COMANDO DA AERONÁUTICA

<u>CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS</u>

FINAL REPORT
IG - 062/CENIPA/2018

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PR-GGE**
MODEL:	**737-8EH**
DATE:	**06APR2018**

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 06APR2018 serious incident with the 737-8EH aircraft, registration PR-GGE. The serious incident was classified as "[SCF-NP] System/Component Failure or Malfunction Non-Powerplant / Unintentional/explosive decompression".

Shortly after reaching flight level FL250 (25,000ft), the cabin altitude alert sounded, indicating that the atmospheric pressure inside the aircraft (cockpit and passenger cabin) had reached values compatible with 10,000ft altitude.

The pilots started an emergency descent to the FL100 (10,000ft).

During the descent, the oxygen masks of the passenger cabin fell down automatically.

When reaching 10,000ft of altitude, the situation was normalized and the flight proceeded to the destination at FL090.

The landing was performed without additional abnormalities.

The aircraft had no damage.

All occupants left unharmed.

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

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
APU	Auxiliary Power Unit
B739	Type Rating which included aircraft model 737-8EH
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CMA	Aeronautical Medical Certificate
CTR	Control Zone
FCOM	Flight Crew Operations Manual
FDR	Flight Data Recorder
FL	Flight Level
IFRA	Instrument Flight Rating - Airplane
LABDATA	Flight Data Recorders Read-out and Analysis Laboratory
LOFT	Line Operation Flight Training
MEL	Minimum Equipment List
METAR	Aviation Routine Weather Report
NTSB	National Transportation Safety Board (USA)
PF	Pilot Flying
PLA	Airline Pilot License – Airplane
PM	Pilot Monitoring
PN	Part Number
PPR	Private Pilot License – Airplane
QRH	Quick Reference Handbook
RS	Safety Recommendation
SBCF	ICAO Location Designator - Tancredo Neves International Airport, Confins - MG
SBRJ	ICAO Location Designator – Santos Dumont Aerodrome, Rio de Janeiro - RJ
SN	Serial Number
TPR	Aircraft Registration Category of Regular Public Transport
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
WPS	Words Per Second

1. FACTUAL INFORMATION.

Aircraft	**Model:** 737-8EH **Registration:** PR-GGE **Manufacturer:** Boeing Company	**Operator:** GOL Airlines S.A.
Occurrence	**Date/time:** 06APR2018 - 2240 UTC **Location:** Outside the Aerodrome **Lat.** 22°23'12"S **Long.** 042°54'31"W **Municipality – State:** Teresópolis – RJ	**Type(s):** [SCF-NP] System/Component Failure or Malfunction Non-Powerplant **Subtype(s):** Unintentional/explosive decompression

1.1 History of the flight.

The aircraft took off from the Santos Dumont Aerodrome (SBRJ), Rio de Janeiro - RJ, to the Tancredo Neves International Airport, Confins – MG, at about 2230 (UTC), in order to transport personnel, with 6 crewmembers and 167 passengers on board.

At about 1 minute and 33 seconds after reaching FL250, the cabin altitude alert sounded, indicating that the atmospheric pressure inside the aircraft had reached values compatible with altitudes above 10,000ft.

The crew began the descent to the FL100 (10,000ft), during which the oxygen masks of the passengers' cabin fell down automatically. Upon reaching FL100, the situation was normalized. The crew continued the descent to FL090 and the flight continued on that level up to the destination. The landing occurred on SBCF, with no additional abnormalities.

The aircraft was not damaged.

All occupants left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	6	167	-

1.3 Damage to the aircraft.

Nil.

1.4 Other damage.

Nil.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	Commander	Copilot
Total	9,000:00	10,000:00
Total in the last 30 days	08:55	71:55
Total in the last 24 hours	01:15	01:15
In this type of aircraft	7,740:25	7,795:05
In this type in the last 30 days	08:55	71:55
In this type in the last 24 hours	01:15	01:15

N.B.: The data related to the flown hours were obtained through the Operator. The data related to the total time are approximate and were provided by the pilots.

1.5.2 Personnel training.

The commander took the PPR course at the Muriaé Aeroclub - MG, in 2001.

The copilot took the PPR course at the Paraná Aeroclub - SP, in 2002.

1.5.3 Category of licenses and validity of certificates.

The commander had the PLA License and had valid B739 aircraft type (which included aircraft model 737-8EH) and IFRA Ratings.

The copilot had the PCM License and had valid B739 aircraft type and IFRA Ratings.

1.5.4 Qualification and flight experience.

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

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 35824, was manufactured by the Boeing Company, in 2008 and it was registered in the TPR category, having flown 34,778 hours since its manufacture.

The aircraft had valid Airworthiness Certificate (CA).

The technical maintenance registers were with their records updated.

The last inspection of the aircraft, the "Check A" type, was carried out on 06APR2018 by the GOL Airlines S.A. maintenance organization, in Recife – PE, having flown 8 hours and 20 minutes after the inspection.

The aircraft had two engines located under the wings and an Auxiliary Power Unit (APU) located in the rear (tail) section.

Some aircraft systems and components were duplicated and worked redundantly. For purposes of differentiation between these systems and components, the manufacturer identified those located on the left side of the aircraft with number "1" and those located on the right side with number "2". When a system or component did not have redundancy, it was not identified with a number, for example: engine 1 (left side); engine 2 (right side) and APU (without redundancy).

One of those systems, which provided the conditions for the aircraft to fly at high altitudes, was the pressurization and air-conditioning system.

Cabin pressurization systems have been widely used by commercial aviation airplanes for years and mostly have similar operating logic. Through air bleeding from the engines, valves keep the interior of the aircraft pressurized, providing to the occupants an environment compatible with the human physiology throughout the flight.

However, when the system does not operate properly, the cabin is depressurized. Under these conditions, airplane occupants need to use oxygen masks to avoid problems arising from atmospheric pressure at high altitudes.

In situations of cabin depressurization, the safety procedure to be adopted consists generally of using oxygen masks and performing descent to a safe altitude where the atmospheric pressure values are compatible with the respiratory system of the human being.

After reaching safety altitude, it is possible to complete the flight without the occupants of the aircraft having to use oxygen masks to breathe. Usually this safety altitude is about 10,000ft.

The aircraft was equipped with a pressurization and air conditioning system that had two main objectives:

- keep the air pressure inside the aircraft in values consistent with human physiology, even when the airplane was flying at high altitudes where the atmospheric pressure was too low; and

- keep the ambient temperature comfortable for crew and passengers.

According to the 737 Flight Crew Operations Manual (FCOM), the pressurization and air conditioning system processed air bleeding from engines 1 and 2 and/or APU, through bleed valves called Bleed 1, Bleed 2 and APU Bleed, respectively. The Bleeds regulated the amount of bleeding air, as demanded by other aircraft systems.

The air bleeding from the engines and/or the APU was supplied at high temperature values and therefore needed to be cooled before being used to acclimatize and pressurize the cockpit and passenger cabin. This cooling was accomplished through two air-conditioning valves, each one related to a system, denominated Pack 1 and Pack 2. These Packs sent air inside the aircraft and the temperature was adjusted by the crew, between 18° C and 30° C.

When on the ground, the air conditioning system could also be supplied by an external air source (Ground Air Source), which supplied air directly to the packs. In that case, it was not necessary to bleed the engines or the APU to acclimatize the interior of the aircraft.

The interaction of the pilots with the system was accomplished through a pressurization control panel installed in the upper right part of the Overhead Panel, located in the ceiling of the cockpit. The pressurization control panel had switches for system operation, instruments for monitoring parameters and warning lights for abnormal situations.

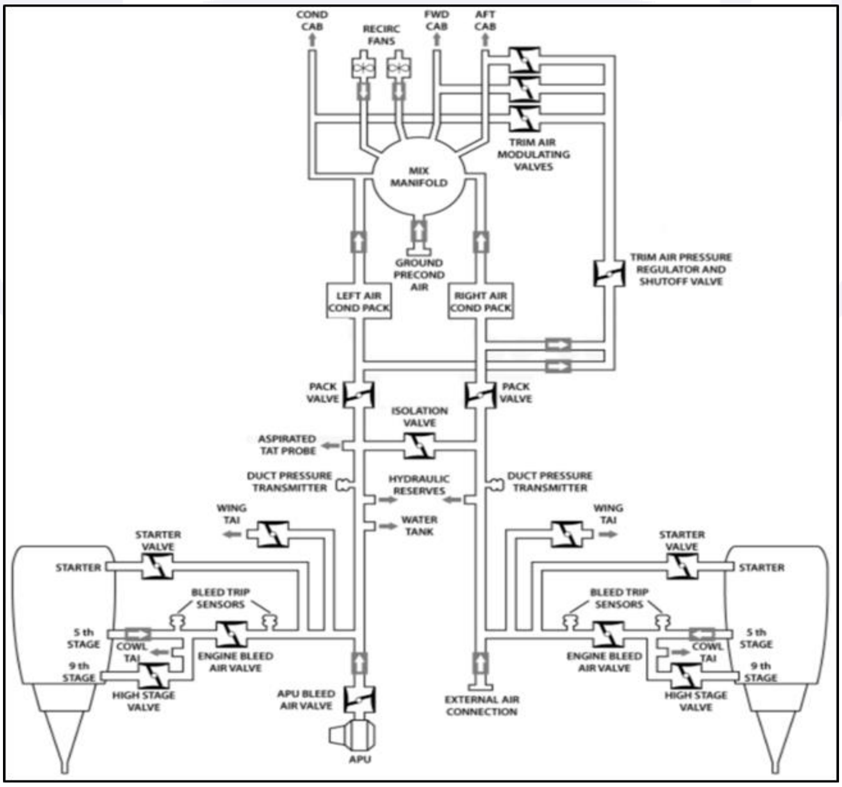

Figure 1 - Diagram of the pressurization and air conditioning system.

