

Log 1880



# National Transportation Safety Board

Washington, D.C. 20594  
Safety Recommendation

Date: April 7, 1986

In reply refer to: A-86-25 through -29

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

The Safety Board has been reviewing problems that have been experienced by the Pratt & Whitney Aircraft JT8D-1 through -17AR engines. These problems include failures of combustion chambers, removable sleeve spacers in the high-pressure compressor, combustion chamber outer cases, second-stage low-pressure turbine disks, second-stage fan blades, and high-pressure and low-pressure turbine blades.

On February 5, 1986, during a walkaround predeparture inspection of an Eastern Airlines (Eastern) Boeing 727 at LaGuardia Airport in New York, New York, a hole was discovered in the No. 1 engine cowling at the 10 o'clock position, aft looking forward (ALF). The airplane had operated earlier in the day as flight 344 from West Palm Beach, Florida. The flightcrew of flight 344 said there were no engine problems during the flight.

Inspection of the engine, a Pratt & Whitney JT8D-15, disclosed that the No. 8 combustion chamber (10 o'clock position ALF) was cracked and burned severely from the third liner band to the rear support mount; approximately 60 percent of the chamber was missing. The uncontained hot combustion gases burned a 1-inch by 3-inch hole through the inner wall of the combustion chamber outer case. The hot combustion gases escaping from the hole in the outer case subsequently burned a 3-inch by 3-inch hole in the fan air outer duct and the 4-inch by 6-inch hole in the airplane engine cowling discovered during the walkaround inspection.

Examination of the other eight combustion chambers on the engine revealed that all eight chambers had extensive axial and circumferential cracking; three chambers had large areas of burned and missing liner material. Further, the attachment bolts for the retaining pin of the No. 3 combustion chamber (about 4 o'clock ALF) had backed out of their mating threads in the diffuser case, permitting the combustion chamber to become detached from its forward mount.

The engine records indicate that the combustion chambers had been installed in the engine in December 1980 and had accumulated 16,327 operating hours and 10,710 cycles since that time. The engine was repaired in an engine maintenance shop on February 15, 1982, because of foreign object damage (FOD) it had sustained, and again on October 24, 1984, because of excessive gearbox oil consumption. There is no record to indicate that the combustion chambers had been inspected during either shop visit or at any other time since December 1980. The operating time or cycles and the extent of any repair work accomplished on these chambers prior to December 1980 is not known. However, previous weld repairs were evident on the liners, and because there is no record that these repairs were made after December 1980, the total operating time on these chambers must have been more than 16,327 hours.

The engine on which these combustion chambers were installed had been maintained by Eastern under an engine condition (performance) monitoring (ECM) program approved by the Federal Aviation Administration (FAA). A successful ECM program compares engine operating data (such as rotor speeds, fuel flow, and exhaust temperature) gathered during stabilized flight with baseline data and detects, at an early time, abnormal variations (or trends) in engine performance. The program includes monitoring trends of engine characteristics, such as starting and acceleration times. Abnormal variations or trends indicate the need for maintenance.

The potential catastrophic effects of cracked combustion chambers was demonstrated in an accident on August 22, 1985, in which a British Airtours Boeing 737 experienced failure of a combustion chamber (No. 9) in a JT8D-15 engine on takeoff from Manchester, England. In that accident, however, the outer combustion case ruptured, and fragments of the engine punctured a wing fuel tank, resulting in a catastrophic fire which destroyed the airplane, fatally injuring 55 persons.

On August 28, 1985, as a result of the Manchester accident, the FAA issued Telegraphic Airworthiness Directive (TAD) No. T85-17-51, which required the immediate inspection for evidence of combustion chamber distress (and repair or replacement, if necessary) of all JT8D-15 engines with certain combustion chambers (Part Nos. 778714 and 778715), except for those engines maintained under an ECM program approved by the FAA. On September 25, 1985, the FAA revised the TAD to include the JT8D-1 through -17AR models of the engine, and all combustion chambers, except for those with Part Nos. 5001958 and 5001959. The revised TAD again exempted from the inspection those engines being operated under an approved ECM program.

