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INVESTIGACIÓN
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E **I**NCIDENTES DE
AVIACIÓN **C**IVIL

Report
IN-030/2018

Incident involving an Airbus A320-214 aircraft, registration EC-JFN, at Adolfo Suárez Madrid-Barajas Airport on 3 July 2018

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Notice

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 5.6 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.

Contents

Abbreviations

° ′ ″	Sexagesimal degrees, minutes and seconds
%	Per cent
ºC	Degree(s) Celsius
A/C	Air Conditioning system
ACC	Area Control Centre or Area Control
ACM	Air Cycle Machine
AENA	Spanish Airports and Air Navigation
AESA	Spain’s National Aviation Safety Agency
AFS	Aeronautical Fixed Service
AIP	Aeronautical Information Publication
AMM	Aircraft Maintenance Manual
AOG	Aircraft On Ground
APP	Approach centre or approach service
APU	Auxiliary Power Unit
ATA	Air Transport Association
ATC	Air Traffic Control
ATPL	Airline Transport Pilot License
ATS	Air Traffic Service
CAMO	Continuing Airworthiness Management Organisations
CAVOK	Ceiling And Visibility OK
CC	Cabin Crew
CGA	Airport Management Centre
CIAIAC	Civil Aviation Accident and Incident Investigation Commission
CM1	Pilot in the left seat
CM2	Pilot in the right seat
COS	Cabin Odour Sheet
COSRS	Cabin Odour or Smoke Reporting Sheet
CPL(A)	Commercial Aircraft Pilot License
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DAR	Data Access Recorder
DMU	Data Management Unit
EASA	European Aviation Safety Agency
EBBR	ICAO code for Brussels Airport (Belgium)
ECAM	Electronic Centralised Aircraft Monitor
ECS	Environmental Control System
ECU	Electronic Control Unit
EDP	Engine Driven Pump
EECU	Electronic Engine Control Unit
FCOC	Fuel Cooled Oil Cooker
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FCV	Flow Control Valve
FDR	Flight Data Recorder

FMGC	Flight Management Guidance Computer
FOD	Foreign Object Damage
ft	Feet
h	Hours
HEPA	High Efficiency Particulate Air
HP	High Pressure
hPa	Hectopascals
HPV	High Pressure Valve
IDG	Integrated Drive Generator
IFR	Instrumental Fight Rules
ILS	Instrument Landing System
IP	Intermediate Pressure
IR(A)	Instrument Rating
QAR	Quick Access Recorder
kg	Kilograms
kg/sec	Kilograms/second
km	Kilometers
kt	Knot(s)
LAPL	Light Aircraft Pilot License
LCL	Local
LECM	Madrid FIC/ACC
LEMD	ICAO code for Adolfo Suárez Madrid-Barajas Airport
LIFUS	Line Flying Under Supervision
LPC	Line Proficiency Check
m	Metre(s)
mm	Millimetre(s)
m/s	Metre(s)/second
m^2	Metre(s) squared
MAREP	Maintenance Report
MEA	Minimum En-route Altitude
MEP	Multi-piston engine aircraft
METAR	Aviation routine weather report
MO	Operating Manuals
MPD	Maintenance Planning Document
MPL	Missing Part List
s/n	Series number
N1	Speed of the low-pressure compressor
N2	Speed of the high-pressure compressor
OACI	International Civil Aviation Organisation
OCC	Operator Conversion Course
OEB	Operations Engineering Bulletins
OPC	Operational Proficiency Check
p/n	Part number
PBE	Protection Breathing Equipment
PCMCIA	Personal Computer Memory Card International Association
PF	Pilot Flying
PIREP	Pilot report

PM	Pilot Monitoring
PPL (A)	Private Pilot License
PRV	Pressure Regulating Valve
psi	Pressure per square inch
PTU	Power Transfer Unit
PV	Flight plan
QNH	Atmospheric pressure (Q) at nautical height
QRH	Quick Reference Handbook
RAT	Ram Air Turbine
RWY	Runway
s	Seconds
SEP	Single-piston engine aircraft
SFE	Simulator Flying Examiner
SIB	Safety Information Bulletin
SOF	Smell Odour Fumes
TAF	Terminal Aerodrome Forecast
TCP	Cabin crew
TCPV	Central flight plan processing system
TLPV	Local flight plan processing system
TMA	Traffic Management Area
TMA	Aircraft Maintenance Technician
TSM	Troubleshooting Manual
TWR	Control tower
UE	European Union
UTC	Universal Time Coordinated

Synopsis

Owner/Operator:	Iberia L.a.e., S.A.
Aircraft:	Airbus A320-214, registration EC-JFN, n/s: 2391
Date and time of incident:	Tuesday 3/July/2018, 14:43 UTC[1]
Site of incident:	Adolfo Suárez Madrid-Barajas Airport (LEMD) - Madrid
Persons on board:	6 crew members and 168 passengers, unharmed
Type of flight:	Commercial air transport - Scheduled - International - With passengers
Phase of flight:	Ascent
Flight rules:	IFR
Date of approval:	25/November/2020

Summary of incident

On 3 July 2018 the Airbus A320-200 aircraft, registration EC-JFN, commenced flight IBE-3214 to Brussels (Belgium), taking off from Adolfo Suárez Madrid Barajas Airport - LEMD (Madrid).

During the ascent, at 3500 feet, the flight crew noticed an intense smell of burning and observed smoke in the cockpit, coming from the air conditioning outlets. The captain declared an emergency and requested a return to the departure airport.

Smoke was also reported in the passenger cabin, and the captain of the aircraft instructed the use of oxygen masks.

The aircraft was cleared to return to LEMD and landed without incident. The smoke had completely dissipated from the aircraft, although the smell of burning persisted.

While waiting on the stand before proceeding with disembarkation, a maintenance technician informed the captain that he had detected an obvious hydraulic fluid leak in one of the engines.

Neither crew nor passengers were harmed, and the aircraft did not sustain any damage during the incident.

The investigation has determined the incident was most likely caused by an inadequate maintenance practice, which led to the contamination of the bleed air from engine 1 and caused smoke to enter the cabins through the air conditioning vents.

[1] The times quoted are UTC. Local time can be calculated by adding two units to the UTC.

The air was most probably contaminated by the residues of grease, oil and bird remains, which were burned during the routine operation of the engine, having not been removed during the maintenance carried out after the bird ingestion during the preceding flight. Oil spills left by prior maintenance procedures could also be a factor.

The report contains three safety recommendations addressed to the operator and company responsible for the maintenance of the aircraft, and one to the manufacturer of the aircraft, so that they can implement good practices in their maintenance procedures, ensure the continuous training of their crew, flight records reliability and include additional tasks in the aircraft's maintenance and troubleshooting manuals to reduce the risk of in-flight cabin smoke events.

1. FACTUAL INFORMATION

1.1. History of the flight

On 3 July 2018, the Airbus A320-214 aircraft, operated by Iberia L.a.e. S A. registration number EC-JFN and flight call sign IBE3214, departed from Adolfo Suárez Madrid-Barajas Airport - LEMD at 14:06 UTC, destined for Brussels Airport (Belgium) - EBBR with 174 people on board. It was aircraft's first flight following the replacement of engine #2 due to bird ingestion in both turbines.

The flight crew consisted of a certifier/trainer captain and a co-pilot in the LIFUS line supervision phase[2].

The aircraft took off from LEMD runway 14L at 14:27:39 UTC without incident. During the ascent, at approximately 3500 ft, *pack 1*[3] was connected, and smoke began to filter into the cockpit through the air conditioning vents, quickly becoming denser.

The captain, who up until that point had been acting as the PM[4] supervising the flight, decided to take control of the plane, switching to the role of PF[5] and transferring communications to the co-pilot, instructing him to use his oxygen mask and requesting the corresponding QRH procedure for "SMOKE/FUMES/ AVNCS SMOKE".

The smoke began to filter into the passenger cabin and, at 14:30:11 UTC, the crew declared an emergency (MAYDAY[6]). After levelling at approximately 7000 ft and receiving the relevant ATC clearances, the aircraft began its return to LEMD. The co-pilot had started the QRH procedure, but about three minutes after it first appeared in the cockpit, the smoke began to dissipate. The pilots, therefore, removed their oxygen masks and focused on landing the plane, abandoning the QRH procedure. They descended to 5000 ft, turning at the end to intercept ILS 18R, and landed without further incident seventeen minutes after take-off.

The cabin crew did not use the smoke hoods but communicated with the captain and advised the passengers to prepare for a precautionary landing[7].

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[2] LIFUS: *Line flying under supervision* forms part of the operator's conversion course in accordance with aviation operation regulations.

[3] *Pack:* the set of air conditioning system components that cool the air. There are two packs installed.

[4] PM: the *Pilot Monitoring* is the pilot responsible for monitoring flight management procedures and performing tasks such as communications and the reading of checklists to cross-check the actions of the PF

[5] PF: the *Pilot Flying* is the pilot responsible for piloting the aircraft using the aircraft's controls..

[6] MAYDAY: distress-call repeated three times to indicate an imminent threat to life or the viability of the aircraft itself.

[7] Precautionary Landing: landing made when there is no immediate danger to the aircraft but it is considered more advisable to land than to continue flying. It is a landing urgent enough to declare PAN PAN, and the captain informs the purser of the situation and his/her intentions to ensure the passengers are properly informed. However, it is not considered as urgent as an "emergency landing", which is carried out when there is an imminent risk to the aircraft and its contents, requiring the use of the MAYDAY distress signal.
In this case, the operator's *Operating Manuals,* part B, defines a Precautionary Landing as one that takes place on an airport runway and (depending on the evolution of events) may require the evacuation or emergency evacuation of the aircraft but is not yet a matter of necessity and has not been ordered by the captain. The cabin crew must carry out a detailed review of the condition of the cabin prior to landing and be prepared for the possibility of having to evacuate the passengers

After the emergency was cancelled, the aircraft exited the runway and headed to a remote stand[8]. The passengers disembarked normally following a twenty-minute wait for the stairs and the buses required to transport them to the terminal.

Neither the crew nor the passengers required medical assistance after the incident.

The aircraft did not sustain any damage during the incident and returned to service two days after the event, on 05/07/2018.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor				
None	6	168	174	
Total	6	168	174	

1.3. Damage to the aircraft

The aircraft did not sustain any damage as a result of the incident.

1.4. Other damage

There was no third-party damage.

1.5. Personnel information

1.5.1. Technical crew

1.5.1.1. Captain

The 44-year-old Spanish captain had an airline transport pilot license for aircraft, ATPL(A), issued by Spain's National Aviation Safety Agency (AESA) on 12/12/2003 with the following ratings:

- Instrumental flight rating, IR(A), and
- Type rating for the AIRBUS A-320 aircraft, valid until 31/05/2019.

He also had a Private Pilot License, PPL(A), issued on 16/12/1993 and a commercial pilot license, CPL(A), issued on 06/03/1995.

[8] Remote stand: airport stands generally reserved for aircraft that will be parked for an extended period of time.

He had a total of 14571.39 hours of flying time, of which 3634.07 hours were in the type of aircraft involved in the incident.

Of his total flying time, 10759.37 hours were as co-pilot and 3422.02 were as captain.

Of his total flying time in A320 aircraft, 212.05 hours were as co-pilot and 3422.02 were as captain.

He had been working for the operator for over 21 years.

His activity preceding the flight was as follows:

- in the last 90 days he had flown: 207.92 h
- in the last 30 days he had flown: 51.78 h
- in the last 24 h: 5.62 h
- his pre-flight rest period was 13:34 h, and his last flight before the incident was from Paris-Orly Airport to Adolfo Suárez Madrid-Barajas.

His most recent CRM was carried out on 06/05/2016. Although the operator's OM states that CRM courses should be carried out every two years, in this particular case, there was an error in the course management programme and a three-year expiry date was set by mistake.

His most recent line and operational proficiency checks (LPC & OPC) were dated 20/04/2018.

According to the records provided by the operator, his course history was up to date according to EU regulation 965/2012, emergency and safety equipment course included.

His Language Proficiency certificate was valid, certifying level 6 English.

His class 1 and 2 medical certificates were valid until 27/11/2018 and until 27/11/2019 for the LAPL.

He qualified as a certifier/trainer for the A320 fleet on 01/03/2016 and had accumulated 1,341.01 flight hours in that role.

The captain had no previous experience of flying with the co-pilot of the incident flight until the "pairing"[9] began on 01/07/2018.

However, his role as trainer of the co-pilot during the affected flight meant that he was aware of the co-pilot's LIFUS progress and his performance during the six sectors they had flown together in the two days leading up to the event.

[9] Pairing: pairing of flight crew.

1.5.1.2. Co-pilot

The 21-year-old Spanish co-pilot had a commercial pilot license, CPL(A), issued by Spain's National Aviation Safety Agency (AESA) on 03/03/2017 with the following ratings:

- IR(A) instrumental flight rating, valid until 28/02/2019
- MEP (Land) valid until 31/03/2018
- SEP (Land) valid until 31/03/2019
- Type rating for the AIRBUS A-320 aircraft, valid until 28/02/2019

He had a total of 562.81 hours of flying time, of which 261.13 hours were as co-pilot in the type of aircraft involved in the incident.

He had joined the company recently, on the 26/02/2018.

His activity preceding the flight was as follows:

- in the last 90 days he had flown: 208.4 h
- in the last 30 days he had flown: 44.23 h
- in the last 24 h: 5.62 h
- his pre-flight rest period was 13:34 h, and his last flight before the incident was from Paris-Orly Airport to Adolfo Suárez Madrid-Barajas.

His most recent CRM was carried out on 06/03/2018.

His most recent line and operational proficiency checks (LPC & OPC) were dated 20/02/2018 and 19/03/2018 respectively.

After the flight affected by the smoke event, the co-pilot flew one more leg for the company and then resigned his position.

The co-pilot had no previous experience of flying with the captain of the affected flight until the pairing began on 01/07/2018.

His Language Proficiency certificate was in force and certified level 6 in English.

His class 1 medical certificate was valid until 06/10/2018, class 2 until 06/10/2022, and for LAPL until 06/10/2022.

1.5.2. Cabin crew

The cabin crew was made up of three flight attendants and a purser.

The 47-year-old purser had a valid Passenger cabin crew certificate issued on 17/04/2013, as well as a class CC (Cabin Crew) medical certificate valid until 29/03/2019. He had 13470 flight hours, of which 1459 hours were as a purser in the A-320 fleet.

As for the three remaining members of the cabin crew, all had valid Passenger cabin crew certificates and medical certificates on the date of the incident.

1.6. Aircraft information

1.6.1. General information

The AIRBUS A320-214 aircraft registration EC-JFN was manufactured in 2005 with serial number 2391 and had two CFM-56-5B4/P type engines with serial numbers 577164 (engine 1) and 577627 (engine 2).