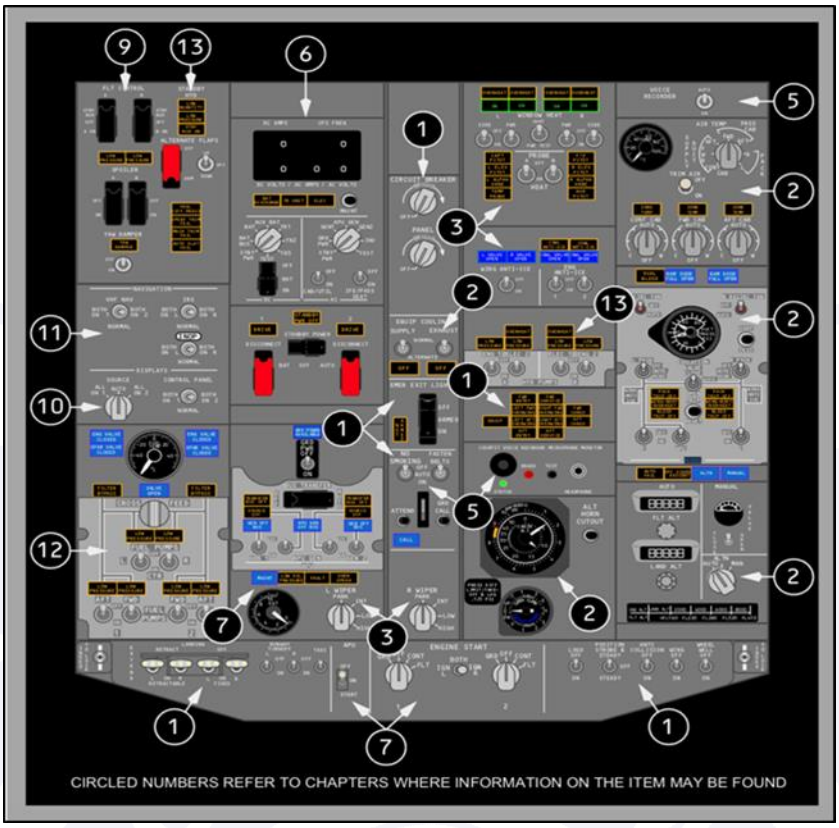

Figure 2 - Overhead Panel. The circles with number 2 indicate controls and indicators related to the pressurization and air conditioning system.

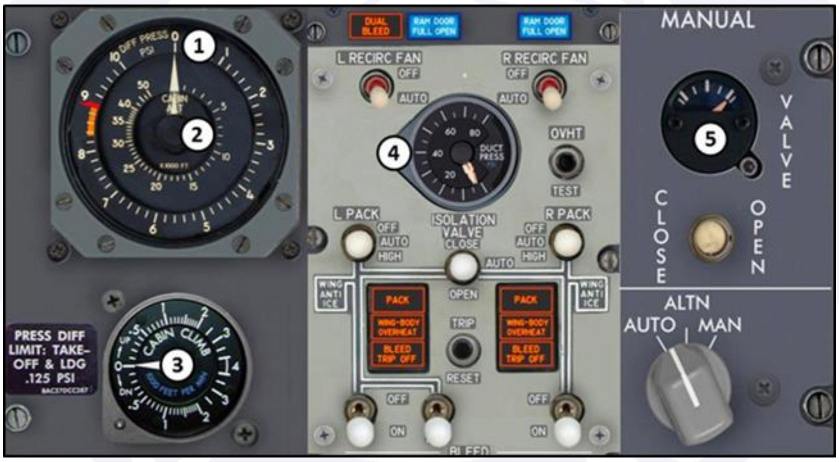

Figure 3 - Overhead Panel cutting with the pressurization and air conditioning system control panel indicators: 1 - pressure differential; 2 - cabin altitude; 3 - ramp up / down ratio; 4 - pressure in the pneumatic ducts; and 5 - Outflow valve position indicator.

Located above and to the left of the pressurization control panel, there was a double gauge that showed the cabin altitude and pressure differential (Figure 3 - instruments 1 and 2). The pressure differential was shown on a scale that considered the atmospheric pressure inside the cabin compared to the atmospheric pressure of the outside air (actual altitude of the aircraft).

Just below this manometer, there was a cabin climb rate gauge (Figure 3 - instrument 3). This instrument measures the variation of the atmospheric pressure inside the cabin, translating this variation in a scale of thousands of ft./min.

There was another pressure gauge indicating the pressure in the system ducts (instrument 4 of Figure 3). This instrument had two pointers identified with the letters "L" and "R" that allowed the monitoring of the pressure in each of the ducts that carried bleeding air to the Packs. If the pressure in one of the ducts was "zero," it would mean that the Pack on that side was not receiving bleeding air from any Bleed.

Above and to the right there was an Outflow valve position indicator (instrument 5 of Figure 3), which allowed to monitor when the valve was open, closed or in an intermediate position.

In the open position, the valve allowed the air inside the cabin to be expelled, depressurizing the aircraft. On the other hand, when the valve closed, it kept the air confined inside the cabin.

These openings and closures occurred automatically when the valve knob (in the lower right corner of Figure 3) was in the AUTO position. When the knob was placed in the MAN position, the Outflow opening and closing control was performed by the pilots using the switch located just below the position indicator.

Each of the Bleeds (engine 1, engine 2 and APU) had an ON / OFF switch. The operating logic for each of the positions was as follows:

- **ON**

- the valve remained open whenever the corresponding engine was in operation; and

- **OFF**

- the valve was closed.

Each of the Packs (1 and 2) had an OFF / AUTO / HIGH switch. The operating logic for each of the positions was as follows:

- **OFF**

- the Pack remained off;

- **AUTO**

- the Pack adjusted the airflow to low whenever both Packs were running;

- the Pack regulated the airflow to high whenever only one Pack was operating, provided that the aircraft was in flight and the flaps were retracted; and

- the Pack regulated the airflow to high when a Pack was being powered by the APU (Bleed from both engines to OFF).

HIGH

- the Pack regulated the airflow to high. When on the ground and powered by the APU in the HIGH position, this Pack provided the maximum airflow.

Between the two Packs switches, there was the Isolation Valve switch with three positions: AUTO; OPEN and CLOSE. The operating logic for each of the positions was as follows:

- **AUTO**

- the valve remained closed if the Bleeds 1 and 2 switches were in the ON position and the switches of both Packs were in AUTO or HIGH; and

- the valve will open automatically if the switch of any Bleed or Pack is in the OFF position.

- **OPEN**

- the valve remained open.

- **CLOSE**

- the valve remained closed.

In normal situations, the pressurization system operated in isolation between the sides, with Bleed 1 providing air bleeding from engine 1 to Pack 1 and, similarly, Bleed 2 supplying air bleeding from engine 2 to Pack 2. The isolation between the two sides was performed through the Isolation Valve.

In normal flight conditions, the Isolation Valve was set to the AUTO position, but under abnormal operating conditions of one of the Bleeds, for example, the Isolation Valve could be set to the OPEN position. In this position, the valve remained open and allowed a cross feed, allowing Bleed 2 to provide air bleeding for Pack 1, or allowing bleed 1 to provide air bleeding to pack 2.

APU Bleed was directly attached to Pack 1 and, via the Isolation Valve, was able to deliver air also for Pack 2, if needed.

According to the operation manuals, each Bleed valve of the engines should only feed one Pack at a time. In return, the APU Bleed could feed the two Packs simultaneously on the ground or a single Pack in flight. The APU Bleed operation was restricted to 17,000ft altitude, according to manuals.

It is important to note that with the Bleed of a certain engine running, this meant the bleeding of air from the high-pressure compressor to supply other systems of the aircraft.

This air bleeding reduced the power generation capacity for the flight. In normal flight situations, this deficit did not represent significant limitations. However, in situations where maximum power was required, such as a short runway take-off or overcoming obstacles in the flight path, such a limitation could be of relative importance.