On November 8, 1985, the FAA published a Notice of Proposed Rulemaking (NPRM) at 50 FR 46444, Docket No. 85-ANE-34, which proposed an Airworthiness Directive (AD) that would supersede the TADs and require, in accordance with specified time schedules, an initial and repetitive inspection and repair or replacement, if necessary, of the combustion chambers on JT8D-1 through -17AR engines operated with or without an ECM program. Those engines operated under an ECM program would be allowed a longer interval between the installation or repair date and the initial inspection. The proposed AD also would limit the maximum single circumferential crack length and the cumulative circumferential crack length that could be weld-repaired. On January 10, 1986, the Safety Board responded to the NPRM, agreeing that the actions of the proposed AD were urgently needed. The AD has not yet been issued.

In light of the incident of February 5, 1986, however, the Safety Board has reassessed its position on the AD, concluding that it is inadequate in several aspects. The severity of the deterioration of the combustion chambers on the No. 1 engine on the Eastern Boeing 727 strongly suggests that engines with an extensive accumulation of operating time since installation or repair of the combustion chambers should be inspected as soon as possible. However, the time schedules specified in the proposed AD do not specifically address very high-time engines and thus do not ensure their prompt inspection. In fact, under the proposed AD, the combustion chambers involved in the Eastern incident, which had accumulated at least 16,327 operating hours since installation without inspection or repair, would not have required inspection and repair until 1,000 hours (or 1,000 cycles, whichever occurs first) after the effective date of the AD. Further, under the schedules specified in the AD, these combustion chambers would not require inspection any sooner than the inspection of combustion chambers with less time on them, perhaps even thousands of hours less time.

The Safety Board concludes that the combustion chamber inspections should be scheduled so that those chambers with the greatest amount of time since installation or repair will be inspected first. Further, those combustion chambers with operating time significantly greater than the threshold limit requirements specified in paragraphs 2(b) or 2(c) of the proposed AD should be inspected (and repaired or replaced, if necessary) within less than the 1,000 hours (or 1,000 cycles whichever occurs first) permitted by the proposed AD.

The Safety Board also is concerned about the provisions in the proposed AD that would permit, under certain conditions, more time before inspection for engines operated under ECM programs than would be allowed for engines not operated under ECM programs. This concern arises because the engines on the Eastern Boeing 727 were being operated under an ECM program that should have detected abnormal variations or trends in the performance data or other characteristics of the engine and thus resulted in the removal of the combustion chambers of the No. 1 engine long before the incident of February 5, 1986. The deterioration of the majority of the combustion chambers on that engine clearly demonstrates that either the ECM program failed to provide warning indicators or the indicators were not used effectively. The Safety Board concludes that before permitting credit for the ECM program to extend the combustion chamber inspection threshold as cited in the proposed AD, the FAA should review each ECM program it has approved to ascertain that these programs can provide sufficient advance warning of combustion chamber deterioration to warrant the extension of time. Further, the FAA should monitor periodically the use of ECM programs by operators to ensure their continued effectiveness as a maintenance reliability tool.

Cracks in the combustion chambers are not the only problems operators of the JT8D-1 through -17AR engines have been experiencing. The JT8D engines also have been experiencing failures of the removable sleeve spacers in the high-pressure compressor. On September 6, 1985, a McDonnell Douglas DC-9 aircraft operated by Midwest Express Airline crashed shortly after takeoff at Milwaukee, Wisconsin, killing all 31 persons on board. Investigation of the accident disclosed a failure of the right engine, a JT8D-17 engine. The failure was caused by the fracture of the removable sleeve spacer between the ninth and tenth stage rotors in the high-pressure (HP) compressor of the engine. Pieces of the spacer and other engine parts penetrated the compressor case, the fan outer duct, and the engine cowling. The accident is still under investigation and the probable cause has not yet been determined. That fracture was the 46th recorded fracture of a removable sleeve spacer in the JT8D-1 through -17AR engines. (Another has occurred since this accident, in December 1985.) Sixteen of these fractures resulted in penetration of the compressor case, and of these, eight penetrated the engine cowling.

