



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: October 16, 2008

In reply refer to: A-08-85 Urgent and -86

The Honorable Robert A. Sturgell
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20591

In this letter, the National Transportation Safety Board recommends that the Federal Aviation Administration (FAA) take action to address a safety issue concerning uncontained engine failures as a result of cracking in the 2nd stage turbine hub blade retaining lugs on Pratt & Whitney (P&W) PW2037 engines. The Safety Board identified this safety issue during its investigation of an uncontained engine failure that occurred on August 6, 2008. Although the investigation is continuing, information gathered to date has raised serious concerns that warrant immediate action by the FAA.

On August 6, 2008, Delta Air Lines flight 624, a Boeing 757-232 equipped with PW2037 engines, experienced an uncontained failure of the right engine's high pressure turbine (HPT) 2nd stage hub¹ at McCarran International Airport (LAS), Las Vegas, Nevada. The pilots stated that, at the start of the takeoff roll, they heard a loud bang and observed that the right engine had lost power. The pilots further stated that they rejected the takeoff and stopped the airplane on the runway. After airport fire department personnel determined that no fire was present and that it was safe to proceed, the airplane was permitted to taxi to the gate, where the passengers and crew deplaned normally. The airplane was operating on an instrument flight rules flight plan under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 as a regularly scheduled passenger flight from LAS to John F. Kennedy International Airport, Jamaica, New York. The 2 pilots, 4 flight attendants, and 166 passengers on board were not injured.²

The Safety Board's examination of the right engine revealed a hole in the bottom of the core cowl that was in line with a hole through the engine's HPT and low pressure turbine (LPT) case flanges. (See figure 1.) The disassembly of the engine revealed that portions of

¹ An uncontained engine failure occurs when an internal part of the engine fails and is ejected, or results in other parts being ejected, through the engine casing and cowling.

² Additional information about this incident, ENG08IA038, can be found on the Safety Board's website at <<http://www.nts.gov/ntsb/query/asp>>.

five consecutive 2nd stage turbine hub blade retaining lugs were missing.³ (See figure 2.) In addition, at the location of these lugs, three consecutive 2nd stage turbine blades were fractured through the blade root with only the bottom root serration remaining in the blade slot, and an adjacent 2nd stage turbine blade was missing completely. The examination of the 2nd stage turbine hub also revealed that 11 other randomly located blade retaining lugs had visual cracks. According to Delta Air Lines' maintenance records, the engine had accumulated 10,880 hours and 4,392 cycles⁴ since its last routine overhaul, at which time the 2nd stage turbine hub was inspected.

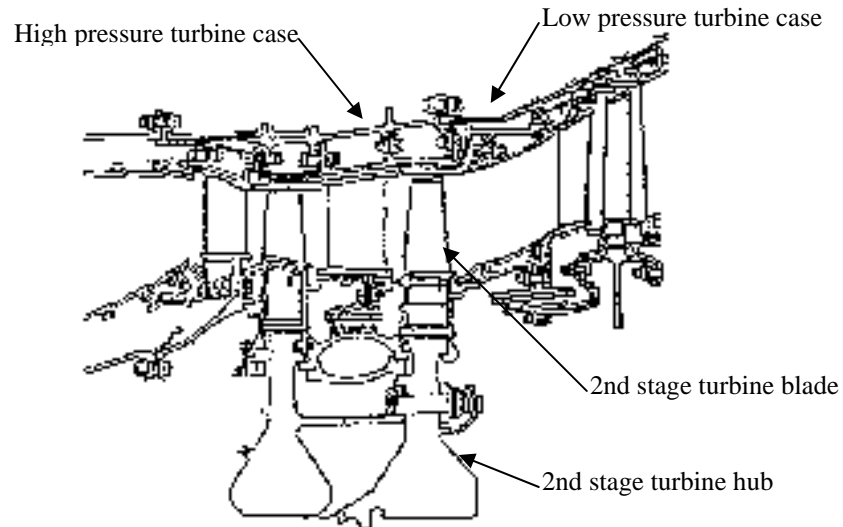


Figure 1. PW2037 HPT and LPT cross-section
Source: Pratt & Whitney

³ The PW2037 2nd stage turbine hub has 64 blade slots.

⁴ A cycle is one complete takeoff and landing sequence.

