# Final Report
# IN-038/2019

Incident involving an Airbus A321 operated by British Airways PLC, registration G-MEDN, on 05 August 2019 at Valencia Airport (Valencia, Spain)

Please note that this report is not presented in its final layout and therefore it could include minor errors or need type corrections, but not related to its content. The final layout with its NIPO included (Identification Number for Official Publications) will substitute the present report when available.

MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA

SUBSECRETARÍA

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

# Notice

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission regarding the circumstances of the accident object of the investigation, its probable causes and its consequences.

In accordance with the provisions in Article 5.4.1 of Annexe 13 of the International Civil Aviation Convention; and with Articles 5.6 of Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010; Article 15 of Law 21/2003 on Air Safety; and Articles 1 and 21.2 of RD 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent their recurrence. The investigation is not intended to attribute any blame or liability, nor to prejudge any decisions that may be taken by the judicial authorities. Therefore, and according to the laws detailed above, the investigation was carried out using procedures not necessarily subject to the guarantees and rights by which evidence should be governed in a judicial process.

Consequently, the use of this report for any purpose other than the prevention of 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.

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# ABBREVIATIONS

| | |
|---|---|
| ° ‘ “ | Sexagesimal degrees, minutes and seconds |
| °C | Degrees Celsius |
| % | Per cent |
| ADEM | Advanced Diagnostics and Engine Management |
| AEMET | Spain’s State Meteorological Agency |
| AFS | Auto Flight System |
| AFT | Abbreviation of “after” |
| AOC | Air operator certificate |
| ATA | Air Transport Association |
| ATC | Air traffic control |
| ATPL (A) | Airline transport pilot license (aircraft) |
| APU | Auxiliary power unit |
| CEOPS | Airport operations centre |
| CFDS | Centralised Fault Display System |
| CPL (A) | Commercial pilot license (aircraft) |
| CRC | Continuous repetitive chime |
| CVR | Cockpit voice recorder |
| DME | Distance measuring equipment |
| ECAM | Electronic centralised aircraft monitoring |
| ECS | Environmental control system |
| EGT | Exhaust gas temperature |
| ENG | Abbreviation of “engine” |
| EPR | Engine pressure ratio |
| E/WD | Engine warning display |
| FAA | United States Federal Aviation Administration |
| FAP | Flight attendant panel |
| FBC | Front bearing compartment |
| FCOM | Flight Crew Operating Manual |
| FDR | Flight data recorder |
| FL | Flight level |
| FPV | Flight path vector |
| ft | Foot |
| FWD | Abbreviation of “forward” |
| h | Hour |
| HP | High pressure |
| hPa | Hectopascal |
| HPC | High-pressure compressor |
| HPT | High-pressure turbine |
| IAE | International Aero Engines |
| IAF | Initial approach fix |
| IFR | Instrument flight rules |
| IGB | Internal gear box |

| | |
|---|---|
| ILS | Instrument landing system |
| IP | Intermediate pressure |
| IR | Instrument rating |
| kg | Kilogramme |
| km | Kilometre |
| kt | Knot |
| LAV | Abbreviation of “lavatory” |
| LEVC | ICAO code for Valencia Airport |
| LLP | Life-limited parts |
| LP | Low pressure |
| LPT | Low-pressure turbine |
| m | Metre |
| MCD | Magnetic chip detector |
| METAR | Aviation routine weather report (in aeronautical meteorological code) |
| MMCD | Master magnetic chip detector |
| MPD | Maintenance planning document |
| NM | Nautical mile |
| NOTAM | Notice to Airmen |
| ICAO | International Civil Aviation Organisation |
| OPV | Overpressure valve |
| PA | Public address system |
| PA-VLC | Valencia Airport self-protection plan |
| PBE | Protective breathing equipment |
| PBN | Performance-based navigation |
| PFR | Post-flight report |
| PLC | Public Limited Company |
| PMP | Main command post |
| pph | Pounds per hour |
| PRV | Pressure regulating valve |
| psi | Pounds per square inch |
| QNH | Altimeter setting to obtain elevation above sea level when on the ground |
| QRH | Quick Reference Handbook |
| RH | Right hand |
| SD | System display |
| SMA | Airport medical service |
| SSEI | Rescue and Firefighting Service |
| STAR | Standard instrument arrival |
| S/N | Serial number |
| TCP | Cabin crew |
| UK CAA | United Kingdom Civil Aviation Authority |
| UTC | Coordinated universal time |
| VHF | Very high frequency |

# Synopsis

| | |
|---|---|
| **Aircraft Owner and Operator**: | British Airways PLC |
| **Aircraft**: | AIRBUS A321-231, registration G-MEDN, S/N 3512 |
| **Date and time of incident**: | 05 August 2019: 16:45 h[1] |
| **Site of incident**: | Valencia Airport (Valencia, Spain) |
| **Persons on board of the Aircraft**: | 8 +175, unharmed |
| **Type of flight of the Aircraft:** | Commercial air transport - scheduled - international - with passengers |
| **Phase of flight of the Aircraft**: | Landing - Landing roll-out |
| **Flight rules:** | IFR |
| **Date of approval:** | 23 February 2022 |

**Summary of incident**:

On Monday, 05 August 2019, at 16:43 h, the Airbus A321-231 aircraft operated by British Airways PLC, registration G-MEDN, landed on runway 12 at Valencia Airport. Before entering the apron through gate B, it stopped on rapid exit taxiway H4 and declared MAYDAY. Its captain subsequently ordered an emergency evacuation due to a possible fire on board.

The aircraft was flying from London Heathrow Airport (United Kingdom) to Valencia Airport. At 16:05 h (while it was over the Pyrenees at around 160 NM from Valencia and 80 NM from Barcelona), the pilots received an ENG 2 STALL ECAM caution that resolved without issue, the engine recovering automatically. Next, the purser informed the pilots that there was “a slight mist in the cabin”. Four minutes later, there was an ENG 2 OIL FILTER CLOG caution that required no action on their part. The pilots analysed the option of diverting to Barcelona, but after assessing the situation, they decided to continue to Valencia.

The flight passed without further incident until the final approach to runway 12 at Valencia Airport, when, at an altitude of 6,000 ft, the co-pilot noticed white smoke entering behind his position and becoming increasingly thicker. At 16:39 h, the pilots put on their oxygen masks. At no time did the pilots notify the control tower that anything was out of the ordinary, and they completed the landing at 16:43 h.

[1] Time in UTC. Local time can be calculated by adding 2 h to the UTC. Unless otherwise indicated, all times in this report are expressed UTC.

Two seconds after landing, the ECAM ENG 2 OIL LO PR warning activated, and once on the ground, the flight crew received the FWD CARGO SMOKE and ENG 2 OIL FILTER CLOG alerts. The captain immediately stopped the aircraft before entering the apron and ordered an emergency evacuation after declaring MAYDAY to the control tower.

No one was injured during the flight or the evacuation of the aircraft.

The initial findings indicated that engine 2 had lost most of its oil, with some of it being ingested by the engine’s bleed air system and leaking into the cabin, having condensed in the form of whitish smoke.

The aircraft sustained minor damage during the emergency evacuation and engine number 2 was disassembled and transferred to the manufacturer's facilities to undergo a thorough inspection. The inspection found that the oil loss had been triggered by the failure of bearing number 3.

The investigation has identified the cause of the incident as the misalignment and breakage of bearing number 3 (and its hydraulic seal) in engine number 2. This resulted in the bleed air from engine number 2 becoming contaminated with engine oil, which, in turn, caused smoke to enter the passenger cabin and the presence of oil in the anti-ice system.

No safety recommendations are issued.

# 1. FACTUAL INFORMATION

## 1.1 History of the flight

On Monday, 05 August 2019 at 14:49 h, the Airbus A321-231 aircraft operated by British Airways PLC, registration G-MEDN, took off from London Heathrow Airport (United Kingdom) bound for Valencia Airport with a total of 183 people on board (of which 8 were flight crew). Its callsign was BA422.

The flight crew consisted of 2 pilots and 6 cabin crew. It was the first flight of the 2 they had been assigned for that day[2]. On this flight, the captain was the pilot flying.

The flight proceeded normally until 16:05 h when, as the aircraft was at FL350 flying over the Pyrenees, the flight crew received the ECAM ENG 2 STALL caution, which automatically resolved.

The flight crew performed the QRH ENG STALL procedure and activated the anti-ice systems of the affected engine and the wings.

At 16:06 h, the cabin crew informed the pilots that a noise had been heard and a slight mist had formed in the passenger cabin, which disappeared moments later.

At 16:09 h, the flight crew received another caution, ECAM ENG 2 OIL FILTER CLOG, which required no action on their part.

After performing the procedures associated with both the ECAM cautions, analysing the recent events and assessing the available options, at 16:11 h, the pilots took the decision to continue to their destination.

At 16:13 h, the aircraft began its descent to Valencia Airport. The captain handed the controls to the co-pilot to focus on observing the engine parameters.

During the descent, the flight crew continued to monitor the parameters of the affected engine without detecting any further abnormalities, and the cabin crew confirmed that the situation in the cabin had not deteriorated.

The cabin crew secured the passenger cabin and informed the pilots.

At 16:39 h, when the aircraft was at an altitude of 6,000 ft on the ILS approach to runway 12 at Valencia Airport, both the flight deck and the passenger cabin began to fill with white smoke.

The pilots donned their oxygen masks.

[2] The second flight should have been the return flight from Valencia to London - Heathrow.

The captain carried out the immediate actions in the QRH emergency list for SMOKE / FUMES / AVNCS SMOKE.

During the approach, the ECAM LAVATORY SMOKE, AVIONICS SMOKE and AFT CARGO SMOKE alerts were activated.

Despite the smoke, the visibility on the flight deck was sufficient for the pilots to see the flight instruments and controls.

In the passenger cabin, the purser instructed the other cabin crew members to put on their smoke hoods, and the passengers were instructed to keep their heads down.

At 16:42 h, the aircraft was cleared to land on runway 12, and the captain resumed control.

The aircraft landed at 16:43 h and exited runway 12 via the H4 rapid-exit taxiway.

Once on the ground, the flight crew received the ECAM ENG 2 OIL LO PR, FWD CARGO SMOKE and ENG 2 OIL FILTER CLOG alerts.

After stopping the aircraft on rapid-exit taxiway H4 before reaching the apron, the flight crew declared MAYDAY and requested immediate assistance from the firefighting services. It was 16:44 h.

The captain issued the "ATTENTION CREW AT STATIONS"[3] call, and the flight crew began to perform the procedures associated with the ECAM alerts.

After opening the windows on the flight deck, the smoke dispersed rapidly.

The captain issued the ALERT CALL[4] to the cabin crew.

At 16:46 h, the access door to the flight deck was opened and two cabin crew members wearing smoke hoods entered. With the door open, the pilots could see that the visibility in the passenger cabin was significantly reduced.

At 16:47 h, the pilots asked the tower to verify any external evidence of fire on the aircraft.

After consulting with the firefighting services, the tower reported no external evidence of fire on the aircraft.

[3] The pilot makes the ATTENTION CREW AT STATIONS call through the passenger announcement (PA) system when the aircraft is on the ground and stationary. It tells the cabin crew to increase their level of alert due to a potentially dangerous situation.

[4] The pilot makes the ALERT CALL through the passenger announcement (PA) system or intercom when the purser is required go immediately to the flight deck. The message is as follows: “WILL THE SENIOR CABIN CREW MEMBER REPORT TO THE FLIGHT DECK IMMEDIATELY.”

At 16:48 h, the captain ordered the emergency evacuation, and at 16:49 h, he notified the tower that the aircraft was being evacuated.

There were no injuries.

The aircraft was towed to a remote location on the airport apron.

### 1.2 Injuries to persons

After the evacuation, 48 passengers received medical assistance at the airport. Three of them (2 children and 1 adult) were transferred to hospital and discharged that same evening. Most of them were treated for minor bruises sustained while evacuating down the slides and/or eye irritation from the smoke.

| ***Injuries*** | **Crew** | **Passengers** | **Total in the aircraft** | **Others** |
|---|---|---|---|---|
| Fatalities | | | | |
| Serious | | | | |
| Minor | | | | |
| Unharmed | 2 + 6 | 175 | 183 | |
| TOTAL | 8 | 175 | 183 | |

### 1.3 Damage to the aircraft

The right engine suffered confined internal damage.

In addition, the deployment of the evacuation slides caused minor damage to the aircraft.

The exterior inspection of the aircraft after the incident found the following evidence:

- The slats on the right wing were leaking oil. The oil was coming from engine 2's bleed air ducts for the right wing's anti-ice system.
- The right engine was leaking oil.
- The metal chip detectors accessed by lifting the cowlings of engine 2 were completely filled with ferrous debris.
- An initial boroscopic inspection of the engine revealed significant amounts of engine oil in the third stage of the high-pressure compressor.
- On the right side of the aircraft all 4 slides were deployed, while only the front and rear access door slides were deployed on the left.

The interior inspection of the aircraft after the incident found the following evidence:

- The passenger oxygen masks had not been deployed (the "oxygen" panel in the flight deck showed that the mechanism for their deployment had not been activated).

- Five used cabin crew smoke hoods[5] were found.
- One cabin crew smoke hood was still stored, i.e., it had not been used.
- In the cockpit, the two pilot oxygen masks had been worn.
- The "fire" panel on the flight deck showed that the 3 fire handles (engines 1 and 2 plus the APU) had been activated and the extinguishing agent bottle had been discharged into engine 2.
- The "cargo smoke" panel on the flight deck showed that the extinguishing agent bottle[6] had been discharged in the hold.
- The ECAM engine display indicated that there was no oil remaining in engine 2.
- The flight recorder breakers were pulled out.
- The charge indicator for battery 2 showed that it had no charge.

### 1.4 Other damage

There was no other damage.

### 1.5 Information about the crew

#### 1.5.1 Information about the flight crew on board the aircraft

The 53-year-old captain had an Airline Transport Pilot License (ATPL(A)) issued by the United Kingdom Civil Aviation Authority (UK CAA) on 30 November 2013 with A320/IR/PBN ratings valid until 31 July 2020. He had a Class 1 medical certificate valid until 31 December 2019 and an English proficiency level of 6. He had a total of 16,000 flight hours, of which 8,000 h were on the type of aircraft involved in the incident. He had been working for the operator since 1998 and had been a captain since 2008.

The 32-year-old co-pilot had a Commercial Pilot License (CPL(A)) issued by the UK CAA on 21 October 2014 with A320/IR/PBN ratings valid until 31 August 2020. He had a Class 1 medical certificate valid until 12 November 2019 and an English proficiency level of 6. He had a total of 3,000 flight hours, of which 2,800 h were on the type of aircraft involved in the incident. He had been working for the operator since 2019. He previously flew the same type of aircraft for another operator.

#### 1.5.2 Information about the cabin crew on board the aircraft

Flight attendant no. 1

The purser was 45 years old and held a Cabin Crew Attestation issued by British Airways PLC under the competent authority of the UK CAA on 5 April 2013. He also had a valid cabin crew medical certificate in force until 04 May 2022.

