency due to fire and smoke on board, and requested from ATC a heading for returning to SBBR.

Brasília Center cleared the aircraft to descend and return to SBBR. Meanwhile, the copilot managed to successfully extinguish the fire. The aircraft made a safe landing on the runway 29R of SBBR.

There was minor damage to the aircraft in the cockpit.

Neither the crewmembers nor the passengers were injured.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	5	91	-

1.3 Damage to the aircraft.

The right windshield and the windshield heating system were slightly damaged.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown		
	Pilot	Copilot
Total	6,000:00	720:00
Total in the last 30 days	52:00	59:00
Total in the last 24 hours	08:30	08:30
In this type of aircraft	2,825:00	85:00
In this type in the last 30 days	52:00	59:00
In this type in the last 24 hours	08:30	08:30

N.B.: Data provided by the company.

1.5.2 Professional formation.

The aircraft captain took his Commercial Pilot course (airplane category) at the COMAIR Aviation Flight in 1988.

The copilot took the Private Pilot course (airplane category) at the Maricá Flying School in 1999, and the Commercial Pilot course (airplane category) at the TAM Training Division also in 1999.

1.5.3 Category of licenses and validity of certificates.

The captain held an Airline Transport Pilot license, and valid rating for MK28 aircraft, as well as a valid airplane IFR-rating.

The copilot held a Commercial Pilot license (airplane category), and valid rating for MK28 aircraft, as well as a valid airplane IFR-rating.

1.5.4 Qualification and flight experience.

The captain had an Enroute-Instructor qualification, and his experience in Fokker 100 aircraft at the time of the event had reached a total of 2,825 hours.

The copilot was qualified, and, up to the time of the event, had gathered a total of 85 flight-hours in the type of flight and equipment. He had been acquiring en-route experience in the aircraft for a little more than one month, in accordance with the company's training program.

His previous experience was based on small aircraft, and he had worked as flight instructor in the São José dos Campos flying school.

Both the captain's and the copilot's simulator training was up-to-date.

1.5.5 Validity of medical certificate.

Both pilots had valid Aeronautical Medical Certificates.

1.6 Aircraft information.

The serial number 11415 aircraft was manufactured by *Fokker in* 1992, and had been registered in the Regular Public Air Transport (TPR).

The aircraft airworthiness certificate was valid.

The aircraft was compliant with the prescribed inspections, and its airframe and engine logbook records were up-to-date.

The last comprehensive inspection ("Check C" type) was done at the *Aerovias del Continente Americano* workshop in *Eldorado de Bogotá*, *Colombia*, on 19 April 2010. It flew 1,925 hours after the inspection, in a total of 40,800 hours of flight.

The aforementioned workshop was certified by the ANAC for this type of service.

The aircraft was within the prescribed weight and balance limits.

The PN D20543-406 SN 0970 windshield involved in the occurrence had been installed in the aircraft by the Avianca workshop of SBSP on 18 September 2009.

The PN AE5751MK1, SN 0970, transformer involved in the occurrence had been installed in the aircraft by the Avianca workshop of SBSP on 16 November 2011.

Window Heat System

The Window Heat system of the Fokker 100 aircraft was normally activated at the preparation of the flight deck, more specifically at the conduction of the *Clear to Start* checklist.

The chapter relative to System Operation - Ice and Rain Protection - Window Heat of the Fokker 100 Aircraft Operation Manual (AOM) reads:

> The flight deck front windows and sliding windows are electrically heated. Two independent systems automatically control the window heat to the required temperature for anti-icing, demisting and increased impact resistance. Each system has two operating channels. One channel provides temperature control and monitoring for a front window, the second channel controls the adjacent sliding window. Heating of the left and right windows can be individually switched off and on via the controls at the WINDOW HEAT panel. In the event of a front window malfunction the respective channel is automatically de-activated and an alert is presented. Failure of the sliding window heating is indicated on the maintenance test panel only.

The Fokker 100 Maintenance Training Manual (ATA 30) - Icing and Rain Protection - reads:

> The windshields and sliding windows are electrically heated. Each window has a conductive coating on the inner side of its outer pane, which is the heating element. Heating of windows is necessary:
>
> - to increase their impact resistance;
> - to make their service life longer.
>
> Left and right heating systems are the same. When the heating system are switched on, heating of the windshields and sliding windows occurs fully automatic; that is when the temperature of a windshield or sliding window is less than 38ºC (100ºF), the heating is ON, more than 42ºC (107ºF) the heating is OFF. So the temperature operates round 40ºC. When the systems are switched on, the heating of the windshields occurs at reduced power during the first 10 minutes of operation. This is to prevent damage of the windshields because of quick temperature increase.

The Figure 1 shows the basic functioning of the Window Heat system, the controls of which are accessed on the right side of the upper panel. The functioning of the system, after the activation by means of a push-button, is fully automatic, without interference from the pilot after the conduction of the Clear to Start Checklist procedures.

