COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG - 055/CENIPA/2016

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PR-GOV**
MODEL:	**737-76N**
DATE:	**28MAR2016**

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 28MAR2016 serious incident with the 737-76N aircraft model, registration PR-GOV. The accident was classified as “[SCF-NP] System/Component Failure or Malfunction Non-Powerplant – Unintentional/Explosive Decompression”.

During a cruise flight, on the FL380 (38,000ft), the aircraft had problems with the pressurization system.

The crew tried to act manually on the system in order to control the atmospheric pressure inside the aircraft (cockpit and passengers’ cabin). However, they were unsuccessful in their attempts and the cabin started to raise its altitude at a rate of 2,000ft/min.

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

During the descent, on the FL300 (30,000ft) approximately, the oxygen masks in the passenger cabin dropped automatically.

Upon reaching 10,000ft of altitude the situation was normalized. The flight continued to its destination with the aircraft flying at that altitude. The landing was carried out without additional abnormalities.

The aircraft was undamaged.

All the occupants left unharmed.

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

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ACMS	Aircraft Condition Monitoring System
AMM	Aircraft Maintenance Manual
ANAC	Brazil's National Civil Aviation Agency
ATS	Air Traffic Services
CENIPA	Aeronautical Accident Investigation and Prevention Center
CINDACTA	Air Defense and Air Traffic Control Integrated Center
CMA	Aeronautical Medical Certificate
CSB	Component Service Bulletin
FCOM	Flight Crew Operations Manual
FTD	Fleet Team Digest
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Aircraft
LABDATA	Flight Data Recorders Read-Out and Analysis Laboratory
LH	Left Hand
LN	Line Number
MTBUR	Mean Time Between Unscheduled Removal
NTSB	National Transportation Safety Board (USA)
NVM	Non-Volatile Memory
PCCV	Precooler Control Valve
PCM	Commercial Pilot License – Airplane
PLA	Airline Pilot License – Airplane
PN	Part Number
PPR	Private Pilot License – Airplane
RH	Right Hand
SBBE	ICAO Location Designator - Val de Cães Aerodrome, Belém - PA
SBEG	ICAO Location Designator – Eduardo Gomes Aerodrome, Manaus - AM
SIGWX	Significant Weather Chart
SLFPM	Sea Level Feet Per Minute
SSMCVR	Solid State Memory Cockpit Voice Recorder
SSMFDR	Solid State Memory Flight Data Recorder
SN	Serial Number
TPR	Aircraft Registration Category of Regular Public Transport
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

1. FACTUAL INFORMATION.

Aircraft	**Model:** 737-76N **Registration:** PR-GOV **Manufacturer:** Boeing Company	**Operator:** GOL Airlines S.A.
Occurrence	**Date/time:** 28MAR2016 - 0026 UTC **Location:** En-route **Lat.** 02°10'24"S **Long.** 053°14'23"W **Municipality – State:** Porto de Moz – PA	**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 Val de Cães Aerodrome (SBBE), Belém - PA, to the Eduardo Gomes Aerodrome (SBEG), Manaus - AM, at about 2300 (UTC) on 27MAR2016, with five crewmembers and 133 passengers on board.

During the cruise flight, leveled on the FL380, the aircraft had problems with the pressurization system with the lighting of two warning lights: LH BLEED TRIP OFF and RH BLEED TRIP OFF.

The crewmembers tried to act manually on the system and closed the Outflow valve, in order to control the pressurization of the aircraft. However, they were unsuccessful in their attempts and the cabin's altitude began to rise at an approximate rate of 2,000ft / min, even with the Outflow valve fully closed.

The crewmembers initiated an emergency descent to the FL100.

Approximately, when crossing the FL300, the oxygen masks in the passengers' cabin dropped automatically.

Upon reaching 10,000ft of altitude, the situation was normalized and the flight continued to the destination at that altitude.

The landing was carried out without additional abnormalities.

The aircraft was undamaged.

All occupants left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	5	133	-

1.3 Damage to the aircraft.

There was no damage to the aircraft.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	Pilot	Copilot
Total	9.978:25	4.384:00
Total in the last 30 days	65:40	51:14
Total in the last 24 hours	08:06	08:06
In this type of aircraft	7.878:24	3.183:59
In this type in the last 30 days	65:40	51:14
In this type in the last 24 hours	08:06	08:06

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

1.5.2 Personnel training.

The commander took the PPR course at the Rio Grande do Sul Aeroclub – RS, in 1973.

The copilot took the PPR course at the EJ *Escola de Aeronáutica* – SP, in 2006.

1.5.3 Category of licenses and validity of certificates.

The commander had the PLA License and had valid B739 aircraft type Rating (which included the 737-76N model) and IFRA Rating.

The copilot had the PCM License and had valid B739 aircraft type Rating (which included the 737-76N model) and IFRA Rating.

1.5.4 Qualification and flight experience.

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

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 28580, was manufactured by Boeing Company, in 1998, and it was registered in the TPR category.

The aircraft had valid Airworthiness Certificate (CA).

The technical maintenance records were updated.

The last maintenance activity on the aircraft, the "Overnight Check" type was carried out on 27MAR2016 by the maintenance organization GOL Airlines S.A, in Confins - MG, with the aircraft having flown 4 hours and 23 minutes after this Check.

The last inspection of the aircraft, the "Check A" type was carried out on 19FEB2016 by the maintenance organization GOL Airlines S.A, in São Paulo - SP, with the aircraft having flown 284 hours and 44 minutes after the inspection.

