
Uncontained engine failure, Airbus A300-605R, October 19, 1993

Micro-summary: This Airbus A300-605R experienced an uncontained engine failure on climbout.

Event Date: 1993-10-19 at 1001 PDT

Investigative Body: National Transportation Safety Board (NTSB), USA

Investigative Body's Web Site: <http://www.nts.gov/>

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		NTSB ID: LAX94IA018		Aircraft Registration Number: N41063	
		Occurrence Date: 10/19/1993		Most Critical Injury: None	
		Occurrence Type: Incident		Investigated By: NTSB	
Location/Time					
Nearest City/Place LOS ANGELES		State CA	Zip Code 90009	Local Time 1001	Time Zone PDT
Airport Proximity: Off Airport/Airstrip		Distance From Landing Facility: 8		Direction From Airport: 197	
Aircraft Information Summary					
Aircraft Manufacturer Airbus Industrie		Model/Series A-300-605R		Type of Aircraft Airplane	
Sightseeing Flight: No			Air Medical Transport Flight: No		
Narrative					
Brief narrative statement of facts, conditions and circumstances pertinent to the accident/incident:					
History of the Flight					
<p>On October 19, 1993, at 1001 hours Pacific daylight time, an Airbus A-300-605R, N41063, experienced an uncontained engine failure during climb-out from Los Angeles International Airport, Los Angeles, California. The airplane was being operated as a scheduled domestic passenger flight to Miami, Florida, under Title 14 CFR Part 121, when the incident occurred. The airplane, operated by American Airlines as flight number 915, received minor damage to the fuselage. Two flight crew members, both certificated airline transport pilots, 8 cabin crew members, and 76 passengers were not injured. Visual meteorological conditions prevailed. The flight departed Los Angeles at 0959 hours. The pilot reported that after departure from runway 25R, about 6,000 feet mean sea level (msl), a loud bang was heard followed by "engine fire" and "reverser unlocked" annunciator lights in the number one engine. The number one engine instruments decreased to zero. The pilot discharged the number one engine fire extinguisher and declared an emergency. The first officer, who was flying the airplane at the time, proceeded to return and land on runway 25R at Los Angeles. There was no evidence of fire. The passengers disembarked the airplane at the terminal gate.</p>					
Aircraft Information					
<p>The airplane had accumulated a total time in service of 13,905.07 flight hours and 5,515 cycles since being delivered on February 2, 1989. The most recent inspection, a phase B check, was accomplished on September 24, 1993, 175 flight hours and 72 cycles before the incident. The number one engine had accrued 1,328 hours and 520 cycles since April 30, 1993, when the engine was installed on the airplane. The most recent engine inspection was accomplished during the latest phase B check listed above for the airplane. The engine's 3-to-9 compressor spool had accrued 11,094 hours and 4,404 cycles since new.</p>					
<p>Compressor rotor blades (airfoils) are attached to the compressor spool in stages (rows) that rotate between alternating stages of fixed (stator) vanes. Air, taken into the engine through the fan section, passes through successive stages of compressor rotor blades and compressor stator vanes, being compressed as it passes from stage to stage through 14 stages of blades. The 3-to-9 compressor spool is a one piece forging that was originally produced from a 13-inch billet of titanium.</p>					
Flight Recorders					
<p>The airplane's digital flight data recorder (DFDR) provides aircraft and engine parameters that are recorded by sample numbers within the recorder. The DFDR sample number 90793 at 1001:50 hours indicated that the airplane was climbing through 6,203 feet msl, at 241 knots, on a 197 degree magnetic heading. Beginning at sample number 90794, also recorded at 1001:50 hours, the number one engine fan speed (N-1) suddenly decreased to flight idle and the engine parameters decreased to</p>					

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near zero within 10 seconds. The engine event occurred over the Pacific Ocean about 8 miles west of the Los Angeles airport.

During the initial readout of the DFDR data, performed by the operator, it was noted that the recorder lost data synchronization at or near the time of the number one engine failure, and some data was not recovered. The DFDR tape was sent to the National Transportation Safety Board's recorder laboratory where additional, but not all, data was recovered. An examination of the DFDR tape was then conducted at the Transportation Safety Board of Canada (TSB) where the remaining data was recovered.

Wreckage and Impact Information

Safety Board investigators examined the airplane at the operators maintenance facility on October 19 and 20, 1993. The airplane received damage to the left side of the aircraft. A large quantity of nicks and gouges were visible along the inboard leading edge slat, underside of the inboard section of the left wing, and along the left side of the fuselage from the wing root aft to about the lower navigation light. The 8th stage check valve and a small portion of compressor section airfoil from the number one engine were found embedded in the left side of the ram air turbine fairing. The wing and fuselage were not punctured by any debris.

Examination of the number one engine revealed that the right side of the engine's high pressure compressor case was ruptured in an outward direction. An 8-inch wide hole was oriented circumferentially from about an 11 o'clock position around the right side to about a 3 o'clock position. Engine ducting, tubing, and hardware were separated or bent outward in areas adjacent to the compressor case opening. The lower right side of the compressor case exhibited an outward bulge. Examination of the compressor section revealed that the 6th stage segment of the 3-to-9 stage compressor spool was missing entirely from the engine. The engine pylon was not damaged.

No metal splattering was visible in the tailpipe. The fan disk and low pressure turbine turned freely. The aft portion of the compressor rotor and the high pressure turbine turned freely. The forward portion of the compressor could not be rotated. There was no evidence of foreign object damage (FOD).

The right fan duct inner flow path exhibited about a 12-inch wide hole adjacent to the compressor case rupture. A 34-inch wide section of the right side thrust reverser cowl, oriented circumferentially from about a 12 o'clock position to about a 5 o'clock position, separated from the engine and was not located. The upper thrust reverser cascade segment, oriented on the right side of the engine, was bent upward. The center cascade segment was separated from the cowl and not located. The lower cascade segments were still attached. The lower latches holding the thrust reverse halves together were found still latched.

Beginning on October 26, 1993, Safety Board investigators conducted an engine examination at the engine manufacturers maintenance facility in Ontario, California. The compressor/stator module was separated from the other engine modules. The upper case half of the high-pressure compressor was removed and revealed that the entire 6th stage disk of the compressor rotor (3.329 inches wide) separated at the spacer lands between stage 5 and 6, and at the spacer lands between stage 6 and 7.

Compressor rotor blades attached to stage 1 through stage 4 exhibited leading edge damage, trailing edge damage, and blade bending. Stage 5 rotor blades were broken off entirely. Compressor rotor blades in stage 7 and aft received extensive damage including numerous missing blade pieces.

The compressor stator inlet guide vanes were bent in a clockwise direction. The inner shrouds of the vanes exhibited rotational damage and removal of large slivers of shroud material.

The fan mid-shaft, located through the center of the compressor rotor assembly, exhibited about a 1

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and 1/2-by 3-inch circumferential gouge in the plane of the 6th stage disk. Areas of splattering of metal were visible adjacent to the gouge. The mid-shaft also exhibited a bright scoring mark adjacent to the high pressure compressor rear bumper bearing.

The engine manufacturer reported that the absence of significant impact damage to the fan mid-shaft and axial cracks in the remaining pieces of the 3-to-9 spool was consistent with a separation of the stage 6 disk due to a bore to rim crack. Disk rim initiated separations have shown damage that goes beyond a single disk in which axial cracks propagate through the spacer arms to adjacent disks. This type of crack was not apparent in this incident.

Tests and Research

The engine manufacturer reported that the 3-to-9 high pressure compressor spool for this engine was forged from 6-2-4-2 titanium. During the production history of the spool (26 years), it has progressively been forged from one piece 16-inch billets, to one and two piece 13-inch billets, to one and two piece 9-to 10-inch billets. As a result of previous spool separations, all one piece spools are subject to various service bulletins that call for a one-time immersion ultrasonic inspection. Service Bulletin 72-418 applies to CF6-80C2 engines.

As a result of the immersion ultrasonic inspections, 12 CF6-50 16-inch billet spools have been found with cracks or crack-like indications. No CF6-50 13-inch billet spools have been found cracked. One 13-inch CF6-80C2 billet spool was found cracked prior to this incident. These cracks have been attributed to a phenomena known as "Dwell time Fatigue" (also referred to as "Quasi-Cleavage Cracking").

Dwell time fatigue is characterized by flat, faceted internal crack initiation that may occur in areas subjected to high stress at low temperature over a period of time. Susceptibility to dwell time fatigue is associated with the presence of regions of microscopically aligned colonies of alpha phase titanium crystals. The colonies are aligned so that the basal plane is perpendicular to the axis of stress. The colonies form naturally during the billet manufacturing process. Subsequent billet reduction and part forging normally breaks up and randomizes the colonies; however, they may persist into the final part, resulting in a structure that is susceptible to fatigue over time (dwell time) under certain conditions.

Both halves of the 3-to-9 high pressure compressor spool (stages 3-5 and stages 7-9) were subjected to a metallurgical examination by the engine manufacturer. The results of the examination were reviewed by the National Transportation Safety Board Materials Laboratory. The examination included an inspection for cracks, voids, inclusions, and cracked/voided hard alpha anomalies. No such discrepancies were found. Residual stress measurements, taken at the stage 7 bore area, indicated that the part was within specifications. Photomicrographs of material from the stage 5 disk area revealed a uniform microstructure. Material from the stage 7,8, and, especially, the stage 9 disk area revealed evidence of the aligned alpha colony structure that has been associated with dwell time fatigue.

Including this incident, there have been four uncontained failures involving the 3-to-9 spool in CF6-50 model engines (16-inch billet) and one in the CF6-80C2 (13-inch billet). The engine manufacturer indicated that of the CF6-50 failures, three were attributed to a "type 1" defect (hard alpha) and one was attributed to dwell time fatigue. The failure mode for the stage 6 disk of the incident spool (CF6-80C2) has not been determined.

The engine manufacturer reported that there were seven additional 3-to-9 compressor spools (sister spools) forged from the same heat-lot as that of the incident spool. Examination of the sister spools has not revealed any cracks.

The engine manufacturer reported that there were eight heat-lot sister spools from the only other

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previous CF6-80C2 compressor crack that had been found in a 13-inch billet. Examination to this point of the sister spools has resulted in rejection of two spool assemblies for dimensional variations; however, no cracks have been found.

Additional Information

From January 24 to February 13, 1994, the engine manufacturer conducted an underwater search for the missing compressor spool segment. The search utilized remotely operated cameras and side scanning sonar in ocean depths of about 250 feet. Examination of the ocean bottom revealed rock outcroppings and limited visibility. The search did not locate any engine or aircraft hardware.

The engine manufacturer reported that an engineering and metallurgical evaluation to address the CF6 3-to-9 compressor spool issues is still in progress.

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Landing Facility/Approach Information						
Airport Name LOS ANGELES INTERNATIONAL		Airport ID: LAX	Airport Elevation 126 Ft. MSL	Runway Used 0	Runway Length	Runway Width
Runway Surface Type:						
Runway Surface Condition:						
Type Instrument Approach: NONE						
VFR Approach/Landing: None						
Aircraft Information						
Aircraft Manufacturer Airbus Industrie		Model/Series A-300-605R		Serial Number 506		
Airworthiness Certificate(s): Transport						
Landing Gear Type: Retractable - Tricycle						
Homebuilt Aircraft? No		Number of Seats: 267	Certified Max Gross Wt. 337800 LBS		Number of Engines: 2	
Engine Type: Turbo Fan		Engine Manufacturer: GE		Model/Series: CF6-80C2A5	Rated Power: 61300 LBS	
- Aircraft Inspection Information						
Type of Last Inspection AAIP		Date of Last Inspection 09/1993	Time Since Last Inspection 175 Hours		Airframe Total Time 13905 Hours	
- Emergency Locator Transmitter (ELT) Information						
ELT Installed? No		ELT Operated?		ELT Aided in Locating Accident Site?		
Owner/Operator Information						
Registered Aircraft Owner WILMINGTON TRUST CO.		Street Address RODNEY SQUARE NORTH				
		City WILMINGTON		State DL	Zip Code 19890	
Operator of Aircraft AMERICAN AIRLINES		Street Address P.O. BOX 619616				
		City DFW AIRPORT		State TX	Zip Code 75261	
Operator Does Business As:				Operator Designator Code: AALA		
- Type of U.S. Certificate(s) Held:						
Air Carrier Operating Certificate(s): Flag Carrier/Domestic						
Operating Certificate:			Operator Certificate:			
Regulation Flight Conducted Under: Part 121: Air Carrier						
Type of Flight Operation Conducted: Scheduled; Domestic; Passenger/Cargo						
FACTUAL REPORT - AVIATION						

 <p>National Transportation Safety Board FACTUAL REPORT AVIATION</p>	NTSB ID: LAX94IA018
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First Pilot Information

Name On File	City On File	State On File	Date of Birth On File	Age 55
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Sex: M	Seat Occupied: Left	Principal Profession: Civilian Pilot	Certificate Number: On File
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Certificate(s): Airline Transport

Airplane Rating(s): Multi-engine Land

Rotorcraft/Glider/LTA: None

Instrument Rating(s): Airplane

Instructor Rating(s): None

Type Rating/Endorsement for Accident/Incident Aircraft? Yes	Current Biennial Flight Review?
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Medical Cert.: Class 1	Medical Cert. Status: Valid Medical--no waivers/lim.	Date of Last Medical Exam: 04/1993
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- Flight Time Matrix	All A/C	This Make and Model	Airplane Single Engine	Airplane Multi-Engine	Night	Instrument		Rotorcraft	Glider	Lighter Than Air
						Actual	Simulated			
Total Time	20000	1800								
Pilot In Command(PIC)										
Instructor										
Last 90 Days	200	200								
Last 30 Days										
Last 24 Hours	5	5								

Seatbelt Used? Yes	Shoulder Harness Used? Yes	Toxicology Performed? No	Second Pilot? Yes
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Flight Plan/Itinerary

Type of Flight Plan Filed: IFR

Departure Point Same as Accident/Incident Location	State	Airport Identifier	Departure Time 0959	Time Zone PDT
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Destination MIAMI	State FL	Airport Identifier MIA	
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Type of Clearance: IFR

Type of Airspace: Class B; Class D; Class E

Weather Information

Source of Briefing: Commercial Weather Service; Flight Service Station; National Weather Service

Method of Briefing:

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Weather Information					
WOF ID	Observation Time	Time Zone	WOF Elevation	WOF Distance From Accident Site	Direction From Accident Site
LAX	1051	PDT	126 Ft. MSL	0 NM	0 Deg. Mag.
Sky/Lowest Cloud Condition: Clear			0 Ft. AGL	Condition of Light: Day	
Lowest Ceiling: None		0 Ft. AGL		Visibility: 10 SM	Altimeter: 30.00 "Hg
Temperature: 23 °C	Dew Point: 12 °C	Wind Direction: 190		Density Altitude: Ft.	
Wind Speed: 4	Gusts:	Weather Conditions at Accident Site: Visual Conditions			
Visibility (RVR): 0 Ft.	Visibility (RVV) 0 SM	Intensity of Precipitation: Unknown			
Restrictions to Visibility: None					
Type of Precipitation: None					

Accident Information		
Aircraft Damage: Minor	Aircraft Fire: None	Aircraft Explosion: None

Classification: U.S. Registered/U.S. Soil					
- Injury Summary Matrix	Fatal	Serious	Minor	None	TOTAL
First Pilot				1	1
Second Pilot				1	1
Student Pilot					
Flight Instructor					
Check Pilot					
Flight Engineer					
Cabin Attendants				8	8
Other Crew					
Passengers				76	76
- TOTAL ABOARD -				86	86
Other Ground	0	0	0		0
- GRAND TOTAL -	0	0	0	86	86

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Administrative Information

Investigator-In-Charge (IIC)

SCOTT R. ERICKSON,

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