CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL

Report IN-001/2017

Incident involving an Airbus A-320, registration EC-HTD, en route from the Malaga-Costa del Sol Airport to the Barcelona - El Prat Airport (Spain) on 21 February 2017

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO

Informe técnico

IN-001/2017

Incident involving an Airbus A-320, registration EC-HTD, en route from the Malaga-Costa del Sol Airport to the Barcelona-El Prat Airport (Spain) on 21 February 2017

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO
SUBSECRETARÍA
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

NIPO Línea: 161-18-148-6

NIPO Papel: 161-18-140-2

Deposito Legal: M-20207-2018

Maquetación: David García Arcos

Impresión: Centro de Publicaciones

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Tel.: +34 91 597 89 63
Fax: +34 91 463 55 35

E-mail: ciaiac@fomento.es
http://www.ciaiac.es

C/ Fruela, 6
28011 Madrid (España)

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 object of the investigation, and its probable 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 5.5 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., 4. 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.

Contents

Abbreviations

° ' "	Sexagesimal degrees, minutes and seconds
°C	Degree centigrade
AEMET	National Weather Agency
AESA	National Aviation Safety Agency
AIMS	Airline information management system
AOG	Aircraft on ground
APU	Auxiliary power unit
ASAC	Airbus Statement of Airworthiness Compliance
ATA	Air Transport Association
ATC	Air traffic control
ATPL(A)	Airline traffic pilot license (airplane)
BMC	Bleed monitoring computer
CAME	Continuing airworthiness management exposition
CAMO	Continuing airworthiness management organization
CAVOK	Ceiling and visibility OK
CC	Cabin crew
CPC	Cabin pressure controller
CVR	Cockpit voice recorder
DME	Distance measuring equipment
E	East
ECAM	Electronic centralized aircraft monitoring
FAV	Fan air valve
FC	Flight cycles
FCOM	Flight crew operating manual
FCV	Flow control valve
FDR	Flight data recorder
FL	Flight level
ft	Feet
FWC	Flight warning computer
h	Hour
HP	High pressure
HPa	Hectopascal
ICAO	International Civil Aviation Organization

IDG	Integrated drive generator
IFR	Instrumental flight rules
ILS	Instrument landing system
IP	Intermediate pressure
IPC	Illustrated parts catalogue
IR(A)	Instrumental rating (airplane)
km	Kilometer
kt	Knot
LEAL	ICAO code for the Alicante Airport
LECL	ICAO code for Levante control center
LEMG	ICAO code for the Malaga Airport
LLP	Life-limited part
m	Meter
MEA/MORA	Minimum enroute altitude/Minimum off-route altitude
MEL	Minimum equipment list
METAR	Aviation routine weather report
MHz	Megahertz
MMEL	Master minimum equipment list
N	North
NM	Nautical mile
NOTAM	Notice containing information concerning the establishment, condition or change in any aero nautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations
OEB	Operations engineering bulletin
OHDS	Overheat detection system
OPV	Over-pressure valve
PF	Pilot flying
PFR	Post-flight report
PM	Pilot monitoring
PRV	Pressure regulating valve
psi	Pound per square inch
QNH	Atmospheric pressure adjusted to mean sea level
QRH	Quick reference handbook
SB	Service bulletin
SL	Sensing line
SMM	Safety management manual

SMS	Safety Management System
SSFDR	Solid state flight data recorder
TLT	Temperature limitation thermostat
UTC	Universal coordinated time
VOR	VHF omni-directional range

Synopsis

Owner and Operator:	VUELING
Aircraft:	AIRBUS A-320, registration EC-HTD
Date and time of incident:	Tuesday, 21 February 2017 at 20:41 h[1]
Site of incident:	En route from the Malaga-Costa del Sol Airport to the Barcelona-El Prat Airport (Spain) at FL300
Persons aboard:	7 crew, no injuries
	169 passengers, no injuries
Type of flight:	Air transport– Scheduled – Domestic - Passenger
Type of operation:	IFR
Phase of flight:	En route
Date of approval:	28 February 2018

Summary of the incident:

On Tuesday, 21 February 2017 at 20:41, an A320 aircraft, registration EC-HTD, operated by Vueling with 176 persons aboard, suffered a pressurization system fault at FL300 while flying from the Malaga to the Barcelona airport. This resulted in a MAYDAY declaration and an emergency descent to land at the Alicante Airport.

After taking off from the Malaga Airport with the auxiliary power unit (APU) deferred, shortly after crossing FL100 the "AIR ENG 1 BLEED ABNORM PR" and "AIR PACK 1 FAULT" warnings were received almost simultaneously. After unsuccessfully attempting to reset the affected system, the crew decided to continue with the flight and limit the flight level to FL300. A short time later, at FL300, the "AIR PACK 2 FAULT" warning was received, and after declaring a MAYDAY, the crew began an emergency descent to FL100. The maximum cabin altitude reached was 6700 ft. The use of oxygen masks was not necessary. Under those conditions, the crew decided to divert to the Alicante Airport, where the aircraft landed at 21:08:49.

The aircraft was not damaged and everyone aboard disembarked normally. No medical attention was necessary.

1 Unless specified otherwise, all times in this report are local. To obtain UTC, subtract one hour.

The investigation has determined that the most likely cause of the incident was the degradation (not detected earlier) of the bleed regulation in the aircraft. It was also determined that the correct model of pressure regulating valve (PRV) was not installed in the aircraft's no. 1 engine due to a component identification error in the IPC[2].

This report contains one safety recommendation for Airbus.

2 Illustrated Parts Catalogue

1. FACTUAL INFORMATION

1.1. History of the flight

On Tuesday, 21 February 2017, an A320 aircraft, registration EC-HTD and callsign VLG2116, operated by Vueling, took off from the Malaga-Costa del Sol Airport at 20:24:10 h en route to the Barcelona-El Prat Airport with 176 persons aboard. It was the fourth and last flight of the day, all with the same crew. They had previously flown round-trip between Barcelona and Jerez de la Frontera (Cádiz), and then from Barcelona to Malaga.

They left with the APU inoperative. Shortly after taking off from Malaga the first warning was received in the cockpit for the bleed system in the left engine ("AIR ENG1 BLEED ABNORM PR"), followed by the warning for the air pack associated with the same engine ("AIR PACK 1 FAULT"). The crew continued to climb and reset the system. Four minutes later, while at approximately FL120, the ECAM[3] system displayed the same warning. This time, the crew were unable to reset the system and decided to continue the flight, limiting the maximum cruise altitude to FL300.

At 20:40:01, by which time the aircraft was at its cruising altitude, there was a pressurization warning for the right engine bleed valve ("ENG 2 BLEED ABNORM PR"), followed by a warning for the number 2 cooling pack ("PACK 2 FAULT"), as a result of which the crew declared an emergency (MAYDAY) and began an emergency descent to FL110.

3 ECAM: Electronic centralized aircraft monitoring.

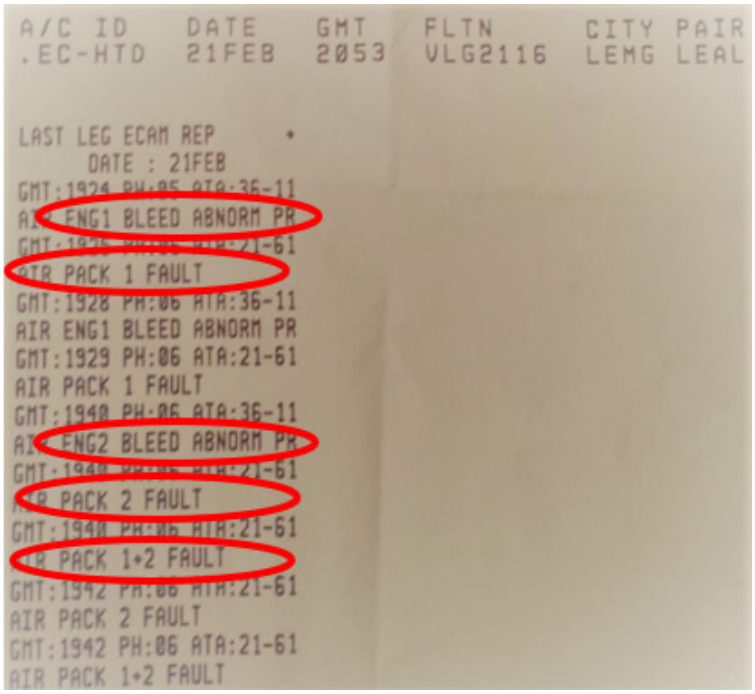

Figure 1. Post-flight report showing warnings on the ECAM display

The use of oxygen masks was not necessary but the crew, in light of what had happened, decided to divert to the Alicante Airport, initiating a continuous descent and landing at 21:08:49.

