Technical report

IN-005/2022

Incident on 8 February 2022, involving a BOEING B767-332ER aircraft operated by Delta Air Lines, registration N1602, in UIR LECM (Galicia, Spain)

MINISTRY OF TRANSPORT AND SUSTAINABILITY MOBILITY

DEPUTY SECRETARY

CIVIL AVIATION ACCIDENT AND INCIDENT INVESTIGATION COMMISSION

FOREWORD

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident and its causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.6 of Regulation (UE) nº 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1 and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

Comisión de Investigación de Accidentes e Incidentes de Aviación Civil – CIAIAC

Subsecretaría
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CONTENTS

ABBREVIATIONS

°C	Degrees Celsius (centigrade)
AC	Alternate current
ACARS	Aircraft Communication Addressing and Reporting System
ACC	Area Control Centre or Area Control
AEMET	State Meteorological Agency
AESA	Spain's National Aviation Safety Agency
AMM	Aircraft maintenance manual
APU	Auxiliary power unit
ATC	Air Traffic Control
ATPL(A)	Airline transport pilot license (aircraft)
BITE	Built-in test equipment
CAVOK	Clouds and visibility OK (visibility 10 km or more, no cloud below 5,000 feet, absence of cumulonimbus and towering cumulus and no significant meteorological phenomena)
CAS	Calibrated airspeed
CIAIAC	Civil Aviation Accident and Incident Investigation Commission
CPC	Cabin pressure controller
CVR	Cockpit voice recorder
DC	Direct current
EDDM	ICAO code for Munich-Franz Josef Strauss International Airport (Germany)
EICAS	Engine indicating and crew alerting system
FAA	United States Federal Aviation Administration
FAR	Federal Aviation Regulations
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FDR	Flight data recorder
FIC	Flight information centre
FIM	Fault isolation manual
FL	Flight level
ft	Feets
ft/min	Feets per minute
h	Hours
hPa	Hectopascals
IFR	Instrument flight rules
IPC	Illustrated parts catalogue
KATL	ICAO code for Hartsfield-Jackson International Airport (Atlanta, United States)
KJFK	ICAO code for John F. Kennedy International Airport (New York, United States)
kg	Kilograms
km	Kilometres
km/h	Kilometres per hour
kt	Knots
LEBL	ICAO code for Josep Tarradellas Barcelona-El Prat Airport (Spain)
LECM	Madrid FIC/ACC
LEMD	ICAO code for Adolfo Suárez Madrid Barajas International Airport (Spain)
LEST	ICAO code for Santiago/Rosalía de Castro Airport (Spain)

NVM	Non-volatile memory
m	Metres
M	Mach number
m^2	Square metres
MCC	Maintenance Control Centre
METAR	Aviation routine weather report (in aeronautical meteorological code)
MHz	Megahertzs
NM	Nautical miles
ICAO	International Civil Aviation Organisation
OBM	On-Board Manual
OFV	Outflow valve
PF	Pilot flying
PN	Part number
PM	Pilot monitoring
psi	Pounds per square inch
PSU	Passenger service units
QNH	Altimeter subscale adjustment to obtain elevation while over land (precision adjustment to indicate elevation above mean sea level)
QRH	Quick Reference Handbook
RD	Royal Decree
SB	Service Bulletin
SN	Serial number
TCP	Cabin crew
TLB	Technical log book
EU	European Union
UIR	Upper flight information region
UTC	Coordinated universal time
Vmo/Mmo	Maximum operating speed or maximum operating mach number
WAFC	World Area Forecast Centre

Technical report

IN-005/2022

Owner:	Delta Air Lines
Operator:	Delta Air Lines
Aircraft:	BOEING B767-332ER, N1602 (United States)
Date and time of the incident:	8 February 2022, 6:24 h[1]
Site of incident:	UIR LECM (Galicia)
Persons on board:	9 (crew members), 59 (passengers)
Type of flight:	Commercial air transport - Scheduled - International - With passengers
Phase of flight:	En route
Flight rules:	IFR
Date of approval:	**31 May 2023**

Synopsis

Summary:

On Tuesday, 8 February 2022, the Boeing 767-332ER aircraft operated by Delta Air Lines was en route between John F. Kennedy International Airport in New York (USA) and Adolfo Suárez Madrid Barajas International Airport (Spain).

The aircraft's technical logbook stated that, during the previous flight, the automatic pressurisation control had failed and that once on the ground, maintenance had carried out the relevant checks but had not found any anomalies.

When the aircraft was flying over the Atlantic Ocean, the crew received an indication of a failure of the automatic cabin pressurisation system. From that moment on, the crew began manually controlling the cabin pressure[2] and

[1] Unless otherwise indicated, all times in this report are expressed UTC. Local time at the departure airport (New York) can be calculated by subtracting 5 hours from the UTC. Local time at the destination airport (Madrid) can be calculated by adding 1 hour to the UTC

[2] In this report, the cabin pressure inside the aircraft cabin is expressed in psi or its cabin altitude equivalent in ft.

continued the flight. While flying over Galicia in the Iberian Peninsula, the cabin pressure dropped due to a loss of manual control of the pressurisation system. The crew had to use their oxygen masks, and the passenger oxygen masks were also deployed. The crew declared an emergency and descended. Subsequently, after regaining manual control of the pressurisation system, the aircraft climbed to continue the flight and landed at the destination airport without further incident.

The occupants of the aircraft were unharmed, and the aircraft did not sustain any damage.

After the flight, maintenance inspected the aircraft and found ice on the outflow valve, a tube near the valve leaking water, and a broken plastic clamp securing the tube.

The investigation has revealed that the incident was caused by water leaking from a tube with a broken clamp which, when it froze, blocked the outflow valve doors.

The following factors are thought to have contributed:

- The use of plastic tube clamps in the vicinity of the OFV (section 46), the deterioration of which had previously caused leaks in other incidents in the avionics compartment (section 41), where they had since been replaced by metal clamps.
- The absence of a fault in the BITE ground test performed prior to the flight.
- The fact that there is no requirement to perform a visual inspection of the OFV during Task 803 of 21-31 of the FIM when the automatic pressurisation system becomes inoperative in flight, the manual operation is normal, and the BITE does not detect a fault on the ground.

Two safety recommendations have been issued to the operator to pass on the lessons learned from this event to the flight personnel and maintenance personnel.

A recommendation has been issued to the manufacturer of the pressure controller to assess the possibility that the CPC may not register a blockage of the OFV by an external element and the implications that this entails.

Lastly, two recommendations have been issued to the aircraft manufacturer with regard to considering replacing the plastic clamps and evaluating whether to include additional actions in Task 803 of 21-31 of the FIM when the BITE test returns no fault on the ground following a failure of the automatic pressurisation system with the manual control operating normally in flight.

1. FACTUAL INFORMATION

1.1. History of the flight

1.1.1. Information about the previous flight

On Monday, 7 February 2022, the BOEING B767-332ER aircraft operated by Delta Air Lines with registration N1602 flew from Josep Tarradellas Barcelona-El Prat Airport (LEBL, Spain) to New York John F. Kennedy International Airport (KJFK, United States).

During the flight, the automatic pressurisation control system became inoperative, producing a CABIN AUTO INOP warning to the crew while the aircraft was cruising at FL340. The flight proceeded to its destination and landed at 20:01 h without incident, with the cabin pressurisation being manually controlled.

The crew recorded the incident in the aircraft's technical logbook or TLB. Subsequently, the maintenance personnel carried out the required procedures to locate and remedy the failure of the automatic pressurisation system. The tests performed by maintenance (BITE test) did not return any fault indications, they did not find any fault history, and the system functioned normally. As a result, the aircraft was dispatched for its next flight with the automatic pressurisation system operative.

1.1.2. Information about the incident flight

Approximately four hours later, at 00:44:04 h on Tuesday, 8 February 2022, the aircraft with registration number N1602 and call sign DAL126 took off from New York John F. Kennedy International Airport (KJFK, United States) to carry out a commercial air passenger transport flight to Adolfo Suárez Madrid Barajas International Airport (LEMD, Spain).

The flight crew consisted of three pilots: a captain under supervision, a line training captain and a co-pilot.

1.1.2.1. Cruise

At 03:42:44 h, when the aircraft was flying over the Atlantic Ocean at FL370, the CABIN AUTO INOP warning illuminated on the flight deck, indicating to the pilots that the automatic pressurisation system had failed. At the time, the flight deck was occupied by the line training captain (PM) and the co-pilot (PF). According to the crew, they referred to the *Quick Reference Handbook (QRH)*[3], began manually controlling the cabin pressurisation and notified maintenance via ACARS[4]. Maintenance indicated that one of their assumptions was that the outflow valve (OFV) was affected by a water leak but that they could move it.

At 06:24:44 h, when the aircraft was flying over Galicia, the CABIN ALTITUDE[5] warning was activated, indicating that the cabin altitude had exceeded 10000 ft.

Moments later, at 06:25:31 h ATC instructed the aircraft to descend to FL340. The flight deck, at that time, was occupied by the captain under supervision (PF) and the co-pilot (PM). They acknowledged the instruction and commenced the descent.

1.1.2.2. Descent to the safety altitude

The pilots had started the memory items for the excessive cabin altitude procedure, putting on their oxygen masks and establishing communications with each other. The PM tried to control the cabin altitude without satisfactory results, reaching a cabin altitude of close to 15500 ft when the aircraft reached FL340. Moments earlier, in the passenger cabin, the passenger and cabin crew oxygen masks had been automatically deployed[6].

Meanwhile, the flight attendants, who had been on their feet finishing the breakfast service, put on their oxygen masks and took their seats. The flight attendants indicated that all passengers were seated and had put on their oxygen masks.

At 06:28:35 h and approaching FL340, the flight crew requested further descent, after which they were cleared to descend to FL300.

ATC asked the aircraft if the reason for continuing to descend was turbulence, to which the flight crew replied that they were having difficulties with the cabin pressurisation.

[3] Version dated 27 September 2021.

[4] A coded communications system (compliant with ARINC standards) between an aircraft and a ground station. It is used in aviation by airlines to monitor the status of the aircraft in flight and to carry out operational and logistical communications. It provides maintenance with information about the aircraft's condition and any possible faults before its arrival, allowing them to plan the tasks they will need to perform in advance.

[5] According to the data extracted from the FDR. The pilots recall receiving this warning as they were descending through FL340.

[6] See section 1.6.4

The cabin altitude reached approximately 18400 ft, and at 06:30:07 h, as the aircraft was descending through FL320, the flight crew declared an emergency, requesting clearance to descend to 10000 ft.

Meanwhile, the line training captain, who was in the crew rest area, saw the oxygen masks deploy in the passenger cabin and returned to the flight deck. After entering the flight deck, the captain under supervision informed him that an emergency had been declared, and they were descending.

The line training captain took the right-hand seat, the co-pilot moved to the jump seat, and they re-fitted their oxygen masks. According to his statement, he tried to control the OFV during the descent, and before levelling off at FL120, he managed to regain manual control of it.

At 06:35:13 h, the CABIN ALTITUDE[7] warning was deactivated, and at 06:36:48 h, the aircraft reached and maintained FL120. The cabin altitude had descended to approximately 8000 ft.

The flight crew contacted the cabin crew to enquire about the condition of the passenger cabin. The cabin crew informed them that both they and the passengers appeared to be fine and that there were no signs of any injuries. After that, the line training captain, at the request of the captain under supervision, informed the purser that they would continue the flight to Madrid and that he would make a passenger announcement to explain what had happened.

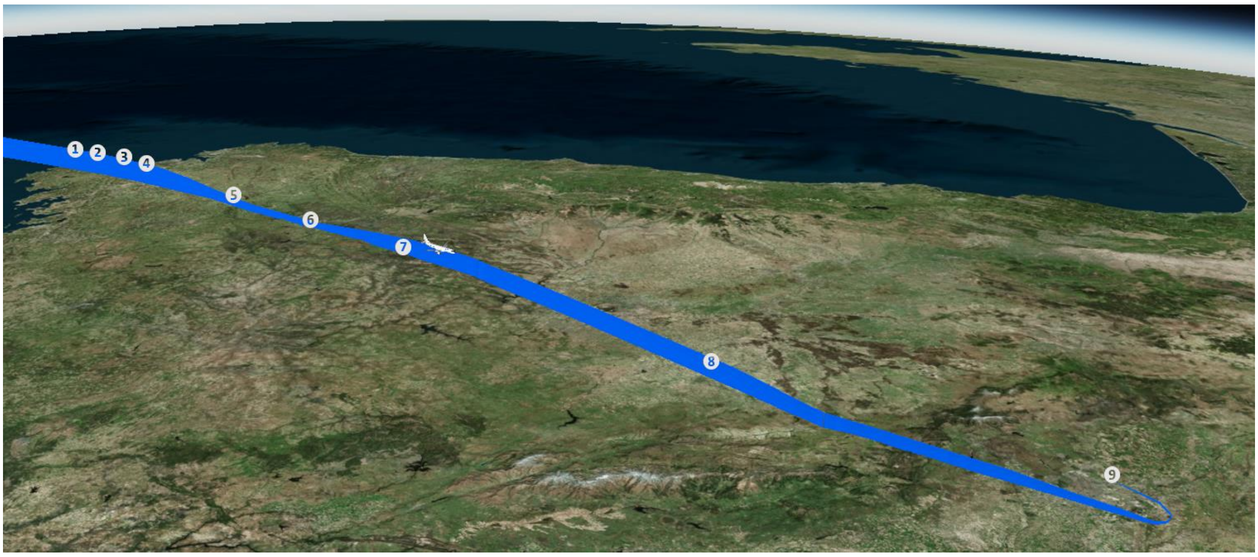
At 06:39:08 h, the flight crew informed ATC that they had regained control of the pressurisation and that the emergency was over.

1.1.2.3. Continuation of the flight and landing

ATC requested information about their intentions and asked if they were able to climb, to which the crew replied in the affirmative. ATC subsequently cleared the aircraft to climb to FL280.

At 06:44:56 h, the aircraft reached FL280, which it maintained for approximately 13 minutes until 06:57:59 h. At that time, it began its descent towards LEMD, where it landed on runway 32L at 07:16:06 h. During this period, there were no further incidents with the manual pressurisation control.

[7] See section 1.6.3



(1)	06:24:44	FL370	Activation of CABIN ALTITUDE warning
(2)	06:25:31	FL370	ATC request to initiate descent
	06:26:11	FL370	Start of descent
(3)	06:28:35	FL340	Estimated position when the passenger oxygen masks were deployed
(4)	06:30:07	FL320	Emergency declaration
	06:31:07	FL300	Extension of speedbrakes
(5)	06:36:15	FL120	Aircraft at FL120
(6)	06:39:42	FL120	Start of climb to FL280
(7)	06:44:56	FL280	Aircraft at FL280
(8)	06:57:59	FL280	Start of descent from FL280
(9)	07:16:06	GND	Landing at LEMD

FIG. 1 FLIGHT PATH FROM ACTIVATION OF CABIN ALTITUDE WARNING TO LANDING.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor				
None	9	59	68	
TOTAL	9	59	68	

1.3. Damage to the aircraft

The aircraft did not sustain any damage.

1.4. Other damages

There was no further damage.

1.5. Personnel information

1.5.1. Flight crew

The flight crew consisted of three pilots:

<u>Line training captain</u>

The 52-year-old line training captain had an airline transport pilot license (ATPL (A)) issued by the Federal Aviation Administration (FAA) with a valid B767 rating.

He also had a Class 1 medical certificate, with a last recognition date of 20 December 2021, valid and in force at the time of the event.

He had been working for the operator for 22 years. His total and recent experience both on the type of aircraft involved in the incident and in total on other types is shown below:

	Last 24 h (h)	Last 90 days (h)	Total (h)
Hours in type	00:00	129:16	4540:00[8]
Total	-	-	8835:00[9]

He had rested for 8 days before the flight. During the flight, he acted as PM and provided training to the captain under supervision for his promotion to B767-type captain.

On 22 December 2021, he received recurrent training in which, some syllabi contain abnormal pressurization operations, including emergency descent.

Captain under supervision

The 48-year-old captain under supervision had an airline transport pilot license (ATPL (A)) issued by the FAA with a valid B767 rating.

He also had a Class 1 medical certificate, with a last recognition date of 18 November 2021, valid and in force at the time of the event.