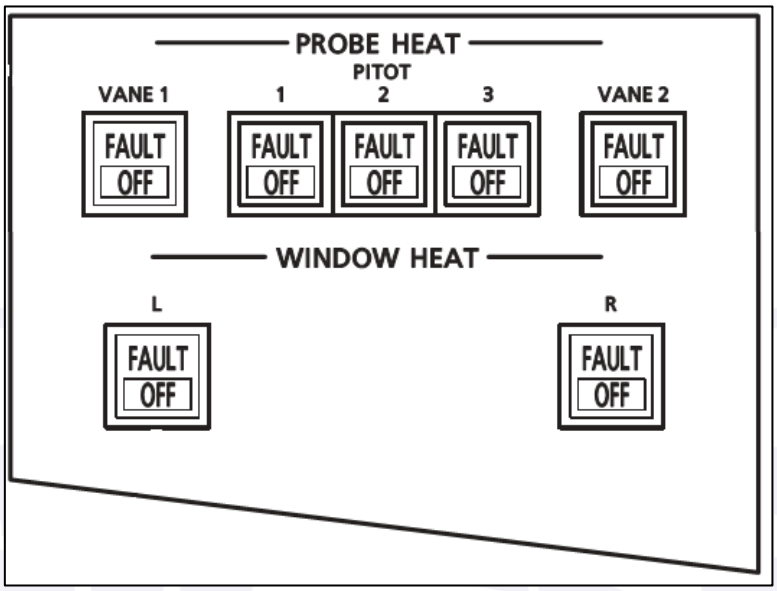


Figure 1 - *Window Heat Panel.*

Thus, in case of system malfunctioning, the respective control channel would be automatically de-activated, in accordance with the system description contained in the Fokker 100 AOM.

1.7 Meteorological information.

Nil.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Communications proceeded uneventfully until the beginning of the emergency, and then became troublesome, with the pilots having difficulty understanding each other and ATC after wearing their oxygen masks.

It was also observed that the pilots' workload was highly increased by requests of information made by the ATC agency, which asked, for example, the aircraft endurance, while the pilots were busy with the emergency.

1.10 Aerodrome information.

Nil.

1.11 Flight recorders.

The data contained in the *Flight Data Recorder (FDR)* and *Cockpit Voice Recorder (CVR)* was successfully read out at the laboratory of the CENIPA (Aeronautical Accident Investigation and Prevention Center).

1.12 Wreckage and impact information.

There was no impact. The aircraft made a safe landing on runway 29R of SBBR.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

Not investigated.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

Not investigated.

1.14 Fire.

Fire started in the right-hand side windshield, and was effectively extinguished by the copilot.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

The pertinent PR-OAF windshield and its corresponding transformer were sent to the Materials Division of the Aerospace Science and Technology Department (DCTA) for analysis (Figures 2 and 3).

Figure 2 - Right-hand-side windshield.

Figure 3 - Transformer.

Initially, it is worth pointing out that, in addition to the event in question, the problem was observed in three other aircraft, according to a technical report issued by the air company. In the occurrences, a short circuit was observed and, in some cases, formation of smoke.

In the event in question, the terminal presented a burn resulting from short-circuit (Figure 4) The corresponding circuit-breaker did not disarm.

Figure 4 - Windshield: general aspect of the failure.

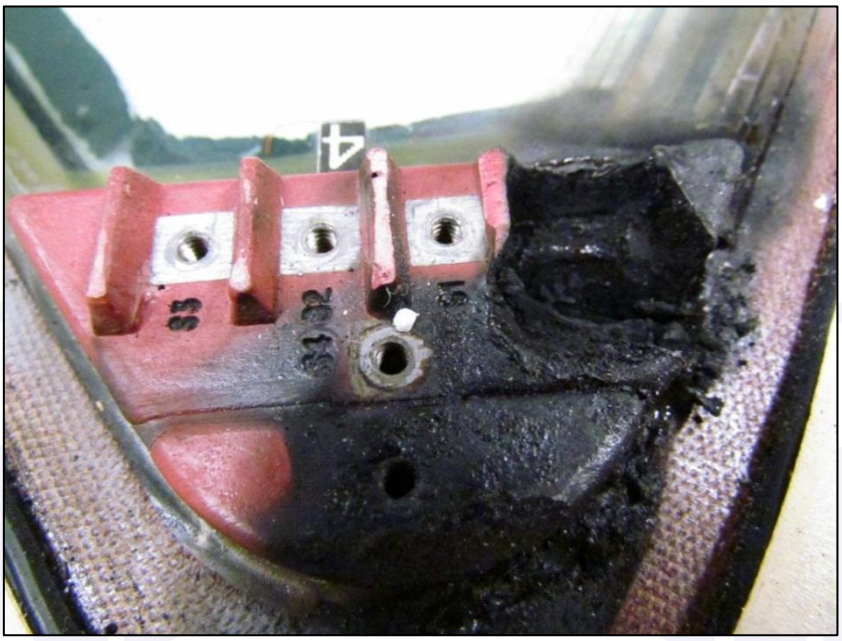


Figure 5 - Detail of the short circuit in the connecting terminals between the windshield and the transformer.

Windshield assembled with misplaced transformer terminals.

While examining the item, the investigators observed that the transformer terminals had been assembled in discordance with the specifications of the manufacturer's manual.

