National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 13, 1999

In reply refer to: A-99-51 through -54

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On October 15, 1998, Delta Air Lines flight 915, a McDonnell Douglas MD-88, N902DE, experienced an uncontained failure[1] in the No. 2 (right) engine, a Pratt & Whitney (P&W) JT8D-219, immediately after takeoff from Logan International Airport, Boston, Massachusetts. The pilots reported that, just after takeoff, they felt a light thump, the airplane yawed to the right, and the cockpit instrumentation indicated that the No. 2 engine had lost power. The pilots then declared an emergency and returned to Boston. None of the 128 passengers, 4 flight attendants, and 2 pilots on board were injured. The airplane was operating on an instrument flight rules flight plan under the provisions of 14 Code of Federal Regulations Part 121 as a regularly scheduled passenger flight from Boston to Atlanta, Georgia.

The examination of the No. 2 engine revealed that the rear sections of the upper and lower forward cowl doors were deflected away from the engine and that the rear cowl doors were missing. The airplane's vertical stabilizer and fuselage adjacent to the No. 2 engine sustained minor damage from impact by the upper cowling. Subsequent disassembly of the engine revealed the combustion chamber outer case (CCOC) had ruptured axially from the fuel drain boss[2] at the bottom of the case.

The CCOC is a barrel-shaped structure that houses the combustion chambers and contains four circular-shaped bosses, mounted on which are two igniter plugs, a pressure port, and a fuel drain (see figure 1). The ruptured CCOC was assembled in six pieces: the front flange[3] and body, the four bosses, and the rear flange. The front flange and body of the case and the four bosses were made of AMS [Aerospace Material Specification] 5613 410 stainless steel,[4] and all of the

[1] An uncontained engine failure occurs when an internal part of the engine fails and is ejected through the cowling or causes other pieces of the engine to be ejected through the cowling.
[2] A boss is a raised or reinforced portion of a part onto which a smaller part is attached.
[3] A flange is a thin extension from an object that is used to attach that object to another.
[4] AMS 5613 410 stainless steel is an iron-based alloy with 0.12 percent carbon and 12.5 percent chromium.

pieces of the case were welded together using 410 stainless steel weld wire, as specified by the CCOC's engineering drawing.

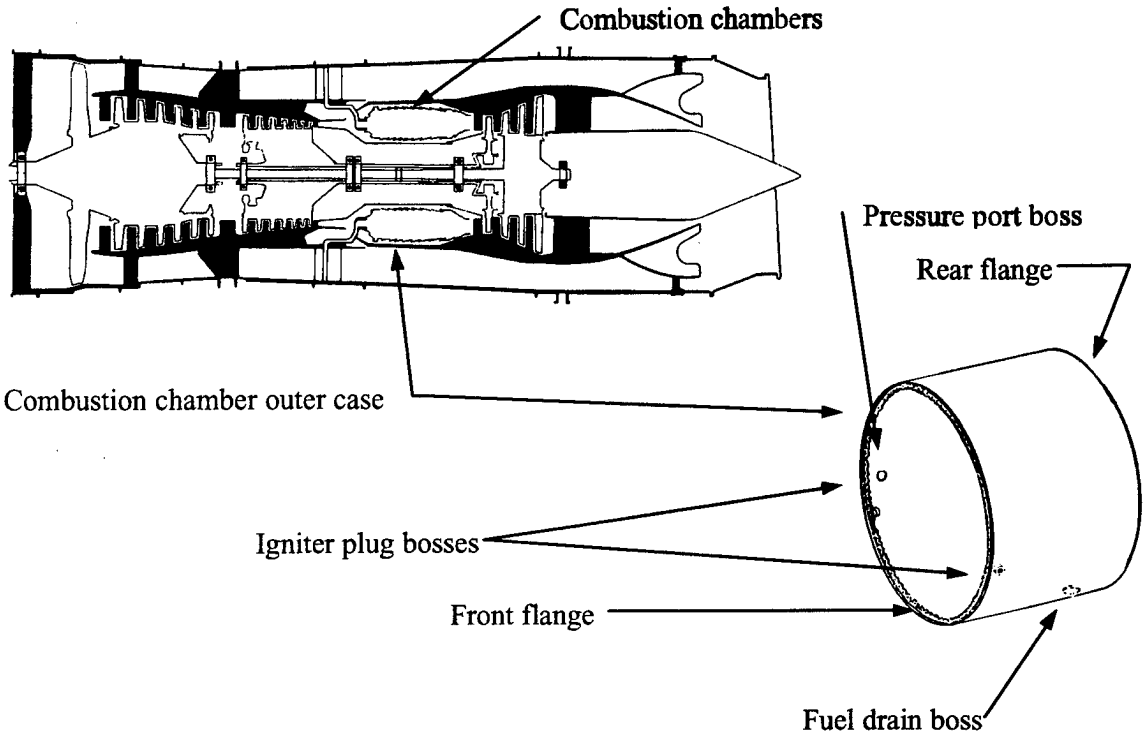

Figure 1. JT8D-200 engine cross section showing the location of the CCOC, and an enlarged view of the CCOC showing the location of the bosses and the case's front and rear flanges.