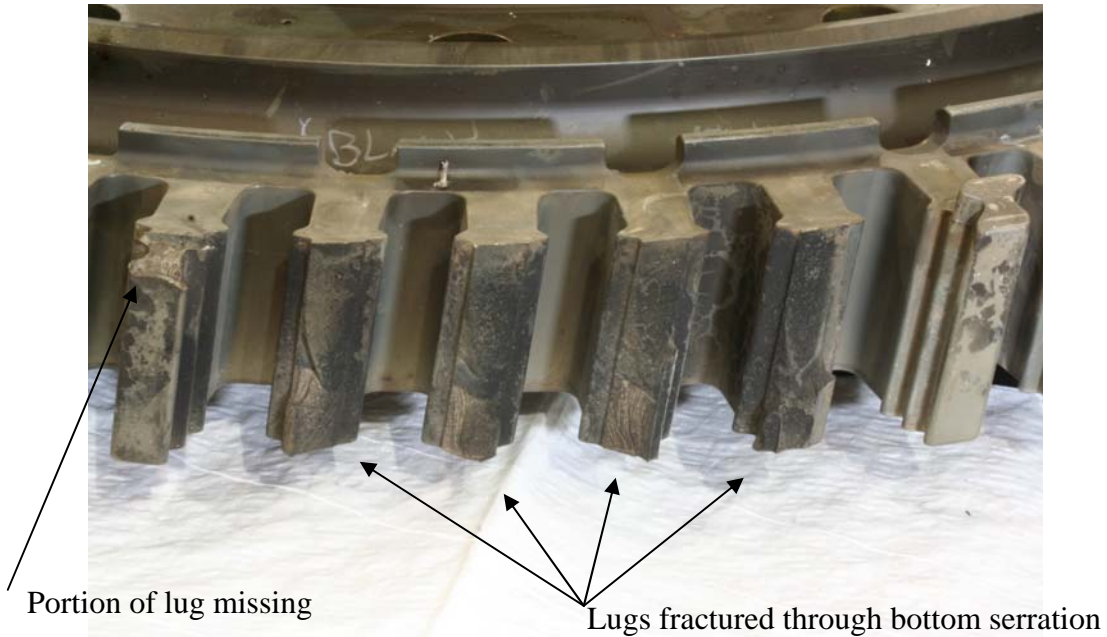


Figure 2. 2nd stage HPT hub showing five consecutive lug fractures

Source: Pratt & Whitney

The damage within the HPT module indicated that the four 2nd stage turbine blades separated simultaneously and then, within one-quarter revolution, penetrated the HPT and LPT cases at the flange. According to 14 CFR 33.19, 33.75, and 33.94, turbine blade separations should be contained. However, the regulations require the containment of only a single blade release. Thus, the simultaneous release of four large PW2037 2nd stage turbine blades exceeded the design capability of the cases and resulted in an uncontainment.

Delta Air Lines also reported finding, during a routine overhaul, an American Airlines PW2037 2nd stage turbine hub with cracks in two adjacent blade retaining lugs.⁵ In addition, the Safety Board has learned that at least four other PW2037 2nd stage turbine hubs have had cracks in the blade retaining lugs. The Board has been unable to obtain specific details about these four PW2037 2nd stage turbine hubs because P&W, despite being a party to this investigation, has not yet responded to the Board's requests for information about these hubs. P&W did state that in 2006, in response to these cracked hubs, it added to the PW2037 engine manual an inspection of the 2nd stage turbine blades to check for uneven wear on the blades' root serrations.⁶ However, neither the Delta Air Lines nor the American Airlines engines received

⁵ The PW2037 2nd stage turbine hub had been installed on an American Airlines (and a former Trans World Airlines) Boeing 757. American Airlines has the capability to overhaul Rolls-Royce RB211-535 engines, which power most of its Boeing 757 fleet, but had been contracting with Delta Air Lines for the overhaul of the PW2037 engines that were acquired from Trans World Airlines. According to maintenance records, the American Airlines PW2037 2nd stage turbine hub had operated 14,426 hours and 5,855 cycles since its last overhaul.

⁶ The inspection in the PW2000 Series Engine Manual, Task 72-52-17-200-014, HPT Second Stage Blade Assembly – Inspection/Check – 14, “Visually Inspect HPT 2nd Stage Blade Assembly Root Contact Marks,” was incorporated into the manual in the February 1, 2006, revision.

this inspection because their last overhaul occurred before P&W revised its engine inspection procedures.

