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COMISIÓN DE
INVESTIGACIÓN
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E INCIDENTES DE
AVIACIÓN CIVIL

Report IN-045/2004

In-flight engine failure involving a McDonnell Douglas MD-83, registration EC-FTS, operated by Spanair, on 21 July 2004 at Alicante Airport

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Foreword

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

In accordance with the provisions of Law 21/2003 and pursuant to Annex 13 of the International Civil Aviation Convention, the investigation is of exclusively a technical nature, and its objective is not the assignment of blame or liability. The investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents.

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

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

Table of contents

Abbreviations

00°	Degree(s)
00 °C	Degrees centigrade
ATC	Air Traffic Control
CIAIAC	Civil Aviation Accident and Incident Investigation Commission (Spain)
CSN	Cycles since new
CRM	Crew resource management
CVR	Cockpit voice recorder
DC	Douglas Corporation
DFDR	Digital flight data recorder
EGT	Exhaust gas temperature
EPR	Engine pressure ratio
FCU	Fuel control unit
FF	Fuel flow
FL	Flight level
ft	Feet
FOD	Foreign object damage
h	Hour(s)
HPC	High pressure compressor
HPT	High pressure turbine
ILS	Instrument landing system
IR(A)	Instrumental Rating (A)
kg	Kilogram(s)
kt	Knot(s)
lb	Pound(s)
LH	Left hand
LPC	Low pressure compressor
LPT	Low pressure turbine
m	Meter(s)
MD	McDonnell Douglas
MTOW	Maximum takeoff weight
N1	Engine fan speed
N2	Engine compressor speed
QNH	Altimeter setting to obtain altitude above sea level
rpm	Revolutions per minute
S/N	Serial number
SB	Service bulletin
TACC	Terminal Area Control Center
TSN	Time since new
UTC	Coordinated universal time
VOR	VHF omnidirectional range

Synopsis

Owner and operator:	Finansskandic AB and Spanair
Aircraft:	McDonnell Douglas, MD-83
Date and time of incident:	21 July 2004; 12:41 h[1]
Place of incident:	Alicante Airport
Persons aboard and injuries:	152, 19 passengers and 1 person on the ground, minor injuries
Type of flight:	Commercial Air Transport. Schedule. Domestic. Passengers
Date of approval:	28th May 2008

Incident summary

The aircraft took off from Alicante Airport en route to Palma de Mallorca at 12:38. While at an altitude 5,400 ft, the captain noticed a failure of the left engine and decided to return to the airport. Once on the ground, after being notified of a fire in the left engine, the crew ordered the evacuation of the aircraft.

During the evacuation, 19 passengers and 1 fireman were slightly injured.

The investigation revealed that the probable cause of the incident was the simultaneous or near simultaneous breakage of two stator vanes in the 8th stage of the HPC resulting in general engine failure.

This final report includes two (2) Safety Recommendations lead to the operator.

[1] Time reference in this report is local time. It is necessary to subtract two hours to obtain Universal Coordinated Time (UTC).

1. FACTUAL INFORMATION

1.1. History of the flight

The aircraft, with callsign AEA9363, took off from Alicante airport at 12:38 en route to Palma de Mallorca. The pilot flying was the captain, and the copilot was handling communications. The start-up, taxi, takeoff and initial climb phases proceeded without incident.

At 12:41, while the aircraft was at an altitude of 5,400 ft and cleared to climb to FL 120, the captain noticed that the left engine was failing and informed the copilot. They immediately contacted ATC to notify them of the situation and to indicate their desire to return to the airport.

Upon contacting the passenger cabin to inform of their return to Alicante, a flight attendant confirmed that a noise had been heard coming from the left engine.

They declared emergency and were cleared by ATC to land on a runway of their choice.

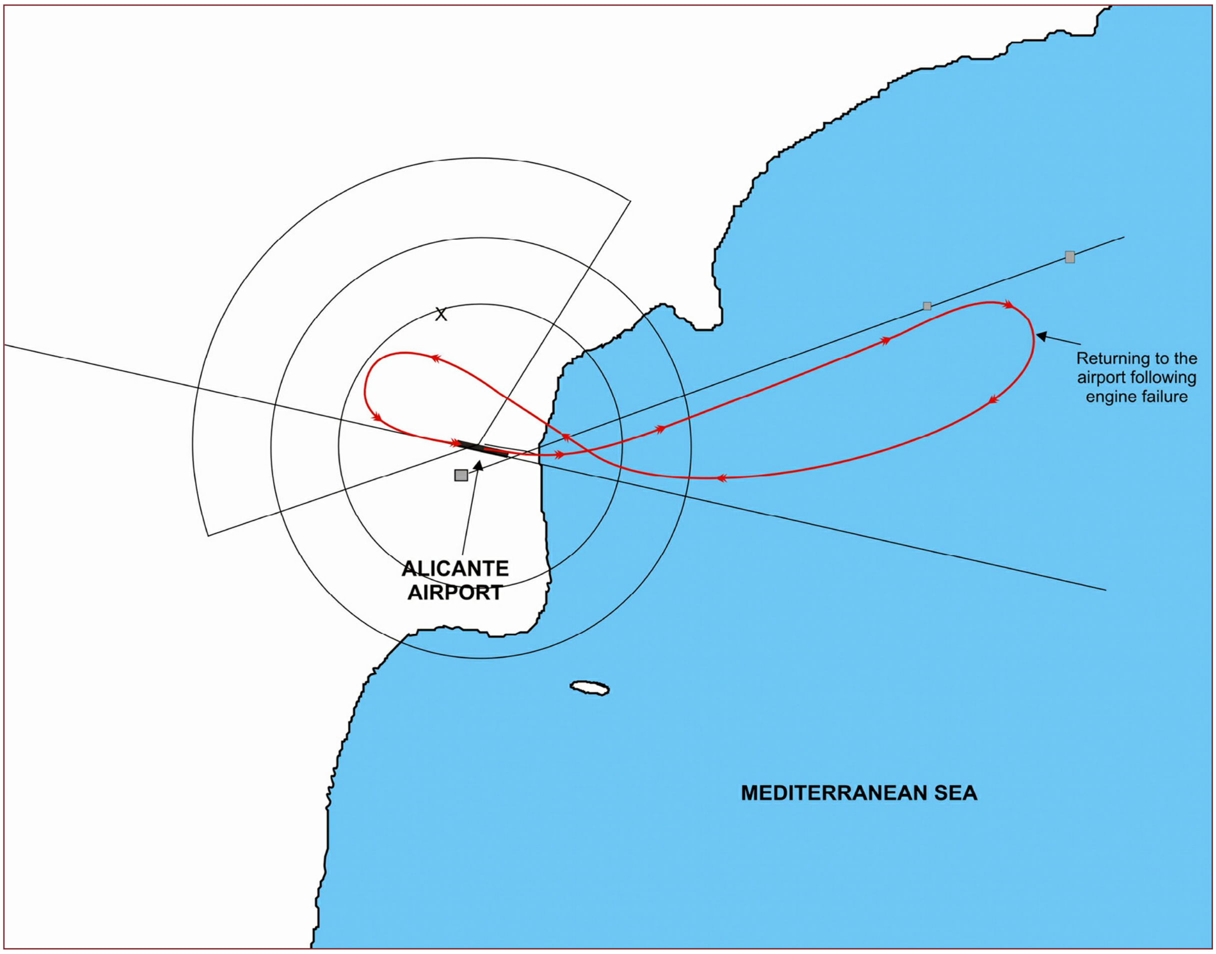

Figure 1. Aircraft flightpath

They initiated the engine failure emergency checklist three times, but failed to complete it due to interruptions from ATC personnel and, the last time, because they deemed it necessary to focus on the landing itself.

They were cleared to land on runway 10. The crew decided to make a visual approach.