At the top center of the panel, there was the DUAL BLEED warning, which consisted of a warning light of the pressurization system that was intended to prevent a Pack from being fed by more than one Bleed. This light went on whenever:

- the APU Bleed was in the ON position;

- the Isolation Valve was in OPEN; and

- the Bleed from engine 1 or Bleed from engine 2 is ON.

1.7 Meteorological information.

The weather conditions were favorable for the visual flight.

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.

The aircraft was equipped with a Flight Data Recorder (FDR) model SSFVR, P/N 980-4700-042 and S/N 3642, capable of recording 256 Words Per Second (WPS).

It also had a SSCVR Voice Recorder (CVR), P/N 980-6022-001 and S/N 120-09997, with a recording capacity of two hours.

The data from both recorders were preserved and the content was downloaded at the CENIPA LABDATA.

1.12 Wreckage and impact information.

Nil.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

Not investigated.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The commander had sixteen years of aviation experience and had been in the company for twelve years. He had completed flight simulator training for the last time in July 2017 and Line Operation Flight Training (LOFT) in January 2018. He was returning from a vacation and consequent distancing from the air activity.

Coworkers have described him as a willing, communicative, well liked and a highly respected person.

The copilot had fifteen years of experience in aviation and was in the company for eleven years. He had completed flight simulator training for the last time in December 2017.

The chief flight attendant had been working for the company for thirteen years and had her operational training updated, as well as the other crewmembers.

It was the first flight of the day for all components of that crew.

Upon taking over the aircraft, the commander of this flight was warned by his predecessor about a problem related to the Bleeds. As a result of the report received, the commander who took the plane decided to request the presence of the company's maintenance team next to the aircraft.

The maintenance section made the necessary interventions and released the plane for the flight. However, during the beginning of the taxi for takeoff, the crew noticed the DUAL BLEED light on, which represented a problem related to the pressurizing system. As a result, they returned to the apron and requested, once again, the presence of the company's maintenance team.

The maintenance technicians evaluated the condition presented and decided to dispatch the aircraft with the Bleed 1 valve closed and locked, rendering it inoperative. This action imposed some operational restrictions on the aircraft but did not impede the flight, in accordance with the manufacturer's manuals and current legislation.

The return of the aircraft to the apron and the performed maintenance actions had, consequently, a delay in the take-off time. The intervention time of the maintenance team lasted approximately one hour and ten minutes. After the completion of the work, it was decided to continue the flight, once the operational limitations imposed by the fact that Bleed 1 was inoperative allowed.

During the time it remained on the ground, the temperature inside the aircraft went up considerably. This created an environment of uncomfortable heat for crewmembers and passengers, who remained on board during the maintenance team's interventions.

According to crewmembers' perception, the flight delay, the maintenance management, and significant temperature increase inside the cabin, coupled with the implicit organizational pressure that exists for the flights punctuality in commercial aviation, created a work overload.

The operational restrictions resulting from the maintenance action required a specific configuration of the aircraft pressurization system. The operation with Bleed 1 disabled required pilots to adopt a procedure that was not usual for them.

During an interview, both said it was an uncommon fact and reported not remembering when it would have been the last time they had to perform a takeoff in those conditions, with that procedure. Despite this, the pilots said they did not feel any discomfort when they faced the situation presented.

Still with the aircraft on the ground, the pilots consulted the operation manuals and made a briefing of the procedures that they would execute before, during and after the takeoff. Such procedures were intended to configure the pressurization system correctly for each of these phases.

After the take-off, the commander consulted the manuals again before reconfiguring the pressurization system in the operational condition of inoperative Bleed 1. This consultation was carried out under the cabin light that, according to the commander himself, did not provide a good luminosity (the flight happened at night).

The commander read the specific item in the manual aloud, sharing the directions with the copilot.

The copilot sometimes asked the commander about the procedures adopted and the correct operation of the pressurization system. The commander confirmed the information he had passed on and verbalized, on more than one occasion, that the system was working properly. On these occasions, the copilot agreed with the arguments presented by the commander.

The climb proceeded to the FL250 and, shortly after leveling, the cabin altitude alert sounded. The crew then made a descent to FL090 and, as they crossed the FL150, the passengers' oxygen masks fell down automatically.

When leveling on FL090, they found that the cabin temperature had not been altered, and the chief flight attendant told the cabin crew that the oxygen masks had fallen from their compartments.

According to the report, the crew did not feel physiological symptoms of depressurization nor were there complaints of malaise on the part of the passengers.

The crew decided not to declare emergency because they found that they would quickly reach the safety level (FL100).

In order to understand the event that had just occurred, the commander consulted the aircraft manual again and realized that he had confused the item relating to the operation of the aircraft with disabled Bleed 1.

The pilots decided, together with the company, not to return to the airport of origin, for administrative and operational reasons. The flight proceeded to the destination airport on FL090.

All crewmembers reported being rested for the flight and there were no communication and / or relationship barriers in the cabin environment.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

After the event, it was detected that not all oxygen masks of the passenger cabin had fallen from their compartments to be available to the occupants of the aircraft. The lavatory mask "A" did not fall and in the mask compartment of the 1R station, they were tangled and with no use conditions. In row 12, on seats D, E and F, the mask compartment did not open.

The preventive maintenance task related to the operation of the aircraft masks did not require checking all of them. TASK 35-090-00-01 / 02 was performed every 12,000 hours, according to the Boeing maintenance program, where the manufacturer requested inspection of only 10% of the passengers' masks.

1.16 Tests and research.

Nil.

1.17 Organizational and management information.

The airline had a robust and well-structured physical and functional structure. The Operations, Flight Schedule and Safety sectors worked in a coordinated and integrated manner, following defined criteria and in accordance with the legislation in force at the time.

Regarding the operational training, the crew considered the company rigorous as to the fulfillment of the program.

Although they had their operational trainings up to date, the technical crew (pilots) did not remember when they had performed training of the situation they experienced. They usually trained rapid descent and emergency descent.

The flight schedule was considered adequate, with an average of eleven monthly departures per crewmember. The company had a good work environment, which allowed, consequently, a good relationship among colleagues.

1.18 Operational information.

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

The aircraft took off from SBRJ to SBCF to conduct a regular passenger flight leg.

It was the first stage of the day for that crew, with takeoff and landing scheduled for the nighttime.

The takeoff straight line of SBRJ's 20L runway had natural obstacles known to pilots and required minimal aircraft performance to be overcome. For this reason, the use of engine Bleeds during the take-off from the SBRJ was conditioned to the performance of the aircraft, considering factors such as: weight, temperature, atmospheric pressure and wind prevailing at the aerodrome.

Depending on the scenario presented, it could be recommended, or even necessary, that the take-off was performed with the Bleeds of the engines in the OFF position and the Bleed of the APU in ON, in order not to bleed air from the engines and thus to use all the power available for take-off. In this condition, the APU Bleed would provide air for the Packs and pressurization would normally occur.

In this flight, the pilots were informed that the aircraft would be dispatched in accordance with item 36-5-2 of the Minimum Equipment List (MEL).

According to the manufacturer's manuals, the aircraft had an altitude limitation of 25,000ft, when operating with only a Bleed of the engines running. In view of this, the flight planning was changed, so that the flight was performed in the FL250.

Sixteen minutes before takeoff, while the maintenance technicians completed the procedures to disable Bleed 1, the pilots held a briefing on the configuration of the pressurization panel in Bleed 1 inoperative condition. This dialogue was recorded by the CVR.

During this briefing, the pilots correctly consulted the MEL by reading the operating procedures for item 36-5-2, step 3, letter "B" (For left engine bleed inoperative) shown in Figure 4. Both pilots agreed verbally that according to MEL procedures, Bleed 2 would be used to supply air bleed to Pack 1 and for this, Isolation Valve should remain in the OPEN position during the flight at cruising altitude.

Operating Procedures

NOTE 1: Use of the APU bleed air is limited to 17,000 feet. One air conditioning pack will be unusable when dispatching with: (1) the right engine bleed inoperative, (2) the left engine bleed inoperative and flight altitude greater than 17,000 feet, or (3) both engine bleeds inoperative.

NOTE 2: When dispatching with a single engine bleed on for takeoff (airplane pressurized), V1(MCG) should be determined based on AC packs OFF. Takeoff performance should be based on AC packs AUTO.