He had been working for the operator for 21 years. His total and recent experience both on the type of aircraft involved in the incident and in total on other types is shown below:

	Last 24 h (h)	Last 90 days (h)	Total (h)
Hours in type	00:00	38:01	5248:00[8]
Total	-	-	12493:00[10]

He had rested for 7 days before the flight. During the flight, he acted as PF and was being trained for promotion to B767-type captain by the line training captain.

On 9 January 2022, he received recurrent training in which, some syllabi abnormal pressurization operations, including emergency descent.

[8] With the operator.

[9] 8835 h with the operator and a total of approximately 12000 h reported by the pilot.

[10] 12493 h with the operator and a total of approximately 20000 h reported by the pilot.

Co-pilot

The 48-year-old co-pilot had an airline transport pilot license (ATPL (A)) issued by the FAA with a valid B767 rating.

He also had a Class 1 medical certificate, with a last recognition date of 2 December 2021, valid and in force at the time of the event.

He had been working for the operator for 4 years. His total and recent experience both on the type of aircraft involved in the incident and in total on other types is shown below:

	Last 24 h (h)	Last 90 days (h)	Total (h)
Hours in type	00:00	171:06	2604:00[11]
Total	-	-	2604:00[12]

He had rested for 4 days before the flight. The co-pilot was acting as the relief pilot, occupying the seat of whichever pilot (PF or PM) was resting.

On 5 February 2022, he received recurrent training in which, some syllabi contain abnormal pressurization operations, including emergency descent.

1.5.2. Cabin crew

The cabin crew consisted of 1 purser and 5 flight attendants.

The 60-year-old purser covering door 1L, had 32 years of experience with the operator.

The 51-year-old flight attendant covering door 1R had 24 years of experience with the operator.

The 53-year-old flight attendant covering the MID-L-CENTER door, had 2 years of experience with the operator and had been flying with other operators since 1997.

The 60-year-old flight attendant covering the MID-R-CENTER door, had 30 years of experience with the operator.

The 52-year-old flight attendant covering door 2L had 14 years of experience with the operator.

The 29-year-old flight attendant covering door 2R had 7 years of experience with the operator.

[11] With the operator

[12] 2604 h with the operator and a total of approximately 20000 h reported by the pilot.

According to the information provided by the operator, they had all rested for at least 6 days prior to the flight, except for the cabin crew member covering gate 2L, who had rested for 89 hours.

1.5.3. Maintenance personnel

The 35-year-old maintenance technician who serviced the aircraft before the flight had 9 years of experience with the operator.

The operator was asked about the age and experience of the Maintenance Control Centre (MCC) coordinator who communicated with the aircraft during the incident flight via ACARS, but as of the date of this report, this information has not been provided to the investigation.

1.6. Aircraft information

1.6.1. General information

The B767-332ER aircraft, registration N1602, is a twin-engine medium and long-range wide-body aircraft designed to carry passengers and cargo. The aircraft is a low-wing monoplane with a semi-monocoque metal airframe and retractable tricycle landing gear. Its general specifications are as follows:

• Manufacturer	BOEING COMPANY
• Model	B767-332
• Year of manufacture	1999
• Series number	29694
• Maximum landing weight	145149 kg
• Maximum take-off weight	186880 kg
• Maximum zero fuel weight	133809 kg
• Passenger capacity	216
• Engine type	CF6-80C2B6F
• Information about the owner and operator	Delta Air Lines
• Wingspan	50.88 m
• Length	54.94 m
• Height	15.85 m
• Vmo/Mmo	360 kt/ 0.86 M
• Maximum operating altitude	43100 ft

At the time of the incident, the aircraft had 99721.5 h and 13978 cycles. The flights and cycles of its engines are shown below:

Series number	Total hours	Total cycles
706619	53957	9253
704233	91431	15396

1.6.2. Airworthiness status

The aircraft was registered with the FAA on 25 January 1999, with an expiry date on 30 June 2022.

It held a transport category certificate of airworthiness issued by the FAA on 22 January 1999 with indefinite validity provided preventative maintenance and alterations are performed in accordance with FAR Parts 21, 43 and 91.

It should be noted that the OFV installed on the aircraft was identified with PN 606832-1 Series 1 and SN 79-2452. The last inspection of this part and its motors were carried out on 10 December 2021. The OFV was cleaned, inspected and checked at that time.

We consulted the operator about the maintenance records for the water line PN 79211-012 and the clamp PN CA62507-56BL, and it informed us that both were the original factory-fitted parts.

1.6.3. Information about the pressurisation control system

Section 21-31-00 of the *Aircraft Maintenance Manual (AMM)*[13] and Chapter 2 of the *BOEING Flight Crew Operations Manual (FCOM)*[14] provide information on the cabin pressurisation control system.

The pressurisation control system provides a comfortable and safe pressure inside the cabin during flight. To achieve this, the air conditioning system supplies a constant flow of conditioned air to the cabin, and the pressurisation system regulates the amount of air that is exhausted through the OFV overboard.

The pressurisation system has two modes of operation, automatic and manual.

[13] Version dated 22 December 2014.

[14] Version dated 18 April 2021.

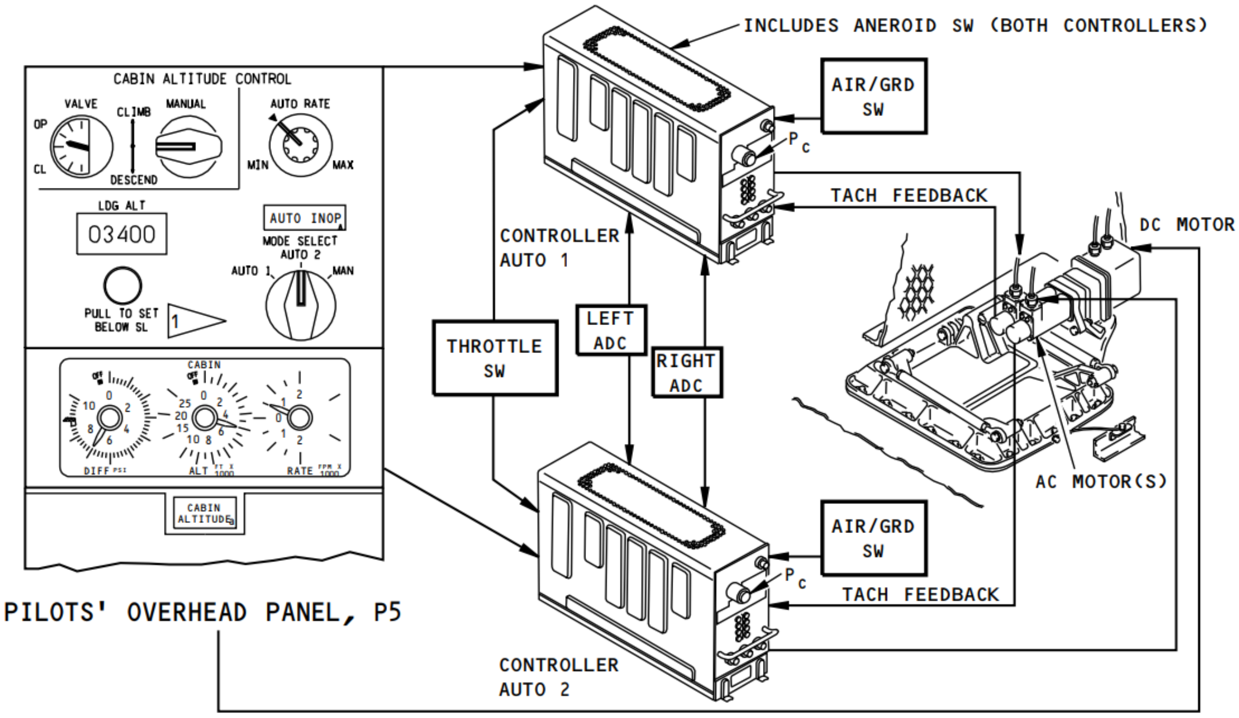


FIG. 2 PRESSURISATION CONTROL SYSTEM[15]. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

The automatic mode consists of two pressure controllers (CONTROLLER AUTO 1 and CONTROLLER AUTO 2) that automatically regulate cabin pressurisation through the OFV. The controllers are programmed to maintain an ideal cabin pressure depending on the aircraft's flight altitude.[16]

If the selected cabin pressure controller or CPC fails, control automatically switches to the other pressure controller.

If both automatic pressure controllers fail, the CABIN AUTO INOP warning is activated on the flight deck, and the flight crew can control the OFV manually from the pressurisation panel located on the pilots' overhead panel.[17] In this situation, the QRH provides a guide so that the pilots can set the recommended cabin altitude for each flight altitude.

If the cabin altitude exceeds 10000 ft, an excessive cabin altitude warning system alerts the crew. The warning deactivates when the cabin altitude returns to 8500 ft.

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[15] Image extracted from section 21-31-00 of the AMM (Figure 4/21-31-00-990-804).

[16] According to Figure 7/21-31-00-990-809 of the Boeing AMM, at FL350 and FL370, which were the cruise levels, they maintain approximately 5300 ft and 6200 ft of cabin altitude, respectively.

[17] See section 1.6.6

It should also be noted that each CPC is equipped with a Built-in Test (BITE) function that allows the system's integrity to be monitored and displays any previously recorded or existing faults. Performing this test on the ground helps maintenance, for example, to identify which system failure has generated a particular warning in the EICAS[18].

The CPC's non-volatile memory (NVM) stores one fault per flight for up to eight previous flights. This memory is manually erased at the end of the BITE test during reset.

More detailed information on the system's components is provided in section 5.1.

1.6.4. Information about the oxygen system

Point 1.40.6 of the BOEING 767-332ER FCOM describes the oxygen system. The system consists of two separate oxygen systems, one for the flight crew and one for the passengers. In addition, portable emergency oxygen cylinders are located throughout the aircraft.

Individual oxygen generators supply the oxygen system for the passengers, cabin crew positions and lavatories. Oxygen masks and oxygen generators are located above each group of seats in passenger service units (PSUs). The masks drop automatically from the PSUs if the cabin altitude exceeds 14000 ft and can also be deployed manually from the flight deck by pressing the passenger oxygen switch. Once deployed, when the masks are pulled, oxygen flows through them for 12 minutes.

1.6.5. Information about the water system

Section 38-10-00 of the AMM provides information on the aircraft's water system. The system has three tanks for storing potable water.

Supply tubes distribute potable water from the water tank to the lavatories and galleys. These tubes are flexible and made of Teflon with a reinforced nylon coating. The supply tubes run from below the water tank to just below floor level. These tubes run to all the kitchens and washbasins from below or through the part.

One of the water supply tubes is located near the OFV at station 1562.

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[18] A video of the BITE test referenced by the manufacturer in its Service Information Letter (SIL) regarding the CPC fault isolation and reset procedure (Revision 0 of 15 June 2018) can be found at the following link: https://www.youtube.com/watch?v=lzxcW5FuQUc

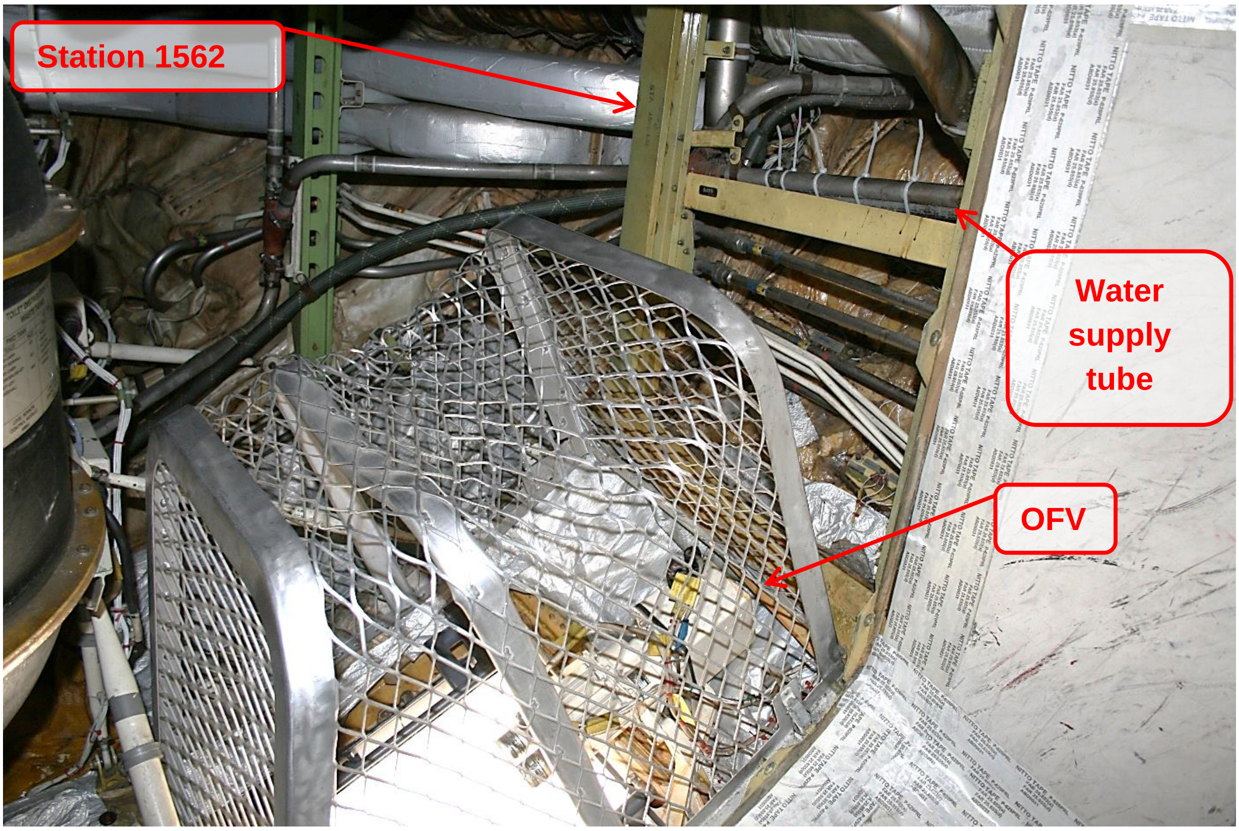

FIG. 3 POSITIONS OF THE OFV AND WATER SUPPLY TUBE

1.6.6. Inoperative automatic cabin control procedure

Section 2.7 of the operator's Boeing 767-332ER QRH contains the procedure to be followed by the flight crew if the automatic pressurisation control failure warning is activated. An extract is shown below:

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DELTA 2.7
767-300 Operations Manual

AUTO INOP **CABIN AUTOMATIC INOPERATIVE**

Messages: CABIN AUTO INOP

Condition: One of these occurs:
- The automatic pressurization control is failed
- The cabin altitude mode selector is in manual

1 CABIN ALTITUDE MODE SELECT . . . . MAN

Use momentary actuation of the cabin altitude manual control to avoid large and rapid pressurization changes.

2 CABIN ALTITUDE MANUAL control . . . . Move to CLIMB or DESCEND as needed to control cabin rate and altitude

Note: Recommended cabin rate is approximately 500 FPM for climbs and descents.

Recommended cabin altitude in cruise is:

FLIGHT LEVEL	CABIN ALTITUDE
Up to 230	Landing Field Elevation
260	2000
300	4000
350	6000
400 and above	8000

3 **Checklist Complete Except Deferred Items**

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November 10, 2017 2.7

FIG. 4 EXTRACT OF THE CABIN AUTOMATIC INOPERATIVE PROCEDURE.

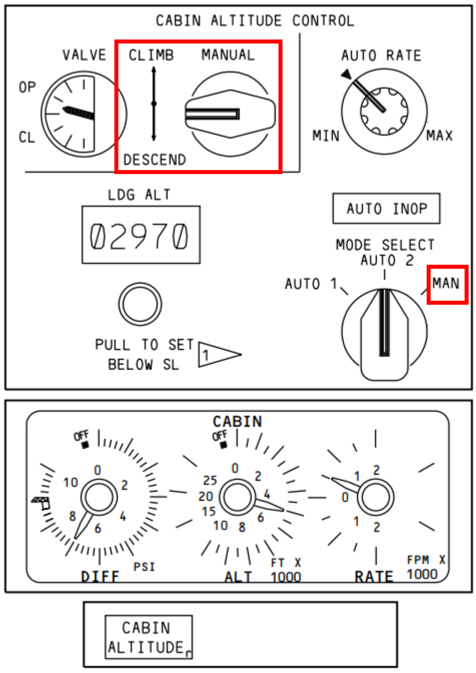

FIG. 5 CONTROL PANEL, INDICATION OF PRESSURISATION AND CABIN ALTITUDE LIGHT[19]. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

The procedure requires pilots to set the mode selector to manual (MAN) and, using the manual cabin altitude control switch, control the cabin altitude by making the necessary adjustments to keep it within the desired range.