They finished the before landing checklist and the landing proceeded normally. Once on the ground, the aircraft left the runway via taxiway C4 and stopped, notifying ATC that they were clear of the runway.

After being informed by ATC of a fire in the left engine, the crew decided to evacuate the aircraft. No fire warnings were received for the left engine.

During the evacuation, 19 passengers and one firefighter were slightly injured.

Airport emergency response teams applied fire extinguishing agents to the left turbine where they had seen the fire.

Although the tailcone was jettisoned, the slide did not deploy.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor		19	19	Not applicable
None	6	127	133	Not applicable
TOTAL	**6**	**146**	**152**	**1**

1.3. Damage to aircraft

Damage to the aircraft was limited to the left engine.

1.4. Personnel information

The aircraft crew consisted of the pilot, copilot, the purser and 3 flight attendants.

1.4.1. *Pilot information*

The most relevant information concerning the captain of the aircraft is as follows:

Pilot information		
Age	35 years old	
Nationality	Spanish	
License	Airline transport pilot (since 12 Feb 1997)	
Ratings (expiration)	DC9 80/MD88/MD90 (until 22 Mar 2005)	
	IR(A) (until 22 Mar 2005)	
Exp.	Total	7,361 h
	On the type	6,860 h
	Last 90 days	154 h
	Last 60 days	124:17 h
	Last 30 days	29:35 h
Activity	Time flight activity began	07:25 h
	Previous rest	72 h
Medical certificate	Type	Class 1
	Date	Valid until 02 Feb 2005

The pilot had completed two courses on CRM in the 6 months prior to the incident. The CRM courses consisted of 3 parts: the first provided theoretical information using audiovisual techniques, the second presented practical cases also using audiovisual techniques, and in the third they held training exercises together with the cabin crew.

He had also taken 1 periodic theoretical refresher course and 2 periodic simulator refresher courses.

1.4.2. *Copilot information*

The most relevant information concerning the copilot of the aircraft is as follows:

Copilot information	
Age	37 años
Nationality	Española
License	Piloto comercial de aeronave (desde 17-02-1998)
Ratings (expiration)	DC9 80/MD88/MD90 (hasta 18-05-2005)
	IR(A) (hasta 18-05-2005)

Copilot information *(continuation)*		
Exp.	Total	No available
	On the type	No available
	Last 90 days	171:35 h
	Last 60 days	120:40 h
	Last 30 days	70:10 h
Activity	Time flight activity began	07:25 h
	Previous rest	Over 48 h
Medical certificate	Type	Class 1
	Date	Valid until 10 Jan 2005

The copilot had not taken any CRM courses in the 6 months prior to the incident.

He had taken 1 periodic theoretical refresher course and 5 periodic simulator refresher courses.

1.5. Aircraft information

The MD-83 is a narrow-body passenger turbojet aircraft with a medium range and a 155-172-passenger capacity, depending on the version. Its design evolved from that of the Douglas Corporation DC-9, following that company's merger with McDonnell Co. The McDonnell Douglas Corporation was then bought by Boeing, which is responsible for the type certificate.

The aircraft's most relevant data are listed below:

General information		
Registration	EC-FTS	
Manufacturer	McDonnell Douglas Corporation	
Model	Douglas MD-83	
Serial number	49621	
Year of manufacture	1988	
Engine 1	Manufacturer	Pratt & Whitney
	Model	JT8D-219
	Serial number	728179

General information *(continuation)*		
Engine 2	Manufacturer	Pratt & Whitney
	Model	JT8D-219
	Serial number	718143

Technical characteristics		
Dimensions	Wingspan	107.8 ft
	Height	29.6 ft
	Lenght	147.9 ft
Restrictions	MTOW	160,000 lb
	Minimum crew	2 pilots

1.5.1. *Power plant*

The MD-83 power plant consists of two Pratt & Whitney JT8D-219 engines. This engine model is a medium bypass dual spool turbofan with a single stage fan, a six-stage LPC and a seven-stage HPC. It has nine combustion chambers in a can-annular arrangement. The HPT has one stage, while the LPT features three stages. The exhaust consists of a fluid mixing stage and an exhaust nozzle.

The engine has a rated takeoff thrust of 21,700 lb at an ambient temperature of up to 28.8° C. At ambient temperatures above 28.8° C, the allowable thrust is reduced so as not to exceed the gas temperature limit at the turbine intake.

The EGT limit at takeoff power is 625° C, and the revolution limits are 8,350 rpm (101.6%) N1 and 12,550 rpm (102%) N2. The EPR[2] limit at takeoff power at sea level with temperatures below 28° C is 2.034.

The following data are from the number one engine installed on the Spanair aircraft:

Manufacturer:	Pratt & Whitney
Model:	JT8D-219
Engine:	#1 (LH)
Serial number (S/N):	728179

[2] The EPR (engine pressure ratio) is the ratio between the total pressure of the gases at the exhaust and the compressor intake. In this type of engine, EPR is the primary indicator of thrust.

Time since new (TSN):	10,642
Cycles since new (CSN):	7,675
Hours since last inspection:	1,673 h
Cycles since last inspection:	895
Date of last inspection:	9 Jun 2003
Time since installation:	334 h
Cycles since installation:	218 h
Date of installation:	9 Jun 2004

Spanair was operating the engine S/N 728179, owned by Willis Lease Finance Company, under a rental agreement. Before being installed on the Spanair aircraft, the engine had been inspected after accumulating 1339 hours and 677 cycles on other aircraft since its last workshop inspection. Said inspection, made in February of 2004, consisted of start-up and vibration checks, and a visual and boroscopic inspection of the turbine area.

During the previous inspection, made in June of 2003, the engine was disassembled to repair both the HPC eighth stage stator and sulfidation of the LPT second stage blades.

The engine maintenance schedule calls for an inspection of the "8th Support and Shroud (pre SB 6117)" every four months.

A summary of the history of the number 1 engine is shown below:

Engine maintenance information		
Engine repaired	Engine hours	8,969 h
	Engine cycles	6,780
	Repair start date	1 Oct 2002
	Repair finish date	9 Jun 2003
	Description	During the previous heavy maintenance activity in June of 2003, the engine was disassembled to pepair both the HPC eighth stage stator and sulfidation of the LPT second stage blades.
Last engine inspection (prior to installation on aircraft EC-FTS)	Engine hours	10,308 h
	Engine cycles	7,457
	Date	19 Feb 2004
	Description	Engine checked and tested. Boroscopic inspection performed.

Engine maintenance information *(continuation)*		
Engine installed on aircraft EC-FTS	Aircraft hours	50,670 h
	Aircraft cycles	29,698
	Engine hours	10,308 h
	Engine cycles	7,457
	Date	9 Jun 2004
Status on date of incident	Aircraft hours	51,004 h
	Aircraft cycles	29,916
	Engine hours	10,642 h
	Engine cycles	7,675
	Date	21 Jul 2004

According to information from the DFDR, the number one engine exceeded 638 °C of EGT, which is the hightest temperature logged, and the EPR fell below one, that is, it lost all thrust. Two compressor stalls[3] were felt, with both high and low rotor rpm's dropping sharply, though they kept turning. The crew placed that engine's throttle lever at idle and did not execute the engine shutdown procedure until after landing. The fuel flow decreased noticeably, though a reading of 0 was never recorded on the DFDR. No fire warnings were received for the engine.

1.5.2. *Tailcone emergency exit*

The aircraft has an emergency exit in the tailcone at the aft end of the passenger cabin. If the emergency exits are armed and the handle located in the door of the aft passenger entrance is actuated, the tailcone detaches and the slide deploys automatically.

The tailcone exit may be actuated from three different places: the passenger after entrance door, using a handle on the inside of the tailcone (non-pressurized area), and using another handle on the outside of the aircraft.