The plane had a pressurization system responsible for maintaining the air pressure inside the aircraft at values compatible with human physiology, even when the plane was flying at high altitudes when the atmospheric pressure was very low. Through bleed air from the engines, valves kept the interior of the aircraft pressurized, providing the occupants with an environment compatible with human physiology throughout the flight.

Each of the PR-GOV engines had a valve type PCCV, Part Number 3289562-5, Serial Number 11110 and SN 2341 manufactured by Honeywell. The PCCVs were the butterfly-type valves, with spring opening, actuated and controlled pneumatically.

These components were responsible for controlling the air flow from the engine to the primary cooling system, as part of the aircraft's pressurization system.

1.7 Meteorological information.

The SIGWX, valid at 0600 (UTC) on 28MAR2016, indicated the presence of isolated cumulus nimbus clouds based below FL250 and top at FL500, Northwest and Southeast of SBEG (Figure 1).

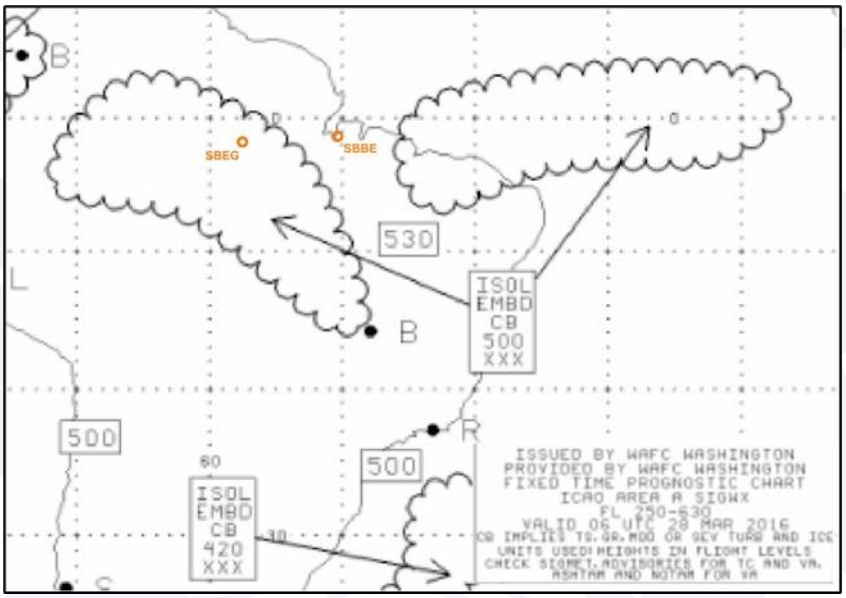


Figure 1 - SIGWX FL 250 / FL 630 (AMERICAS) valid for 0600 (UTC).

1.8 Aids to navigation.

Nil.

1.9 Communications.

The dialogues between the pilots inside the cockpit were recorded by the SSMCVR. During the management of the abnormal condition, the pilots demonstrated good situational awareness.

The crewmembers carried out the checklist items associated with the abnormal condition and performed all the actions provided for in the aircraft and operator's manuals.

Before starting the descent, the pilots coordinated with the air traffic control agency, with an emergency declaration.

1.10 Aerodrome information.

The occurrence took place out of the Aerodrome.

1.11 Flight recorders.

The aircraft was equipped with a flight data recorder, Solid State Memory Flight Data Recorder (SSMFDR), PN 980-4700-042 and SN 6268, with a recording capacity of 256wps (words per second), manufactured by Allied Signal.

It also had a voice data recorder, Solid State Memory Cockpit Voice Recorder (SSMCVR), PN 980-6022-001 and SN 09607, with a two-hour recording capacity, manufactured by Honeywell.

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

1.12 Wreckage and impact information.

Nil.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

Nil.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

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

1.14 Fire.

There was no fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

There was a history of poor reliability related to the PCCV in Boeing's worldwide fleet.

The first document published by the aircraft manufacturer was the FTD 737NG-FTD-36-06003 Precooler Control Valve and Pressure Relief Shut Off Valve Anomalies, dated 01NOV2006, with last revision on 23JUN2010. The document was applicable to the entire Boeing 737NG fleet.

In the FTD-36-06003, Section Background, Boeing reported that, since the beginning of 2005, it started receiving numerous reports from operators about anomalies in pneumatic systems.

Since then, Boeing and Honeywell have started joint research to determine a solution to the problem.

In the Final Action Section of the FTD, it was reported that Boeing and Honeywell had completed the qualification tests and were providing certification for a new PCCV, expected to be incorporated on the second trimester of 2010.

> **737NG-FTD-36-06003**
>
> **Precooler Control Valve and Pressure Relief Shut Off Valve Anomalies**
>
> **Background**
>
> In early 2005, Boeing began to receive numerous reports of pneumatic system anomalies which were traced to discrepant precooler control valves. Operators also reported experiencing a significant difference between the MTBUR of precooler control valves installed on 737 classic airplanes versus those installed on 737NG airplanes. Repair data gathered from Honeywell's overhaul facility supported these reports.
>
> Boeing visited Honeywell's overhaul facility in April 2006 to observe the internals of precooler control valves as they were being tested, repaired, and overhauled. At this time, Boeing and Honeywell also visited the overhaul facility located at a nearby operator and confirmed they had collected similar findings.
>
> Boeing and Honeywell then initiated an effort to investigate the root cause of accelerated wear and early failure of precooler control valves installed on 737NG airplanes. Boeing researched archived vibration data collected during the original 737NG certification flight testing. In addition, in July 2006, Boeing instrumented and

flight tested several bleed air components, including the precooler control valve, to assist Honeywell in determining the root cause for premature failure of these components.