Turning the switch to DESCEND closes the OFV and increases cabin pressure. Turning the switch to CLIMB opens the OFV and decreases cabin pressure.

For reference, the procedure provides a guide with recommended cabin altitudes for different flight altitudes. When flying at FL350, the recommended cabin altitude is 6000 ft; at FL400 or above, it is 8000 ft.

Pilots can verify the result of these actions through the cabin altitude, climb/descent rate and differential pressure indicators located on the same panel.

[19] Image extracted from section 21-31-00 of the AMM (Figure 501/21-31-00-990-819).

1.6.7. Excessive cabin altitude or rapid decompression procedure

Section 2.1 of the operator's Boeing 767-332ER QRH[20] contains the procedure to be followed should the cabin altitude warning be activated, which was the procedure used by the pilots. The procedure is shown below:

DELTA
767-300 Operations Manual
2.1

CABIN ALT

CABIN ALTITUDE
or
Rapid Depressurization

CABIN ALTITUDE

Messages: CABIN ALTITUDE

Condition: A cabin altitude exceedance occurs.

1 Don the oxygen masks.

2 Establish crew communications.

- -

3 Check the cabin altitude and rate.

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

To descend:

Select lower altitude on MCP and select FLCH.

Move the thrust levers to idle.

Extend the speedbrakes.

If structural integrity is in doubt, limit airspeed and avoid high maneuvering loads.

Descend at VMO/MMO.

4 **If** the cabin altitude exceeds 14,000 feet:

PASS OXY switch . . . . Push and hold for 1 second

▼ Continued on next page ▼

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2.2
DELTA
767-300 Operations Manual

▼CABIN ALTITUDE or Rapid Depressurization continued▼

5 Advise the cabin by PA when the descent is complete and use of the oxygen system can be discontinued. Request passenger and cabin status.

172, 174, 179, 185-187, 191-192, 194

Caution! Speedbrakes may autostow to the 50% flight detent if airspeed exceeds 320 knots. Do not override autostow function unless airspeed is less than 315 knots.

■ ■ ■ ■

VALVE

APU BLEED VALVE

Messages: APU BLEED VAL

Condition: The APU bleed valve is not in the commanded position.

■ ■ ■ ■

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FIG. 6 PROCEDURE TO BE FOLLOWED IN THE EVENT OF CABIN ALTITUDE WARNING OR RAPID DEPRESSURISATION

First, the procedure requires that the pilots put on their oxygen masks and establish communication between themselves. These first two actions are performed by memory. Next, the procedure requests that the cabin altitude and rate parameters be checked so that the pilots can determine whether the cabin is controllable or uncontrollable (see indicators in Figure 5). It also states that descent should be initiated without delay to the higher of the following two altitudes, 10000 ft or the lowest available safety altitude.

[20] In the CABIN ALTITUDE or Rapid Depressurisation procedure provided by the manufacturer, the emergency descent is performed when the cabin is uncontrollable and forms part of the procedure's memory items, as it can be seen on appendix 5.5.

If the cabin altitude has exceeded 14000 ft, the switch located on the flight deck that deploys the passenger oxygen masks must be activated. Lastly, advise the passenger cabin when the descent is complete and use of the oxygen system can be discontinued, and request passenger and cabin status.

Additionally, chapter 7.5 of the operator's *Flight Crew Training Manual (FCTM)*[21] contains basic techniques and procedures in regard to performing a rapid or emergency descent due to depressurisation.

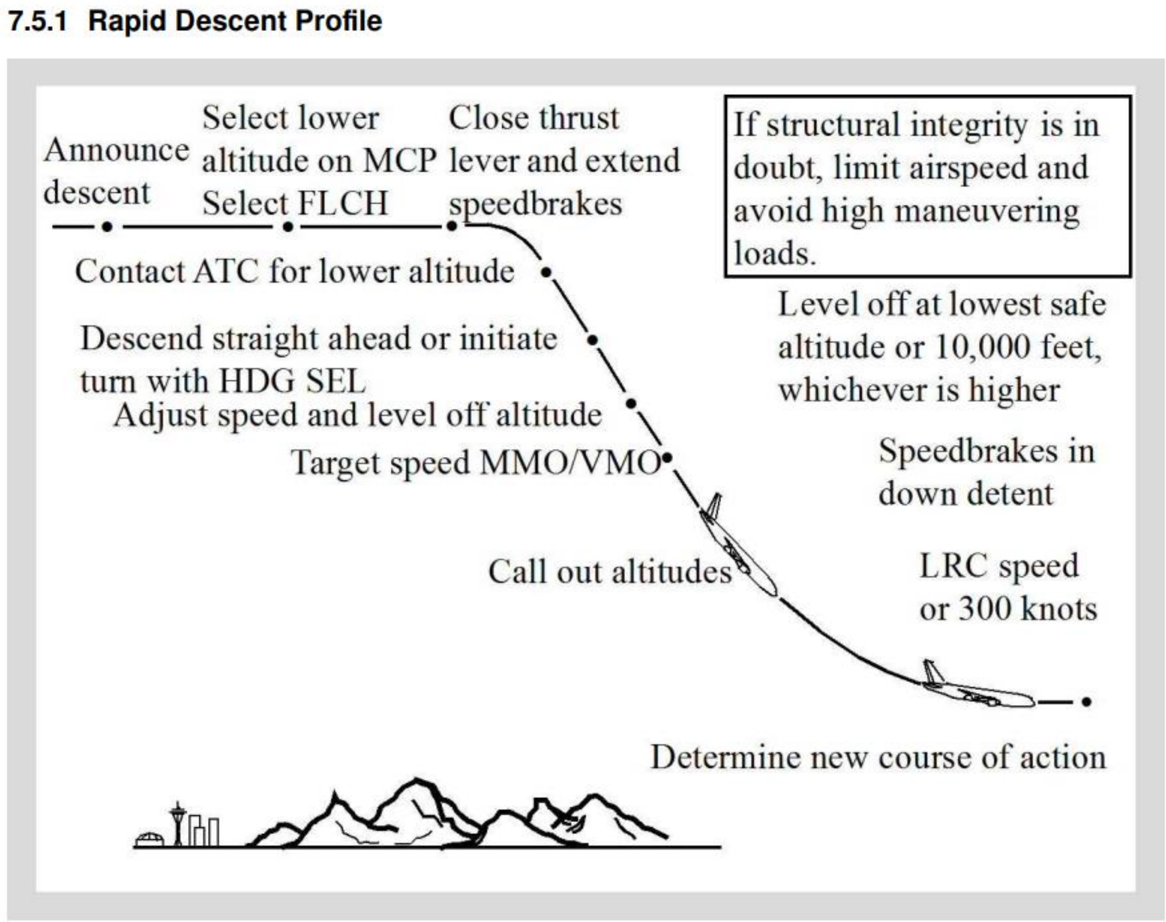


FIG. 7 EXTRACT FROM THE OPERATOR'S FCTM CONTAINING THE RAPID OR EMERGENCY DESCENT PROFILE

This manual explains that once the aircraft has levelled off after descent, the new course of action is determined based on weather, oxygen, remaining fuel, medical condition of crew and passengers, terrain and available airports.

According to the flight crew, after descending to the safety altitude at FL120, they decided to continue to the destination (they were approximately 250 NM away) as the weather

[21] Version 3.0.0. dated 7 June 2021.

conditions were favourable and they had regained manual control over the pressurisation. The cabin crew had informed them that both they and the passengers were fine.

In addition, they decided to climb and were cleared to FL280. They explained that they based their decision on optimising the remaining fuel, and although ATC had given them the minimum safe altitude of FL120, they also considered flying at a higher altitude for better terrain clearance.

They do not recall having taken coordination measures to deal with the fact that the oxygen masks in the passenger cabin had been deployed and the oxygen generators had been activated.

1.6.8. Decompression response procedure for cabin crew

A decompression response procedure for cabin crew can be found in section 3.4.3 of the *On Board Manual (OBM[22])* on Specific Risks and Emergencies. An extract is shown below:

To respond to decompression:
1. Don nearest oxygen mask.
2. Sit down and fasten seat belt. If a vacant seat is not available, sit on an armrest and/or stabilize yourself wherever you are.
3. Instruct passengers to: • Remove face covering, don mask, sit down, and fasten seat belt. • Adjust their own masks before assisting others. • Remove eye glasses (as needed). • On the 717, instruct passengers to remove mask from open PSU panel. *NOTE:* Use situational awareness to determine best method to instruct passengers (e.g., use of automatic decompression announcement, use of PA system to deliver announcement, shouting instructions). *NOTE:* Passengers using a Portable Oxygen Concentrator (POC) should discontinue use of POC and use the O2 mask from the PSU.

To respond to decompression: (Continued)
4. Once Captain indicates aircraft has reached a safe altitude, obtain PO_2 bottle and check cabin. • Visually check lavatories for passengers. • Walk through cabin and reassure passengers. • Check for structural damage or other potential danger. • Reseat passengers as necessary. *NOTE:* As needed, use PO_2 to administer oxygen to self, while checking cabin and assisting passengers.
5. Check passengers and other crewmembers for injuries and administer first aid as needed (may include supplemental oxygen).
6. Report situation to flight deck crew.
7. Have passengers place used oxygen masks in their seat pockets, if possible. Do not restow or attempt to pull masks out of PSUs.
8. Prepare cabin and passengers for landing, according to flight deck crew's instructions.

FIG. 8 EXTRACT FROM THE DECOMPRESSION RESPONSE PROCEDURE FOR CABIN CREW

In summary, the procedure instructs cabin crew members to don an oxygen mask and sit down. It then stipulates that they should instruct passengers to remove their COVID-19 face coverings, don oxygen masks and fasten their seat belts.

[22] Version dated 16 March 2021

Once the captain indicates that the aircraft has reached a safe altitude, check the well-being of the passengers and the integrity of the cabin. Coordinate with the flight crew and prepare the cabin for landing as instructed.

According to the cabin crew members, the incident occurred as they were finishing the breakfast service. After automatic decompression announcement was made to the passengers, they secured the trolleys and sat down, putting on their oxygen masks. During the descent, they instructed the passengers to put on their oxygen masks. After receiving the captain's message that the descent was complete, they used the portable oxygen cylinders while checking on the well-being of the passengers and found that they were all well.

The line training captain informed the purser and explained what had happened to the passengers. According to the cabin crew, the information provided to the passengers by the line training captain reassured and comforted them.

1.7. Meteorological information

1.7.1. Information about the general meteorological conditions

According to the information provided by AEMET, the meteorological conditions at altitude over the North Atlantic were dominated by a slightly cyclonically curved polar jet stream with a maximum speed of 160 kt. This configuration created a favourable environment for high-level turbulence, which could occasionally be strong up to FL420. In the Atlantic basin, there were also isolated and embedded cumulonimbus clouds whose tops reached FL320.

Meanwhile, the presence of a closed anticyclonic circulation over the Iberian Peninsula was diagnosed, with a quasi-zonal westerly jet stream with a speed of 140 kt in the north and another zonal jet stream from the east over the Gulf of Cádiz with a speed of 80 kt.

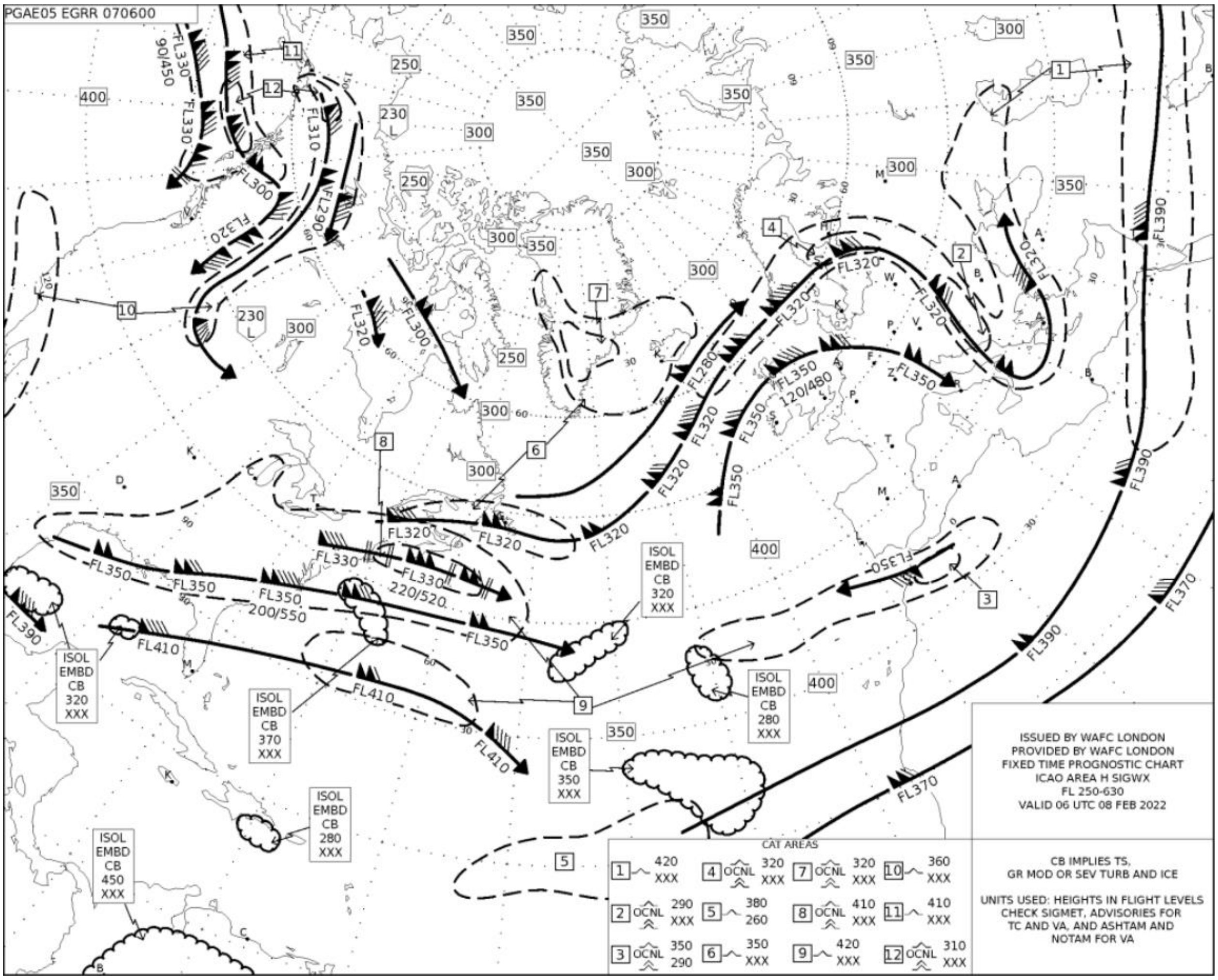


FIG. 9 SIGNIFICANT PHENOMENA MAP FOR FL 250 - FL 630 ON 8 FEBRUARY 2022 AT 06:00:00 H FORECAST BY LONDON WAFC

The surface analysis at 00:00:00 h (see 5.3) shows the presence of a powerful and extensive anticyclone centred on France and a low-pressure system over the Moroccan and Saharan Atlantic coast. The extreme north of the Iberian Peninsula is affected by persistent cloud.

1.7.2. Meteorological information for the incident area.

According to the information provided by AEMET, the incident zone was affected by locally reduced visibility mainly due to haze or fog, with zero-degree isotherm at FL120. Additionally, and towards the north coast, locally cloudy skies with cumulus and stratocumulus with bases at FL 10 - FL 20 and tops at FL 30 - FL 40 along with turbulence at low levels between the surface and FL 20 - FL 30 were forecast.