The transformer had eight terminals. These terminals had electric resistances that were different from each other, and the correspondence between the resistance measured in the windshield and in the terminals was determined by means of a table (AMM Task 56-11-00-400-814). According to the *TASK 56-11-00-400-814-A,* page 3, item 6, the values of the resistance varied from 30 Ohms (terminal 1) to 42.75 Ohms (terminal 8). The difference of resistance between the terminals was small. For example, the difference of resistance between the terminal 1 and 2 was 5%, and between the terminals 1 and 8 was approximately 50%.

The misplacement of the terminals 1 and 8 would result in an increment of 55 volts, and this could lead to a short circuit. However, the wrong assembly of the terminals does not explain the long time elapsed before the occurrence of the short circuit, indicating that the wrong assembly had not been a critical factor.

Alteration of the windshield electric resistance.

The manufacturer of the aircraft informed that the electric resistance of the windshield could vary on account of problems in the heating system or degradation of the window (delamination).

The windshield is a laminate which is exposed to severe conditions of operation. The material endures variations of pressure, temperature, humidity, and radiation during the landing and takeoff cycles. These factors may lead to processes of delamination, capable of causing fluctuations in the values of the assembly electric resistance.

There was a recommendation made by the manufacturer stating that, when the resistance of the window fell within the limits of the AMM Task 56-11-00-400-814, its electric terminal should be connected to the corresponding terminal of the transformer, whereas, if the resistance of the window was out of these limits, it had to be replaced.

According to the operator, when a window presented visual signs of delamination, it was immediately replaced with a new one.

Malfunctioning of the Circuit Breaker

The investigation committee identified two other occurrences associated with Window Heat short-circuits prior to the occurrence of the event in question, and another one during the preparation of this report, some of them with the presence of smoke. The report sent by the company's Engineering Department pointed out that the electric terminals of the *window heat* had been installed incorrectly, and made a recommendation for the maintenance sector to conduct an immediate inspection of the windshield electric resistance of the entire Fokker 100 aircraft fleet.

The same report also pointed out that the circuit breaker did not function because it would only disarm if the problem occurred in the window temperature control unit, resulting in an increase of the current in the circuit breaker in question. When the short circuit occurred only at the Terminal 1 of the windshield, the circuit was broken, increasing the windshield resistance, since the connection between Terminal 2 and the Control Unit connector (P4042C, Terminal F) no longer received the signal.

1.17 Organizational and management information.

Nil.

1.18 Operational information.

Both pilots declared that, due to the high temperature in the cockpit, part of the taxiing was made with open windows. The investigating committee verified that such procedure was incompatible with the company's Standard Operating Procedures (SOP).

They also reported having smelled an unusual odor as the aircraft was approaching Taxiway Uniform. Since they were taxiing behind another jet aircraft, the pilots thought that such momentary smell was due to the exhaust gases being emitted by the preceding aircraft.

The pilots proceeded with the taxi uneventfully, and made the takeoff as planned. Soon after the beginning of the takeoff, the recorder shows an action taken by the captain, between the speed of 80kt and V1, for turning off the Auxiliary Power Unit (APU). Such procedure was not included in the company's SOP.

Conversation not related to the operation of the aircraft was recorded between the second segment of the takeoff and the transition altitude, before the AFTER TAKEOFF CHECKLIST compliance, a period that was within the concept of STERILE COCKPIT. The conversation continued until after the aircraft passed FL100, contrary to the prescriptions contained in the company's SOP, Section 1.

The crew made contact with the company when the aircraft was above FL100, as prescribed in the SOP, page 28 - *Communications with the Company*.

At the moment of the failure, the aircraft was on the frequency of Brasilia Control Center (ACC-BR), and had already been cleared to climb to FL330.

As the aircraft was passing FL200 during the climb, fire started in the electric terminal located on the upper right corner of the right windshield. The captain took over the aircraft controls, without using the standard phraseology (I HAVE CONTROL).

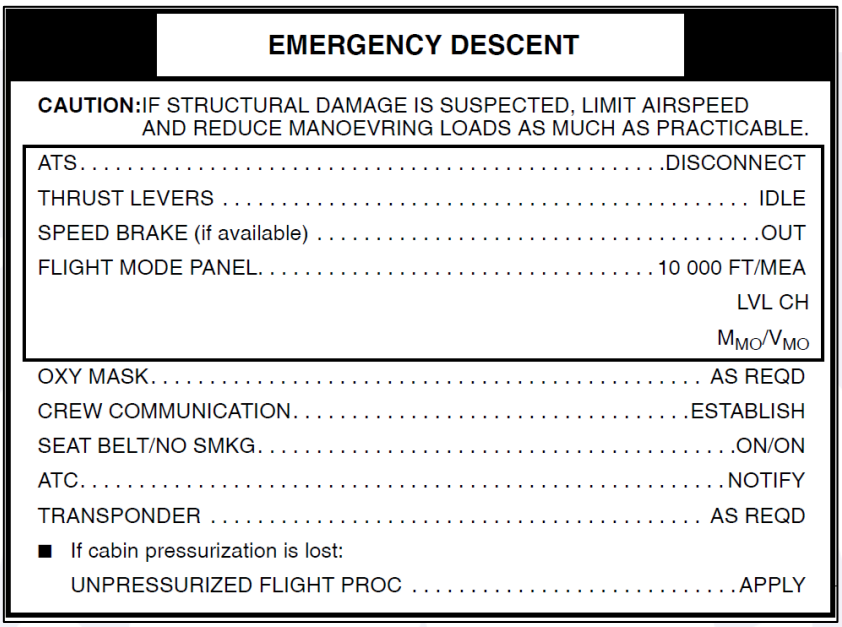
This is the point used as reference in this report for the description of the sequence of events reported below (the time elapsed is marked with an asterisk).

