National Transportation Safety Board
Washington, DC 20594

Brief of Incident

Adopted 12/22/2010

ENG08IA038

File No. 27755 | 08/06/2008 | Las Vegas, NV | Aircraft Reg No. N666DN | Time (Local): 15:40 PDT

Make/Model:	Boeing / 757
Engine Make/Model:	Pratt & Whitney / PW2037RTC
Aircraft Damage:	None
Number of Engines:	2
Operating Certificate(s):	Flag Carrier/Domestic
Name of Carrier:	DELTA AIR LINES INC
Type of Flight Operation:	Scheduled; Domestic; Passenger Only
Reg. Flight Conducted Under:	Part 121: Air Carrier

	Fatal	Serious	Minor/None
Crew	0	0	4
Pass	0	0	166

Last Depart. Point:	Same as Accident/Incident Location
Destination:	Jamaica, NY
Airport Proximity:	On Airport/Airstrip
Airport Name:	McCarran International Airport
Runway Identification:	25R
Runway Length/Width (Ft):	14510 / 150
Runway Surface:	Asphalt
Runway Surface Condition:	Dry

Condition of Light:	Day
Weather Info Src:	Weather Observation Facility
Basic Weather:	Visual Conditions
Lowest Ceiling:	None
Visibility:	10.00 SM
Wind Dir/Speed:	/ 006 Kts
Temperature (°C):	39
Precip/Obscuration:	

Pilot-in-Command Age: 55

Certificate(s)/Rating(s)

Airline Transport; Commercial; Flight Engineer; Multi-engine Land; Single-engine Land

Instrument Ratings

Airplane

Flight Time (Hours)

Total All Aircraft:	12035
Last 90 Days:	183
Total Make/Model:	8120
Total Instrument Time:	UnK/Nr

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HISTORY OF FLIGHT

On August 6, 2008, about 1540 Pacific daylight time, Delta Air Lines flight 624, a Boeing 757-232 airplane, N666DN, experienced an uncontained release of high pressure turbine material from the right engine, a Pratt & Whitney (P&W) PW2037, as the power was increased for takeoff at the McCarran International Airport, Las Vegas, Nevada. The captain stated that at the start of the takeoff roll, they heard a loud bang, they observed that the right engine had lost power, and the right engine fire warning had illuminated. The captain stated that they stopped the airplane on the runway and shutdown the right engine. The captain also stated that they declared an emergency and requested that the airport fire department personnel inspect the engine. The captain stated that the engine fire warning light went out when they shut down the engine, so they did not discharge a fire bottle into the engine nacelle. The airport fire department personnel stated that they observed a hole in the bottom of the right engine's nacelle and saw a glow inside the nacelle, so they discharged a fire bottle into the nacelle through the open pressure relief doors. After the airport fire department personnel had determined that there was no fire, the airplane was allowed to taxi back to the gate where the passengers and crew deplaned normally. The examination of the airplane revealed that there was no other damage. The airplane was operating on an instrument flight rules flight plan under the provisions 14 Code of Federal Regulations (CFR) Part 121 as a regularly scheduled flight from Las

Vegas to John F. Kennedy International Airport, Jamaica, New York. The 2 pilots, 4 flight attendants, and 166 passengers on board were not injured.

ENGINE DISASSEMBLY AND EXAMINATION

The engine was removed from the airplane and shipped to Delta's Technical Operations Center, Atlanta, Georgia for disassembly and examination. The examination of the engine revealed a hole through the flanges between the high and low pressure turbine cases in line with the 2nd stage turbine rotor at the bottom of the engine. The disassembly of the engine revealed that there were four adjacent 2nd stage turbine blades missing from the 2nd stage turbine hub. One of the four blades was missing completely and from the other three blades, only the bottom serration of the blade root remained in the blade slot. The remaining 2nd stage turbine blades remained in the hub's blade slots. There were two adjacent blades that were adjacent to the missing blades that were 1/4- and 1/2-inch long. All of the other 2nd stage turbine blades were nearly full length, but had rub marks with heat discoloration on the tips and nicks, dents, and material broken from the leading and trailing edges. The disassembly of the engine also revealed the 2nd stage turbine hub had four adjacent blade retaining lugs fractured between the inner and middle serrations. The fracture surfaces on the lugs had dark-colored, elliptical-shaped flat areas that radiated from the front acute corner. The remainder of the 2nd stage turbine hub was intact, although a subsequent fluorescent penetrant inspection (FPI) of the hub revealed that there were 59 crack indications on 35 of the 60 blade retaining lugs.

2ND STAGE TURBINE HUB HISTORY

According to Delta Air Lines' maintenance records, the 2nd stage turbine hub, PN 1B6002J SN DKLBA86546, had accumulated 29,097.5 hours and 12,549 cycles since new and 10,880.7 hours and 4,392 cycles since the last heavy maintenance was accomplished. According to the PW2000 Engine Manual, Section 05-10-00, Table 804, PN 1B6002 2nd turbine hubs have a life limit of 15,000 cycles. The maintenance records show that 2nd stage turbine hub had undergone an overhaul between December 10 and 22, 2004. The records show that during the overhaul, the hub underwent a four-step chemical descaling process, was grit blasted with 500 grit aluminum oxide, steam cleaned, oven dried, FPIed, steam cleaned again, and then dimensionally inspected.