The aircraft had accumulated 31288:51 flight hours and 22385 cycles. Engine 1 had accumulated 33646 flight hours and 19130 cycles, and engine 2 had 30073 flight hours and 19907 cycles.

The aircraft operated by IBERIA LÍNEAS AÉREAS DE ESPAÑA S.A. OPERATOR had a valid air operator certificate for the Commercial Air Transport of Passengers and Goods.

The aircraft had a valid station license dated 20/03/2015, and a noise level certificate issued on 07/09/2010.

1.6.2. Maintenance information

Maintenance was carried out by a maintenance centre approved by AESA as a Continuing Airworthiness Management Organisation (CAMO). It also has EASA maintenance organisation approval as per Annexe II (Part 145) of regulation (EU) No. 1321/2014. The organisation responsible for maintenance was authorised to carry out line and base maintenance overhauls for AIRBUS A320 aircraft and CFM56-5B SERIES engines, as well as for other aircraft.

The maintenance programme approved by the authority and in force for the A319/A320/A321 fleet at the time of the event was Maintenance Programme Document #: AMP-IBE-A32X Rev. 43 TR05, dated 26/06/2018. It was applicable to the aircraft involved in the incident, registration EC-JFN, s/n: 2391 identified as type AIRBUS A320-200 (Specification: B).

We have investigated the maintenance inspections performed on the aircraft during the 18 months prior to the incident. The following inspections are highlighted, with a general nature, which were successfully completed:

- Type A1 inspection, between 05/05/2018 and 08/05/2018, with certificate of release to service from 05/05/2018 when the aircraft had 30849:02 flight hours and 22083 cycles. These inspections are performed every 750 flight hours, 750 flight cycles or four months.
- Type D inspection on 03/03/17: when the aircraft had 27772 flight hours and 19980 cycles. This type of inspection, which is the most complete and rigorous inspection performed on aircraft, is carried out every six years. Furthermore, this inspection was carried out alongside the Type E check, which is performed every twelve years.

The inspections that involved work on elements particularly relevant to the incident, specifically, the air conditioning system (ATA 21) were as follows:

- In the A1 inspection: work was carried out on the ATA 21, specifically the ventilation system of the avionics equipment, the lavatories and the galley[10]. General checks of the ATA 29 hydraulic system, particularly the hydraulics related to the landing gear, were also performed.
- In the type D inspection, we have identified several routine tasks performed on the ATA 21 air conditioning system which may be related to the incident, including general visual inspections of the air recirculation system and the filters; operational checks on the ventilation and extraction of the smoke configuration control circuit; and the installation of clamps and bellows on the pack outlets and between the by-pass valves and the mixer unit of the air conditioning system.
- Also, during this inspection and within the planned component replacements as per the applicable MPD[11], the ATA 21's main and primary heat exchangers, the condensers and the avionics compartment fan were changed. With regard to unplanned component replacements, the air plenum chambers of both packs 1 and 2 were repaired.

In addition, the following findings relating to the ATA 21 were identified in scheduled inspections:

- The reheater in air conditioning pack 1 was inoperable.
- The forward avionics compartment ventilation ducting was in poor condition.

The corresponding components were replaced.

1.6.3. Airworthiness status

According to AESA's record of active registrations, the aircraft with serial number 2391 and registration EC-JFN was registered on the 13/07/2005, with registration number 7267. The registration certificate states the aircraft's base as the Adolfo Suárez Madrid-Barajas Airport.

[10] Galley: the food preparation area of an aircraft.
[11] MPD: Maintenance Planning Document: document, provided by the aircraft manufacturer to specify the necessary repetitive maintenance tasks.

At the time of the incident, it had the corresponding airworthiness certificate issued by AESA on 26/05/2011, with its airworthiness review certificate being valid until 10/04/2019.

1.7. Meteorological information

1.7.1. General situation

Prevailing winds from the south-west affecting the Peninsula and the Balearic Islands. At low levels, there was an Atlantic anticyclone centred to the west of the Azores and extending to the western half of the peninsula and the Canary Islands. Relatively low pressures over the Mediterranean coast and the Ebro valley. Developing cloudiness, in the northern half of the peninsula; convection was beginning to form around Teruel in the Lower Aragon region. Temperatures reached 34ºC in the Ebro Valley, the interior of the Mediterranean provinces and the Balearic Islands.

1.7.2. Conditions at the incident site

According to the METAR data, at the time of the incident, the conditions at Madrid-Barajas Airport were as follows:

METAR LEMD 031300Z 25005KT 190V330 9999 FEW058 29/10 Q1017 NOSIG=

METAR LEMD 031330Z 21007KT 170V340 9999 FEW058 30/10 Q1017 NOSIG=

METAR LEMD 031400Z VRB06KT 9999 FEW080 30/09 Q1017 NOSIG=

METAR LEMD 031430Z 22007G23KT 130V300 CAVOK 30/08 Q1017 NOSIG=

METAR LEMD 031500Z 21004G17KT CAVOK 30/07 Q1016 NOSIG=

(*Conditions described by the METAR at 14:30 and 15:00 h at Adolfo Suárez Madrid-Barajas Airport: wind between 23 and 17 kt, temperature 30ºC, high visibility, dew point between 8 and 7 ºC and a QNH between 1017 and 1016 hPa.*)

The expected TAF was:

TAF LEMD 031100Z 0312/0418 22010KT CAVOK TX33/0316Z TN16/0406Z TEMPO 0312/0320 21010G20KT PROB30 TEMPO 0312/0319 FEW040TCU BECMG 0318/0320 VRB05KT BECMG 0409/0411 23012KT TEMPO 0412/0418 23015G27KT=

After consulting the remote sensing images and the records detailed above, we can confirm there was no convective activity, significant cloud cover, or reduced visibility at the time of the incident. The only significant parameter was the wind, which was blowing with moderate intensity from the south-west, reaching values exceeding 20 kt, although oscillating in direction from south-east to north-west.

1.8. Aids to navigation

After the appearance of smoke in the cockpit and the declaration of MAYDAY, the aircraft's return to LEMD, as well as its approach and landing, were coordinated by the ATC, ACC and control tower services, using AFS and RADAR contact to facilitate the manoeuvres with minimum communications. The aircraft was authorised to approach runway 18R with no restrictions and did so without issue.

All the aids required for manoeuvring were operational on the day of the incident.

The flight was operating under instrumental flight rules (IFR).

The RADAR trace provided by the Palestra system[12] shows the trajectory of the aircraft and its return and descent following the MAYDAY call. The aircraft ascended until it reached level 67 and then began descending to level 19. The PV Palestra Radar information confirmed that the aircraft took off from LEMD-14R at 14:28, and landed on LEMD-18R at 14:43. The TLPV and TCPV provided information consistent with the above and did not reveal any other information relevant to the incident.

1.9. Communications

The transcript of the TWR tape on the various frequencies confirms the executive reports.

The transcription from TMA 11, confirms the aircraft's MAYDAY communication at 14:30:11 due to smoke in the cabin, and its request for vectors to return to runway 18L as soon as possible. In RADAR contact, the aircraft was instructed to fly at its discretion towards runway 18L. It replied that it was turning right to pick up a tailwind towards runway 18L, maintaining 7000 ft altitude. Indicating that the aircraft involved in the incident was going to land on runway 18R, all other take-offs were stopped. The control tower ended the communication indicating that operations on the two runways had been halted.

According to the communications transcript from TMA 5, the aircraft declared PAN PAN[13] as a result of smoke in the cabin at 14:33:11. Control asked the aircraft if it could maintain 9000 ft. The aircraft requested 7000 ft, and this altitude was accepted. At 5000 ft, the aircraft made its turn to the right and, there being no other traffic, was cleared to approach runway 18R. It landed without further incident.

[12] Palestra System: automated record of air traffic control services

[13] PAN PAN: the call repeated three times to indicate an urgent situation that does not imply imminent danger to the aircraft or life

1.10. Aerodrome information

The Adolfo Suárez Madrid-Barajas Airport (ICAO code LEMD) belongs to the network of national airports managed by the AENA (Spanish Airports and Air Navigation). It is located 13 km to the north-east of Madrid. Its elevation is 609 m.

It is equipped with four parallel runways, two to two, and five passenger terminal buildings, as well as aprons and taxiways to facilitate the movements of aircraft on the ground and service equipment.

It has four paved runways: 14L/32R, 14R/32L, 18L/36R y 18R/36L. Thus, the configurations published in the AIP are:

- Between 07:00 h and 23:00 h:
  - Preferential: Northern Configuration
    Arrivals: 32L/32R
    Departures: 36L/36R
  - Non-preferential: Southern Configuration
    Arrivals: 18L/18R
    Departures: 14L/14R
- Between 23:00 h and 07:00 h:
  - Preferential: Northern Configuration
    Arrivals: 32R
    Departures: 36L
  - Non-preferential: Southern Configuration
    Arrivals: 18L
    Departures: 14L

The preferential configurations are maintained so long as the component wind, including gusts, does not exceed 10 kt in tailwind and/or 20 kt in crosswind. Departure from the preferential configurations may also be permitted for safety reasons, due to the closure of any runway or to aid air navigation when aircraft are unable to perform the standard instrument-led departures and arrivals, or when any of the following meteorological conditions are anticipated or occur:

- condition of the runway surface adversely affected and/or with inadequate braking action,
- cloud ceiling lower than 500 ft above the aerodrome’s elevation,
- visibility less than 1.9 km,
- reported or forecast wind shear, storms on approach or departure,
- or any other meteorological condition that impedes the preferential configurations.

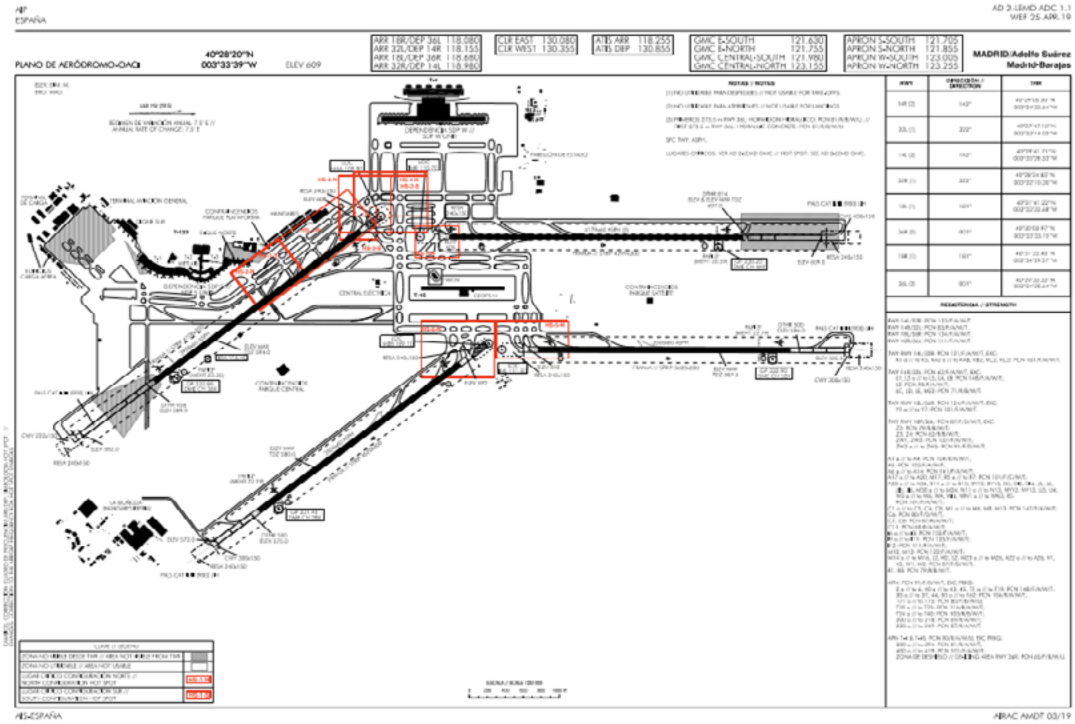

Figure 1: Plan of Adolfo Suárez Madrid-Barajas Airport

1.11. Flight recorders

The Airbus A320-214 aircraft was equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR).

By the time CIAIAC was made aware of the incident, it was too late to use the recorder itself. Therefore, the information from the flight data recorder was obtained from the DAR. We were unable to obtain information from the cockpit voice recorder for the same reason.

Both the operator and the aircraft manufacturer, with the available DAR data and dataframe, provided the following flight milestones[14]:

- At 14:11:12 UTC: aircraft was at LEMD airport (GS = 0kt, HDG = 360°)
  - APU was ON. APU bleed valve and X-Bleed valve were open.
  - Engine 2 was ON with N1A stable around 20%.
  - Engine 1 was being started.
  - Thrust levers were set at IDLE notch.

[14] It should be noted that accuracy of the data and Booleans cannot be guaranteed, – eg ECAM page selection is not recorded correctly.

At that time, air conditioning / pneumatic panel configuration was as follow:

P/B or Light	State	Remark
ENG 1 BLEED P/B	ON	Remained in these states during entire flight
ENG 2 BLEED P/B	ON	
APU BLEED P/B	ON	-
HOT AIR P/B	ON	Remained in this state during entire flight
PACK 1 P/B	ON	-
PACK 2 P/B	OFF	-
RAM AIR P/B	ON	Remained in this state during entire flight

No smoke warning was recorded (avionics / lavatory / cargo), as during the entire flight. No smoke was detected in the avionics ventilation ducts (BLOWER P/B and EXTRACT P/B lights recorded OFF), as during the entire flight.

No low pressure hydraulic warnings were triggered during the entire flight.

- At 14:11:52 UTC: APU Master Switch and APU Bleed were selected OFF. Within the next ten seconds, pack 2 was selected ON and pack 1 was selected OFF.
- At 14:14:13 UTC: the aircraft began to taxi.
- At 14:16:20 UTC: while aircraft was taxiing pack 1 was selected ON.
- At 14:25:30 UTC: pack 1 was selected OFF. PACK 2 was selected OFF until the end of the flight.
- At 14:26:46 UTC: aircraft was aligned on runway 14R (HDG = 144°)
    - Both FDs were engaged.
    - Aircraft GW was 65.7T (< MTOW = 73.5T) and CG = 28.1%.
- At 14:27:00 UTC: the aircraft began take-off run.
- At 14:27:39 UTC: aircraft took off (MLGs recorded uncompressed).
- At 14:28:30 UTC: crossing 2050 ft RA (3760ft QNH), pack 1 was selected ON and remained in this state until end of flight.
- At 14:29:18 UTC: crossing 3600 ft RA (5300 ft QNH), Master Caution triggered for three seconds.
- At 14:29:26 UTC: crossing 3660ft RA (5400 ft QNH), AP2 engaged in CLB / NAV modes.

- At 14:30:01 UTC: crossing 4100ft RA (5900 ft QNH).
  - Speed mode changed from Managed to Selected.
  - Speed target was reduced from 250 kts to 220 kts.
  - CAS was 221 kt and continued to follow its target.