The pilots donned their oxygen masks, and began an emergency descent, with the intention (as identified in their request to ATC) of returning to SBBR. From the data recorded in the FDR, it is possible to clearly verify that the captain disengaged the autopilot upon taking over the aircraft controls, and started a left turn, declaring emergency on the ACC-BR frequency. The crew, however, did not make use of standard phraseology,

that is, the words MAYDAY, MAYDAY, MAYDAY, something that made coordination with ATC difficult at first.

The fact that the pilots were wearing oxygen masks, according to the captain, made it difficult for them to communicate with each other and with ATC. Sometimes, he had to take off his mask in order to be able to speak with the copilot, and he even inhaled some smoke. In addition, the captain reported that it was the first time he wore the mask, since he had not received training for that, not even in the simulator.

The emergency descent procedures were listed in the *Emergency Descent Checklist,* and were described in the *Quick Reference Handbook (5.06, page 1)*, as follows:



EMERGENCY DESCENT

CAUTION: IF STRUCTURAL DAMAGE IS SUSPECTED, LIMIT AIRSPEED AND REDUCE MANOEVRING LOADS AS MUCH AS PRACTICABLE.

ATS	DISCONNECT
THRUST LEVERS	IDLE
SPEED BRAKE (if available)	OUT
FLIGHT MODE PANEL	10 000 FT/MEA LVL CH M_{MO}/V_{MO}
OXY MASK	AS REQD
CREW COMMUNICATION	ESTABLISH
SEAT BELT/NO SMKG	ON/ON
ATC	NOTIFY
TRANSPONDER	AS REQD

■ If cabin pressurization is lost:

UNPRESSURIZED FLIGHT PROC ..... APPLY

Figure 6 - *Quick Reference Handbook.*

In the *Emergency Procedures - Miscellaneous - of the AOM, 3.07.01, Page 2,* the recommendations relative to the *Emergency Descent* were the following:

> *Use of Autopilot is recommended throughout the procedure.*
>
> *Descend to 10.000ft or MEA, whichever is higher.*
>
> *After level-off, retract the speed brake, engage ATS and select the required speed.*
>
> *The oxygen requirements for emergency descent will be met even without the use of speedbrakes.*
>
> *In case of prolonged flight above 10.000ft cabin altitude, consider the use of oxygen for passengers and crew. When using crew oxygen for supplemental purposes select the mask regulators to NORM.*
>
> *The unpressurized flight procedure can be found in chapter Abnormal Procedure, section Air.*

Additionally, the section *Flight Techniques - Abnormal Operation, 7.09.01, page 10* of the AOM contained the following recommendations regarding an *Emergency Descent*:

> *In case of rapid decompression combined with a high flight altitude,* ***apply the procedure for "excessive cabin altitude"*** *(*emphasis added*), as presented at MFDS and subsequently follow the emergency descent procedure as described below. It is recommended to keep the AP engaged throughout the maneuver. If ATS is engaged, depress either AT disconnect button while retarding the thrust levers. Is structural damage is suspected, limit speed and reduce maneuvering loads as much as possible. In case prolonged flight above 10.000 ft. is required, select oxygen mask regulators to NORM. When the oxygen masks are no longer*

> *required, close the doors of the mask compartment and push the reset lever fully down in order to restore radio communication to normal.*

Nonetheless, the *Section 03, page 24* of the company's SOP, stated that the procedure to be applied for the case mentioned above was the one memorized for *"Emergency Descent"*, even if the procedure for *"Excessive Cabin Altitude"* was being presented in the MFDS:

> *In case of rapid decompression combined with a high flight altitude,* ***apply the memorized procedure for "EMERGENCY DESCENT"*** *(*emphasis added*), even if "EXCESSIVE CABIN ALTITUDE" is presented at MFDS. After the memorized procedure described on the next page follow the "EXCESSIVE CABIN ALTITUDE" as presented at MFDS. It is recommended to keep the AP engaged throughout the maneuver. If structural damage is suspected, limit speed by pressing speed hold on FMP and reduce maneuvering loads as much as possible. In case prolonged flight above 10,000 ft. is required, select oxygen mask regulators to NORM. When the oxygen masks are no longer required, close the doors of the mask compartment and push the reset lever fully down in order to restore radio communication to normal.*

At thirty-four seconds*, with the aircraft being flown manually, the Bank Angle alert was activated, an indication that there was excessive banking of the wings (more than 35º)

At forty-one seconds* (seven seconds later), the Bank Angle alert was activated again, due to the high banking of the wings. This Bank Angle alert occurred concomitantly with the sound alert of disengagement of the autopilot, which, up to that moment, was being pressed by the aircraft captain. At forty-nine seconds*, the Bank Angle alert was activated a third time and, similarly, the autopilot disengagement switch was being pressed. It should be noted that the Call-Out prescribed in Section 1, Page 36 of the SOP (Rev 10) was never complied with (it established a maximum 30º-banking condition for the pilot to call out *Bank Angle*).