[5] Information on the use of PBE (Protective Breathing Equipment) by the cabin crew is provided in section 1.15.3.

[6] This aircraft was equipped with a single bottle of extinguishing agent in its hold. Having two bottles is optional.

His type rating (A319/320/321) was valid until 30 November 2019.

Flight attendant no. 2

Flight attendant no. 2 was 45 years old and held a Cabin Crew Attestation issued by British Airways PLC under the competent authority of the UK CAA on 05 April 2013. He also had a valid cabin crew medical certificate in force until 05 June 2020

His type rating (A319/320/321) was valid until 30 September 2019.

Flight attendant no. 3

Flight attendant no. 3 was 46 years old and held a Cabin Crew Attestation issued by British Airways PLC under the competent authority of the UK CAA on 05 April 2013. He also had a valid cabin crew medical certificate in force until 20 October 2020.

His type rating (A319/320/321) was valid until 31 July 2020.

Flight attendant no. 4

Flight attendant no.4 was 39 years old and held a Cabin Crew Attestation issued by British Airways PLC under the competent authority of the UK CAA on 05 April 2013. He also had a valid cabin crew medical certificate in force until 13 February 2022.

His type rating (A319/320/321) was valid until 29 February 2020.

Flight attendant no. 5

Flight attendant no.5 was 52 years old and held a Cabin Crew Attestation issued by British Airways PLC under the competent authority of the UK CAA on 05 April 2013. He also had a valid cabin crew medical certificate in force until 27 May 2021.

His type rating (A319/320/321) was valid until 30 June 2020.

Flight attendant no. 6

Flight attendant no. 6 was 53 years old and held a Cabin Crew Attestation issued by British Airways PLC under the competent authority of the UK CAA on 05 April 2013. He also had a valid cabin crew medical certificate in force until 21 April 2022

His type rating (A319/320/321) was valid until 30 April 2020.

## 1.6 Information about the aircraft

### 1.6.1 General information about the aircraft

The Airbus A321-231 aircraft, registration G-MEDN and serial number 3512, was built in 2008 and registered with the UK CAA on 09 October 2012. It previously belonged to the operator British Midland.

The aircraft had a maximum take-off weight of 83,000 kg, a maximum landing weight of 75,500 kg, and two IAE[7] V2533-A5 turbofan-type engines with serial numbers V12922 (engine 1 or left) and V12924 (engine 2 or right).

Its main dimensions are:

- Length: 44.51 m
- Wingspan: 34.10 m
- Height: 11.75 m

It had a certificate of airworthiness issued by the UK CAA and an airworthiness review certificate valid until 08 May 2020.

The aircraft was operated by British Airways PLC, whose Air Operator Certificate (AOC) was last renewed on 01 August 2019. The AOC covered the operation of Airbus A321 aircraft, such as the G-MEDN.

At the time of the incident, the aircraft had 37,301.76 flight hours and 11,067 cycles.

Its last scheduled maintenance overhaul was carried out by Iberia Mantenimiento in its hangar in Madrid, and it obtained its release to service certificate on 04 May 2019, when the aircraft had 36,680.58 flight hours and 10,635 cycles. It consisted of a C8 overhaul in accordance with the Iberia WP S8089039 procedure. During this type C overhaul, 5,600 maintenance orders were performed on the aircraft, and there are 975 items on the list of tasks carried out.

The aircraft's deferred tasks list did not contain any relevant elements.

### 1.6.2 V12924 Engine History (Engine 2 or right)

Engine 2 was built in 2008 by IAE and was a V2533-A5 model with serial number V12924. At the time of the incident, the engine had 35,909 hours and 10,679 cycles.

Of the most recent maintenance actions carried out on it, the following are relevant:

| | Date | Engine 2 hours | Engine 2 cycles |
|---|---|---|---|
| C8 overhaul | April-May 2019 | 35,288 h | 10,248 |
| MCD Inspection[8] | 12 July 2019 | 35,725 h | 10,562 |

From May to July 2011, engine 2 was dismantled and taken to the workshop for repair after having ingested aqueous fire-extinguishing foam with the engine at idle (at that time, it had 12,034 hours and 2,800 cycles).

[7] International Aero Engines.

[8] Magnetic chip detector (MCD).

According to the records, as part of the repair, the mechanics replaced all the life-limited parts (LLP) and visually inspected the front bearing compartment (FBC). Removing the bearings, gears, or seals from the front compartment was not deemed necessary.

Once the repairs were completed, the engine was tested and refitted on the aircraft.

Work was carried out on engine 2 during the last scheduled major C8 overhaul (May 2019 in Madrid) carried out by Iberia Mantenimiento in accordance with the Iberia WP S8089039 procedure.

From the completion of the C8 overhaul until the day of the incident, the engine accumulated a further 621 hours and 431 cycles.

In addition, engine 2's magnetic chip detectors were inspected as per the 600-hour intervals scheduled in the Maintenance Planning Document (MPD).

The last of these inspections took place on 12 July 2019, 184 hours and 117 cycles before the incident, and the results were found to be within the limits established by the aircraft maintenance manual. The last 4 MCD inspections all returned satisfactory results and are summarised in the following table:

| Date of inspection MMCD[9] and MCD | Engine 2 cycles | Engine 2 hours |
|---|---|---|
| 12 July 2019 | 10,562 | 35,725.12 |
| 23 March 2019 | 10,146 | 35,148.08 |
| 09 December 2018 | 9,682 | 34,563.69 |
| 06 September 2018 | 9,214 | 33,979.11 |

Furthermore, following the incident, the manufacturer reviewed engine 2's ADEM (Advanced Diagnostics and Engine Management) trend data for the last 12 months and the FDR data for the flight prior to the incident. Again, no anomalies or unusual performances were detected.

The number 3 bearing (bearing 3) installed in the engine had part number 2A1170 and serial number PCWKAJ2132. It was the type of number 3 bearing introduced in 2004. According to a report issued by the engine manufacturer, as of January 2020, there were more than 1,500 bearings of this type in service. Over the last 10 years, they had accrued 45.5 million flight hours, during which time 6 events related to this type of bearing had occurred. In addition, IAE has confirmed that no quality issues have been detected for any of the components in the engine's front bearing compartment (FBC).

Finally, it should be noted that, beyond the regular scheduled maintenance (i.e. daily checks), no specific ECS / BLEED / ENGINE maintenance was required during the 5 sectors flown prior to the event.

[9] Master magnetic chip detector (MMCD).

Engine 2's next scheduled visit to the maintenance hangar was scheduled for the second half of 2021.

### 1.6.3 Description of the V2533-A5 engine and its operation

The G-MEDN aircraft was equipped with two IAE V2533-A5 turbofan-type engines with serial numbers V12922 (the left or number 1) and V12924 (the right or number 2).

The V2533-A5 engine is composed of:

1. Two compressor-turbine assemblies in which each turbine operates its associated compressor via a shaft:
    - The low-pressure (LP) compressor-turbine assembly and
    - The high-pressure (HP) compressor-turbine assembly.
2. An accessory gearbox, and
3. A combustion chamber.

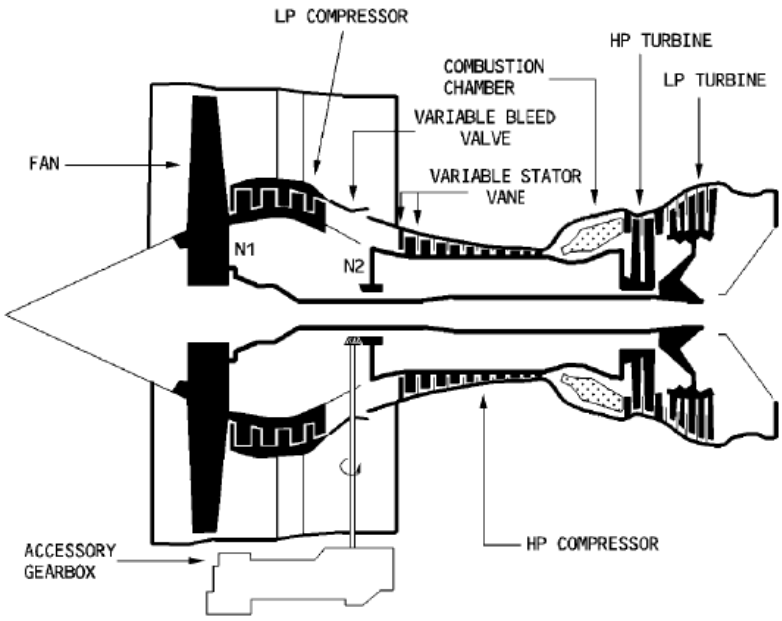



Fig. 1: IAE V2500 Engine diagram

When running, the air entering the engine (after passing through the FAN) is compressed by the low and high-pressure compressors (LP COMPRESSOR and HP COMPRESSOR). This air is then mixed with fuel and ignited in the combustion chamber. The gas produced by the combustion is what drives the high and low-pressure turbines (HP TURBINE and LP TURBINE).

When there is a disruption of airflow through an engine compressor, a compressor or engine stall can occur. It can be identified by a loud bang, fluctuations in the engine parameters

and an increase in the exhaust gas temperature (EGT). The fault is indicated by the ENG 1(2) STALL caution on the ECAM display.

Deteriorated engine components are one of the things that can cause a compressor stall.

The engine operating parameters are shown on the ECAM displays on the flight deck.

The following primary engine parameters are permanently shown on the ECAM Engine Warning Display (E/WD):

- Engine Pressure Ratio (EPR)
- Exhaust Gas Temperature (EGT)
- N1 (fan and low-pressure rotor rotation speeds)
- N2 (high-pressure rotor rotation speed)

Secondary engine parameters, such as the oil quantity or the level of high and low-pressure rotor vibration, are shown on the ECAM System Display (SD) on the flight deck.

### 1.6.4 Engine V2533-A5 bearings

In the V2533-A5 engine, the shaft is supported by 5 bearings positioned in 3 bearing compartments.

- The front compartment (FBC) houses the number 1, 2 and 3 bearings.
- The central compartment houses the number 4 bearing.
- The rear compartment houses the number 5 bearing.

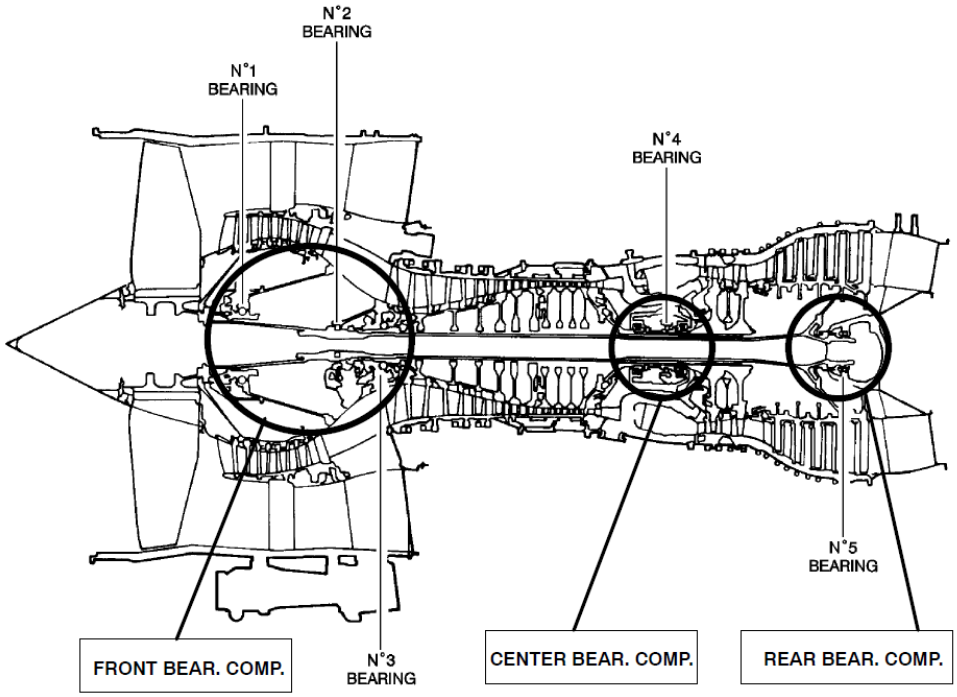



Fig. 2: Location of the bearings in the IAE V2500 engine

The low-pressure rotor is supported by three bearings, number 1, number 2 and number 5, while the high-pressure rotor is supported by two bearings, number 3 and number 4.

Bearing number 3 is a thrust bearing located in the Front Bearing Compartment (FBC).

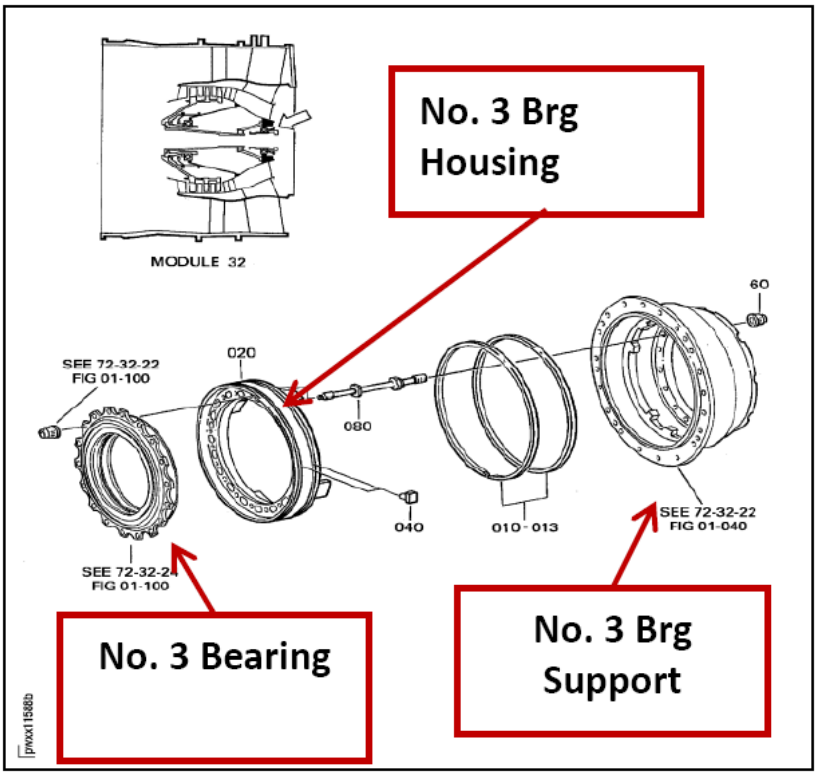



Fig. 3: Bearing no. 3. Position and parts

The compartment is sealed to prevent oil leakage with carbon seals supported by pressurised air from stage 2.5 of the low-pressure compressor and a hydraulic seal supported by air from the 8th stage of the high-pressure compressor.