- At 14:30:03 UTC: SALTFCU was reduced from 24000 ft to 7000 ft. Seven seconds later, AP/FD modes changed from CLB / NAV to ALT* / NAV, and A/THR mode changed from THRUST to SPEED.

- At 14:30:43 UTC: aircraft levelled-off at 7000 ft QNH.

- At 14:30:49 UTC: In Flight Turn back initiated.

- At 14:32:11 UTC: SALTFCU was changed from 7000 ft to 5000 ft and SVS was set to -450 ft/min. Aircraft started to descent and AP modes changed from ALT / HDG to V/S / HDG.

- At 14:39:18 UT: aircraft was initiating its final descent, crossing 2550 ft RA (4920ft QNH) and was performing a final right turn towards runway 18R of LEMD. AP1 was engaged (dual AP mode)

- At 14:42:10 UTC: crossing 1200 ft RA, A/THR was disconnected.

- At 14:42:14 UTC: Master Caution triggered during nine seconds.

- At 14:42:18 UTC: crossing 1150 ft RA, both APs were disengaged. Master Warning triggered during two seconds. CPT was pilot flying.

- At 14:43:44 UTC: aircraft touchdown on LEMD runway 18R. GW was 64.9T > MLW (64.5T). Overweight: +0.4T.

- At 14:47:20 UTC: recording ends.

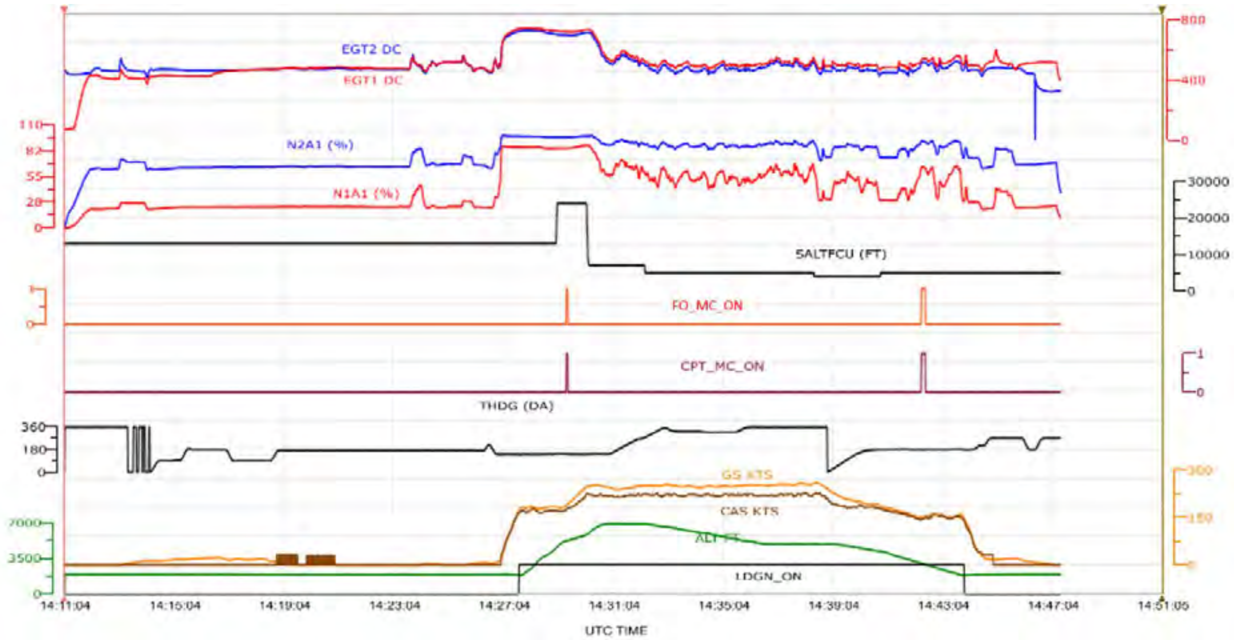

Figure 2: Aircraft's FDR records during the flight

1.12. Wreckage and impact information

The aircraft did not sustain any damage during landing. However, after the flight, the operator's maintenance staff detected a hydraulic fluid leak in engine 2, specifically through the hydraulic pump shaft, which is housed in the accessory box in the lower part of the engine.

After changing the pump and testing it on-ground, it was found to be faulty again and replaced for a second time.

1.13. Medical and pathological information

There were no injuries to persons other than some respiratory discomfort experienced by a member of the cabin crew due to smoke inhalation. No one needed medical treatment.

The crew did not continue to fly on the day of the incident.

1.14. Fire

N/A.

1.15. Survival aspects

N/A.

1.16. Tests and research

1.16.1. Information provided by the aircraft's crew

1.16.1.1. Information provided by the flight's captain

Before the flight, the crew was informed that the aircraft would be coming from the hangar to make its first flight following a major maintenance intervention. The maintenance was performed due to a dual-engine bird ingestion event the day before the incident flight. Engine 2 had been replaced as a result. After carrying out the required boroscopic inspection, engine 1 was declared to be working correctly.

As they were taxiing for take-off, they noticed "a slight burning smell that was difficult to pin down" but was similar to "burnt glue". However, as they were departing there was traffic queuing immediately behind them, and the captain initially put it down to exhaust fumes from another aircraft having entered the air conditioning system. Nonetheless, in his words "something told him there was something wrong".

When the captain connected A/C system pack 1 at 3,500 ft, the smell became more noticeable and smoke began to enter through the CM2 air conditioning outlets. Within a few seconds, the smoke thickened and quickly began to invade the cockpit. He commented that pack 2 was not connected at any point in the flight.

The captain had already decided to declare an emergency and return to LEMD as soon as possible. He did not have sufficient confidence in the co-pilot's abilities and, therefore, decided to take control of the aircraft and communications himself while instructing the co-pilot to fit his emergency mask and fitting his at the same time.

Meanwhile, the CABIN-to-COCKPIT communications channel was activated. The captain initially indicated that he could not respond because "he was busy flying the aircraft" but he did answer the second time. The purser said very clearly "WE HAVE SMOKE IN THE CABIN", to which he replied "OK, WE'LL RETURN TO MADRID, WE'LL BE THERE IN AROUND 10 MIN".

He levelled the plane to 7000 feet, declared "MAYDAY, MAYDAY, MAYDAY due to SMOKE IN CABIN", and requested vectors.

ATC authorised him to turn right and return at his discretion to runway 18R. He then began the manoeuvre.

According to his statement, while the smoke was still present and they had the emergency masks on, he reviewed, out loud, the MEMORY ITEMS, OEB, ECAM (which did not show any warnings) and NORMAL CHECKLISTS (the AFTER TAKE-OFF checklist was still pending because he believed dealing with the smoke in the cockpit should take priority), as well as the RESET COMPUTER and lastly, the QRH SMOKE / FUMES / AVNCS SMOKE procedure. He instructed the co-pilot to locate and read this last list, although the priority, in his words, was "to have in mind the most appropriate and rapid way of reaching runway 18R, and then and execute it".

As the smoke was dissipating the co-pilot began to read the QRH list, but the captain couldn't hear him properly because of the oxygen mask. As he was trying to establish adequate communications, the captain observed that the smoke had disappeared, so he asked the co-pilot to remove his mask because he needed him to reset the FMGC data for the approach. The captain also removed his mask. They were a few minutes away from touching down.

Once everything was configured, he transferred the communications to the co-pilot. The purser called to report that the smoke had almost disappeared. The captain told him to instruct the cabin crew, inform the passengers and prepare for a PRECAUTIONARY LANDING.

After the read-through of the APPROACH checklist, he landed the aircraft.

Given the situation, they informed ATC that the circumstances were more PAN PAN than MAYDAY so that they could update the emergency services on the ground.

They taxied accompanied by the "follow-me" cars and the fire brigade.

Once the aircraft was stationary, they had to wait around twenty minutes for the stairs and buses needed to disembark the passengers. The captain used this time to go into the passenger cabin and liaise with the passengers, trying to calm them down because many of them were extremely unsettled.

Once the stairs were in place, a TMA boarded the plane and told the captain that engine 2 was leaking oil. He went down to check it and confirmed that it was indeed losing fluid very quickly. According to his testimony, it eventually turned out to be hydraulic fluid rather than oil, as the "HYD Y RSVR LO LVL" warning was displayed.

In his statement, the captain concludes that, in retrospect, having analysed the incident, they failed to establish rapid and effective communications. This meant that, with the exception of using the oxygen masks and commencing the diversion, they did not complete the initial "SMOKE/FUMES/AVNCS SMOKE" steps.

1.16.1.2. Information provided by the co-pilot

According to information provided by the operator, the co-pilot did not offer his own account of the incident or write a separate report, thereby ratifying the captain's version of events.

1.16.1.3. Information provided by the Cabin Crew Manager (Purser)

According to the statement provided by the purser of the affected flight, he noticed a burning smell a few minutes after take-off as he was making the introductory passenger announcement. At that moment, two members of the cabin crew simultaneously notified him of the presence of smoke in the passenger cabin, verifying that there was a significant amount of smoke at the height of the emergency windows. He immediately notified the cockpit of the situation. The flight crew informed him that they were aware of the issue and were preparing to return to LEMD. In the meantime, the cabin crew tried to locate the source of the possible fire.

After a short while, the smoke dissipated completely, and he assumed, in his words, "that oil or hydraulic fluid had probably be burned in an engine and entered the cabin through the aircraft's ventilation system". The captain informed him that in around ten minutes they would be making a "Precautionary Landing". He, therefore, made an announcement on behalf of the captain to explain what was happening: the obvious technical problems, the possible cause, and the fact that they were returning to LEMD.

After the announcement, he walked the length of the aircraft to check on the passengers and offer reassurance. According to the purser's testimony, the aircraft landed without further incident and once on the stand with the fire brigade and Guardia Civil outside, the captain requested the stairs and buses for disembarkation. He also explained what had happened to the passengers, informing them that they would be transferred to the terminal and that the company would help them continue their journey as soon as possible.

Once the passengers had disembarked, the entire crew convened for a debriefing[15] where they discussed the most relevant aspects of the incident. During the meeting, the captain informed them that they would not be continuing their rotation and recommended they attend a medical centre for assessment.

The purser underwent several tests at a hospital, all of which returned results within the normal parameters. Lastly, he commented that one of the passengers on the flight made an unauthorised recording of the explanations provided by the captain and the auxiliary crew, despite their requests for him to stop filming. Upon leaving, when the captain reproached him, the passenger replied that he had already posted the recording on the internet.

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[15] Debriefing: a post-flight informative session in which the crew meets to analyse the recently executed flight, with particular focus on any aspects to be improved.

1.16.2. Reports and communications relevant to the incident

1.16.2.1. Flight logs

Reports from the aircraft's technical logs around the time of the incident show the following information in the PIREP[16] and MAREP[17]:

02/07/2018:

MAREP

00:00h: PCMCIA card installed in DMU.

03/07/2018

MAREP – before the incident flight:

01:45h: "Minimum idle check"[18] of engines 1 and 2 for oil leakage.

03:00 h – 06:00 h: Replacement of the damaged engine's QAR and IDG components, engine 2 repaired in the workshop, now installed.

07:00 h: Idem previous, installation of the starter.

08:00 h: Idem previous, installation of the ECU.

09:00 h: Installation of landing gear security devices (task 32-00-00-481-001A of the AMM).

09:45 h: Drainage of fuel tanks.

10:00 h: Daily inspection.

10:00 h: Replacement of PCMCIAs in DMU.

11:45 h: Commissioning of engine 2, CFM56-5B p/n 643171 replaced by p/n 577627.

11:45 h: Installation of landing gear security devices (task 32-00-00-481-001A of the AMM).

MAREP – after the incident flight:

18:10 h: Replacement PCMCIA.

19:21 h: Loss of hydraulic fluid from the hydraulic pump of engine 2 detected during the post-flight inspection, the hydraulic pump shaft was found to be broken, and the pump was replaced.

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[16] PIREP: Pilot Report: technical report from the pilot-in-command.

[17] MAREP: Maintenance report: technical report of the actions taken by maintenance personnel.

[18] Minimum idle check: the idle check provides instructions to make sure there are no leaks from the engine connections.

23:30 h: Running of engine 2 at 80% of N1. No odour or smoke detected.

23:30 h: Daily inspection.

23:30 h: Drainage of fuel tanks.

23:30 h: Second replacement of hydraulic pump in engine 2.

23:30 h: Ventilation system cleaned.

PIREP

19:21 h: Odour detected in cockpit during take-off; followed by thick smoke. Smoke dissipated in three minutes but odour persisted.

04/07/2018

MAREP

08:00 h: Running of engine 2 at 85% of N1 with no odour or smoke perceived. Idle check carried out to verify the correct operation of the hydraulic pump in engine 2.

19:30 h: Performance of all the corresponding tasks included in the manufacturer's Troubleshooting Manual.

23:30 h: Daily inspection.

23:30 h: Drainage of fuel tank.

23:30 h: According to the standard work order for engine 1, no odour was detected during the operational check, particular attention was paid to the bleed air system of engine 1, running at 80% of N1 no odour or fault was detected.

23:30 h: Replacement of cabin air-recirculation filters.

1.16.2.2. Post-flight maintenance report

The maintenance warnings identified by the TMA that inspected the aircraft after landing were related to the disconnection of the autopilot at 14:42 UTC and "hot brakes" at 14:46 UTC.

Regarding the reported failures, the report shows an ATA 32-49-18 tyre pressure failure at 14:18 UTC and an ATA 79-34-15 oil pressure failure at 14:46 UTC.

1.16.2.3. Cabin Odour or Smoke Reporting Sheet (COSRS)

To identify a "smell or fumes event in the cabin" (known as an SOF event: Smell Odour Fumes event) the aircraft manufacturer has a reporting system that uses the COSRS (Cabin Odour or Smoke reporting sheet) linked to the TSM 05-50-00-810-831-A problem-solving task 'Identification of the Cause of Cabin Odours or Smoke', which guides maintenance personnel in establishing the likely cause of the event.

According to the COSRS report completed by the flight crew (the captain), the event occurred at 14:27 UTC, in the take-off phase. The APU started the aircraft, and the air conditioning packs were connected while it was at a standstill. The power changes took place with no APU bleed air and the cross bleed valve closed. The aircraft did not require the use of the de-icing system.

The event occurred when pack 1 was connected, pack 2 remained disconnected, and the bleeds from both engines were activated with x-bleed valve closed. The smoke and odour were detected in both the cockpit and the passenger cabin. The captain described the smell as being like burnt oil.

The reported description of the event indicated the presence of a faint smell during the take-off roll, with dense smoke appearing after connecting pack 1. The smoke gradually disappeared over the next few minutes, although the smell lingered in the cabin until the moment the aircraft was chocked after landing.