[…]

Final Action

Boeing and Honeywell have completed PCCV qualification testing and are currently working to provide certification and release of Honeywell Component Service Bulletin 3289562-36-1878. The current schedule for production incorporation of the new PCCV and release of this bulletin is 2nd quarter 2010.

In June 2010, Boeing and Honeywell started a program to convert the PCCVs PN 3289562-5 to the PCCVs PN 3289562-6. The intention of the program was to increase the reliability of the system through the implementation of the new valves with PN ending in -6.

However, there were reports of failures in the PCCV valves, of the new PN 3289562-6, with less than 2,000 hours of operation, according to an extract from the 737NG-FTD-36-11001 Reliability of Precooler Control Valve, PN 3289562-6, of 27ABR2011 (last revision 11JUL2014).

737NG-FTD-36-11001

Reliability of Precooler Control Valve P/N 3289562-6

Background

Boeing and Honeywell worked to investigate the reliability of Bleed System Precooler Control Valves P/N 3289562-5 and implemented Honeywell CSB 3289562-36-1878 in June of 2010.

However, operators began reporting a number of discrepant dash 6 valves which had accumulated less than 2000 hours when installed on 737-600/-700/-800/-900 airplanes.

Examination of removed dash 6 valves show a new anomaly not previously seen in older series valves, accelerated wear on the Servo Valve Pivot Lever. This wear can preclude the valve from opening and cause a Bleed System over temperature trip.

According to the FTD-36-11001, the new PCCVs (-6) showed an accelerated wear of the Servo Valve Pivot Lever internal component, a problem not observed in previous models (PN 3289562-5).

In order to solve the problem, Honeywell and Boeing started tests to introduce new materials in the production of the PCCVs that did not present the observed wear and tear.

Until the tests were completed, Boeing did not impose any restrictions on the dispatch of aircraft with the PCCVs, PN 3289562-6, installed. However, the manufacturer recommended that operators perform the Precooler Control Valve System Health Check, following the parameters of the Maintenance Task 36-12-00-700-801 of the AMM of the 737NG.

737NG-FTD-36-11001

Reliability of Precooler Control Valve P/N 3289562-6

Interim Action

At this time, operators may continue to dispatch with Precooler Control Valves P/N 3289562-6 installed. There are no airplane limitations or restrictions.

Operators may choose to perform 737NG AMM task 36-12-00-700-801, Precooler Control Valve System Health Check. This test will show if the Precooler Valve is operating properly and closing/opening at the correct control pressure.

In January 2013, Boeing implemented a new PCCV model manufactured by Honeywell, the PN 3289562-7. It was the intention of both companies to issue service

bulletins for the conversion of the PCCVs models PN 3289562-5 / -6 to the PCCV model PN 3289562-7, by the end of 2013.

However, in July 2013, operators reported problems with premature failures in the PCCVs PN 3289562-7 with approximately 1,000 hours of operation. As a result, the companies decided to cancel the program for converting the PCCVs PN 3289562-5 / -6 to PN 3289562-7.

737NG-FTD-36-11001

Reliability of Precooler Control Valve P/N 3289562-6

Final Action

Boeing and Honeywell are working to implement corrective action for the accelerated wear on the dash 6 valves. The 3289562-7 valve is expected to complete qual testing in Jun '12 and be introduced into production and available for retrofit sometime in the 4th Q of 2012.

As of Jan 2013 - Boeing has implemented the new P/N 3289562-7 Precooler Control Valve starting at Line Number 4337 scheduled to deliver in Feb 2013. The Honeywell Component Service Bulletins to convert a -5 to -7 and -6 to -7 are scheduled to be released in Mar 2013.

As of late Apr 2013 - There has been a delay to the Honeywell Service bulletin release date. Because this valve is applicable to both the 737CL and the 737NG, both programs had to be accounted for in the certification of the Service Bulletins. This has taken longer than expected. Boeing now expects that the Service Bulletins will be approved and released by the end of Jun 2013.

As of Jul 2013 - Operators have reported removals of the -7 valve for cause. These valves have roughly 1000 hours of service life. As a result, Boeing and Honeywell have cancelled the Component Service Bulletins that would modify a -5 to -7 and -6 to -7.

As of 21 April 2014 - Boeing and Honeywell have ceased delivering -7 PCCV's. As of Line number 4735, -5 PCCV's have been delivered. Honeywell has released Component Service Bulletins 3289562-36-1909 and CSB 3289562-36-1911 to convert -7 and -6 PCCV's to -5 PCCV's. It is suggested that operators incorporate these Honeywell CSB's.

Operator Action

Operators are advised to halt efforts towards Honeywell CSB 3289562-36-1878 to convert a -5 to -6 valve for economic reasons. At this time, there are no changes in airplane operations to be advised. Operators may continue to dispatch with dash 6 valves installed. ETOPS operations are not affected at this time.

As of Jan 2013 - Operators are advised to incorporate Honeywell CSB 3289562-36-1903 to convert from -5 to -7 valve upon receipt of the CSB. Also, operators are advised to incorporate Honeywell CSB 3289562-36-1900 to convert from -6 to -7 valve upon receipt of the CSB.

As of Aug 2013 - Operators are now advised that Honeywell CSB 3289562-36-1903 and 3289562-36-1900 have been canceled. Because of early wear failures of the -7, there is no modification plan to convert valves to the -7 configuration.