At fifty-seven seconds*, the chief flight attendant made the first (unsuccessful) attempt to contact the cockpit crew.

Then, the captain made contact with ATC, informing that there was a lot of smoke on board, and requested a heading for an immediate return to SBBR. Concomitantly with this situation, the excessive-speed alert was activated, indicating that the V_{MO} limit was being exceeded. The aircraft was being flown manually, and the investigators observed that no speed call-outs were ever made by the copilot regarding such condition.

In relation to the communications between the aircraft and ATC, it is worth pointing out that there was a delay for the setting aside of an exclusive frequency for dealing with the emergency, since there were other aircraft being controlled on the frequency being used by the ATC unit.

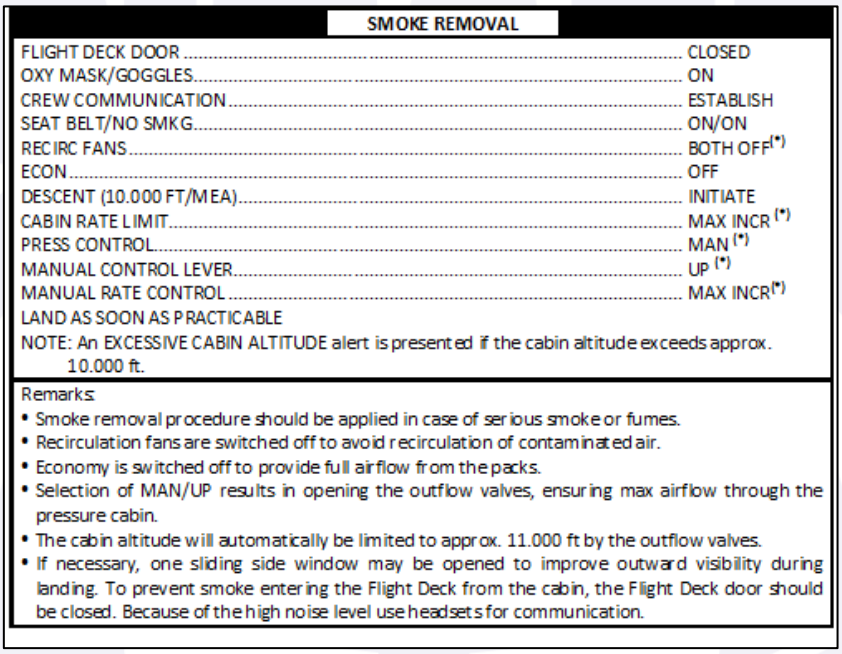
At three minutes and seven seconds*, an alert known as *C-Chord* was activated. This alert was an indication that the aircraft was being flown manually, and that it was 750ft away from the selected altitude (either above or below). In this case, one understands that the aircraft was above the selected altitude because it was descending to FL 150.

As for the action taken by the crew for fighting the fire and smoke on board, it is important to highlight that, in addition to commencing the return-to-aerodrome and emergency descent procedures, the copilot grabbed the fire extinguisher and sprayed chemical powder on the flames coming from the right windshield heat system. His action was effective in extinguishing the flames, but a large amount of smoke remained in the cockpit.

At three minutes and twenty-nine seconds*, ATC cleared the aircraft to descend to FL100. Fifteen seconds later (at three minutes and forty-four seconds*), the copilot announced that the fire had been completely extinguished.

The investigating committee understands that, in accordance with the emergency descent procedures established, an order for the wearing of oxygen masks and smoke-goggles was applicable. The “Fasten Seat Belts” sign was not illuminated. Besides, considering the pilots’ report of the smoke present in the flight deck, the procedures for smoke removal were not carried out.

The procedures established by the manufacturer for *Electrical Smoke, Smoke Removal, Air Conditioning Smoke, Cabin Equipment Smoke, Toilet Smoke e Cargo Compartment Smoke* were the following:



SMOKE REMOVAL

FLIGHT DECK DOOR	CLOSED
OXY MASK/GOGGLES	ON
CREW COMMUNICATION	ESTABLISH
SEAT BELT/NO SMKG	ON/ON
RECIRC FANS	BOTH OFF(*)
ECON	OFF
DESCENT (10.000 FT/MEA)	INITIATE
CABIN RATE LIMIT	MAX INCR (*)
PRESS CONTROL	MAN (*)
MANUAL CONTROL LEVER	UP (*)
MANUAL RATE CONTROL	MAX INCR(*)

LAND AS SOON AS PRACTICABLE

NOTE: An EXCESSIVE CABIN ALTITUDE alert is presented if the cabin altitude exceeds approx. 10.000 ft.