1. Do not dispatch into known or forecast icing conditions.
2. Associated engine bleed switch is selected to the OFF position.
3. For left engine bleed inoperative:
   A. At altitudes 17,000 feet and below, operate the left pack using the APU bleed air, the right pack using the right engine bleed and the isolation valve CLOSE.
   B. At altitudes above 17,000 feet, operate with the APU bleed air OFF.
      1) Limit altitude to FL 250.
      2) Operate the left pack using the right engine bleed, the right pack OFF and isolation valve OPEN.
4. For right engine bleed inoperative:
   A. Limit altitude to FL 250.
   B. Operate the left pack using the left engine bleed, right pack OFF, and isolation valve CLOSE.
      NOTE: At altitudes 17,000 feet and below, increased air flow will occur when flaps are extended (takeoff and landing) and the APU is used instead of engine bleed to supply bleed air to the operating pack. Refer to Boeing Operations Manual, NO ENGINE BLEED TAKEOFF AND LANDING PROCEDURE.
5. For both engine bleeds inoperative:
   A. Limit altitude to 17,000 feet.
   B. Operate the left pack using APU bleed and isolation valve CLOSE. Refer to Boeing Operations Manual, NO

19 June 2015
(Continued)

Figure 4 - MEL Item 36-5-2, highlighting step 3, letter "B".

Three minutes after the briefing about the configuration of the pressurization panel in cruise flight, the CVR recorded a dialogue among the pilots regarding the take-off procedure they would take (take-off briefing).

On the day of the incident, the conditions prevailing in SBRJ were as follows:

- aircraft weight: 61,765 kg;
- temperature: 26 ° C
- atmospheric pressure: 1013 HPa;
- direction / wind intensity: 020° / 5kt

Under these conditions, it was possible to use the pressurization panel in two take-off configurations:

- configuration A - Bleed 2 ON and APU Bleed OFF (maximum weight 62,000kg); and
- configuration B - Bleed 2 OFF and APU Bleed ON (maximum weight 62,500kg).

During the take-off briefing, the pilots decided to use the B configuration (Bleed 2 OFF and APU Bleed ON). The pilots verbalized that they would configure the pressurization panel as follows:

- APU Bleed ON;
- Bleeds of the engines OFF;
- Packs 1 and 2 in AUTO; and
- Isolation Valve in OPEN.

The take-off briefing took place without the aircraft manual being consulted, and the pilots commented the procedures. However, the Supplementary Procedures aircraft manual recommended a different sequence for takeoff with the APU Bleed pressurizing the aircraft, as shown in Figure 5.

Takeoff (when cleared to enter the departure runway)

PACK switches .... AUTO

ISOLATION VALVE switch...CLOSE

WING ANTI-ICE switch .... OFF

The WING ANTI-ICE switch must remain OFF until the engine BLEED air switches are repositioned to ON and the ISOLATION VALVE switch is repositioned to AUTO.

Figure 5 - Supplementary Procedures: #Bleeds OFF Takeoff - APU Bleed.

The sequence of the manual stated that the Isolation Valve should be placed in CLOSE for takeoff, a position contrary to what the pilots commented on the briefing (OPEN).

Shortly after the take-off briefing with the APU Bleed ON, the pilots reviewed the procedures they would take after takeoff. Initially the revision of the procedures was performed from memory, which generated doubts among the pilots regarding the correct position of the Isolation Valve (OPEN or CLOSE). The commander then consulted the MEL again.

However, at that point, the commander mistakenly read step 4, letters "A" and "B", item 36-5-2 (For right engine bleed inoperative) instead of reading step 3, letter "A" (left engine bleed inoperative) and both pilots agreed that the Isolation Valve would be placed in CLOSE after takeoff, unlike what they had agreed during the first briefing.

Figure 6 shows the correct procedure for the situation (For left engine bleed inoperative) in green; and the wrong procedure for the situation (For right engine bleed inoperative) in red.

3. For left engine bleed inoperative:
   A. At altitudes 17,000 feet and below, operate the left pack using the APU bleed air, the right pack using the right engine bleed and the isolation valve CLOSE.
   B. At altitudes above 17,000 feet, operate with the APU bleed air OFF.
      1) Limit altitude to FL 250.
      2) Operate the left pack using the right engine bleed, the right pack OFF and isolation valve OPEN.
4. For right engine bleed inoperative:
   A. Limit altitude to FL 250.
   B. Operate the left pack using the left engine bleed, right pack OFF, and isolation valve CLOSE.

Figure 6 - Operating procedures for Bleed inoperative. In green the procedure for bleed 1 inoperative (which should have been adopted) and in red the procedure for Bleed 2 inoperative (not applicable for that flight).

One of the differences between the two procedures was the position of the Isolation Valve. The procedure for bleed 1 inoperative (green) prevised that the valve was placed in the OPEN position, in order to allow Bleed 2 to supply air to Pack 1. In contrast, in Bleed 2 inoperative procedure (red), Isolation Valve was placed in CLOSE position to ensure direct feed to Pack 1 and prevent Bleed 1 from supplying air to Pack 2.

After the maintenance work, the crew was authorized to carry out the pushback and later the engines start and taxi for take-off.

As the operation was exclusively for commanders at the Santos Dumont Airport, it was decided that the Pilot Flying (PF) during the take-off and climb phases would be the commander and that the copilot would perform the Pilot Monitoring (PM) function.

Before starting the taxi, the copilot set up the pressurization panel as agreed in the briefing:

- APU Bleed ON;

- Bleeds of the engines OFF;

- Packs 1 and 2 in AUTO; and

- Isolation Valve in OPEN.

Upon taking off in this configuration, the aircraft began to be pressurized by APU's Bleed, which fed both Packs, as shown in Figure 7.

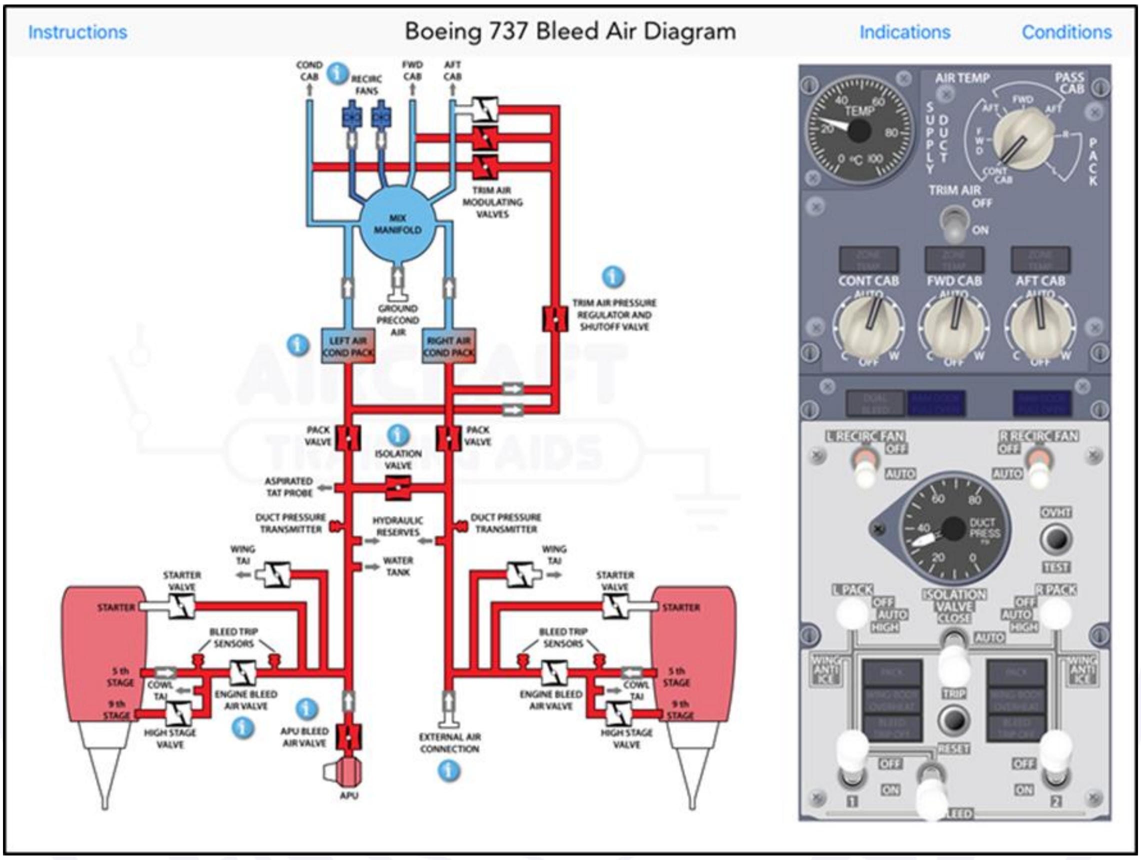

Figure 7 - Pressurizing panel, as configured for taxi start. In this configuration, the APU Bleed was powering the Packs.

After retracting the flaps, while the copilot made contact with the air traffic control, the commander began to reconfigure the control panel of the pressurization system. It should be noted that this panel was located in the Overhead Panel, an area that was of the responsibility of the Pilot Monitoring and therefore, of the copilot at that time of the flight.

The commander set the Bleed 2 to the ON position and the APU Bleed to OFF. The copilot turned his attention back to the panel, and together they completed the next steps. They set the Pack 2 switch (right) to OFF and closed the Isolation Valve.