The ruptured CCOC was examined at the National Transportation Safety Board's materials laboratory. This examination revealed a fatigue fracture that had multiple origins along the weld on the exterior side of the fuel drain boss. The fracture had propagated about 150° around the boss and then axially, about 1½ inches forward and ½ inch rearward. The fatigue striations indicated that the crack had existed for approximately 1,340 cycles before the CCOC ruptured. The fracture originated from a mechanically thinned area of the boss' flange that had grinding marks consistent with previous work. The measured thickness of the boss flange adjacent to the fatigue fracture was 0.080 inch; however, the fuel drain boss' engineering drawing required a thickness of 0.099 to 0.109 inch.

The ruptured CCOC was manufactured by P&W in October 1986. Manufacturing records show that, after assembly, the CCOC was rejected twice during postwelding inspections because of crack indications and/or weld imperfections in two of the boss welds. The CCOC was reworked[5] by P&W after each rejection, and the part was accepted after its third inspection.

[5]According to the P&W JT8D-200 Engine Manual Section 72-41-11, Repairs -02, -03, and -07, the procedure for repairing or reworking a CCOC that has crack indications or imperfections in a boss weld is to use a grinder to

Delta Air Lines' maintenance records show that the ruptured CCOC had been in service for 28,502.6 hours and 24,294 cycles since new and that the CCOC had been installed on the engine in May 1995 during the last overhaul, 9,084.9 hours and 6,978 cycles before the rupture occurred. The records show that the CCOC, before installation on the engine, had undergone fluorescent penetrant and magnetic particle inspections with no cracks noted. The records do not show any weld repairs to the ruptured CCOC's bosses. Because the metallurgical examination revealed that the cracking initiated approximately 1,340 cycles before the rupture, the Safety Board concludes that the crack had not initiated at the time of Delta's May 1995 engine overhaul.

Although this CCOC rupture was the first to occur on a JT8D-200 engine, the JT8D-1 through -17AR engines, which have a CCOC that is very similar to the JT8D-200 CCOC,[6] have had at least 10 CCOC ruptures that initiated from boss welds and at least 9 others from rear flange bolt holes.[7] Because of the history of CCOC ruptures and cracking, the Federal Aviation Administration (FAA) issued a series of airworthiness directives (AD), including AD 96-23-14, which mandates repetitive on-wing eddy current and ultrasonic inspections of the JT8D-1 through -17AR CCOC bosses and rear flange. The Safety Board notes that P&W developed one-piece CCOCs that have thicker flanges and integral bosses for the JT8D-1 through -17AR and JT8D-200 engines. Because these bosses are not welded in, the boss weld from the area where the cracks that led to ruptures were initiating would thus be eliminated for engines with the one-piece case. Therefore, the Safety Board believes that the FAA should require that all P&W JT8D-1 through -17AR and JT8D-200 engines have a one-piece, integral boss CCOC installed at the next shop visit that the engine's CCOC becomes accessible.

Because of the size of the JT8D-1 through -17AR and JT8D-200 operating fleet, it will be several years until all of the engines are retrofitted with the one-piece, integral boss CCOC. Thus, interim actions are also needed.

Because the maintenance records indicated that Delta did not accomplish any weld repairs to the ruptured CCOC, the Safety Board concludes that the grinding adjacent to the weld that thinned the fuel drain boss flange was done by P&W during its rework of the CCOC.[8] The Safety Board is concerned that other JT8D-1 through -17AR and JT8D-200 CCOCs that were reworked during manufacture may have been accepted with a below-minimum thickness case wall or boss flange from which a crack could initiate and propagate to rupture. Therefore, the Safety Board believes that the FAA should require, as an interim action, P&W to identify all JT8D-1 through -17AR and JT8D-200 engine CCOCs that had boss welds reworked during manufacture; require repetitive on-wing inspections of those CCOCs for boss weld cracks at intervals appropriately less than 1,340 cycles in service; and, if cracks are found, require the removal of those engines from

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rout out the area of the indication or imperfection and adjacent weld material before rewelding the part. The repair procedures further state that the material adjacent to the weld must not be reduced.

[6] The JT8D-1 through -17AR and JT8D-200 engines are type certificated separately.