As of 21 April 2014 - Operators are now advised that Boeing and Honeywell are now delivering -5 PCCV's due to their higher reliability rates. As a result, Honeywell has released Component Service Bulletins 3289562-36-1909 and CSB 3289562-36-1911 to convert -7 and -6 PCCV's to -5 PCCV's. It is suggested that operators incorporate these Honeywell CSB's.

On 21APR2014, operators were informed that Boeing and Honeywell would distribute the PCCV model PN 3289562-5, because this component has greater reliability than the PN 3289562-6 / -7 models.

As a consequence, Honeywell issued CSB 3289562-36-1909 and CSB 3289562-36-1911, containing instructions for converting the PCCVs PN 3289562-6 / -7 to PN 3289562-5, respectively.

On 11JUL2014 (last revision on 22MAR2017), Boeing issued the 737NG-FTD-36-14001 Reliability of Precooler Control Valve, PN 3289562-7, applicable to the entire 737NG fleet.

The FTD reported that the company had removed the PCCVs model PN 3289562-7 from the production line, replacing them with the PCCVs PN 3289562-5, from the production of the Line Number (LN) 4735 aircraft, in January 2014.

> 737NG-FTD-36-14001
>
> Reliability of Precooler Control Valve P/N 3289562-7
>
> Interim Action
>
> 1. The interim action removed the -7 PCCV from production and replaced it with the -5 PCCV at line number 4735.
>
> 2. Honeywell released CSBs 3289562-36-1909 and 3289562-36-1911 for retrofitting the -7 PCCV to the -5; or -6 PCCV to the -5 configuration, respectively.
>
> 3. Honeywell will continue to repair -7, -6, and -5 PCCVs. Conversions per the noted CSBs will be done at operator request.
>
> 4. It is the recommendation of Boeing and Honeywell that operators convert their -7 and -6 PCCVs to -5 PCCVs.

The document also contained information related to a new model of PCCV, PN 63292146-1, developed to solve the reliability problem associated with the PCCVs of previous models, PN 3289562-5 / -6 / -7.

The new PCCVs were incorporated into the production line of the Boeing 737NG from the LN 6109, delivered to its operator on 10JUL2016.

The aircraft manufacturer recommended that operators contact their local Honeywell representatives to coordinate the program to replace the old PCCVs with the new model PN 63292146-1.

The FTD-36-14001 had no restrictions on the continuity of operations with the PCCVs of previous PN installed.

However, the document, in its Operator Action Section, established that the monitoring of the PCCVs, PN endings -6 and -7, via ACMS, could prevent low pressure cases in the system ducts. Item 3 of the Section, specifically, provided guidance to operators for whom ACMS was not available, instructing them to monitor pressure in the pipelines at a time close to the top of the climb.

> 737NG-FTD-36-14001
>
> Reliability of Precooler Control Valve P/N 3289562-7
>
> Operator Action
>
> 1. Operators may wish to "de-couple" airplanes line number 4337 - 4734 by removing a -7 PCCV and installing a -5 or -6 PCCV in its place. ETOPS operators especially may wish to review this for their ETOPS operated aircraft. It is believed that this may reduce the likelihood of dual low pressure or dual bleed trip events. We have reports of one operator taking this action.
>
> 2. Operators have found that monitoring the -7 and -6 PCCVs via ACMS data gathering (precooler out temperature) has been helpful in avoiding serious low duct pressures and bleed trips.
>
> 3. If ACMS is not available, operators can have their flight crews monitor duct pressures near the top of climb. Near the top of climb is where a closed or almost

closed PCCV will most likely manifest itself as a low duct pressure due to elevated temperatures of the bleed air.

4. Boeing recommends reviewing SIL D201609000031 and contacting your local Honeywell representative to help coordinate a PCCV replacement program for the new P/N 63292146-1.

The operator monitored the pressure in the ducts of the pneumatic system of the engines through the Pneumatic Duct Pressure Survey. This survey consisted of a form that was filled in by the pilots taking note of the pressure values in the ducts at specific times of each flight. The collected data were compared to reference values, as shown in Figure 2.

CONDITION	TAKEOFF	CLIMB	CRUISE	IDLE/DESCENT
Normal Operation	34 to 50 psig	34 to 50 psig	26 to 50 psig	WTAI OFF-18 to 25 psig

Figure 2 - Table of reference values for the Pneumatic Duct Pressure Survey.
Source: Operator.

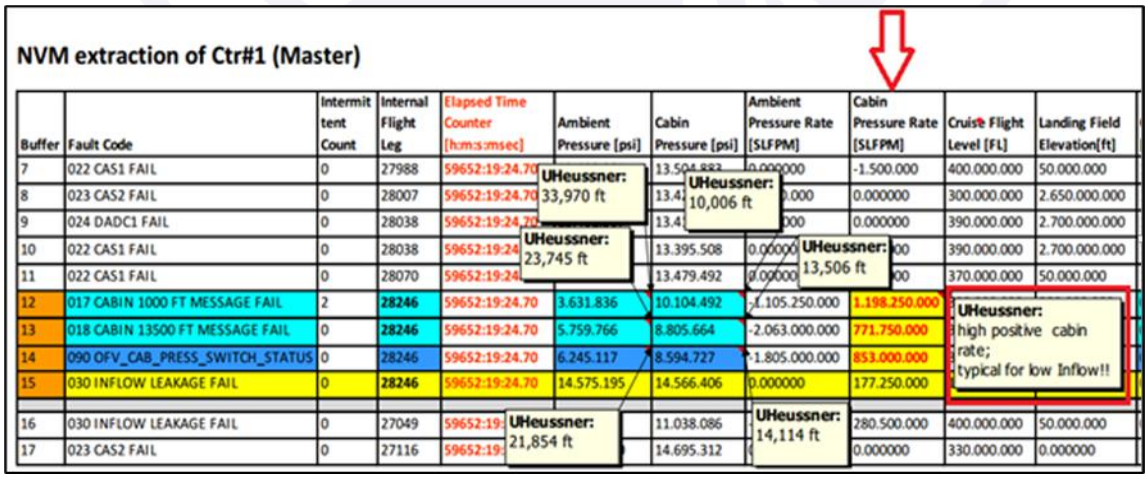
Figure 3 shows the pressure values collected on the PR-GOV aircraft, three minutes before the top of the climb, in the period of six months prior to the flight of the incident (September 2015 to March 2016).