Figures 8 and 9 illustrate how the pressurization system was configured after the pilots intervention on the control panel.

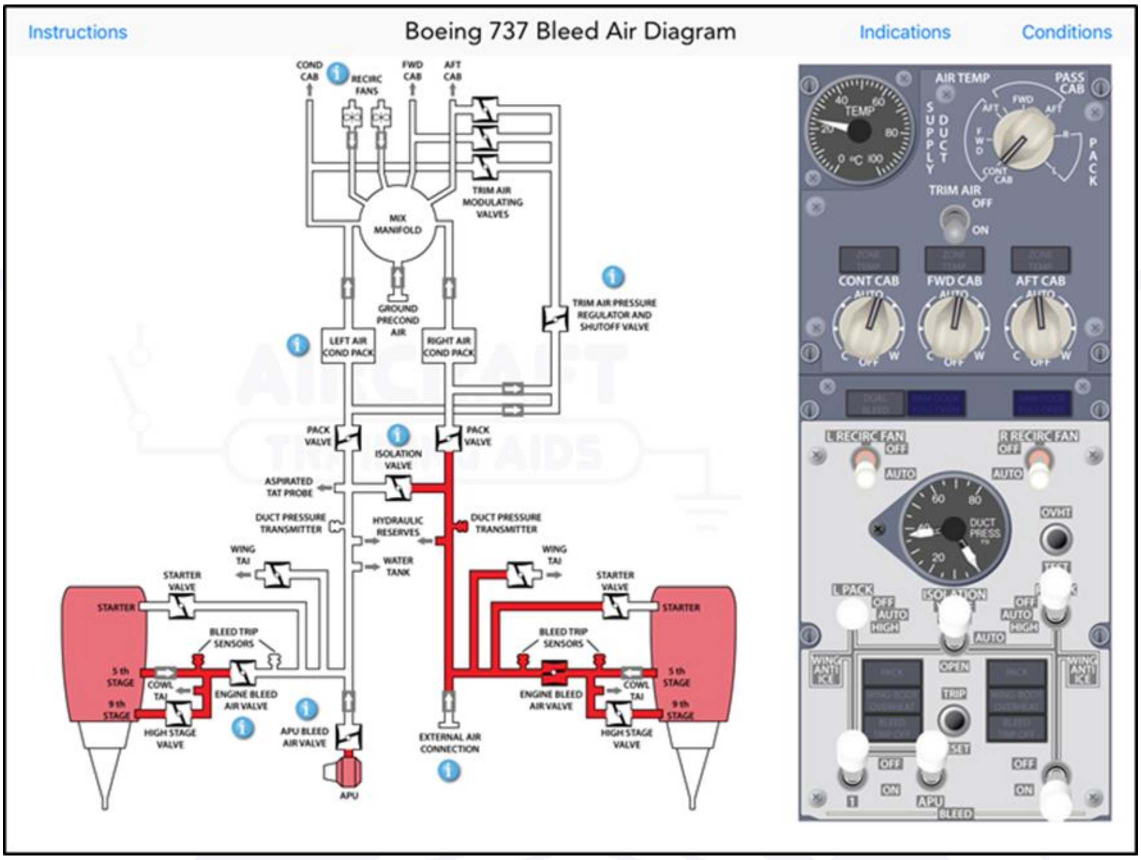

Figure 8 - Pressurization panel, as configured after take-off. In this configuration, none of the Packs was being powered.

Figure 9 - Pressurization panel of a B737-800 flight simulator, reconstituting the configuration adopted after take-off.

In this configuration, with the Isolation Valve closed, Bleed 2, despite being in the ON position, was not providing bleed air to Pack 1 and could not cause the bleed air of engine 2 to power Pack 2, as this Pack was in the OFF (closed) position.

Pack 1 was in AUTO (open) but could not receive bleed air from Bleed 2 because the Isolation Valve was in CLOSE (closed), preventing cross feed.

It is noted in Figure 9 that the pointer corresponding to the left duct (identified with the letter "L") was set to zero in that configuration. This indicated that the duct on that side was not pressurized and that the Pack on the left side was not receiving bleed air from any source.

Figure 10 illustrates how the pressurizing panel should have been configured if the MEL procedures from item 36-5-2, step 3, letter A (For left engine bleed inoperative) had been correctly adopted by the pilots.

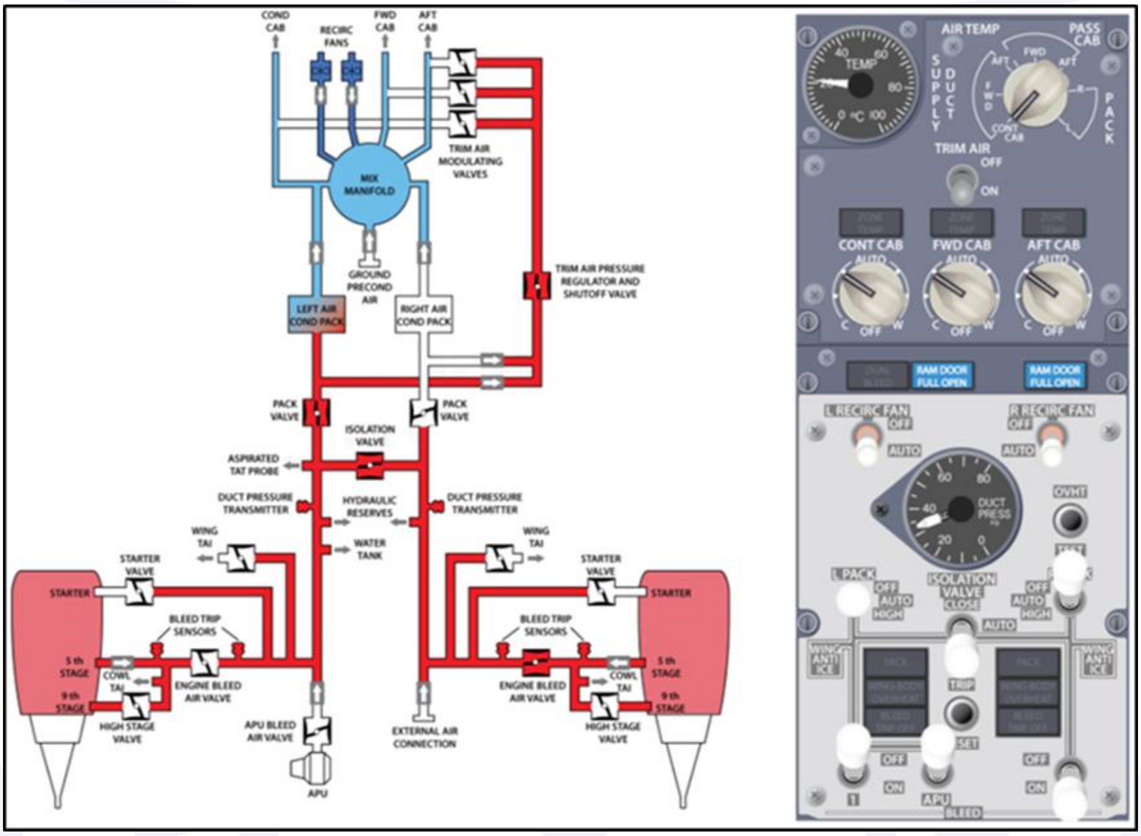

Figure 10 - Pressurization panel, as recommended by MEL item 36-5-2, step 3, letter "A" (For left engine bleed inoperative). In this configuration, Pack 1 would be powered by Bleed 2.

After the misconfiguration of the panel, the copilot expressed doubts about the correct positioning of the Isolation Valve and the commander consulted the MEL to make sure the procedure was correct. However, he read the letter "B" from step 4 of item 36-5-2 (For right engine bleed inoperative) again, instead of reading the correct procedure (For left engine bleed inoperative).

It is worth mentioning that reading the MEL, or any other checklist associated with the operation of the aircraft, was the Pilot Monitoring responsibility and not the Pilot Flying. Despite this, the commander, who was the PF at that time, was the one who read the MEL.

Soon after the aircraft crossed the minimum safety altitude, the copilot read the After Takeoff Checklist. At that moment, he voiced the positions at which each switch on the pressurization panel was, and again expressed distrust of the procedure.

The commander pointed out that while the aircraft was climbing at a rate of 3,000ft / min, the cabin was rising at a rate of 1,000ft / min. The copilot agreed with the commander's interpretation.

Three minutes later, the copilot again questioned whether the indications of the pressurization system were consistent. He realized that the differential pressure indicator between the inside and the outside of the aircraft was not rising (differential increasing).

The commander said that the indicator was rising slowly and pointed out that the aircraft was passing an altitude of 17,000ft while the cabin altitude was only 4,000ft and once again, the copilot agreed with the commander.

Soon after, the pilots commented that they found the temperature inside the aircraft a little warm. However, no change was made to the pressurization control panel configuration and the rise continued until leveling in the FL250.

