DEPARTMENT OF TRANSPORTATION
TIONAL TRANSPORTATION SA TY BOARD
WASHINGTON, D.C. 20591

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OFFICE OF
THE CHAIRMAN

September 25, 1970

Honorable John H. Shaffer
Administrator
Federal Aviation Administration
Washington, D. C. 20590

Rec ~~CY 70-49~~
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Dear Mr. Shaffer:

The National Transportation Safety Board is now investigating the JT9D-3 engine failure and in-flight fire involving American Airlines, Boeing 747, N743PA, which occurred during takeoff from the San Francisco International Airport on September 18, 1970. A failure occurred in the No. 1 engine 13 seconds after lift-off, followed by a fire warning. The flight returned to the airport after shutdown of the engine and extinguishing of the engine fire.

During the return to the airport, the flightcrew experienced difficulty in extending the landing gear and the wing flaps after parts of the failed engine severed the hydraulic and pneumatic systems' supply lines. The captain elected to "go around" and extended the landing gear by the alternate system. The aircraft made a successful landing, and there were no injuries to the 15 crewmembers or the 127 passengers.

Our preliminary investigation of the engine failure revealed that a separation occurred to the rim portion of the second-stage turbine disk. It has been confirmed that failures of at least four of seven first-stage turbine blades contributed to the fracture of numerous second-stage turbine vane feet. As a result of the cumulative effect of the broken vane feet, an aft deflection of the nozzle support resulted, causing interference with and rubbing of the second-stage turbine disk. Progressive weakening of the disk rim area resulted in the in-flight failure of the rim. We have also confirmed that although failure mode of this second-stage turbine disk rim was similar to that of the Air France JT9D-3A engine failure of August 17, 1970, the failure mechanism was entirely different.

As a result of our investigation and meeting with Pratt & Whitney engineering staff personnel and your Eastern Region Flight Standards personnel, immediate inspection action was initiated. This was considered fully responsive to the immediate needs of this situation. The Safety Board commends the Administrator's formalizing this corrective action in the form of your engineering alerts of September 19 and 23, 1970.

In view of the potentially catastrophic results of the failure such as experienced by American Airlines, the Board remains concerned about this matter in the longer range sense and would urge the Administrator to initiate further expeditious actions in order to preclude recurrence of similar failures. Accordingly, the Board offers the following observations.

It is generally recognized that the JT9D engine is normally operating near critical turbine temperature conditions. This is particularly true when operating in high ambient temperatures. Several JT9D engines have recently been removed from service and returned to Pratt & Whitney for overhaul, because of failed first-stage turbine blades as well as broken second-stage vane feet. There is evidence that these failures had occurred as the result of operation at higher-than-desirable temperatures.

In the case of the most recent American Airlines turbine disk rim separation, there was evidence that at least six first-stage turbine blades had sustained varying degrees of fractures some time prior to the final failure. Our technical staff finds it most difficult to reconcile the fact that the airborne vibration monitoring equipment installed in the aircraft was either inadequate or was not effectively utilized in detecting this condition. We also feel that other engine instrumentation, namely: fuel flow, engine pressure ratio, and exhaust gas temperature should have been capable of collectively reflecting appropriate changes in the engine's operating parameters, if such instrumentation were properly calibrated and the respective readings were recorded and closely analyzed.

In this area, we recommend the following be considered.

1. Initiate appropriate action toward the operators' maintaining a program of current engine condition monitoring.

2. Review engine instrumentation calibration and existing instrument tolerances to assure the most precise engine operating parameter indications.

Further, it appears that the reliability of the Boeing 747 auxiliary power units is somewhat marginal. When engine starts must be accomplished by the use of ground units, pneumatic duct pressures may often be less than what is required, even when multiple units are used. The result is usually a start that may involve a temperature rise, approaching the "recoverable stall" condition. Since exhaust gas temperature, although above normal under these conditions often do not exceed the published limits, no record is made of these occurrences, and there is no possible way to determine how many times an engine hot section has been exposed to higher-than-normal temperatures. The effects of thermal transients are known to be cumulative and conceivably affect turbine blade reliability.

As another measure toward improving the service reliability of first-stage turbine blades, it is recommended that appropriate action be initiated to:

1. Improve the reliability of auxiliary power units in order to reduce the probability of high thermal transients while starting engines with marginal air supply.

2. Ensure that flightcrews maintain adequate pneumatic air duct pressure during engine starts.

3. Record any abnormal starts when an approach to a "recoverable stall" is experienced.

4. Establish precise limitations regarding the number of "approaches to recoverable stall" conditions which may be tolerated without cumulative adverse effects upon turbine blade durability.

The Safety Board is aware that the manufacturer has developed an improved type first-stage turbine blade (vented) which is expected to provide improved cooling characteristics and be more reliable when operating at high temperatures.

With respect to the improved first-stage turbine blades, the Safety Board recommends:

1. Incorporation of the "vented" first-stage turbine blade in all JT9D series engines be the subject of regulatory action as soon as sufficient production is assured and service bulletins and engineering orders are formulated by the manufacturer.

Water injection is presently being used on an optional basis by individual operators. Since water injection allows utilization of 45,000 pounds of thrust versus 43,500 pounds for takeoff, some operators elect to use water only when takeoff weight, runway lengths, and ambient temperature conditions require the maximum thrust rating of 45,000 pounds. We believe that the use of water injection on those aircraft so equipped would be beneficial in providing for turbine blade cooling. The Safety Board recognizes that there are some operators whose engines are not equipped for water injection at this time, and to require use of water injection for all takeoffs would constitute an economic burden. However, we believe that the benefits may justify the expense.

The Board, therefore, recommends the following:

1. Consideration should be given to require the use of water injection for all takeoffs regardless of takeoff thrust requirements.

2. Upon installation of the improved, "vented" turbine blades in all engines, the mandatory use of water injection could be rescinded.

Technical details of the items outlined above have been discussed by members of both your Eastern and Western Region engineering staffs and our Bureau of Aviation Safety investigative personnel. Our staff members will be available for further discussions, if desired.

Sincerely yours,

John H. Reed

John H. Reed
Chairman

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cc: NC-1(2), NM-2, NM-3, NM-4, NM-5, NE-1, NG-1, NP-1, NE-51, NE-513, NA-87c, NA-87, NE-515(3), NA-80(2), NA-81, NA-82, NA-88, NA-86(3), NA-86b, Sec. Volpe(5), Mr. Kemp-FAA-FS-50, Mr. Bardach-BOB, 1 each Field Office, NA-85(NAAIS) NOTATION 510 Approved by Board 9/25/70