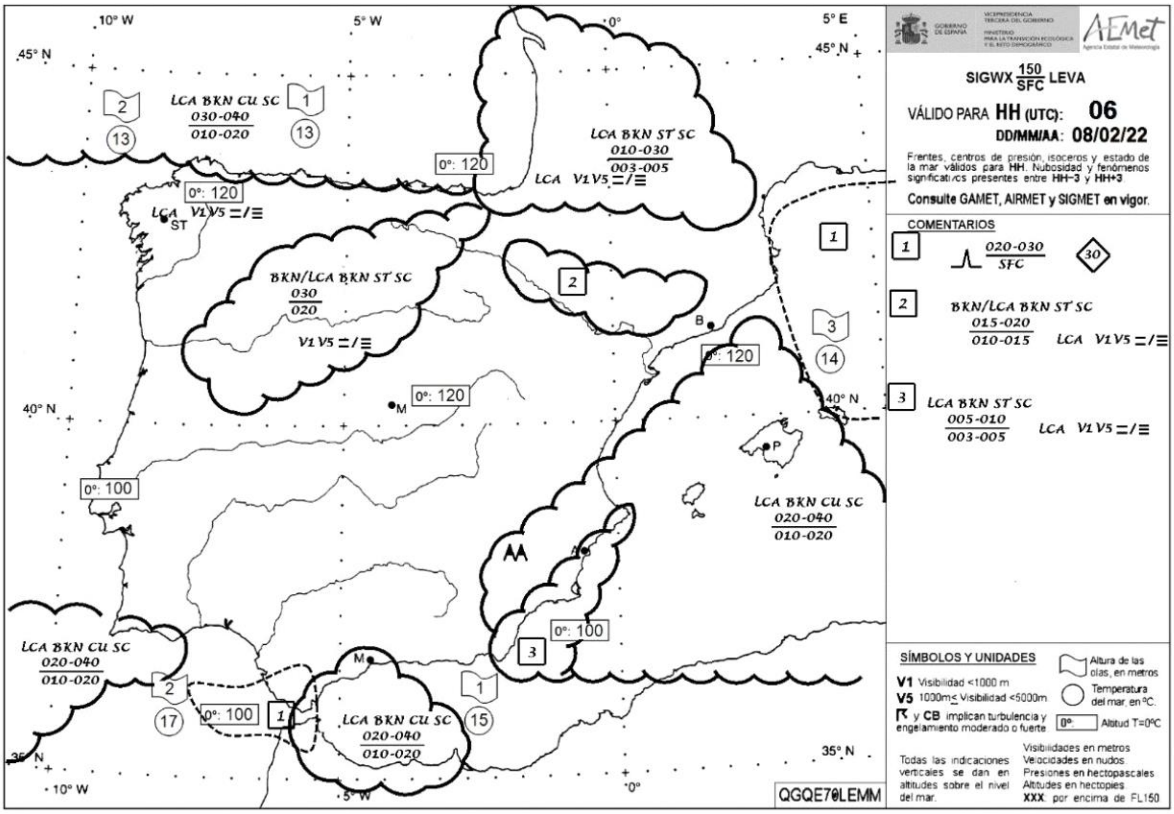


FIG. 10 LOW LEVEL FORECAST FOR 8 FEBRUARY 2022 AT 06:00:00 H

Being in the vicinity of the area of the incident, we have included the following METAR for Santiago de Compostela Airport, where the weather conditions were favourable:

METAR LEST 080630Z 10006KT CAVOK 05/03 Q1027 NOSIG=

Wind direction 100º with a speed of 6 kt. Visibility greater than 10 km, absence of clouds below the reference height, no cumulonimbus or tower-shaped cumulus clouds, and no significant weather phenomena. The temperature was 5°C, the dew point was 3°C and the QNH was 1027 hPa. No significant changes were expected.

On the section of the route between Santiago de Compostela and Madrid, the weather was also favourable, and the flight flew over an area of stratus and stratocumulus clouds with bases in the FL 20s and tops in the FL 30s.

At the destination airport, LEMD, the weather conditions were favourable. The airport METAR at 06:30 UTC and 07:30 UTC were as follows:

METAR LEMD 080630Z 36002KT CAVOK 01/M02 Q1030 NOSIG=
METAR LEMD 080730Z 35002KT CAVOK 01/M03 Q1031 NOSIG=

The wind was from the N with a speed of 2 kt. Visibility greater than 10 km, absence of clouds below the reference height, no cumulonimbus or tower-shaped cumulus clouds, and no significant weather phenomena. The temperature was 1°C, the dew point between -2°C and -3°C and the QNH was between 1030 hPa and 1031 hPa. No significant changes were expected.

1.8. Aids to navigation

Not applicable.

1.9. Communications

The most relevant communications between the flight crew and the air traffic control service and a translated extract of the content of the flight's ACARS messages with the maintenance centre have been incorporated into section 1.11 on flight recorders.

1.10. Aerodrome information

Not applicable.

1.11. Flight recorders

The aircraft was equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR), which recorded the last 25 and 2 hours of flight, respectively.

The flight data recorder (FDR) was from the manufacturer Fairchild, model F1000, with part number S800-2000-00 and series number 02415.

The cockpit voice recorder (CVR) was from the manufacturer L3, model FA 2100, with part number 2100-1025-22 and series number 000926076.

The download of both recorders was performed at the CIAIAC laboratory. The information downloaded from the CVR could not be used in the investigation as the recorded interval did not contain the period in which the pressure loss occurred.

Below, the extracted information is segregated into different phases. This section also integrates the communications with ATC and the ACARS communications with the MCC. Graphs depicting the information extracted from the FDR can be found in section 5.4.

The autopilot and the autothrottle were engaged throughout the flight.

1.11.1. Take-off, climb to final cruising level FL370 and CABIN AUTO INOP warning

At 00:44:04 h, the aircraft took off from KJFK airport in New York.

At 01:01:36 h, the aircraft reached FL350, which was its initial cruise level. While the aircraft was flying at FL350, the cabin pressure[23] inside the cabin was 12 psi (5500 ft cabin altitude).

At 02:17:16 h, the aircraft left FL350 climbing to FL370.

At 02:18:56 h, the aircraft reached FL370, which was the final cruise level. The internal cabin pressure was 11.7 psi (6100 ft of cabin altitude).

At 03:42:44 h, the CABIN AUTO INOP warning was activated, indicating that the automatic pressurisation system had failed. According to the pilots, the pressurisation was switched to manual control.

At 03:59 h, the flight crew contacted the MCC via ACARS to inform them that the automatic pressurisation system had failed and they were controlling it manually. From this time until 04:15 h the following messages were exchanged:

- MCC asked them which mode they were in (AUTO 1 or AUTO 2) and if they had received any status messages.
- The flight crew replied that they were previously in AUTO 2, that AUTO 1 wasn't working, and that they had control over the OFV, but it wasn't smooth.
- MCC replied that the manual DC motor has more power than the AUTO AC motor and that their concern was that there was a water leak in the valve, but that they could move it.

From the moment the pressurisation was switched to manual control until seven minutes before the CABIN ALTITUDE warning was activated, the pressure inside the cabin varied between 10.3 psi minimum and 11.9 psi maximum (approx. between maximum 9500 ft and minimum 5700 ft cabin altitude).

[23] This value is recorded every 64 seconds by the flight data recorder.

1.11.2. Activation of CABIN ALTITUDE warning

At approximately 06:17:04 h, when the aircraft was flying at FL370, the cabin pressure inside the cabin, which was 11.4 psi (6800 ft cabin altitude), began to decrease.

Seven minutes later, at 06:24:44 h, the cabin pressure inside the cabin had reduced to approximately 10.1 psi (10000 ft cabin altitude) and the CABIN ALTITUDE and MASTER WARNINGS were activated. The MASTER WARNING was deactivated 2 seconds later.

At 06:25:31 h, ATC instructed the aircraft to start a descent to FL340. The flight crew acknowledged the clearance.

At approximately 06:26:11 h, the aircraft started the descent from FL370 to FL340.

- At 06:26:40 h, while descending through 36600 ft, the internal cabin pressure value was approximately 9.3 psi (12100 ft cabin altitude).
- At 06:27:44 h, while descending through 35100 ft, the internal cabin pressure value was approximately 8.9 psi (13200 ft cabin altitude).

During its descent from FL370 to FL340, the aircraft’s maximum vertical speed was -1792 ft/min.

At 06:28:35 h, the aircraft reached FL340. At the same time, the aircraft requested clearance to descend to a lower altitude and had to repeat their request at 06:28:43 h, after which ATC cleared them to descend to FL300.

At 06:28:47 h, the internal cabin pressure was approximately 8.1 psi (15500 ft of cabin altitude). Since the passenger oxygen masks deploy automatically when the cabin altitude exceeds 14000 ft, they were probably deployed as the aircraft reached FL340.

1.11.3. Descent from FL340 to FL120 and emergency declaration.

At 06:28:54 h, ATC asked if they were experiencing turbulence. The pilots replied that they had no turbulence but that they were having some difficulty with cabin pressurisation. The aircraft continued its descent to FL300.

- At 06:29:51 h, while descending through 32700 ft, the internal cabin pressure was approximately 7.2 psi (18400 ft of cabin altitude).

At 06:30:07 h, the pilots declared an emergency and requested clearance to descend to FL100. ATC asked for confirmation that they were requesting a lower altitude, and after fifteen seconds, cleared them to descend to FL260. Another aircraft on the frequency then advised ATC that DAL126 had declared an emergency and was immediately descending to FL100.

At 06:30:12 h, the engines went to idle (43% N1)

At 06:30:55 h, while descending through 30400 ft, the internal cabin pressure was approximately 7 psi (19140 ft of cabin altitude). At this same time, ATC cleared flight DAL126 to descend immediately.

At 06:31:07 h, while descending through FL300, the deployment of the speedbrakes was recorded.

- At 06:31:59 h, while descending through 25600 ft, the internal cabin pressure was approximately 7.4 psi (17800 ft of cabin altitude).

The vertical speed during the descent reached - 5573 ft/min and the maximum CAS was 302 kt.

At 6:32:47 h, the LECM controller informed the aircraft that the sector’s minimum altitude was FL120, and the flight crew acknowledged this.

- At 06:33:03 h, while descending through 20700 ft, the internal cabin pressure was approximately 8.5 psi (14300 ft of cabin altitude).
- At 06:34:07 h, while descending through 16600 ft, the internal cabin pressure was approximately 9.6 psi (11300 ft of cabin altitude).

At 06:34:45 h, while descending through FL140, the speedbrakes began to retract.

At 06:35:11 h, while descending through FL130, the internal cabin pressure value was approximately 10.8 psi (8300 ft of cabin altitude), and the CABIN ALTITUDE warning was deactivated.

From the interviews, we know that the passengers were briefed over the public address system, but without the CVR data, we do not know at what point this occurred.

1.11.4. Flight at FL120, climb, cruise at FL280, descent, approach and landing

At 06:36:15 h, while maintaining FL120, the internal cabin pressure was approximately 10.7 psi (8200 ft of cabin altitude).

At 06:39:08 h, the flight crew informed ATC that they had regained control of the pressurisation and that the emergency was over.

ATC requested information about their intentions and asked if they were able to climb, to which the crew replied in the affirmative.

At 06:39:26, ATC cleared the aircraft to climb to FL280.

After maintaining FL120 for approximately 4 minutes, at 06:39:42 h, the aircraft began to climb to FL280.

At 06:44:56 h, the aircraft reached FL280, which it maintained for approximately 13 minutes until 06:57:59 h. It then began its descent towards LEMD, where it landed on runway 32L at 07:16:06 h.

During these phases of flight, the cabin altitude varied between approximately 9000 ft and 2000 ft.

1.11.5. Preservation of the flight recorders

Annex 6 to the Convention on International Civil Aviation on the Operation of Aircraft, Part I on International Commercial Air Transport[24], states:

> *11.6 FLIGHT RECORDER RECORDS*
>
> *The operator shall ensure, to the extent posible, in the event the aeroplane becomes involved in an accident or incident, the preservation of all related flight recorder records and, if necessary, the associated flight recorders, and their retention in safe custody pending their disposition as determined in accordance with Annex 13.*

The information downloaded from the CVR could not be used in the investigation as the recorded interval did not contain the period in which the pressure loss occurred. The CVR recording started once the aircraft was parked on the ground at LEMD airport.

The investigation has not been able to access the organisation’s Operations Manual. Therefore, the procedure that the operator establishes when an accident or serious incident occurs could not be accessed.

1.12. Wreckage and impact information

The landing was carried out without incident. After landing, the aircraft stopped on a parking stand, and the passengers disembarked normally without using the emergency exits. The aircraft did not sustain any damage.

1.13. Medical and pathological information

Not applicable.

[24] Twelfth edition of July 2022 and eleventh edition of July 2018.

1.14. Fire

No fire broke out.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

1.16.1. Inspection of the pressurisation system and field tests

On the day of the incident, when the aircraft arrived in Madrid, the operator’s maintenance personnel reported that they had found ice in the OFV.

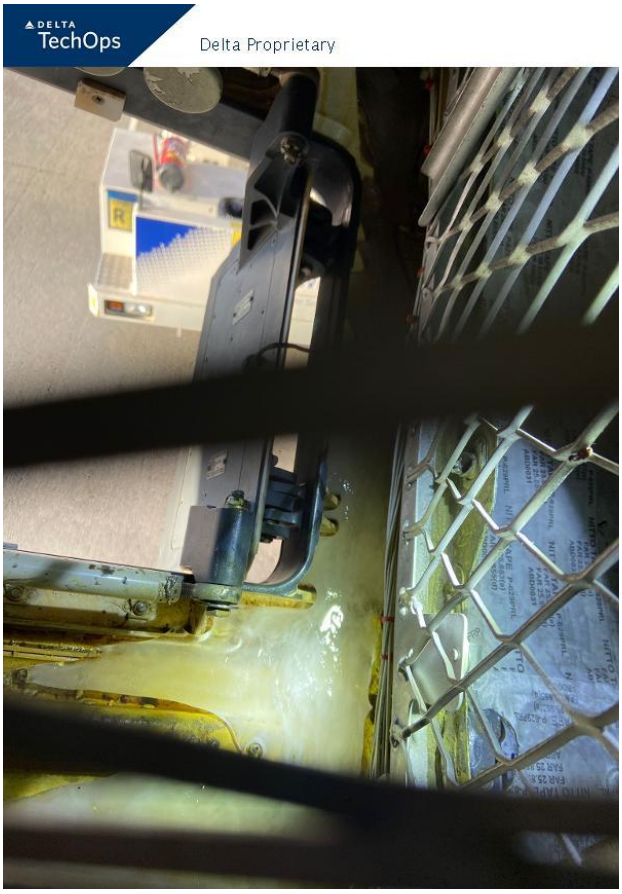


FIG. 11 REMAINS OF ICE IN THE OFV[25]

[25] Photo courtesy of DELTA TechOps.

When the CIAIAC inspected the aircraft on 9 February 2022, the protective cage of the OFV was removed, and the OFV was visually inspected. A functional in-aircraft test of the OFV was also carried out and confirmed that it was working correctly.

During the inspection, it was not possible to check the condition of the oxygen masks after the event because they had been stowed to prepare the aircraft for its return.

Subsequently, the operator’s maintenance personnel detected a water leak from the tube with PN 79211-012 underneath the rear galley at station 1562, which was secured with a broken plastic clamp with PN CA62507-56BL.

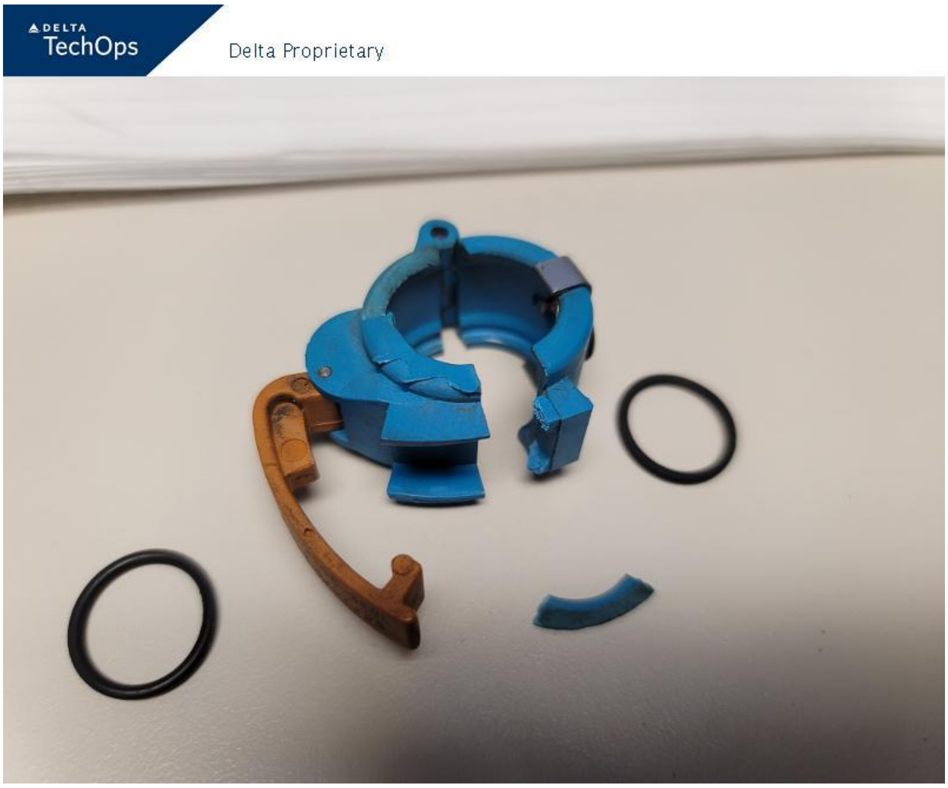


FIG. 12 CLAMP[26]

The image in Figure 3 shows the location of the water supply tube. In this area, the water leak was visible, but its exact origin was hidden. The images below show the location of the tube (number 90) and the clamp highlighted in red, with a close-up labelled as A:

[26] Photo courtesy of DELTA TechOps.