1.16.2.4. Report from the service controllers

The report from the service controller at the Madrid-Barajas Airport control tower, position CLD W, stated that on the 03/07/2018 at 13:58 UTC, he called the aircraft involved in the incident for start-up. They asked him to update the flight plan as it looked like they might miss their slot. Once the flight plan was updated, it began without incident. From the point of view of the CLD position, there was nothing out of the ordinary.

On 03/07/2018 at 14:17 UTC, TWR reported that the affected traffic had taxied to holding point LC RWY 14R without incident.

The control tower service controller, position LCL 14R, reported that APP LECM had advised that the affected traffic had declared MAYDAY due to smoke in the cabin. They cancelled take-offs on runways 14R and 14L and removed the aligned aircraft from the runway. The aircraft had a tailwind approaching runway 14R and asked APP about possible clearance to make a visual approach to 14R if necessary. Eventually, the aircraft touched down on runway 18R without further incident.

The control tower service controller, position LCL 18R, noted in the executive report that he had nothing further to add to the previous transcripts already made.

In the ATC journal, as is the norm in this type of situation, the following information was reported:

- According to the ATC journal, an operating position in the LEMC Control Room unit reported an operational incident involving an aircraft that had declared MAYDAY due to smoke in the cabin but touched down safely at 14:44 UTC (exact recorded data: 14:43:44 UTC) on RWY18R. The technical position of said unit did not report anything of note.

- According to the ATC journal of the ATS LEMD unit, an operational EMERGENCY/URGENCY was reported at 14:30, indicating that the aircraft involved in the incident had reported smoke in the cabin and was making an emergency return to the airfield. The CGA and fire brigade were notified, with 18R and ACC coordinating for take-offs on both runways. Eventually, the aircraft landed without further incident on 18R, and at 14:45, the runway was checked following the emergency landing.

1.16.3. Tests/Inspections

1.16.3.1. Information on the maintenance carried out after the flight prior to the incident

Given the nature of the incident and considering that it was the first flight made by the aircraft after a major maintenance intervention, it was decided that, due to its relevance, a brief summary of the actions carried out by the maintenance organisation during the pre-incident intervention should be included in this section.

The preceding flight took off from Barcelona Airport and landed at Madrid-Barajas. The flight was made two days before the incident on 01/07/2018. Upon arrival, the following crew notes were included in the flight report: "SUSPECTED BIRD IMPACT ON FINAL. BURNT SMELL AFTERWARDS INSIDE AIRCRAFT".

The crew indicated that when they were on their final approach, around 100 feet above sea level, they noticed a burning smell inside the aircraft and suspected a bird strike with medium-sized birds, presumably pigeons.

Consequently, the aircraft was towed to a hangar for a detailed inspection.

The visual inspection confirmed bird ingestion in both engines. Engineers carried out the required AMM 05-51-14-200-803-A inspection for engines that have undergone a bird strike as per the aircraft maintenance manual. They found evidence of bird ingestion in both engines. The AMM 36-11-00200-804 task to inspect the cold bleed airflow route is required following confirmed bird ingestion and should also have been carried out. However, there is no evidence that the technicians cleaned the ducting, or confirmed bird remains inside it.

The AMM tasks corresponding to foreign object engine damage (FODs), AMM 05-51-19-200-001-A and 72-00-00-200-006A, were carried out and included the specified boroscopic inspections.

Due to the soiled condition of engine 2, the impeller was removed for cleaning.

The inspection found that engine 1 was within the required operating limits.

In engine 2, a crack was found on the leading edge of a blade tip in the first stage of the compressor. The part had exceeded its permitted limit and an engine replacement was, therefore, required.

Engine 1 Engine 2

Photographs 1 and 2. Remains of birds in engines

After this operation, the fan blades removed from engine 2 were reassembled.

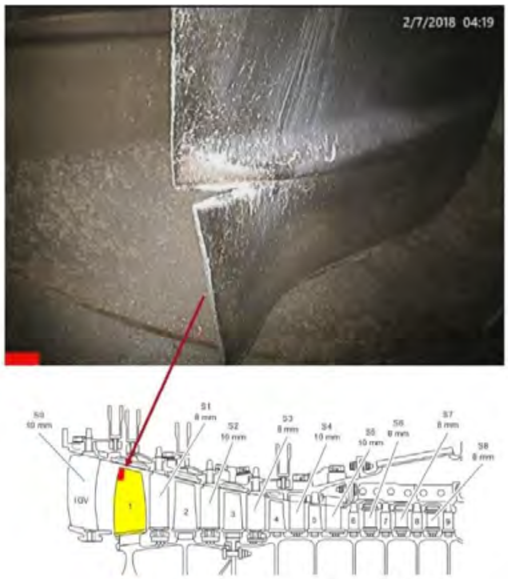
The following day, 02/07/2018, the engine with s/n: 577627 was received from the Engine Workshop where it had been repaired. The damaged engine 2 was, therefore, dismantled and replaced with the one from the workshop according to AMM 71-00-00 PB 40.

The components missing from the repaired engine were removed from the damaged engine and installed in the repaired engine as per its MPL parts list. These parts were the IDG, the QAR, the starter and ECU.

Both engines were then idled for approximately fifteen minutes.

The air conditioning packs were not connected while running the engines.

Finally, the engines were commissioned without cleaning engine 1 after the bird ingestion.



Photograph 3. Damage to impeller blade engine 2

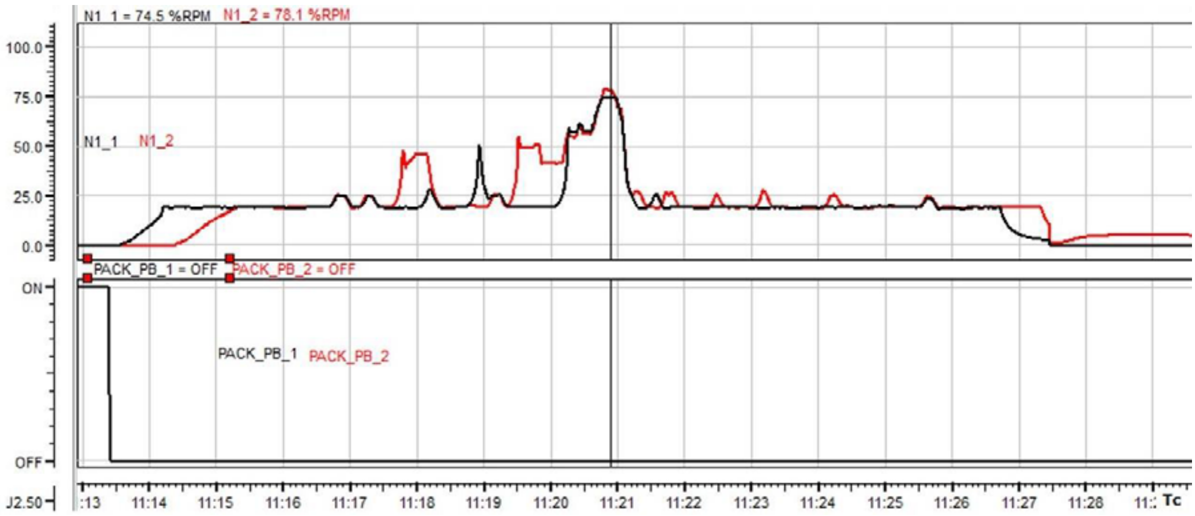


Figure 3. Graphic showing the parameters recorded when running engines 1 and 2.

1.16.3.2. Information on the post-incident maintenance

The incident flight was the first flight made by the aircraft after the replacement of engine 2. During the flight, an emergency was declared when smoke was detected, both in the flight deck and in the passenger cabin, as the aircraft was climbing shortly after take-off. As a result, it returned to the airport of origin.

The crew noticed an odour in the cockpit during take-off followed by dense smoke that disappeared after approximately three minutes, although the smell persisted.

Upon its arrival at the airport, maintenance personnel attended to carry out an initial inspection and assess the situation.

The first issue observed was a large puddle of liquid under engine 2 and a steady stream of fluid spilling down the drain mast. The fluid was initially believed to be lubricating oil.

When maintenance personnel boarded the aircraft, the crew informed them that the smoke had made the air unbreathable and that they had been forced to use the oxygen masks, removing them when it subsequently disappeared.

On reviewing the aircraft warnings and oil level, they found nothing abnormal. However, the hydraulic fluid level in the yellow system was found to be at zero.

They proceeded to open the cowlings of engine 2, and observed that hydraulic fluid was leaking through the hydraulic pump shaft p/n: 4205401 s/n 2415. This pump was the one that came installed in the engine repaired at the Engine Workshop, which replaced engine 2 after it was damaged as a result of bird ingestion during the preceding flight.

Consequently, this hydraulic pump, with s/n 2415, was replaced with s/n K1263, according to procedure AMM 29-13-51 PB 401.

Next, the breakdown analysis was performed according to TSM 05-50-00-810-831-A to identify the cause of the smoke in the cabin.

On 04/07/2018, as part of the breakdown analysis, engine 2 was tested at 80% of N1 as per the maintenance manual. Neither smoke nor odour was detected. During the engine test, the shaft of the newly installed hydraulic pump broke.

Hydraulic pump, s/n K1263, was, therefore, replaced again by s/n K1785 according to AMM 29-13-51 PB 401.

Engine 2 was tested again to ensure the hydraulic pump was working correctly, but this time at 85% of N1.

Having consulted the aircraft manufacturer for possible additional tests, a series of checks were performed and documented. No further failures were detected. Nonetheless, the maintenance centre raised the issue of the repeated pump shaft failures with the pump manufacturer to try and establish the potential cause.

The COSRS completed by the crew confirms that engine 2's air conditioning pack 2 was not connected at the time the smoke appeared in the cabins nor at any other point in the flight.

Furthermore, on 05/07/2018, the possibility that the event was influenced by the replacement of a broken reheater in pack 1 during a scheduled maintenance overhaul was analysed. However, they were unable to determine any link between the part and the incident.

In a subsequent evaluation, the TSM was consulted to identify the potential failures that could be caused by a reheater malfunction. The following were highlighted:

- Pack 1 high discharge temperature
- Pack 1 flow indication failure
- Pack 1 flow control valve failure
- Pack 1 overheating

None of these failures were identified, and its influence was ultimately discounted.

According to the operator's maintenance personnel, based on the evidence provided, they were unable to determine the origin of the smoke in the cabin.

The aircraft returned to service and subsequent flights reported no smell or smoke issues.

1.16.3.3. Information from the manufacturer of the aircraft involved in the incident

Based on the information and test results provided by the maintenance centre, the aircraft manufacturer indicated that it would have been impossible for hydraulic fluid leaking from engine pump 2 to reach the air conditioning system and cause smoke to enter the cabin, as it is drained via the drain mast and would not be burned in the engine.

However, it did consider, as a potential cause, that the smell and smoke generated by the burning bird remains, which could have remained in the air system, contaminating the engine bleed ducting that feeds the air conditioning system. Nevertheless, it also indicated that, if this was the case, it should have been noticed when the engines were run-in, as long as the packs had been connected, which did not happen.

The aircraft manufacturer also stated that they did not believe the repeated hydraulic-pump-shaft failure had any bearing on the appearance of smoke in the cabin.

What could be verified is that the smoke and odour was generated exclusively by engine 1 because pack 1 was the only one connected.

The data from the FDR confirms that the X-bleed valve was closed throughout the flight. The bypass valve of pack 2 was also closed throughout the flight. These two valves are shown in Figure 4 below, marked in red with a green box around them.

As can be observed, in this configuration, engine 1 was supplying pack 1 while engine 2 and pack 2 were isolated from the air conditioning system. Therefore, the smell must have been generated by engine/system 1.

Engine 2 was replaced according to task AMM 71-00-00-400-042-A: "Installation of the power plant". Analysing the required subtasks specified by this document, after checking the thrust reverser, the antifreeze and the fuel return valve, the correct functioning of the engine bleed systems that feed the air conditioning system must also

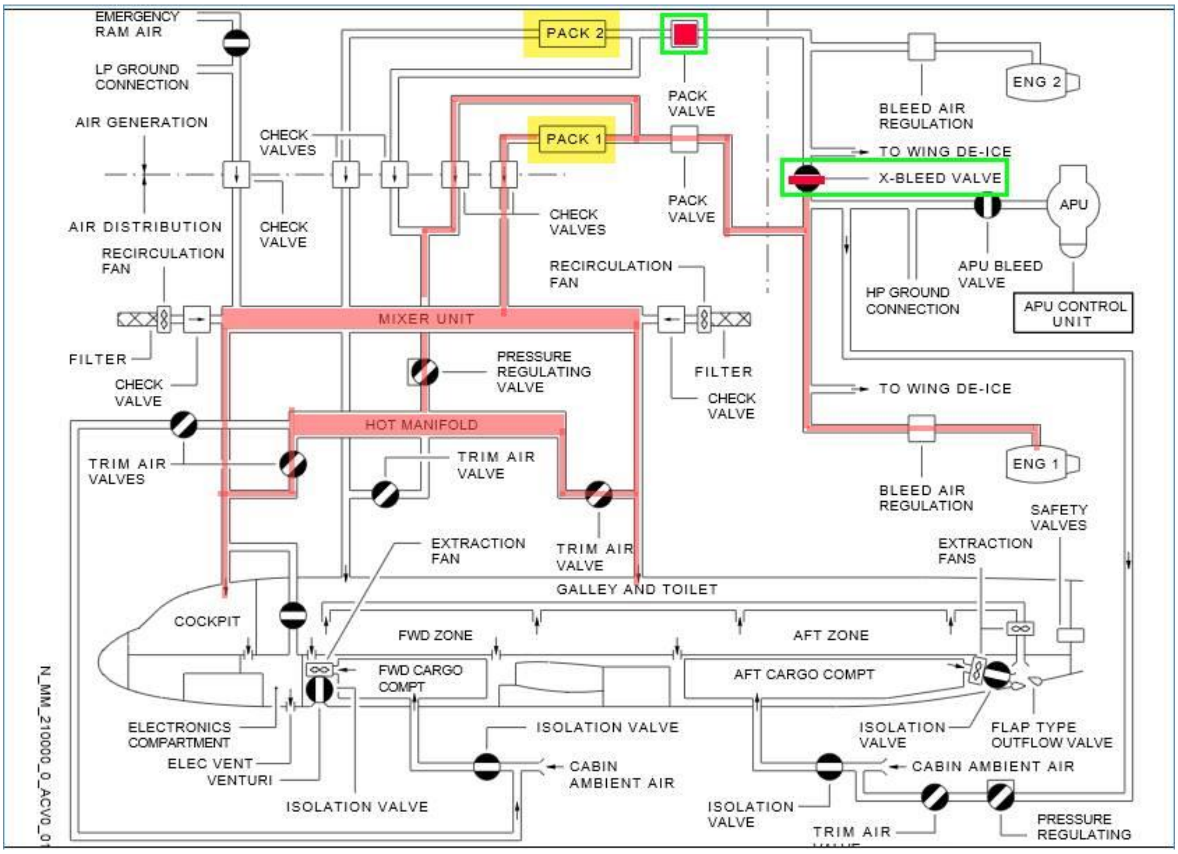


Figure 4. Engine 2 Air Conditioning System

be checked. To do this, you have to switch from the APU's bleed system to that of the engine, in order to supply pack 1 or 2, according to the engine being installed. The objective is to check bleed control aspects but, by default, the process also tests the packs' supply to the cabin.