The aircraft did not sustain any damage and everyone aboard disembarked normally. No one required medical attention.

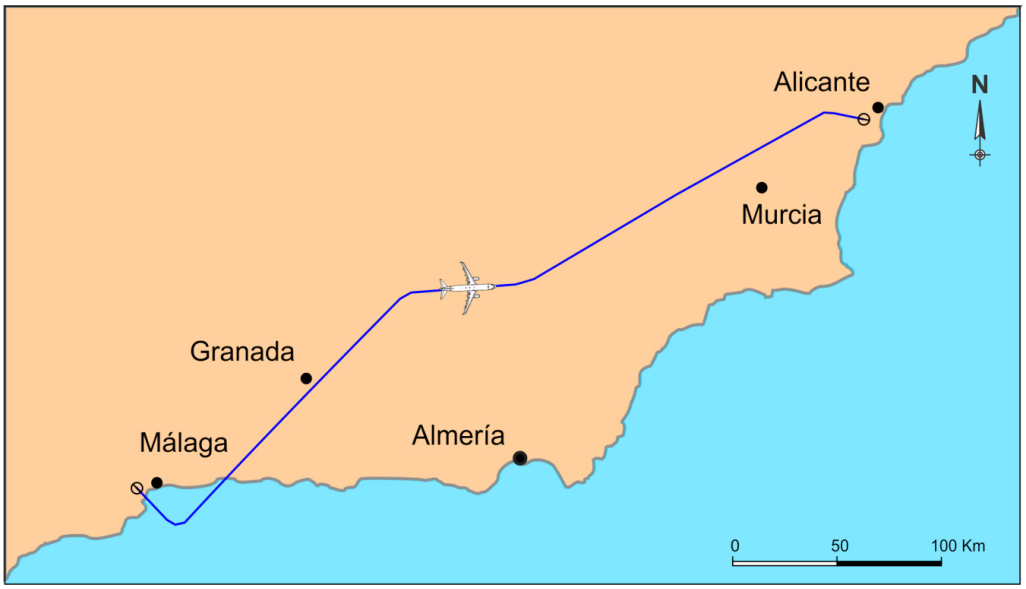

Figure 2. Flight path of VLG2116

1.2. Injuries to persons

Injuries	Crew	Passengers	Total	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	7	169	176	-
TOTAL	**7**	**169**	**176**	-

1.3. Damage to aircraft

The aircraft was not damaged.

1.4. Other damage

None.

1.5. Personnel information

1.5.1. Flight crew

The pilot, 39 years of age, had an airline transport pilot license (airplane), ATPL(A), issued on 5 November 2012, an instrument rating, IR(A), and an AIRBUS A-320 type rating, both of which were valid until 30 April 2018.

He had a total of 5,000 flight hours, of which 4710:20 had been on the type. He had been at the airline over six years, and it was where he first worked as a transport pilot.

In the last 90 days he had flown 176:55 h, and in the last 30 days 63:30 h.

He had a class-1 medical certificate that was valid until 1 July 2017.

The copilot, 36 years of age, had an airline transport pilot license (airplane), ATPL(A), issued on 28 July 2010 and the same ratings, which were valid until 30 June 2017. He also had an ATR 42/72 type rating that was valid until 31 March 2017.

He had a total of 5,700 flight hours, of which 616:17 had been on the type. In the last 90 days he had flown 162:49 h, and in the last 30 days 71:24 h.

He had a class-1 medical certificate that was valid until 6 June 2017.

1.5.2. Cabin crew

The cabin crew purser, 39 years of age, had a cabin crew certificate that was issued on 21 October 2003 and was valid until 8 April 2017, as well as a cabin crew medical certificate that was valid until 10 February 2020. He had a total of 3828 flight hours and had been a purser since July 2009.

The investigation verified that the cabin crew and medical certificates of the other four members of the cabin crew were valid and in effect on the date of the incident.

1.6. Aircraft information

1.6.1. General information

The AIRBUS A320-214 EC-HTD was manufactured in 2001 with serial number 1550. It had two CFM-56-5B4/P engines with serial numbers 643513 and 697718. It had a total of 41074 flight hours and 30073 cycles, while the number 1 engine had 14576 flight hours and 10501 cycles, and the number 2 engine had 28291 flight hours and 12227 cycles.

At the time of the incident, the aircraft had the relevant certificate of airworthiness, issued by Spain's National Aviation Safety Agency (AESA) on 20 January 2010. Its airworthiness review certificate was valid until 5 August 2017.

The aircraft was maintained by IBERIA LÍNEAS AÉREAS DE ESPAÑA, S.A. OPERADORA, which is shown on the listing of maintenance organizations approved by AESA as per Annex II (Part 145) of Regulation (EU) No. 1321/2014 (Rev. 11, updated February 2018), with reference ES.145.011 and scope A1 (Line/Base); B1; C1; C2; C3; C4; C5; C6; C7; C8; C9; C12; C13; C14; C15; C17; C18; C19; C20; D1.

Maintenance history

The investigation analyzed the history of maintenance checks conducted on the aircraft in the 18 months prior to the incident, that is, from 1 August 2015 until 21 February 2017.

The following general checks were satisfactorily completed:

- A4 check from 19 to 21 August 2015, with 37369 flight hours and 27387 cycles on the aircraft.

- C1 check from 24 October to 4 November 2015, with 37922 flight hours and 27787 cycles on the aircraft.

- 20-month check in October 2016, with 40366 flight hours and 29568 cycles on the aircraft.

Note: The time intervals for the above checks are:

A4 check: every 3000 FH[4] or 3000 FC[5] or 484 days (whichever comes first).

C1 check: every 7500 FH or 5000 FC or 730 days (whichever comes first).

20-month check: every 20 months.

Specifically, the following checks involving specific tasks related with the air conditioning (ATA [6] 21) and the pneumatic (ATA 36) systems were carried out:

- During the A4 check in August 2015, the pressure regulating valve (PRV) on the #1 engine was replaced. The original, with part number 6774E010000 and serial number 00578, was replaced by another with part number 6774G010000 and serial number 6774-07442.

- Between August 2015 and February 2017, twelve maintenance tasks were performed on the aircraft involving the aforementioned ATAs. These tasks resulted in the replacement of the bleed pre-cooler in engine #1, the flow control valve (FCV) (2), the deactivation of components (ram air intake actuator) and operational tests of the BMC[7] and CPC[8] computers. None of these maintenance activities were directly related to the pressure regulating valves (PRV).

4 FH: Flight hours

5 FC: Flight cycles

6 ATA: Air Transport Association.

7 BMC: Bleed monitoring computer.

8 CPC: Cabin pressure controller.

1.6.2. Information specifically related to the incident

1.6.2.1. Auxiliary power unit (APU)

The APU was deactivated on 10 February 2017 because of the low time left on one of its life-limited parts (LLP). It was deferred pending maintenance. It was eventually replaced on 4 March 2017.

The last check of the AESA-approved minimum equipment list (MEL) was on 24 December 2016, and of the master minimum equipment list (MMEL) on 17 October 2016.

The MEL indicated that flying with the APU inoperative was allowed (section 49.19.01A).

1.6.2.2. Pneumatic system on the aircraft

The pneumatic system provides air (taken from the engine bleed air) to operate some systems in the airplane, including air conditioning packs 1 and 2, which are used to supply the air that pressurizes and conditions both the cockpit and the passenger cabin.