When the tailcone emergency exit is actuated, the tailcone is release and falls. It then turns 90° and moves to the left side of the aircraft to keep the tailcone from interfering with the deployment of the slide.

[3] A compressor stall occurs when the amount of airflow through the last stages of the compressor is less than the airflow at the compressor intake, as a result of which the airflow in the initial stages slows and their blades stall aerodynamically. This phenomenon leads to a reversal of air flow that is felt as a detonation or a bang.

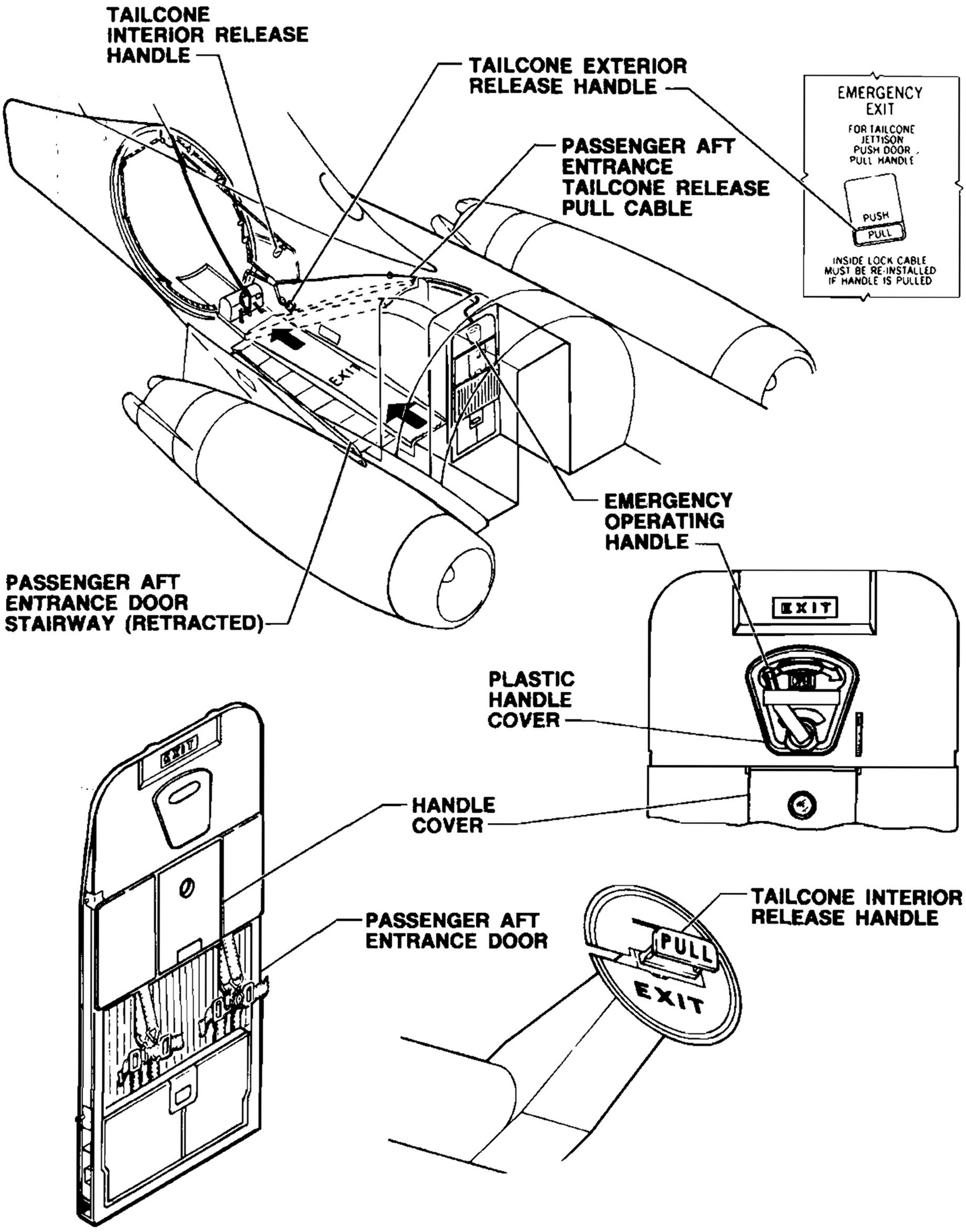

Figure 2. Tailcone jettison system

As it falls, it pulls on the slide container via the slide lanyard, moving it next to the tailcone, leaving the slide exposed so it can deploy and inflate.

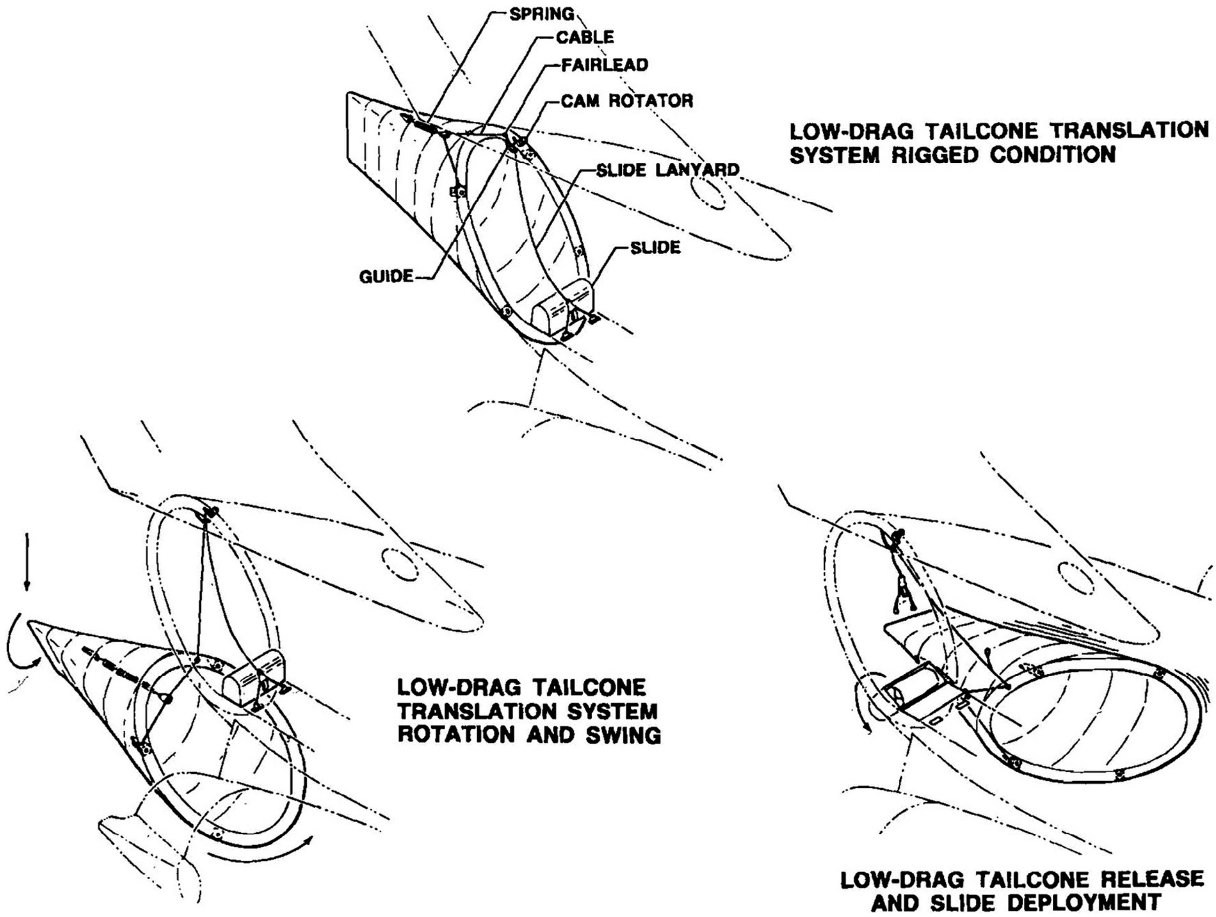

Figure 3. Low drag tailcone translation system

The command to release the tailcone and deploy the slide employs a set of clasps and cables which are attached to a bar on the door and to the clamping bolts on the tailcone and on the slide release system using various rings, velcro strips and automatic buttons. These components must be set correctly if the release command is to be properly transmitted.