As a result of these spacer failures, on November 8, 1985, the National Transportation Safety Board issued Safety Recommendations A-85-120 and -121 to the FAA. These recommendations asked the FAA to require that all six removable sleeve spacers in the HP compressor be replaced with integral sleeve spacers as soon as practical, but not later than the next time the engine is in a facility in which the maintenance can be accomplished. The Board also recommended that the FAA notify foreign operators and authorities of this action.

On January 2, 1986, the FAA published a Notice of Proposed Rulemaking at 51 FR 37, Docket No. 85-ANE-46, in which it proposed to issue an AD that would require:

- (1) A one-time, on-wing, eddy current inspection of stages 7-8, 8-9, and 9-10 HP compressor removable sleeve spacers in accordance with Pratt & Whitney Alert Service Bulletin (ASB) No. 5649 for cracks at 12 critical locations;
- (2) Replacement of stages 7-8 and 9-10 stage removable sleeve spacers at next HP compressor rotor disassembly within the next 2 years or 4,000 cycles, whichever is later; and
- (3) Replacement of the 8-9, 10-11, 11-12, and 12-13 stage removable sleeve spacers with integral sleeve spacers, whenever the HP compressor is disassembled.

On February 18, 1986, the Safety Board commented on the NPRM, recommending that the 7-8 and 9-10 stage removable sleeve spacers be replaced as soon as practical; that is, the next time the engine is in a maintenance facility in which the compressor can be partially or completely disassembled, but no later than 4,000 cycles time-in-service from the effective date of the AD.

Safety Board comments were based on its understanding that the on-wing eddy current inspection could detect a crack in the pedestal of the spacer just below the knife edge seal, and that an existing crack undetected by the inspection would therefore take at least 8,000 cycles to propagate through the pedestal and into and across the cylinder of the spacer. However, the Board was subsequently informed by Pratt & Whitney that the on-wing inspection would not necessarily detect a crack until it had propagated almost into the spacer cylinder, at which time fracture of the spacer could occur in about 1,000 cycles.

The results of a statistical analysis performed by Pratt & Whitney using a probabilistic risk evaluation model (PREM) suggested that there was a 60-percent probability that there would be no additional cowling penetrations even if a crack cannot be detected until it propagates into the cylinder. According to Pratt & Whitney, 60 percent represents an acceptable engineering standard in the industry. The Safety Board reviewed this analysis with Pratt & Whitney's JT8D Engineering Program Manager and members of his staff. As a result of this review, the Board was concerned that certain data used in the PREM do not accurately reflect the recent frequency of spacer fractures and, therefore, the 60-percent probability may be optimistic. In fact, when Pratt & Whitney repeated the calculations using adjusted data (but still not quite the data that the Board believes accurately reflect the current situation), a 45-percent probability of no additional cowling penetrations resulted. The Board is concerned about this low probability level and the fact that even this level could be optimistic.

As a result of these developments, the Safety Board is concerned that the 4,000 cycles or 2 years, whichever is longer, provided by the proposed AD may not adequately protect against additional spacer ruptures and possible damage to vital components of airplanes. However, the FAA, Pratt & Whitney, and several air carrier operators have stated that, because of their concerns about the capacity limitations at overhaul and maintenance facilities, about delayed deliveries of the replacement integral sleeve spacer, and about difficulties in scheduling the repairs, the 2-year replacement timeframe is optimistic, and replacement of all removable sleeve spacers in the fleet in the 2 years is doubtful.

Discussion with the FAA, Pratt & Whitney, and several air carriers also has revealed that some airplanes powered by the JT8D-1 through -17AR engines fly routes of more than 3,000 and even 3,500 cycles per year. Thus, in only 2 years, these airplanes could be

flown 7,000 cycles or more. However, spacers that are found to be crack-free during the initial (and proposed to be a one-time) inspection already could have undetected cracks near the bottom of the pedestal of the inspected spacer, and these cracks could propagate through the cylinder and fracture the spacer in about 1,000 cycles. Consequently, it is clear to the Safety Board that a one-time inspection followed by replacement in 2 years or more may not adequately prevent additional spacer fractures.