A fault in any bleed system component can affect the air flow received by the packs.

As the diagram in Figure 3 shows, at the air duct in each engine, downstream of the intermediate-pressure (IP) and high-pressure (HP) lines, there is a pressure regulating valve (PRV) that cuts off and regulates the pressure provided by the system. This valve maintains a supply pressure to the system of 45 ± 5 psi.

According to the FCOM[9], the PRV closes the system in two ways:

- Pneumatically, if the intake pressure at the valve is below 8 psi or if there is return flow.
- Electrically by:
    - Placing the BLEED switch in the OFF position
    - Actuating the ENG FIRE switch

9 FCOM: Flight Crew Operating Manual.

- The bleed monitoring computer (BMC), in the following cases:
  - overtemperature
  - overpressure
  - loss
  - opening of starter valve
  - APU bleed connected

If the pressure regulating fails, there is another valve (OPV[10]) that closes due to overpressure when the pressure rises above 85 psi.

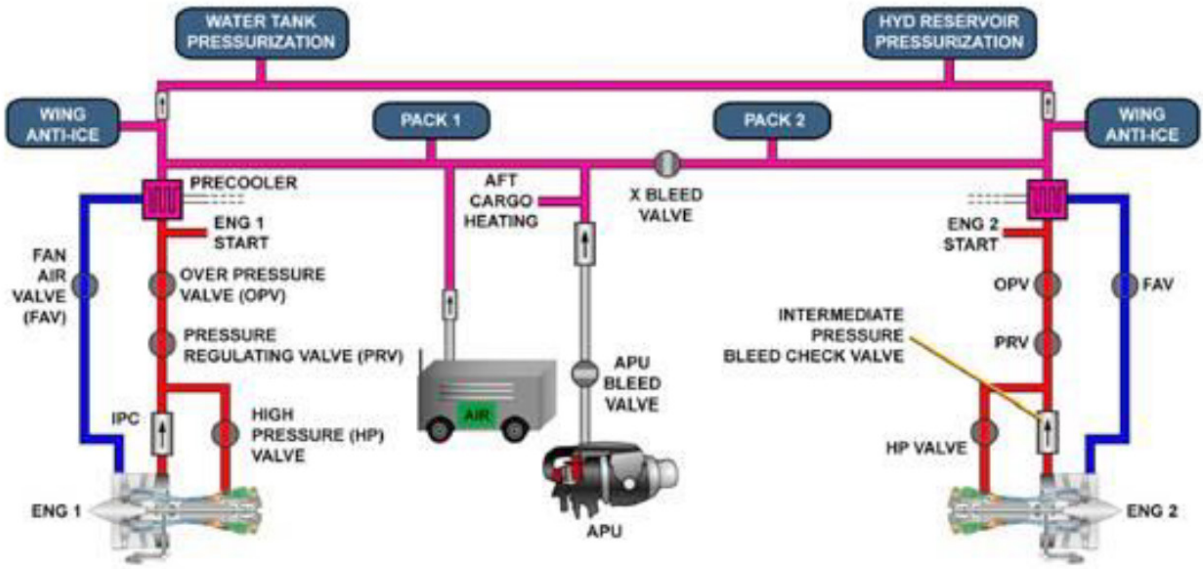

Figure 3. Simplified pneumatic system diagram

Before the distribution header to the various systems, a bleed precooler regulates the bleed air temperature by means of a temperature limitation thermostat (TLT). This pre-cooler uses cold air from the engine fan to regulate the temperature to an approximate value of 200° C.

10 OPV: Overpressure valve.

Aircraft EC-HTD did not have modification MOD 31261[11] installed, which allowed for a type-E PRV to be replaced by a type-G PRV.

At the time of the incident, the TLTs and PRVs installed on the aircraft were:

COMPONENT	Part number	Serial number
TLT (ENG1)	341E030000	03862
TLT (ENG2)	341E030000	05104
PRV (ENG1)	6774G010000	6774-07442
PRV (ENG2)	6774E010000	01290

1.7. Meteorological information

According to the information provided by the National Weather Service (AEMET), there was an isolated low-pressure area with a low temperature centered over the western coast of Morocco (at a temperature of -22° C at medium levels). On the surface there was a broad high-pressure area that extended from the Azores to the entire peninsula and through to the western Mediterranean. The most unstable area, associated with a cold core, was at the line situated on the sea.

According to the 20:00 and 20:30 METARs, when the aircraft took off from the Malaga Airport the wind was calm, visibility was optimal, the temperature was 14° C, the dew point between 9° and 10° C, and the QNH was 1018 hPa.

METAR LEMG 211900Z 21001KT CAVOK 14/10 Q1018 NOSIG=

METAR LEMG 211930Z 00000KT CAVOK 14/09 Q1018 NOSIG=

According to the 21:00 and 21:30 METARs, at the Alicante Airport there was a 5-kt wind from the northeast, high visibility and the temperature was 13° C, the dew point between 7° and 5° C and the QNH was 1023 hPa.

METAR LEAL 212000Z 05005KT CAVOK 13/07 Q1023 NOSIG=

METAR LEAL 212030Z 04005KT CAVOK 13/05 Q1023 NOSIG=

Remote sensing images during the flight from Malaga to Alicante indicate there

11 Basically consisting of an update to the BMC to Standard 8.

was no significant convective activity, although there probably was some turbulence at low levels, as forecast in the low-level map, due to the intense wind that was blowing in the Strait. At FL100, the wind was from the southeast at about 15 kt, and at FL300 it was from the east-southeast at around 30 kt.

1.8. Aids to navigation

On the day of the event, NOTAMs E0133/1 and E0134/17 were in effect and reported that the Category 1 ILS for runway 10 at the Alicante Airport was inoperative, as was its associated DME.

The crew made the VOR approach to runway 10, so this condition is not deemed to have affected the operation or outcome of the incident flight.

1.9. Communications

The aircraft took off from the Malaga Airport at 20:24:10. The communications between the crew and the airport control tower did not indicate that there had been any problems prior to, during or after the takeoff.

During the subsequent climb, the crew initially contacted the Seville Control Center at 20:28:37, and specifically with sector LECS-CEN on 132.6 MHz. The aircraft climbed normally, in keeping with the instructions received.

At 20:29:38, the crew requested FL300 as the final level, confirming that they had a "minor fault in the pressurization system".

At 20:36:38, they contacted Sector LECS-NO1 on 132.675 MHz, confirming they wanted a final flight level of FL300 and requesting a specific destination (ARPEX). ATC confirmed they had the airplane on radar.

At 20:40:31, the crew reported an emergency (MAYDAY three times) and informed they were emergency descending on course 080° to the right to FL100.

At 20:42:35, they requested vectors to return to the Malaga Airport. ATC confirmed they could turn left and maintain FL110, though upon the crew's request, control cleared them to turn right while maintaining FL110, since ATC specified that the minimum altitude in that area was 10,600 ft.

At 20:43:28, the control station contacted the Malaga control tower, and specifically approach (LEMGAPP), on the hotline to report that the aircraft would be returning.

At 20:43:32, the crew informed they would rather proceed to the Alicante Airport, which was on their heading. They were cleared to fly directly to Alicante at FL110. They were initially given a vector of 065° and runway 10 in use.

At 20:43:37, LECS-NO1 again contacted LEMGAPP to report that the aircraft was proceeding to Alicante after all. They then contacted the Levante Control Center (LECL) on the hotline to report that the airplane had declared an emergency and was proceeding to the Alicante Airport. LECL confirmed they had the airplane on radar.

At 20:50:06, the crew contacted LECL on 124.75 MHz and stayed in constant communication. They were guided during the approach to the Alicante Airport until 21:02:45, when they were transferred to the airport control tower on 118.15 MHz.

There were no communications of significance during the landing, and the aircraft finally touched down at 21:08:49.

1.10. Aerodrome information

1.10.1. Alicante Airport

The Alicante Airport (LEAL) is located 9 km southeast of the city. Its reference point is at coordinates 38° 16′ 56″ N - 003° 32′ 29″ E and an elevation of 43 m (142 ft). It has one runway in a 10/28 orientation that is 3000 m long and 45 m wide.