1.5.3. *Operator's emergency procedure. Engine failure*

The emergency procedure described in the operator's Operations Manual for an in-flight engine failure and which the crew used is as follows:

ENGINE FAILURE

Note: Plan to land at the nearest Emergency airport

1. Autothrottle .... OFF.
2. Throttle, affected engine .... IDLE.

3. Eng sync .... OFF.
4. Engine Instruments .... OBSERVE.

◆ **N1 or N2 or OIL PRESS indicate zero or any other indication of severe damage.**

CAUTION.
Prior to performing item 5. L/P and R/P must verify that correct fire handle is selected.

5. Fire handle, affected engine .... PULL.
6. Fuel crossfeed .... ON.
7. Perform ENGINE SHUTDOWN Checklist, this section
8. [End of procedure]

◆ **N1, N2 and OIL PRESS indicate a rotating and undamaged engine.**

9. At PiC discretion: Perform IN FLIGHT ENGINE START Check list, this section Check fuel balance and use crossfeed as required
10. [End of procedure]

The crew was unable to complete the engine failure procedure.

1.6. Meteorological information

Weather data for the surroundings at the time of the incident are as follows:

At 10:00:

07009KT 040V120 9999 FEW015 SCT025 BKN200 27/20 Q1015 NOSIG=

At 10:30:

08010KT 050V120 9999 FEW015 SCT025 28/20 Q1015 NOSIG=

At 11:00

08010KT 050V110 9999 FEW015 SCT025 28/20 Q1016 NOSIG=

1.7. Communications

During the flight, the aircraft was in contact with Alicante tower and with TACC Valencia. After landing and coming to a stop on taxiway C-4, the control tower informed the crew of a fire in the left engine.

All communications were carried out without incident.

1.8. Aerodrome information

The Alicante aerodrome has one runway on a 10/28 orientation and measuring 3,000 m long by 45 meters wide. The aerodrome is at an elevation of 43.21 m.

The aircraft exited runway 10 via taxiway C-4, as shown in Figure 4. The crew reported clear of the runway and, after being notified of a fire in the left engine, decided to evacuate the aircraft.

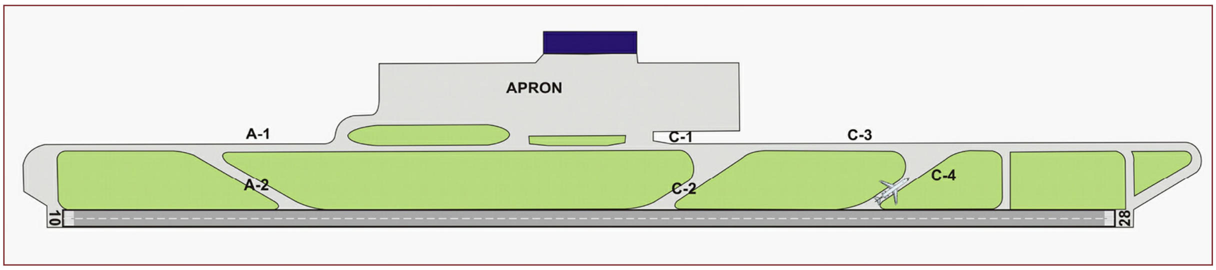

Figure 4. Airport diagram showing location of aircraft after landing

1.9. Flight recorders

The aircraft was equipped with two flight recorders:

1. A Sundstrand DFDR, model UFDR, P/N:980-4100-DXUN and S/N: 4002. This recorder can log 60 parameters for up to 25 hours.
2. A Sundstrand CVR, model AV557C, P/N:980-6005-079 and S/N: 13603. It features a magnetic tape and a 30-minute recording time.

1.9.1. *Flight data recorder*

According to the information logged by the DFDR, the following sequence of events involving engine number 1 took place:

10:38:38: Takeoff run initiated, takeoff EPR selected.

10:41:39: Left engine fails. EPR falls to 1, N1 to 38% and N2 to 75%. Highest temperature logged is 638 °C before recorder goes off scale.

10:42:22: Left engine rpm's drop to 17% (N1) and 37% (N2).

10:42:44: Number 2 engine EPR dropped to 1.7.

10:51:20: Right engine EPR fell to 1.1, possibly during the landing flare.

10:51:27: Aircraft landed. No reverse thrusters deployed on either engine to stop the landing run.

10:52:07 : Last data point.

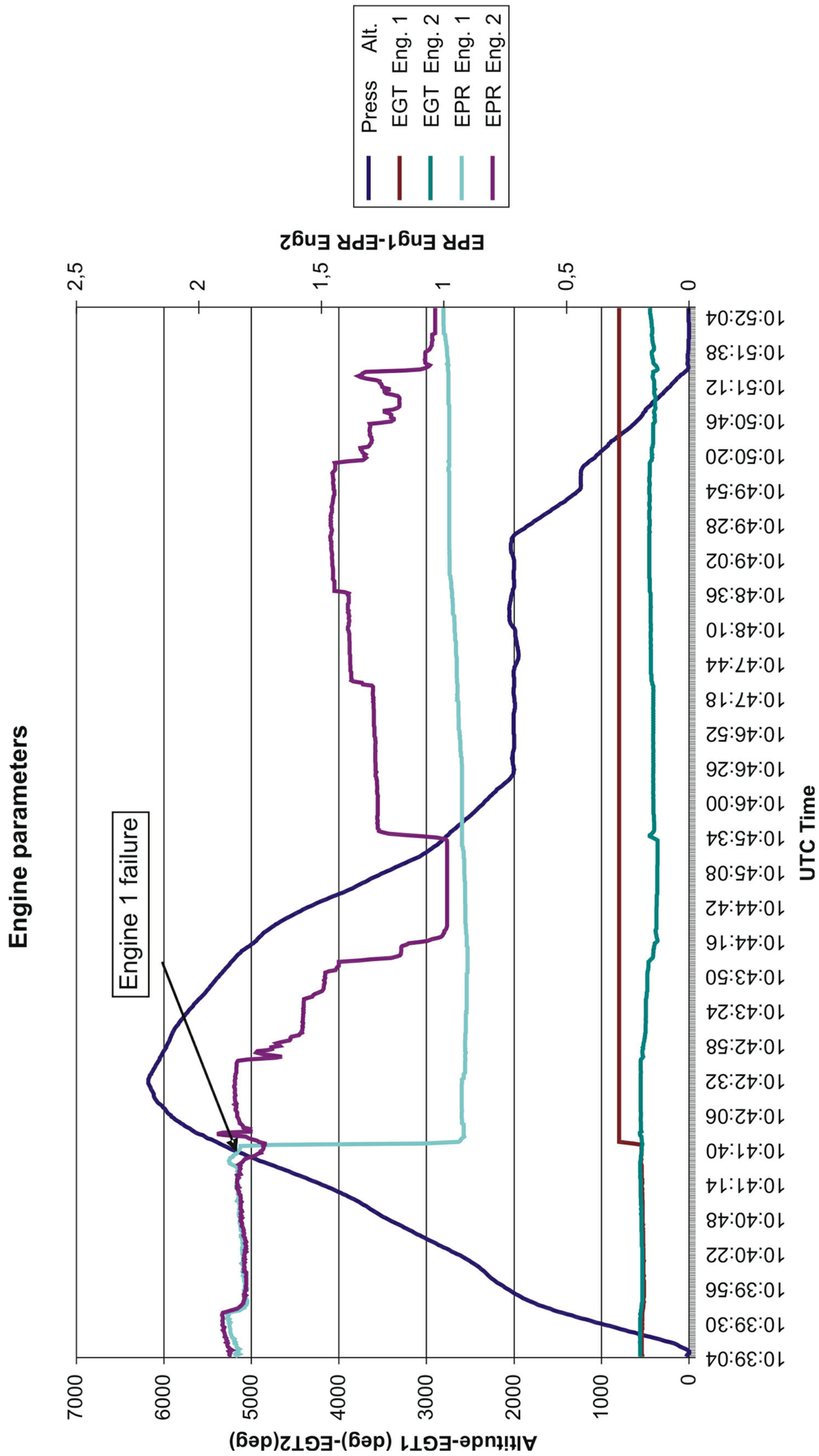

Figure 5. Progression of the exhaust temperature and EPR for both engines during the flight

