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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: August 25, 1995

In reply refer to: A-95-81 through -83

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

About 12:50 p.m. eastern daylight time, on August 21, 1995, an Atlantic Southeast Airlines (ASA), Embraer EMB-120, N256AS, operating as Delta Airlines flight 7529, made an off airport forced landing near Carrollton, Georgia. The pilots reported an engine failure as the flight was climbing through about 18,000 feet. Flight 7529 was en route from Atlanta, Georgia, to Gulfport, Mississippi, as a scheduled commuter passenger flight operating under the provisions of Title 14 Code of Federal Regulations (CFR) Part 135. There were 26 passengers, two pilots, and one flight attendant aboard the flight.

The airplane hit trees and crashed about 4 to 5 miles southeast of the West Georgia Regional Airport. The airplane broke apart during the crash sequence, and a severe ground fire erupted. The captain and four passengers have died. Many of the other occupants sustained serious impact and burn injuries.

The readouts of the cockpit voice recorder (CVR) and flight data recorder (FDR), examination of the wreckage, and observations of the passengers aboard flight 7529 have revealed that an emergency involving the left engine occurred suddenly as the airplane was climbing through 18,000 feet. The pilots advised air traffic control (ATC) that they had an engine problem and initially requested to return to Atlanta. Later, the pilots advised ATC that they were unable to maintain altitude and that they needed to land at an emergency airport immediately. The controller pointed out that the West Georgia Regional Airport was about 10 miles away.

The CVR and FDR showed that the pilots had difficulty maintaining altitude

and heading. The airplane continued its descent until it hit the ground. Although the investigation is continuing, the evidence gathered thus far has raised serious concerns that the Safety Board believes that the Federal Aviation Administration (FAA) should take immediate action to correct. In accordance with the provisions of Annex 13 to the Convention on International Civil Aviation, accredited representatives from the Department of Civil Aviation/Department of Investigation and Prevention of Aeronautical Accidents (DAC/DIPAA) of Brazil and the Transportation Safety Board of Canada (TSBC) are participating as the countries of manufacture of the airframe and of the engines, respectively.

Examination of the wreckage has revealed that a portion of one of the four propeller blades of the left engine had separated in flight. This was confirmed by the passengers' observations and statements by the flightcrew that the left engine was severely damaged and had misaligned from its installed position during the flight. The propeller blades are manufactured by Hamilton Standard Corporation. The blade installed on the EMB-120 is a model 14RF.

The inboard portion of the fractured propeller blade that remained attached to the propeller hub was immediately removed from the propeller assembly and transported to the Safety Board's laboratories in Washington, D.C., for examination. The separated portion of the blade has not yet been recovered. The examination has revealed that the blade spar fractured at blade station 16.6, which is located about 13.2 inches outboard from the blade butt end. The spar fracture was on a flat transverse plane and contained crack arrest positions typical of fatigue cracking. The fatigue crack had emanated inside-outward from an origin area on the taper bore hole of the blade. A large ratchet mark[1] with smearing damage was noted at the origin area. From the origin area, the fatigue cracking propagated toward the flat side (face) of the blade and circumferentially around both sides of the taper bore hole. The fatigue cracking had progressed through about 75 percent of the spar cross section before the remainder of the blade separated in overstress.

Preliminary examinations have revealed that the taper bore surface, including the area adjacent to the fatigue initiation area, contained a series of nearly circumferential abrasion marks within a distance of about 1.5 inches inboard of the fracture surface. The taper bore was free of abrasion marks further inboard. High

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[1] A ratchet mark is a vertical step in the fracture plane that typically separates fatigue origin areas on slightly offset planes

magnification examination revealed small corrosion pits in the taper bore surface adjacent to the fatigue origin area. In addition, examination of the origin area with a scanning electron microscope has found the presence of chlorine-rich deposits on the fracture adjacent to one of the origin areas.