Últimos 6 meses		Motor #1		Motor #2	
Data	FL	N1 (%)	LH Press (PSI)	N1 (%)	RH Press (PSI)
03/09/15	230	98.1	41	98.1	41
02/10/15	333	99.9	41	99.9	41
04/11/15	280	98.4	40	98.4	44
26/11/15	290	98.5	40	98.5	40
04/12/15	320	99.5	45	99.5	42
15/01/16	310	98.4	40	98.4	41
19/01/16	330	99.4	42	99.4	44
03/02/16	300	98.4	41	98.4	41
25/02/16	330	99.7	40	99.7	40
04/03/16	270	99.2	40	99.3	42
12/03/16	280	99.2	40	99.2	40
18/03/16	350	100.4	40	100.4	40

Figure 3 - Table with the values collected during the Pneumatic Duct Pressure Survey in the six months prior to the incident. Source: Operator.

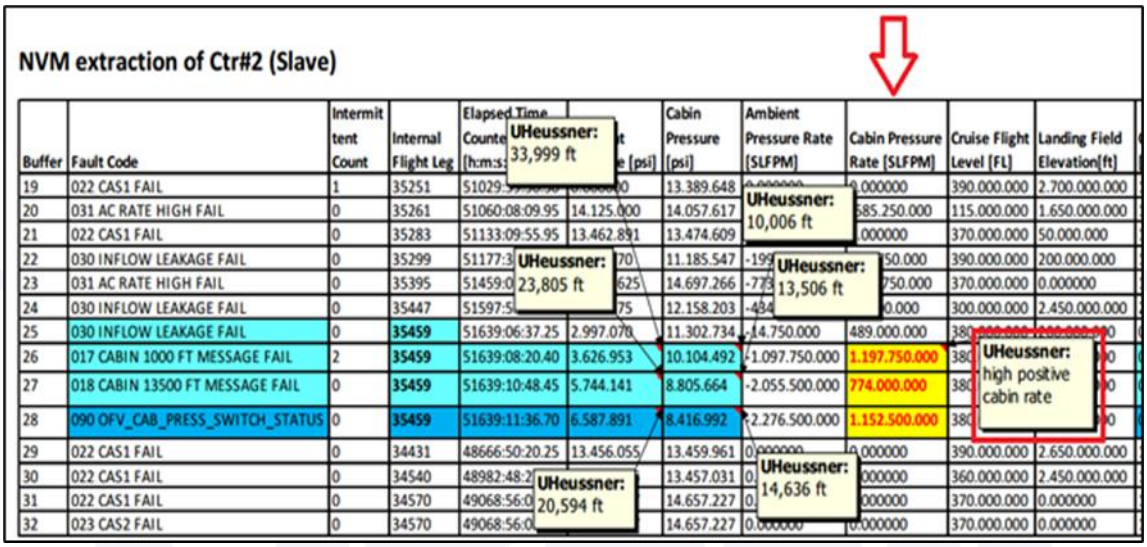
The PCCVs PN 3289562-5, SN 11110 and SN 2341, which equipped the aircraft, had NVM, memory cards that stored operating parameters. The PCCVs' NVMs contained incident flight data, which were successfully extracted.

The Service Engineering Investigation of Service Request, ID 3-3494066228, of 15APR2016, compiled the data in tables for each of the PCCVs that equipped the aircraft.



Buffer	Fault Code	Intermittent Count	Internal Flight Leg	Elapsed Time Counter [h:m:s:msec]	Ambient Pressure [psi]	Cabin Pressure [psi]	Ambient Pressure Rate [SLFPM]	Cabin Pressure Rate [SLFPM]	Cruise Flight Level [FL]	Landing Field Elevation[ft]
7	022 CAS1 FAIL	0	27988	59652:19:24.70		13.504.883	0.000000	-1.500.000	400.000.000	50.000.000
8	023 CAS2 FAIL	0	28007	59652:19:24.70		13.4	.000	0.000000	300.000.000	2.650.000.000
9	024 DADC1 FAIL	0	28038	59652:19:24.70		13.4	.000	0.000000	390.000.000	2.700.000.000
10	022 CAS1 FAIL	0	28038	59652:19:24		13.395.508	0.00000	.00	390.000.000	2.700.000.000
11	022 CAS1 FAIL	0	28070	59652:19:24		13.479.492	0.00000	.00	370.000.000	50.000.000
12	017 CABIN 1000 FT MESSAGE FAIL	2	28246	59652:19:24.70	3.631.836	10.104.492	-2.105.250.000	1.198.250.000		
13	018 CABIN 13500 FT MESSAGE FAIL	0	28246	59652:19:24.70	5.759.766	8.805.664	-2.063.000.000	771.750.000		
14	090 OFV_CAB_PRESS_SWITCH_STATUS	0	28246	59652:19:24.70	6.245.117	8.594.727	-1.805.000.000	853.000.000		
15	030 INFLOW LEAKAGE FAIL	0	28246	59652:19:24.70	14.575.195	14.566.406	0.000000	177.250.000		
16	030 INFLOW LEAKAGE FAIL	0	27049	59652:19:		11.038.086		280.500.000	400.000.000	50.000.000
17	023 CAS2 FAIL	0	27116	59652:19:		14.695.312		0.000000	330.000.000	0.000000