However, as this AMM task is carried out after maintenance has been performed on a particular engine, it only tests that specific engine and its related systems. In other words, the system is not tested as a whole with both engines running at the same time, nor are both packs of the A/C system connected at the same time. Therefore, the task only tests the pack corresponding to the revised engine.

The aircraft manufacturer also confirmed that the air conditioning system is designed to renew the air in the aircraft cabin approximately every three minutes.

1.16.3.4. The operator's analysis of the event

The operator's report confirms the facts reported by the crew and maintenance personnel.

The operator's analysis drew the following conclusions:

- Before applying take-off power, the air conditioning system packs were disconnected.
- When the flight crew connected pack 1, an odour became noticeable. This was followed by a haze of smoke that entered through the air conditioning vents and became increasingly dense. Shortly afterwards, smoke also began to filter into the passenger cabin at the height of the emergency windows.
- At no time did any ECAM warning appear.
- The smoke began to dissipate about three minutes after it initially appeared.
- According to the operator, the flight crew abandoned the QRH procedure without completing it due to communication difficulties caused by the oxygen masks and because the smoke had dissipated.
- They returned to LEMD, landing seventeen minutes after taking off.
- The cabin crew did not use the smoke hoods.
- Only one member of the cabin crew visited the operator's medical service because of mild respiratory discomfort caused by smoke inhalation as a precaution. No further symptoms were observed, and no medical treatment was required.
- The crew did not continue to fly on the day of the incident.

With regard to maintenance interventions, the operator reported the following:

- With the aircraft on the ground, maintenance detected a hydraulic leak from engine 2, specifically from the yellow hydraulic system's EDP pump, which is located in the accessory box in the lower part of the engine. The pump shaft was broken, and the hydraulic system circuit was low on fluid. At first, it was suspected this could have caused the smoke in the cabin.
- The pump was replaced, and technicians ran engine 2 to verify that no smoke/odour was produced. They ran the engine with pack 2 connected. The pump shaft failed again. It was replaced, and they re-ran both engines maintaining N1 at around 85% but, on this occasion, with both of the packs connected.
- The operator consulted the aircraft manufacturer to see if the actions taken up to that point were sufficient to put the aircraft into service. The manufacturer discounted the fluid leak as a potential cause of the incident.

- The captain submitted the COSRS, indicating that the smell perceived in the cabin was like burning oil.
- After receiving the COSRS report and information on the subsequent actions taken, engine 1 was identified as the probable source of the smoke and this information was relayed to the manufacturer.
- Both the engine and aircraft manufacturers were consulted for further tests. The operator ran both engines alternately at 75% of N1 with the packs connected to confirm that neither smoke nor odour were produced. No further data has been provided and no definitive explanation for the source of the smoke has been established.
- The operator confirmed that, before the incident, the aircraft had been in the hangar undergoing maintenance following bird ingestion in the engines. Engine 2 had been replaced, and a boroscopic inspection had been carried out on engine 1. Both engines were run to 74% of N1 (in both) without connecting the packs, rendering the aircraft fit for service.
- During the flight, only pack 1 was connected and it remained connected until the end of the flight. Pack 2 was not connected at any point during the flight.
- There was no indication of a fault in the hydraulic system. The level, pressure and temperature of the yellow hydraulic system were normal throughout the flight and until the engine stopped.
- The decision was taken to change the HEPA filters in the air conditioning system.
- This same aircraft experienced a similar incident on 22/11/17, with the crew of that flight also declaring a smoke emergency on take-off. In that event, the aircraft had come from the hangar after changing engine 2. Maintenance concluded that the smoke could have been caused by traces of grease and oils left in the engine after its replacement.
- With regard to the failure of the two hydraulic pumps, the operator indicated that despite performing several tests and studies to identify the root cause of their failure, the pump manufacturer has not been able to determine the cause of the problem. Furthermore, the pump manufacturer has been unable to reproduce pump operating conditions with sufficient shear strain to break the shaft.

With regard to the crew:

- The pilots began distributing tasks and reading the "SMOKE/FUMES/AVNCS SMOKE" QRH procedure. The captain took over as PF and the PM co-pilot took charge of communications. The masks made communication between the flight crew difficult, and this may explain why they didn't follow the QRH procedure to the stage where they would have had to disconnect pack 1, which was filtering smoke into the cabin.
- The cabin crew communicated well but in their rush to find the source of the smoke they neglected to use the smoke hoods.
- The purser addressed the passengers in-flight to reassure them, while the captain, due to the circumstances of the event, was only able to address them once on the ground.

The conclusions were:

- The yellow system hydraulic leak does not seem to be related to the cabin smoke event.
- The operator reported that it had been unable to determine the cause and origin of the smoke definitively.
- It made an internal recommendation to improve crew members' awareness of the COSRS protocol, using this incident as an example.
- It confirmed that engine 1 produced the contaminated air due to bird ingestion during the preceding flight. The engine tests at low power were carried out without the packs connected. The smoke was detected when pack 1 was connected with the X-BLEED valve closed. The operator considers it unlikely that the smoke was caused by organic debris.
- With respect to engine 2, in addition to the loss of hydraulic fluid it confirmed that it was possibly contaminated by the engine change. It also confirmed that engine 2 was tested at power with the packs disconnected. Engine 2 had been recently installed, and pack 2 was disconnected with the X-BLEED valve closed at all times during the flight.
- What seems clear is that there was no in-flight transfer of air from engine 2 to engine 1 because only pack 1 was connected.
- Burning birds, or their remains, can generate odours and smoke, but if smoke is produced , it is unlikely to be thick. There may have been residue transfer during the pre-flight procedures (start-up, ground air-conditioning, taxiing for take-off with the packs connected).
- The operator reported that it had been unable to definitively identify the origin of the smoke, nor even which engine was the source.
- However, taking into account the factors above, the operator suggested the aircraft manufacturer be requested to update the AMM to specify that engines should be tested with the packs connected after they are changed. Furthermore, it proposed that, whenever possible after a cabin smoke event, the filters should be kept in quarantine to enable subsequent analyses and air quality measurements with the aircraft on the ground.

1.16.3.5. Recorded flight data relevant to the post-flight findings

A summary of the flight data recorded in each of the flight phases is shown in the following table, which includes the parameters detailed below in relation to each of the aircraft's engines:

- Pressure (psi) of the hydraulic fluid in each of the aircraft systems: green, yellow and blue (parameters HYDP_GR, HYDP_YE and HYDP_BL respectively).
- Oil pressure (psi) in engine 1 and 2 (parameters OIP_1 and OIP_2 respectively).
- Oil temperature (°C) in engine 1 and 2 (parameters OIT_1 and OIT_2 respectively).
- Airflow (kg/sec) in pack 1 (PFL parameter) and pack 2 (PFR parameter) of the air conditioning system.

- Position of the flow control valve in pack 1 and 2: fully closed (value 0: FUL_CLSD) or not completely closed (value 1: NFC).
- Position of the pressure regulating and high pressure valves: PRV (Pressure Regulating Valve) and HPV (High Pressure Valve): fully closed (FUL_CLSD) o not fully closed (NFC).

PHASE OF FLIGHT	UTC	HYDRAULIC PRESSURE (GR/YE/BL) (psi)	ENGINE 1				ENGINE 2			
			PRESSURE (psi)/Tª OIL (ºC) ENGINE 1	FLOW pack1 (kg/sec)	FLOW CONTROL VALVE pack 1	PRV1/ HPV1	PRESSURE (psi)/Tª OIL (ºC) ENGINE 2	FLOW pack2 (kg/sec)	FLOW CONTROL VALVE pack 2	PRV2/ HPV2
START-UP	14:11:02 14:12:11	3036-3032 3104-3068 3004-3012	LOW PRES 0-12 284-284	0.06	0 FUL_CLS D	FUL_CLSD	25-26 48-48	0.02	0 FUL _CLSD	FUL_CLSD
	14:12:12 14:13:19	3016-3036 3064-3072 3016-3044	12-29 284-284	0.02	0 FUL_CLS D	FUL_CLSD	26-32 48-60	0.11-0.63 0.31	1 NFC	NFC
TAXI OUT	14:13:20 14:16:32	3016-3024 3060-3056 2912-3000	29-23 245-256	0.03-0.31	0 FUL CLSD	FUL_CLSD	31-24 60-83	0.66-0.53	1 NFC	NFC
	14:16:33 14:25:42	3024-3016 3056-3048 3000-2984	23-31 256-263	0.31-0.33	1 NFC	NFC	24-29 83-94	0.53-0.30	1 NFC	NFC
	14:25:43 14:26:57	3016-3028 3048-3060 2984-2848	31-43 263-271	0.33-0.05	0 FUL_CLS D	FUL_CLSD	29-40 94-97	0.30-0.03	0 FUL _CLSD	FUL_CLSD
TAKE-OFF	14:26:58 14:27:41	3028-3028 3052-3056 2992-2896	49-48 271-271	0.06	0 FUL_CLS D	FUL_CLSD	47-50 97-97	0.03	0 FUL _CLSD	FUL_CLSD
INITIAL ASCENT	14:27:42 14:28:15	3028-3016 3060-3056 2868-2924	48-47 271-216	0.06	0 FUL_CLS D	FUL_CLSD	50-48 97-88	0.03	0 FUL _CLSD	FUL_CLSD
ASCENT	14:28:16 14:28:38	3016-3020 3052-3052 2868-2932	47-47 216-216	0.06-0.34	0 FUL_CLS D	FUL_CLSD	48-50 88-88	0.03-0.03	0 FUL _CLSD	FUL_CLSD
	14:28:39 14:32:28	3020-3008 3952-3060 2932-2924	47-38 216-228	0.34-0.66	1 NFC	HPV- FUL_CLSD PRV-NFC	50-40 88-98	0.03-0.03	0 FUL _CLSD	FUL_CLSD
DESCENT	14:32:29 14:39:42	3008-3000 3060-3060 2956-2968	37-39 228-236	0.66	1 NFC	HPV- FUL_CLSD PRV-NFC	39-43 98-111	0.02	0 FUL _CLSD	HPV- FUL_CLSD PRV-NFC
APPROACH	14:39:43 14:42:27	3004-3024 3060-3056 2872-2976	39-42 236-239	0.66	1 NFC	HPV-NFC PRV-NFC	42-46 111-116	0.02	0 FUL _CLSD	HPV- FUL_CLSD PRV-NFC
FINAL APPROACH	14:42:28 14:43:43	3020-3028 3056-3052 2952-2968	41-38 239-218	0.67	1 NFC	HPV- FUL_CLSD PRV-NFC	45-43 116-114	0.02	0 FUL _CLSD	HPV- FUL_CLSD PRV-NFC
LANDING	14:43:44 14:44:18	2988-3000 3056-3048 2968-2920	33-28 218-213	0.66-0.47	1 NFC	HPV-NFC PRV-NFC	39-31 114-112	0.02	0 FUL_CLSD	HPV- FUL_CLSD PRV-NFC
TAXI IN	14:44:19 14:47:11	3000-3008 3044-2872 2912-2988	28-24 213-279	0.45-0.63	1 NFC	HPV- FUL_CLSD PRV-NFC	31-1 112-111	0.02-0	0 FUL_CLSD	HPV- FUL_CLSD PRV-NFC
ENG.STOP	14:47:12 14:47:13	3008 2528 2952	21 -	0.58	1 NFC	HPV- FUL_CLSD PRV-NFC	1 -	0	0 FUL _CLSD	HPV- FUL_CLSD PRV-NFC

Findings according to the data above:

- Maximum altitude reached: 6908 ft QNH.
- Low oil pressure is registered in engine 1 during the first minute after start-up but gradually increases until it stabilises during the taxi for take-off. The oil temperature

in engine 1 is considerably higher than that registered in engine 2 during all phases of flight. Throughout the flight, the oil temperatures of engine 1 are higher those of engine 2, being double the values of engine 2 as a minimum, and three times the values of engine 2 as a maximum. On the ECAM engine warning screen, the indication flashes if the oil temperature rises above 155 °C and stops when it drops below 140 °C. It turns amber if the temperature exceeds 140 °C for more than fifteen minutes, or instantly when it exceeds 155 °C. In this event, the ECAM screen did not show any warnings despite the fact that the oil temperature of engine 1 was presumably above 155 °C throughout the flight, therefore exceeding the fifteen minutes mentioned above. Engine 2 maintained values below 140 °C. If the oil temperature is high, it becomes too fluid, loses its lubricating capacity, decreases its pressure and does not distribute properly.

After subsequent analysis carried out by the operator and the aircraft manufacturer, it has been concluded that these recorded data are not coherent and have been erroneously decoded. Due to the operator customized this parameter, the operator will investigate the possible causes and manage its correction. Therefore, these records cannot be considered in the investigation.

- No hydraulic fluid pressure below typical values of around 3000 psi is recorded in any of the hydraulic systems until the last two recorded seconds corresponding to engine shutdown, when the yellow system pressure drops by one 16%, well beyond typical operational fluctuations. At the end of start-up, pack 2 is connected and remains connected while the aircraft taxies until one minute before take-off. During the taxi, pack 2 is connected at the same time as pack 1 for nine minutes.
- During take-off, both packs are disconnected.
- After a few seconds, pack 1 is connected (pack 2 remains disconnected), and it stays open until the aircraft has landed and the engines are stopped.
- Towards the end of start-up and the beginning of the taxi, the valves of pack 2 are open (13 minutes). For the remainder of the flight, they are closed.
- Pack 1's valves are closed except for the nine minutes coinciding with pack 2 while the aircraft is taxiing for take-off. After the ascent, they remain open for the rest of the flight.
- The oil pressure in both engines remained at typical and similar values, with no significant variations throughout the flight.

1.16.3.6. Crew/cockpit resource management (CRM)

If there is smoke in the aircraft, immediate and effective communication between the crew is critical. The information that the cabin crew gives to the flight crew, and vice versa, will determine the course of actions to be taken.

All members of the crew must be informed and inform passengers of the situation.

In the incident under investigation, the smoke was first detected in the cockpit when the pack 1 air conditioning system was connected on reaching around 3500 ft during the ascent. The previously perceived odour became more noticeable, and smoke began to enter through the CM2 air conditioning vents, thickening in a few seconds, and rapidly filling the flight deck.

The captain decided to declare an emergency and return to LEMD as quickly as possible. According to his testimony, the captain was not confident that the co-pilot would be able to perform the manoeuvre while remaining calm over the radio. He, therefore, decided to take control of the aircraft and the communications, instructing the co-pilot to put on his emergency mask and locate the QRH. The captain also put on his emergency mask.