The Safety Board has been involved in the investigation of three other in-flight failures of Hamilton Standard models 14SF[2] and 14RF propeller blades in the past 2 years. On March 13, 1994, an Inter-Canadien ATR-42-300, Canadian registration CG-IQV, experienced an in-flight separation of the propeller assembly, the engine inlet duct, and the reduction gear box of the right engine while climbing through 16,500 feet about 80 miles southeast of Val d'Or, Quebec. The airplane landed successfully. The reduction gearbox and propeller assembly were recovered and examined at the laboratories of the TSBC in Ottawa, Ontario. The investigation was conducted under the direction of the TSBC, and the Safety Board participated in the investigation in accordance with the provisions of Annex 13.

Examination of the Canadian ATR-42 airplane revealed a 41-inch-long by 1-inch-wide vertical gash in the right side of the fuselage between bulkheads 21 and 22 adjacent to passenger seat row 3. There was some damage to seat 3D, skin damage to the wing leading edge inboard of the nacelle, and minor buckling of the lower wing surface and landing gear fairing.

The investigation determined that a portion of one of the propeller blades had separated chordwise about blade station 22 (about 18.5 inches from the blade butt end). The metal spar section of the blade at this point is about 5 inches wide and 2 inches thick with composite material forming the airfoil section. The fracture surface showed that fatigue cracking had initiated at the base of a small corrosion pit (about 0.03 inch deep and 0.07 inch diameter) along the wall of the tapered balance weight hole in the spar. Four other corrosion pits were noted in the general location of the fracture similar in depth and size to that found at the fatigue origin. Origin of the fatigue cracking was on the taper hole surface in the area corresponding to the face of the blade. The cracking propagated toward the face of the blade and in opposite directions toward the leading and trailing edges of the blade. The cracking covered about 75 percent of the surface of the fracture.

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[2] The model 14SF propeller blades installed on the ATR-42 are similar in design to the model 14RF blades installed on the EMB-120. Similarly designed Hamilton Standard blades are installed on several other turbopropeller-model airplanes.

Examination of the fatigue crack revealed striation banding from the face of the blade to the terminus of the crack that appeared to be associated with the number of flight cycles of the airplane. The striations suggested about 1,800 cycles (flights) before the crack propagation processed rapidly to overstress failure.

The failed propeller blade had accumulated about 12,038 flight hours and 12,630 cycles since new. The propeller had been overhauled at 4,748 hours and 5,357 cycles.

On March 30, 1994, a Nordeste Airlines Embraer EMB-120 lost a major portion of one blade of a Hamilton Standard model 14RF composite blade while at cruise at 22,000 feet over Brazil. An uneventful engine-out landing was performed at Salvador, Brazil. Although no fuselage damage was noted, the cabin depressurized and there was structural damage to the left engine and nacelle. The investigation was conducted by the DAC/DIPAA of Brazil. The Safety Board participated in the investigation in accordance with the provisions of Annex 13.

Examination of the fractured blade revealed fatigue cracking in a similar location and manner as on the Canadian ATR-42 airplane. The fracture was located at blade station 17.9 (about 14.5 inches from the butt end), and the origin area of the fatigue cracking was at a corrosion pit with a depth of 0.024 inch.

The fractured blade had accumulated about 4,210 flight hours and 5,010 cycles since new. It had never been overhauled.

According to the Hamilton Standard representatives, the Canadian and Brazilian occurrences were the first such failures of models 14SF and 14RF propeller blades. Both fatigue fractures were believed to have initiated from corrosion pits in an area where a cork is inserted into the taper bore to retain lead wool inserted to balance the blade.

The models 14SF and 14RF propellers were first manufactured in 1985 and are used on a variety of airplanes, including the DeHavilland DASH-8, ATR-42 and -72, ATP, EMB-120, SAAB 340B, CASA CN 235, and Canadair CL-215T airplanes. According to FAA officials, about 15,000 propeller blades of this type are in service worldwide, with about 4,900 operating in the United States.