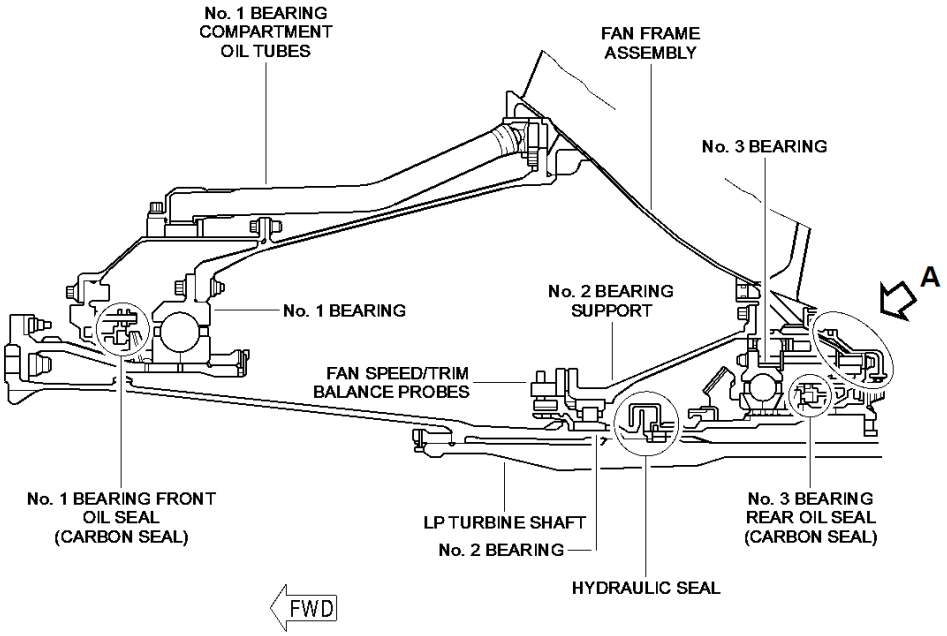



Fig. 4: Location of the seals in the front bearing compartment

### 1.6.5 Air supply to the cabin

The primary source of air for the aircraft cabin comes from air extracted (bled) from the engines. Air is drawn from the 7th and 10th stages of the engine's high-pressure compressor.

Subsequently, this engine bleed air passes through a pressure regulation valve (PRV), an overpressure valve (OPV) and a pre-cooler in which the air is cooled before being distributed to the air conditioning packs and other users, including anti-ice systems, among others.

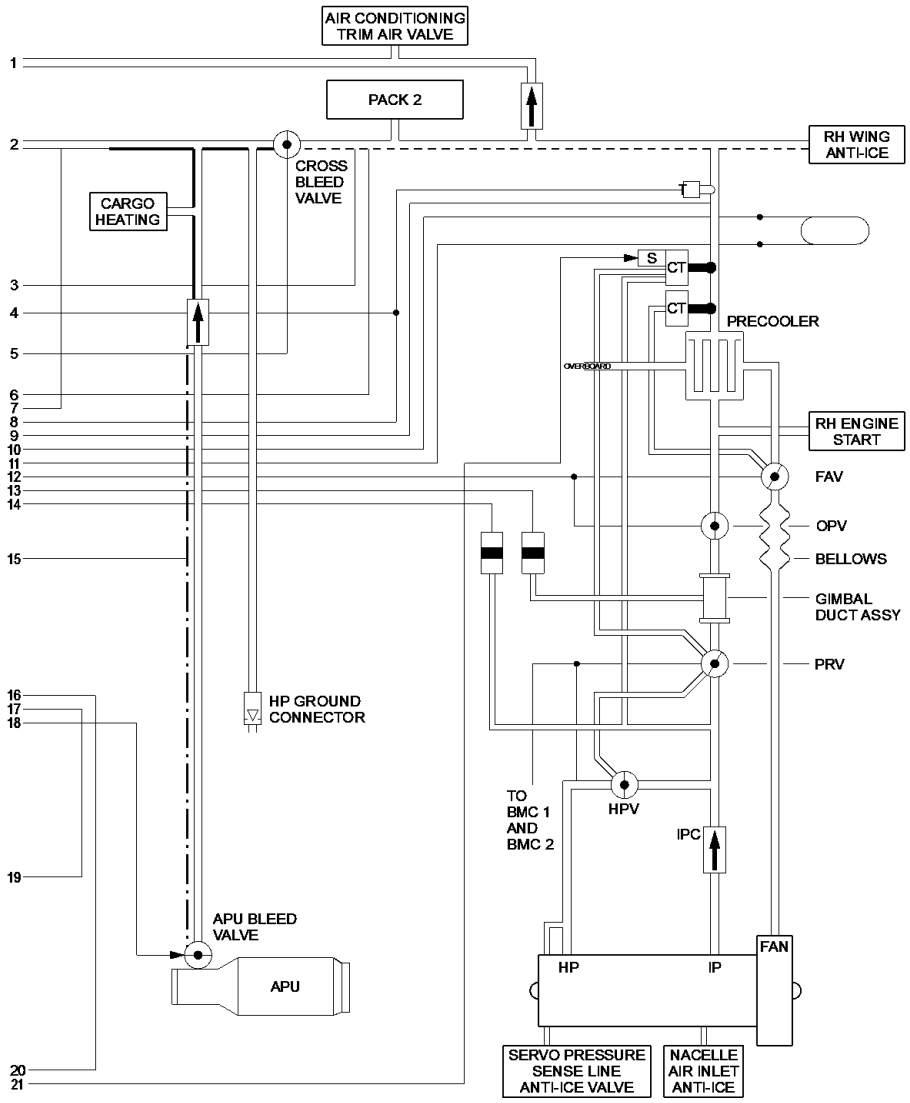



Fig. 5: Engine bleed air diagram

This air is then distributed to the flight deck and passenger cabin after passing through an air conditioning pack control valve (PACK VALVE), the air conditioning pack itself, and a mixer unit.

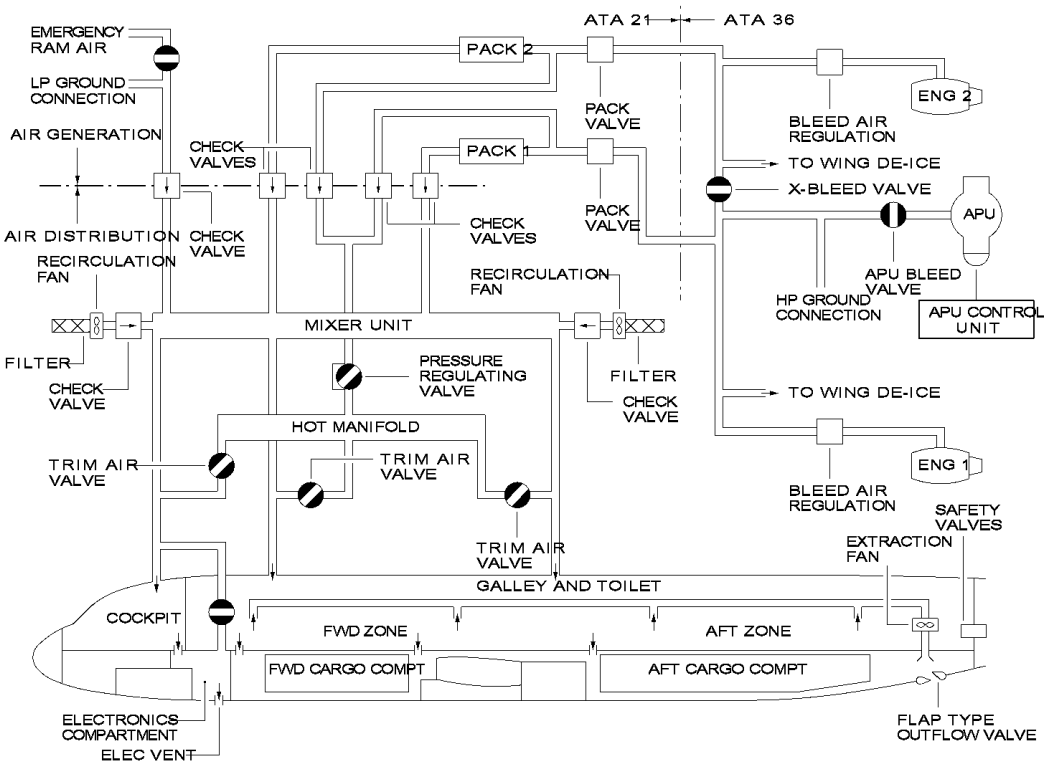



Fig. 6: Diagram of the air conditioning system

The conditioned air supplied to the flight deck and passenger cabin is also distributed to the avionics and cargo compartment.

### 1.6.6 Engine oil system

The engine oil system provides lubrication and cooling for various engine components.

The oil is stored in a tank and pumped to the various engine elements that need lubrication, such as the bearing compartments. Subsequently, the oil is collected by the scavenge pumps and returned to the oil tank after passing through the “scavenge filter”.

The filter is equipped with a differential pressure device that activates the ECAM ENG 1(2) OIL FILTER CLOG caution when it detects that the pressure difference between the inlet and outlet of the filter is greater than 12 psi, warning the flight crew that the oil filter is clogged.

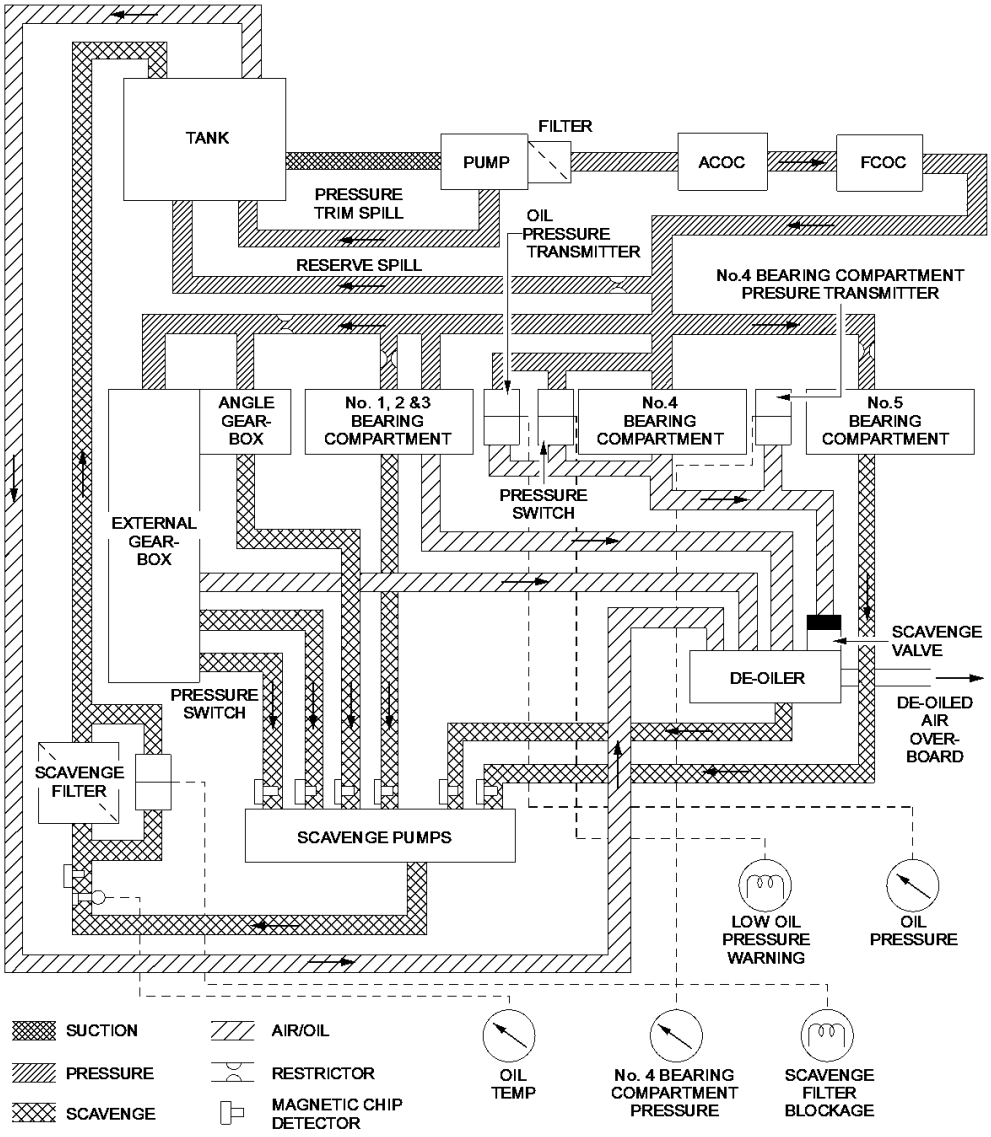



Fig. 7: Diagram of the engine oil system

The system is equipped with magnetic chip detectors that provide an indication of the wear on the engine components, including the bearings. In the event of wear on any of the components, these magnetic detectors trap the metallic particles that come loose as a result of that wear.

The material collected by the magnetic chip detectors is visually inspected periodically to verify the condition of the components.

In addition, the system is equipped with a low oil pressure indicator so that when the oil pressure drops below 60 psi, the ECAM ENG 1(2) OIL LO PR message appears.

### 1.6.7 Smoke detection

On the Airbus A321, smoke is either detected by smoke detectors installed in certain locations on the aircraft or directly detected by the crew. The aircraft has smoke detectors in the toilets, the avionics compartment, and the cargo holds.

The system installed in the avionics compartment also includes a smoke detector in the exhaust duct. When the smoke concentration exceeds the alarm threshold, the ECAM AVIONICS SMOKE caution activates on the flight deck.

The lavatories have a smoke detector in their air extraction ducts. When the smoke concentration exceeds the alarm threshold, the ECAM LAVATORY SMOKE warning activates on the flight deck.

The cargo holds have four smoke detectors in the front cargo hold and six in the rear. When the smoke concentration exceeds the alarm threshold, the ECAM FWD CARGO and/or AFT CARGO SMOKE warning activates on the flight deck.

### 1.6.8 Post-flight report (PFR)

The Centralised Fault Display System (CFDS) facilitates maintenance tasks by displaying fault messages on the cockpit instrumentation. It provides access to maintenance reports, such as the post-flight report (PFR).