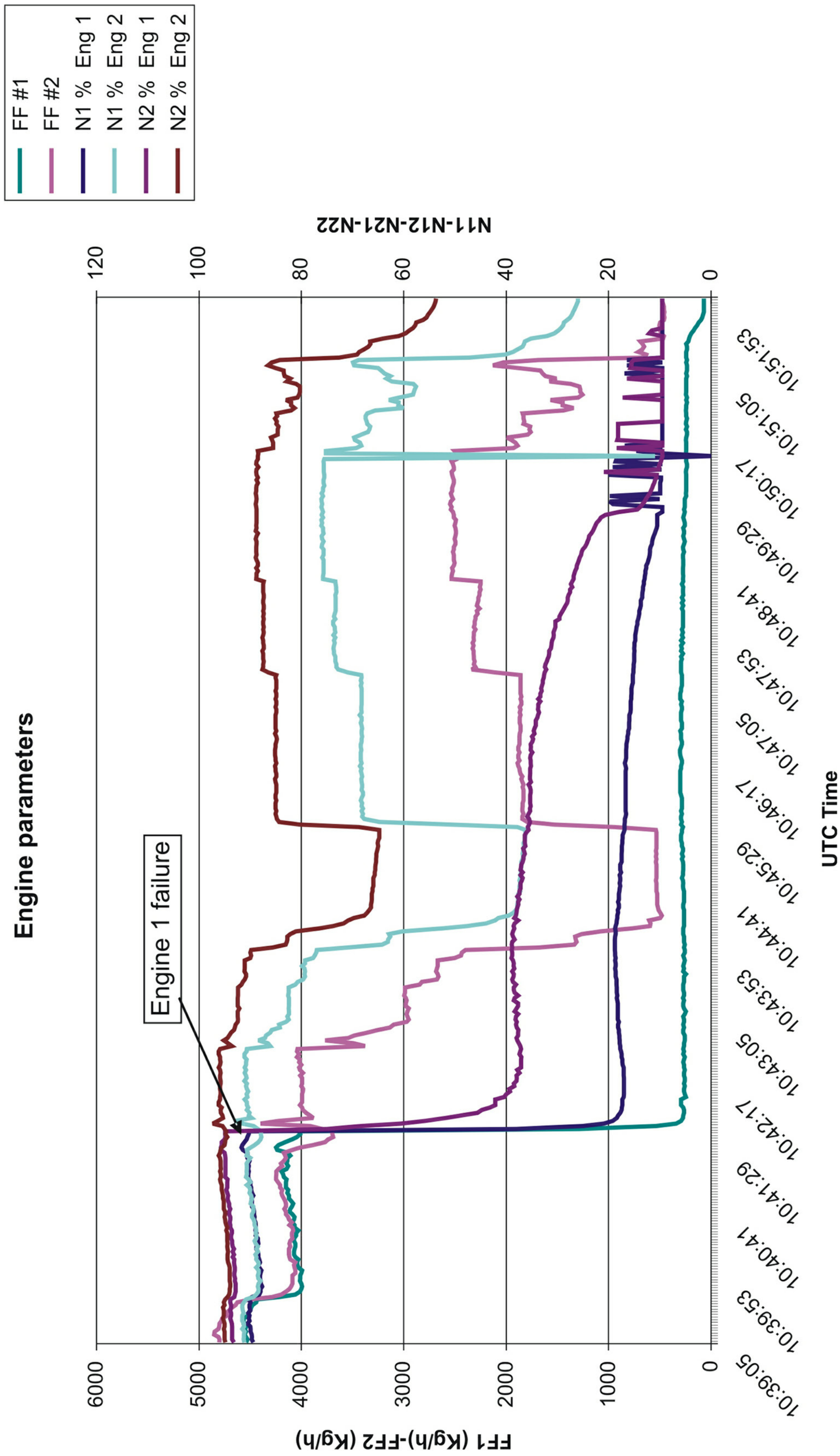

Figure 6. Progression of rpm's and fuel flow for both engines during the flight

In the seconds prior to the failure of the left engine, the average engine parameters were as follows:

Engine	N1 (%)	N2 (%)	EPR	EGT (°C)	FF (kg/h)
#1	90.64	95.03	1.844	540	4,137
#2	89.78	95.49	1.808	550	4,038

At no time was the fire warning for the number 1 engine received.

1.9.2. *Cockpit voice recorder*

The first mention by the captain of the left engine failure appears on the CVR at 10:41:44. During the emergency, the captain was the pilot flying, while the copilot was in charge of communications and emergency management.

An emergency was declared and ATC notified at 10:41:55. They were then asked if they wanted to return to the airport, and they were informed that they could turn around, going rightward.

At 10:42:44, they were informed by ATC that runway 28 was available but had a strong tailwind gusting up to 14 kt. The crew expressed a preference for runway 10, and ATC instructed them to proceed to the VOR and that they could make a VOR approach, ILS or visual.

At 10:43:27, the crew informed the cabin attendants of the engine failure and that they were returning to Alicante.

At 10:43:50, the captain called for the approach checklist. The copilot noted they had not performed any emergency checklists.

At 10:44:06, the copilot initiated the descent checklist, in keeping with the company's Operations Manual. She was interrupted by a QNH report from ATC.

At 10:44:23, the copilot resumed the checklist.

At 10:44:28, she completed the descent checklist. The captain expressed his desire not to start the engine and asked the copilot to shut it down.

At 10:44:56, just as the copilot was starting the engine failure checklist, ATC contacted the aircraft, informing them they were the only traffic and asking if they were going to make a visual approach.

At 10:45:23, they confirmed their intention to make a visual approach.

At 10:45:38, the copilot did the approach checklist and the captain reiterated his intention to shut down the engine.

At 10:46:02, ATC requested information on the number of passengers aboard.

At 10:46:31, the copilot started the engine failure checklist once again.

At 10:46:42, the captain insisted the engine was damaged.

At 10:46:44, ATC instructed the crew to contact the control tower.

At 10:47:15, they informed the control tower they were entering left downwind.

At 10:47:51, the copilot resumed the engine failure checklist, with the pilot insisting once again that he shut it down. The copilot started the engine failure checklist but was interrupted by the landing gear warning.

At 10:49:13, they performed the before landing checklist.

At 10:50:02, they acknowledged they were clear to land.

At 10:51:32, they landed.

At 10:51:58, they reported clear of the runway.

At 10:52:07, they were informed about the fire in the left engine, after which they decided to evacuate the aircraft.

1.10. Fire

Once disassembled, the engine showed no signs of external fire.

At no time were flames seen issuing from the left turbine.

1.11. Survival aspects

Once the emergency was declared, the airport firefighting service was alerted. Three vehicles were dispatched to combat the emergency. The vehicles were situated at the intersection of exits A-2, C-2 and C-4 with A-1, C-1 and C-3, respectively, as shown in the figure.