As the result of these two blade failures, on April 18, 1994, Hamilton

Standard issued alert service bulletins (SBs), and on April 22, 1994, the FAA issued airworthiness directive (AD) 94-09-06. AD-94-09-06 called for a one-time ultrasonic inspection of the taper bore areas of the Hamilton Standard models 14SF and 14RF propeller blades within 45 days of the effective date of the AD (May 2, 1994). The inspection could be accomplished with the propellers installed on the airplane.

According to preliminary information, the failed propeller blade from Delta flight 7529 had been inspected in accordance with AD-94-09-06 on May 19, 1994. The blade was rejected by an ultrasonic "indication"[3] and was sent to Hamilton Standard for further inspections and work. Maintenance records indicate that an incoming inspection confirmed the indication that was located about blade station 18.5 on the face of the blade. The taper bore area was visually inspected by borescope, and no cracks or corrosion pits were noted. The taper bore area was blended locally over a diameter of about 1¼ inches, and a final ultrasonic inspection revealed that the indication was no longer present. The blade was then returned to service on September 30, 1994. At the time of the accident, the blade had accumulated about 2,398 flight hours and 2,425 cycles since it was returned to service.

AD-94-09-06 was superseded by AD-95-05-03, effective March 23, 1995, which only addresses blades that have not been shot peened.[4] AD-95-05-03 calls for, in general, an ultrasonic inspection of the affected blades that had accumulated 1,750 cycles since the last ultrasonic inspection required by AD-94-09-06 (paragraph (a) (1)) and thereafter a repetitive ultrasonic inspection at intervals not to exceed 1,250 cycles since the last inspection (paragraph (a) 2)). It also calls for terminating action by December 31, 1997.

The terminating action (paragraph (d)) of AD-95-05-03 includes removal of the cork and lead wool balance material from the blade, cleaning of the bore surface, and borescope inspection of the taper bore for corrosion pits in accordance with the provisions of various SBs issued by Hamilton Standard. Paragraph (d)(2)

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[3] An "indication" refers to an echo on the ultrasonic inspection that might indicate a crack or other defect that needs further examination

[4] The surface of the taper bore on about 12,000 of the 14SF and 14RF blades were shot peened during production. As a result of process changes during the production history, about 3,000 of the blades were not shot peened inside the taper bore

specifies: "For blades found with no corrosion pits, mark the blade and return it to service in accordance with the Hamilton Standard SB's listed in paragraph (d) of this AD." The separated blade from Delta flight 7529 had markings consistent with the requirement, even though it was inspected before AD-95-05-03 was issued, apparently because the markings on the blade were applied as specified in the SB's instructions.

The Safety Board believes that the abrasion marks found on the taper bore surface of the blade from flight 7529 were created during the maintenance and inspection activities at Hamilton Standard in 1994. The Safety Board is concerned that the fatigue failure may have initiated from these abrasion marks or from corrosion pits that existed before the maintenance was performed.

The Safety Board is concerned that other models 14SF and 14RF propeller blades may have fatigue cracking that has not been detected by current airworthiness actions and that an in-flight blade separation could lead to another catastrophic accident. The Safety Board is also concerned that the terminating actions contained in existing ADs are not sufficient to prevent other cracking from occurring. The Safety Board believes that the FAA should require an immediate ultrasonic inspection before further flight[5] of all Hamilton Standard models 14RF and 14SF propeller blades[6] that have accumulated more than 1,250 cycles since the last ultrasonic inspection, regardless of whether the terminating actions of AD-95-05-03 have been previously accomplished.

The Safety Board is aware that none of the previous failures that initiated in the taper bore have been on blades with a shot-peened taper bore. Nevertheless, it is likely that corrosion could also occur in some of these blades that have not been overhauled. Additionally, to the Safety Board's knowledge, none of these blades have been ultrasonically inspected since the inspection required by AD 94-09-06. Therefore, the Safety Board believes that the FAA should evaluate the need for additional inspections for these shot-peened blades to verify that corrosion is not occurring in the taper bore.