The following table is an extract from the post-flight report generated after the incident flight:

| Time in UTC | Phase | ATA | ECAM messages |
|---|---|---|---|
| **16:05** | 06 | 77-11 | ENG 2 STALL |
| **16:09** | 06 | 77-00 | ENG 2 OIL FILTER CLOG |
| **16:39** | 06 | 26-00 | SMOKE LAVATORY SMOKE |
| **16:40** | 06 | 26-00 | AVIONICS SMOKE |
| **16:41** | 06 | 26-00 | SMOKE AFT CARGO SMOKE |
| **16:43** | 07 | 77-11 | ENG 2 OIL LO PR |
| **16:44** | 08 | 26-00 | SMOKE FWD CARGO SMOKE |
| **16:44** | 09 | 77-00 | ENG 2 OIL FILTER CLOG |

Table 1: Extract from the PFR for the incident flight

The different flight phases being as follows:

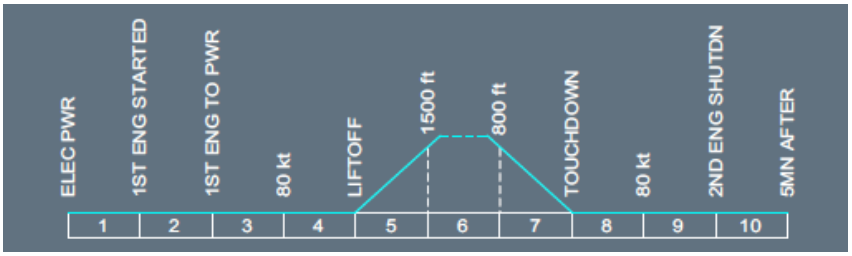



Fig. 8: Numbers assigned to the different flight phases

## 1.7 Meteorological information

The METAR for Valencia Airport at 16:30 and 17:00 UTC on the day of the incident were:

LEVC 051630Z 12010KT 090V170 9999 FEW030 30/22 Q1012 NOSIG=
LEVC 051700Z 13010KT 100V160 9999 FEW020 29/22 Q1012 NOSIG=

The wind was from the southeast with a speed of 10 kt, and visibility was in excess of 10 km. There were few clouds with a base that varied from 3,000 ft at 16:30 UTC to 2,000 ft at 17:00 UTC. The temperature alternated between 30ºC at 16:30 and 29ºC at 17:00 UTC. The dew point was 22ºC, and the QNH was 1,012 hPa. No significant changes were predicted.

AEMET's analysis of the incident indicated scattered clouds[10], light winds and good visibility in the area comprising the provinces of Huesca, Gerona and Valencia. The remote sensing images showed no convective activity outside the Pyrenees and no precipitation echoes on the radar.

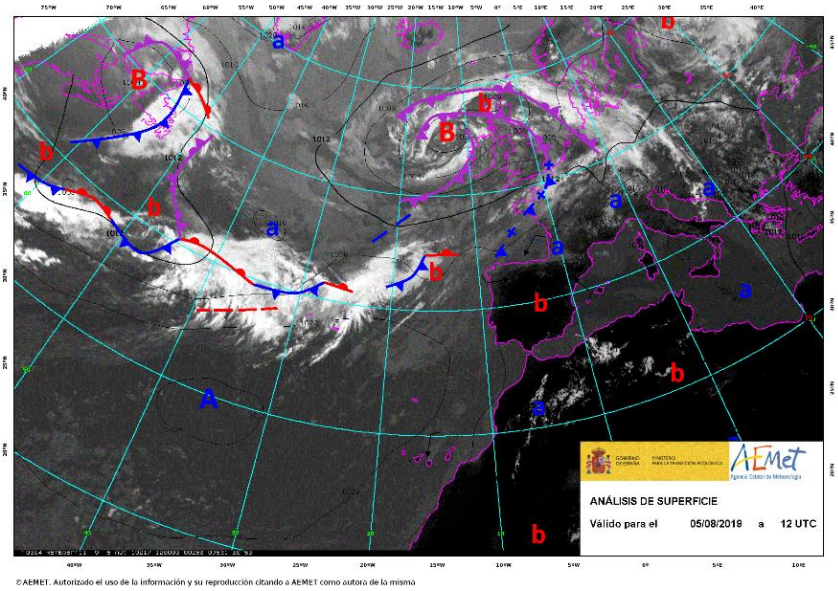



Fig. 9: Surface meteorological analysis (source AEMET)

## 1.8 Aids to navigation

All the navigation systems were functioning correctly.

[10] The triangle defined by the provinces of Huesca, Gerona and Valencia covers the area where the ECAM ENG 2 STALL and ENG 2 OIL FILTER CLOG cautions were activated, and the subsequent descent and approach were carried out.

### 1.9 Communications

We were given access to the cockpit voice recorder (CVR) that recorded the flight crew's communications with the ground operations personnel and air traffic control services. The most relevant conversations are summarised below:

16:05:53 Aircraft to FL350 8 minutes before commencing descent

- At 16:05:53, the captain announces the ECAM ENG 2 STALL caution.
- At 16:05:57, the captain indicates that the engine has recovered by itself and later says he wants to check the engine parameters. From this moment on, both pilots will be periodically checking the engine parameters.
- At 16:06:33, the pilots discuss the QRH ENG STALL procedure.
- At 16:06:44, the co-pilot answers a call from the purser via the intercom. The purser explains that they had heard a thud and that a light mist has formed in the passenger cabin. The co-pilot asks the purser to keep him informed of any changes.
- At 16:08:04, the pilots execute the QRH ENG STALL procedure, activating the anti-ice system for the engine and wings. They then continue to monitor the engine parameters.
- At 16:09:20, the captain announces the ECAM ENG 2 OIL FILTER CLOG caution and they complete the associated procedure.
- At 16:11:06, the pilots analyse the two failures and, after evaluating the available options, decide to continue to Valencia.

16:13:50 Start of the descent

- At 16:13:50, they begin the descent.
- At 16:15:06, they finish the descent and airport approach briefing.
- At 16:15:12, the captain hands over control of the aircraft to the co-pilot.
- At 16:19:05, the captain calls the purser, and they discuss the conditions in the passenger cabin. The captain informs him that he'll make an announcement to the passengers without mentioning the noise and the mist and explains that they have had a compressor stall and that this could be responsible for the mist.
- At 16:20:07, the captain makes the passenger announcement.
- At 16:21:27, after being transferred by ATC, the captain contacts Valencia approach.
- At 16:28:12, the captain calls the handling agent and informs them that they'll need maintenance on arrival in Valencia.
- At 16:36:32, Valencia approach instructs them to proceed to OPERA[11] and clears them for approach using ILS Z for runway 12.

16:39:00 Aircraft at an altitude of 6,000 ft, configured with flaps 2 and 13 NM from runway 12

- At 16:39:00, the co-pilot warns that smoke is entering the cabin.

[11] The OPERA waypoint is the initial approach fix (IAF) of ILS Z for runway 12 at Valencia Airport.

- At 16:39:05, the captain orders the use of the oxygen masks on the flight deck.
- At 16:39:29, after establishing communications between the two pilots, the captain asks the co-pilot to keep the aircraft on the ILS.
- At 16:39:32, the co-pilot disconnects the autopilot and the flight directors, requesting that the captain selects the “bird” or FPV (flight path vector) and “managed” speed.

16:39:40 Aircraft at 5,200 ft and 11 NM from runway 12

- At 16:39:40, the CRC[12] corresponding to the LAV SMOKE warning can be heard.
- At 16:39:47, Valencia approach transfers the G-MEDN to tower.
- At 16:39:52, the co-pilot requests the landing gear be extended.
  At 16:39:57, the captain can be heard identifying himself, possibly trying to contact the cabin crew.

16:40:40 Aircraft at 3,400 ft and 8 NM from runway 12

- At 16:40:40, a single chime sound[13] corresponding to an AVIONICS SMOKE caution is recorded.
- At 16:40:49, the captain indicates that he has completed the immediate actions included in the SMOKE FUMES AVIONICS SMOKE QRH list.
- At 16:41:34, the co-pilot requests the flaps be extended to the FULL position.
- At 16:41:50, they complete the before-landing checklist.

16:41:54 Aircraft at 1,500 ft and 4 NM from runway 12

- At 16:41:54, a CRC sound corresponding to an AFT CARGO SMOKE warning is heard.
- At 16:42:03, Valencia tower clears them to land on runway 12.
- At 16:42:35, the captain takes control of the plane.
- At 16:42:39, the captain asks the co-pilot to select the flight directors and approach mode.

16:43:51 Landing and landing roll-out

- At 16:43:51, a sound similar to that of the aircraft making contact with the runway can be heard, followed two seconds later by a CRC sound corresponding to an ENG 2 OIL LO PR warning.
- At 16:43:53, the co-pilot announces the extension of the spoilers, the thrust reversers, and the aircraft's deceleration.
- At 16:44:08, a CRC sound corresponding to an FWD CARGO SMOKE warning is heard.
- At 16:44:23, the captain tells the co-pilot he intends to stop the aircraft after leaving the runway.

[12] The CRC or “Continuous Repetitive Chime” alert alerts the crew to red warnings.

[13] The “single chime” is a bell that sounds once to alert the crew to amber cautions.

16:44:44 Aircraft stopped on rapid-exit taxiway H4

- At 16:44:44, the captain tells the co-pilot to declare MAYDAY.
- At 16:44:51, a sound similar to that of the pilots removing their oxygen masks can be heard.
- At 16:44:54, the co-pilot declares MAYDAY and requests the assistance of the firefighting service. Eleven seconds later, he declares the emergency again.
- At 16:45:15, Valencia tower tells him that the firefighters are on their way.
- At 16:45:21, the crew begins to carry out the actions associated with the CARGO SMOKE ECAM warnings, and the captain makes the “ATTENTION CREW AT STATIONS” call.
- At 16:45:58, a noise that sounds like the opening of the cockpit windows is heard.
- At 16:46:10, the captain issues the ALERT CALL.
- At 16:46:14, a sound similar to a request for access to the flight deck can be heard.
- At 16:46:38, the captain asks the purser about the conditions in the passenger cabin and informs him of his intention to have it inspected.
- At 16:46:46, the co-pilot attempts to communicate with the firefighting service.
- At 16:47:21, the tower asks the crew for information on the emergency and the captain replies that they have indications of smoke in the cargo holds.
- At 16:47:48, the captain asks the tower if they can see any signs of fire in the rear of the aircraft from their position.
- At 16:48:16, they complete the ECAM actions related to smoke.
- At 16:48:31, the tower informs the crew that the firefighters can’t see any signs of fire on the aircraft.
- At 16:48:52, the captain makes the decision to evacuate the aircraft.
- At 16:49:46, the pilots notify the tower that they are evacuating the aircraft.

### 1.10 Aerodrome information

According to Spain’s AIP, Valencia Airport (LEVC) is located 8 km west of the city of Valencia. Its elevation is 240 ft, and it has a 3,215 m-long by 45 m-wide runway designated 12/30. Both thresholds are equipped with an ILS/DME.

The airport's rescue and firefighting service is category 7[14].

The aerodrome map is shown below. The H4 rapid-exit taxiway where the aircraft stopped is marked by a red circle with a light-yellow background.

[14] The category indicates the level of protection provided by the aerodrome’s rescue and firefighting services, according to ICAO Annexe 14. This level is appropriate for aircraft such as the A321.

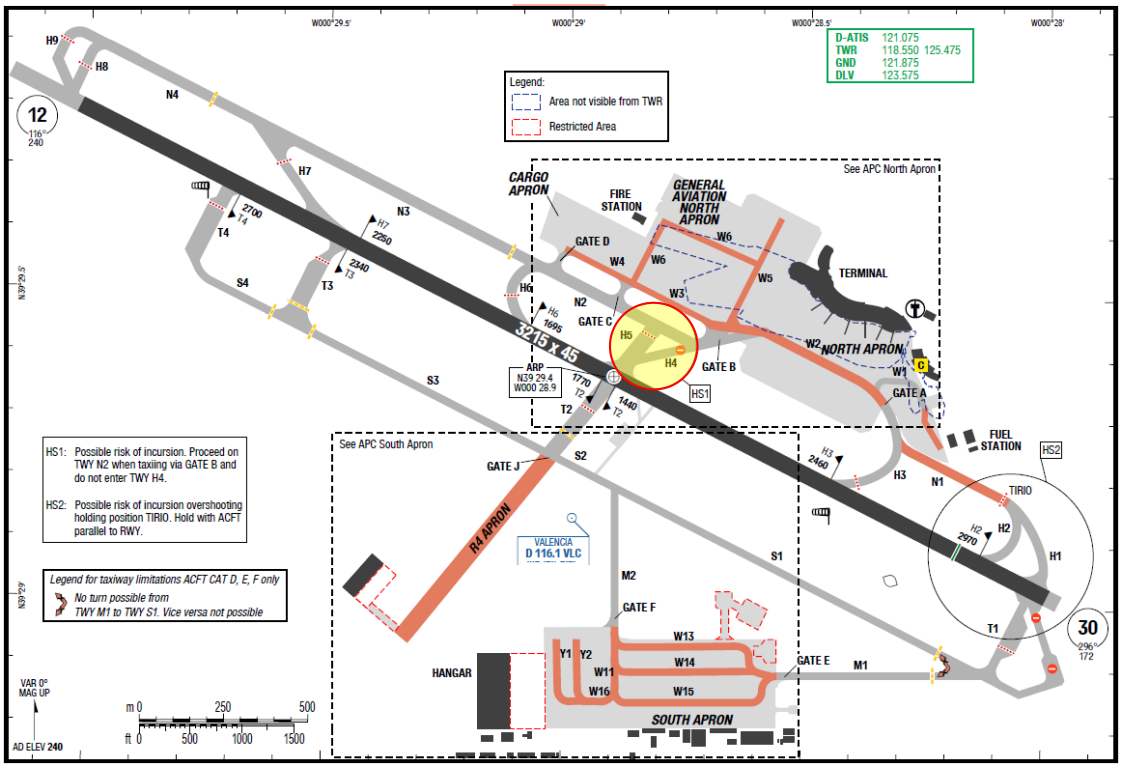



Fig. 10: Layout of Valencia Airport. Source LIDO.

Regarding the airport's management of the emergency, the following points contained in the final internal report issued by the Valencia Airport Department of Operations and Safety (AENA) are relevant:

Following the MAYDAY call, the airport tower declared an emergency, closed the runway and alerted the SSEI, CEOPS and the SMA[15]. Due to the ongoing emergency, RATE 0 was in effect between 16:43 h and 17:13 h.

The SSEI immediately rushed to the aircraft with a full team as soon as they were notified, and at 16:46 h, they were adjacent to the aircraft with SSEI members in position around it.

At the same time, the Main Command Post (PMP) was set up, activating the Partial Emergency phase of the Valencia Airport Self-Protection Plan (PA-VLC).

When they opened the doors and deployed the slides, the department chief ordered the deployment of a line of hoses and instructed the rest of the team to assist with evacuating the passengers via the slides.

At 16:52, CEOPS called the National Police and the Civil Guard. Airport personnel were sent to the baggage hall to attend to the passengers, and a NOTAM[16] was prepared to publish the runway closure.

[15] Rescue and Firefighting Service, Airport Operations Centre (CEOPS) and Airport Medical Service, respectively.

[16] Notice distributed by means of telecommunication containing information relating to the establishment, condition or modification of any aeronautical installation, service, procedure or hazard whose timely knowledge is essential to the personnel in charge of flight operations.

The passengers were evacuated via the slides and moved away from the aircraft in groups.

SSEI personnel boarded the aircraft by ladder to check that no one remained on board. After confirming, at 16:57 h, that all the passengers and crew had been evacuated, they remained on alert next to the aircraft.

SMA personnel headed to the aircraft with the "follow me" vehicle after loading it with some of the emergency/disaster supplies. On enquiring after arriving at the scene, they were informed by the handling agents and the crew that nobody required medical assistance. They were later dispatched to the terminal building to locate the passengers.

At 16:53 h, the handling agent's first bus reached the area of the aircraft and began transporting the passengers to the terminal building.

At 17:04 h, the CEOPS called the 112 emergency number to request two ambulances with medical personnel, indicating that although there were no serious injuries, some of the passengers may have been affected by smoke inhalation.