1.10.2. Malaga Airport

The Malaga Airport (LEMG) is located 8 km northeast of the city. Its reference point is at coordinates 36° 40′ 30″ N - 004° 29′ 57″ E and an elevation of 16 m (52 ft). It has one runway in a 13/31 orientation that is 2400 m long and 45 m wide, and another in a 12/30 orientation that is 2750 m long and 45 m wide.

1.11. Flight recorders

The flight data recorder (SSFDR) and cockpit voice recorder (CVR) were recovered from the aircraft.

1.11.1. Solid-state flight data recorder

The SSFDR unit removed from the aircraft was made by HONEYWELL, with part number 980-4700-042 and serial number SSFDR-11870.

An analysis of the data revealed that at 20:24:49, while climbing through 1600 ft, the first warning for the left engine bleed system ("AIR ENG1 BLEED ABNORM PR") was received in the cockpit, followed by a warning for a fault in the air pack associated with that same engine ("AIR PACK 1 FAULT"). The crew continued with the climb and reset the systems. Four minutes later, climbing through 12000 ft, the ECAM system displayed the same warning.

The crew continued climbing to FL300, leveling off at 20:39:49. At 20:40:01, a warning was displayed indicating a fault in the right engine bleed system ("AIR ENG2 BLEED ABNORM PR") as well as a fault involving the air pack associated with that engine ("AIR PACK 2 FAULT"), which resulted in an ECAM alert for both packs, namely AIR PACK 1+2 FAULT. Twenty seconds later, the crew descended in OPEN DESCENT mode to FL110, increasing the indicated airspeed to 300 kt. Two minutes later, during the descent, the crew unsuccessfully tried to reset the number 2 pack. The maximum cabin altitude reached was 6700 ft.

The aircraft reached FL110 at 20:45:53. The crew decided to divert to the Alicante Airport, during the descent to which, at 20:57:05, the crew reset, this time successfully, the pack on the right engine while flying level at 7000 ft.

The approach and landing were made within the parameters specified in the company's standard procedures.

The aircraft landed on runway 10 at 21:08:49.

Below is a graph of the incident aircraft's altitude versus the local time, showing five significant milestones along the flight.

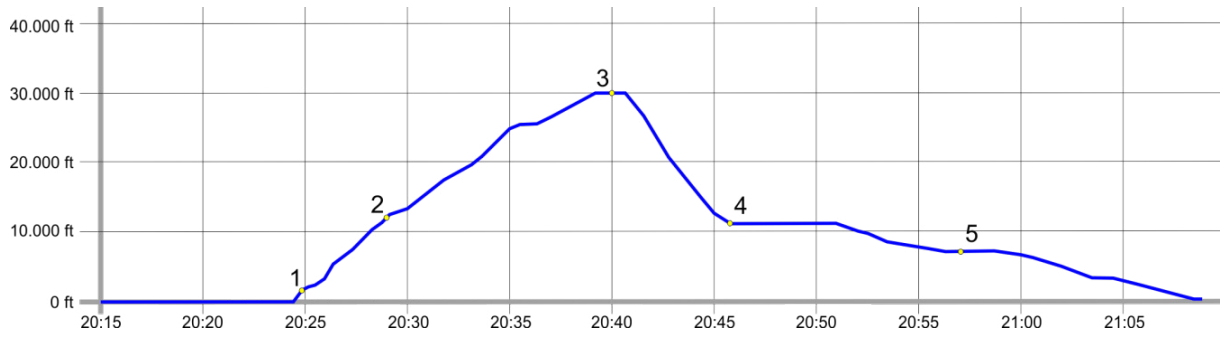

Figure 4. Altitude profile of the flight with significant milestones

Legend for Figure 4:

1. 20:24:49 h. Climbing through 1600 ft, first warning AIR ENG 1 BLEED ABNORM PR and AIR PACK 1 FAULT
2. 20:28:55 h. Climbing through 11900 ft, second warning AIR ENG 1 BLEED ABNORM PR and AIR PACK 1 FAULT
3. 20:40:01 h. At FL300, AIR ENG 2 BLEED ABNORM PR and AIR PACK 2 FAULT warning.
4. 20:45:42 h. Emergency descent completed once FL110 reached
5. 20:57:05 h. At 7000 ft, the crew reset PACK 2

1.11.2. Cockpit voice recorder

The CVR was also manufactured by HONEYWELL and had part number 980-6022-001 and serial number 0706.

Five audio tracks were downloaded from it, three of them in high quality and lasting half an hour, recording the pilot's microphone, the copilot's microphone and the area microphone. The other two were two hours long, with one containing a mix of the tracks from the two pilots and the other the area microphone in the cockpit.

Listening to the CVR revealed that the information recorded on it was from the ferry flight from the Alicante to the Barcelona airports, and that the information from the incident flight had been erased.

The operator reported that the order to preserve the recorders was issued after the ferry flight, which made it impossible to preserve the entirety of the information from the incident flight. In this regard, the operator noted that it was opening an internal investigation to determine if there had been a fault in the process that is documented in both the Operations Manual and in the CAME[12] so that it could be corrected. The operator stated it was the first time it had had a problem in terms of preserving data, and seemed determined to correct the issue diligently.

The operator stated that even though the resolution of the event was consistent with the emergency declared by the captain, maintenance (AIRMAN[13]) did not view the event as a severe incident, which is why the CVR and FDR units were not downloaded and quarantined. The messages displayed by the AIRMAN maintenance system recorded the event as dispatchable[14] (based on its severity criteria), with the

12 CAME: Continuing Airworthiness Management Exposition.

13 Airman Web is software created by Airbus for tracking and monitoring the technical conditions of the entire fleet during flight phases. The system relays information in real time from the airplane to the ground using the ACARS system.

14 In orange. Had it been in red, it would have indicated non-dispatchable.

diversion of the aircraft being interpreted as a precautionary measure.

In an effort to keep this mistake from happening again, the operator took the following actions:

- A MAYDAY declaration (whatever its cause) was added in the CAME to the list of events requiring the CVR and FDR units to be downloaded and quarantined.

- The requirement to quarantine these units directly after these events, before making any reports or queries, was added to the CAME and Operations Manual.

1.12. Wreckage and impact information

The aircraft landed without causing any damage.

1.13. Medical and pathological information

Not applicable.

1.14. Fire

There was no fire.

1.15. Survival aspects

Not applicable in this case.

1.16. Tests and research

1.16.1. Investigation conducted by the aircraft manufacturer (Airbus)

The PRV that was installed in the aircraft's left engine was a G-type model, which includes a port on the valve actuator that connects the sensing line (SL) to the bleed duct through a flexible coupling. This sensing line connects the valve downstream with the closing chamber of the valve's pneumatic actuator, transmitting the regulated static pressure to the closing chamber.

The supplier of this component informed that the PRV was sent with the port not activated, meaning with a cover on its pneumatic actuator. The G-type model of the PRV could be installed in the system even if the sensing line were not installed as long as the aforementioned cover was installed on the connector for the sensing line.

If the valve were to be installed without the protective cover and without the rest of the installation (flexible coupling), there would be a leak from the closing chamber on the valve's pneumatic actuator. This could potentially lead to an over-pressure situation that would make the PRV open more than required, a condition that would trigger the ECAM "AIR ENG BLEED FAULT" alert. The BMC would automatically isolate the bleed air system by closing the PRV.

Another possible consequence would be a leak in the area of the PRV, which is located in the nacelle area of the #1 engine inside the engine's firewall panel. This area is not protected by the overheat detection system of the pneumatic system[15] as it is considered a hot zone, meaning no ECAM alert would be activated.

In its report, Airbus does not consider it very probable that the G-type PRV would have been installed in the #1 engine without the protective cover since said PRV had been in use on aircraft EC-HTD since 21 August 2015, 18 months before the incident. However, the installation of a type-G PRV in engine 1 of the aircraft EC-HTD must be regarded as an error, as this is not allowed by the IPC since this aircraft did not have the modification required (MOD 31261).