Figure 4 - Operating parameters of NVM, S/N 11110.
Source: Service Engineering ID 3-3494066228.



Buffer	Fault Code	Intermittent Count	Internal Flight Leg	Elapsed Time Counte [h:m:s	e [psi]	Cabin Pressure [psi]	Ambient Pressure Rate [SLFPM]	Cabin Pressure Rate [SLFPM]	Cruise Flight Level [FL]	Landing Field Elevation[ft]
19	022 CAS1 FAIL	1	35251	51029:	0	13.389.648		0.000000	390.000.000	2.700.000.000
20	031 AC RATE HIGH FAIL	0	35261	51060:08:09.95	14.125.000	14.057.617		585.250.000	115.000.000	1.650.000.000
21	022 CAS1 FAIL	0	35283	51133:09:55.95	13.462.891	13.474.609		.000000	370.000.000	50.000.000
22	030 INFLOW LEAKAGE FAIL	0	35299	51177:3	70	11.185.547	-199	50.000	390.000.000	200.000.000
23	031 AC RATE HIGH FAIL	0	35395	51459:0	625	14.697.266	-773	750.000	370.000.000	0.000000
24	030 INFLOW LEAKAGE FAIL	0	35447	51597:5	75	12.158.203	-484	0.000	300.000.000	2.450.000.000
25	030 INFLOW LEAKAGE FAIL	0	35459	51639:06:37.25	2.997.070	11.302.734	-14.750.000	489.000.000	380	0
26	017 CABIN 1000 FT MESSAGE FAIL	2	35459	51639:08:20.40	3.626.953	10.104.492	-1.097.750.000	1.197.750.000	380	0
27	018 CABIN 13500 FT MESSAGE FAIL	0	35459	51639:10:48.45	5.744.141	8.805.664	-2.055.500.000	774.000.000	380	0
28	090 OFV_CAB_PRESS_SWITCH_STATUS	0	35459	51639:11:36.70	6.587.891	8.416.992	-2.276.500.000	1.152.500.000	380	0
29	022 CAS1 FAIL	0	34431	48666:50:20.25	13.456.055	13.459.961	0	0.000000	390.000.000	2.650.000.000
30	022 CAS1 FAIL	0	34540	48982:48:2		13.457.031	0.	000000	360.000.000	2.450.000.000
31	022 CAS1 FAIL	0	34570	49068:56:0		14.657.227	0.	000000	370.000.000	0.000000
32	023 CAS2 FAIL	0	34570	49068:56:0		14.657.227	0.000000	0.000000	370.000.000	0.000000

Figure 5 - Operating parameters of NVM, S/N 2341.
Source: Service Engineering ID 3-3494066228.

Of all the recorded parameters, the most significant was the Cabin Pressure Rate, columns highlighted by the red arrows. This parameter was measured in SLFPM and recorded the reason why the pressure inside the valves varied in relation to the pressure at sea level. In other words, the variation of this parameter indicated the reason for the decrease or rise of the PCCVs.

The NVMs recorded values of Cabin Pressure Rate of the valves in the order of 1,198,250,000 and 1,197,750,000 SLFPM. It should also be noted that the parameters were recorded to six decimal places, so that the last six figures refer to thousandths and millionths of feet per minute. Thus, the recorded values corresponded to 1,198ft/min and 1,197ft/min.

According to the Service Engineering ID 3-3494066228, the recorded values represented a high rate of climb from the cabin, indicating a low inflated air flow into the aircraft, according to the text in the comment boxes highlighted by the red rectangles in Figures 4 and 5.

The PCCVs were sent to Honeywell to be dismantled and inspected internally. It was found that there were flaws such as gap in the butterfly plate, in addition to clogging and leakage of internal holes.

1.17 Organizational and management information.

Nil.

1.18 Operational information.

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

The aircraft took off from SBBE to SBEG to perform a regular passenger flight. It was the second leg of the day for that crew. The first leg was completed by the crew on the same aircraft, between the cities of Fortaleza - CE, and Belém - PA, without any abnormality in the pressurization system being detected.

There were no abnormalities during the takeoff, climb and leveling phases. During the cruise flight, with the aircraft leveled on the FL380, the BLEED TRIP OFF lights in the pressurization panel were switched on, first from the left Bleed Valve and then from the right Bleed Valve (Figures 6 and 7).

Figure 6 - Boeing 737NG Overhead Panel.
Fonte: Flight Crew Operations Manual (FCOM).

Figure 7 - Pressurization panel, with emphasis on the BLEED TRIP OFF lights.
Source: FCOM.

According to the FCOM, the amber BLEED TRIP OFF light came on when there was excessive temperature or pressure in the bleed air from the engines. When this happened, the respective valve closed automatically.