Until that moment, the only fact established was that the smoke was coming from the CM2 air outlet. They did not disconnect pack 1. The captain took the controls and made the decisions to return to LEMD and use the oxygen masks. They did not communicate with the passenger cabin.

Meanwhile, the CABIN-to-COCKPIT communications channel was activated. The captain who was "busy flying the aircraft" according to his testimony, did not accept the call the first time but did respond the second time. The purser informed him that there was smoke in the passenger cabin, to which the captain replied that they were returning to LEMD and it would take approximately ten minutes.

Up until the moment the purser succeeded in communicating with him, the captain was unaware that the smoke had also infiltrated the passenger cabin.

The captain levelled the aircraft to 7000 feet, declared "MAYDAY, MAYDAY, MAYDAY due to SMOKE IN CABIN", and requested vectors.

Communication with the co-pilot was compromised due to interference from the oxygen masks. Therefore, given that the smoke was dissipating, when the co-pilot began to read the QRH the captain instructed him to remove his mask, removing his own at the same time. They did not complete the QRH procedures.

The captain did not address the passengers until the aircraft came to a halt on its stand. He did speak to them while they were waiting for the stairs and the passenger buses, trying to calm them down as many were extremely anxious.

With regard to the cabin crew's communications, the purser first noticed the burning smell as he was making the introductory passenger announcement. At that moment, two other members of the cabin crew simultaneously notified him of the presence of smoke in the passenger cabin. He informed the flight deck of the situation and was told that they were aware of the issue and were intending to return to LEMD. Meanwhile, the cabin crew were trying to locate the source of a possible fire.

As the captain had told him they would be back at LEMD in ten minutes, the purser made an announcement on behalf of the captain to explain what was happening: the obvious technical problems, the possible cause, and the fact that they were returning to LEMD and preparing for a "Precautionary Landing". The smoke in the passenger cabin had completely disappeared a few minutes before landing.

The first step of identifying the source of the smoke and initiating measures to minimise the risk of fire on board the aircraft was reduced to establishing if the smoke was coming from the emergency exits.

Analysis of in-service events involving cabin smoke has shown that, in most cases, cabin crew members have few problems identifying the source of the smoke.

The main areas where cabin crew struggle to identify the source of the smoke are the air conditioning system, the side panels and the ceiling panels. Smoke coming from these areas can generally be attributed to:

- The auxiliary power unit (APU)
- Cabin recirculation fans
- Cargo compartments
- Crew rest compartments
- Electric wiring
- Bleed air from the engine (due to bird ingestion, for example).

Typically, the cabin crew do not have access or only have limited access to these areas, and are sometimes not even able to visually monitor the zone. Therefore, their priority should be to inform the captain, monitor the situation and prepare a fire extinguisher, PBE (Protection Breathing Equipment) and fire gloves.

According to the purser's testimony, once the passengers had disembarked, the entire crew convened for a debriefing[19], where they discussed the most relevant aspects of the incident. During this meeting, the captain informed them that they would not be continuing their rotation and recommended they go to a medical centre for assessment. Some members of the cabin crew followed this instruction, and after several tests, their results were found to be within the normal range and the smoke/odours they inhaled had not affected their health.

1.17. Additional information

Not applicable.

1.18. Useful or effective investigation techniques

Not applicable.

[19] Debriefing: a post-flight informative session in which the crew meets to analyse the recently executed flight, with particular focus on any aspects to be improved.

2. ANALYSIS

2.1. Analysis of the meteorological conditions

At the time the event occurred, the meteorological conditions in the area of the incident and at Madrid Airport (LEMD), were suitable for the flight. There is no evidence of any unforeseen adverse conditions being a factor in the incident.

2.2. Analysis of the flight

Until the cockpit smoke event occurred, the flight was operating normally as per the established procedures. There was no evidence of any operational anomaly. According to their testimonies, up until that point, the crew believed that take-off had been carried out without incident. However, while taxiing for take-off, they noticed "a slight burning smell, which was difficult to pin down" but, as the captain indicated, smelled similar to "burnt glue". Nevertheless, he didn't think it was important because there were other aircraft nearby, and he assumed their exhaust fumes had entered the air conditioning system.

The climb to 3500 feet took place according to the usual parameters, and there were no ECAM warnings or abnormal values on the instrumentation panels. It was at this altitude that, on connecting pack 1, smoke began to come out of the CM2 A/C. The burning smell was noticeable for fifteen minutes during the taxi for take-off. According to the captain, when the smoke began to filter in, the smell became more pronounced. We can, therefore, assume that it was the same smell detected while taxiing but not regarded as significant until the smoke appeared in the cockpit.

Given that the smoke had thickened and rapidly invaded the cockpit, the captain decided to declare an emergency and return to LEMD as soon as possible.

The captain believed the most suitable distribution of flight-deck functions for the immediate return to LEMD was for him to act as PF, taking control of the aircraft and communications, and for the co-pilot to perform the functions of PM, completing the QRH procedure. He instructed the co-pilot to use the emergency mask and he put his on at the same time.

Given the circumstances, this was the correct decision. According to his testimony, his priority was to return to LEMD as soon as possible while simultaneously dealing with the smoke in the cockpit as quickly as they could.

With the emergency masks on, the captain went through the MEMORY ITEMS, OEB, ECAM, NORMAL CHECKLISTS, RESET COMPUTER and finally, the QRH SMOKE / FUMES / AVNCS SMOKE out loud. He, therefore, followed the procedures correctly.

The captain instructed the co-pilot to locate and read this last list, but by the time he started to read it, the smoke was clearing. They were unable to communicate properly with the masks on, and when the smoke had dissipated entirely, he told the co-pilot to remove his mask whilst he did the same. Given that they were just minutes away from touching down, they abandoned the QRH because the captain needed the co-pilot to reset the FMGC data for the approach.

While this was happening, the CABIN-to-COCKPIT communications channel had been activated, but the captain decided not to answer as he was “busy flying the aircraft”. When the cabin crew attempted to make contact a second time, he responded. The purser informed him of the presence of smoke in the passenger cabin, and he replied that they would be back in Madrid in around 10’.

From that moment on, the operation was controlled and carried out according to procedures. He levelled the plane to 7000 feet, declared “MAYDAY, MAYDAY, MAYDAY due to SMOKE IN CABIN”, and requested vectors. After receiving clearance from ATC, he turned right to return at his discretion to runway 18R and began the manoeuvre.

Once everything was configured, he transferred the communications to the co-pilot. The purser called to report that the smoke had almost disappeared. The captain told him to instruct the cabin crew, inform the passengers and prepare for a PRECAUTIONARY LANDING.

Given the situation, they informed ATC that the circumstances were more PAN PAN than MAYDAY so that they could update the emergency services on the ground.

He went thought the approach checklist, and the rest of the landing sequence was carried out without incident.

The passengers and crew disembarked normally after waiting approximately 20’ for the stairs and buses required to transfer them to the terminal. The captain used this time to speak to the passengers, reassuring them and informing them that the operator would ensure they could continue their journey as soon as possible.

We have therefore concluded that the flight, including the emergency declaration that involved the aircraft’s return to the departure airport, was carried out in a safe and controlled manner.

2.3. Analysis of the management of the emergency

From the analysis of the evolution of the emergency, it is clear the captain thought the best way of managing the situation (smoke in the cockpit) was to change roles so that he could take charge of immediately flying the aircraft back to runway 18R, while the co-pilot assumed the role of PM.

Once the decision to return to LEMD had been made, the captain changed the crew roles and reorganised the cockpit workload so that he could concentrate on immediately flying the aircraft back to land on runway 18R.

He then ordered the co-pilot to put on his oxygen mask. According to the captain, from that moment on, he could not hear the co-pilot clearly and was unable to establish proper communications between them. They then carried out the first QRH instruction following an anticipated return to the airfield.

In the brief period after the crew had fitted their oxygen masks, the smoke began to clear. The co-pilot was already going through the QRH, and the captain was trying to establish communications with him but was unable to hear him properly. In the meantime, the smoke had disappeared. The captain removed his mask, telling the co-pilot to do the same. This stage of the emergency appears to have been slightly chaotic, and it seems both the captain and the co-pilot were somewhat slow to react. That said, they were finally able to resolve the situation satisfactorily because even though the smell remained, the smoke had dissipated, and given the compromised communications, they made the correct choice in removing the masks.

We have not been able to determine why the flight crew struggled to communicate with each other whilst wearing the oxygen masks. There is no evidence of failures in the intercom system, and we have been unable to ascertain whether the flight crew performed all the actions necessary to correctly establish and maintain communication whilst wearing oxygen masks.

The operator, IBERIA, obliges all new flight crew members and those already working for them to complete the in-house emergency and safety equipment course. In both cases, the course covers crew usage of oxygen masks in line with part D of the *Operations Manual.*

The initial emergency declaration was correct. Subsequently, with the situation under control, the captain downgraded the situation to a PAN PAN emergency so as not to allocate excessive airport emergency resources unnecessarily. This decision demonstrates a clear awareness of the level of severity and risks stemming from the situation, which, by that time, was already fully controlled.

He asked the co-pilot to programme the FMGC for the approach, and once configured, he transferred communications to him. This was the appropriate procedure.

Given the high workload of the flight crew, communications with the cabin crew were initially delayed. After the second call, the purser entered the cockpit to indicate that the smoke had almost disappeared. At that moment, the captain told him that he had declared an emergency, that he intended to return to Madrid and that he expected it would take 10’. He instructed him to prepare for a precautionary landing.

The crew stated that they carried out the approach and landing checklists without further incident and according to procedures.

After verifying that there were no ECAM warnings or related actions required, the QRH reading should have been the next immediate priority. Due to communication issues between the flight crew whilst wearing the oxygen masks, it was not performed adequately.

Despite the fact that, as a result of a glitch in the operator's course control system, the captain had not completed his CRM training within the period established by the Operating Manuals, we believe that, given the situation, he managed the resources available to him during the emergency correctly.

2.4. Analysis of the aircraft's maintenance and the cause of the smell/smoke in the cabin

The dual-engine bird ingestion event that occurred during the flight prior to the one being investigated was decisive with regard to several aspects of the incident because it led to a major maintenance intervention in the aircraft.

The captain began the flight warning of the need to be especially attentive to the aircraft since it was its first flight after significant maintenance had been carried out, although afterwards his actions were more influenced by his lack of confidence in the co-pilot than by the possible assessment of this fact.

The scheduled maintenance overhauls performed on the aircraft were carried out satisfactorily and in accordance with the approved maintenance programme and the AMM. Prior to the event, some corrective maintenance involving the replacement of components relating to the ATA 21 (A/C) was also carried out as per the TSM.

After the event, a maintenance technician carrying out a post-flight maintenance inspection in accordance with procedures and the AMM identified the loss of hydraulic fluid through the hydraulic pump of engine 2.

Since this took place after the event and considering that the pressure values of the three hydraulic systems, especially the yellow system linked to the broken EDP, were adequate throughout the flight, it seems unlikely it was related to it. Furthermore, any hydraulic fluid leak in the EDP could not be the root cause of the smell and smoke detected in the cabin, because hydraulic fluid coming from the EDP would drain directly through the drainage pipe to the drain mast and would not be burned by the engine.

As evidenced by previous maintenance interventions confirmed by the operator and the maintenance organisation, there were precedents for excess service residues, mainly greases and oils, in engine replacements.

Considering the smell was noticed at the beginning of the flight after the engines were started during the taxi for take-off, and that it entered the cabin through the A/C outlets, it must have been produced by something linked to the ignition of the engines. It cannot have been the hydraulic fluid leak because it had not yet occurred. Furthermore, it must have been linked to the on-ground connection of the packs, which circulated the smell.

Another element initially considered a possible factor in the event was the discovery of the broken reheater in a maintenance overhaul of pack 1. However, this has since been dismissed because its malfunction would have caused high discharge temperatures, flow indication failures, control valve failures or overheating in pack 1. None of these failures were identified.

According to the records obtained from the DAR, the values corresponding to the pack airflow rate were correct at all times. Therefore, we have also ruled out any other type of pneumatic system malfunction as the cause.

The antifreeze system has also been discounted because, according to the COSRS, it wasn't used during the flight.

The COSRS also confirmed the APU started the aircraft. This means that before take-off, whilst taxiing and during the period when both packs were connected, the cabin air was not being supplied by the engine bleed-air system. This explains why the smoke event did not occur when the plane was on the ground but began when the aircraft configuration was modified during the ascent, changing its power source and connecting pack 1.

The design of the A/C system itself confirms that, provided the cross bleed valve is closed, pack 1 is exclusively supplied by air from engine 1, and pack 2 is exclusively supplied by air from engine 2. Therefore, the smoke that entered the cabin on connecting pack 1 was produced by the distribution of air from engine 1, in which there must have been some type of burning debris. The pack 2 air conditioning connected to engine 2 was not used in the flight.

Specifically, pack 1 was connected during the taxi for take-off between minutes 14:16:33 and 14:25:42 (nine minutes nine seconds). Pack 2 was connected as soon as the aircraft was started at minute 14:12:12 until 14:25:42 (thirteen minutes thirty seconds), so that both packs were connected at the same time for nine minutes nine seconds.

Before take-off, the two packs were disconnected and remained disconnected until 14:28:39. Three minutes later, pack 1 was connected. The smoke began to appear in the cabin and cockpit during the ascent. Pack 1 remained connected until the engines stopped on the runway at 14:47:13 (a total of 18 minutes 24 seconds).

Considering the smoke appeared during the ascent, at the precise moment in which A/C system pack 1, which is fed by bleed air from engine 1, was connected, the only engine involved in the incident was engine 1.

In the maintenance intervention prior to the incident, work on engine 1 consisted of a boroscopic inspection to verify the ingestion of birds as reported by the crew. It was indeed confirmed, as was the fact that no damage had been sustained as a result. Once this was established, the AMM does not specify that the engine must be cleaned. We can, therefore, presume that there could have been bird remains inside the engine and that they would have been burnt during the subsequent flight, contributing to the cabin odour/smoke event.

The task that is specified by the AMM is TASK 36-11-00200-804, which requires an inspection of the cold bleed-air flow path. This task should have enabled the technicians to find and remove any bird remains. Presumably, it was not carried out correctly because no residues were detected during the procedure.

An inspection of engine 2 also found evidence of bird ingestion, but in this case, it had caused severe damage to the blades of the compressor, which meant the engine had to be replaced.

In accordance with the AMM, the recently installed new engine underwent operational checks, which should have included testing it with pack 2 only, as per the requirements of the corresponding subtask, but it was performed with it disconnected.

Consequently, the engine was not tested with both A/C packs connected at the same time. If it had been, it could have simulated the operational behaviour of the systems during the subsequent flight more accurately.