Remarks:

- Smoke removal procedure should be applied in case of serious smoke or fumes.
- Recirculation fans are switched off to avoid recirculation of contaminated air.
- Economy is switched off to provide full airflow from the packs.
- Selection of MAN/UP results in opening the outflow valves, ensuring max airflow through the pressure cabin.
- The cabin altitude will automatically be limited to approx. 11.000 ft by the outflow valves.
- If necessary, one sliding side window may be opened to improve outward visibility during landing. To prevent smoke entering the Flight Deck from the cabin, the Flight Deck door should be closed. Because of the high noise level use headsets for communication.

Figure 7 - Procedures for smoke removal.

At three minutes and forty-eight seconds*, ACC-BR handed over control of the aircraft to Brasilia Approach Control (APP-BR). Four seconds later, a *double chime* alert indicated altitude deviation. After two seconds, the captain acknowledged an ATC instruction for frequency change (at that point, an exclusive frequency had already been assigned for the aircraft in emergency).

While the facts mentioned above were unfolding, the cabin manager (chief flight attendant) attempted four times to make contact with the flight deck but got no answer from the pilots. At four minutes and six seconds from the beginning of the emergency, he finally managed to establish contact and received instructions from the captain.

The flight attendants then started preparation for landing, but failed to deliver the emergency speech to the passengers, in addition to not mentioning the presence of fire and smoke on board. One of the flight attendants later reported that the smell of smoke was noticeable as far as the seventh row of passenger seats.

At six minutes and thirty-one seconds*, the captain reported that the aircraft had reached the altitude of 6,000ft, and was cleared to fly direct to COCHO (NDB), maintaining the altitude of 6,000ft. Forty-three seconds later, the captain requested runway 29 to be inserted in the FMS. The CVR did not record any orders relative to Approach Preparation.

The *SOP* - Revision 10 (in force at the time), had the following instructions concerning the preparation for approaches and landing:

APPROACH PREPARATION (Section 01 - Page 119)

COMPANY POLICY

The approach preparation procedure is mandatory for any type approach regardless of meteorological conditions.

NOTE: Before an approach preparation and briefing is conducted, the PF must transfer control.

The PF must complete the approach preparation procedure as a filter for the subsequent checklist. Crews are encouraged to begin these tasks at least 10 minutes prior to the TOD. This task can best be accomplished when the approach plate is being reviewed. The AP and AT must be engaged and the PF continues to monitor the flight. The tasks are:

Tune and identify all frequencies with the correct bearings selected. Marker volume adjusted if applicable. The VORs and courses should be set for missed approach. The ADFs should be adjusted for basic aid or outer / middle marker, as applicable. Ensure both ADF pointers selected to ON.

Set FPA to -3.0. Set MDA, DA or DH as applicable (each pilot sets own side). The selector should be left in FPA for non-precision and visual approaches, M/DA for CAT I approaches and in DH for CAT II approaches.

The STAR and approach in use should be selected in the FMS. Ensure all waypoints on FLT PLN page coincide with chart / approach clearance.

Enter bearing / distance to point for FAF or intended landing runway in PROG page. After passing FAF, select the landing runway in non-precision approach.

Select landing flaps on the TO/APPR page on FMS. Note weight below limits. Ensure GO AROUND altitude is correct.

NOTE: Prior to starting descent below 10,000ft AGL, a complete briefing for the arrival and the approach should be performed; as well as all non-essential communications with the company.

All the subsequent cockpit procedures were performed without compliance with the standard established by the company. The checks were done in an uncoordinated manner and without following the company's checklist (the captain did not determine execution of the APPROACH PREPARATION and BEFORE LANDING checklists).

The captain made a direct approach to runway 29R, and landed the aircraft. Then, it taxied on its own power to the parking area. Emergency evacuation of the passengers was not necessary.

1.19 Additional information.

Precedents of fire aboard

A study of fifteen fire events between 1967 and 1998 conducted by the Transportation Safety Board of Canada revealed that the average time spent between finding out the fire and landing the aircraft was 17 minutes.

In January 2004, the US Federal Aviation Administration (FAA) issued the Advisory Circular (AC) 120-80 "In-flight Fires", following a study conducted by the National Transportation Safety Board (NTSB) on aircraft accidents and incidents involving fire in flight.

The Circular provided guidance on how to deal with this situation, and emphasized an "immediate and aggressive" response from the crew, aiming at locating the source of the fire and extinguishing it right away. Any fire, no matter how small, may grow out of control if it is not put out quickly. The priority will always be to extinguish the fire.

Adaptation to the use of oxygen masks

According to the reports made by the pilots, on account of the scarce time reserved for simulator training, the instructors did not require their students to wear the masks correctly, and concentrated on the operational procedures, instead.

Wearing the masks would require detailed preparation of the cockpit for the next training session, since masks had to be cleaned and put away. Many times, the utilization of such equipment was just “simulated”.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The investigating committee concentrated efforts on the analysis of the windshield (PN D20543-406, SN 0970) installed on the aircraft on 18 September 2009, and on the transformer (PN AE5751MK1, SN 0970) installed on 16 November 2011.

It is worth pointing out that the aircraft was compliant with all inspections, which had been done in workshops certified by the ANAC.

After analyzing the two items, the DCTA concluded that the terminals of the transformer of the right windshield heating system had been assembled in an erroneous way.