According to the airplane operating manuals, pilots should perform a check of the pressurization system parameters after leveling at the cruise level.

For FL250 flights, the manufacturer's manuals recommended that the pressure differential should be 7.45psi, the cabin altitude should be approximately of 4,000ft, and the pressure in the air ducts should be between 26 and 50psi.

Pilot Flying	Pilot Monitoring
WHEN REACHING CRUISE ALTITUDE	
	LOGO Light (if applicable) OFF
	PRESSURIZATION Check Verify Cabin Altitude Indicator and Cabin Differential Indicator in normal range. Normal cruise pneumatic duct pressure 26 to 50 PSI.

Figure 11 – Level off check.

Selected FLT ALT	Differential Pressure Limit
At or below 28,000 feet	7.45 psid
28,000 feet to 37,000 feet	7.80 psid
Above 37,000 feet	8.35 psid

Figure 12 - Altitude and pressure differential check table.

There was no time to perform the level off check. One minute and thirty-three seconds after reaching the cruise level, cabin altitude reached 10,000ft, activating Cabin Altitude Warning's audible and luminous alerts.

These alerts required, as a response from the crew, a series of actions described in the Quick Reference Handbook (QRH), which should be carried out initially as memory items, due to the urgency of the situation. The main objectives of these required actions were to prevent pilots from becoming incapacitated, due to the effects of hypoxia and regain control of the aircraft pressurization system.

When hearing the Cabin Altitude Warning sound alert or seeing the Cabin Altitude warning light, pilots should put on their oxygen masks, establish communication between them, and try to control the cabin altitude. This control required placing the pressurizing mode selector in MAN (manual) and actuating the Outflow Valve switch to CLOSE until the Outflow Valve indication was fully closed.

If the cabin altitude could not be controlled, the crew should activate a switch responsible for forcing the passengers' oxygen masks down, even if there is an automatic drop mask system in such cases, and perform an emergency descent until the FL100 or even the minimum safety altitude in the sector, whichever is higher.

BOEING 2.1

737 Flight Crew Operations Manual

CABIN ALTITUDE WARNING
or
Rapid Depressurization

CABIN ALTITUDE **(If installed and operative)**

Condition: One or more of these occur:
- A cabin altitude exceedance
- In flight, the intermittent cabin altitude/configuration warning horn sounds or a CABIN ALTITUDE light (if installed and operative) illuminates.

1 Don oxygen masks and set regulators to 100%.

2 Establish crew communications.

3 Pressurization mode selector . . . . MAN

4 Outflow VALVE switch . . . . Hold in CLOSE until the outflow VALVE indication shows fully closed

5 **If** cabin altitude is **uncontrollable**:

Passenger signs . . . . ON

PASS OXYGEN switch . . . . ON

►►Go to the Emergency Descent checklist on page 0.1

■ ■ ■ ■

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6 **If** cabin altitude is **controllable**:

Continue manual operation to maintain correct cabin altitude.

When the cabin altitude is at or below 10,000 feet:

Oxygen masks may be removed.

7 **Checklist Complete Except Deferred Items**

▼ Continued on next page ▼

March 31, 2016 D6-27370-76N-GOT 2.1

Figure 13 - Cabin Altitude Warning or Rapid Depressurization non-normal checklist.

2.2 BOEING

737 Flight Crew Operations Manual

▼CABIN ALTITUDE WARNING or Rapid Depressurization continued▼

Deferred Items

Note: Use momentary actuation of the outflow valve switch to avoid large and rapid pressurization changes.

Descent Checklist

Pressurization . . . . **Move outflow VALVE switch to OPEN or CLOSE as needed to control cabin altitude and rate**

Recall . . . . Checked

Autobrake . . . . ___

Landing data . . . . VREF ___, Minimums ___

Approach briefing . . . . Completed

Approach Checklist

Altimeters . . . . ___

At Pattern Altitude

Outflow VALVE switch . . . . Move to OPEN until the outflow VALVE indication shows fully open to depressurize the airplane

Landing Checklist

YA201 - YD256, YK721 - YT708

ENGINE START switches . . . . CONT

Speedbrake . . . . ARMED

Landing gear . . . . Down

Flaps . . . . ___, Green light

■ ■ ■ ■

Figure 14 - Cabin Altitude Warning or Rapid Depressurization non-normal checklist (continuation).

However, the descent also did not follow the entire procedure provided in the QRH for an Emergency Descent.

After putting on their masks and communicating with each other (steps 1 and 2 of the Cabin Altitude Warning or Rapid Depressurization procedure), the first item of the Emergency Descent checklist consisted of informing the cabin crew and ATC about the descent of the aircraft.

BOEING 0.1

737 Flight Crew Operations Manual

Emergency Descent

Condition: One or more of these occur:
- Cabin altitude cannot be controlled
- A rapid descent is needed.

1 Announce the emergency descent. The pilot flying will advise the cabin crew, on the PA system, of impending rapid descent. The pilot monitoring will advise ATC and obtain the area altimeter setting.

2 Passenger signs . . . . ON

3 **Without delay**, descend to the lowest safe altitude or 10,000 feet, whichever is higher.

4 ENGINE START switches (both) . . . . CONT

5 Thrust levers (both) . . . . Reduce thrust to minimum or as needed for anti-ice

6 Speedbrake . . . . FLIGHT DETENT

If structural integrity is in doubt, limit speed as much as possible and avoid high maneuvering loads.

7 ⚠ Set target speed to Mmo/Vmo.

- -

YA608, YA610, YA631, YA732, YA733, YB119, YN107 - YN702

Caution! When gross weight is greater than 64,864 kgs, speed brake will autostow to the 50% flight detent if airspeed exceeds 320 knots. Do not override autostow function unless airspeed is less than 320 knots.

YC453, YC573

Caution! When gross weight is greater than 70,308 kgs, speed brake will autostow to the 50% flight detent if airspeed exceeds 320 knots. Do not override autostow function unless airspeed is less than 320 knots.

▼ Continued on next page ▼

September 14, 2017 D6-27370-76N-GOT 0.1

Figure 15 - Emergency descent checklist.

0.2

BOEING

737 Flight Crew Operations Manual

▼Emergency Descent continued▼

8 **When** approaching the level off altitude:

Smoothly lower the SPEED BRAKE lever to the DOWN detent and level off. Add thrust and stabilize on altitude and airspeed.

9 Crew oxygen regulators. . . . . Normal

Flight crew must use oxygen when cabin altitude is above 10,000 feet. To conserve oxygen, move the regulator to Normal.

10 ENGINE START switches (both) . . . . . .As needed

11 The new course of action is based on weather, oxygen, fuel remaining and available airports. Use of long range cruise may be needed.

■ ■ ■ ■

Figure 16 - Emergency descent checklist (continuation).

The crew found communication difficulties in the sector and started the descent without informing the ATC about the procedure and without setting 7600 on the transponder. At one point, the pilots were forced to stop the descent to divert from another aircraft that was in the same sector.

The use of the speedbrakes, item 6 of the checklist, was delayed and only occurred after the aircraft crossed the FL220 in descent.

During the descent, the aircraft speed was not kept constant at VMO (340kt).

When the aircraft crossed approximately 15,000ft of altitude, the cabin reached 14,000ft and passengers' oxygen masks fell automatically.

The pilots did not command the fall of the masks manually, despite it was stated on item 5 of the Cabin Altitude Warning or Rapid Depressurization non-normal checklist.

The descent was made until FL090 and the flight went to the destination, at that level, landing without additional intercurrences.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a regular passenger flight, with SBRJ take-off and SBCF destination.

When the crew involved in the incident took over the aircraft, the pilots were informed that there was a problem with the Bleed valves.

Given this scenario, the crew requested support from the maintenance team, which released the aircraft for flight after verification. However, during the first taxi attempt for takeoff, the DUAL BLEED light turned on. The pilots decided to return and request the maintenance aid again.

The identification of the fault required a waiting time of one hour and ten minutes on the ground. The passengers remained on board during all this time.

During the services performed, the air conditioning of the aircraft was impaired as the problem situation involved components that were an integral part of the aircraft's pressurization and air conditioning system.

As a result, the temperature inside the aircraft went up considerably and the environment became uncomfortable for crew and passengers.

Other factors resulting from the time spent on the ground for evaluation of the aircraft were the delay of the flight and the management of the activities by the commander of the aircraft, who had to make several coordination contacts with the company and with the air traffic control.

After interventions by the technical team, it was decided that the aircraft would be dispatched with Bleed 1 inoperative. This special condition was allowed by the manufacturer's manuals and was contained in the aircraft MEL, but implied some performance limitations that directly influenced the flight profile to be performed.

One of these limitations was related to the configuration of the pressurization control panel. Upon learning that they were going to take off with Bleed 1 inoperative, the pilots devoted themselves to checking the aircraft manuals regarding specific procedures for this situation.