1.16.2. Investigation conducted by the operator (Vueling)

The aircraft operator reviewed the affected system and was unable to identify a single component that could have caused both failures.

Taking 1 January 2017 as a reference date, the operator did not find any problem logs relating to the pneumatic system bleed until the date of the incident.

An analysis of the AIRMAN maintenance records showed that the PFR[16] had identified a fault involving the PRV that had been repeated as many as five times in the last fifteen flights. It was designated as "PRESS REG-V 4001HA2 OR SOL

15 OHDS: Overheat Detection System.

16 PFR: Post-flight report.

10HA2 OR SENSE LINE". This type of fault does not trigger an alert on the ECAM and is thus transparent to the crews, which do not enter it into the flight log.

The "AIR ENG2 BLEED ABNORM PR" detected in the operator's maintenance control system, obtained from the PFR, was the first time it appeared in the last 15 flights. In the last, it is coincident with the warning mentioned in the above paragraph, which the maintenance manual identifies with the need for a repair task.

The only entries related to the pneumatic system in the flight logs since the reference date are those from the day of the event:

- AIR ENG1 BLEED ABNORMAL PRESS
- PACK 1 FAULT
- PACK 2 FAULT

The operator reported that until the date of the incident in question, the assessment of repetitive malfunctions relied on the data contained in the flight logs. In the wake of this incident, it set up a new procedure that is based on the data in the maintenance system.

It also stated that it had not identified any maintenance activity in the previous weeks that could have been related to the systems that failed.

To repair the fault, the following components were removed and replaced:

COMPONENT	Part number	Serial number
TLT (ENG1)	341E030000	03862
TLT (ENG2)	341E030000	05104
PRV (ENG1)	6774G010000	6774-07442
PRV (ENG2)	6774E010000	01290

Following its internal investigation of the incident, the operator took the following corrective actions:

Involving Airworthiness Maintenance

- Increase APU availability in the Vueling fleet.

  To do this, the work capacity of the maintenance stations was increased in

an effort to raise the number of deferred items that can be closed outside the main maintenance centers. Also increased was the number of man-hours devoted to closing out deferred items at the Barcelona Airport, specifically those affected by limitations (including the APU). In addition, starting in April 2017, weekly follow-up meetings were held with all of the Iberia maintenance stations in order to track their performance, spare parts status and man-hours, as well as any needs by the stations. The graph below shows the downward trend in deferred APU items from 1 January 2017 to 1 February 2018 (13 months):

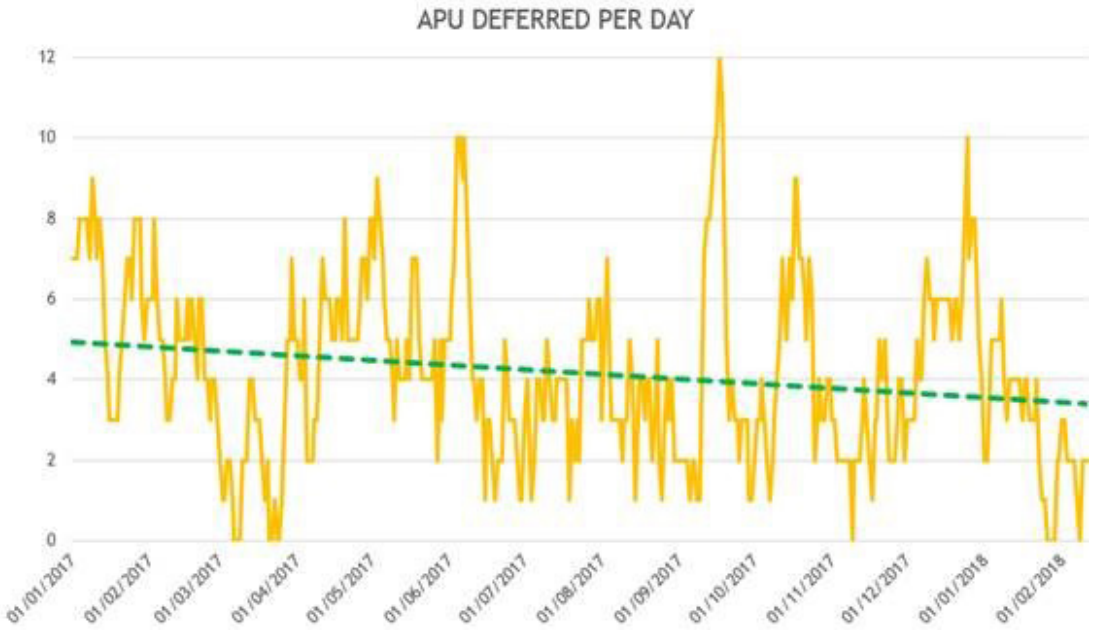

Figure 5. Trend in deferred APU items (source Vueling)

- Assess if an APU deferment is suitable to avoid reaching the lifetime limits of limited-life parts, this unit being a safety component in events such as the one in question.

  To this end, and after consulting with Airbus, Vueling issued a maintenance circular (MX1712-01 - OVERDUE LLP - NO POSSIBILITY TO FLY UNDER MEL) that states that in cases similar to this one (a part of the APU has not expired but is close to its limit, and the desired action is to defer the APU), the Airbus ASAC (Airbus Statement of Airworthiness Compliance) Department must be contacted, or the manufacturer of the APU (if the affected part belongs to the central engine of the APU), to obtain a specific decision on the case in question.

- Evaluate if the wear exhibited by the units checked in the workshop is acceptable and as expected, considering their time in operation in the aircraft after installation.

To do this, Vueling consulted with the manufacturer of the PRV and TLT (Liebherr) after the incident and sent it the affected parts for analysis. The manufacturer's analysis of these parts showed wear and signs of leaks of varying magnitudes, which it determined were higher than expected considering the number of cycles. In particular, as concerns the PRV in the #2 engine, it proceeded to perform a series of corrective maintenance actions on some of its components, but without stating whether these deviations from the optimal service conditions were sufficient to cause the pressurization system fault that originated in the #2 engine.

Vueling also contacted Iberia to obtain information on the affected equipment. Its Reliability Department noted that the average unscheduled removal time for these components is, in general, longer than that guaranteed by the manufacturer. As a result, there is no reason to think that they fail more often than they should. Its Maintenance and Operational Safety Department was also unable to determine the reason for the greater than expected wear on the parts installed in EC-HTD that were checked by Iberia and then sent to Liebherr after the event.

- Check every PRV installed in the Vueling fleet in an effort to ensure they are properly compatible and, if not, to replace them immediately.

  This step was carried out on all the aircraft with a similar configuration to EC-HTD that could have been subject to the same problem. The result was that there were eight aircraft that could have been subject to a similar error. All eight aircraft were grounded, and a total of three PRVs with the wrong part number were found, which were replaced with the correct unit.

- Evaluate the viability of setting up a new procedure that will make it possible to identify and preventively deal with repetitive faults using the alerts received in the maintenance control system (AIRMAN) for critical airplane components.

  The operator stated that this action is still being evaluated by the CAMO[17], as it would imply changing the procedure for the data provided by AIRMAN and the technical means are not yet in place for commencing this procedure. Through its Safety Management System (SMS), the operator is tracking its progress and reports that it has not detected any more events that increase the risk in this regard.

17 CAMO: Continuing Airworthiness Management Organization.

Involving part-M Quality Control

- Ensure that the procedures and actions carried out by the maintenance services provider after this event are adequate in terms of ensuring that the components are checked beforehand in order to ensure they are compatible before being installed in an aircraft.

  Because the actions taken by Iberia are satisfactory to Vueling and no event of similar characteristics has been identified, it was agreed with Part-M Quality to integrate this tracking as part of the operational safety assurance specified in the operator's SMM[18], meaning that during the audits, the established procedure is verified to be available and is utilized.

The company also stated that it had an internal procedure to check BLEED/PACK INOP/IDG[19] INOP limitations in the fleet. This procedure specifies that due to the elevated penalty involved in operating an aircraft with an inoperative PACK and the associated AOG[20] risk, a BLEED/PACK INOP/IDG INOP condition must be actively monitored daily and documented in the fleet control system (AIMS[21]).