After the BLEED TRIP OFF lights were turned on, the pilots observed that the cabin's climb/descent ratio indicator had a positive ratio in the order of 2,000ft/min (Figures 8 and 9).

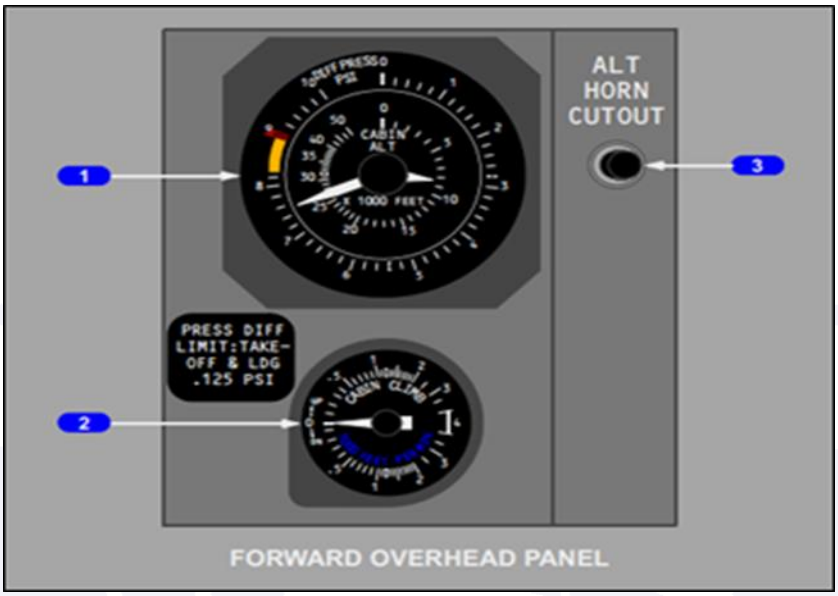


Figure 8 - Cabin altitude panel.
Source: FCOM.

Figure 9 - Representation of a cabin climb marking 2,000ft/min positive.
Source: Adapted from FCOM.

Given the situation, the pilots tried to control the cabin altitude by switching the pressurization system from automatic control mode (AUTO) to alternate mode (ALTN) and manual mode (MAN). However, they were not successful (Figure 10).

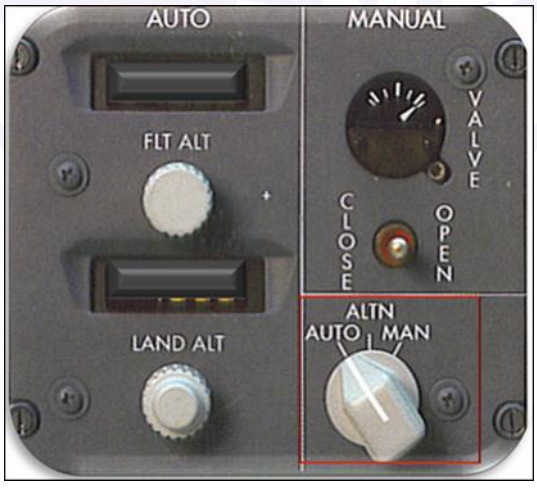


Figure 10 - Pressurization control modes.

Despite the pilots' actions, the cabin climb remained positive. In order to minimize the consequences of depressurization, the pilots declared an emergency and started a descent to the FL100, in coordination with the air traffic control agency.

The cabin altitude continued to rise and, when the aircraft crossed the FL300, it reached 14,000ft. At that moment, the oxygen masks automatically dropped from their compartments.

After the descent, the aircraft was leveled at the FL100, 80 NM far from the destination. In coordination with the operator's management, it was decided to continue on this flight level until Manaus - AM.

The landing took place without additional abnormalities.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a regular passengers flight.

The crew took over the aircraft in Fortaleza - CE, and completed the first leg to Belém - PA, without any abnormality related to the pressurization system. The second leg of the crew consisted of a flight between Belém - PA, and Manaus - AM.

The take-off, climb and leveling phases were completed normally. The cruise flight was performed with the aircraft leveled on the FL380. During the cruise flight, the BLEED TRIP OFF lights of both pressurization systems (right and left) were switched on, indicating abnormality.

The pilots observed that the cabin altitude started to increase at a rate of 2,000ft/min. In an attempt to control the cabin altitude, they changed the control modes of the pressurization system to Alternate (ALTN) and Manual (MAN), but were unsuccessful.

Despite the pilots' actions, the cabin climb remained positive. In order to minimize the consequences of a depressurization, the pilots declared an emergency and started a descent to the FL100, in coordination with the air traffic control agency. However, even making an emergency descent, the cabin reached 14,000ft of altitude and the oxygen masks automatically fell from their compartments.

After the descent, the flight continued on the FL100 to its destination, without further abnormalities.

The SSMCVR analyzes showed that all the pilots' actions during the management of the abnormal condition were well coordinated and were in accordance with what the aircraft and operator's manuals recommended.

At the beginning of 2005, operators of Boeing 737NG began to report situations of malfunction of the PCCV valves that, consequently, led to the depressurization of the aircraft.

The numerous reports led Boeing and Honeywell, manufacturers of the aircraft and the PCCVs, respectively, to take a series of actions to try to solve the problem.

In June 2010, companies instituted a program to convert the PCCVs model PN 3289562-5 to PCCV PN 3289562-6. However, the PCCVs PN 3289562-6 started to fail with less than 2,000 hours of operation, due to the wear of the Servo Valve Pivot Lever, a problem that did not occur with the PCCVs of the previous model (PN 3289562-5).