At 17:10 h, following the runway inspection, the tower was informed that the airport could resume operations with gate B and the H4 rapid-exit taxiway remaining inoperative and publishing the corresponding NOTAM. The runway reopened at 17:12 h.

The traffic that had been in a holding pattern then began to land, with the exception of one aircraft that was diverted to another airport (THY-9AE).

The passengers were attended to in baggage reclaim hall number 3 (airport staff assisted the passengers by providing water and trying to calm and inform them). Those who needed assistance went to the first aid room, located in the same area.

In the end, 48 passengers were treated, of which 3 (one adult and two children) were transferred to the Manises Hospital in Valencia. Most of the ailments were mild (bruising from using the slides, sore eyes due to the smoke, etc.). It was later confirmed that all three had been discharged.

At 17:19 h, the Electrical Department was asked to beacon the affected area.

At 17:23 h, 112 was contacted to request another ambulance because only one had arrived at the airport.

At 17:55 h, after confirming that all the passengers were well and had been taken care of, the end of the emergency was declared.

Finally, at 20:47 h, the operation to dismantle the aircraft's slides began, and at 22:20 h, it was towed to stand No. 23.

The area was inspected (gate B and rapid exit H4) and declared operational, and the NOTAM was cancelled (22:48 h).

The passengers were accommodated in hotels, and the departure of flight BAW445 (Valencia-London Heathrow)[17] was rescheduled for the following day, at 12:00 h on another aircraft that British Airways PLC sent to Valencia Airport on a positional flight.

### 1.11 Flight recorders

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

The Communications section provides a summary of the relevant flight deck conversations recorded by the CVR.

The following parameters were registered during the cruise phase when the right engine STALL occurred.

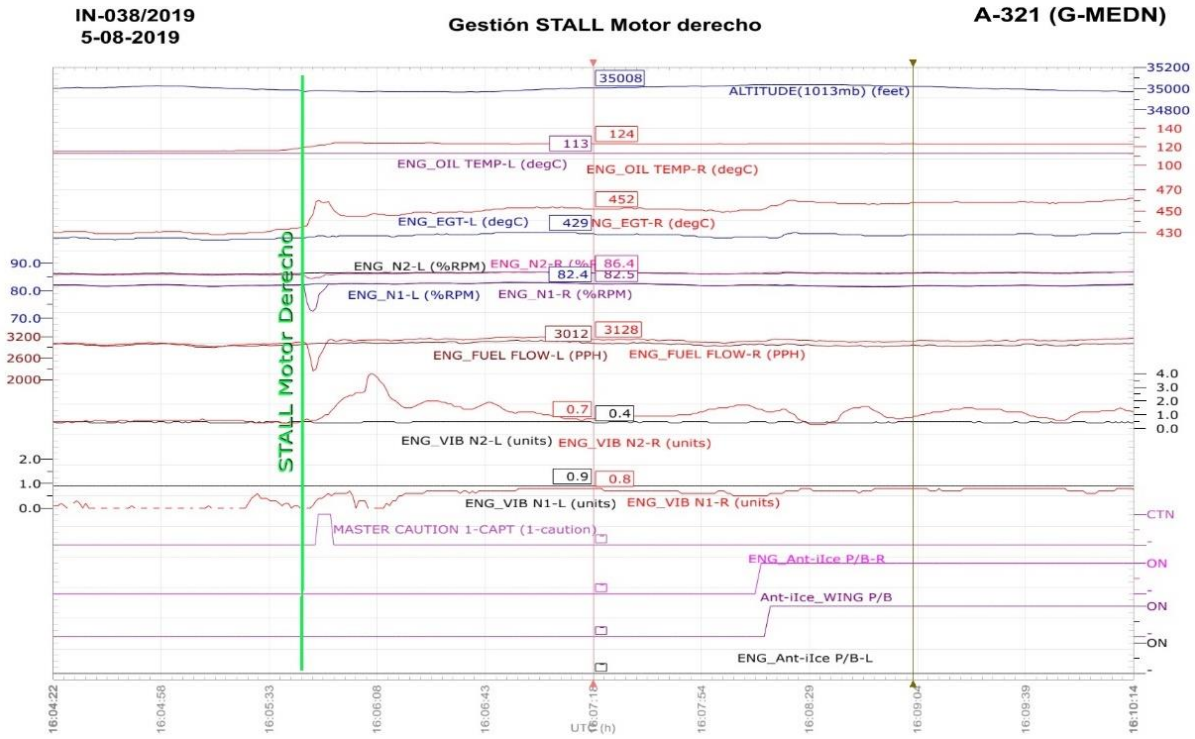



Fig. 11: Relevant parameters during the cruise phase in which the STALL occurred

[17] This flight should have been made by the G-MEDN aircraft, departing at 17:30 h that same day.

- At 16:05:44 h, there was a drop in N1 in the right engine, which fluctuated between 82% and 72%. The right engine's EGT peaked at 460ºC (the left engine's EGT remained unchanged at about 430ºC). For the remainder of the flight, the left engine's EGT remained at 430ºC, while the right EGT hovered between 450ºC and 460ºC, some 20ºC to 30ºC more than the values prior to the STALL. In addition, the oil temperature in the right engine was around 10ºC higher than the temperature in the left engine for the remainder of the flight. The most significant engine parameters before and after the ENG 2 STALL (at 16:05 h) remained at the following values until the start of the descent to Valencia airport (at 16:13 h):

| | Before the ENG 2 STALL | | After | |
|---|---|---|---|---|
| | Engine 1 | Engine 2 | Engine 1 | Engine 2 |
| Engine oil temperature | 113ºC | 113ºC | 113ºC | 124ºC |
| EGT | 430ºC | 435ºC | 430ºC | 450-460 ºC |
| N1 rpm | 82.4% | 82.4% | 82.4% | 82.4% |
| N2 rpm | 86.4 % | 86.4 % | 86.4 % | 86.4 % |
| Fuel flow | 3,012 pph | 3,128 pph | 3,012 pph | 3,128 pph |
| N1 Vibrations | 0.9 | 0-0.5 | 0.9 | 0.5-1 |
| N2 Vibrations | 0.4 | 0.4 | 0.4 | Peak of 4 and later 0-2 |

- At 16:05:49 h, the MASTER CAUTION light came on.
- After the right engine STALL, the N2 vibrations peaked at 4, the highest vibration value recorded during the flight.[18]
- Subsequently, at approximately 16:09:10, the ENG 2 OIL FILTER CLOG message was displayed (this caution is not registered in the FDR, but it was verbalised on the flight deck at 16:09:20, which tells us it happened a few seconds before).

The parameters during the approach and landing phases in which the alerts generated when smoke entered the cabin and the loss of oil pressure in the right engine occurred are shown below.

[18] The ECAM alerts the flight crew when the vibration level exceeds 5 units.

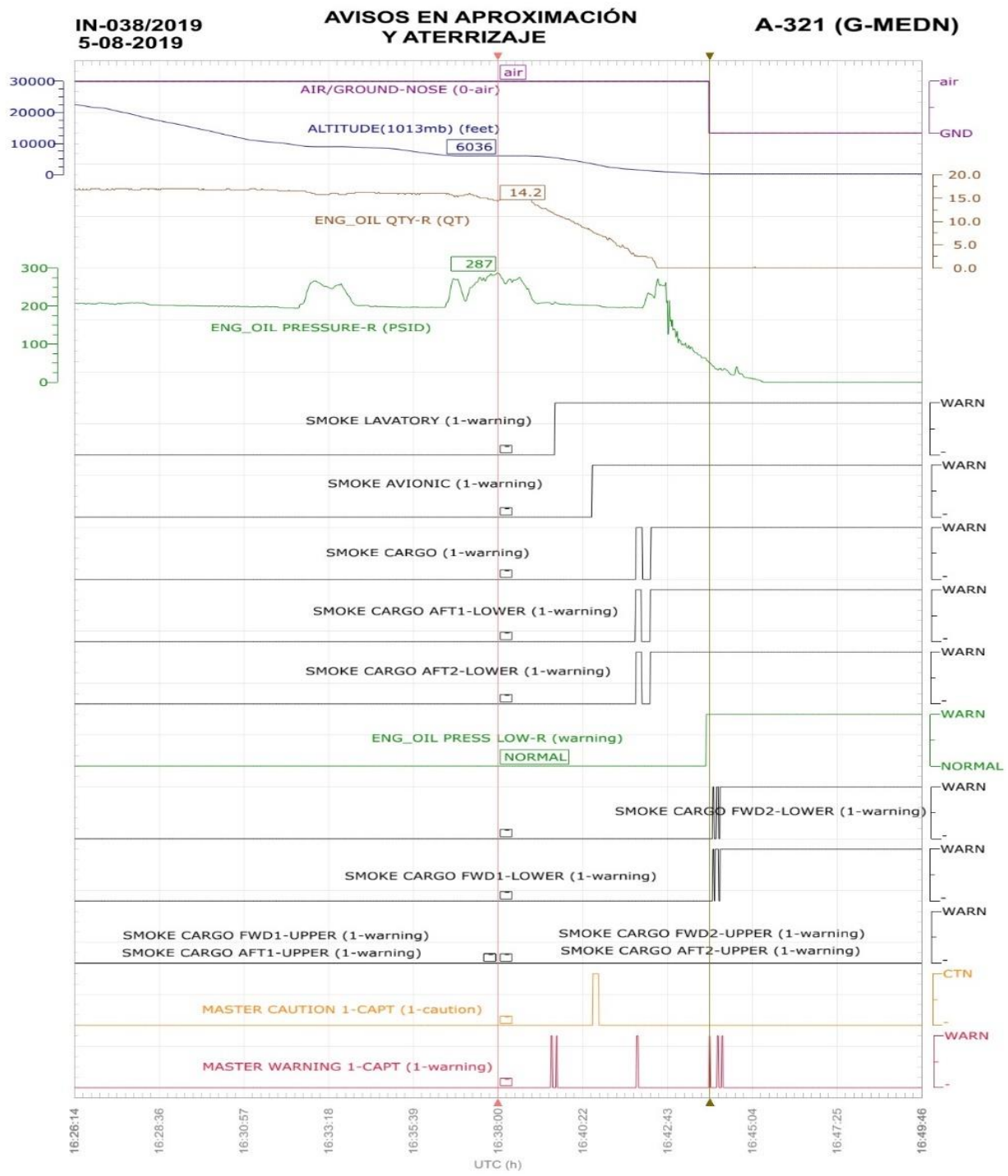



Fig. 12: Relevant parameters during the approach and landing phases

- The graph indicates that at 16:38:55, the oil level in the right engine began to drop rapidly, just before the smoke alerts were activated. The oil level indicator showed 0 (zero) 3 minutes and 31 seconds later, at 16:42:26.

- The right engine oil pressure then began to decrease rapidly, falling below 80 psi at 16:43:28 and below 60 psi at 16:43:48 a few moments before touching down at 16:43:51.

### 1.12 Aircraft wreckage and impact information

The damage to the right engine was internal and confined to that engine.

There was no further damage other than that incurred as a result of deploying the slides.

### 1.13 Medical and pathological information

According to the crew's statements, the smoke in the cabin made visibility difficult, but it didn't have a particularly intense smell or smell like burning, nor did it make people cough or irritate the eyes (at least during the time they were exposed to its effects).

48 passengers (none of the crew) required some type of assistance on the ground due to minor ailments (bruising from using the slides, sore eyes from the smoke, etc.). Three of them (2 children and 1 adult) were transferred to a nearby hospital and discharged that same evening.

As a result of the smoke inhalation, some of the crew members reported the following symptoms:

- Dry throat for several days and
- headache.

### 1.14 Fire

No fire broke out.

### 1.15 Survival aspects

#### 1.15.1 General information

The A321 G-MEDN aircraft was equipped with four Type I aircraft access doors, two on each side. These doors, found at the front and rear of the aircraft, are typically used to board and disembark passengers.

In addition, it has four emergency exits near the wings to be used in the event of an evacuation, two on each side.

All of the doors are equipped with evacuation slides for the emergency evacuation of passengers and crew.

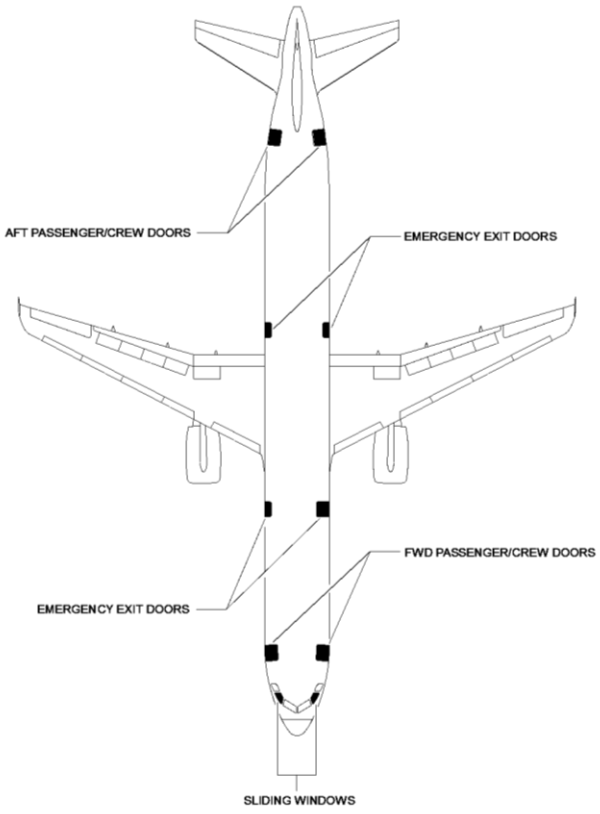



Fig. 13: Doors and emergency exits

### 1.15. 2 Evacuation of the aircraft

The aircraft was evacuated through 6 of the 8 available exits. All 4 slides on the available exits on the right side were opened and deployed, while only the slides of the two aircraft access doors (front and rear) were opened and deployed on the left side. In other words, the two emergency exits near the aircraft's left wing were not opened (2L and 3L).

Before take-off on every flight, the passenger who sits next to each of these four emergency exits receives instructions from the cabin crew on how to open them should they hear the evacuation announcement from the flight attendants or pilots. In this incident, the passengers who should have opened those two doors did not do so, despite having been informed how and when to do so before the flight.

All passengers evacuated the aircraft using the slides and following the instructions of the cabin crew.

During the evacuation, some of the passengers took packages or hand luggage with them.

### 1.15.3 PBE Protective Breathing Equipment (smoke hood)

PBE (Protective Breathing Equipment) is used by cabin crew to protect their respiratory systems from smoke and toxic gas fumes.

They supply the crew members with oxygen in the event of a fire, smoke or noxious gases while allowing them to move freely around the aircraft.

The units on board the G-MEDN were the hood type, which covers the head (protecting the eyes, nose and mouth) and incorporates a visor and a voice transmitter.


Fig. 14: Model of PBE installed in the G-MEDN

The smoke hood is designed to allow two-way communication, both by voice and through the intercom.

According to the operator's Operating Manual, part D, in effect on the date of the incident, the recurrent annual cabin crew training covers the use of PBE.