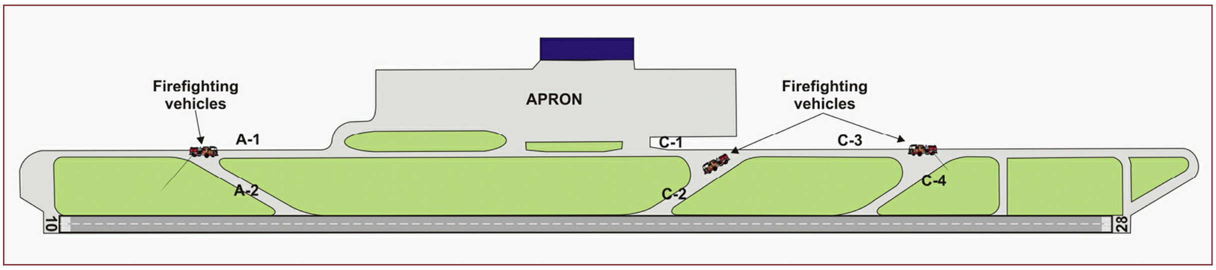

Figure 7. Position of the firefighting vehicles

When the aircraft passed the position occupied by one of the vehicles (A2), the vehicle entered the runway and followed it. From the vehicle they noted a fire inside the left engine, as evidenced by a bright red color, while the right was dark. Firefighting personnel informed ATC of this fact.

As soon as the aircraft stopped on taxiway C-4, firefighting personnel applied extinguishing agents to the engine.

Once in taxiway C-4, the aircraft contacted ATC to report clear of the runway. They were immediately notified of the fire in the left engine, which prompted the crew to order an evacuation and to warn the cabin attendants not to use the aft exits.

During the emergency, doors 1L and 1R were opened in emergency mode, as were the four windows above the wings and the tailcone exit. Although the tailcone did release, the slide did not deploy.

Before initiating the evacuation, the copilot exited the aircraft to help with and expedite the evacuation, as required by the company's Operations Manual.

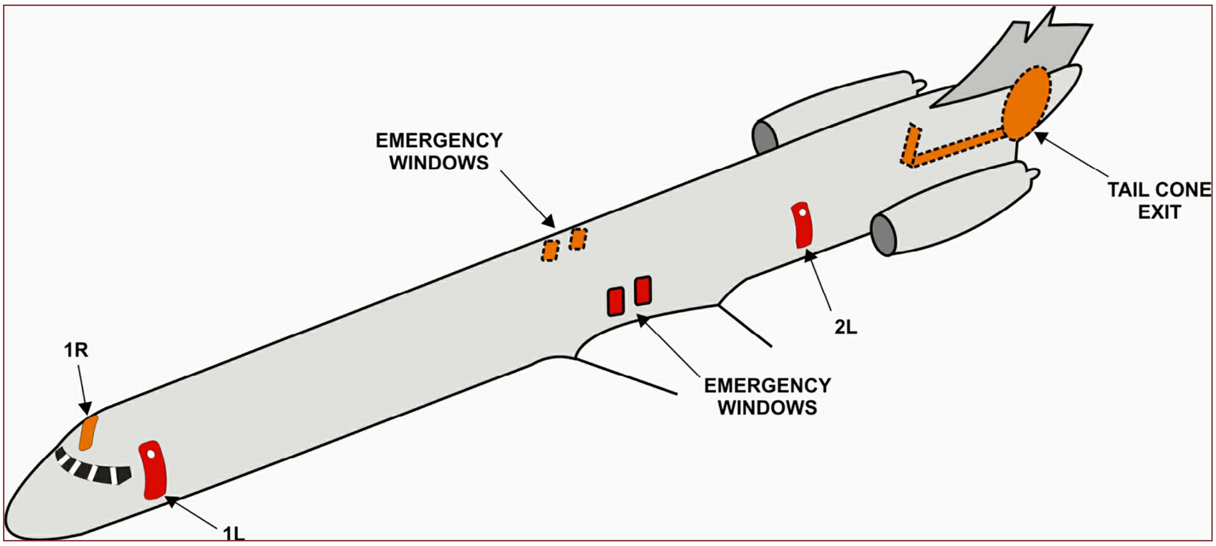

Figure 8. Emergency exits on the MD-83

The evacuation was carried out quickly, mainly via doors 1L and 1R, since the passengers did not want to jump from the windows onto the wings. Neither the tailcone nor exit 2L were used.

Once the passengers were safely off, the cabin crew gathered some of the survival gear and exited the aircraft.

Nineteen passengers and one firefighter were slightly injured during the evacuation and treated in the airport's facilities. The injuries were the result of friction burns, bruises, excoriations, panic attacks and a gash.

Once outside the aircraft, the cabin crew rounded up the passengers so they could be transported to the airport terminal aboard the airside buses. Two of the passengers were taken by ambulance to the airport clinic.

1.12. Tests and research

1.12.1. *Engine disassembly report*

The left engine, S/N 728179, was removed from the aircraft after the incident and taken to a workshop, where it was thoroughly disassembled and inspected.

The disassembly report details the damage. Data from said report was used to draft a summary of the engine's condition after the in-flight failure, provided below.

Before the disassembly, the report noted the absence of both fire on the outside of the engine and of any fuel or oil leaks. The engine's fire detection systems were functioning properly. The LPC rotated freely but the HPC had seized.

Turbine and exhaust areas

All the blades in the 1st stage of the HPT, and those in the 2nd and 3rd stages of the LPT burned off uniformly. All the blade roots remained in the disk slots and only some blade tips from the fourth stage were found among the debris. The forward faces of the front knife-edge seals exhibit heavy metal spray, but the knife-edge seals exhibit no unusual tip rub.

There were no impacts or excessive friction of rotating components, indicating the absence of any significant imbalance in the turbine during the failure sequence. It is believed that the tips of the blades from the 4th stage detached while the turbine was rotating slowly.

The LPT and HPT cases showed no distortion or bulging and no impact marks to the outer shrouds; their casing inside were covered in molten or half-molten metal.

Turbine exhaust case was visually intact and no gas leak had occurred from the primary flowpath to the fan, though the heat had caused the aluminum fairings to warp and partially melt.

Diffuser

Fuel lines to fuel nozzles were intact, there were no leaks.

Metal splatter was found on the combustor can domes. This is characteristic of compressor airfoil failures.

HPC area, compressor stages 7 to 13

In stages 9 to 13 of the HPC, all the rotor blades were fractured, bent, rubbed down or liberate from their blade slots, though many of their roots were still in place.

The stator vanes of stages 9 to 13 were damaged, but practically all remained in place.

During the disassembly minor damage to the 7th stage were observed.

Six adjacent vanes detached from the 8th stage stator. All the remaining blades in stator 8 were damaged, especially along their trailing edges.

Figure 9. Fatigue failure of the vane

When the first two vanes in the 8th stage stator detached, they left a stub in the outer shroud which was consistent with a known failure mode. The failure start in High Cycle Fatigue at the trailing edge braze joint with the outer shroud and propagates towards the leading edge, leaving an about 5 mm stub at the leading edge.

The other four detached stator vanes showed signs of having been torn off as the result of an impact.

Another vane from the 8th stage stator showed a trailing edge crack originating at the outer end braze.

All the 8th stage rotor blades were heavily rubbed and torn along their trailing edges.

The knife-edge seals of the disk spacers showed evidence of asymmetric rub consistent with imbalance having caused the rub of the 8^{th} stage disk bore to the LPT shaft.

The outer shroud of the HPC 8^{th} stage rotor was heavily battered and bulged outwards.

LPC stages 1 to 6 and fan area

There was no evidence of FOD. Minor damage typical of stall phenomena was noted on the tips of fan blades and on the leading edge of other blades.