1.16.3. Investigation carried out by the maintenance services provider (Iberia)

The analysis carried out by the maintenance services provider indicated that the type-G PRV on the #1 engine was installed at Iberia's Madrid workshop on 21 August 2015 upon completion of an A4 check of aircraft EC-HTD to close out a deferred item opened on the 18th of that same month.

In the IPC, the type-G valve was shown as a conditional spare for the type-E valve that was installed on the aircraft.

The condition for installing the type-G PRV to replace a type-E valve in the CFM56-5B engine is that the aircraft had modification MOD 31261 implemented, which could be done in the factory or through service bulletin SB 36-1054. This modification had been implemented on many of Iberia's aircraft, and the incident aircraft, registration EC-HTD, had been flown by Iberia. However, MOD 31261 had not been implemented on EC-HTD.

18 SMM: Safety Management Manual.

19 IDG: Integrated Drive Generator.

20 AOG: Aircraft on Ground: Condition that prevents an aircraft from flying.

21 AIMS: Airline Information Management System. The software generally used by Vueling to control its crews (scheduling and daily tracking) and keep operational control of its airplanes (where they are at all times) and flights (number of passengers, fuel, etc.).

The Iberia report concludes that given the time elapsed since the valve was installed, it was impossible to determine the conditions under which it was installed. It identified as the causes a mistake in the use of the IPC that determined the PRV to be compatible, and insufficient or unavailable information on the modifications (MOD) implemented in the airplane.

It proposed the following corrective actions:

- Enhance the component applicability procedure as per the IPC by establishing means to verify compatibility if not enough information is available to check applicability.

- Ask the continuing Airworthiness Management Organization (CAMO) for the information needed to ensure the correct application of the IPC, if not available.

- Carry out a technical analysis to find out why a PRV that was not applicable had been installed for a year and a half without being detected and the effect it could have had on the failure of the packs.

As concerns these actions, the maintenance services provider stated that it has created the procedure ***Standard Work SW-GA-04 Rotable/Repairable Component Replacement,*** dated 10 April 2017, to ensure that components are applicable as per the IPC, specifying that the same part number that is removed always be installed and setting up means of verification if insufficient information is available to check the applicability.

This procedure includes asking the CAMO for the information required to ensure the proper application of the IPC if said information is not available.

1.17. Organizational and management information

Part B of the company's Operations Manual (OM-B: ASPECTS INVOLVING THE OPERATION OF THE AIRCRAFT), and specifically Section 3.1.3, "Unpressurized and partially pressurized flight", explains in detail the actions to take in the event of a cabin depressurization. It also specifies to follow the limitations published in the minimum equipment list (MEL) that are included in the aircraft's flight manual (FCOM PRO-SPO-20).

It then goes on to describe a depressurization and the actions to take, differentiating between a rapid or explosive depressurization (Section 3.1.3.1) and a slow depressurization (Section 3.1.3.2).

Finally, it explains the actions for the passenger cabin crew to take in the event of a loss of pressure through a seal in a door, window or at any junction in the aircraft's structure, and provides information on useful consciousness, which varies depending on the altitude and is shown in a table, indicating the time of useful consciousness versus the altitude at which the depressurization takes place.

On 5 March 2014, the Standards Department of the Operations Office issued an information memo titled "DUAL BLEED FAULT Version 2", in which it confirmed that until further notice, every flight made with a deferred bleed would be limited to a maximum flight level of 315 for the entire fleet, even if the MEL allows[22] flying above this level depending on the type of FWC[23] on the airplane.

It also included a reminder on the procedures and/or recommendations if dispatched with a deferred bleed valve and a DUAL BLEED FAULT alert is received once airborne, which were as follows:

- Correct application of the MEL in the dispatch and of the associated operating procedure.

- When possible, review the QRH procedure "AIR ENG 1+2 BLEED FAULT" (36.01A) to be ready just in case.

- Keep in mind that the airplane can almost always be re-pressurized with the APU BLEED at FL200 (except in highly unlikely situations, such as LEAK ON SIDE 1 AND/OR ENG 1 FIRE).

- Although each situation is different, a slow and/or controlled depressurization (in case of a DUAL BLEED FAULT and/or DUAL PACK FAULT) should not be confused with an EMER DESC and the associated memory items[24]. One of the goals of this situation is to avoid as much as possible the automatic release of passenger masks or avoid activating them manually if not needed.

The alerts present in this incident, ENG 1 (2) BLEED ABNORM PR and PACK 1 (2) OFF, correspond to ECAM procedures published by the manufacturer in the FCOM (3.02.36 and 3.02.21).

The Abnormal and Emergency Procedures section of the Quick Reference Handbook (QRH) published by the aircraft operator explains the actions to take in the event

22 As long as the APU is operational.

23 FWC: Flight Warning Computer.

24 Memory Items: Steps to be performed from memory during a specific emergency procedure.

that the bleed system in both engines fails (AIR ENG 1+2 BLEED FAULT (36.01C), non-ECAM procedure). This procedure instructs the crew to reset the two bleed valves (ENG 1+2 BLEED… OFF THEN ON) and if neither one resets, to initiate a descent to FL100 or MEA/MORA[25].

This manual also contains the "white" operations engineering bulletin OEB PROC-40 "AIR ENG 1 (2) BLEED ABNORMAL PR OR AIR ENG 1(2) BLEED FAULT.

According to the Airbus FCOM, an OEB is issued to quickly inform operators of any deviation from the initial design objectives that has a significant impact on operations. It gives operators technical information and operating procedures of a temporary nature intended to address these deviations. An OEB can be "red" or "white" depending on its priority.

Those published in the QRH have a procedure (PROC) associated with them in the corresponding section of the manual, which includes:

- The title of the OEB PROC

- The possible ECAM alerts that require performing the OEB PROC. The flight crew shall ignore the ECAM procedure and the associated status and perform the QRH OEB PROC in its place.

- The operating OEB procedure that the crew must perform.

1.18. Additional information

The flight crew and the purser were interviewed, and they explained the timeline of the flight and answered the questions asked of them in an effort to clear up how the events unfolded.

1.18.1. Information provided by the captain

They received depressurization alerts while at an approximate altitude of 6000 ft. The alerts were displayed on the ECAM display and involved the bleed valve on the left engine, specifically "ENG 1 BLEED ABNORM PR" and then "PACK 1 FAULT". They tried to reset them but it did not work.

They remained at FL300 instead of climbing to their planned altitude of FL380, since they had taken off with the APU inoperative.

25 MEA/MORA: Minimum Enroute Altitude/Minimum off-Route Altitude.

The decision to stay at that altitude was his, not dictated by procedure. The pilot flying (PF) was the copilot and he was the pilot monitoring (PM).

He spoke with the purser and asked him to review the slow and fast depressurization procedure during the climb.

They continued climbing with the copilot at the controls.

With only the #2 pack running, the altimeter climb rate for the cabin was correct. They had not received any similar alerts in that day's previous flights.

While at cruise altitude, level at FL300, he reviewed the QRH to read the OEB, when the same alert was received, "ENG BLEED ABNORM PR", but this time for the bleed valve on the #2 engine, as a result of which he did not have time to carry out the procedure associated with the OEB.

He reset the system but could not clear the problem, so he decided to make a rapid descent to FL100 and divert to the Alicante Airport. This airport, despite being 20 NM further away than Malaga, has a simpler approach maneuver and more favorable terrain around it. The weather at that time was CAVOK [26].

He informed the purser, who had gone into the flight deck, of the situation but he did not inform the passengers, since the cabin pressure was not climbing very fast.

The purser exited the cockpit and carried out his procedures before returning to the cockpit, at which point the pilot inquired about the condition of the passengers and cabin crew. The purser replied that everyone was fairly calm and that the depressurization was barely noticeable.

At FL100, the pilot informed the passengers over the PA that they had completed the rapid descent. By that time they were nearing Alicante.

Once level at FL100, he again reset pack 2. This time it worked, and he left it on. He did not, however, attempt to reset pack 1 since he was not sure if there were any connections between the two packs, and since pack 2 was running, he thought that was sufficient.

