Log 2390

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: November 3, 1992

In reply refer to: A-92-114 through -117

Honorable Thomas C. Richards
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On October 4, 1992, El Al flight 1862, a Boeing 747-200F, crashed shortly after takeoff from Schiphol Airport in Amsterdam, The Netherlands. The airplane struck an apartment complex about 6 miles from the airport. Three flight crewmembers, the one passenger, and about 50 persons on the ground were killed. The airplane was destroyed by impact and severe ground fire.

The investigation of this accident is under the jurisdiction of the Aeronautical Inspection Directorate of The Netherlands Department of Civil Aviation, Ministry of Transport and Public Works. The National Transportation Safety Board and other U. S. investigators are participating in the investigation as the State of Manufacture of the airplane, in accordance with the provisions of Annex 13 to the Convention on International Civil Aviation. The U.S. Accredited Representative from the Safety Board is the leader of the U.S. team, which consists of investigators from the Safety Board, Federal Aviation Administration (FAA), Boeing Commercial Airplane Company, and Pratt & Whitney.

Flight 1862 departed runway 01L at Schiphol Airport about 17:22 UTC en route to Tel Aviv, Israel. About 6 minutes after takeoff, the flightcrew declared a MAYDAY, reported a problem with the No. 3 engine, and stated their intent to return to land. The flightcrew then reported problems with the No. 4 engine and flaps shortly before the airplane crashed. According to preliminary information gathered during the investigation, including information from air traffic control radar

data and from the airplane's flight data recorder (FDR) (the cockpit voice recorder has not been recovered), the airplane had reached about 6,000 feet when the Nos. 3 and 4 engines suddenly lost power. The airplane made about 1 3/4 circles to the right before descending into the ground. The FDR data recovered to date shows no obvious anomalies prior to the loss of thrust on the two engines.

Recovery of wreckage to date and eyewitness reports show that the Nos. 3 and 4 engines separated in flight and that damage occurred to the leading edge of the right wing between the two engines. Both engines, part of the engines' support structures (engine to wing pylons), and portions of the right wing leading edge material have been recovered on land and in the water, about 6 miles from the main impact area.

The portions of engines and cowling that were recovered indicate that the No. 3 engine separated first, rotated outboard and struck the No. 4 engine before the No. 4 engine separated from the airplane. The focus of the investigation, which is still underway, has been on the No. 3 pylon-to-wing attachments and, specifically, because of known service problems, the midspar attachment hardware. There are two midspar attachments for the engine pylon, and each of them consists of a lug attached to the wing spar that mates with a clevis on the pylon structure. The lug and clevis are joined by the transverse insertion of a fuse pin. Significant portions of both the inboard and outboard midspar attachments were found. On the inboard side, the wing lug and most of the pylon clevis were recovered, but no parts of the fuse pin were found. On the outboard side, one-half of the wing lug and the entire pylon clevis were found. In addition, the center portion of the outboard fuse pin that passed through the wing lug remained with the lug and was recovered. The ends of the fuse pin which passed through the pylon clevis were not found.

An examination of the inboard midspar attachment hardware disclosed that the wing lug and the inboard lug of the pylon clevis were undamaged around the circumference of the fuse pin hole. The outboard lug of the pylon clevis was broken, and a circumferential segment around the fuse pin hole was missing. It has not been determined whether the fracture resulted from impact loads, preexisting corrosion, or low cycle, high stress fatigue damage. However, the chord of the missing segment was less than the diameter of the fuse pin. Thus, for the wing lug and pylon clevis to have separated, the inboard fuse pin had to have been broken or the retaining nut had to have separated and permitted the pin to migrate transversely out of position.

An examination of the outboard midspar attachment hardware disclosed that both the recovered portion of the wing lug and pylon clevis were circumferentially intact around the fuse pin hole and that the fuse pin fractures permitted the separation of the lug and clevis. A metallurgical examination of the recovered portion of the fuse pin revealed fatigue cracking in a radial direction that extended through about 50 percent of the pin wall on the outboard fracture surface. However, the Safety Board's metallurgist noted that the ultimate overload fracture did not appear to have emanated from the fatigue area. Thus, the Safety Board believes that the evidence to date is insufficient to determine conclusively whether the pylon separation initiated as a result of the outboard fuse pin fatigue cracking or whether the cracking and ultimate fracture of the outboard pin was secondary to some other structural failure, possibly a fracture of the inboard fuse pin.

The midspar pylon attachment fuse pins on B-747 airplanes have a history of service problems dating back to the late 1970s. The fuse pins installed in airplanes manufactured in the 1970s were of a one piece design ("old style" pins). It was determined that these pins were susceptible to cracking from fatigue as a result of circumferential machine grooves in the bore recesses. On August 10, 1979, Boeing responded to this problem by issuing Service Bulletin (SB) 747-54-2063, which established a recurrent inspection program for the fuse pins. The inspection interval cited was 2,500 hours. In 1981, Boeing developed a "new style" fuse pin that consists of a cylindrical pin with inserts in each end retained by a through bolt and washer assembly. The new style pins were installed in newly manufactured airplanes and were made available to replace the old style pins of the older airplanes.