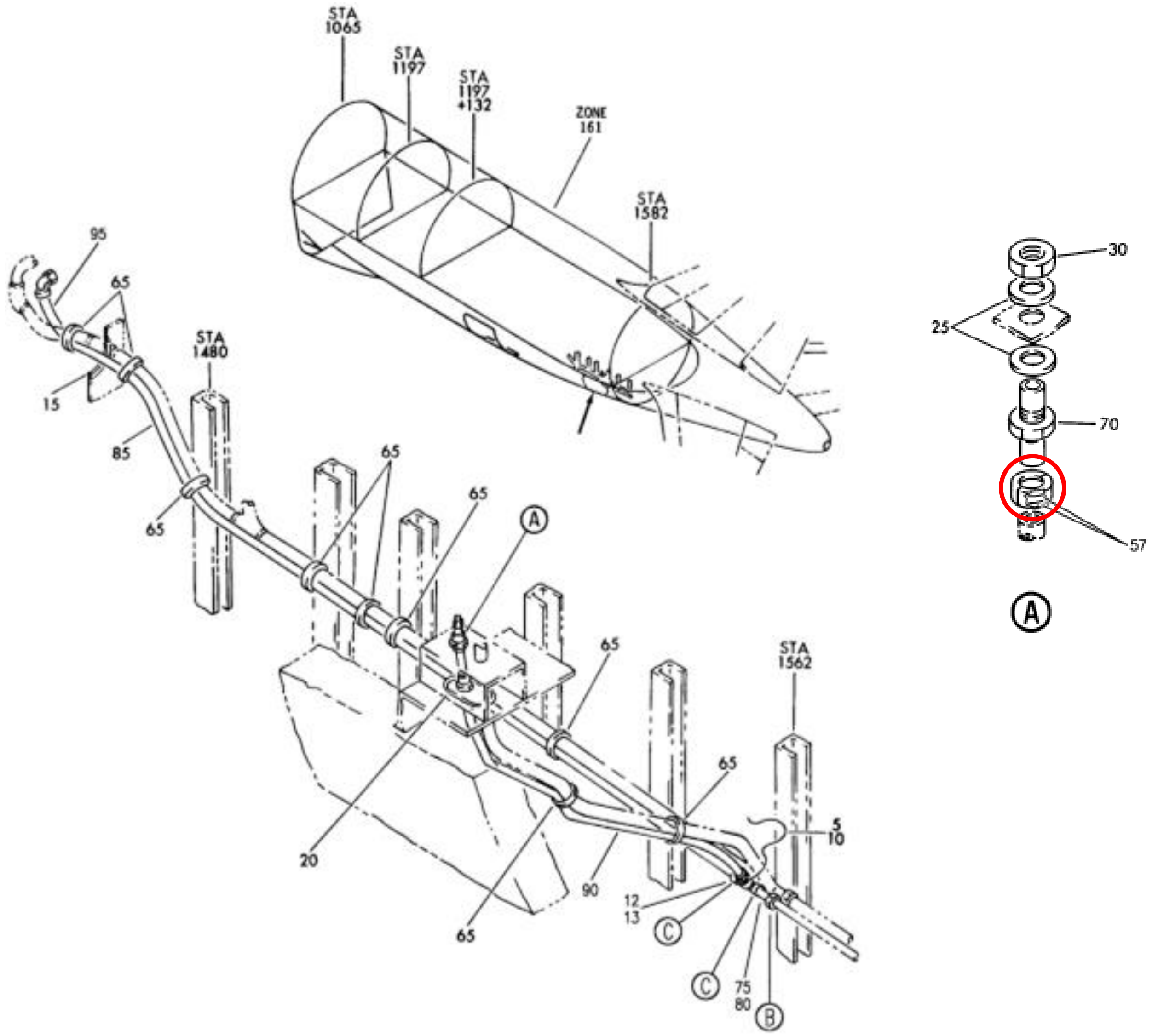


FIG. 13 LOCATION OF THE TUBE (NUMBER 90) AND THE CLAMP HIGHLIGHTED IN RED[27]. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

1.16.2. Ground BITE test of cabin pressure controllers

Section 21-31 of the *Aircraft Maintenance Manual (AMM)* contains task *21-31-00-705-001 BITE Test - Automatic Cabin Pressure Controllers*, which consists of a ground test of the CPC to check the system's integrity.

The main steps to follow to conduct the BITE test can be found in section 5.2.

This test was performed on the following occasions:

[27] Images extracted from section 38-11-57-59 of the *IPC*.

- On 7 February 2022, before the start of the incident flight, the operator's maintenance staff carried out a BITE test on both controllers at KJFK as the automatic cabin pressure control had failed during the previous flight and the flight had to be continued in manual mode. The maintenance personnel recorded in the aircraft logbook that they found no indications of a fault, could not duplicate the fault and found no history of faults.
- On 9 February 2022, before the arrival of the CIAIAC investigators, the maintenance staff performed a BITE test on both controllers, which, according to the information provided, no fault indication was found.
- Subsequently, in the presence of the CIAIAC, during the inspection carried out on the same day, the maintenance staff performed the BITE test again. Once more, no faults were detected, and the memories of both CPCs were cleared on completion.
- Maintenance re-ran the BITE test on both controllers on 2 March 2022 after the aircraft had completed several flights following the incident. No faults were detected.

1.16.3. Functional test of the OFV conducted by Honeywell

A visual inspection and functional test of the OFV was carried out on 2 August 2022 at Honeywell's premises. No anomalies were observed that would prevent normal operation.

1.17. Organizational and management information

During the investigation, we were unable to gain access to the organisation's *Operations Manual*.

1.18. Additional information

1.18.1. Information about similar events

We asked the operator for any reports of similar occurrences. Delta informed us of an incident involving a BOEING B767-332ER aircraft, registration N172DZ, on 10 February 2022 during flight DAL131 from Munich-Franz Josef Strauss International Airport (EDDM, Germany) to Hartsfield-Jackson Atlanta International Airport (KATL, United States).

During cruise, the flight crew received an AUTO INOP indication, consulted the QRH, began manual cabin pressurization control and contacted maintenance.

While in cruise over West Virginia, the flight crew noted that the OFV had stopped moving and the cabin altitude was increasing; the flight crew declared an emergency and initiated a descent.

The flight crew noted that the cabin altitude did not exceed 10500 ft and that the passengers' oxygen masks had not been deployed, so they continued to KATL without further incident.

Maintenance personnel inspected the aircraft and observed ice in the area around the OFV and a broken galley water line connector. Maintenance replaced the OFV and the water line connector.

1.18.2. Information provided by the CPC manufacturer

Given the circumstances of the incident, the manufacturer of the CPC was consulted.

The manufacturer would expect that the BITE ground test would not detect a fault, as the OFV would no longer be blocked after the ice melted, but indicated that it would expect there to have been an indication of an AC MOTOR fault, as the valve was stuck in a particular position and temporarily could not be controlled.

According to the SIL, the AC MOTOR fault indicates a problem with the AC motor circuit on the OFV, and could be caused by a problem with the OFV or in some cases with the output circuit on the CPC.

Task 803 of sections 21-31 of the FIM stipulates that if the AC MOTOR light comes on when performing the ground BITE test, the OFV actuator should be replaced as a first step to isolate the fault.

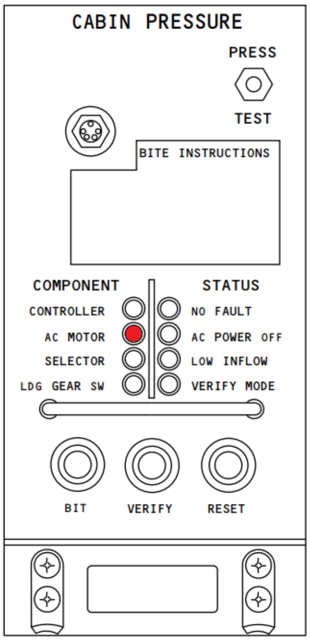


FIG. 14 CABIN PRESSURE CONTROLLER[28]. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

[28] Image extracted from section 21-31-00 of the AMM (Figure 5/21-31-00-990-805).

1.18.3. Troubleshooting actions.

We consulted the operator to obtain details of how the pre-flight troubleshooting procedure was carried out at KJFK prior to the incident flight.

According to the information provided, the troubleshooting was based on the pilot's report. TLB record 7989996 indicated "Cabin auto inop. Used manual to control cabin Alt".

The maintenance technician followed task *803* called *EICAS Msg CABIN AUTO INOP Shows -Fault Isolation* described in *Fault Isolation Manual (FIM) 21-31* and *AMM 21-31.* Task 803 with the message EICAS CABIN AUTO INOP and the manual operation functioning normally, consists of performing a BITE test on both controllers and reseting them at the end of the test if no fault has been detected.

Task 803 only requires a visual inspection of the OFV if the manual operation is not functioning normally.

It should be noted that during the investigation it was confirmed that the technician at KJFK did not consider the possibility of a water leak and a visual inspection of the OFV was not carried out.

1.18.4. Information on the Boeing 767-38A0073 service bulletin

On 12 November 2013, Boeing issued service bulletin 767-38A0073[29] to ensure through its compliance that the potable water system clamps in section 41 (forward section of the aircraft) would not leak water onto the electronic equipment in the main equipment centre (MEC), resulting in a short circuit and thus a potential loss of various functionalities essential for safe flight.

With the incorporation of this bulletin, the blue plastic clamps with PN CA6250()-56BL or PN CA6200()-56BL were replaced by purple metal clamps with PN 14C33-08.

The aircraft with registration N1602 was manufactured with plastic clamps, and this service bulletin was completed before the incident.

The image below shows the differences between the clamps. The first is the plastic clamp, and the second is the metal one.

[29] It was published in conjunction with ADs 2017-02-03 and 2018-01-02 to address the replacement of plastic clamps in the main equipment centre (MEC) of section 41.

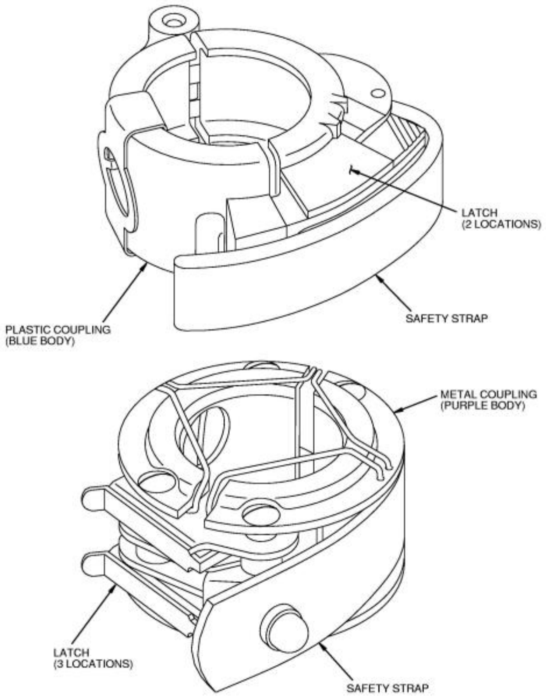


FIG. 15 PLASTIC AND METAL CLAMPS USED IN THE WATER SYSTEM[30]. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

The IPC provides one-way interchangeability from the plastic CA625 series to the metal 14C33 series. However, there are no publications explicitly addressing the need to make this change in section 46 (the section in which the OFV is located).

1.18.5. Actions taken by the operator

After the incident, the operator implemented the following actions to prevent a recurrence.

With regard to the pressurisation system, after identifying that the broken water line clamps associated with the incident (aircraft registration N1602) and the 10 February 2022 event (aircraft registration N172DZ) were plastic, Delta TechOps[31] developed a plan to replace them with a metal clamp on the B767-300/400 aircraft. As of 9 November 2022, all plastic clamps on in-service aircraft have been replaced.

[30] Image taken from Appendix B of Service Bulletin 767-38A0073.

[31] Delta TechOps is the maintenance, repair and overhaul division of Delta Air Lines.

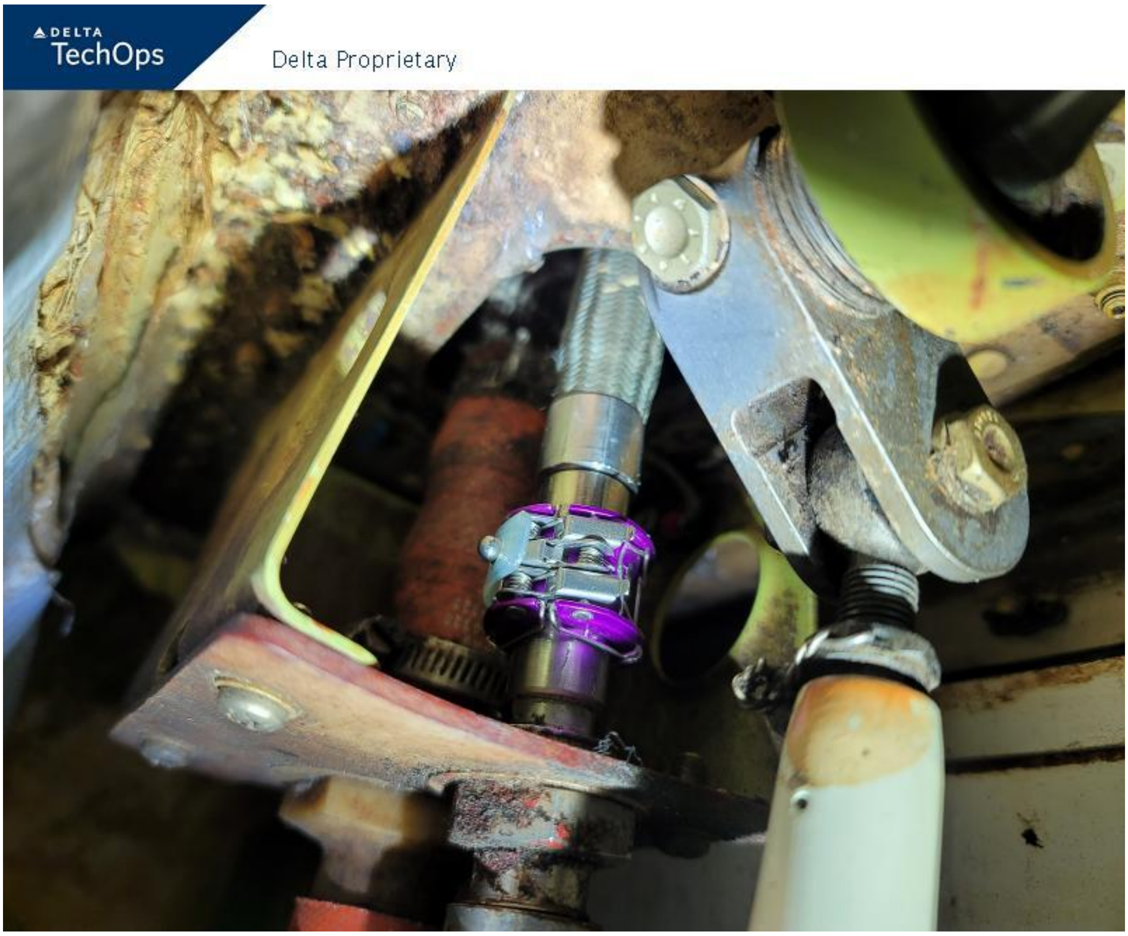


FIG. 6 REPLACEMENT METAL CLAMP.

Additionally, the 767-300 series aircraft with fittings instead of clamps had the drains cleaned and flushed to mitigate the possibility of overflow. Any aircraft that was not in service will have the fleet campaign actions performed prior to return to service.