P&W stated that some of the previous cracks in the PW2037 2nd stage turbine hubs might have been related to the dimensional spacing of the root serrations in the hubs and/or the blade roots, which resulted in the load being transferred to the bottom serrations. P&W accomplished a dimensional inspection of the Delta Air Lines 2nd stage turbine hub blade retaining lugs. P&W reported that at least several of the lugs did not conform to the engineering drawing because the blade retaining serrations appeared to have excess material and the serrations' surfaces were not flat. Because the investigation is ongoing, the effect of this nonconformance on the hub's blade retaining lugs is not yet known.

P&W also stated that the Delta Air Lines 2nd stage turbine hub with the fractured blade retaining lugs appeared to be different from the previous instances of 2nd stage turbine hubs with blade retaining lug cracks. However, in a May 6, 2008, briefing to the FAA on 14 CFR 21.3 events,⁷ P&W stated the American Airlines 2nd stage turbine hub had 2 lug cracks and 26 other crack indications. P&W's briefing to the FAA further indicated that the lugs that were measured were nonconforming.

Because the Delta Air Lines hub had five adjacent fractured blade retaining lugs and the American Airlines hub had two adjacent fractured blade retaining lugs, the Safety Board is concerned that a string of consecutively fractured blade retaining lugs could result in the simultaneous release of multiple blades, which would exceed the design capability of the engine's cases and lead to an uncontainment. In the Delta Air Lines event, the uncontained debris penetrated the engine's cases and cowling at the bottom and did no other damage to the airplane. However, if the debris had come out of the engine from the left side rather than at the bottom, it would have been directed at the fuel tank in the wing, which could have resulted in a fuel leak and fire.

The Safety Board is concerned about the risk of uncontained failures in high time PW2037 engines, such as the Delta Air Lines and American Airlines engines, that have not had inspections of the 2nd stage turbine blade roots for uneven wear. The Board is also concerned about the possibility of two potential failure modes because of P&W's statement that the fractures on the Delta Air Lines 2nd stage turbine hub appeared to be different from previous events. However, P&W's briefing to the FAA, which indicated that the American Airlines 2nd stage turbine hub's retaining lugs were nonconforming, suggests that the problem may be more widespread in the PW2037 fleet.

The Safety Board concludes that the serious nature of these two independent potential failure modes, which could cause future uncontained engine failures, requires timely action to address the hazard until the cause of the failures can be determined and appropriate action can be taken to prevent a recurrence. Therefore, the Safety Board believes that the FAA should require that P&W PW2037 engines be removed from service for inspection of the 2nd stage turbine hubs

⁷ Title 14 CFR 21.3, "Reporting of Failures, Malfunctions, and Defects," states that the holder of a type certificate shall report to the FAA any failure, malfunction, or defect in any product, part, process, or article that it determines has resulted in an occurrence such as an engine failure.

when they have accumulated significantly fewer hours and/or cycles than the incident engine (10,880 hours and/or 4,392 cycles). The Safety Board further concludes that the risk of future uncontained 2nd stage turbine hub failures in PW2037 engines will not be eliminated with only a one-time inspection. Therefore, the Safety Board believes that the FAA should require that P&W PW2037 2nd stage turbine hubs undergo recurring inspections when they have accumulated significantly fewer hours and/or cycles than the incident engine (10,880 hours and/or 4,392 cycles) until the cause for the previous instances of cracking is identified and corrective action to prevent future cracking is implemented.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require that Pratt & Whitney PW2037 engines be removed from service for inspection of the 2nd stage turbine hubs when they have accumulated significantly fewer hours and/or cycles than the incident engine (10,880 hours and/or 4,392 cycles). (A-08-85) Urgent

Require that Pratt & Whitney PW2037 2nd stage turbine hubs undergo recurring inspections when they have accumulated significantly fewer hours and/or cycles than the incident engine (10,880 hours and/or 4,392 cycles) until the cause for the previous instances of cracking is identified and corrective action to prevent future cracking is implemented. (A-08-86)

In response to the recommendations in this letter, please refer to Safety Recommendations A-08-85 Urgent and A-08-86. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our Tumbleweed secure mailbox procedures. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Acting Chairman ROSENKER and Members HERSMAN, HIGGINS, SUMWALT, and CHEALANDER concurred with these recommendations.

[Original Signed]

By: Mark V. Rosenker
Acting Chairman