RESEARCH AND TESTING

The 2nd stage turbine hub was dimensionally inspected at P&W's East Hartford, Connecticut facility. The dimensional inspection using a coordinate measuring machine (CMM) revealed that all of the hub's diametrical features conformed to the engine manual requirements. The dimensional inspection of the blade retaining lug serrations using a CMM and an optical comparator revealed the serrations' profiles were to 0.0092 inches below minimum tolerance dimension meaning the slots were missing material.

The metallurgical examinations of the hub that were conducted at P&W's and the Safety Board's Materials Laboratory revealed the four dark-colored, elliptical-shaped fracture surfaces were consistent with fatigue cracks at elevated temperatures that had originated from multiple origins along the root radius between the inner and middle serration. Several of the crack indications that were noted during the FPI of the hub were broken open to reveal fatigue cracks that were similar in shape and morphology, but smaller than the fatigue cracks on the four fractured lugs. The visual examination of the hub's blade slot serrations revealed a wavy surface pattern that was most prominent at the forward edge of the slot and continued aft between 0.3 and 0.6 inches from the front face. The metallurgical examination of the hub did not reveal any material anomalies.

The review of Delta's PW2037 2nd stage turbine hub cleaning process revealed that the cleaning process had to be modified to use a more aggressive cleaning process to remove the varnish-like scale from the hub to facilitate the FPI. The PW2000 Engine Manual originally required the hubs be blasted with plastic bead media in accordance with Service Process Operation Procedure (SPOP) 19. Delta reported that as the 2nd stage turbine hubs accumulated more and more time and returned for the second and third overhauls that it had become increasingly difficult to adequately clean the hubs with SPOP 19 plastic bead media

blasting in preparation for the FPI. SPOP 10 500 grit aluminum oxide dry grit blasting was also authorized by the PW2000 Engine Manual to use as an alternate procedure on those hubs that could not be adequately cleaned by SPOP 19. If the Delta part inspectors determined the part was not adequately cleaned to permit the FPI, they would route the part back to the cleaning shop for additional cleaning usually recommending the more aggressive SPOP 10 dry grit blast procedure. Delta stated that the use of SPOP 10 dry grit blasting had become so prevalent to clean the second stage turbine hub that they made it the part of the standard cleaning process rather than an alternate if SPOP 19 did not clean the hub. Ultimately, P&W revised the PW2000 Engine Manual to delete SPOP 19 in favor of SPOP 10.

The SPOP 10 procedures list how to prepare the part to be blasted, provide guidance on where to position the nozzle in relation to the part providing distance and angle to work surface, and pressures. The SPOP 10 procedures also has a caution that states, “DO NOT STAY IN ONE AREA FOR MORE THAN TWO SECONDS. USE CONTINUOUS MOTION.” In support of the investigation, P&W conducted a series of grit blasting tests on test panels made of the same material as that of the PW2037 2nd stage turbine hub. The tests showed that if the panels were grit blasted in accordance with the SPOP 10 procedures, there was only a minimal amount of material removed from the surface. The tests also showed that if the blasting gun was held too close to the part, was allowed to dwell in one spot, or held at an angle of about 45 degrees, there would be significant amounts of material removed.

OTHER PW2037 2ND STAGE TURBINE HUBS

Delta reported that in June 2007, it had found another PW2037 2nd turbine hub that was operated by a U.S.-registered Part 121 air carrier that had multiple cracks in the blade retaining lugs. The FAA was aware of this hub having been notified by P&W in accordance with 14 CFR 21.3. Although the hub with the multiple cracks was found 14 months prior to the occurrence of the uncontained incident at Las Vegas, P&W reported that it had not determined the cause of the cracks in that hub. A dimensional inspection of the hub found deviations of the blade slot serration profiles similar to what was noted on the Delta hub from the Las Vegas incident. The metallurgical examination of that hub found fatigue cracks that were very similar to those found on the 2nd stage hub that fractured at Las Vegas. The review of the maintenance records of that hub revealed it had undergone multiple grit blasting cycles before the inspector would accept the part for inspection.

Probable Cause(s)

The National Transportation Safety Board determines the probable cause(s) of this incident as follows.

The engine experienced an uncontained release of high pressure turbine material due to fatigue cracks that occurred on four consecutive blade retainig lugs on the 2nd stage turbine hub. The cracked lugs resulted in the release of four 2nd stage turbine blades that penetrated the engine's cases and nacelle. The lugs cracked due to loss of material and resultant increase in stress load on the blade slot serrations due to excessve grit blasting when the hub was being overhauled by Delta Air Lines. Contributing to the uncontained incident was the FAA's and Pratt & Whitney's failure to act in a timely manner when another PW2037 2nd stage turbine hub was found to have multiple cracks in the blade retaining lugs.