The aircraft MEL had specified how the panel should be configured for Bleed 1 or Bleed 2 inoperative. The pilots consulted the publication and held a briefing of the procedures they would take to carry out the flight regarding the configuration of the pressurization panel. Until then, the briefing dealt with the correct and appropriate procedures for Bleed 1 inoperative situation.

Approximately three minutes after this briefing, pilots turned their attention to takeoff procedures with the APU Bleed ON. Although this was not a routine procedure, the pilots did not consult the aircraft manuals during this conversation and the procedures were commented from memory.

The pilots verbalized that they would configure the pressurization panel as follows:

- APU Bleed ON;

- Bleeds of the engines OFF;

- Packs 1 and 2 in AUTO; and

- Isolation Valve in OPEN.

However, the Supplementary Procedures aircraft manual recommended the Isolation Valve to be placed in CLOSE in that situation.

Shortly after this briefing, the pilots reviewed the procedures they would take after takeoff. Initially the review of the procedures was performed from memory, which raised doubts as to the correct position of the Isolation Valve (OPEN or CLOSE). The commander then consulted the MEL again.

However, at that point, the commander mistakenly read step 4, letters "A" and "B", item 36-5-2 (For right engine bleed inoperative) instead of reading step 3, letter "A" (left engine bleed inoperative) and both pilots agreed that the Isolation Valve would be placed in CLOSE after takeoff, unlike what they had agreed on the first briefing.

Procedures for Bleed 1 or 2 inoperative were similar, but not identical, and were very close to one another, described on the same page of the manual, with no emphasis on the terms "left" and "right", being differentiated only by the text and numbering of paragraphs.

Operating Procedures

NOTE 1: Use of the APU bleed air is limited to 17,000 feet. One air conditioning pack will be unusable when dispatching with: (1) the right engine bleed inoperative, (2) the left engine bleed inoperative and flight altitude greater than 17,000 feet, or (3) both engine bleeds inoperative.

NOTE 2: When dispatching with a single engine bleed on for takeoff (airplane pressurized), V1(MCG) should be determined based on AC packs OFF. Takeoff performance should be based on AC packs AUTO.

1. Do not dispatch into known or forecast icing conditions.
2. Associated engine bleed switch is selected to the OFF position.
3. For left engine bleed inoperative:
   A. At altitudes 17,000 feet and below, operate the left pack using the APU bleed air, the right pack using the right engine bleed and the isolation valve CLOSE.
   B. At altitudes above 17,000 feet, operate with the APU bleed air OFF.
      1) Limit altitude to FL 250.
      2) Operate the left pack using the right engine bleed, the right pack OFF and isolation valve OPEN.
4. For right engine bleed inoperative:
   A. Limit altitude to FL 250.
   B. Operate the left pack using the left engine bleed, right pack OFF, and isolation valve CLOSE.
      NOTE: At altitudes 17,000 feet and below, increased air flow will occur when flaps are extended (takeoff and landing) and the APU is used instead of engine bleed to supply bleed air to the operating pack. Refer to Boeing Operations Manual, NO ENGINE BLEED TAKEOFF AND LANDING PROCEDURE.

Figure 17 - Procedures of MEL 36-5-2.

In both cases, to fly above 17,000ft, the procedures described determined that Pack 1 (left) should be used to pressurize the aircraft and that Pack 2 (right) should be turned OFF.

It is added that, below that altitude, Pack 2 should be in AUTO: "operate the left pack using the APU bleed air, **the right pack using the right engine bleed** and the isolation valve CLOSE". Above 17,000ft, the Pack 2 should be set to OFF and the isolation valve to OPEN.

As Bleed 1 (left) was inoperative, Pack 1 (left) was to be supplied by Bleed 2 (right) after 17,000ft. According to the architecture of the system, this feeding was done in a crossway and, therefore, it could only be possible if the Isolation Valve was set to OPEN. This was the situation experienced by the pilots on the day of the incident.

Therefore, the positioning of the Isolation Valve was the most important difference between the procedures.

The briefings were developed while the maintenance crew disabled Bleed 1. It is interesting to note that the flight was delayed at that time, the passengers were on board, the cabin was at high ambient temperature and the pilots were managing aspects related to flight planning in the special aircraft dispatch condition.

All these combined aspects generated a work overload on the crew, especially on the pilots; as well as they may, therefore, have raised the stress level in the cabin to the extent of affecting their performance in the management and configuration of the aircraft pressurization system.

Before starting the taxi, the copilot set up the pressurization panel according to the combined briefing, that is, he left the Isolation Valve in OPEN.

According to the operation manuals, the APU should only feed one Pack in flight, so the Isolation Valve should be in CLOSE for takeoff. This divergence did not impair the aircraft pressurization or performance during takeoff. However, it showed that the pilots had doubts about the correct setting of the pressurization control panel.

After retracting the flaps, while the copilot made contact with the air traffic control, the commander began to reconfigure the control panel of the pressurization system.

He put Bleed 2 in the ON position and the Bleed APU turned OFF. The copilot turned his attention back to the panel and together they completed the procedure by setting the Pack 2 switch (right) to OFF and the Isolation Valve to CLOSE. These actions were performed from memory, without reading the MEL.

At that time of the flight, the commander performed the Pilot Flying function and, according to the operating manuals, he should be focused on the conduction of the flight.

Other tasks such as the reconfiguration of the pressurization panel and the MEL reading were under the responsibility of the Pilot Monitoring, a function performed by the copilot at that time of the flight.

All of these procedures were carried out below 10,000ft at the time of the flight in which several actions are being carried out by the copilot, such as: contact with the air traffic control and after take-off checks.

The fact that the reconfiguration was carried out in memory, without consulting the MEL, by the crewmember who was supposed to be conducting the flight, denoted an informal cabin environment, which favored non-compliance with current procedures and failure to divide tasks, contributing for the pilots not to realize the error they were making in the configuration.

It is worth mentioning that with the APU Bleed being used to provide pressurization in the correct configuration, the aircraft could fly up to 17,000ft altitude, there being no reason to reconfigure the pressurization panel soon after take-off.

The procedures adopted after take-off were mostly correct, except for the placement of the Isolation Valve in CLOSE. Upon closing it, the pilots definitively isolated the left side from the right side and prevented cross feeding. As a result, no Pack was receiving bleed air from engine 2 and the aircraft gradually began to lose the pressurization obtained while using the APU Bleed on take-off.

After the wrong reconfiguration of the panel, the copilot expressed doubts about the correct positioning of the Isolation Valve. The commander then consulted the aircraft manual. During the consultation, he read the procedure for Bleed 2 (right) inoperative again, instead of reading the procedure for Bleed 1 (left) inoperative.

Less than a minute later, after the aircraft crossed the minimum safety altitude, the copilot read the After Takeoff Checklist. At that moment, he once again expressed mistrust regarding the procedure adopted in the pressurization panel.

The commander highlighted the difference between the aircraft rate of climb (3,000ft / min) and the cabin rate of climb (1,000ft / min). The commander's statements led the pilots to believe that the system was working properly. After all, if the aircraft were depressurized, the cabin rate of climb would be equal to the rate of rise of the aircraft.

Three minutes later, the copilot realized that the pressure differential indicator was not increasing and questioned the commander again. This, in turn, stated that the indicator was normal and pointed out that the aircraft was crossing 17,000ft of altitude, while the cabin was only at 4,000ft. Once again, the commander's statements led the pilots to believe that the aircraft was being pressurized.

Despite doubts as to the proper operation of the pressurization system, the copilot's interventions were not sufficiently assertive to raise the need to check other instruments related to the pressurization system.

Thus, even with the copilot's inquiries, the commander remained committed to the procedures performed, sustaining his position that the aircraft was being properly pressurized.

The climb continued until leveling on the FL250.

When analyzing the dialogues recorded by the CVR, it was noticed that the pilots were based on the following parameters to evaluate if the cabin was or was not being pressurized:

- rate of climb of the aircraft greater than the rate of climb of the cabin;

- aircraft altitude greater than cabin altitude; and

- pressure differential increasing.

The pilots did not check an important instrument, the manometer that indicated the pressure in the ducts. This instrument was indicating pressure equal to "zero" on the pointer with the letter "L" (left duct). This information, if observed, would show pilots that there was no pressurized air in the left duct, which would be indicative that Pack 1 was not receiving bleed air from any source.

It is noteworthy that the level off check prevised that the pressure in the ducts to be checked between 26 and 50psi. In addition, it also predicted that pilots would compare the cabin altitude and pressure differential values constant at the time of leveling with the pre-set values for the flight level they were maintaining.

For the FL250, the manual indicated that the pressure differential should be 7.45psi and that the cabin altitude should be at approximately 4,000ft. At the time of leveling, however, the instruments indicated that the cabin altitude was approximately of 8,000ft and the pressure differential was decreasing, already below 7.45psi.