Hamilton Standard specialists calculate that the corrosion pits on the blade

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[5] The Safety Board acknowledges that the FAA may have to permit special flight permits to enable operators to move the airplanes to a location where inspections can be performed.

[6] Applicability should reference blades cited in paragraph (a)(2) of AD 95-05-03.

from the Canadian ATR-42 were of a size that would be expected to initiate fatigue cracking. However, corrosion pits on the blade from the Brazilian EMB-120 were not large enough to have initiated fatigue cracks, given the loading spectrum that is expected for that blade.

On August 3, 1995, the major portion of another model 14RF propeller blade separated in flight from the right engine of a LUXAIR EMB-120, Belgium registration LX-LGK. The propeller assembly and gearbox also separated from the airplane; however, the airplane landed successfully at Luxembourg with no other significant damage. The investigation of that incident is under the direction of the Civil Aviation Administration of Belgium. The Safety Board is assisting in the investigation in accordance with the provisions of Annex 13.

The separated blade and associated gearbox and propeller assembly were recovered. The butt and remaining portion of the blade were shipped to Hamilton Standard in the United States for examination under the supervision of the Safety Board on behalf of the Belgium authorities. Examination of the blade revealed that it had fractured in fatigue at station 9, substantially inboard of the previous failures. The fatigue had propagated for about 75 percent of the cross section before it separated in overstress. The fatigue had initiated on the exterior of the blade spar on the flat (face) side. The location and mechanism of the origin is not similar to that of the previous failures involving the Canadian and Brazilian airplanes or the current failure of the Delta flight 7529 propeller.

Preliminary analysis of the fracture on the Belgium EMB-120 suggests that the origin of the fatigue was from an external "ding" on the flat surface of the blade. The source of this mechanical damage has not been determined; however, Hamilton Standard representatives have suggested that such damage could have been created during the original manufacture of the blade or by improper handling of the propeller assembly when it was not attached to the gearbox. They reported that they had seen cases where a propeller assembly had been placed on the top of an open-ended metal drum with the shank of the blades in direct contact with the hard metal rim of the drum. This is not in compliance with the maintenance manual procedures. Such a practice could cause damage that could initiate fatigue cracking.

The blade loading on the EMB-120 installation is reportedly one of the lightest of the various uses of the Hamilton Standard 14 series propeller blades.

However, because three of the four failures have occurred on blades installed on EMB-120 airplanes, the Safety Board is concerned that the vibrational characteristics and loading of this propeller/engine/airframe combination may not be fully understood, and that an analysis of the propeller loading for the EMB-120 installation should be conducted. This concern extends to the possible lack of understanding of the effects on the fatigue life and resonant frequencies of the blades from in-service wear and maintenance practices.

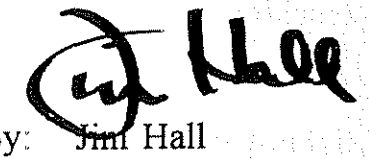
As a result of its preliminary findings in this accident, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Immediately implement the ultrasonic inspection program on Hamilton Standard propeller blades cited in paragraph (a)(2) of airworthiness directive (AD) 95-05-03, irrespective of prior compliance with paragraph (d) of the AD. Require the initial inspection before further flight on any propeller blades that have accumulated 1,250 cycles since the last ultrasonic inspection or since the visual and borescope inspection required by paragraph (d) of the AD. (Class I, Urgent Action) (A-95-81)

Conduct a vibration and loads survey and analysis of the propeller installation on the Embraer EMB-120 airplanes with applicable Hamilton Standard propellers throughout the ground and flight operating range of the engine with specific consideration for the effects of propeller in-service wear, maintenance, or other changes may have on the resonant frequencies. Based on the findings, broaden the survey and analysis to other installations as appropriate. (Class II, Priority Action) (A-95-82)

Review the current overhaul and inspection requirements for all Hamilton Standard 14 series propeller blades for which the taper bore hole has been shot peened to determine whether additional inspections or maintenance should be required. (Class II, Priority Action) (A-95-83)

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



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Chairman