Since he was in a high workload situation, he performed the procedure to reset the pack without looking at the QRH. During this time, he was monitoring all the

26 CAVOK. Ceiling and visibility OK. Current visibility, clouds and weather conditions better than required values or conditions.

parameters and verified them to be normal.

He noted that they did the rapid descent without using the masks since the cabin pressure remained below 7,000 ft at all times. Although they could have climbed to FL380, he preferred not to because the APU was not operational and he did not want to climb higher so he could avoid having to descend quickly from that level in case of a fault.

They kept the emergency (MAYDAY) declaration active until they were able to land normally.

The pilot also stated that this type of fault is unusual, and that the aircraft manufacturer has a special procedure (OEB) in place that is temporarily valid. The OEB specifies that the procedure will no longer apply once a permanent solution is in place.

The OEB is not necessarily applicable to the entire fleet; rather, it can apply just to specific aircraft. He stated that the OEB is Airbus's response to a series of events of a temporary nature that can be closed out once a series of improvements is made to the affected airplanes.

Another question he clarified is that the airline has a diverse fleet in terms of the provenance of the airplanes, since they come from different airlines and there are as many as fourteen versions. Simulator training is conducted on a generic airplane on which they practice the different variations.

The simulators are located in Barcelona and Madrid. The engine version can be set on the simulator, but there is no option to modify the software version used by ECAM to display faults.

1.18.2. Information provided by the copilot

It was his first time in a flight rotation with the captain.

He confirmed that they had four flights that day and that on the incident flight, he was the pilot flying.

He had flown with the APU inoperable on other aircraft before.

On the fourth flight, the #1 pack failed. They reset it but it did not work. They proceeded with the flight and he asked the captain what flight level they had to reach according to the operational flight plan. The pilot confirmed that their flight

level was FL380, but since they were flying without the APU, they decided to stay at FL300, which they requested as their final flight level.

On the incident flight, they reviewed the procedure in case the other pack failed and when the purser went into the cockpit, they told him that if the other unit failed, they would have to descend. Just then it failed and the captain instructed him to descend. When the #2 pack disconnected, he felt a mild depressurization in his right ear as they descended, but they did not use the oxygen masks.

He seemed to recall that he started the descent with a 45° right turn.

The depressurization was slow and since there was no structural damage, he deployed the air brakes, increasing the indicated airspeed in SELECTED mode to 320 kt, thus increasing the descent rate.

The captain decided to proceed to the Alicante Airport and coordinated with the purser. He continued as the pilot flying and also handled the radio communications.

While descending, they were instructed to maintain a minimum altitude of 11,000 ft, though they were later told they could descend below 10,000 ft.

The weather was good and they flew the VOR approach to runway 10. They reduced the indicated airspeed and briefly reviewed the approach procedure, since they were close to the airport. They made the approach by shortening the maneuver to mile 10-12 of the VOR, and landed without problems. Once they vacated the runway, ATS asked about their situation, at which point they declared an end to the emergency and taxied to a remote parking stand.

In his opinion, the passengers were relaxed and nobody made any complaints. When they returned to Barcelona, that same day, they did so with the same passengers, who were appreciative.

It was his first such incident, though he had practiced the depressurization procedure in the simulator.

When asked if there was any aspect that could have been improved, he said that they may have been able to descend slower, but in general he thought they had done a good job, considering that it was preferable to reach a lower flight level as quickly as possible to preclude the possibility of the aircraft depressurizing at a higher flight level. He also thought that perhaps they should have donned the oxygen masks.

1.18.3. Information provided by the purser

There were four cabin crew (CC) on the flight plus an instructor, who was doing the purser's annual monitoring.

When he told the captain of the situation in the cabin, the latter replied that a pack had failed and that if the other failed, they could have a slow depressurization, in which case they would have to land. He informed his colleagues and asked them to check the masks. One of the CC had been at the airline for 15 days, so he helped him check the bottles.

He received a call from the flight deck to inform him that they were conducting an emergency descent. He relayed this to the rest of the CC, which began to check the cabin and inform the passengers. The descent maneuver was slow and did not impede their mobility throughout the cabin.

Once the descent was completed, the pilot made an announcement to the passengers in Spanish and English, also informing them that they would be landing at the Alicante Airport.

They landed normally and once on the ground, the coordinator told them that an airplane was flying in from Barcelona which they would very likely use to continue on their flight. The entire crew returned that same afternoon to Barcelona.

In general, the passengers reacted calmly. The depressurization was not as he might have imagined; rather, it was very gradual. No one complained of an ear ache and no one required medical attention.

As for his colleagues, he stated they were not afraid. They were all fine. During the emergency they secured everything in the rear and went to the front of the airplane. Nothing shifted about in the cabin because everything had been secured.

They did not sit down when the emergency descent was announced, but had the masks dropped, the procedure instructs them to take a seat and don the mask immediately.

1.19. Useful or effective investigation techniques

Not applicable in this case.

2. ANALYSIS

2.1. General

The crew of the aircraft had the necessary and valid licenses and permits required for the operation of the flight.

Their duty time prior to the incident flight was within regulatory limits.

All of the aircraft's documentation was valid

The aircraft took off from the Malaga-Costa del Sol Airport at 20:24:10 on 21 February 2017 en route to the Barcelona-El Prat Airport with 176 persons aboard.

It was the fourth and final flight of the day, all made with the same airplane and crew.

The weather during the flight was not limiting to the operation.

The crew's coordination with ATC and the coordination between ATC stations pertaining to the emergency facilitated the operation of the flight between the MAYDAY and the landing in Alicante.

2.2. Analysis of the operation

The crew were on the fourth scheduled flight that day on aircraft EC-HTD. The aircraft had been dispatched with the auxiliary power unit deferred, as per the operator's MEL, since the start of their duty period.

During the departure maneuver from the Malaga Airport (1600 ft and climbing), the aircraft issued an abnormal pressure alert for the bleed system in the left engine, accompanied by a warning that the pack associated with that engine had failed. After resetting the fault, it reappeared as they were climbing through 12000 ft.

Since the APU was not available to supplement the engine bleed to the packs, and in keeping with the instructions issued by the operator in its information note "DUAL BLEED FAULT version 2", the crew decided to limit the flight level to FL300, which was authorized by ATC.

The captain stated that his intention was to analyze the initial situation and apply the OEB PROC-40 "AIR ENG 1 (2) BLEED ABNORMAL PR OR AIR ENG 1 (2) BLEED FAULT" once level at their cruise altitude, in an effort to solve the indicated fault.

They did not have time to execute this procedure because shortly after reaching the set flight level, the aircraft issued an abnormal pressure alert for the bleed system, this time for the right engine, along with a warning that the pack associated with this engine had failed. This new indication implied that the aircraft would be unable to maintain the differential pressure in the cabin.

The QRH "AIR ENG 1 + 2 BLEED FAULT" procedure requires closing the crossfeed valve and reset both bleed valves. If neither one is recovered, the procedure instructs descending to FL100 or to the MEA/MORA (whichever is higher), though it does not explicitly call for an emergency descent.

The flight crew informed both ATC and the cabin crew that they were doing an emergency descent and carried out the memory items for this procedure, but without donning the oxygen masks.

In his statement, the captain indicated his intention to make a rapid, not emergency, descent, since he saw that the cabin altitude was rising slowly and there was no risk that the masks would automatically deploy. In fact, the maximum cabin altitude recorded was 6700 ft.

The information note "DUAL BLEED FAULT version 2" refers to the required descent in the following terms:

"Although each situation is different, a slow and/or controlled depressurization (in the event of a DUAL BLEED FAULT and/or DUAL PACK FAULT) should not be confused with an EMERG DESC and its associated memory items. One of the goals in this situation is to avoid, to the extent possible, the automatic dropping of the passenger masks or avoid activating them manually when not necessary".

This paragraph indicates to crews that in case of a fault, such as those that occurred in this incident, the aircraft will depressurize slowly, meaning that an emergency descent is not required, as specified in the manufacturer's abnormal procedures.