During the use of the APU on takeoff, the cabin was pressurized. However, when the pilots reconfigured the pressurization control panel by turning off the Bleed from the APU, Pack 1 stopped receiving bleed air from the APU and Pack 2 was turned off.

The pilots turned on the Bleed 2, however, they put the Isolation Valve into CLOSE. In this situation, Pack 1, which no longer received bleed air from the APU Bleed, also could not receive bleed air from Bleed 2. In that way, the aircraft gradually lost pressurization.

In view of the above, it is possible to affirm that the parameters observed by the pilots in moments of doubt, indicated that the aircraft was not being pressurized correctly.

It is observed that the attention of the pilots was fixed in only a few parameters to determine whether the aircraft was being pressurized during the climb, which was probably triggered by the lack of knowledge they had about the operation of the aircraft pressurization system.

Without correcting the problem, the cabin was depressurized and the associated cabin altitude warnings (visual and sound) were triggered.

Once the pilots detected the depressurization, they started a descent to the FL100, safety level.

The emergency checklist for cabin depressurized established, from the third item, to try to control cabin altitude by actuating the manual mode pressurization selector and closing the Outflow Valve, trying to keep the aircraft pressurized.

Other simple actions, such as bringing the Isolation Valve to OPEN, could have reestablished the pressurization of the aircraft, if the pilots were aware of its misplacement.

However, the pilots did not follow the steps of the checklist as established. Instead, they focused attention on descending to the FL100 before passengers' oxygen masks were ejected from their compartments, a fact that occurs when cabin altitude reaches values above 14,000ft.

In the process, the pilots started the descent before making contact with the ATC in the sector and did not set 7600 on the transponder, probably because they believed they would be able to communicate, and made unsuccessful attempts throughout the descent. This action prevented the flight controller from directing aircraft flying in that region away from the vicinity of the incident aircraft. Consequently, during the descent, the aircraft approached other traffic. Thus, in order to avoid a situation of excessive proximity, the pilots had to change the flight trajectory.

The fact of starting a rapid descent without communicating the air traffic control, in a region of intense air traffic, could have put the aircraft in collision route with other airplanes. This action posed a risk to all aircraft flying in that sector at the time of the failure.

As they passed the FL150, the passengers' oxygen masks (with exceptions noted in the report) fell from their compartments.

It was noted that in a situation where masks were essential to avoid compromising the health of passengers, the fact that some of them were not available could be understood as a latent risk to the operations of the aircraft.

Although there is a maintenance task to ensure that the oxygen masks are correctly ejected from their compartments in case of cabin depressurization (TASK 35-090-00-01 / 02, every 12,000 hours), it was not possible to ensure that the checks provided therein have been made properly. Thus, it was not clear what would have compromised the fall of some masks.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid Aeronautical Medical Certificates (CMA);

b) the pilots had valid B739 type aircraft (which included the 737-8EH model) and IFRA ratings.

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

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

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

f) the maintenance technical registers were with the records updated;

g) the weather conditions were favorable for the flight;

h) when the crew involved in the incident took over the aircraft, the pilots were informed that there was a problem related to the Bleed valves;

i) the crew requested support from the maintenance team;

j) the maintenance technicians released the aircraft for the flight, after verifications;

k) during the first taxi attempt for takeoff, the DUAL BLEED light turned on;

l) the pilots returned and requested the maintenance aid again;

m) the identification of the fault required a waiting time of one hour and ten minutes;

n) during that time, the passengers remained on board;

o) the air conditioning of the aircraft was impaired during this period;

p) the temperature inside the aircraft went up considerably;

q) the environment became uncomfortable for crew and passengers;

r) there was flight delay;

s) the aircraft was dispatched with Bleed 1 inoperative, according to the MEL;

t) procedures for Bleed 1 or 2 inoperative were similar and were located next to each other in the MEL;

u) during the briefings, the pilots demonstrated doubts and confusions about the procedures related to the pressurization system;

v) sometimes the pilots verbalized that they would perform different actions for the same procedure;

w) the take-off was performed with Bleeds 1 and 2 in OFF; the APU Bleed in ON; Packs 1 and 2 in AUTO and the Isolation Valve in OPEN;

x) after take-off, the crew put Bleed 2 ON; Pack 2 OFF; the Isolation Valve in CLOSE and the APU Bleed in OFF;

y) this configuration prevented Pack 1 from receiving bleed air from Bleed 2 and the aircraft pressurization;

z) the aircraft began to be slowly depressurized;

aa) during the climb, the crew did not correctly interpret the indications of the pressurization system;

bb) the crew did not have time to carry out the pressurizing check after leveling;

cc) the cabin has been depressurized;

dd) the masks fell automatically when the aircraft crossed the FL150;

ee) the lavatory A mask did not fall from its compartment;

ff) masks of station 1R were tangled and unuseable;

gg) the compartments of the masks in the row 12, on seats D, E and F did not open;

hh) after the depressurization, the crew did not perform all the actions required by the checklist for the situation;

ii) the pilots did not act, in order to attempt to control the cabin altitude prior to starting descent into the FL100;

jj) the pilots had difficulties to contact the ATC;

kk) the pilots started to descent to FL100 without establishing contact with the ATC and without setting 7600 on the transponder;

ll) the crew did not perform the emergency descent maneuver as recommended in the QRH;

mm) the flight was stabilized and completed in the FL090;

nn) the landing on SBCF occurred without additional intercurrences;

oo) the aircraft was not damaged; and

pp) all occupants left unharmed.

3.2 Contributing factors.

- **Attention – a contributor.**

The attention of the pilots was fixed only on a few parameters to determine whether the aircraft was being pressurized, which, together with the lack of knowledge of the system, prevented them from broadening the analysis of the situation and taking the necessary actions to correct the problem.

- **Attitude – a contributor.**

The performance of the commander in functions that competed to the copilot (Pilot Monitoring), in some moments of the flight, as in the configuration of the pressurization panel, even without consulting the MEL, indicated an attitude of nonobservance regarding the procedures prevised in the operation manual, which interfered with the cabin coordination for the problem management.

- **Communication – a contributor.**

There was no effective communication between the pilots, which affected the crew's ability to identify and correct the problem in a timely manner to avoid depressurizing the aircraft.

Interventions made by the copilot with the commander about the correct operation of the pressurization system were not sufficiently assertive to the point where the commander was doubtful of the procedures they performed. In contrast, the commander, in this interaction, remained convinced about the actions taken, generating compliance in the copilot.

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

Tasks related to the pressurization panel configuration were associated with the Pilot Monitoring function (copilot at that time). However, the Pilot Flying (commander at that time) took the initiative to set the panel shortly after take-off. The configuration was performed from memory without consulting the MEL. This fact denied the division of tasks and contributed to the pilots not realizing the error they were making in the configuration.

During the moments of doubt in the flight, the Pilot Flying was the one who read the MEL, a task that should be performed by the Pilot Monitoring.

- **Team dynamics – undetermined.**

The way in which the collaboration and cooperation took place in flight, although subtly, led to an informal climate, which failed to consider the responsibilities formally established for the crew, allowing the commander (Pilot Flying on this flight) to execute actions related to the Pilot Monitoring function, in addition to performing procedures based from memory. This dynamic of the crew may have made it difficult to identify the real problem of the aircraft pressurization system.

- **Emotional state – undetermined.**

The flight delay, with the organizational implications and the special aircraft dispatch condition, generated a work overload, which may have increased the level of stress in the cabin to the point of confusion in the reading of the MEL procedure, as well as it may have affected the performance of the pilots in the management and configuration of the aircraft pressurization system.

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-062/CENIPA/2018 - 01 **Issued on 12/18/2019**

Work together with GOL Airlines S.A., in order that the pilots' training of that company emphasizes the operation and interrelation of all the components of the aircraft pressurization system.

IG-062/CENIPA/2018 - 02 **Issued on 12/18/2019**

Act in conjunction with GOL Airlines S.A., so that the CRM trainings of that operator emphasize the assertiveness and correct division of tasks during the flight, especially as regards the reading of the checklist and the actuation in the aircraft system switches.

IG-062/CENIPA/2018 - 03 **Issued on 12/18/2019**

Verify if the procedures provided in TASK 35-090-00-01 / 02 have been performed correctly by Gol Airlines S/A, in order to ensure that the instrument and equipment requirements prevised in RBAC No. 121, regarding the provision of oxygen for passengers of pressurized aircraft with a turbine engine are being complied with, since, in this incident, in some seats, as well as in one of the lavatories, there was no automatic release of the oxygen masks when the cabin pressure altitude reached more than 14,000 ft.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

Crewmembers were referred to CRM training with emphasis on the pressurization system.

The operator included in its CRM training, elements that assist the development of assertiveness in the face of the critical analysis of the actions applied when detecting failures, aiming at the proper mapping, correction and mitigation of these problems.

The Maintenance Department performed a drop test of oxygen masks on some aircraft of the company to verify if they were being ejected correctly from their compartments, in case of cabin depressurization.

On December 18th, 2019.