[7] FAA Service Difficulty Report (SDR) data identified only 5 of the at least 19 CCOC ruptures on JT8D-1 through -17AR engines. The Safety Board has frequently found that the SDR database does not capture many reportable events.

[8] Although P&W's acceptance in 1986 of a CCOC with a below-minimum thickness boss flange raises questions about the adequacy of its postmanufacturing inspection procedures at that time, this issue is no longer relevant because P&W is currently producing only the one-piece, integral boss CCOC.

service for replacement of the CCOC. Periodic inspections should continue until a one-piece, integral boss CCOC is installed.

The Safety Board notes that, as a result of the CCOC rupture incident, Delta Air Lines developed an on-wing procedure to inspect all of its JT8D-200 engines that have a similar CCOC to the one that ruptured. Delta found that eight CCOCs had cracks in the boss welds and reported that all of these CCOCs were removed from service. In addition, during shop inspections, Delta found four other CCOCs that had cracks around the boss welds. According to Delta, a visual inspection of these 12 cases did not reveal any evidence of mechanical thinning adjacent to the crack,[9] as was found on the CCOC that ruptured.

On March 31, 1999, P&W issued Alert Service Bulletin (ASB) JT8D A6359 (effective May 1, 1999), which calls for an initial on-wing inspection procedure for JT8D-200 CCOC fuel drain boss weld cracks.[10] However, an ASB is only a recommendation by a manufacturer to the operators and therefore does not require that the action be accomplished, as would be the case if the action were contained in an FAA AD. P&W stated that, as of May 13, 1999, it had not received any reports from JT8D-200 operators of CCOC inspections accomplished in accordance with ASB JT8D A6359 or occurrences of CCOC cracking.

The Safety Board has no reason to believe that Delta's findings from its on-wing inspection procedure would be atypical of the remainder of the JT8D-200 engine fleet. As previously stated, it will be several years before all of the affected JT8D-200 engines can be disassembled to permit the installation of a one-piece, integral boss CCOC. Therefore, the Safety Board believes that the FAA should require, as an interim action for those P&W JT8D-200 engine CCOCs that did not have the boss welds reworked during manufacture, repetitive on-wing inspections of the bosses at appropriate intervals for cracks in the welds and, if cracks are found, require the removal of those engines from service for replacement of the CCOC. Periodic inspections should continue until a one-piece, integral boss CCOC is installed.

In addition, Delta reported that its inspections found four CCOCs with nonmagnetic bosses. Because 410 stainless steel is magnetic, this finding indicates that those CCOC bosses were manufactured with an alternate material, the properties of which were not evaluated for the design and certification of the CCOC. In ASB JT8D A6359, P&W stated that the use of this alternate material is likely to reduce the crack propagation life. Therefore, the Safety Board believes that the FAA should require a one-time inspection to identify any P&W JT8D-1 through -17AR and JT8D-200 CCOCs with nonmagnetic bosses. If such bosses are found, require the removal of those engines from service for replacement of the CCOC with a one-piece, integral boss CCOC.

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

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[9] The cycles since new for the 12 CCOCs with cracks ranged from 15,724 to 24,805, and the cycles since last inspection ranged from 5,575 to 11,799.

[10] The ASB stated that recurring inspection intervals for the fuel drain boss and initial and recurring inspections for the pressure port boss would be provided in a forthcoming ASB.

Require that all Pratt & Whitney JT8D-1 through -17AR and JT8D-200 engines have a one-piece, integral boss combustion chamber outer case (CCOC) installed at the next shop visit that the engine's CCOC becomes accessible. (A-99-51)

Require, as an interim action, Pratt & Whitney to identify all JT8D-1 through -17AR and JT8D-200 engine combustion chamber outer cases (CCOC) that had boss welds reworked during manufacture; require repetitive on-wing inspections of those CCOCs for boss weld cracks at intervals appropriately less than 1,340 cycles in service; and, if cracks are found, require the removal of those engines from service for replacement of the CCOC. Periodic inspections should continue until a one-piece, integral boss CCOC is installed. (A-99-52)

Require, as an interim action for those Pratt & Whitney JT8D-200 engine combustion chamber outer cases (CCOC) that did not have the boss welds reworked during manufacture, repetitive on-wing inspections of the bosses at appropriate intervals for cracks in the welds and, if cracks are found, require the removal of those engines from service for replacement of the CCOC. Periodic inspections should continue until a one-piece, integral boss CCOC is installed. (A-99-53)

Require a one-time inspection to identify any Pratt & Whitney JT8D-1 through -17AR and JT8D-200 combustion chamber outer cases (CCOC) with nonmagnetic bosses. If such bosses are found, require the removal of those engines from service for replacement of the CCOC with a one-piece, integral boss CCOC. (A-99-54)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman