Uncontained engine failure, Douglas DC-9-32, March 18, 1997

Micro-summary: **This Douglas DC-9-32 experienced an uncontained engine failure after V1, took off, and returned for a successful landing.**

Event Date: **1997-03-18 at 1332 CST**

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

Investigative Body's Web Site: **http://www.ntsb.gov/**

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1. Accident reports can be and sometimes are revised. Be sure to consult the investigative agency for the latest version before basing anything significant on content (e.g., thesis, research, etc).

2. Readers are advised that each report is a glimpse of events at specific points in time. While broad themes permeate the causal events leading up to crashes, and we can learn from those, the specific regulatory and technological environments can and do change. ***Your company's flight operations manual is the final authority as to the safe operation of your aircraft!***

3. Reports may or may not represent reality. Many many non-scientific factors go into an investigation, including the magnitude of the event, the experience of the investigator, the political climate, relationship with the regulatory authority, technological and recovery capabilities, etc. It is recommended that the reader review all reports analytically. Even a "bad" report can be a very useful launching point for learning.

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National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB ID: FTW97IA128	Aircraft Registration Number: N12508
Occurrence Date: 03/18/1997	Most Critical Injury: None
Occurrence Type: Incident	Investigated By: NTSB

Location/Time

Nearest City/Place	State	Zip Code	Local Time	Time Zone	
HOUSTON	TX	77032	1332	CST	

Airport Proximity: On Airport	Distance From Landing Facility:	Direction From Airport:

Aircraft Information Summary

Aircraft Manufacturer	Model/Series	Type of Aircraft
McDonnell Douglas	DC-9-32	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 FLIGHT

On March 18, 1997, approximately 1332 central standard time, a Douglas DC-9-32, N12508, operated by Continental Airlines (COA), under Title 14 CFR Part 121, as scheduled domestic passenger flight 1682, from Houston Intercontinental Airport (IAH), Houston, Texas, to Indianapolis, Indiana, experienced a total loss of power in the No. 2 (right) engine during initial takeoff climb. The flight returned to IAH and landed without further incident at 1355. Emergency crews extinguished a fire in the No. 2 engine with foam after the airplane stopped on the runway. There was no emergency evacuation, and there were no injuries to the 96 passengers or the 5 crewmembers. The airplane sustained minor damage. Instrument meteorological conditions prevailed, and an IFR flight plan was filed.

In written statements provided to the NTSB investigator-in-charge (IIC), the captain and the first officer of flight 1682 reported that no discrepancies were noted during completion of the pre-flight checklists. The captain stated that power indications for the takeoff on runway 14L were "normal" until "just after liftoff" when he heard "a sound similar to a compressor stall," the airplane yawed, and the No. 2 engine readings "dropped." The first officer stated that "shortly after rotation, [he] heard a loud pop with subsequent power loss in the right (#2) engine." Both crewmembers reported that the first officer, who was the pilot flying, "flew the engine out profile." According to the captain, the airplane "had a problem climbing," which he believed was "due to the drag of a large piece of cowling hanging from the engine." The first officer stated that the airplane was "very close" to maximum gross takeoff weight and "very sluggish to climb."

According to FAA personnel at the Houston Intercontinental Air Traffic Control Tower, flight 1682 was cleared for takeoff at 1330 and, at 1332, declared an emergency and requested a return to IAH for landing. At 1337, the captain advised the controller that the No. 2 engine had failed, and at 1340, he further advised that the right hydraulic system had also failed. After the flight was vectored around thunderstorms in the area, the first officer executed a single-engine approach to runway 27, landing at 1355. According to the captain, "at no time" during the flight was there a cockpit fire warning, and the crew was not aware of the No. 2 engine fire until the airplane was stopped on the runway and contact was made "with the fire captain by radio who advised the fire was out and not to evacuate."

FLIGHT RECORDERS

The cockpit voice recorder (CVR) was not readout. At the request of the NTSB IIC, the Digital Flight Data Recorder (DFDR) was readout by COA. The tabular data indicated that the takeoff roll began at FDR count 17913. During the next 45 seconds (17914 to 17959), the engine pressure ratio (EPR) of both engines increased to and stabilized at 2.10, and the indicated airspeed increased to 151 knots. At FDR count 17959, the pitch began to increase. Between FDR count 17959 and 17965 (6

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seconds), the pitch increased from 2 to 10 degrees nose up, and the indicated airspeed reached 165 knots. At FDR count 17966, the No. 2 engine EPR dropped to 1.63, and the pitch reached 11 degrees nose up. At FDR count 17967, the No. 2 engine EPR further dropped to 1.11, the pitch reached 12 degrees nose up, and the altitude began to increase. During the next 60 seconds (17968 to 18028), the airplane climbed to 636 feet MSL. Using the IAH field elevation of 98 feet MSL, an initial takeoff rate of climb of 538 feet per minute was calculated for the airplane.

TESTS AND RESEARCH

Following the incident, the No. 2 engine, a Pratt & Whitney (P&W) JT8D-15, serial number 701016, was removed from the airplane and shipped to Greenwich Air Services, Dallas, Texas. On April 3, 1997, it was examined at Greenwich by representatives from the NTSB, FAA, P&W, and COA. The engine was not disassembled. For a detailed description of the damage to the engine refer to the Powerplants Group Chairman's Factual Report.

The exterior of the thrust reverser was sooted with most of the soot concentrated on the upper thrust reverser bucket. The exterior of the fan exhaust outer duct was discolored blue, and there was approximately half a shovel full of loose, solidified molten metal and debris at the bottom of the duct. A mound of solidified molten metal and debris (approximately 3 to 4 shovels full) lined the lower portion of the turbine nozzle rear case with airfoil segments and fir tree roots visible in the debris. All of the 2nd, 3rd, and 4th-stage low pressure turbine blades and vanes, as well as almost all of the low pressure turbine disk rims, were burned away. All of the 1st-stage high pressure turbine blades and almost all of the 1st-stage high pressure turbine disk rim were burned away. All of the 1st-stage vane trailing edges were burned with all the remaining vane material blackened and granular.

Forward of the turbine section, there was no visible heat damage or soot on the exterior of the fan ducts, wire bundles, or engine components. The terminal ends of one fire detector loop were separated on each side of the J-flange support bracket at the 5:30 clock position. (All references to the clock are as viewed from aft looking forward.) The terminal ends of the second fire detector loop, which shared the same bracket, were intact. The hydraulic quick-connect junction-box from the 3 o'clock position was hanging underneath the engine. The flexible hydraulic lines from the hydraulic pump to the junction-box were intact. One of the rigid hydraulic lines to the junction-box at the 3 o'clock position and two of the rigid hydraulic lines to the junction-box at the 9 o'clock position were severed at the B-nuts.

Between H- and J-flanges, the diffuser outer duct was fractured from the 2 to 8:30 clock locations. The crack extended circumferentially around the duct, a maximum of 5 inches forward of the J-flange. Between J- and K-flanges, the combustion chamber outer upper fan duct was circumferentially torn from the 2 to 3 o'clock location, approximately 11 inches aft of the J-flange. The combustion chamber outer lower fan duct was fractured from 6 to 9 o'clock. The fracture extended circumferentially around the duct then traversed forward, across J-flange, into the diffuser outer fan duct at approximately the 8:30 clock location. Additionally, the lower fan duct was missing the forward-most 26 inches (approximately 40 percent of the duct's length) from the 3 to 6 o'clock location.

The combustion chamber outer case (CCOC) was axially cracked along the 6 o'clock location from the rear flange to the weld seam located 1 1/2 inches aft of the forward flange. The axial crack extended around the right side of both the front and rear drain bosses in the vicinity of their respective weld seams. At the weld seam aft of the forward flange, the crack split in two directions, passing circumferentially around the CCOC adjacent to the forward weld seam. The circumferential cracks on the right and left sides continued to approximately the 2 o'clock and 8 o'clock locations respectively.

Visual examination of the CCOC crack in the vicinity of the forward drain boss revealed

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approximately 3.5 inches of reddish (rust-colored) discoloration along the fracture surface. The discoloration extended partially around the circumference of the boss-to-case weld seam and axially aft approximately 1.25 inches. The two adjacent fracture surfaces in the vicinity of the forward drain boss and a 10 inch segment of the CCOC forward flange, which included the split-point at the 6 o'clock location, were machine-cut from the CCOC. The three segments were hand-carried to the NTSB Materials Laboratory, Washington, DC, for metallurgical examination. For a detailed description of the metallurgical findings refer to the Metallurgist's Factual Report.

According to the NTSB metallurgist, scanning electron microscope examination of the fractures adjacent to the forward drain boss revealed "features characteristic of a fatigue crack that emanated from multiple origins on the inside diameter surface" in the area where the reddish discoloration (identified as an oxide layer) was noted. Several origins were located at corrosion pits on the inside diameter surface. The metallurgist reported that fatigue propagation was from the inside to the outside diameter surface and was through the wall thickness for a distance of approximately 0.5 inch. He further reported that the depth of the fatigue crack decreased with increasing distance extending away from the through-the-wall portion of the crack, and that the areas of the fracture outside the fatigue region "contained features typical of overstress separation."

The metallurgist performed a striation count at one end of the through-the-wall portion of the fatigue crack. The accumulated striations from the inside diameter (fatigue origin) to a point .004 inches from the outside diameter (total distance .069 inches) totaled 6,299. The accumulated striations from the inside diameter to the outside diameter (total distance .073 inches) could not be determined due to mechanical damage to the outside diameter edge.

ADDITIONAL INFORMATION

Review of maintenance records by representatives from the NTSB, FAA, COA, P&W, and the Independent Association of Continental Pilots (IACP) revealed that the last overhaul of engine serial number 701016 was performed by COA at their engine buildup facility in Los Angeles, California, (LAX EBU) on August 31, 1994. At the time of the incident, the engine had accumulated 4,665 cycles and 5,462 hours since this overhaul.

The maintenance records indicated that the combustion chamber outer case (CCOC) installed in the engine was a part number 767197 bearing serial number KU-4547. Visual examination of the CCOC revealed that the serial number was actually KV-4547. P&W Technical Support Engineering personnel estimated that the CCOC had accumulated a total of 23,314 cycles and 34,853 hours at the time of the incident. The calculation of these times was based on the following information: After manufacture, the CCOC left the factory with engine serial number 666417 in September 1981 and was delivered to El Alitalia. This engine was sold to People Express in June 1984. In June 1990, engines 666417 and 701016 were both in COA's LAX EBU, and at that time, the CCOC went from one engine to the other.

As part of the 1994 overhaul of engine 701016, the CCOC received a fluorescent penetrant inspection, and no cracks were detected. At the time of the incident, the CCOC had accumulated 4,665 cycles and 5,462 hours since the fluorescent penetrant inspection.

On December 23, 1995, an on wing ultrasonic inspection of the CCOC's Ps4 boss and its forward and rear drain bosses was performed by a COA maintenance inspector at IAH. No cracks were detected during the inspection. At the time of the incident, the CCOC had accumulated 2,295 cycles and 2,789 hours since the ultrasonic inspection. There were 204 cycles remaining until the next scheduled ultrasonic inspection, which COA performs at intervals of 2,500 cycles.

The ultrasonic inspection was conducted as per COA's Engineering Authorization (EA)7251-01043 Revision G entitled "JT8D - On-Wing and Shop Inspection Requirements of Combustion Outer Cases."

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Section 2.1.2 of the EA provided instructions for the on wing ultrasonic inspection of the Ps4 and drain bosses. (Other sections of the EA provided instructions for on wing eddy current inspection of the CCOC's rear flange and for in shop inspections of the CCOC.) According to the introduction section of the EA, the inspections were required by FAA Airworthiness Directive (AD) 87-11-07 R1 and their purpose was "to identify and remove from service those outer cases which have developed cracks." Additionally, the EA listed P&W Alert Service Bulletin (ASB) 5676 Revision 8 in the reference data section.

ASB 5676 Revision 8 contained five inspection procedures "intended to detect cracks in the combustion chamber outer case drain boss weld[s], Ps4 boss weld and the rear flange." The inspection procedure identified as NDIP-763 described the on-wing ultrasonic inspection for crack detection at the Ps4 and drain boss locations. According to this procedure, each boss was inspected "by inserting an ultrasonic probe assembly into the bypass duct of the engine, positioning the probe on the combustion chamber outer case around the boss and monitoring the pulser/receiver for the presence of ultrasonic reflection signals." The procedure specified the use of ultrasonic probe assembly part number 47937.

Figures 5B, 6B, and 7B of EA7251-01043 specified the use of ultrasonic probe assembly part number 47260. Research revealed that in mid-1994, COA sent their probes to P&W for modification or replacement to part number 47937 in accordance with P&W ASB 6124. The probe used to perform the CCOC inspection in December 1995 was a part number 47937. According to P&W personnel, the modification to the probe re-positioned the transducers and improved the sound beam direction at the critical weld areas to ensure an adequate inspection.

During a telephone interview, the maintenance inspector who performed the ultrasonic inspection of the CCOC on December 23, 1995, stated that he did not specifically recall performing that particular inspection. He further stated that he performs 1 of these on wing inspections approximately every 3 months and has completed a total of 5 to 6 of these inspections. He indicated that it takes about 3 hours to complete an inspection and reported that he has never found a crack in a CCOC as a result of an inspection. The inspector explained that he can tell the ultrasonic probe is positioned properly by seeing the return from the bolt holes in the boss on the screen of the pulser/receiver. He added that he also uses a mirror and a flashlight to verify that the probe is positioned properly. He stated that he was confident the inspection can be accomplished as it is written and that he was performing the inspection properly.

Another COA maintenance inspector who has performed this type of inspection was also interviewed by telephone, and he reported that you can readily tell if the ultrasonic probe is coupled (in contact with the surface of the CCOC) by the return on the screen of the pulser/receiver. He further reported that it is a challenge to get the probe in contact with the forward drain boss; however, he saw no possibility that the inspection would be performed incorrectly. He emphasized that coupling is determined by ultrasonic returns on the screen, and proper position is determined using a mirror on a pole and a flashlight, then confirmed by identifying the bolt holes in the boss on the screen. The inspector stated that while this inspection is time consuming and requires patience, it can be done.

During a telephone interview, COA's non-destructive testing (NDT) supervisor stated that the on wing procedure is a reliable inspection. He further stated that if there is a crack, the inspector will see it. He expressed the opinion that the only better inspection method would be to provide removable panels in the fan duct allowing physical access to the bosses. He reported that the ultrasonic probe is checked against a standard before the inspection is performed, and it is also rechecked for calibration after the inspection. According to the NDT supervisor, before performing any ultrasonic inspection (such as an on wing CCOC inspection), a COA inspector must first complete a 40 hour NDT-ultrasonic class and then receive specific training in each task to be performed.

On June 18, 1997, COA issued Fleet Campaign Directive (FCD)7200-01481, entitled "JT8D Combustion

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Chamber Outer Case Ultrasonic Inspection." The FCD called for an additional inspection of the CCOC Ps4 and drain bosses "for all JT8D-7B/-9A/-15/-17/-17R" engines and was justified as follows:

Placement of the ultrasonic probes is critical in order to get reliable CCOC on-wing inspections. The FCD introduces a procedure to use a video monitor to verify proper placement of the probe.

The FCD listed P&W ASB 6228 in the reference section. This ASB was issued on November 7, 1995, and superceded ASB 5676. It contained inspection procedure NDIP-856, which superceded NDIP-763, and included the use of a video monitoring system "to visually assist in the probe placement and verify the proper probe position during inspection." As diagrammed in NDIP-856, the system consists of a video camera with infrared light source mounted on a telescopic extension rod and connected to a video monitor. According to the procedure, during the inspection of each boss, the camera is inserted into the engine and positioned to provide light and video capability to the inspection area.

As of December 29, 1997, COA had completed inspections as per FCD7200-01481 on 221 engines and involved 82 airplanes. As a result of the inspections, six engines were removed due to crack indications and disassembled. One CCOC was found to be cracked and it was scrapped. The other five crack indications were not confirmed during the shop inspection and were attributed to weld geometry.

The airplane, with the exception of the No. 2 engine and the cockpit voice recorder (CVR), was released to COA on March 20, 1997. The No. 2 engine, with the exception of the sections cut from the CCOC, was released to COA on April 3, 1997. The CCOC sections and the CVR were released to COA on June 18, 1997.

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Landing Facility/Approach Information

Airport Name	Airport ID:	Airport Elevation	Runway Used	Runway Length	Runway Width
HOUSTON INTERCONTINENTAL	IAH	98 Ft. MSL	14L	11071	150

Runway Surface Type: Concrete

Runway Surface Condition: Wet

Type Instrument Approach:

VFR Approach/Landing:

Aircraft Information

Aircraft Manufacturer	Model/Series	Serial Number
McDonnell Douglas	DC-9-32	47797

Airworthiness Certificate(s): Transport

Landing Gear Type: Retractable - Tricycle

Homebuilt Aircraft?	Number of Seats:	Certified Max Gross Wt.	Number of Engines:
No	109	110000 LBS	2

Engine Type:	Engine Manufacturer:	Model/Series:	Rated Power:
Turbo Fan	P&W	JT8D-15	15500 LBS

- Aircraft Inspection Information

Type of Last Inspection	Date of Last Inspection	Time Since Last Inspection	Airframe Total Time
Continuous Airworthiness	01/1997	84 Hours	48243 Hours

- Emergency Locator Transmitter (ELT) Information

ELT Installed?	ELT Operated?	ELT Aided in Locating Accident Site?

Owner/Operator Information

Registered Aircraft Owner	Street Address	City	State	Zip Code
FIRST SECURITY BANK NA TRUSTEE	79 SOUTH MAIN STREET	SALT LAKE	UT	84111

Operator of Aircraft	Street Address	City	State	Zip Code
CONTINENTAL AIRLINES	2929 ALLEN PARKWAY	HOUSTON	TX	77019

Operator Does Business As:

Operator Designator Code: CALA

- 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

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First Pilot Information

Name	City	State	Date of Birth	Age
On File	On File	On File	On File	59

Sex: M | Seat Occupied: Left | Principal Profession: Civilian Pilot | Certificate Number: On File

Certificate(s): Airline Transport; Flight Instructor; Commercial

Airplane Rating(s): Multi-engine Land; Single-engine Land

Rotorcraft/Glider/LTA: None

Instrument Rating(s): Airplane

Instructor Rating(s): Airplane Single-engine

Type Rating/Endorsement for Accident/Incident Aircraft? Yes | Current Biennial Flight Review?

Medical Cert.: Class 1 | Medical Cert. Status: Valid Medical--w/ waivers/lim. | Date of Last Medical Exam: 01/1997

- Flight Time Matrix	All A/C	This Make and Model	Airplane Single Engine	Airplane Mult-Engine	Night	Instrument Actual	Instrument Simulated	Rotorcraft	Glider	Lighter Than Air
Total Time	26000	6000								
Pilot In Command(PIC)	19000	6000								
Instructor										
Last 90 Days	240	240								
Last 30 Days	70	70								
Last 24 Hours	5	5								

Seatbelt Used? Yes | Shoulder Harness Used? Yes | Toxicology Performed? No | Second Pilot? Yes

Flight Plan/Itinerary

Type of Flight Plan Filed: IFR

Departure Point	State	Airport Identifier	Departure Time	Time Zone
Same as Accident/Incident Location		IAH	1330	CST

Destination	State	Airport Identifier
INDIANAPOLIS	IN	IND

Type of Clearance: IFR

Type of Airspace: Class B

Weather Information

Source of Briefing: Company

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
IAH	1340	CST	98 Ft. MSL	0 NM	0 Deg. Mag.

Sky/Lowest Cloud Condition: Scattered 500 Ft. AGL

Condition of Light: Day

Lowest Ceiling: Broken 800 Ft. AGL

Visibility: 2 SM

Altimeter: 30.00 "Hg

Temperature: 22 °C

Dew Point: 21 °C

Wind Direction: Variable

Density Altitude: Ft.

Wind Speed: 5

Gusts:

Weather Condtions at Accident Site: Instrument Conditions

Visibility (RVR): 0 Ft.

Visibility (RVV) 0 SM

Intensity of Precipitation: Light

Restrictions to Visibility:

Type of Precipitation: Rain

Accident Information

Aircraft Damage: Minor

Aircraft Fire: Ground

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				3	3
Other Crew					
Passengers				96	96
- TOTAL ABOARD -				101	101
Other Ground	0	0	0		0
- GRAND TOTAL -	0	0	0	101	101

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Administrative Information

Investigator-In-Charge (IIC)

GEORGIA R. SNYDER

Additional Persons Participating in This Accident/Incident Investigation:

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