Conclusion of the disassembly report

In light of the damage, it is believed that the engine failure resulted from the simultaneous or near simultaneous released of two vanes on the 8th stage stator as a result of High Cycle Fatigue cracking, which led to the breakage of 4 other vanes on the 8th stage stator. Downstream damage then occurred in stages 9 to 13. The general failure of the compressor caused successive increase in turbine entry temperature and eventually turbine overheat to the point of melting turbine airfoils.

Based on its condition, it appears that an auto-shutdown probably occurred, prior to pilot action, caused by the fuel flow being cut off as a result of the N2 dropping below the speed required to sustain the engine running. Thus, there was probably an emission of smoke from the hot debris rather than an active fire on landing. The failure was fully contained (debris exited only through the tailpipe) and no engine fire occurred.

The fire warning loops installed on the engine were serviceable.

1.12.2. *Tailcone slide inspection report*

An inspection of the tailcone slide did not reveal any defects. It was concluded that an improper installation had kept it from deploying.

Figure 10. HPC 8th stage stator

Faced with this possibility, the company took the initiative of inspecting all the tailcone slides in its MD80 fleet without finding any discrepancies.

1.13. Additional information

1.13.1. *Information on previous engine failures and actions taken by Pratt & Whitney*

In January of 2004, the manufacturer, Pratt & Whitney, published a document entitled "JT8D-200 All Operator Wire: JT8D/72-36/CTS:WRM:04-01-19-1", which it reported on two incidents involving similar circumstances and one operator. 3 day later, on 22nd of January 2004, an update of this document entitled "JT8D-200 All Operator Wire: JT8D/72-36/CTS:CRC:04-22-1" was issued. This document also stated that the risk of a double engine failure was remote and that corrective actions were, therefore, unnecessary.

After the disassembly of the engine in a previous incident in May of the same year, P & W published an update to the document (JT8D-200 All Operator Wire: JT8D/72-36/CTS:CRC:04-05-28-1), explaining the failure mechanism due to crack initiation and propagation in high cycle fatigue, initiating at the trailing edge o the vanes an the inner location of the outer shroud. Pratt & Whitney was aware of thirty-six liberations of 8th stage stator vanes related to brazed stators since 1990. None of these events had resulted in case penetration; fourteen of these events had resulted in an In Flight Shut Down.

There were no reports of 8th stage stator vane cracking at the trailing edges in new production strap welded stator assemblies.

It additionally states that while the failure mechanism could depend on the type of operations involved, the braze of the vanes should be adequate for most types of operations and complies with all safe operating requirements, insisting that the risk of a double engine failure in flight is extremely remote.

A different document (Special Instruction No. 1F-04, Boroscope procedure for 8th stage stator vanes, Feb 2004) provides instructions for the on wing preventive inspection of engines, though said inspection is generally not required or even recommended.

Later, on 6 May 2005, a Service Bulletin was issued (SBJT8D 6472, Engine-stator assembly, 8th stage compressor-conversion from a braze-repaired to a strap-welded configuration) which provide a modification which converts braze-repaired 8th and 9th stage compressor stator assemblies to the original strap welded configuration. The necessity and convenience of its implementation was left to the operators' discretion depending on their situation.

1.13.2. *Actions taken by the company to remedy the deficiencies noted in the in-flight engine failure procedure*

During the investigation, it was noted that the company's procedure for an in-flight engine failure was ambiguous and led to incorrect determinations by the crew concerning whether or not the engine was damaged, so it could be shut down, or not, so it could be restarted.

After being informed of this fact, the company took the following actions:

1. The company's procedures committee analyzed the engine failure checklist. The manufacturer and another operator were also consulted on its suitability. Eventually, it was decided not to modify said procedure.
2. Several engine failures were included in the simulator training program during the first half of 2007, with special emphasis being placed on explaining and clarifying the engine failure procedure.
3. An explanation was included of the engine failure procedure in bulletin number 13 of the company's MD fleet, published on 10 April 2007, which clarifies the meaning of the phrase "any other indication of severe damage," as shown below:

ENGINE FAILURE

Esta check list considera dos opciones:

La primera: *N1 or N2 or OIL PRESS indicate zero or any other indication of severe damage.*

Además de no girar el N1, o el N2, o no haber presión de aceite "other indication of severe damage" se refiere a que el motor haya producido fuertes vibraciones durante el fallo, o ruido que nos puede ser comunicado por los TCP's, o el EGT se haya pasado de sus limites con caída de potencia (porque si el EGT se dispara sin caída de potencia leer el EGT INOPERATIVE OR READ HIGH).

En todos estos casos hay daños severos y el motor se tiene que terminar de parar tan pronto sea posible leyendo ENGINE SHUTDOWN. *No intentar poner en marcha.*

La otra opción es: *N1, N2 and OIL PRESS indicate a rotating and undamage engine* (se considera presión aceptable, por encima de 5 psi).

Si no hemos observado vibraciones ni explosiones durante la parada y el EGT es normal, consideramos que no hay daños severos y a discreción del PiC se puede intentar ponerlo en marcha.

Figure 11. Explanation of the engine failure procedure

1.13.3. *Company policy concerning emergency situations*

According to information provided by company personnel, whenever an in-flight emergency takes place, the tasks sharing is such that one member of the flight crew is charged with controlling the aircraft and handling communications while the other manages the emergency.

2. ANALYSIS

2.1. Engine failure

It became apparent during the left engine disassembly that the initial fault was the high-cycle fatigue failure of two stator vanes on the 8th stage. The engine had accumulated 10,642 flying hours and 7,675 cycles since new, and only 1,673 flying hours and 895 cycles since the last workshop inspection of these stator vanes.

Just before the left engine failure, FDR readings were normal compared to those of the right engine and well below the limits for EGT, N1 and N2. Of the allowed time for applying takeoff power, 5 minutes, only 3 had elapsed since the start of the takeoff run.

The absence of impact damage to previous compressor stages excludes the possibility of FOD to the engine. Likewise, the good condition of the oil and fuel systems preclude other possible failure mechanisms.

The released vanes led to the breakage of four other vanes in the same stator (8th), as well as minor damage to the 7th stage. The released components triggered a cascade of failures in later stages of the compressor which were compounded by the imbalance of rotating elements. The imbalance was obviously a result of the stage 8 stator failure, and not vice versa.

The general failure of the HPC inhibited the air from the air intake from reaching the compressor exit, resulting in a compressor stall and a drop in rpm’s.

In the combustion and turbine area, the decreased quantity of air caused a successive increase in turbine entry temperature and eventually turbine overheat to the point of melting turbine airfoils.

Since the main fuel pump is driven through the main accessory gearbox by the HPT/HPC, the drop in N2 caused a loss of fuel pressure. This loss of fuel pressure could have also cut off the fuel supply from the FCU and the pressurization and dump valve, such that the engine shut itself down (flame out) and stopped the flow of fuel into the combustor that could have fed an internal engine fire. The engine fire reported by the firefighting service, then, was rather the smoke and molten metal being ejected from the engine exhaust.

The failure was completely contained by the engine case, and all material ejected from inside the engine did so via the exhaust nozzle.

The fire detection system did not activate the fire alarm precisely because no fire existed, which kept the fire warning from reaching a high enough temperature to be actuated.

Subsequently, in May of 2005, Pratt & Whitney issued a Service Bulletin (SBJT8D 6472, Engine-stator assembly, 8th stage compressor-conversion from a braze-repaired to a strap-welded configuration), in response to both the case in question and to previous occurrences. Application of the Service Bulletin was left to each operator's discretion. Pratt and Whitney informed that in addition to no engine fire had resulted in any of the events, the determination of Service Bulletin classification is based on a number of factors, including flight safety considerations.