As a result of these new considerations, the Safety Board believes that the on-wing eddy current inspection required by the proposed AD and set forth in Pratt & Whitney ASB No. 5649 must be repeated at 1,000-cycle intervals until stage 7-8, 8-9, and 9-10 removable sleeve spacers within the engine have been replaced by one-piece integral sleeve spacers.

In addition to combustion chamber cracks and removable sleeve spacer fractures, the JT8D engines have experienced failures of second-stage, low-pressure turbine disks because of cracks initiating in an air seal groove and failures of combustion chamber outer cases because of cracks initiating at the flanges and drain bosses. There also have been failures of second-stage fan blades, failure of high- and low-pressure turbine blades, and internal engine fires.

Many of the failed parts had accumulated considerable operating time since new or since repair. Some of the failed parts had time limits for their use, some had no time limits but were to be repaired or replaced only when necessary (on-condition), and some were on engines that were operated under ECM programs. These failures have prompted the Safety Board to issue safety recommendations, Pratt & Whitney Aircraft to issue service bulletins, and the FAA to issue TADs, revised TADs, NPRMs, and ADs. The suggested corrective measures included enhanced inspection programs and engine modifications.

The Safety Board is concerned that addressing each problem as it has arisen has resulted in a rather complex and unwieldy engine maintenance program which operators and repair facilities may find difficult to implement effectively. The Board believes that the FAA should convene a maintenance review board comprised of experts from Pratt & Whitney and maintenance and engine overhaul facilities to review the JT8D-1 through -17AR engine maintenance program, including the time limits on parts, hard time inspection requirements, engine modifications, and criteria for repair replacement of aging components.

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

Issue a Telegraphic Airworthiness Directive and amend the Airworthiness Directive proposed in the Notice of Proposed Rulemaking published at 50 FR 46444, Docket No. 85-ANE-34, to require that the combustion chambers of Pratt & Whitney Aircraft JT8D-1 through -17AR engines be inspected (and removed or repaired, as necessary) in accordance with Pratt & Whitney Service Bulletin No. 5649. Inspection of the combustion chambers should be scheduled with consideration given to combustion chamber time/cycles since installation or repair and to ensure that very high-time combustion chambers are inspected as soon as practical and well before the 1,000 hours (or 1,000 cycles) permitted in the proposed Airworthiness Directive. (Class II, Priority Action) (A-86-25)

Review all Federal Aviation Administration-approved Pratt & Whitney Aircraft JT8D engine condition monitoring (ECM) programs, and establish minimum standards for data reporting, input, and analysis such that all ECM programs can provide warning of combustion chamber deterioration sufficiently in advance of failure to warrant the extension of time to inspection permitted in the Airworthiness Directive proposed in the Notice of Proposed Rulemaking at 50 FR 46444 for engines operated under ECM programs. (Class II, Priority Action) (A-86-26)

Require that Principal Maintenance Inspectors periodically survey the use of Federal Aviation Administration-approved engine condition monitoring programs by air carrier operators to ensure that the data collection and analyses are effective in identifying engine problems. (Class II, Priority Action) (A-86-27)

Issue a Telegraphic Airworthiness Directive and amend the airworthiness directive proposed in the Notice of Proposed Rulemaking published at 51 FR 37, Docket No. 85-ANE-46, to require that the one-time, on-wing eddy current inspection specified in the proposed airworthiness directive be repeated at 1,000-cycle intervals until stage 7-8, 8-9, and 9-10 removable sleeve spacers between the high-pressure compressor are replaced with integral sleeve spacers. (Class II, Priority Action) (A-86-28)

Convene a maintenance review board with experts from the Federal Aviation Administration, Pratt & Whitney Aircraft, air carrier operators, and independent engine maintenance and overhaul facilities to review the maintenance reliability programs under which the Pratt & Whitney JT8D engines are being operated. This board would determine and implement any necessary improvements, including changes in the times between inspections, repairs, and replacement of engine parts, additions or deletions of parts or components permitted to be repaired or replaced only on-condition, and modifications of the use of engine condition monitoring programs. (Class II, Priority Action) (A-86-29)

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

  
By: Jim Burnett  
Chairman