The misplacement of the terminals could generate an increment of 55 volts in the system, and result in overload. However, the erroneous assembly of the terminals does not explain the long period of time elapsed from the day the windshield was installed (18 September 2009) until the occurrence of the short circuit (21 January 2012), indicating that, in itself, the wrongful assembly was not the single cause of the failure.

In consequence, such observation led to the hypothesis that there had been alteration in the electric resistance of the windshield along its period of utilization. The manufacturer of the aircraft informed that the electric resistance of the windshield could vary either due to problems in the heating system or degradation of the windshield (delamination).

Due to the fact that the windshield is a laminate exposed to severe conditions of operation (variations of pressure, temperature, humidity, and radiation during the landing and takeoff cycles), the material may undergo a process of delamination in view of the weathering, something that has the potential to cause fluctuations in the values of the electric resistance of the circuit.

Therefore, there is the possibility that, on account of the time elapsed since the day of the installation, there might have been an increment in the electric resistance of the windshield, and this would explain the long period of time elapsed between the installation of the windshield (18 Sept 2009) and the occurrence of the short circuit (21 Jan 2012).

Thus, it is possible that the uncorrected increment in the resistance of the laminate, together with the wrong assembling of the terminals, may have accelerated the degradation of the windshield, expediting the process of delamination to, finally, cause the short circuit in the heating system.

As for the PR-OAF pilot’s response, it is worth pointing out that the emergency they faced is critical, and that their decision to return to Brasilia was correct, since experience has shown that fire events in the flight deck or in the cabin are probably one of the most serious emergencies, and have to be put under control without delay. Therefore, landing as soon as possible is highly recommendable.

On the other hand, the making of impulsive or uncoordinated decisions has the potential to aggravate a situation, which, in itself, requires special care.

The actions taken after the confirmation of fire on board were not in accordance with the standards prescribed in the manufacturer's manuals and in the company's SOP.

Attention is also drawn to the fact that the pilots were not able to establish two-way communications, to the point that the captain inhaled smoke after taking off his mask for a moment in an effort to talk with the copilot. This fact could have led to *pilot incapacitation*, and aggravate the crisis even further.

Also, by not utilizing the autopilot in critical phases, the captain imposed extra workload on himself. This fact was observed in the various times at which the Bank Angle and Speed alerts were heard, denoting that the pilot's attention was being shared with the tasks of communication, preparation of the aircraft for landing, and troubleshooting.

It was also observed that the pilots were not concerned with the standardizations even before the occurrence of the *Window Heat* failure event. The investigation committee verified that the *Sterile Cockpit* procedure and a number of other standards were not being complied with, such as when the captain switched off the APU between 80 kt and V1.

The investigation committee found out that procedures had different descriptions in two publications addressing the same subject. While the *SOP (Section 3, Page 24)* stated that, in the case of "Rapid Decompression" combined with "Excessive Cabin Altitude", the "Emergency Descent" procedure had to be performed even if the "Excessive Cabin Altitude" appeared in the MFDS, the *Flight Techniques - Abnormal Operation (7.09.01, Page 10)* recommended that in the case aforementioned, the "Excessive Cabin Altitude" procedures was to be performed first, followed by the "Emergency Descent" procedures.

Another important issue refers to the reports made by the pilots, who said that they were not familiarized with the utilization of oxygen masks, and that the masks were not used even in situations trained in the simulators.

Frequently, on account of the scarce time reserved for simulator training, the instructors did not require their students to wear the masks correctly, and concentrated on the operational procedures, instead. Moreover, wearing the masks would require detailed preparation of the cockpit for the next training session, since masks had to be cleaned and put away. Many times, the utilization of such equipment was just "simulated".

The situations described above lead to the belief that more attention should be paid to the training of the crews both on the ground and in simulator sessions. Correct utilization of the masks, more than just "demonstrated", needs to be trained, because it is the best way for a crewmember to become qualified for the operation in the presence of real smoke in the cockpit.

It is also correct to affirm that the use of the autopilot during the emergency descent procedure, the management of the problem, and the maintenance of high situational awareness by the crew would be the best flying technique for the situation.

It is worth pointing out that there was delay in selecting a frequency to be used by the aircraft in emergency, since there were other aircraft in the same sector communicating with the ATC unit on the normal frequency. This may have resulted from the fact that the crew did not inform the nature of the problem in a clear way by means of the prescribed phraseology, and from the very severity of the situation in the cockpit.

The coordination with the cabin crew was also affected, considering that the chief of the flight attendants attempted four times to establish contact with the flight deck without getting any replies. Only after four minutes from the beginning of the emergency did the purser manage to talk with the pilots and receive instructions from the captain.

Such situation corroborates with the conclusion that the in-flight crisis, which began with the Window Heat failure, could have been dealt with better. When communications with the chief flight attendant were postponed, s/he spent four minutes attempting to make contact with the cockpit crew by means of the interphone, disturbing the situation in the flight deck even further.

After being informed of the problem by the captain, the flight attendants started preparation for the landing, but the emergency speech to the passengers was skipped. Neither did they mention the presence of fire and smoke on board. However, smoke could be smelled as far as the seventh roll of seats. All this resulted in strong stress on board and made team coordination difficult, since the passengers did not receive information about what was going on.

