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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: July 22, 1985

Forwarded to:

Honorable Donald D. Engen
Administrator
Federal Aviation Administration
Washington, D. C. 20591

SAFETY RECOMMENDATION(S)
A-85-53 through -56

On May 11, 1985, the captain of a Saudi Arabian Airlines Boeing 737-200 airplane aborted a takeoff from Doha Airport, Qatar, following a catastrophic and uncontained failure of the No. 2 engine. A fragment from the engine penetrated a wing fuel tank and the No. 2 engine caught fire. The airplane was stopped on the end of the runway, and the 98 passengers and 6 crewmembers evacuated the airplane while the airport fire department extinguished the fire. There were no injuries to the occupants as a result of the engine failure and fire.

Investigation of the accident disclosed that the 2nd stage low-pressure turbine (LPT) disk in the Pratt & Whitney JT8D-15 engine ruptured, and that a large segment of the disk exited the engine near the 1:30 o'clock position (aft looking forward). The released segment passed through the engine and caused substantial damage to the low-pressure nozzle case, the hush package and the fan bypass duct outer case. Considerable damage was inflicted on the No. 2 engine nacelle by engine fragments and the ensuing fire.

Examination of the 2nd stage LPT disk revealed that about a 40-degree segment of the disk between the circular channel, which mates with the rotating outer air seal (air seal), and the outside diameter (OD) of the rim was missing. The circular channel in the LPT disk for the air seal is a groove approximately 0.135 inch wide and 0.150 inch deep. The inner wall of the groove forms a mounting shoulder for the air seal. The examination revealed that the fracture had progressed along the bottom corner radius of the inner wall of the groove. The fractured surface evidenced fatigue failure with multiple origins. It appears that following release of the segment, the imbalance of the LPT resulted in total destruction of the turbine blades and the nozzle vanes of the 2nd, 3rd, and 4th stages of the LPT. All engine damage other than the rupture of the 2nd stage disk appeared to have been secondary damage.

The air seal provides mid-span support and stabilizes the 2nd stage LPT disk. The air seal also confines the hot exhaust gases to the gaspath through the turbine section. If for any reason the air seal is loose during engine operations, high and potentially damaging stresses materialize in the 2nd stage turbine disk. For this reason, the tightness of the fit

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of the air seal is critical. Air seal looseness manifests itself as galling (frictional wear damage caused by two parts rubbing together with limited motion) of the groove surfaces and the inside diameter (ID) lip of the air seal. Severe galling creates pockets or cavities which can serve as origins for fatigue. The JT8D engine repair manual provides instructions on how to rework and restore the parts to a serviceable standard if galling is discovered during LPT overhaul. These instructions have been in effect for many years and have been used by most JT8D overhaul and repair facilities to repair 2nd stage LPT disks. The engine manufacturer concedes that because of the small size of the air seal groove in the disk, both plating and machining operations are difficult to perform and that the bottom radii limits of the groove, which are critical, are difficult to inspect for proper plating and machining using conventional methods.

The 2nd stage LPT disk which ruptured in this accident had the air seal groove repaired in accordance with the engine repair manual when it was last processed through overhaul. According to the engine records, the turbine disk and air seal were assembled to the tight limit of the tightness specifications in the manual. The engine operated for a total of 2,731 hours (2,599 cycles) after the repair. Since the fracture appeared to originate at or near the bottom corner radius of the groove, a replication of the groove was made and checked on a comparator at high magnification. This check indicated that the corner radius was approximately 0.010 inch, or considerably sharper than the 0.020 to 0.030 inch specified.

The failure of the 2nd stage LPT disk on the Saudi Arabian airplane was very similar in most respects to the six previous uncontained 2nd stage disk failures on JT8D-15 and -17 engines which occurred on the takeoff roll or initial climb. Following the second failure of a 2nd stage LPT disk (United Airlines Boeing 727 at Chicago in June 1983), the engine manufacturer issued two Service Bulletins (SB) to correct the problem; SB-5510 issued on December 19, 1983, revised February 13, 1984, and Alert SB-5541, issued on April 30, 1984, revised May 4, 1984. Basically, SB-5510 recommended an inspection of the air seal groove on the 2nd stage LPT disk and the inside diameter (ID) of the seal for evidence of galling. SB-5510 recommended that if galling was evident, the parts be reworked as prescribed in the engine repair manual. SB-5510 also provided for a tighter fit between the inside diameter of the air seal and the inner wall of the groove on the disk. This tighter fit is applicable to all 2nd stage LPT disks in all series of the JT8D model engine.

Service Bulletin 5541 prescribed an inspection time interval for accomplishing the provisions of SB-5510 on all -15, -17, and -17R series engines. Subsequently, on September 24, 1984, the Federal Aviation Administration (FAA) issued Airworthiness Directive (AD) 84-16-03 which made the provisions of Service Bulletins 5510 and 5541 mandatory on the JT8D-15, -17, and -17R series engines. The AD required that the modification be accomplished within 5,000 to 17,000 hours operating time whenever the LPT was disassembled for any reason and within 18,000 hours if not accomplished previously.