The operator has not reported any further actions. An internal investigation report following the incident was not provided.

1.19. Useful or effective investigation techniques

None required.

2. ANALYSIS

The following aspects will be analysed: the leak, the use of plastic clamps, the detection and recording of the fault in the CPC memory, task 803 of section 21-31 of the FIM, the position of the OFV and the location of the ice, the management of the depressurisation and the continuation of the flight.

2.1. Analysis of the leak

Following the incident, the operator's maintenance personnel detected a water leak under the rear galley on the left side of the aircraft at station 1562, coming from a tube (PN 79211-012) secured with a broken plastic clamp (CA62507-56BL).

On the flight from Barcelona to New York, the water leak could have caused water to accumulate and ice to form, blocking the movement of the OFV and rendering the automatic pressurisation control system inoperative. The crew managed to control the cabin pressure manually, so the manual mode motor (DC motor) was able to move the OFV and overcome the ice blockage.

Subsequently, during the incident flight from New York to Madrid, the water leak could have once again caused ice to form, blocking the movement of the OFV and rendering the automatic pressurisation control system inoperative, with the situation being further aggravated when the manual control was also unable to overcome the OFV's ice blockage.

2.2. Analysis of the use of plastic clamps

Service Bulletin 767-38A0073 identified the potential for a ruptured plastic clamp to cause a water leak that could affect the electronic equipment in the forward section of the aircraft.

Despite the fact that the IPC provides one-way interchangeability from the plastic CA625 series to the metal 14C33 series, there are no publications explicitly addressing the need to implement said change in section in which the OFV is located (section 46).

As the OFV is an electromechanical device, using metal clamps in its vicinity could have mitigated the consequences of a water leak caused by a broken clamp and a subsequent OFV blockage.

The recording of another incident by the operator two days later, in which a broken plastic clamp led to the formation of ice on the OFV and the failure of the automatic in-flight pressurisation system, confirms the need for metal clamps to be used.

2.3. Analysis of the detection and recording of the fault in the CPC memory

According to the information provided by the CPC manufacturer, if an OFV blockage resulted in a temporary loss of control of the OFV, the in-flight BITE test would have detected and recorded the AC MOTOR fault in the memory.

According to the information received, on the ground, both the BITE test performed by the operator before the start of the incident flight, triggered by the CABIN AUTO INOP warning from the previous flight, and the test performed after the incident, did not find a fault.

The system had detected the failure in flight, but it could not subsequently recover it on the ground. This could be due to the fact that the fault was not recorded or that the BITE ground test was not executed as indicated in the task. The BITE test checks the system's integrity, but on these two occasions, the OFV blockage fault could not be recovered once on the ground. Consequently, we have concluded that the CPC manufacturer should assess the possibility that the system may be failing to record faults and consider the consequences because if the fault (AC MOTOR) had been recorded as expected, task 803 of sections 21-31 of the FIM would have indicated the need to replace the OFV actuator as a first step in attempting to isolate the fault and, therefore, would probably have resulted in the water being identified earlier. Also, given the possibility that the test may not have been executed as the task indicates, we believe it necessary for the operator to disseminate the lessons learned from this incident to the maintenance technicians.

2.4. Analysis of task 803 of 21-31 of the FIM

Before the incident flight, given the simultaneous failure of two independent pressure control systems with the manual system operating normally and a BITE test with no recorded failures, the possibility that the other common system components, including the OFV, may have failed, could have been considered despite the fact that running task 803 of the FIM through the BITE test determined that the system was okay.

Therefore, in the event of the automatic pressure control system becoming inoperative due to the failure of both the independent control systems but with the manual control functioning correctly, we believe the FIM should recommend additional inspections that would have identified the presence of water before the incident flight, such as a visual inspection of the OFV.

2.5. Analysis of the position of the OFV and the location of the ice

The graphs in Figure 23 show that following the failure of the automatic pressure control on the incident flight, the cabin pressure dropped and rose, signalling the active manual control by the crew. Therefore, the OFV was responding to the movements commanded by the crew. From 06:17:04 h, the pressure started to decrease until it reached 10 psi at 06:24:44 h. Consequently, we can determine that this is the period in which the OFV was blocked, leading to depressurisation. It is believed that the water froze in the control arm or the OFV actuator linkage, preventing the motors from closing the OFV.

2.6. Analysis of the management of the depressurisation

During the period that followed the activation of the CABIN ALTITUDE warning indicating that 10000 ft of cabin altitude had been exceeded, all the occupants (passengers and crew) used their oxygen masks, and the aircraft descended to a safe altitude.

Both pilots’ statements indicate that they performed the memory items associated with the CABIN ALTITUDE warning. According to the procedure, the actions required to commence the emergency descent manoeuvre after checking the cabin altitude and rate should have been performed without delay; however, despite having lost control of the pressurisation, they were not taken until six minutes after the warning activated, during which time the cabin altitude rose to 18400 ft, possibly because of the focus on regaining control.

According to the logic that automatically deploys the cabin oxygen masks and the in-cabin pressure data recorded on the FDR, they should have been deployed when the aircraft was near FL340. Despite not making the emergency descent to Vmo as per the CABIN ALTITUDE procedure, the aircraft reached FL120 approximately seven minutes later and within the capacity of the oxygen generators, during which time the passengers and cabin crew were supplied with oxygen through the masks.

On seeing the oxygen masks being deployed, the line training captain in the passenger cabin went to the flight deck and took the co-pilot’s seat. Although he thought the best decision was to exchange positions, in this situation and based on the information gathered during the investigation, there did not appear to be any circumstances in which swapping seats with the qualified, experienced and non-incapacitated co-pilot would assist in regaining control over the pressurisation and completing the emergency descent manoeuvre. For the duration of this exchange, only one pilot (the captain under supervision) remained in a cockpit seat with the oxygen mask in place and in charge of continuing the emergency descent manoeuvre.

This situation could have been avoided if the line training captain had occupied the jump seat using the oxygen mask and assisting the other two pilots through the emergency in the few short minutes that remained to reach a safe altitude.

The lack of a CVR recording covering the period of the incident limited the analysis of the events.

The cabin crew had extensive experience and were completing the breakfast service. They reported during their interviews that they responded to the loss of pressure by taking the actions described in paragraph 1.6.8, ensuring the welfare of the passengers.

On reaching the safety altitude, the line training captain informed the purser and explained what had happened to the passengers. During their interviews, the cabin crew explained that the information provided to the passengers by the line training captain reassured and comforted them.

2.7. Analysis of the continuation of the flight

The flight crew decided to continue to their destination airport in Madrid, from which they were approximately 250 NM away in favourable weather conditions. Having regained control of the pressurisation, they decided to climb, being cleared to FL280.

According to their account, they based this decision on optimising the remaining fuel and even considered flying at a higher altitude for better terrain clearance despite ATC informing them of the minimum altitude they could descend to.

During the prior emergency descent, the oxygen generators that supply the masks in the passenger cabin had been activated, the duration of which was limited. It should be noted that there were 59 passengers on board, i.e. approximately one-quarter of the passenger seats were occupied. During the loss of cabin pressure, the oxygen generators corresponding to these 59 seats were activated. The crew did not recall any coordination measures being taken in this regard.

On the other hand, the automatic pressurisation system had failed on two consecutive flights, and on this occasion, the manual control had also failed temporarily, which was indicative of some kind of anomaly in the pressurisation system and, therefore, a recurrence of the failure for the remainder of the flight could not be ruled out.

Furthermore, taking into account the fact that the crew have recently undergone refresher training on the pressurisation system, the issue of a safety recommendation to the operator to reinforce crew training related to cabin pressure loss and to include the lessons learned from this event is considered appropriate.

3. CONCLUSION

3.1. Findings

- During the flight before the incident, the automatic pressurisation control system became inoperative, and the flight was completed by manual control.
- The BITE test conducted on the ground prior to the incident flight did not return any fault, and the aircraft was dispatched with the automatic pressurisation control system operative.

- During the incident flight, the automatic pressurisation control system became inoperative, and later the crew temporarily lost manual control of the cabin pressurisation.

- Six minutes elapsed between the activation of the excessive cabin altitude warning and the commencement of the emergency descent actions, during which time the cabin altitude rose to 18400 ft.

- The passenger and cabin crew oxygen masks were deployed automatically.

- During the emergency descent to FL120, Vmo was not selected.

- Seven minutes passed between the estimated time at which the masks were deployed and the time at which the aircraft reached FL120, which was within the capacity of the oxygen generators.

- During the emergency descent the line training captain moved to the co-pilot's seat.

- The maximum cabin altitude reached was approximately 19140 ft.

- After the emergency and having regained manual control of the pressurisation, the aircraft re-climbed to FL280 to continue the flight. The automatic pressurisation system remained inoperative.

- During the loss of cabin pressure, the oxygen generators corresponding to the 59 occupied seats were activated. The crew did not recall any coordination measures being taken in this regard.

- After the flight, the operator's maintenance personnel reported that ice was found in the OFV and that there was a tube with a leak and a broken clamp.

- The BITE test conducted on the ground after the incident flight did not return any fault.

- No anomalies were detected in the OFV of the incident that would prevent normal operation.

- The lack of a CVR recording covering the period of the incident limited the analysis of the events.

3.2. Causes/contributing factors

The investigation has revealed that the incident was caused by water leaking from a tube with a broken clamp which, when it froze, blocked the outflow valve doors.

The following factors are thought to have contributed:

- The use of plastic tube clamps in the vicinity of the OFV (section 46), the deterioration of which had previously caused leaks in other incidents in the avionics compartment (section 41), where they had since been replaced by metal clamps.
- The absence of a fault in the BITE ground test performed prior to the flight.
- The fact that there is no requirement to perform a visual inspection of the OFV during Task 803 of 21-31 of the FIM when the automatic pressurisation system becomes inoperative in flight, the manual operation is normal, and the BITE does not detect a fault on the ground.

4. SAFETY RECOMMENDATIONS

Considering that the retrieval of the fault message during the BITE ground test would probably have facilitated the detection of the presence of ice in the outflow valve, the following recommendation is issued:

REC 18/23. It is recommended that Honeywell assess the possibility that the CPC may not register a blockage of the OFV by an external element and the implications that this may entail.

Given that the use of metal clamps in the forward section helps to prevent water leaks that could affect electronic equipment and in view of the fact that the rupture of the plastic clamp next to the OFV caused a water leak that could cause the OFV to jam, the following safety recommendation is issued:

REC 19/23. It is recommended that BOEING consider replacing the CA625 series plastic clamps, whose rupture may affect the OFV.

The tasks that were carried out to detect the fault, given the circumstances before the incident flight, may have complied with the FIM procedure but were insufficient to detect the presence of the blockage in the absence of a BITE test fault. Therefore, the following safety recommendation is issued with the aim of helping to identify the problem.

REC 20/23. It is recommended that BOEING consider incorporating additional measures in Task 803 of 21-31 of the FIM when the automatic pressurisation system becomes inoperative in flight, the manual operation is functioning correctly, and the BITE test does not return a fault on the ground, in order to detect a possible OFV blockage.

Considering that the retrieval of the fault message during the BITE ground test would probably have facilitated the detection of the presence of ice in the outflow valve, the following recommendation is issued:

REC 21/23. It is recommended that Delta Air Lines, Inc. pass on the lessons learned from this incident to all personnel involved in maintenance.

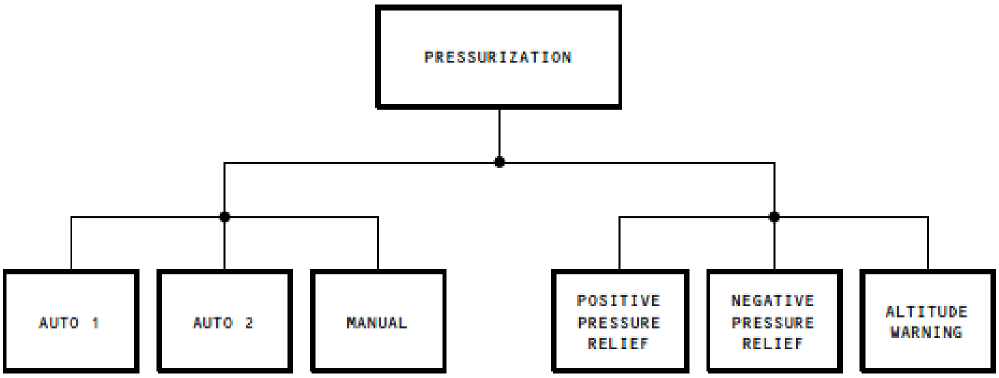
During the determination of the new action plan after reaching the safety altitude and regaining control over the pressurization, the status of the pressurization system and oxygen system were relevant. Considering also that the flight crew had recently completed the refresher training on pressurisation, the following safety recommendation is issued:

REC 22/23. It is recommended that Delta Air Lines, Inc. reinforce its crew training on cabin pressure loss, and include the lessons learned from this event in the training.

5. APPENDICES

5.1. Components of the pressurisation system

A diagram of the pressurisation system is shown below:



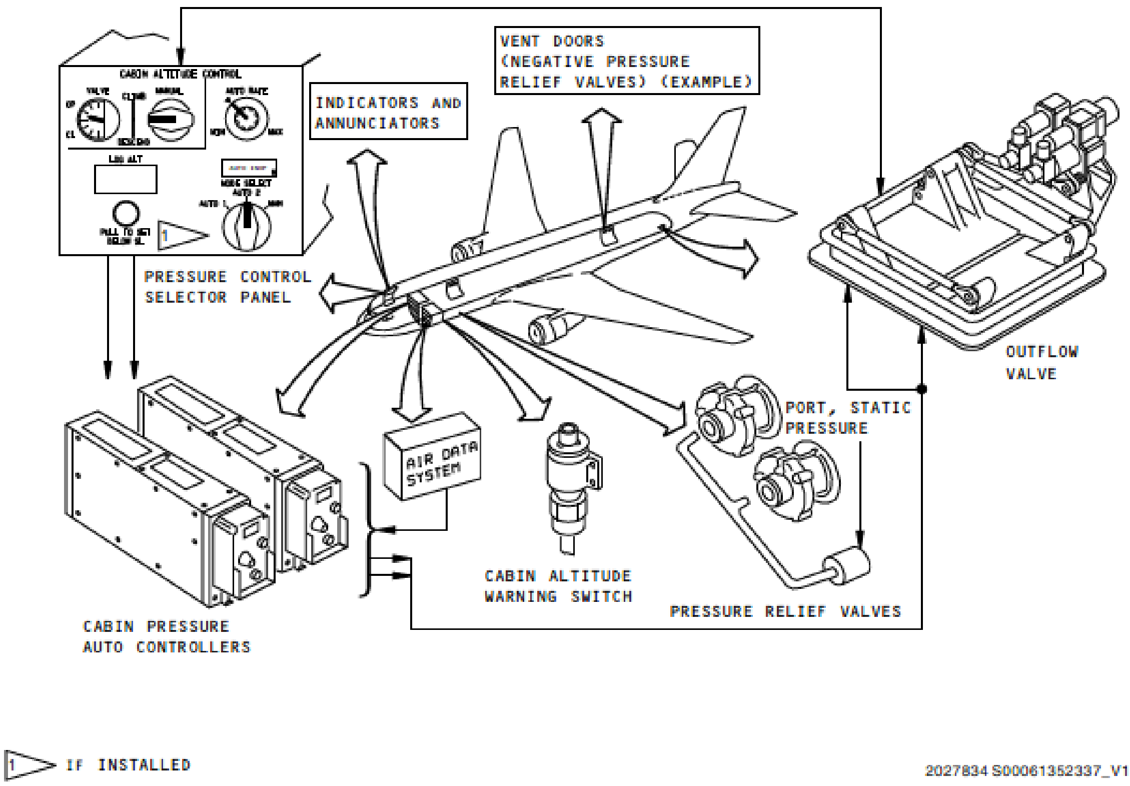


FIG. 7 PRESSURISATION CONTROL SYSTEM[32]. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

[32] Image extracted from section 21-31-00 of the AMM (Figure 1/21-31-00-990-801).