In any event, depending on the depressurization rate and on how long the cabin pressure is estimated to remain above FL100, the flight crew must consider using the oxygen masks to avoid the effects of hypoxia and the consequent reduction in their time of useful consciousness.

Although they initially requested to return to the airport of origin (Malaga), the captain's decision to divert to the Alicante Airport, the topography of the terrain around which would allow them to fly at levels that would not require assisted breathing if the aircraft were to depressurize (FL100 or lower), is judged to have

been correct.

While en route to Alicante at FL070, the crew managed to reset the bleed system on the right engine and its associated air conditioning pack, which remained operational until landing.

2.3. Analysis of the maintenance activities

The aircraft's overall maintenance condition was acceptable, though the APU was deferred as per the MEL, and the PRV in the #1 engine was not in accordance with the IPC. Both aspects are considered in more detail below.

The aircraft was dispatched with the auxiliary power unit out of service, as per the MEL, due to having life-limited components close to expiration. This deprived the crew from having a back-up means of supplying the air packs, and thus from keeping the aircraft pressurized, if the engine bleed failed. This fact by itself, however, cannot be regarded as having caused this incident.

Of all the maintenance activities performed in the 18 months prior to the incident and related to the air conditioning (ATA 21) and pneumatic (ATA 36) systems, it was concluded that only one was directly related to this incident. That was the A4 check in August 2015, when the type-E pressure regulating valve (PRV) that was installed in the #1 engine was replaced with a type-G valve whose part number was not correct.

The investigation tried to find a relationship between this type-G PRV and what happened on the incident flight. To this end, it relied on the statements provided by the manufacturer of the aircraft (Airbus) and the PRV (Liebherr), the operator (Vueling) and the maintenance services provider (Iberia). The result was inconclusive.

After the incident the operator replaced the two temperature limitation thermostats (TLT) and the two pressure regulating valves (PRV) and sent them to the manufacturer for analysis.

The analysis of these components by Liebherr showed wear and signs of leaks, and indicated that the wear on some components was more than expected considering the number of cycles.

However, Iberia's Reliability Department noted that the average time to replace one of these components in the fleet is, in general, longer than that guaranteed by the manufacturer, and there is no concern that they fail more often than they should. Iberia's Maintenance and Operational Safety Department was also unable to

determine the reason for the greater than expected wear on the parts installed in EC-HTD.

The investigation into the incident conducted by the operator and the maintenance services provider determined that the left engine had a type-G PRV installed, which, according to the IPC, is a conditional spare for the type-E PRV it should have had. This component was verified not to comply with the condition required for installation in aircraft EC-HTD, since the required modification (MOD 31261) was not implemented on this aircraft.

Since a year and a half had elapsed between its installation by the maintenance services provider, at the completion of the A4 check, it was not possible to trace the error, which probably occurred as a result of a misinterpretation of the IPC.

In any event, this faulty installation could not be established as the direct cause of the incident since, as mentioned, the aircraft had been flying with the component installed for 18 months without any failures, which makes it unlikely that it was solely responsible for the incident. The type-G PRV installed in the #1 engine probably had its cover in place since after its erroneous installation, when it was placed into operation, no problems occurred during any other flights.

As a result of the operator's (Vueling) internal investigation into this incident, a series of corrective actions were implemented (see 1.16.2).

The findings and the implementation of these actions are deemed sufficient to mitigate a recurrence of similar problems, and as a result no safety recommendations are issued in this regard.

The maintenance services provider (Iberia) also implemented a series of corrective actions (see 1.16.3).

Likewise, the findings and the implementation of these actions are deemed adequate to mitigate a recurrence of similar problems, and as a result no safety recommendations are issued in this regard.

One finding made during the investigation is that the bleed regulating system on this aircraft model is a closed system that does not allow detecting wear of its components over time. In fact, although no direct cause was found that points to any component in particular, the condition in which the PRVs and the TLTs were found was worse than expected considering the number of flight cycles.

As a result, it is appropriate to recommend to AIRBUS, as the manufacturer of the

aircraft, that it establish a scheduled maintenance task to check the operating ranges of the components in the aircraft's bleed system.

2.4. Preservation of the flight recorders

The data from the cockpit voice recorder (CVR) were not available to the investigating team since the recordings were not preserved after the incident flight. Following the incident, the aircraft was taken on a ferry flight to the Barcelona-El Prat Airport, and it was only the recordings from this flight that were available on the CVR.

The operator stated that the order to preserve the flight recorders was issued after the ferry flight, since the maintenance team did not regard the event as a serious incident, and thus did not download and quarantine the flight recorder units.

In an effort to keep this from happening again, the operator (Vueling) implemented a series of actions (see 1.11.2) that, in the opinion of the investigators, address the deficiency identified. As a result, no safety recommendation is issued in this regard.

3. CONCLUSIONS

3.1. Findings

- The crew of the aircraft had the necessary and valid licenses and permits required for the operation of the flight.

- Their duty time prior to the incident flight was within regulatory limits.

- All of the aircraft's documentation was valid.

- The aircraft took off from the Malaga-Costa del Sol Airport at 20:24:10 on 21 February 2017 en route to the Barcelona-El Prat Airport with 176 persons aboard.

- It was the fourth and final flight of the day, all made with the same airplane and crew.

- The weather during the flight was not limiting to the operation.

- The aircraft's overall maintenance condition was acceptable, though the APU was inoperative and deferred as per the MEL, and the pressure regulating valve (PRV) in the #1 engine was not in accordance with the IPC.

- During the A4 check in August 2015, the type-E PRV installed on the #1 engine was replaced with another whose serial number was not correct (type-G), as per the IPC.

- This was the only maintenance activity performed in the 18 months prior to the incident on the air conditioning (ATA 21) and pneumatic (ATA 36) systems that was directly related to this incident.

- While climbing through 1600 ft on the initial climb, the aircraft issued an alert due to problems in the bleed system and air conditioning pack in the left engine.

- After resetting the fault, it came in again as the airplane was climbing through 12000 ft.

- The crew, cleared by air traffic control, decided to limit its flight level to FL300, instead of the planned FL380.

- Shortly after reaching FL300, the aircraft issued an alert due to problems in the bleed system and air conditioning pack in the right engine.

- The crew made an emergency descent to FL100 without donning the masks after declaring a MAYDAY.

- The masks in the passenger cabin did not drop. In fact, the maximum cabin altitude recorded was 6700 ft.

- The crew deemed it appropriate to divert the airplane to the Alicante Airport.

- At FL070, the crew managed to reset the bleed system and the associated air pack on the right engine, which remained in operation until landing.

- The crew's coordination with ATC and the coordination between ATC stations pertaining to the emergency facilitated the operation of the flight between the MAYDAY and the landing in Alicante.

- The crew flew the VOR approach to runway 10 at Alicante, where the airplane landed normally at 21:08:49.

- Neither the crew nor the passengers required medical assistance.

- After landing in Alicante, the operator did not preserve the cockpit voice recorder (CVR), and thus the information from the incident flight was unavailable.

- The type-G PRV installed in the #1 engine should have had the protective cover installed, which would explain why it did not cause problems immediately after being mistakenly placed in service or in the 18 months leading up to the incident flight.

- The cause of the incident could not be directly related to the fact that the part number for the PRV in the #1 engine was incorrect.

- The manufacturer of the TLT and PRV inspected the ones from the incident aircraft and noted that the wear on some of their components was higher than expected, considering the number of cycles.

- The bleed regulation system on this aircraft model is a closed system, which makes it impossible to determine the wear over time of the components installed in the system.

3.2. Causes/ Contributing factors

The investigation has determined that the most likely cause of the incident was the undetectable and undetected degradation of the bleed regulation in the aircraft.

It was also determined that the correct model of pressure regulating valve (PRV) was not installed in the aircraft's no. 1 engine due to a component identification error in the IPC.

4. SAFETY RECOMMENDATIONS

REC 06/18:

It is recommended that AIRBUS, as the manufacturer of the aircraft, establish a scheduled maintenance task to ensure that the operating ranges of the components in the aircraft's bleed system are checked.