On November 14, 1986, the FAA issued Airworthiness Directive (AD) 86-22-01 mandating the inspection program of Boeing SB 747-54-2063 on the old style pins. A revision of the SB was included in the AD that provided for the replacement of the old style pins with new style pins, serving as terminating action for the inspection requirements. Subsequently, an operator reported observing a crack in a new style pin that was determined to have initiated from corrosion pits on the inner circumference surface. On March 29, 1990, Boeing issued another revision to SB 747-54-2063 that detailed a one-time inspection of the new style pins for evidence of corrosion and the presence of primer on the internal surface. On May 28, 1991, the FAA issued AD 91-09-01 mandating the one-time inspection requirement.

On December 29, 1991, a China Airlines, Ltd., B-747-200F crashed near Taipei, Taiwan. The circumstances of that accident were similar to those of the October 4, 1992, accident in Amsterdam. During the investigation, it was

conclusively established that the Nos. 3 and 4 engines and part or all of their respective pylons separated from the airplane. Furthermore, there is evidence that the No. 3 engine struck the No. 4 engine cowling during the separation. However, the cause of the engine separation remains undetermined, and the pylon-to-wing attachment hardware has not been recovered.

Although both the El Al and the China Airlines airplanes were originally manufactured with the old style fuse pins in 1979 and 1980, respectively, it has been established that the fuse pins in the Nos. 3 and 4 pylon attachments on the China Airlines airplane had been replaced with the new style pins in accordance with the relevant SB and AD. Records show that the fuse pins in the Nos. 3 and 4 pylon attachments on the El Al airplane had not been replaced. Moreover, the recovered part of the No. 3 midspar pin confirmed that the old style pins were still on the airplane prior to the accident.

On September 16, 1992, Boeing issued an All Operators Letter that described a pending SB addressing an inspection program for the new style fuse pins. The SB was prompted by the circumstances of the China Airlines accident and a subsequent incident in which Argentina Aerolineas found a severed outboard midspar new style fuse pin at the No. 3 pylon attachment. The condition was found during a walk around inspection in which the right-hand side of the No. 3 pylon was observed to be about 3/4 inch lower than the left-hand side.

The Boeing letter of September 16 advised operators that an SB would be forthcoming that would describe a visual and ultrasonic inspection of the fuse pins for corrosion and cracks, as well as actions to take if anomalies were found. The letter also stated that Boeing was investigating a redesign of all B-747 engine strut attachment fuse pins. Boeing indicated that the FAA would follow the SB with an AD making the provisions of the SB mandatory.

The proposed SB described in the Boeing letter was undergoing coordination and approval at the time the Amsterdam accident occurred. After the accident, on October 5, 1992, Boeing issued the proposed SB as Alert SB 747-54A2150. The Alert SB provides for procedures to inspect engine strut midspar fuse pins for cracks and corrosion on B-747 airplanes powered by Pratt & Whitney JT9D and Rolls Royce RB211 engines. The inspection program addressed only the new style fuse pins. Although it was not known at the time the Alert SB was issued, the bulletin would not have applied to the El Al airplane. Consequently, the FAA's telegraphic AD T92-21-51, which was issued on October 8, 1992, was expanded beyond the

scope of the SB to mandate new inspection programs for both the old style and new style fuse pins. Specifically, the AD requires:

> For old style fuse pins, an initial ultrasonic inspection within 30 days (by November 7, 1992) and recurrent inspection every 500 landings.
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> For new style fuse pins, initial inspections of the pins on pylons 2 and 3 before 5,000 total landings or within 30 days, whichever occurs later; initial inspections of pylons 1 and 4 before 5,000 total landings or within 60 days, whichever occurs later; recurrent inspections of all pylons before 1,000 landings if no corrosion or cracking is found, or before 500 landings if light corrosion is found and removed; and visual inspection of the pylon-to-wing attachment fitting.

In addition to issuing the AD, the Safety Board understands that the FAA has requested Boeing to validate the loads and vibration spectrum for the pylon attachments and structure throughout the airplane's flight envelope.

The Safety Board supports the FAA's issuance of AD T92-21-51 and related actions to examine pylon loads. However, the Safety Board believes that more stringent measures are needed to reassure the continued airworthiness of the B-747 fleet. Moreover, the Safety Board is aware that this view is shared by the airworthiness authorities of some foreign countries.

Specifically, the Safety Board believes that service experience indicates that the recurrent inspection interval (500 cycles) for the old style pins is too long. The summary of Revision 9 to Boeing SB 747-54-2063 cites an incident in late 1985 or early 1986 in which an operator reported finding a fractured midspar old style fuse pin that had accrued only 691 flight hours since it had been ultrasonically inspected per the SB. As in the case of the recent Argentina Aerolineas incident, this fractured pin was also detected during a ground visual inspection by the observation of pylon misalignment. Moreover, the investigation of the Amsterdam accident disclosed that the fuse pins in the engine Nos. 3 and 4 pylon attachments had been ultrasonically inspected 1,136 flight hours before the accident. The Safety Board is concerned that, in the old style fuse pins, the propagation of a fatigue crack from just below the ultrasonically detectable crack size to final failure may occur in considerably fewer cycles than the currently required inspection interval of 500 cycles (approximately 2,000-2,500 flight hours with average airplane use). The Safety Board believes that an inspection interval of 100 cycles or less should be

established and that the replacement of the old style pins should ultimately be required.