2.2. Failure of the inflatable evacuation slide at the aft exit to deploy

According to the inspection, the tailcone slide failed to deploy because of an improperly installed actuating device. Fortunately on this occasion, the type of failure, namely a reported fire in the left engine, prompted the captain to specifically prohibit the aft section from being used during the evacuation, though the tailcone was still released.

Had it been necessary to evacuate via the aft section, the first passengers may have been pushed out the tailcone door by other passengers, resulting in much more serious injuries than those actually produced.

Given the serious consequences than a malfunctioning tailcone slide may have had, the actions taken by the company in checking its remaining fleet to verify proper tailcone installation and assembly are considered adequate from a safety standpoint.

The release of the tailcone itself, however, is considered inappropriate given the flight crew's specific warning not to use the aft exits.

2.3. Emergency management aboard the aircraft

The copilot was handling communications, the emergency procedure and the checklists while the captain was in control of the aircraft. This task sharing during an emergency situation is inconsistent with company policy.

The engine failure took place at an altitude of 5,400 ft. From then on until the landing, the copilot performed the normal descent, approach and before landing checklists, and started the emergency checklist for an "In-flight engine failure" on several occasions, without completing it, in addition to handling ATC communications.

The captain identified the engine failure at 10:41:44, after which they immediately decided to return to Alicante.

From the time they informed approach control of the emergency until they were transferred to the control of Alicante tower at 10:47:15, approach control contacted the aircraft five times.

Each time the copilot was forced to interrupt one of the checklists (descent, approach or engine failure) in order to respond.

The pilot told the copilot that they were going to stop the engine at 10:44:28, since he was convinced the engine was damaged, but the copilot did not understand him correctly until 10:47:51, her intention being to restart the engine each time she initiated the engine failure checklist. Whenever they talked about the condition of the engine, they were interrupted by a communication from ATC that kept them from clarifying this point.

What led the copilot to act in this manner was the in-flight engine failure procedure and an observation of the parameters indicated therein (N1, N2 and oil pressure), which led her to conclude that the engine was undamaged.

After the captain’s insistence that the engine was damaged, they started the engine failure list with the intention of shutting it down, but were forced to interrupt it to focus on the landing once the Landing Gear warning was come out.

This type of engine cuts off the fuel flow once fuel pressure (as detemined by N2) drops below a minimum value, which prevented the addition of fuel to the combustor which could have fueled a core fire and the consequences such an event could have had during the flight. The crew’s most proper course of action would have been to shut down the engine immediately once they were convinced it was damaged.

The combination of having the copilot handle both communications and the engine failure procedure, along with the interruptions from ATC and the ambiguity of the procedure itself, prevented the crew from acting more effectively. Allocating tasks in accordance with company policy and having a better-defined engine failure procedure would have facilitated the full execution of the engine failure procedure.

Of special note is the lack of knowledge on the part of ATC personnel of the tasks that must be completed by a crew during an emergency. The resulting interruptions by ATC personnel in trying to aid in the emergency efforts actually have the opposite effect on a crew that is trying to complete these tasks.

2.4. Engine failure procedure

Completing the engine failure procedure requires making a determination of whether or not the engine is damaged.

This procedure takes into account N1, N2 and oil pressure as indicators to be used by the crew in objectively evaluating whether or not the engine is damaged.

The procedure also refers to "any other indication of severe damage." This phrase is ambiguous and does not give the pilot a chance to make a quick assessment by noting any one specific engine parameter, making him instead focus his attention solely on N1, N2 and oil pressure.

The text as it currently reads does not explicitly consider any other engine parameters, such as a violation of EGT (which happened during the incident), oil quantity, etc., to determine if the engine is severely damaged.

Since in this incident, N1, N2 and oil pressure did not indicate zero, the copilot concluded that the engine was not damaged.

For his part, the captain was convinced that the engine was in fact damaged, and insisted that the engine not be restarted.

At any rate, the procedure was not completed essentially because it was not easy to ascertain whether or not the engine was damaged. In fact, using the information available to the crew, the conclusion could have been reached, following the procedure, that the engine was undamaged.

This lack of specifics led the crew to not shut down the engine.

The operator, once informed of this deficiency in the procedure, took various actions, such as evaluating the procedure, including several engine failures in its training program for the first half of 2007, and, lastly, adding an explanation of the engine failure procedure in bulletin 13 of the MD fleet.

Following the evaluation of the procedure, it was decided not to change it, and though the other measures taken by the company are satisfactory, they are insufficient to prevent the same confusion that took place during this incident from happening again. It is thus advisable to redefine when the engine is "damaged" or "undamaged" in the engine failure procedure.

2.5. Actions of firefighting and evacuation personnel

Following the aircraft's notification that it was returning to the airport and its declaration of an emergency, ATC informed firefighting services of the event. Three vehicles were swiftly deployed along the runway to minimize the response time.

Once the aircraft landed, they proceeded to extinguish what at first seemed like a fire in the left engine. Though it was later discovered, once the engine was disassembled, that there had in fact been no fire, the response to a possible fire situation was correct nevertheless.

Informing ATC and ATC quickly informing the crew which, in turn, ordered the evacuation, were all considered adequate responses to what could been an emergency such as having a fire in the left engine.

Also rapid was the evacuation of the passengers and the response of airport medical services at the scene. The transport of the passengers to the airport terminal was accomplished in a brief period of time.

3. CONCLUSIONS

3.1. Findings

- The flight crew was licensed and qualified for the flight.
- The aircraft was maintained in accordance with regulations.
- The engine that failed was being operated within EPR, EGT and rpm (N1 and N2) limits.
- The fault occurred suddenly, three minutes after takeoff power was selected on both engines.
- No outside causes, such as FOD, were involved.
- The initial fault was tracked to the 8th stage stator of the HPC.
- The crew decided to return to the airport once the emergency took place.
- Task sharing during the emergency was not in accordance with company procedures.
- The captain may have believed the engine to be damaged, and requested the copilot to shut it down.
- As the copilot worked through the engine failure procedure, she concluded that the engine was undamaged and insisted on restarting it.
- The engine fire warning was not come out during the flight.
- The in-flight engine failure emergency procedure was not completed.
- The landing and taxiing were completed with the left engine not shut down and its fuel throttle in the IDLE position.
- ATC reported the existence of a fire in the left engine following the report from the firefighting service to that effect.
- The crew ordered the evacuation of the aircraft.
- The tailcone slide was actuated.
- The tailcone slide did not deploy when the door was opened in emergency mode.
- A disassembly of the engine showed no signs that there had been a fire in the engine.

3.2. Causes

It is believed that the incident was caused by the simultaneous or near simultaneous fatigue failure of two vanes in the 8th stage stator, which led to the subsequent failures downstream and to the general failure of the engine.

4. SAFETY RECOMMENDATIONS

An analysis of the in-flight engine failure procedure and of its performance during this incident resulted in some deficiencies being noted in the definition of said procedure. It is considered that the ambiguity of some of the steps to be taken slows down and confuses the crew when it comes time to assess the situation and make decisions. The following recommendation is therefore made:

REC 09/2008. It is recommended that Spanair perform a review of the in-flight engine failure procedure such that the crew can use a quick evaluation of objective parameters to determine whether or not the engine is damaged.

Another aspect to consider is that during the emergency, task sharing was not in keeping with company policy, resulting in an excessive workload for the copilot and which may have, in turn, contributed to the partial completion of the engine failure emergency procedure. This aspect should be addressed during the company's CRM and refresher (simulator) courses. The following recommendation is issued as a result:

REC 10/2008. It is recommended that Spanair stress the training aspects related to proper task sharing at the cockpit during emergency situations in all of its Type Qualification, Refresher and CRM courses.

The operator informed about its intention of undertaking actions designed to spread and stress the emergency situation concept through the department in charge of the training related to Crew Resource Management (CRM).