In January 2013, a new PCCV model, PN 3289562-7, was implemented. The intention of the companies was to start a program to convert the PCCVs PN 3289562-5/-6 to PCCV PN 3289562-7, by the end of 2013. However, the PCCVs PN 3289562-7 started to show premature failures with approximately 1,000 operating hours. In view of this scenario, the conversion program was canceled.

In January 2014, from the LN 4735, Boeing removed the PN 3289562-7 PCCVs from the production line, replacing them with the PN 3289562-5, because this component has greater reliability than the PN 3289562-6/-7 models.

Finally, in July 2014, Boeing started the implementation of a new PCCV model, PN 63292146-1, intended to replace previous models, PN 3289562-5/-6/-7.

The new PCCVs were incorporated into the production line of the Boeing 737NG from the LN 6109, delivered to its operator on 10JUL2016, a date considerably later than the manufacturing date of the PR-GOV (1998).

The aircraft manufacturer recommended that operators contact local Honeywell representatives to replace old PCCVs with PN 63292146-1 valves. However, it did not impose restrictions on the operation with PCCV of previous PN installed, as long as the operators monitor the pressure in the system ducts.

In this way, the PR-GOV continued to operate with two PCCVs PN 3289562-5 installed. The operator performed the pressure monitoring in the system ducts through the Pneumatic Duct Pressure Survey. Research data, conducted in the six months preceding the occurrence, showed that the PCCVs installed on the aircraft were operating within the limits established by the manufacturer.

Although the data collected indicate a functioning within the parameters, it was a component with a low level of reliability, due to its history of failures.

The PCCVs were sent for laboratory exams. When disassembled, it was found that, internally, there was clearance in the butterfly plate, in addition to clogging and leaks in the internal holes. These failures had a history of problems related to their project, especially with regard to the established material, which caused the components to fail prematurely.

The NVMs of the PCCVs recorded that the valves had a cabin pressure rate variation of approximately 1,200ft/min. These climb rate values were consistent with a situation of low low cabin inflow.

The data extracted from the NVMs, associated with the pilots' reports and the system's BLEED TRIP OFF alerts, are clear indications that the PCCVs have failed, leading to a low inflated air flow into the cabin and the consequent depressurization of the aircraft.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilots had valid B739 aircraft type Rating (which included the 737-76N model) and IFRA Ratings;

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

d) the aircraft had valid CA;

e) the technical maintenance records were updated;

f) there was a history of low reliability related to the PCCVs in Boeing's worldwide fleet;

g) in early 2005, operators reported anomalies in the PCCVs PN 3289562-5;

h) in June 2010, Boeing and Honeywell instituted a program to convert the PCCVs PN 3289562-5 to PCCVs PN 3289562-6;

i) the PCCVs PN 3289562-6 started to fail with less than 2,000 hours of operation;

j) in January 2013, a new PCCV model, PN 3289562-7, was implemented;

k) the PCCVs PN 3289562-7 began to show premature failures with approximately 1,000 hours of operation;

l) in January 2014, the PCCVs PN 3289562-7 were removed from the Boeing production line, being replaced by the old ones of PN 3289562-5;

m) in July 2014, Boeing started the implementation of a new PCCV model, PN 63292146-1;

n) the new PCCVs were incorporated into the production line of the Boeing 737NG from the LN 6109, delivered to its operator on 10JUL2016;

o) there were no restrictions on the operation with PCCV of previous PN installed;

p) the PR-GOV continued to operate with two PCCVs PN 3289562-5 installed until the day of the occurrence;

q) weather conditions were favorable for the flight;

r) the crewmembers took over the aircraft in Fortaleza - CE;

s) the first leg between Fortaleza - CE and Belém - PA, occurred without abnormalities in the pressurization system;

t) the second leg of the day for that crewmembers began between the cities of Belém - PA, and Manaus - AM;

u) the take-off, climb and leveling phases occurred without abnormalities and the cruise flight was developed in FL380;

v) during the cruise flight on FL380, the aircraft had a cabin depressurization;

w) the pilots adopted the actions prevised in the manufacturer's and operator's manuals, in an attempt to control pressurization, but were not successful;

x) a descent to FL100 was carried out, a level that was kept until the destination;

y) oxygen masks automatically dropped from their compartments;

z) examinations performed on the PCCVs installed on the aircraft indicated that the valves had clearance in the butterfly plate, in addition to cloggings and leaks in the internal holes;

aa) data extracted from the NVMs of the PCCVs installed on the aircraft indicated that they failed in flight, causing a low cabin inflow;

bb) cabin pressure rate variations of approximately 1,200ft/min were recorded;

cc) the landing took place without additional abnormalities;

dd) the aircraft was not damaged; and

ee) all occupants left unharmed.

3.2 Contributing factors.

- **Design – a contributor.**

The PCCVs PN 3289562-5/-6/-7 had a history of problems related to their project, especially with regard to the established material, which caused the components to fail prematurely.

The aircraft manufacturer, together with the valve manufacturer, implemented several actions to mitigate these failures. However, the components continued to have a low reliability index until a new PCCV, PN 63292146-1 was developed and introduced to the production line of Boeing 737NG aircraft.

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".

Nil.

The corrective action adopted was considered adequate to mitigate the wealthy associated with the identified contributing factor.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

All the PCCVs in the operator's fleet have been replaced by new PN 63292146-1 valves, which are more reliable and less susceptible to the problems observed in the previous PNs.

On November 16th, 2021.