In addition, the Safety Board is concerned that a crack in the new style pins could also propagate in fatigue more rapidly than the inspection intervals set forth in AD T92-21-51. The Safety Board is aware that corrosion and cracks in the new style pins have been reported per the provisions of the AD and believes that, based on these findings, the FAA should determine if the recurrent inspection interval for these pins should be reduced.

The finding of a cracked lug during an inspection of a Virgin Atlantic airplane and the fact that the cause of the engine separation in the China Airlines accident remains undetermined leads the Safety Board to concur with the recommendation of the United Kingdom's Civil Aviation Authority that an ultrasonic inspection of the midspar attachment wing lug and pylon clevis should be required in lieu of the visual inspection now specified. The Safety Board also believes that an inspection program for the diagonal strut attachment and the upper link attachment should be included since the fuse pins in these attachments are similar in design to the midspar fuse pins and a failure at these attachments will affect the loads applied at the other attachments.

The Safety Board is also unaware of any rationale for the exclusion of airplanes powered by General Electric (GE) engines from the mandated inspection program for the new style pins. The Safety Board believes that pending the completion of a loads and vibration survey of pylon attachments and the determination of identifiable differences between the GE and Pratt & Whitney engine installations, the GE installations should be added to the AD requirements.

The Safety Board does not know the scope of the Boeing loads and vibration survey but believes that it should include sufficient flight test and engineering analyses to fully establish the load spectra at each pylon-to-wing attachment point and to validate the existing safety margins of the structure.

On October 6, 1992, Boeing issued another Alert SB 747-54A2151, which provided instructions to add a midspar fuse pin indication stripe to each side of each nacelle strut. According to Boeing, the indication stripe will provide an easy visual indication of misalignment between the pylon and the aft fairing and could reveal a fractured fuse pin or midspar attachment fitting. Thus, by emphasizing the need for visual observation of the pylon/wing area by flight crewmembers or maintenance personnel before each flight, the risk of engine separation during flight can be

reduced. The Safety Board believes that accidents might already have been avoided by preflight observation of pylon misalignment on at least two occasions--the incident mentioned in SB 747-54-2063 and the more recent incident involving Argentina Aerolineas. Further, the Safety Board is not certain that the flight cycle thresholds and intervals specified for the FAA's AD inspection program have been validated by tests or analyses. Therefore, the Safety Board believes that the FAA should mandate the compliance with Boeing Alert SB 747-54A2151 by issuing an AD. The Safety Board does not view the indicating stripe and preflight observation requirement as a substitute for the actions necessary to correct any structural deficiencies in the pylon design or in the pylon-to-wing attachment hardware, but believes the additional level of redundancy is warranted in the event that deficiencies remain unidentified.

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

Issue a new AD or revise AD T92-21-51 to:

(1.) Reduce the recurrent inspection interval for the old style fuse pins from 500 cycles to 100 cycles or less and specify a time or cycle limit for removal of the old style fuse pins from service.

(2.) Reduce the inspection intervals for the new style pins if the need for a reduction is indicated by the inspection results that are being reported per the current AD requirement.

(3.) Require an ultrasonic inspection, in lieu of the current visual inspection, of the wing spar lug and pylon clevis of the midspar attachments.

(4.) Establish an inspection requirement for the upper link and diagonal brace attachment hardware.

(5.) Apply the inspection program for the new style pins and the pylon attachment fittings to GE-powered airplanes. (Urgent Followup Action) (A-92-114)

Issue a telegraphic Airworthiness Directive to require the installation of a midspar fuse pin indicating stripe on each side of the Boeing 747 engine nacelle struts, in accordance with the provisions of Boeing Service Bulletin 747-54A2151, and to require a check for wing-to-pylon misalignment before each flight. (Urgent Followup Action) (A-92-115)

Require that the Boeing Commercial Airplane Company obtain flight test data that can be used in an engineering analysis to validate that the pylon-to-wing attachments have adequate safety margins for all flight conditions and engine configurations. (Priority Followup Action) (A-92-116)

Require that the Boeing Commercial Airplane Company make available a newly designed fuse pin for the Boeing 747 engine pylon-to-wing midspar attachment to replace current fuse pins that are susceptible to corrosion or fatigue cracking. (Priority Followup Action) (A-92-117)

Chairman VOGT, Vice Chairman COUGHLIN, and Members LAUBER, HART, and HAMMERSCHMIDT concurred in these recommendations.

Susan M. Coughlin Acting Chairman

By: Carl W. Vogt
Chairman