Additionally, at least once every three years they have to carry out realistic training to practice using fire extinguishing systems and protective equipment similar to those on board the aircraft. Furthermore, all cabin crew members have to perform an exercise where they:

- Extinguish a typical aircraft fire (interior fire), with particular emphasis placed on identifying the source of the fire or smoke;
- Correctly fit and use PBE in a smoke-filled environment in a closed simulator.

## 1.16 Tests and research

### 1.16.1 Statement from the flight crew.

The following is a summary of the interviews conducted by the operator with the aircraft captain and co-pilot, along with the additional contributions they made in the separate questionnaires they were asked to complete to aid the investigation.

Both pilots declared that they were adequately rested to begin the day’s scheduled activity, which consisted of two sectors.

The captain indicated that this was his first day of service after a week's holiday and that it was the first time he had flown to Valencia Airport.

For the co-pilot, it was his fifth day of service, having previously flown for two days and spent two days undergoing training and checking in a simulator. He was familiar with Valencia Airport, having flown there with both British Airways PLC and his previous operator. They both stated that it was their first time flying together.

Both recall that the flight dispatch and preparation phases, as well as the taxi, take-off, climb and cruise phases, all proceeded as usual until they began the descent briefing when they were approximately 80 NM from the top of descent.

At that moment, the captain remembers feeling a jolt accompanied by a thudding sound. The master caution light came on, and he looked at the ECAM, which showed the ENG 2 STALL caution. The captain recalls that the engine EPR values fluctuated significatively before returning to normal values. A few minutes later, the ENG 2 OIL FILTER CLOG message appeared. The co-pilot remembers the same sequence of events.

The co-pilot explained that just as they were beginning to analyse what had happened, the purser called the flight deck to advise them that they had heard a thud and a light white mist had formed in the passenger cabin. The mist was described visually, without reference to any smell. The captain recalls that the purser said he wasn't worried about it but that he thought he ought to be aware of the appearance of the mist in the passenger cabin.

After the conversation, the captain declared he felt confident that the thickness of the mist was not going to increase. In his opinion, the severity level was not high, although he remained alert due to the presence of the mist.

They continued with their analysis of the situation and carried out the QRH ENG STALL actions, switching on the anti-ice systems of the affected engine and wings.

They used the TDODAR[19] decision-making model and agreed to continue to Valencia.

They finished the briefing on Valencia Airport while they began the descent, and the captain handed over the controls of the aircraft to the co-pilot so that he could continue monitoring the aircraft's engine parameters for potential abnormalities. The captain explained that based on his conversation with the purser, he decided to inform the passengers that they had commenced the descent without mentioning the incident so as not to alarm them. They commented that they contacted the handling agent to request the presence of a mechanic upon arrival at Valencia airport.

The descent proceeded normally, and they were cleared to use the SAURA4D STAR and later ILS Z to runway 12. The workload in this phase of flight was as expected, although they remained alert due to the incident with the right engine.

They commented that ATC cleared them to proceed to OPERA. The co-pilot recalls that he had to spend some time re-programming the approach as they were asked to proceed to a waypoint that had previously been deleted. They passed OPERA at 6,000 ft, but they

[19] TDODAR is a tool that helps pilots during the decision-making process.

weren't established on the localizer. Later they agreed to descend to 5,000 ft, staying above the glide path. Both pilots remember the completion of this task as being unusually difficult.

The co-pilot stated that just as he initiated the descent to 5,000 ft, he noticed white/grey smoke to his right and rear. He went on to say that he could feel smoke in his throat, while the captain said he could smell it.

The captain ordered the use of the oxygen masks[20] and established communications with the co-pilot, whom he reminded to position them on the ILS. As they were above the path, the co-pilot remembers disconnecting the autopilot and flight directors, activating the flight path vector and selecting SPEED MANAGED. After checking that the co-pilot had the aircraft under control and that they were on course to capture the ILS path, the captain started to go through the SMOKE FUMES AVIONICS SMOKE checklist.

The captain stated that the immediate actions of the SMOKE FUMES AVIONICS SMOKE checklist were completed by 3,000 ft. Both the pilots said that the external visibility was excellent despite the smoke in the cockpit.

The captain recalls trying to communicate with the passenger cabin on two occasions, with no response. They configured the aircraft and completed the pre-landing checklist.

At approximately 700 ft above the ground, the captain took over the controls and reactivated the AFS[21] (the Flight Directors were reengaged). The co-pilot remembers there being a mist on the flight deck.

The captain explained that after he took the controls, he was expecting an imminent engine failure or fire and planning what actions he would take if it happened. The co-pilot was thinking the same.

Both pilots remember the landing and a standard roll-out before exiting the runway via the H4 rapid-exit taxiway, where the pilot stopped the aircraft. The captain put the parking brake on. Both pilots said it was difficult to communicate with the oxygen masks on, so they took them off and opened the cockpit windows.

The captain explained that, after the landing, he told the co-pilot to declare an emergency and request the emergency services. Both pilots recall a CARGO SMOKE message on the ECAM. The captain asked the co-pilot to complete the ECAM actions. ATC informed them that Valencia did not have a frequency for pilots to communicate directly with the firefighting services.

The captain gave the alert call, and the purser and another flight attendant entered the flight deck wearing smoke masks. With the door open, the pilots could see that the visibility in the passenger cabin was significantly reduced.

[20] For both pilots.

[21] Auto Flight System.

The captain stated that, in order to make a considered and methodical decision, he asked the purser about the need to evacuate the plane. He couldn't hear the answer and thought that it was because the purser was wearing a smoke hood. He asked the co-pilot the same question, who replied that at that moment they were safe but that he couldn't be sure they would be later.

Based on the presence of smoke and the ECAM alerts, he made the decision to order the emergency evacuation of the aircraft. The flight attendants left the cockpit.

The co-pilot recalls that they read every instruction on the emergency evacuation list, and when they reached the point that indicated whether the evacuation was necessary, the captain answered yes. The captain initiated a standard emergency evacuation, announcing it over the PA. When they completed the list, the captain asked him to assist with evacuating the passenger cabin. When he reached the middle of the passenger cabin, he realised that most of the passengers had already evacuated the aircraft, so he returned to the front and evacuated the aircraft through door 1L[22].

The captain grabbed his emergency kit and walked to the end of the passenger cabin, checking the rows one by one. At the far end of the passenger cabin, he met up with two cabin crew members who were still on board, and the three of them evacuated the aircraft through door 4L[23].

Once on the ground, he met up with the cabin crew and saw that most of the passengers had already been transported away from the aircraft on buses.

The captain recalled the period immediately after the evacuation as being problematic, primarily because of the airport's insistence that the passengers retrieve their hand luggage from the aircraft. In the end, the passengers entered the aircraft to collect their carry-on luggage in groups of five.

The co-pilot stressed that the fact they were unable to communicate with the firefighting teams by VHF delayed the decision to evacuate the aircraft.

Both concurred that the smoke hoods made it difficult to communicate with the cabin crew.

The captain said that, in retrospect, he should have declared MAYDAY before landing, but he was too focused on the approach and safely landing the aircraft.

### 1.16.2 Statement from the cabin crew

The following text summarises the contributions made by the purser in the questionnaire he was asked to complete to aid the investigation. The statements provided by the other cabin crew members were practically identical to that of the purser.

[22] Door 1L is the front left door of the aircraft.

[23] Door 4L is the rear left door of the aircraft.

The purser (FA 1) stated that the cabin crew members held the following positions on the aircraft:

- FA 1 and FA 6 at door 1L
- FA 2 at door 2R
- FA 3 at door 3R
- FA 4 in the seat facing towards 4R
- FA 5 at door 4L

He explained that the flight proceeded normally until 40 minutes before landing, when he heard a bang and noticed a slight mist that dissipated after 5 minutes.

The flight continued normally until, after pressing the 'cabin ready' button on the FAP[24] , the passenger cabin filled with dense white smoke. He said he put on his smoke hood and instructed FA 6 to do the same and sit down. He got a call from FA 3, whom he also instructed to put on a smoke hood. He called the back of the plane and instructed both the flight attendants there to put on their smoke hoods.

He shouted instructions to the passengers, telling them to keep their heads down and discussed the possibility of carrying out an emergency evacuation with FA 6, reviewing the actions involved.

He described the smoke as dense and white or grey in colour. He didn't notice any particular smell.

He explained that he had trouble communicating via the intercom.

When the captain gave the alert call, he entered the flight deck.

After the evacuation alarm was activated, he proceeded to carry out the actions that corresponded to him during the evacuation and then evacuated through door 1R with his emergency kit, later meeting up with the rest of the crew.

He commented that, during the evacuation, lots of the passengers took their hand luggage with them, which made it difficult.

He remembers getting a small cut on his finger while unsealing the smoke hood and pointed out that communicating while wearing it was challenging.

After the incident he had the sensation of having a dry throat for several days.

[24] Flight attendants press the "cabin ready" button on the forward flight attendant panel (FAP) to notify the flight crew that the passenger cabin is secured for landing.

### 1.16.3 Investigation carried out by the IAE engine manufacturer

After the event, the engine was removed from the aircraft and transferred to the manufacturer's facilities to undergo a thorough inspection.

The inspection resulted in the following conclusions:

- A metallurgical examination determined that the failure of bearing number 3 was the primary cause of the right engine problem during the incident flight. The starting point of the bearing's deterioration could not be conclusively determined from the evidence available.
- The primary damage was chipping or spalling due to rolling contact fatigue, which led to further secondary damage. The bearing's operating time/cycles, material, manufacture or assembly, do not appear to have contributed to the failure.

The inspection revealed the following significant factors:

- Before the engine was disassembled, large amounts of metallic (ferrous) debris were found in the magnetic chip detectors. The analysis of the particles found they were composed of materials used in the bearings of the V2500 engines.

Figs. 15 & 16: Magnetic chip detectors MMCD and FBC MCD[25]

- The oil tank was empty.
- A boroscopic inspection revealed significant amounts of oil in the third stage of the high-pressure compressor (HPC).
- Later, during the disassembly of the engine, traces of metallic particles were also found in the oil system filters.
- Traces of oil were found in the tubes that carry the air extracted from the 7th and 10th stages of the high-pressure compressor to the cabin air conditioning system and in the ducts that supply the anti-ice system.
- With regard to the components in the front bearing compartment (FBC):

[25]The master magnetic chip detector (MMCD) and front bearing compartment (FBC) magnetic chip detector (MCD).

- Bearing 1: neither the bearing, housing, or carbon seal had any visible signs of damage or abnormalities.
- Bearing 2: No visible damage.
- Internal gearbox (IGB): internal damage from impacts. It was evident that bearing 3 had been displaced axially. After disassembling the IGB, it was confirmed that the outer race of bearing 3 had fractured from the 2 o'clock to the 5 o'clock position. Five of the number 3 bearing balls had popped out of the bearing cage and were found inside the IGB. The bearing cage was deformed, and part of it was out of position. Nine of the damper rod nuts that hold the outer race of bearing 3 were broken.
- Hydraulic seal: was found fractured at the point where it threads with the high-pressure compressor stub shaft.
- Bearing 3 support: No visual abnormalities. The 18 rods holding the outer race of bearing 3 were in place, with 9 of the nuts broken. The shaft was twisted, and the carbon seal was misaligned. This misalignment could have caused uneven contact, allowing oil to drip from the FBC onto the HPC.
- Bearing 3: A 125º arc had come out of the outer cage, and there was significant spalling on the running surface. 15 of the balls were in the cage, and 5 had popped out. The balls exhibited severe mechanical damage and wear, the cage had multiple fractures, and there was flaking in the inner race and a fracture in the outer race.

Figs. 17 & 18: Condition and remains of the cage and outer race of bearing no.3


Figs. 19 & 20: Condition and remains of bearing no. 3 in situ

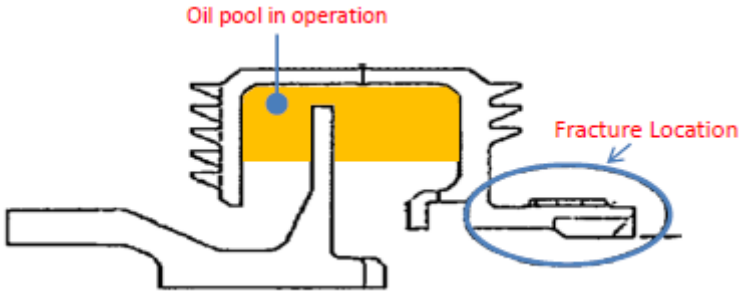



Fig. 21: Section of the hydraulic seal

- High-pressure compressor (HPC): exhibited unusual wear consistent with the rotation axis' loss of alignment, and traces of oil were observed on the blade surfaces.
- Bearing compartments 4 and 5: No abnormalities. They were lubricated, and there were no oil leaks. Their condition was as expected for the number of operating hours/cycles.
- High-pressure (HPT) and low-pressure (LPT) turbines: No abnormalities. Their condition was as expected for the number of operating hours/cycles.

Based on the above, the engine manufacturer has determined the following likely chain of events:

- The spalling of bearing 3 started between the outer race and the bearing balls.
- Operating with the spalling on the outer race caused wear as a result of the friction and contact between the outer race and the number 3 bearing housing due to the increased vibration.
- The outer race began to crack, with parts of it coming loose and damaging the bearing cage.

- The balls caused surface damage as they rolled over the flakes, cracks and gaps in the outer race and also affected the cage housings. This damage caused the cage to crack.
- The damaged bearing was not able to adequately control the position (axial or radial) of the rotor, causing the compressor to stall (ECAM ENG 2 STALL).
- The engine recovered from the stall, but the oil filter became clogged by the metallic debris generated as bearing 3 broke up, resulting in the ENG 2 OIL FILTER CLOG message on the flight deck.
- The outer race and the number 3 bearing cage continued to fracture and possibly release sections of the outer-ring race.
- As the turning shaft lost its alignment, the hydraulic seal fractured, allowing air from the 8th stage of the compressor (HPC) to enter the front bearing compartment (FBC).
- This loss of alignment and consequent injection of high-pressure air into the front bearing compartment allowed oil to leak through the carbon seal into the high-pressure compressor. The majority of the oil will have passed through the engine, but a proportion will have been bled from the high-pressure compressor into the cabin air and anti-ice systems, resulting in the presence of oil in them both.

### 1.17 Organisational and management information

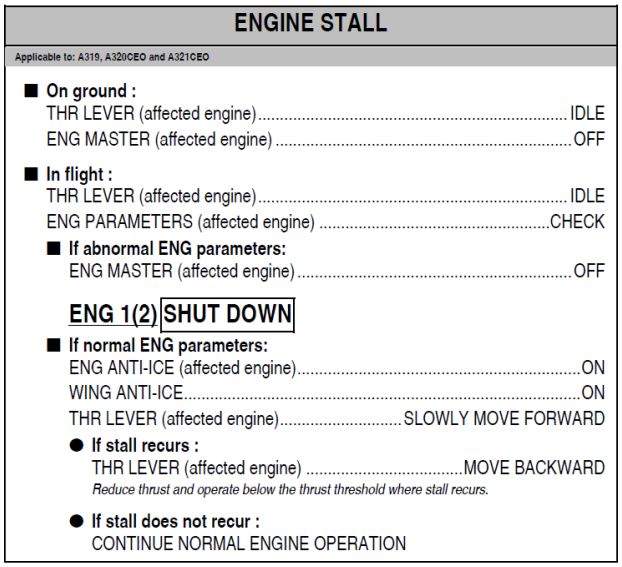
Not applicable

### 1.18 Additional information

#### 1.18.1 Regarding the ENG STALL procedure

The procedure followed by the crew after the ECAM ENG STALL caution has been extracted from the QRH of the manufacturer, Airbus.