Identifying the cause of cabin odour is a specific task in the troubleshooting manual (TSM). Therefore, it is not covered by the maintenance practices specified for bird ingestion and testing engine 2 with pack 1 also connected was not deemed necessary. If this test had been run, we can assume it would have prevented an in-flight smoke event because the problem would have manifested while the engine was being tested on the ground.

The remains of birds in the engine 1 during its operation, when burned, could cause an unusual smell in the cabin, although it is not commonly perceived as a chemical smell like the one described by the crew. This leads us to believe that it must have converged with other additional odours produced by other factors. In any case, it seems unlikely the bird remains could have caused the amount of dense smoke that was produced, which reinforces our assumption that there were multiple agents involved.

The aircraft records confirm that the smoke entered the cabins at the moment pack 1 was connected, which is consistent with the crew's statements.

As for the volume of smoke released, it would depend on the amount of residue in the engine and/or the ducting. According to reports, the smoke was thick, but dissipated rapidly in about three minutes, which is consistent with the hypothesis that multiple agents were burned in engine 1. These agents may have been grease and oil residues from maintenance, including possible spills on components that were not subsequently cleaned, as well as bird debris. All of which are combustible agents that produce dense smoke and smells, primarily of burnt oil.

The fact that no further smoke was generated after about three minutes is consistent with the fact that the design of the air conditioning system allows for the complete renewal of the cabin air in that time frame, and that the causative agents would have disappeared once consumed. It also tallies with the fact that no oil leaks were identified in the post-flight inspection, and that oil pressure was maintained during the flight.

Furthermore, this theory is consistent with the fact that because the QRH list was not completed, pack 1 was never disconnected. Therefore, the bleed air continued to feed the A/C, by this point being smoke-free but still contaminated by the products of oil pyrolysis. This would have caused the persistent burning smell described by the crew, and which had permeated the ducting and bleed-air filters of the A/C system and therefore lasted until the aircraft landed.

According to a maintenance report (MAREP) written on the day of the incident, the aircraft had undergone a maintenance check for oil leaks in both engines just a few hours before the affected flight, confirming the possibility that the components checked may have been inadequately cleaned, leaving oil residues.

As for the presence of a burning smell from the beginning of the flight, it's likely that when pack 2 was connected while the aircraft was still on the ground, maintenance residue such as lubricants and cleaning products were burned, and the smell persisted because it contaminated the A/C system filters. As the crew suggested, there may also have been odours from nearby traffic, which, added to the above, would make identification difficult.

We have therefore concluded that because engine 1 is linked to pack 1, and this was the only pack connected when the smoke appeared in the cabin, the smoke originated in engine 1. Furthermore, this engine had experienced a bird strike on the preceding flight, which, although there was no visible damage, makes it likely that the remains of birds were burned and contaminated the bleed-air pipes when the engine was running, and that this was compounded by the burning of oil and grease residues left by prior maintenance work, with the two factors combining to cause the odour and smoke in the cabins.

2.5. Analysis of the flight records

The conversion of the data file generally provided information consistent with the testimonies of the crew and the records provided by the operator and the aircraft manufacturer.

The warnings identified by the TMA inspecting the aircraft after landing were related to the disconnection of the autopilot at 14:42 UTC, and to "hot brakes" at 14:46 UTC. Other records analysed, such as the decrease in the yellow system's hydraulic-fluid pressure values shortly before cutting the engines, are consistent with the moment the EDP ruptured and the loss of hydraulic fluid occurred.

Since the oil pressure did not vary in either engine throughout the flight, it's reasonable to suppose there were no oil leaks. However, there may have been small internal leaks in faulty or incorrectly installed gaskets or seals in the bearings of the engine's accessory box, which, not being sufficient to show any external evidence of leakage, would not produce significant pressure losses. Another option is that oil residue from the maintenance service may have contaminated engine 1's bleed air, producing smoke in the cabin after pack 1 was connected.

3. CONCLUSIONS

3.1. Findings

- The aircraft's crew had the required valid licenses, permits and medical certificates to carry out the flight.
- The captain had 3634.07 hours of flight experience in the type of aircraft involved incident and had been with the company for 22 years.
- The co-pilot had 261.13 hours of flight experience in the type of aircraft involved and had been with the company for just over four months.
- The co-pilot and captain had no previous experience of flying together until the pairing began on 01/07/2018.
- From take-off to landing, the duration of the flight was seventeen minutes.
- The flight was not affected by any type of limiting meteorological phenomena.
- The aircraft's documentation was in order.
- An AESA-authorised maintenance organisation that maintained the aircraft had a valid EASA Part-145 certificate and appropriate experience in handling the type of aircraft owned by the operator.
- The aircraft was built in 2005 and had a cumulative flight time of 31288:51 hours and 22385 cycles.
- The last scheduled maintenance overhauls performed on the aircraft were a type A1, which takes place every 750 flight hours, 750 flight cycles or four months and was carried out two months before the incident; a type D on 03/03/17, the most complete and demanding inspection carried out every six years, and a type E which was carried out at the same time as the type D and is scheduled every twelve years.
- The aircraft did not sustain any obvious damage as a result of the incident.
- The affected flight was the first flight made by the aircraft following a significant maintenance intervention brought about by a dual-engine bird ingestion event during the preceding flight.
- The bird ingestion damaged engine 2, and it had to be replaced. A boroscopic inspection of engine 1 found it was within operational limits and fit for service, but it was not properly cleaned.
- After the new engine 2 was fitted, both engines were running with packs not connected.
- After the maintenance overhaul due to the bird ingestion, both engines were run without connecting the A/C system packs.
- The odour was first noticed in the aircraft as it began to taxi.
- The captain's COSRS report identified the smell perceived before the appearance of smoke in the cabin as being like the smell of burning oil.
- The smoke was produced when pack 1 was connected in-flight, being observed first in the cckpit and then in the passenger cabin.
- The smoke thickened and then completely dissipated three minutes after it first appeared.

- After take-off, pack 1 was connected and it remained connected until the end of the flight. Pack 2 was not connected at any point during the flight.
- Pack 1 is exclusively supplied by air from engine 1, and pack 2 is exclusively supplied by air from engine 2, provided the cross bleed valve is closed.
- The pilot was acting as PM until the MAYDAY emergency call was declared, after which he took over as PF.
- The crew declared an emergency considering it necessary to return to the departure airport.
- The captain and co-pilot began distributing tasks and reading the "SMOKE/FUMES/AVNCS SMOKE" QRH procedure while using the oxygen masks.
- The "SMOKE/FUMES/AVNCS SMOKE" procedure was not completed for two reasons: firstly, the masks made communication between the crew difficult and, secondly, the smoke had dissipated. As a result, the QRH procedure was not followed to the stage where they would have had to disconnect pack 1, which was filtering the smoke into the cabin.
- From the moment MAYDAY was declared until the passengers disembarked, the crew's coordination with the different ATC units and the emergency services was appropriate for the management of the flight.
- The ECAM screen showed no warning of any kind at any point during the flight.
- The post-flight inspection found that the shaft of the yellow hydraulic system's EDP pump was broken, and, after being replaced, it broke again.
- In the post-flight inspection, the yellow hydraulic system was found to have a low level of hydraulic fluid.
- During the flight, there was no indication of a fault in the hydraulic system.
- The level, pressure and temperature of the yellow hydraulic system were normal throughout the flight and until the engines stopped.
- Operator customized engine oil temperature registered data has been found to be erroneously decoded.
- The investigation has determined that the repeated breakage of the hydraulic pump shaft, according to the pump manufacturer's report, was most likely caused by improper assembly.
- The investigation has determined that the yellow system hydraulic leak was not related to the cabin smoke event.
- Neither crew nor passengers required medical assistance. A member of the cabin crew did go to the operator's medical service but did not require any assistance or subsequent treatment.

3.2. Causes/contributing factors

The investigation has determined the incident was most likely caused by an inadequate maintenance practice, which led to the contamination of the bleed air from engine 1 and caused smoke to enter the cabins through the air conditioning vents.

The air was contaminated most probably by the residues of grease, oil and bird remains, which were burned during the routine operation of the engine, having not been removed during the maintenance carried out after the bird ingestion during the preceding flight. Oil spills left by prior maintenance procedures could also be a factor.

4. OPERATIONAL SAFETY RECOMMENDATIONS

REC 44/20: It is recommended that the operator, Iberia Lae, SA, should step up crew CRM training, focusing especially, in the case of crews in the initial phase of flight, on the importance of CRM skills for the correct execution of procedures in general and emergencies in particular.

REC 45/20: It is recommended that the operator, Iberia Lae, SA, should convey to its maintenance personnel, as a good practice, that during the assembly and installation of elements, components, devices, etc. they must ensure the surfaces, filters and/or ducting of the engine bleed air system and the A/C system in general, are free from potential residues of grease, lubricating oils or any other product that could contaminate the air conditioning system of the A320 series aircraft, thereby increasing the risk of cabin smoke during flight.

REC 46/20: It is recommended that the operator, Iberia Lae, SA, should implement the necessary measures to guarantee for its A320 fleet, the reliability of the data recorded for the engine oil temperature parameter, as well as its correct decoding.

Relating to the A320 series, the following safety recommendation is issued to the aircraft manufacturer, so that when a bird ingestion event occurs, it is ensured that the engine, bleed and air conditioning system are fully tested for remaining contaminants prior to next flight, to reduce the risk of an in-flight smoke/odour event. Therefore, if smoke/odour is detected in the cabin during the engine run, the appropriate troubleshooting task will be called for.

REC 47/20: It is recommended that the manufacturer, Airbus, should supplement the AMM/TSM of the A320 series with the subtask corresponding to perform an engine run with A/C packs and bleeds connected if there is evidence that a bird has been ingested into the engine core, regardless if there is any engine damage or not.

5. ANNEXES

5.1. Specific aircraft information relevant to the incident

5.1.1. The aircraft's air conditioning system (ATA21)

The pneumatic system provides the airflow (obtained from the engines' bleed air) necessary for the operation of some aircraft systems, including air conditioning packs 1 and 2, which are responsible for pressurising and conditioning the air in both the cockpit and the passenger cabin.
The air conditioning system maintains the air in the pressurised compartments at the correct pressure and temperature, as well as providing ventilation for the avionics compartment and ventilation and heating for the aircraft hold.
Given that several of this system's components are referenced throughout the report, a brief summary of how the system works is provided below.
The desired temperature in the cabins is provided by mixing cold air from the packs with hot air from the engine bleed systems or the APU.
The incident aircraft is equipped with two packs located in the lower part of the fuselage, close to the wing-fuselage attachment and in front of the landing gear. Each pack contains a set of components that cool the hot air supplied by the engine bleed systems, the APU or the ground power unit, which enters at a temperature of between 100° and 250°C. This airflow is regulated by the Flow Control Valves that also act as shut-off valves for the packs.

A diagram of the system is shown below (Figure 5):

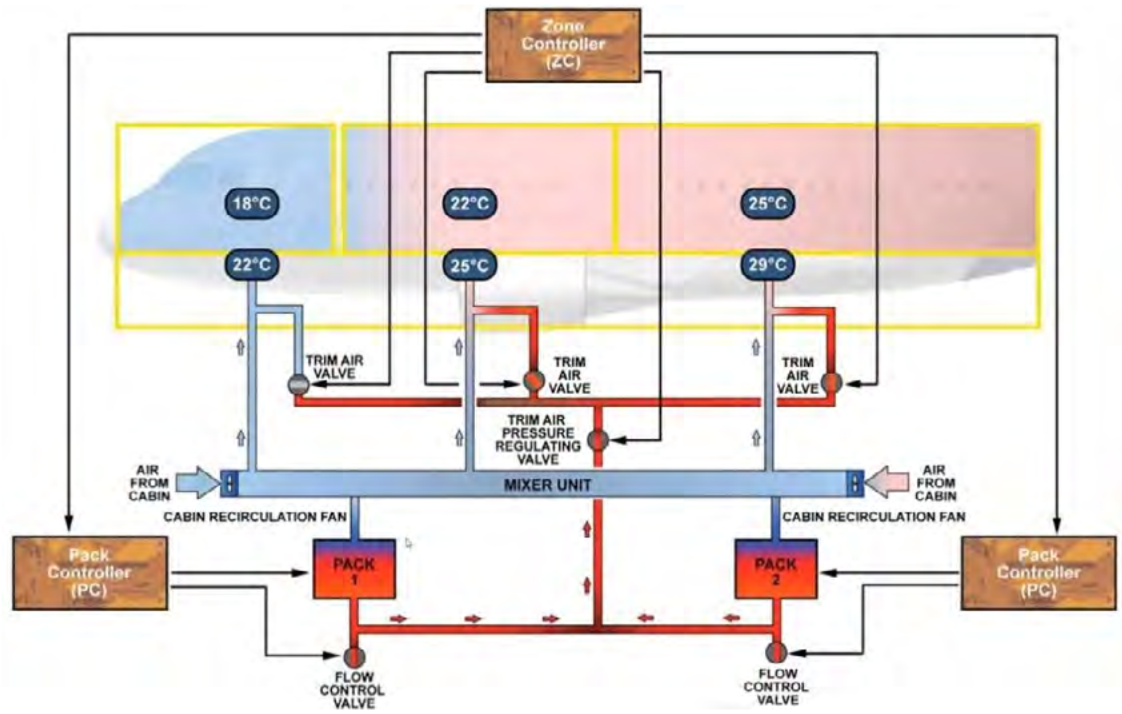


Figure 5. Diagram of the air conditioning system

1. The zone controller is the computer in charge of controlling the temperature in the different zones of the plane. It communicates with the pack controller, obeying its indications and moving the necessary valves to attain a flow of air at a particular temperature and thus achieve the temperature set by the pilots.
2. Once the bleed air has passed through the control valve and been pressure and temperature regulated, it passes through to the primary exchanger. The primary exchanger cools the air and sends it to a compressor where it is compressed, heated and transmitted to the main exchanger, where it is re-cooled by air from outside the aircraft.
3. Next, the air is heated by a reheater then passed through condensers that condense and expel any water particles that could be contained in the bleed air. This air is directed to a turbine where it is cooled once more, reaching a temperature of between 0° and 5°C, and this is the air that leaves each of the packs.
4. The air from the packs is directed to the mixer unit, where it is mixed with the recirculated air from the passenger cabin and then specifically channelled to the three areas of the aircraft: the cockpit, the front passenger cabin and the rear passenger cabin. In an emergency like the cabin smoke event that occurred in this case, the mixer unit can be directly fed by air from outside the aircraft to clean the contaminated air in the cabin.

5. Finally, the cold air that comes from the mixer unit in each zone of the aircraft is mixed with hot air coming directly from the engines or the APU. The zone controller manages the hot air through the regulating valves or "Trim Air Valves" that provide, according to their position, more or less hot air, and this translates to a higher or lower temperature inside the aircraft.

The air used to pressurise and ventilate the cabins is extracted by bleeding the engine compressors whilst airborne or the APU on the ground. This bleed air then passes through the Environmental Control System (ECS) before being distributed to the cabins.