Five of the 2nd stage LPT disk failures have occurred since SB-5510 and SB-5541 were issued (see attachment 1 for the engine manufacturer's list of 2nd stage disk failures through June 14, 1985). However, none of the seven 2nd stage LPT disks had been assembled to the tigher fit described in SB-5510, nor was the modification required at the time of the last disassembly of the involved LPTs, which in all cases antedated the AD. The manufacturer has a high level of confidence that the air seal fit tolerance prescribed in SB-5510 will eliminate the problem. However, the inherent problems associated with the difficult rework process of the groove remain, and the original disks may be approaching a critical period in their operating life because of the looser fit specification that was applicable during their assembly. Furthermore, experience has shown that the progression to failure is accelerated for disks which have been repaired to correct previously detected air seal groove deficiencies. We believe that the potential for more 2nd stage LPT disk failures is high in the JT8D-15, -17, and -17R engines with the attendant possibility of serious consequences.

We recognize that any solution to the problem is complicated by the fact that it is not known how many repaired disks currently are in service and by the fact that the LPT must be removed from the engine and completely disassembled in order to inspect the air seal groove in the disk. It is estimated that there may be as many as 1,000 to 1,500 repaired disks in service in JT8D-15, -17, and -17R engines on B-727, B-737, and DC-9 airplanes with most of them assembled to the looser fit specification. Further, there appears to be no easy solution to the problem other than identification and removal from service of 2nd stage LPT disks with a high potential for failure and subsequent repair and reassembly in accordance with the specifications in SB-5510. Since records showed that the disk which failed on May 11, 1985, had been assembled to a looser fit between the disk and the air seal that was specified in the engine repair manual, the Safety Board believes that the manufacturer should continue studies to verify that the tighter fit provided by SB-5510 is an adequate solution to the problem. The Safety Board believes that the hazards attendant on a rupture of the disk could be catastrophic and, therefore, that the possibility of a rupture must be eliminated as quickly as possible.

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

> Identify the Pratt & Whitney JT8D-15, -17, and -17R series engines in service that have had repairs made to the rotating outer air seal groove in the 2nd stage low-pressure turbine (LPT) disk and which were not reassembled to the tolerances in SB-5510, and require early disassembly of the 2nd stage LPT module for inspection, repair, and reassembly in accordance with SB-5510, or some other approved procedure. (Class II, Priority Action) (A-85-53)
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> Because of the limited operational experience with engines modified in accordance with SB-5510, conduct a directed safety investigation of the Pratt & Whitney JT8D-15, -17, and -17R series engines as LPT modules are disassembled to verify the effectiveness of the tighter fit between the 2nd stage LPT disk and the rotating outer air seal in preventing fatigue cracking of the disk at the air seal groove. (Class II, Priority Action) (A-85-54)
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> Conduct a directed safety investigation of the Pratt & Whitney JT8D-15, -17, and -17R series engines to establish an appropriate inspection program for the engines that have not had repairs to the rotating outer air seal groove in the 2nd stage LPT disk to assure the continued integrity of the disks. (Class II, Priority Action) (A-85-55)

Notify appropriate foreign civil aviation authorities and foreign operators of airplanes equipped with Pratt & Whitney JT8D-15, -17, and -17R series engines of the failures associated with the rotating outer air seal groove on the 2nd stage LPT disk in these engines and of the actions which should be taken to minimize or eliminate the failures. (Class II, Priority Action) (A-85-56)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY, Member, concurred in these recommendations.

Jim Burnett

By: Jim Burnett
Chairman

ATTACHMENT No. 1

SUMMARY OF JT8D LOW PRESSURE TURBINE
2ND STAGE DISK FAILURES

AS OF: June 10, 1985

No.	DATE	OPERATOR	JT8D DASH	DISK REPAIRED	(HRS.) DISK TT / TSO	SB-5510 INCORP.	INVESTIGATION FINDINGS
1.	2/1981	Cruziero Air	-17	Yes	11,244 / 4,773	No	Contamination of nickel plating - Fatigue fracture from multiple origins at the ID & OD Snap diameters.
2.	8/1983	United Airlines	-15	No	14,667	No	Multiple origins at bottom of snap channel. Loose radial fit indications.
3.	5/1984	Air Canada	-15	Yes	17,423 / 3,598	No	Origin at sharp radius in nickel plate on OD snap diameter. Loose radial fit indications.
4.	6/1984	Syrian Air	-17	Yes	14,807 / 6,649	No	Multiple origins at sharp radius in nickel plate. Loose radial fit indications.
5.	12/1984	Royal Brunei	-15	No	15,020	No	Multiple origins at bottom of snap channel. Loose radial fit indications.
6.	1/1985	Air Algerie	-15	Yes	14,245 / 4,066	No	Currently under investigation in Materials Laboratory Findings not released as of this date. (similar to #1 through 5 above)
7.	5/1985	Saudi Arabian Airlines	-15	Yes	21,976 / 2,731	No	Engine disassembled and critical parts sent to Materials Laboratory for analysis. (similar to #1 through 5 above)