The system consists of:

- Pressure control selector panel: Located on the pilots' overhead panel and consists of:

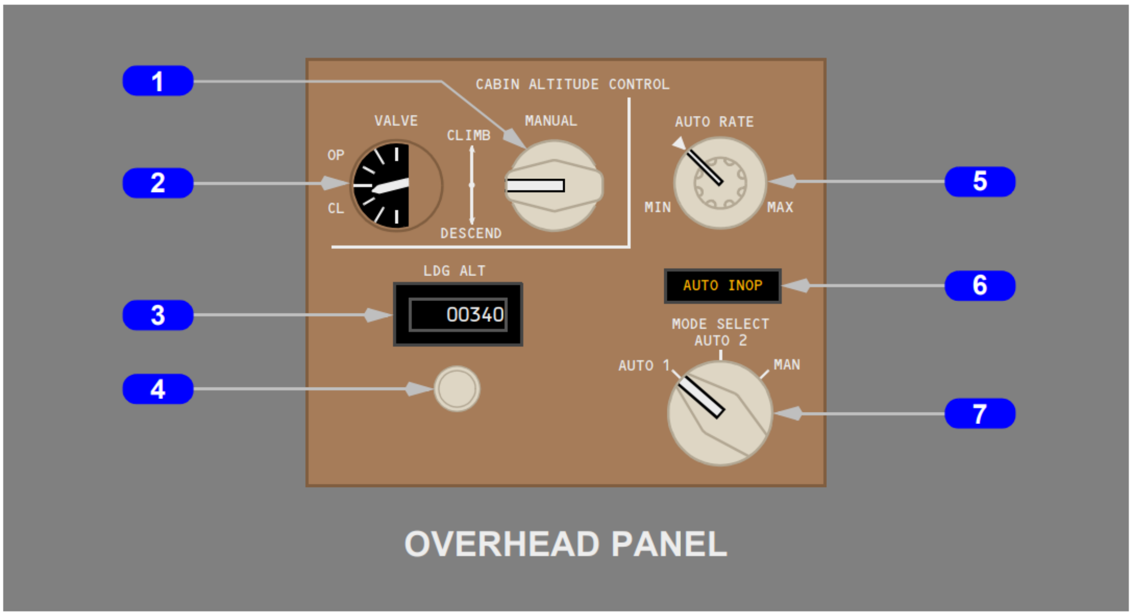


FIG. 18 CABIN ALTITUDE CONTROL PANEL[33]. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

- Cabin altitude MANUAL control (1) for cabin altitude controls the position of the cabin OFV with the cabin altitude mode selector (7) in manual (MAN) mode. CLIMB moves the OFV in the opening direction and DESCEND moves the OFV in the closing direction.
- Outflow VALVE position indicator (2) showing the position of the OFV: OP (Open) and CL (Closed).
- Landing altitude (LDG ALT) selector (4), which allows the landing altitude to be selected by the crew. The landing altitude range selection is -1000 to +14000 ft. The landing altitude indicator (3) displays the selected altitude.
- Cabin altitude AUTO RATE control (5) allows the crew to select the automatic rate limit for cabin pressurisation. The selection range is 50 to 2000 ft/min for climb and 30 to 1200 ft/min for descent. The marked position indicates 500 ft/min for climb and 300 ft/min for descent.
- AUTO inoperative (INOP) light (6), which illuminates in amber when the AUTO 1 and AUTO 2 cabin altitude control functions are inoperative, and MAN mode has been selected.

- Cabin altitude MODE SELECTOR (7) allows the selection of AUTO 1, AUTO 2 or MAN. AUTO 1 activates the Auto 1 cabin altitude control for automatic operation and positions the valve automatically. AUTO 2 activates the Auto 2 cabin altitude control for automatic operation and positions the valve automatically. In MAN mode, the position of the OFV is controlled by the MANUAL cabin altitude control and the AUTO INOP lights are illuminated.

[33] Image extracted from point 2.10.7 of the *FCOM*.

- Cabin altitude indicator:

FIG. 19 CABIN ALTITUDE INDICATION PANEL[34]. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

Consists of a cabin differential pressure indicator (1), a cabin altitude indicator (2) and a cabin altitude rate indicator (3).

- Cabin pressure auto controllers or CPC: Two identical controllers can control the aircraft's pressurisation by modulating the OFV. One controller remains in standby mode, monitoring the performance of the system. The standby controller assumes control of the system if the selected controller fails. Both controllers receive identical signals.

- Outflow valve or OFV: Double-door type. The doors and frame of the valve are made of aluminium with a Teflon coating to guard against binding and excessive friction. Connecting rods on each side of the valve frame link the forward and aft doors. The valve controls the flow of cabin air by modulating the valve doors. The valve is mounted on the lower left side of the aircraft, immediately aft of the bulk cargo compartment. A protective debris screen is installed over the outflow valve to prevent the entry of foreign objects.

- Outflow valve actuator: Mounted directly on the valve frame. It activates both doors simultaneously via a control arm and linkage. The actuator consists of two identical 115 V AC 400 Hz motors, each with a feedback tachometer, a 28 V DC motor and a gearbox. The gearbox DC motor housing also includes a feedback potentiometer and limit switches.

[34] Image extracted from point 2.10.7 of the *FCOM*.

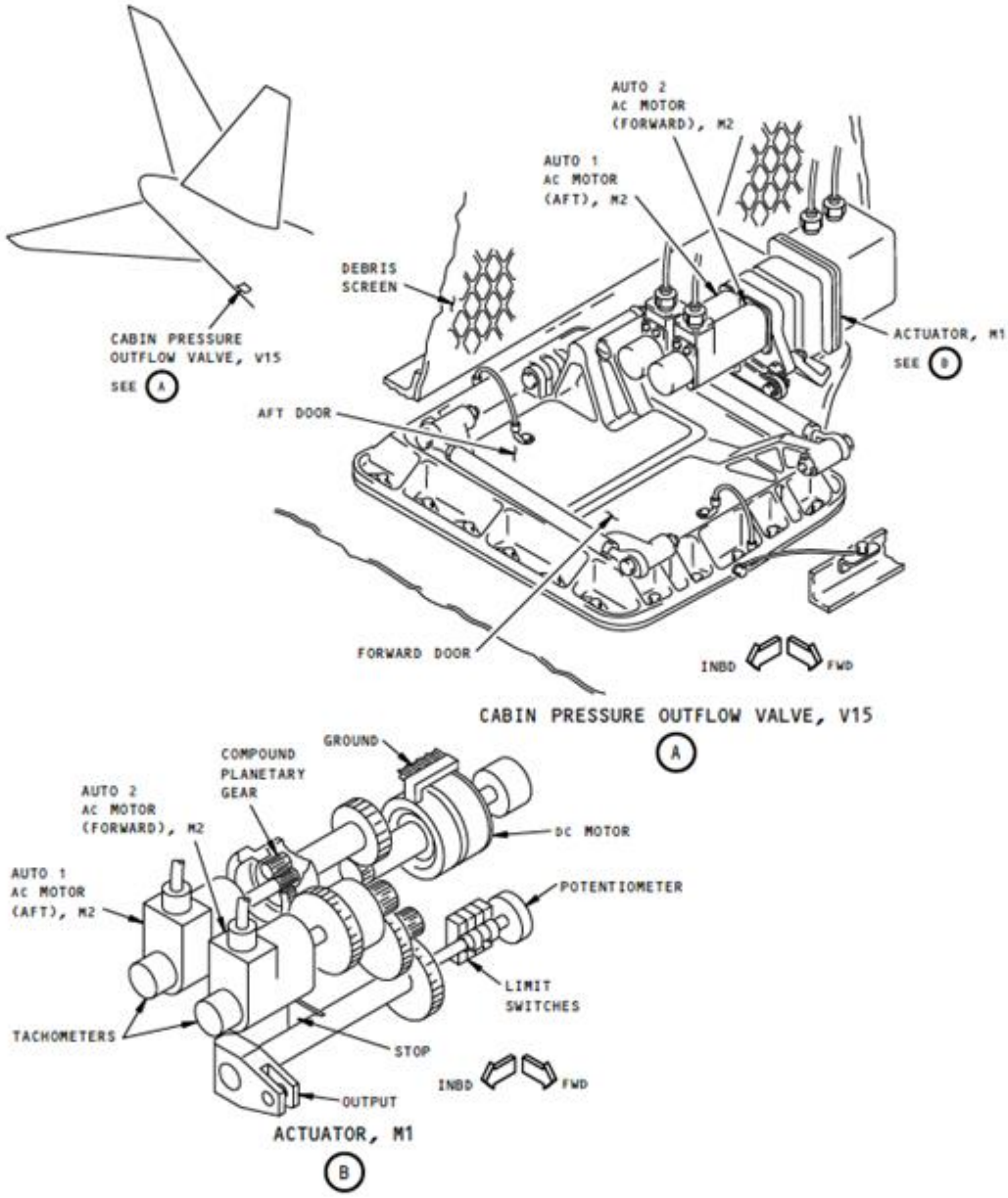


FIG. 20 OFV FOR CABIN PRESSURISATION[35]. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

- Positive and negative pressure relief valves protect the airframe from an excessive pressure differential.

[35] Image extracted from section 21-31-00 of the AMM (Figure 3/21-31-00-990-803).

5.2. Bite test procedure

To perform the BITE test on each of the cabin pressure controllers, the main steps are as follows:

1. Turn the MODE SELECT selector on the pilots' overhead panel to the AUTO 1 (AUTO 2) position.
2. Push the PRESS TEST button to check the operation of the fault lights on the front of the controller. If no fault light illuminates when the PRESS TEST button is pressed, the controller needs to be replaced.
3. Push the BIT button to interrogate the controller´s fault memory.
    - If no faults are present in the fault memory, the NO FAULT light will come on for 30 seconds and then go off.
    - If a fault exists in the fault memory, the fault light of the corresponding component will come on for 15-30 seconds and then go out.
    - Push the PRESS TEST button within 15 seconds after you push the BIT button to display any faults from previous flights legs.
4. Push the VERIFY button to check the current system status.
    - The VERIFY MODE light will remain on for the duration of the verification test (approximately 10 seconds).
    - At the end of the test, the VERIFY MODE light will turn off, and if no faults are detected, the NO FAULT light will come on for 30 seconds. If a fault is found, the light of the corresponding component will come on.
5. To clear the faults in the controller and reset the controller, push VERIFY and then RESET.

5.3. Meteorological maps

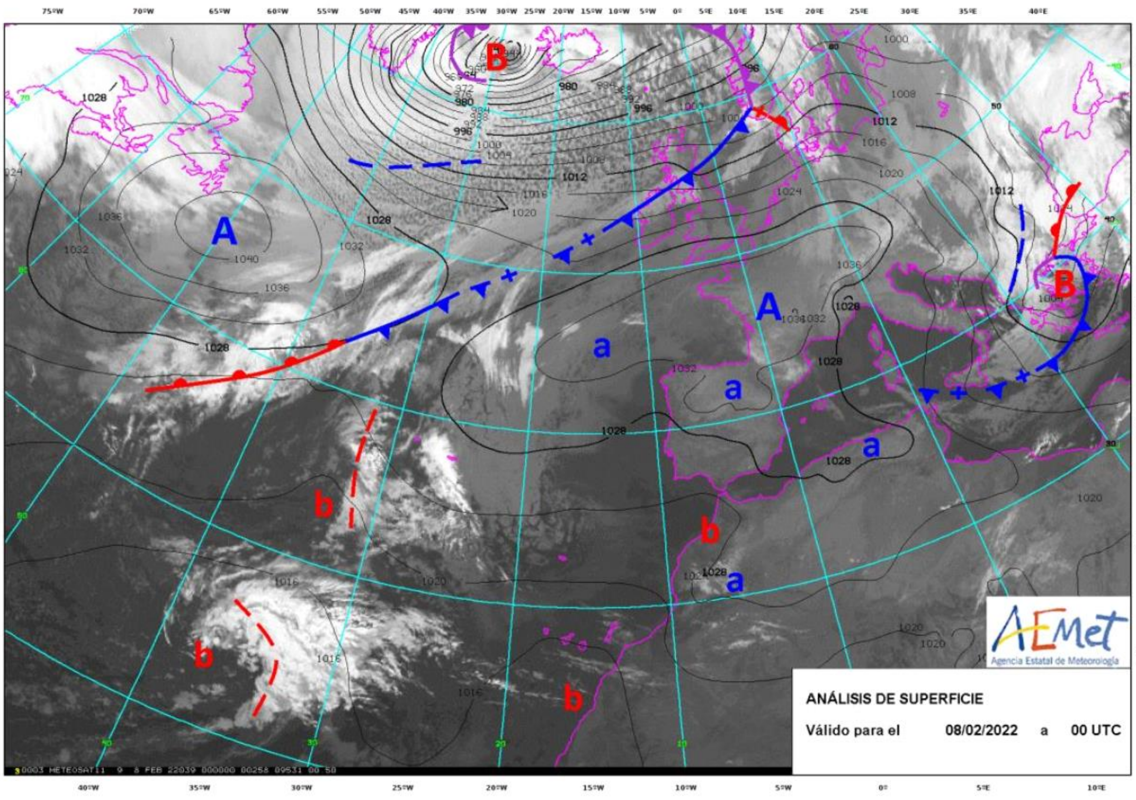


FIG. 21 MID AND HIGH-LEVEL DIAGNOSTIC TECHNICAL GUIDANCE FOR 00:00:00 H ON 8 FEBRUARY 2022 COMBINED WITH THE WATER VAPOUR CHANNEL IMAGE FROM THE METEOSAT SATELLITE

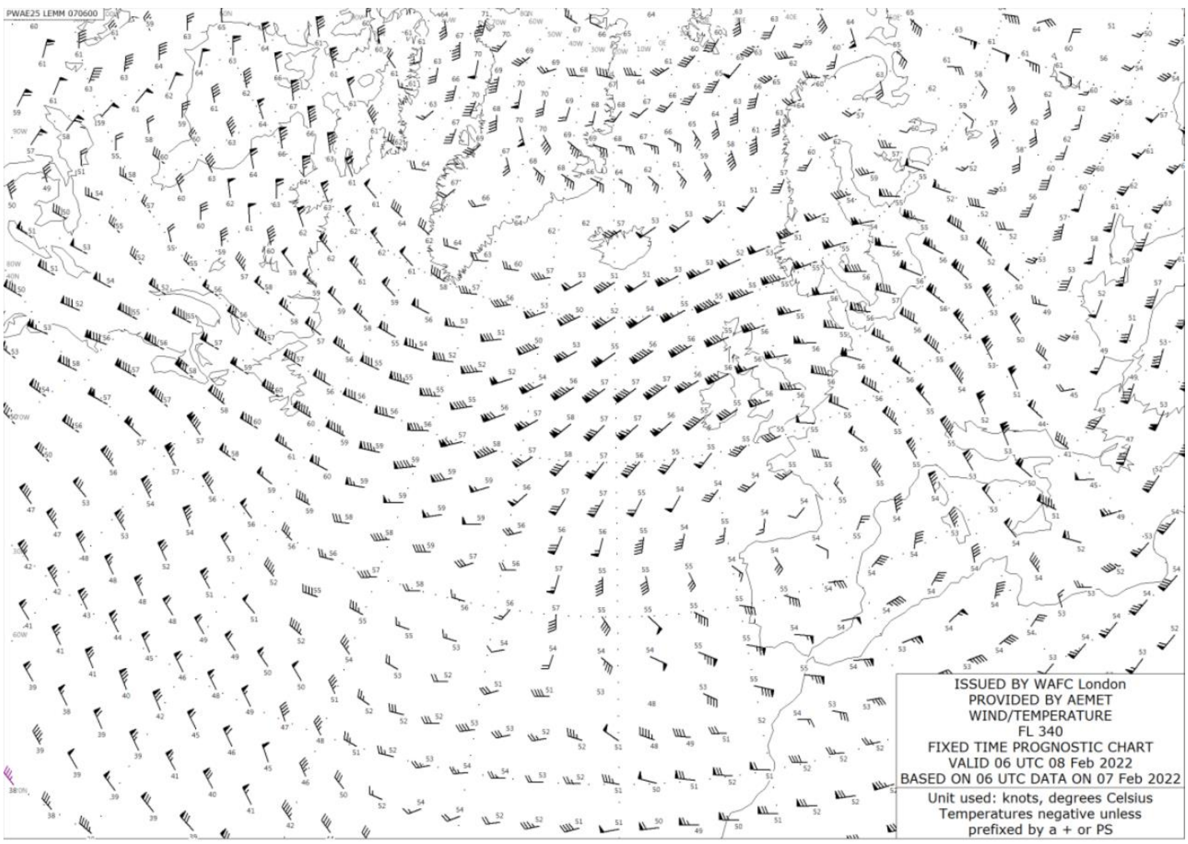


FIG. 22 WIND AND TEMPERATURE AT FL 340 AT 06:00:00 H ON 8 FEBRUARY 2022 FORECAST BY WAFC LONDON.

5.4. Graphics extracted from the FDR

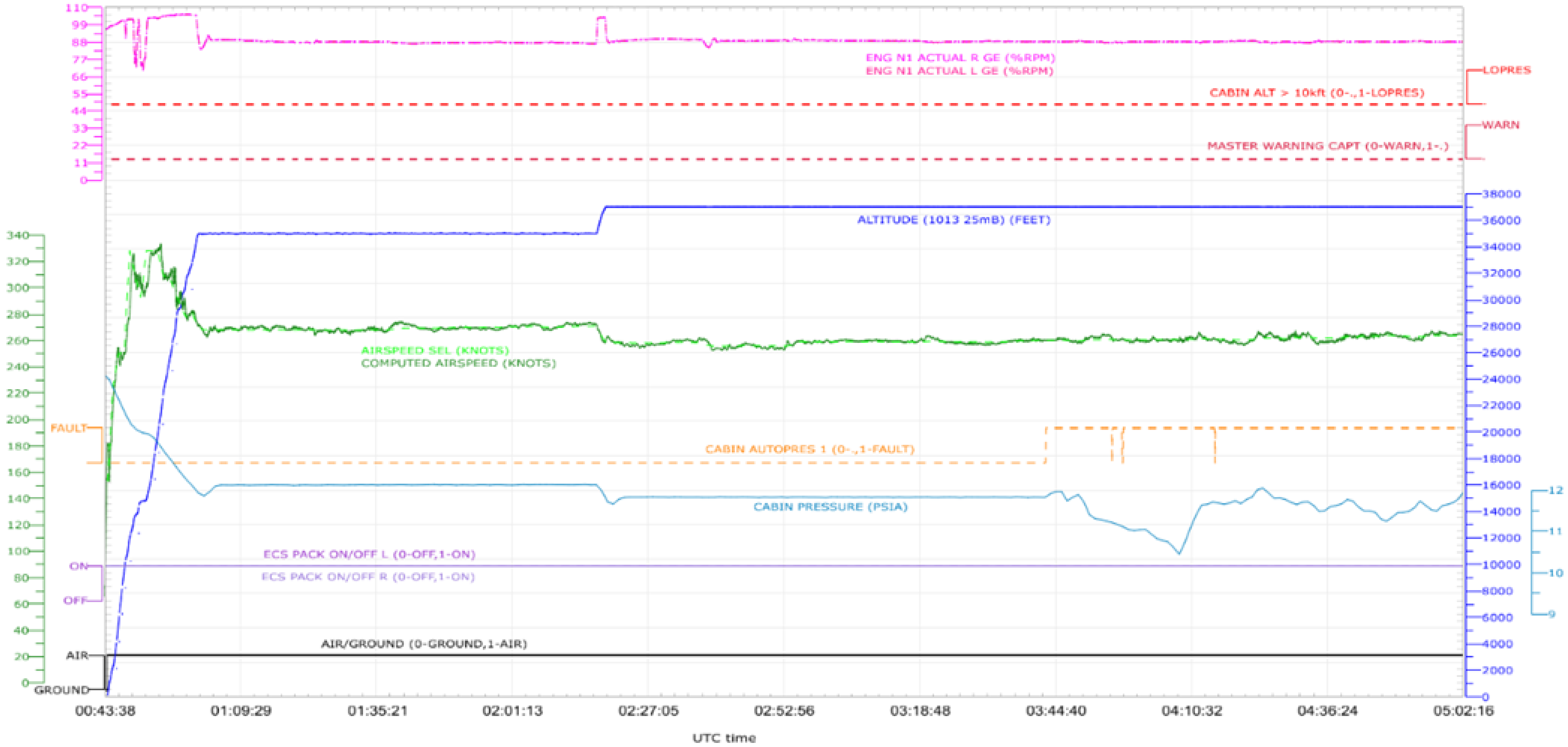


FIG. 23 FLIGHT PARAMETERS FROM TAKE-OFF UNTIL AFTER THE CABIN AUTO INOP WARNING.

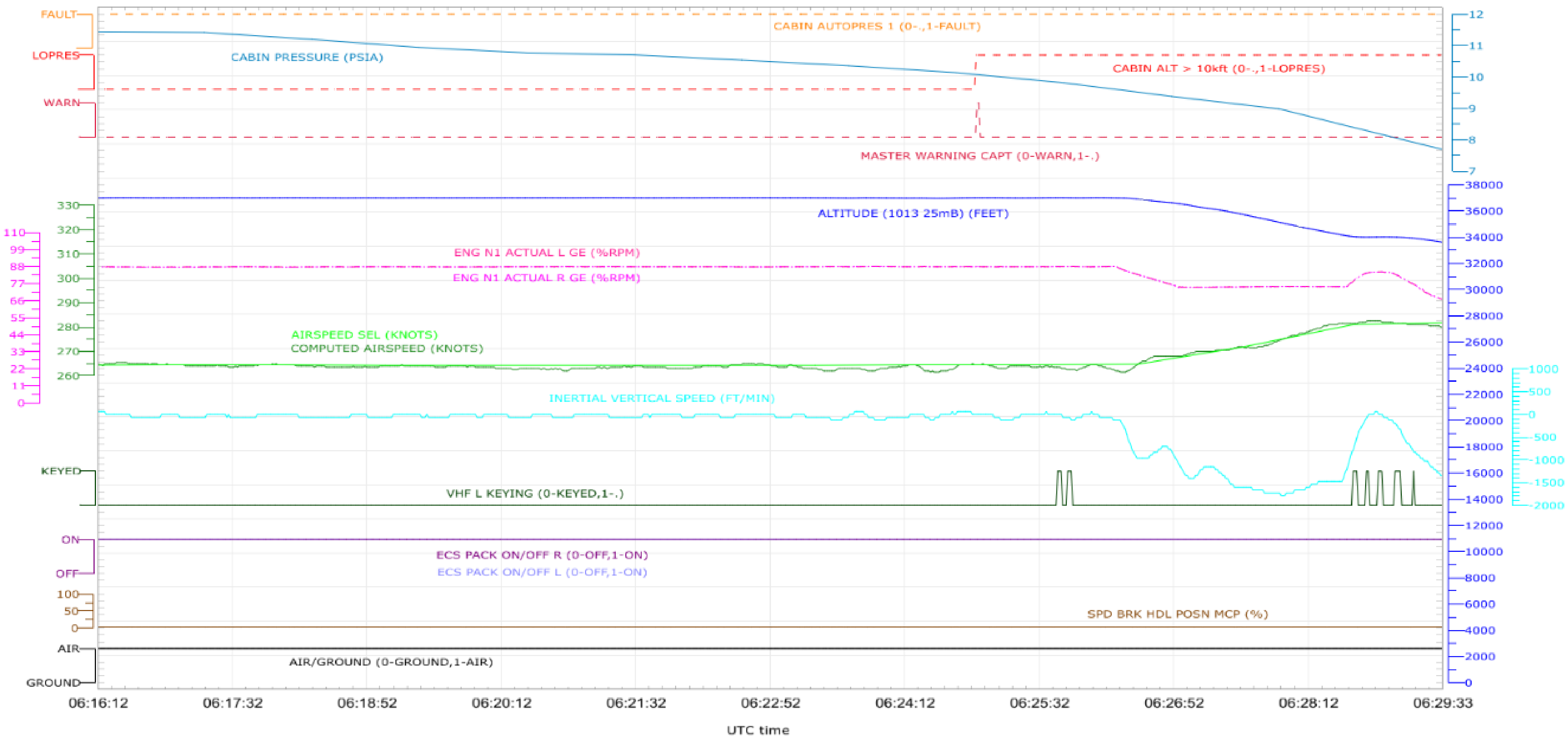


FIG. 24 FLIGHT PARAMETERS FROM ACTIVATION OF CABIN ALTITUDE WARNING TO DESCENT TO FL340.

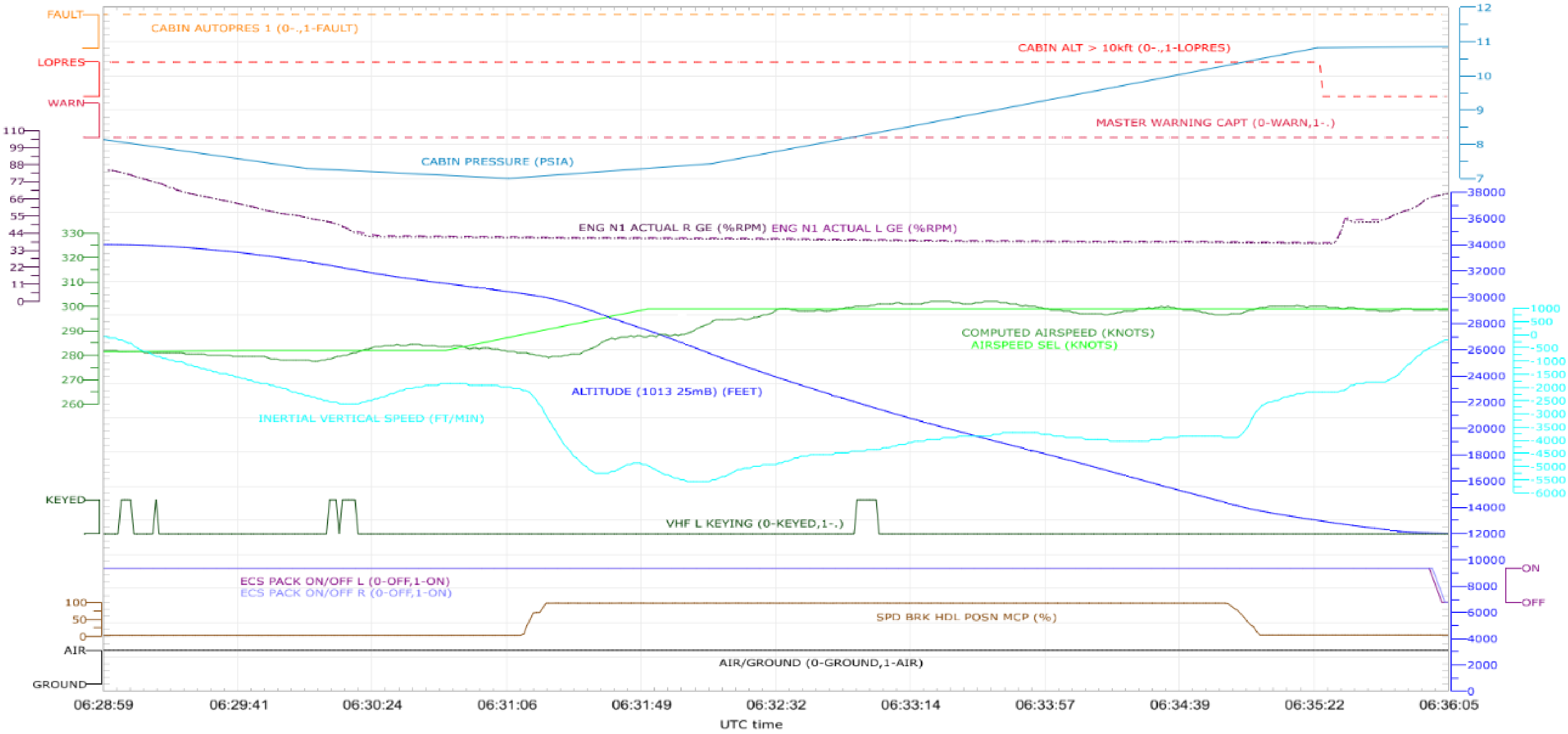


FIG. 25 FLIGHT PARAMETERS DURING THE DESCENT FROM FL340 TO FL120.

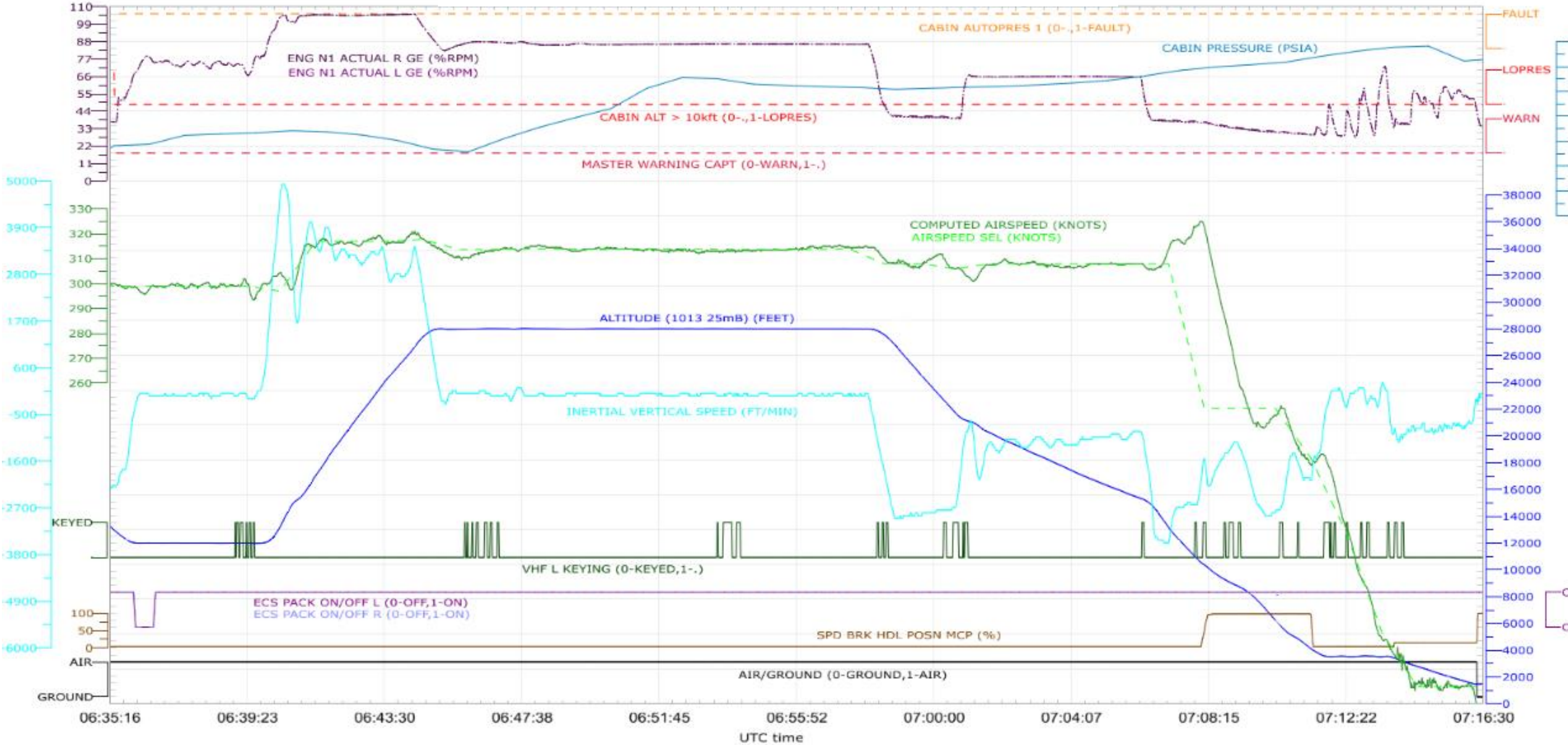


FIG. 26 FLIGHT PARAMETERS AT FL120, CLIMB TO FL280, DESCENT AND LANDING

5.5. Cabin altitude or rapid depressurization procedure

Section 2.1 of the manufacturer's Boeing 767-332ER QRH[36] contains the excessive cabin altitude procedure shown below:

767 Flight Crew Operations Manual

CABIN ALT

CABIN ALTITUDE
or
Rapid Depressurization

CABIN ALTITUDE

Messages: CABIN ALTITUDE

Condition: A cabin altitude exceedance occurs.

1 Don the oxygen masks.

2 Establish crew communications.

3 Check the cabin altitude and rate.

4 **If** the cabin altitude is uncontrollable:

PASS OXY switch . . . . Push and hold for 1 second

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

To descend:

Move the thrust levers to idle

Extend the speedbrakes

If structural integrity is in doubt, limit airspeed and avoid high maneuvering loads.

Descend at VMO/MMO

FIG. 27 MANUFACTURER'S CABIN ALTITUD OR RAPID DEPRESSURIZATION PROCEDURE. IMAGE COPYRIGHT © BOEING. REPRODUCED WITH PERMISSION.

[36] Version dated February 20, 2014.