A problem in the APU could contaminate both ECS packages. However, provided the cross bleed valve is closed, if there were a problem in engine 1, it would only contaminate ECS pack 1, and if there were a problem in engine 2, it would only affect ECS pack 2. If there is any type of contamination (a smoke/odour event in the cabin for example), both the AMM and the manufacturer's TSM stipulate that the packs must be decontaminated after the event. To guarantee the air quality in the cabin, it is essential to ensure that the components and ducting supplying air to the ECS packages are properly cleaned, that high-efficiency particle filters (HEPA) are installed in the recirculation system, and that the ECS package flow control valves that influence the flow of fresh air in the aircraft are working correctly.

Contaminated air can be caused by different sources, either internal or external to the aircraft, the following being most common:

- An intake of exhaust fumes or fuel vapours by the air conditioning system when the aircraft is on the ground, creating temporary unpleasant odours on board.
- Bleed-air contamination as a result of oil and its pyrolysis products due to defective engine or APU conditions, particularly the failure of oil seals or bearings and errors or irregularities in engine or APU maintenance procedures.
- Cabin air contamination by anti-ice or de-icing fluids, as well as aircraft hydraulic fluid, due to system failure or malfunction.

The configuration of the air conditioning system means that an unusual odour coming through the bleed system is first perceived in the cockpit because the fresh air flow here is slightly higher than in the passenger cabin. Additionally, the cockpit receives a high proportion of its fresh air from the engine 1 bleed system, while the passenger cabin receives most of its fresh air from the engine 2 bleed system. Thus, an odour coming from the bleed system of engine 1 and its ECS package will be noticed earlier in the cockpit than in the passenger cabin.

If an unusual odour is caused by contamination from any of the agents described above, once it has reached the distribution ducting, the contaminant is already trapped in the heat exchangers and the condensers of the ECS packs, as well as in the engine bleed-air ducting and even in the mixer unit. The aircraft manufacturer provides a complete decontamination procedure based on the level and source of the contamination. Included tasks in this procedure instruct cleaning of the ECS components step-by-step depending on the findings from the different steps. Replacement of the ECS recirculation filters is instructed in some cases but not all, function of the findings, level of contamination and contaminant.

5.1.2. Information on the cabin air quality

To evaluate the potential causes of the cabin contamination event under investigation, various studies have been taken into consideration, such as the one carried out by AESA on "Cabin Air Quality in Pressurised Aircraft", those carried out by the aircraft manufacturer (i.e. AIRBUS In Service Information[20] Ref. ISI 21.00.00139) and those based on reports from similar events that provide reference statistics, as well as the information disclosed by EASA through its FACTS project on cabin air quality.

According to these studies, the most common sources of fumes, odours and smoke on board, which will be considered in section 2 of this report - Analysis, can be established as the following:

Internal sources:

- oil from the APU
- oil from the engine
- fuel
- hydraulic fluid
- de-icing and/or anti-icing fluid
- electrical faults
- resulting products of engine compressor wash
- the aircraft's own exhaust fumes or fuel vapours ingested by the air conditioning system when the aircraft is on the ground (these odours are temporary)
- recirculation fan failure
- contamination of the ECS system by previous events.

External sources:

- vehicles on the ground (exhaust fumes from the engines of other aircraft or vehicles, or fuel vapours)
- ozone

Finally, elements within the cabin itself can be a cause, such as cabin baggage, cleaning products, disinfectants, food, kitchen equipment and the lavatories.

In the aircraft involved, the primary contributor to the circulation of possible contaminants is the ATA 21 air conditioning system.

Statistically, according to the manufacturer, the most probable causes of cabin smoke/fume events during normal operations are the following:

- faults in electrical equipment and short circuits in electrical wiring;
- overheating of equipment due to malfunction of thermostats or other control devices;
- leakage of very hot air through the pneumatic ducting;
- combustible fluid spills, such as hydraulic oil or glycol, on hot surfaces;
- overheating of galley ovens and oil or fat spillage in/on them.

The aircraft systems most susceptible to cause smoke in the cabin are the engines and the APU.
It should be noted however, that troubleshooting following a smoke or fume event does not always identify the cause.

In the event of a cabin smoke/fume event, the operational procedures listed in *the Flight Crew Operating Manual* (FCOM) should be applied. In particular, the emergency procedure to remove smoke and fumes from the cabin.

[20] The Airbus ISI informs operators of the background information, mitigations available (or ongoing) and best practices to address fume events.

As a matter of priority for operational safety, these procedures specify that pilots should first fit self-protection equipment such as oxygen goggles and masks. Next, they should inform the ATC service and try to isolate, as far as possible, the cabin air emission sources, such as the APU, the air conditioning system packs, the air recirculation fans, etc. Finally, they should attempt to improve the cabin air quality by modifying the ventilation, and it may be necessary to descend to a safe height in order to use an additional air source or even to facilitate the evacuation of smoke in the cabin.

5.1.3. ICAO circular No. 344-AN/202 relative to cabin fume events

ICAO Circular No. 344-AN/202 "Guidelines on Education, Training and Reporting Practices related to Fume Events", instructs on the possible identification of the agent causing smoke in the cabin and its particular dispersed odour.

Although odour descriptors are subjective, they can nevertheless provide a reasonable idea of the causative agent or, at the very least, they can be used as a useful starting point for research. Therefore, the TMA inspecting the aircraft after the event should review the Cabin Odour Sheet (COS) for information on the symptoms experienced by the occupants of the aircraft.

The standard descriptors used to define a type of odour are:

- Acrid: corresponding to smells produced by faulty electrical equipment and engine oil leaks.
- Burnt: produced by faulty electrical equipment, in the galleys, or due to bird ingestion in the engines.
- Dirty socks: produced by engine or APU oil leaks contaminating the ECS.
- Skydrol: for engine hydraulic fluid.

Once information from the smoke and fumes reporting form (COSRS) has been collected, the TMA should focus on identifying the root cause, without limiting the search to downstream components.

If the indications point to hydraulic fluid as the source of the fumes, for example, through the odour descriptors, the TMA should perform a close walk-around of the aircraft, looking closely for evidence of fluid streaking down the fuselage and ending near an air inlet. Actuators, including in the landing gear, should be examined for signs of hydraulic fluid leakage. The TMA should also examine the area around the hydraulic servicing area because over-servicing or spillage during servicing can cause hydraulic fluid to leak out of the servicing area and streak into an air inlet.

If indications are of engine oil, the TMA should begin troubleshooting with a good visual inspection of the engines and APU area. This involves looking closely for any evidence of oil which would suggest a failed oil seal or a possible accumulation of oil in the cowling, which could cause contamination to bleed systems, depending on how the packs were configured during the event.

Oil in these areas could indicate an over-serviced engine or spillage associated with improper servicing. Both of these scenarios could cause oil to be ingested into the compressor section and oil fumes to enter the engine bleed air system.

If no external oil accumulation is noted, the next step is to investigate a possible internal oil leakage. Reported oil fumes just after engine start may be due to a pressure differential across the engine oil seals. The TMA should determine if there has been an increase in oil consumption on any of the engines. If so, the TMA should narrow the investigation to that engine. The TMA should then disconnect the ducting at the low and high-pressure bleed ports on the engine and determine if there is evidence of burnt oil (coking) in either duct. If so, the engine should be considered the source of the contamination.

If it is not possible to remove the ducting at the engine, then the TMA should check the ducting as close to the engine as possible. If the aircraft is equipped with a water separator, the TMA should check for oil contamination there. If contamination is found, this would indicate oil leakage from the engine or APU, which could be identified by tracing the ducting back to each bleed source.

If the Air Cycle Machine (ACM), i.e., the Environmental Control System cooling system (ECS), is equipped with oil-lubricated bearings, the TMA should assess if the oil level is low, or if the ACM has been consuming oil. If so, the TMA should examine the inside of the outlet ducting for signs of contamination.

If the odours are not oil or hydraulic fluid-related, then environmental issues should be considered. For example:

- if the aircraft was de-iced earlier on the day of the event.
- if the odours were noticed on the ground but dissipated after take-off, it could be that ground equipment may have been left running in close proximity to the aircraft.
- if the aircraft was in a long line waiting for take-off, jet exhaust from another aircraft in front of the incident aircraft may have been ingested into the bleed air system.
- if the odour began just after engine start, the possibility that a strong tailwind during engine start caused exhaust fumes to enter the air system should be considered.

- if odours appeared and disappeared while the aircraft was in flight, other sources may be considered, as environmental agents in the flight path, such as fires, etc.

5.1.4. Reference documents from the aircraft's manufacturer

Due to their relevance in the incident, the following documents from the aircraft manufacturer have been evaluated, as well as the specific tasks included in the maintenance manual (AMM), which were carried out during the replacement of engine 2 after the flight before the incident, as well as after the necessary inspections and repairs:

- AMM 29-11-51-860-040-A - Hydraulic Maintenance Procedure after an Engine Installation (with Engine Pump Installed) or after an Engine Pump Installation: after the installation of a new engine, among the tasks to be carried out are those concerning the complete revision of the hydraulic systems as well as their connections, to guarantee that there are no leaks.
- AMM 05-51-19-200-001-A - Inspection of the Engine after a Bird Strike or Slush Ingestion: highlights the need to inspect the entire cold airflow path after hail or bird strike/ingestion.
- AMM 29-13-51-400-004-A - Installation of the Yellow Engine Pump: this task was carried out to install the yellow hydraulic system pump after its failure.
- AMM 21-52-00-00 CONF 00 – Air cooling system: this task describes the installation of the reheaters between the main heat exchanger and the condensers.
- AMM 71-00-00-400-042-A - Installation of the Power Plant: in this task, the installation of a new engine is detailed. However, it should be noted that there is no reference to the need to check the proper functioning of the engine by running it at the same time as the other engine or with both air conditioning packs (packs 1 and 2) connected.

5.1.5. Perception of odours/smoke in the cabin

Taking into account the range of evidence found both during the post-incident inspection of the aircraft (loss of hydraulic fluid), and before the incident (bird ingestion and the subsequent maintenance involving the necessary cleaning and engine service products), as well as the information supplied in the COSRS report which identified the odour as smelling like oil, one can appreciate the variety of elements that could have contributed to the smoke and odour in the cabin.

Many different factors affect the human interpretation of a smell. These include the intensity with which it is perceived, the frequency and awareness of the perception, as well as the expectations linked to it. All of which can lead to the same smell being interpreted differently. Thus the perception of a particular recognised odour in an unfamiliar setting can be identified as a threat and increase the stress level of the perceiver, potentially having a real physiological impact.

The interpretation of an odour is generally based on experience, the non-sensory information of the perceiver and sensory information, such as eye irritation, nasal pungency, etc. These factors combine to complete the possible interpretation. In any case, these identification criteria are not objective.

For all the reasons mentioned above, an odour can influence the perception of risk in a specific situation, triggering conscious and subconscious reactions.

In the case of this event, it should be noted that the captain noticed "a slight burning smell, difficult to pin down" like "burnt glue" when taxiing for take-off. However, as there were other departing aircraft close by, he initially assumed their exhaust fumes had entered the air conditioning system. Nonetheless, in his words, "something told him there was something wrong". However, he continued the ascent without giving it any more thought until the smoke entered the cockpit.

While making the introductory announcement, the purser also smelled burning. Simultaneously, two of the cabin crew alerted him to the presence of smoke in the passenger cabin, verifying that, at the height of the emergency windows, there was a significant amount of smoke and they were trying to identify the source of a possible fire.
After a short time, the smoke dissipated completely, so the purser thought, in his words, "that oil or hydraulic fluid had likely been burned by one of the engines and entered the aircraft through the ventilation system".

5.1.6. Emergency "smoke in cabin" procedure (QRH, "Quick Reference Handbook")

According to the A320 FCOM and FCTM cabin smoke management instructions, if smoke is detected by the crew without an ECAM warning, the flight crew will refer directly to the QRH SMOKE / FUMES / AVNCS SMOKE procedure.
The QRH consists of specific procedures not included in the ECAM. They must be initiated in unusual situations or emergencies by the PF once an appropriate flight path has been assigned and at least 400 ft above the runway if the failure occurs during take-off, approach or a go-around (in some emergencies, once the appropriate route has been provided, the PF can initiate actions before reaching this height). The PM will read the list and the PF will reply after checking the existing configuration.

In this incident, the captain, after adopting the PF function when the smoke appeared in the cabin, was the one who initiated the QRH, ordering the co-pilot to use the oxygen mask and read the list.

The manufacturer indicates that the SMOKE / FUMES / AVNCS SMOKE QRH procedure implements a global philosophy applicable both to incidences of smoke in the passenger cabin and the cockpit. This philosophy involves the following main steps:

- Anticipate diversion
- Immediate actions

It underlines the fact that time is critical, and for this reason, a diversion should be anticipated immediately. In this incident, the decision was taken immediately.

According to the captain, the procedure was not completed beyond donning oxygen masks and initiating the diversion due to communication difficulties caused by the oxygen masks and because the smoke had dissipated entirely. Eventually, the crew removed the masks and carried out the approach and landing with no further incident.

According to the manuals, the crew can abandon the QRH procedure if the conditions for which it was initiated disappear.

The QRH “SMOKE/FUMES/AVNCS SMOKE” includes the following actions:

1.- Land as soon as possible.
2.- If required: crew 100% emergency, use oxygen masks.
    - If smoke is detected, apply immediately:
        - Blower: *off*
        - Extract: *off*
        - Cab fans: *off*
        - Galy and cab: *off*
        - Signs: *on*
        - Ckpt / cab com: establish communication

3.- If the source of the smoke is obvious, accessible and extinguishable: isolate the faulty equipment.
4.- If the source cannot be immediately isolated:
- Initiate diversion
- Initiate descent FL100 or MEA or minimum altitude to avoid obstacles.

5.- If the smoke becomes the greatest threat:
- Consider the removal of the smoke or fumes and the emergency electrical configuration.

6.- If at any time during the procedure, the situation becomes unmanageable:
- Consider landing immediately.

7.- If you suspect the smoke/fumes are coming from the air conditioning:
- *APU Bleed: OFF*
- *BLOWER: AUTO*
- *EXTRACT: AUTO*
- *ALL CARGO ISOL VALVES*
- *pack 1: OFF*

- If the smoke/fumes continue:
- *pack 1: ON*
- *pack 2: OFF*

If the smoke/fumes still persist:

- pack 2: ON
- *BLOWER: OVRD*
- *EXTRACT: OVRD*
- Consider smoke/fumes removal.

8.- If the smoke/fumes are suspected as coming from equipment in the cabin, there is a different procedure.
9.- If the smoke disappears in less than five minutes, restore normal ventilation.

During the management of the emergency, the flight crew carried out the first two steps on the checklist. They subsequently abandoned the procedure because the conditions for which it was initiated had disappeared.