One of the actions to be carried out in-flight if the engine parameters are normal is to switch ON the anti-ice systems of the affected engine and wings to increase the margin on the stall.



**ENGINE STALL**

Applicable to: A319, A320CEO and A321CEO

■ **On ground :**
THR LEVER (affected engine) ..... IDLE
ENG MASTER (affected engine) ..... OFF

■ **In flight :**
THR LEVER (affected engine) ..... IDLE
ENG PARAMETERS (affected engine) ..... CHECK

■ **If abnormal ENG parameters:**
ENG MASTER (affected engine) ..... OFF

**ENG 1(2) SHUT DOWN**

■ **If normal ENG parameters:**
ENG ANTI-ICE (affected engine) ..... ON
WING ANTI-ICE ..... ON
THR LEVER (affected engine) ..... SLOWLY MOVE FORWARD

● **If stall recurs :**
THR LEVER (affected engine) ..... MOVE BACKWARD
*Reduce thrust and operate below the thrust threshold where stall recurs.*

● **If stall does not recur :**
CONTINUE NORMAL ENGINE OPERATION

Fig. 22: QRH engine stall procedure

### 1.18.2 Regarding the ENG OIL FILTER CLOG procedure

The procedure to follow in the event of an ECAM ENG OIL FILTER CLOG caution has been extracted from the FCOM (PRO-ABN-ENG) of the manufacturer, Airbus.

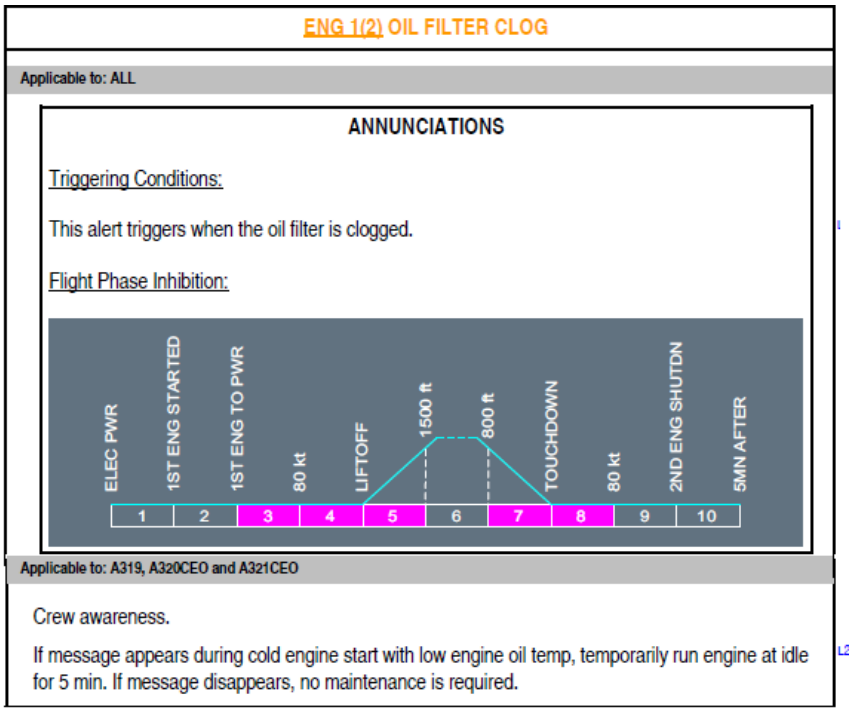


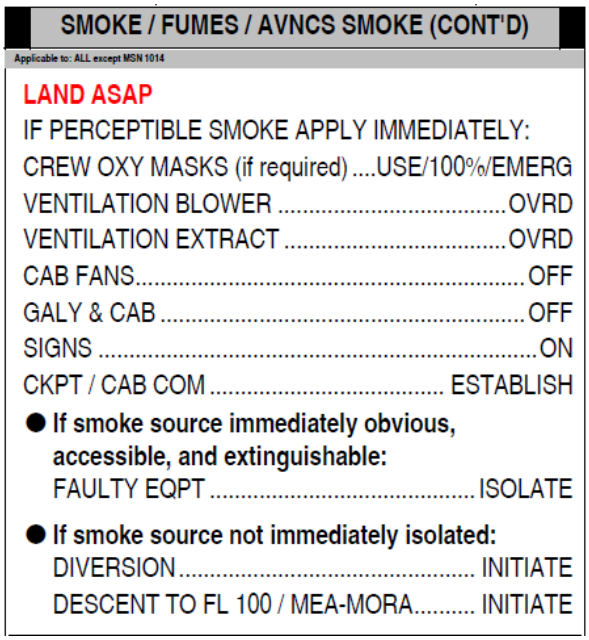

Fig. 23: Engine Oil Filter Clog procedure in the FCOM

The procedure for a clogged oil filter calls for crew awareness.

### 1.18.3 Regarding the QRH SMOKE FUMES AVNCS SMOKE procedure

The first part of the procedure that pilots should follow if smoke is detected in the cabin has been extracted from the manufacturer's (Airbus) QRH.

The following figure shows the immediate steps to be taken in the procedure's first block of actions. They are quick, reversible and straightforward actions aimed at preventing the recirculation of smoke, protecting the crew and ensuring communication between the crew members.



**SMOKE / FUMES / AVNCS SMOKE (CONT'D)**

Applicable to: ALL except MSN 1014

**LAND ASAP**

IF PERCEPTIBLE SMOKE APPLY IMMEDIATELY:

CREW OXY MASKS (if required) ....USE/100%/EMERG

VENTILATION BLOWER .....OVRD

VENTILATION EXTRACT .....OVRD

CAB FANS.....OFF

GALY & CAB .....OFF

SIGNS .....ON

CKPT / CAB COM ..... ESTABLISH

● **If smoke source immediately obvious, accessible, and extinguishable:**

FAULTY EQPT .....ISOLATE

● **If smoke source not immediately isolated:**

DIVERSION..... INITIATE

DESCENT TO FL 100 / MEA-MORA..... INITIATE

Fig. 24: QRH SMOKE FUMES AVNCS SMOKE procedure

In incidents involving smoke, time is critical. According to Airbus, studies have shown that a fire can become uncontrolled within 8 minutes, and, should that happen, the crew may have as little as 15 minutes to land the aircraft.[26]

The FCOM expands the information in the QRH and provides guidance to help crews identify the source of the smoke. It explains that multiple smoke-related ECAM alerts (lavatories, avionics and cargo hold) may indicate that the smoke is coming from the air conditioning system.

Furthermore, it says that an engine or APU failure can cause smoke to enter the flight deck and passenger cabin through the engine's bleed air system, in which case the smoke will recirculate through the aircraft until it disappears from the air conditioning system.

### 1.18.4 Regarding the LAVATORY SMOKE procedure

The procedure stipulates that the flight crew should communicate with the cabin crew to determine and monitor the origin of the smoke and its dissipation.

[26] https://www.airbuswin.com/wp-content/uploads/2019/06/managing-smoke-andfumes-in-flight.pdf

### 1.18.5 Regarding the ENG OIL LO PR procedure

The procedure to follow in the event of an ECAM ENG OIL LO PR alert has been extracted from the FCOM (PRO-ABN-ENG) of the manufacturer, Airbus.

When the oil pressure is below 80 psi, but above 60 psi, the caution appears in amber on the ECAM. The procedure calls for crew awareness due to the reduced oil pressure value.

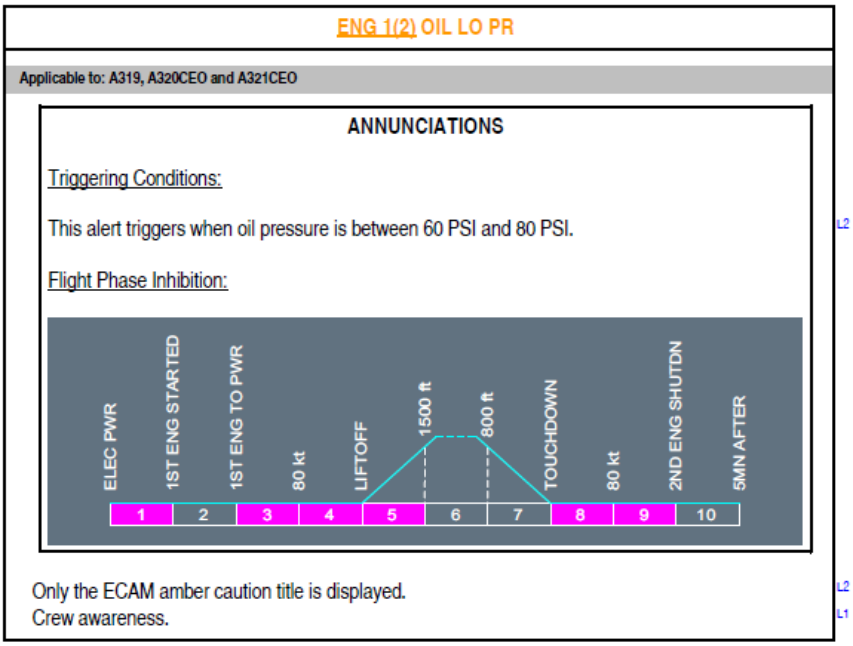



Fig. 25: FCOM ENG OIL LO PR procedure

If the oil pressure is less than 60 psi, the warning appears in red on the ECAM, and the procedure is as follows:

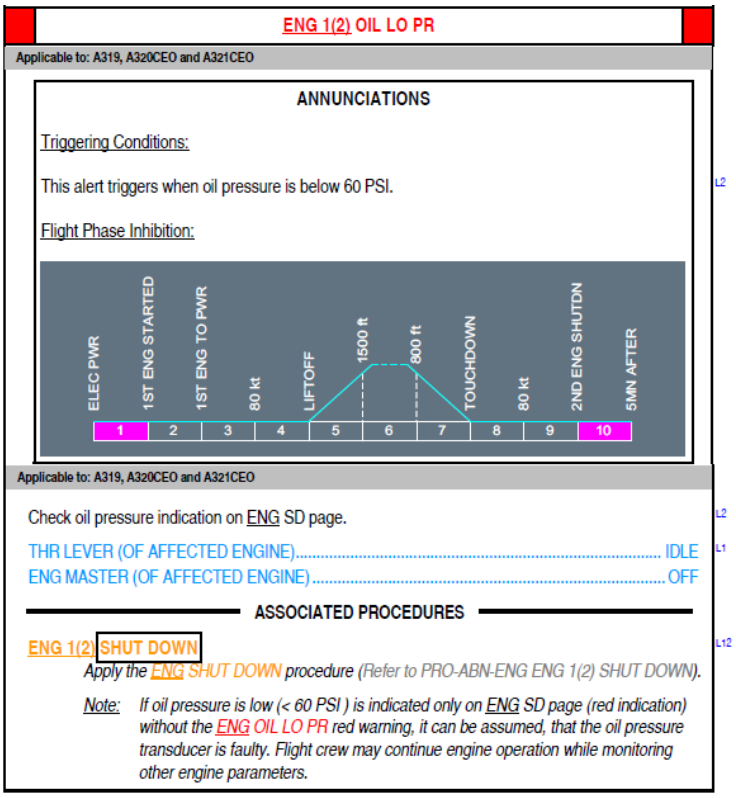
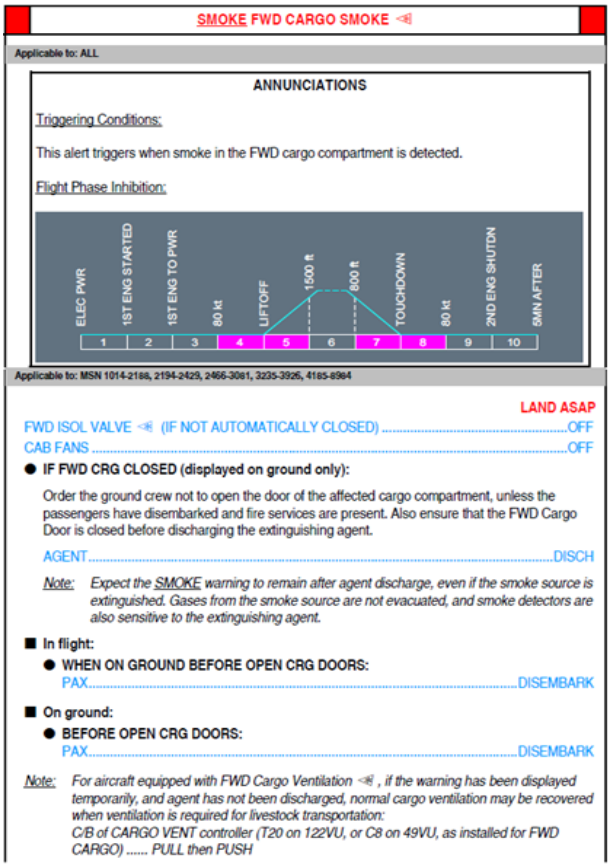


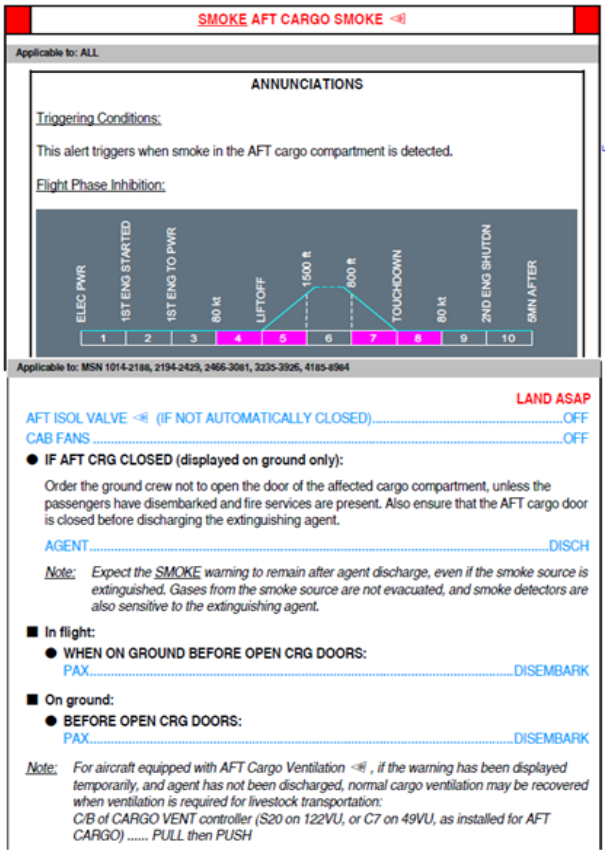

Fig. 26: FCOM ENG OIL LO PR procedure

In this case, the procedure stipulates that the thrust lever be retracted to idle and the affected engine shut down.