The captain made a direct approach to runway 29R, and landed successfully. The aircraft taxied on its own power towards the parking area, and there was no need to make an emergency evacuation of the aircraft.

3. CONCLUSIONS.

3.1 Facts.

a) The pilots held valid aeronautical medical certificates;

b) The pilots held valid type ratings;

c) The pilots' training was up-to-date, including simulator training;

d) The aircraft captain had qualification and experience in the type of flight;

e) The copilot had qualification and was in the process of acquiring enroute flight experience;

f) The aircraft had a valid airworthiness certificate;

g) The aircraft weight and balance parameters were within the prescribed limits;

h) The records of the aircraft airframe and engine logbooks were up-to-date;

i) The aircraft was compliant with all the prescribed maintenance services;

j) The aircraft was to fly a leg from SBBR to SBJP on a regular passenger transport flight;

k) The crew taxied the aircraft toward the SBBR runway 11R threshold with the windows of the flight deck open;

l) As the aircraft was approaching TWY U, both pilots noticed an unusual smell in the flight deck, but then the odor vanished;

m) When the aircraft passed FL200 in the climb, fire started in the electrical terminal located in the right upper corner of the right windshield;

n) The captain took over the aircraft controls, disengaged the autopilot, ordered oxygen masks to be worn, and started an emergency descent;

o) The emergency descent was made with the aircraft being flown manually, contrary to the manufacturer's recommendation;

p) The standard emergency procedures were not complied with;

q) ATC did not select at once an exclusive frequency for use by the aircraft in question;

r) After the oxygen masks were donned, communication between the pilots became difficult, as well as between the pilots and ATC;

s) The captain took off his mask for a moment in order to speak with the copilot, and inhaled a little smoke;

t) The crew were not adequately adapted to the use of oxygen masks

u) Three bank angle alerts and one maximum speed limit (V_{MO}) extrapolation alert went off during the event;

v) The captain became overloaded with the tasks of flying the aircraft in the manual mode, communicating with ATC, and managing the emergency;

w) The copilot made use of the fire extinguisher and applied chemical powder on the flames coming from the right hand side windshield heating system;

x) The flames were completely extinguished as the aircraft was passing FL100;

y) The procedures for removing the smoke from the flight deck were not applied;

z) Contact between the pilots and the purser took place four minutes after the emergency started;

aa) The flight attendants made preparation for the landing, but failed to deliver the emergency speech for the passengers;

bb) The procedures related to the APPROACH PREPARATION and BEFORE LANDING CHECKLIST were neither requested nor conducted accurately;

cc) The captain landed the aircraft on the runway 29R of SBBR;

dd) The DCTA technical report with respect to the windshield (PN D20543-406, SN 0970) and transformer (PN AE5751MK1, SN 0970) confirmed the wrong installation of the transformer of the right hand side windshield heating system;

ee) The aircraft sustained minor damage to the right hand side windshield and respective heating system; and

ff) None of the crew members and passengers was injured.

3.2 Contributing factors.

- **Cockpit coordination - undetermined.**

The inobservance of the procedures required in the SOP regarding a sterile cockpit and the fact that they taxied the aircraft with open windows in the flight deck may have delayed the crew's perception of the windshield heating system problem.

- **Aircraft maintenance - a contributor.**

The inadequate installation of the transformer terminals of the right hand side windshield heating system contributed to the degradation of the safety levels of the aircraft system until the occurrence of a short circuit, which was the source of the fire and smoke in the flight deck.

4. SAFETY RECOMMENDATION.

A measure of preventative/corrective nature issued by a SIPAER Investigation Authority or by a SIPAER-Link within respective area of jurisdiction, aimed at eliminating or mitigating the risk brought about by either a latent condition or an active failure. It results from the investigation of an aeronautical occurrence or from a preventative action, and shall never be used for purposes of blame presumption or apportion of civil, criminal, or administrative liability.

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 National Civil Aviation Agency (ANAC):

IG-544/CENIPA/2015 - 01 Issued on 31/03/2017

Make sure that pilots operating pressurized aircraft are qualified for managing fire/smoke conditions in the flight deck, including correct utilization of oxygen masks.

IG-544/CENIPA/2015 - 02 Issued on 31/03/2017

Take the necessary measures before the operator, in order to assure that all the company pilots faithfully comply with the procedures listed in the company's SOP and aircraft QRH, both in routine and emergency situations.

IG-544/CENIPA/2015 - 03 Issued on 31/03/2017

Take the necessary measures before the operator, in order to assure that all company manuals are duly updated in accordance with the procedures described in the aircraft manufacturer's manuals.

To the Airspace Control Department (DECEA):

IG-544/CENIPA/2015 - 04 Issued on 31/03/2017

Provide guidance to air traffic controllers in relation to the application of CRM concepts, in order to prevent increase of flight crews' workload with requests that are not relevant in a given emergency situation.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

On 10 February 2012, the Avianca Airlines Maintenance Directorate issued the Engineering Order EO F100-56-004, determining conduction of inspection of the entire F28MK0100 fleet of the company, aiming at checking whether the windshield heating system of the aircraft had been correctly installed.

All aircraft were inspected, and the necessary corrective actions established in the aforementioned document were taken.

On, March 31st , 2017.