### 1.18.6 Regarding the ECAM FWD and AFT CARGO SMOKE procedure

The procedure to follow in the event of a forward and aft cargo hold smoke warning has been extracted from the manufacturer's FCOM.




Figs. 27 & 28: ECAM FWD and AFT CARGO SMOKE procedure

The procedure stipulates that the crew should disconnect the cabin fans, discharge the extinguishing agent in the corresponding hold and open the cargo hold after the passengers have disembarked.

The post-incident inspection of the cockpit buttons found the fire-extinguisher bottle had been discharged in the holds when the aircraft was on the ground.

### 1.18.7 Directives and service bulletins

During the lifespan of the IAE V2500 engine, there have been various smoke events and engine failures related to bearing number 3.

These events have led to the publishing of different service bulletins and airworthiness directives over the years. The most recent, AD-2016-25-11, was issued by the FAA and came into effect on 20 January 2017. It requires inspections and corrective actions, including the replacement of bearing number 3.

The right engine of the G-MEDN, with serial number V12924, was not in the batch of engines to which this directive applied.

### 1.18.8 Similar incidents

On 22 September 2016, an Airbus A320-232 operated by Jetstar Airways was flying between Sydney (New South Wales) and Cairns (Queensland) in Australia. During the

flight, the ECAM ENG 2 OIL FILTER CLOG caution appeared, and smoke began to enter the cabin. Engine number 2 failed. The investigation found that the failure of bearing number 3 in the right engine caused the right engine to lose thrust and smoke to enter the passenger cabin and flight deck.

### 1.18.9 Actions taken by the operator

The aircraft's operator, British Airways PLC, drafted an internal report and issued the following 4 internal recommendations with a view to improving emergency and evacuation management:

- Clarification of the communication processes between the passenger cabin and flight deck
- Group control techniques following a "Cabin crew at stations" message
- Airport response at bases with a contracted handling agent
- Crisis response for Head Office staff

Their internal report explains the scope of the recommendations and makes it clear that communication between the passenger cabin and the flight deck (not only during an evacuation but at any time when oxygen masks and smoke hoods are being used) needs to be improved. It also refers to the issue of emergency doors being opened by passengers during an evacuation.

The measures taken include:

- Incorporating the lessons learned from this incident in the flight and cabin crew training syllabi. These include the use of the intercom in emergency situations and the communication problems encountered while the cabin crew were wearing PBEs.
- Review of the communication and training procedures for the use of smoke hoods (PBE).
- Review of the different types of PBE used by the operator.

## 1.19 Special investigation techniques

None required.

# 2. ANALYSIS

## 2.1. General considerations

On 05 August 2019, an Airbus A321-231 aircraft operated by British Airways PLC, registration G-MEDN, was making a scheduled flight with callsign BA422 from London Heathrow (United Kingdom) to Valencia Airport.

The crew of the aircraft had the required licenses and medical certificates for the flight.

The aircraft's documentation was also in order.

The meteorology at the time was in no way limiting and did not have any bearing on the incident.

## 2.2. Condition of engine 2

Having analysed the aircraft's maintenance records as a whole, it has been found that, until the day of the incident, it had been correctly maintained as per the manufacturer's Maintenance Manual and that its deferred tasks list did not contain any relevant elements.

The same assessment applies to engine 2, whose failure was the trigger for the incident. Furthermore, a more specific and in-depth study of the maintenance performed on the aircraft during the months prior to the incident also failed to find any evidence that would lead us to suspect the involvement of anything abnormal or unusual.

The conclusions outlined above are further reinforced by the findings of the manufacturer's study of engine 2's ADEM (Advanced Diagnostics and Engine Management) trend data for the last 12 months, and the FDR data for the flight prior to the incident, which also failed to detect any anomalies or unusual performances.

## 2.3. Engine 2's performance before 16:39:00

At 16:05 h, 1 hour and 16 minutes after take-off as the aircraft was flying over the Pyrenees at FL350 (80 NM from Barcelona and 160 NM from Valencia), the first non-typical event of the flight occurred, specifically affecting engine 2: the ECAM ENG 2 STALL caution. The momentary stall of engine 2's compressor resolved by itself, but had two immediate effects:

- A thud was heard in the passenger cabin and a slight mist formed (in the words of the purser). However, the situation didn't get any worse.
- The noise was also heard on the flight deck (in addition to the ECAM caution), and the pilots focused their attention on monitoring the engine parameters and preventively carrying out the QRH ENG STALL procedure, which involves activating the anti-ice systems of the affected engine and wings.

However, 4 minutes later, at 16:09 h, the ECAM ENG 2 OIL FILTER CLOG caution appeared. The pilots completed the associated procedure, analysed both failures and, after considering the available options, decided to continue to Valencia at 16:11 h. Two minutes later, they began their descent to Valencia Airport.

After the ENG 2 STALL and ENG 2 OIL FILTER CLOG messages, engine 2's operating parameters were within the allowable ranges, and the mist in the passenger cabin had been momentary. However, the flight crew began to monitor engine 2's performance more closely in order to be prepared should they need to make any other decisions.

Based on the evidence available to the flight crew, there was no justification for diverting the flight to an alternate airport. In confirmation of the above, there were no further issues during the descent that began at 16:13 h, and the engine parameters were normal until 26 minutes later.

It wasn't until 16:39:00, just under 5 minutes before landing in Valencia and at an altitude of 6,000 ft, that the decisive event occurred, drastically changing the situation: both the flight deck and the passenger cabin filled with a whitish and, according to the statements from the witnesses, odourless smoke.

The number 3 bearing in engine 2 had deteriorated to the extent that it stopped working properly, and the seal that keeps the lubricating oil within its housing broke, allowing oil to leak into other parts of the engine, including the area where air is bled from the engine into the flight deck, passenger cabin, cargo hold, avionics compartment, lavatories and the anti-ice systems of engine 2 and the right wing.

Thus, at 16:39:00, the severely worn bearing and seal caused the rapid formation of white smoke or mist on the flight deck and in the passenger cabin.

The flight crew reacted quickly, with the captain telling the co-pilot to put on his oxygen mask and checking they could communicate with each other. The captain did not deploy the oxygen masks for the passengers, as the procedure does not call for it. At the time, the cause of the smoke was unknown, and the existence of a fire on board could not be ruled out even though there was no smell of burning.

### 2.4. Management of the emergency and landing

The flight crew focused on the landing (it was 16:39:00, and they were less than 5 minutes away from touchdown). The aircraft had ended up above the ILS glide path, and both pilots concentrated on correcting the flight path.

At 16:39:40, they received a smoke warning for the lavatories (LAV SMOKE), then, 1 minute later, at 16:40:40, a smoke caution for the avionics compartment (AVIONICS SMOKE). This was followed by a smoke warning for the rear cargo hold (AFT CARGO SMOKE) at 16:41:54. In all three cases, the origin of the smoke was the same: bleed air from engine 2

containing suspended oil particles that subsequently condensed, producing the white smoke or mist.

The captain attempted to contact the cabin crew after receiving the ECAM LAVATORY SMOKE warning and continued with the immediate actions on the QRH SMOKE FUMES AVIONICS SMOKE checklist. They finished configuring the aircraft and read the before-landing checklist.

Their workload during this phase of the flight was extremely high, as they had to manage the sudden appearance of smoke in the cabin while simultaneously controlling the aircraft's approach trajectory to runway 12 in Valencia.

The flight crew did not issue any emergency communications to the Valencia control tower, which cleared them to land.

On touching down at 16:43:51, the final smoke message appeared, this time warning of smoke in the forward cargo hold (FWD CARGO SMOKE). This warning completed the full set of alerts from all the onboard smoke detectors.

After that, the captain concentrated on stopping the aircraft as soon as possible, bringing it to a halt on rapid-exit taxiway H4 before it entered the aircraft apron through gate B.

They performed the ECAM procedures and collected information from the Valencia control tower about the aircraft's condition.

Having evaluated the options with the co-pilot and cabin crew, the captain ordered an emergency evacuation at 16:48:52, after declaring MAYDAY at 16:44:54.

## 2.5. Emergency evacuation

Once the captain had ordered the emergency evacuation, and despite the communication difficulties reported by the cabin crew, 6 of the 8 evacuation slides were opened and deployed. The opening of the two doors that were not used (exits 2L and 3L) was the responsibility of the passengers seated next to them. Before take-off, these passengers had been given instructions on how to open the doors if necessary.

Nonetheless, the passengers and crew evacuated via the 6 deployed slides and no one was injured.

On a negative note, some of the passengers carried packages or hand luggage with them during the evacuation.

## 2.6. Management of the passengers on the ground

As soon as the airport staff were made aware of the situation, they quickly deployed the emergency services. The Rescue and Firefighting Service was positioned around the aircraft before the emergency evacuation took place, and the passengers began to board buses to an area of the terminal building close to the first aid room at 16:53 h.

The passengers in need of medical attention were treated in the terminal building and first aid room, and only three people required transferral to a nearby hospital (more as a precaution than due to the severity of their injuries). All three were discharged later that evening.

## 2.7. Analysis of the procedures

Regarding the failure of engine 2, there were no prior indications to suggest that, first, the ENG 2 STALL would be produced and then the ENG 2 OIL FILTER CLOG, and given that after the two cautions appeared, the situation was under control and the parameters were normal, there was nothing to suggest that the number 3 bearing would completely fail at 16:39:00.

## 2.8 Analysis of communication difficulties between the flight crew and the cabin crew wearing the smoke masks

Both the cabin crew and the flight crew referred to difficulties understanding each other while the former wore the smoke hoods.

Smoke hoods are designed to allow two-way communication, both face-to-face and through the intercom and megaphone. The cabin crew had extensive flight experience and had been trained in the use of smoke hoods (PBE); however, they stated that wearing the hood hindered communication.

For this reason, it is deemed necessary to expand the operator’s cabin and flight crew training to cover the communication barriers that can exist while wearing the smoke hoods for the different methods of communication, including face-to-face conversation, the intercom, the passenger announcement system, the megaphone, etc.

In this context, the operator's initiative to address the communication problems encountered while wearing PBEs in the flight and cabin crew training syllabi is deemed correct and appropriate. Therefore, no further safety recommendations are issued on the matter.

# 3. CONCLUSIONS

## 3.1. Findings

- On 05 August 2019, an Airbus A321-231 aircraft operated by British Airways PLC, registration G-MEDN, took off from London Heathrow Airport (United Kingdom) at 14:49 h, bound for Valencia Airport.
- The crew of the aircraft had the required licenses and medical certificates for the flight.
- The aircraft's documentation was also in order.
- The meteorology at the time was in no way limiting and did not have any bearing on the incident.
- At 16:05 h, as the aircraft was at FL350 flying over the Pyrenees, the flight crew received the ECAM ENG 2 STALL caution, which resolved itself automatically.
- The flight crew performed the QRH ENG STALL procedure and activated the anti-ice systems of the affected engine and the wings.
- At 16:06 h, the cabin crew informed the pilots that a noise had been heard and a slight mist had formed in the passenger cabin, which disappeared moments later.
- At 16:09 h, the flight crew received another caution, ECAM ENG 2 OIL FILTER CLOG, which required no action on their part.
- At 16:11 h, the flight crew took the decision to continue to the destination.
- At 16:13 h, the aircraft began its descent to Valencia Airport.
- During the descent, no further anomalies were detected in the engine parameters.
- The cabin crew secured the passenger cabin and informed the pilots.
- At 16:36 h, Valencia approach cleared them for approach using ILS Z for runway 12.
- At 16:39:00, when the aircraft was at an altitude of 6,000 ft on the authorised approach, both the flight deck and the passenger cabin began to fill with white smoke.
- The pilots donned their oxygen masks.
- The ECAM LAVATORY SMOKE (16:39:40), AVIONICS SMOKE (16:40:49) and AFT CARGO SMOKE (16:41:54) alerts were activated. The flight crew carried out the immediate actions in the QRH emergency list for SMOKE / FUMES / AVNCS SMOKE.
- In the passenger cabin, the purser instructed the other cabin crew members to put on their smoke hoods, and the passengers were instructed to keep their heads down.
- At 16:42:03, Valencia tower cleared them to land on runway 12.
- The flight crew did not inform ATC about the smoke in the cabin.
- At 16:43:51, the aircraft landed.
- At 16:44:08, a CRC sound corresponding to a FWD CARGO SMOKE warning was recorded.
- At 16:44:44, the captain instructed the co-pilot to declare MAYDAY. He did as requested 10 seconds later, and then repeated it again 11 seconds after that.
- At 16:45:15, Valencia tower told him that the firefighters were on their way.

- At 16:45:21, the crew began to carry out the actions associated with the CARGO SMOKE ECAM warnings, and the captain issued the “ATTENTION CREW AT STATIONS” call.
- At 16:46:10, the captain issued the ALERT CALL.
- At 16:46:38, the captain asked the purser about the conditions in the passenger cabin and informed him of his intention to have it inspected externally.
- At 16:46:46, the co-pilot attempted to communicate with the firefighting service.
- At that point, the Rescue and Firefighting Service was adjacent to the aircraft, with its members strategically positioned around it.
- At 16:47:21, the tower asked the crew for information on the emergency and the captain replied that they have smoke indications for the cargo holds.
- At 16:47:48, the captain asked the tower if they could see any signs of fire in the rear of the aircraft from their position.
- At 16:48:16, they completed the ECAM actions related to the smoke.
- At 16:48:31, the tower informed the crew that the firefighters hadn’t seen any signs of fire on the aircraft.
- At 16:48:52, the captain took the decision to evacuate the aircraft.
- At 16:49:46, the pilots notified the tower that they were evacuating the aircraft.
- At 16:53 h, the first bus arrived to transport the passengers to the terminal building.
- At 16:57 h, SSEI personnel used a ladder to enter the aircraft and check that nobody remained on board.
- The airport staff assisted the passengers, both when leaving the aircraft and in the terminal building in an area annexed to the first aid room.
- Three passengers (2 children and 1 adult) were transferred to the Manises Hospital and discharged that same evening.
- The failure of bearing number 3 in engine 2 was the primary cause of the right engine problem during the incident flight.
- The breakage of bearing 3, its misalignment and the rupture of its hydraulic seal resulted in the bleed air from engine number 2 becoming contaminated with engine oil, which, in turn, caused smoke to enter the passenger cabin and the presence of oil in the anti-ice system.
- Given that neither the operating time/cycles, material, manufacture, nor assembly of bearing 3 appear to have contributed to the failure, we have been unable to establish the reason for the breakage.

### 3.2. Causes/contributing factors

The investigation has identified the cause of the incident as the misalignment and breakage of bearing number 3 (and its hydraulic seal) in engine number 2. This resulted in the bleed air from engine number 2 becoming contaminated with engine oil, which, in turn, caused smoke to enter the passenger cabin and the presence of oil in the anti-ice system.

## 4. OPERATIONAL SAFETY RECOMMENDATIONS

None.