LOG 1336

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: July 10, 1981

Forwarded to:

Honorable J. Lynn Helms
Administrator
Federal Aviation Administration
Washington, D.C. 20591

SAFETY RECOMMENDATION(S)

A-81-70

At 1755 eastern standard time, January 31, 1981, a Northwest Airlines, Inc., DC-10-40 departed Dulles International Airport for Seattle, Washington. While climbing through 6,000 feet, the flightcrew heard a loud noise, detected indications of a failure of the No. 3 engine, and felt airframe vibrations. The engine was shut down successfully, and there was no fire. The flight returned to Dulles and made a safe landing without further incident.

On May 15, 1981, as a result of the early metallurgical findings which indicated that the No. 30 fan blade in the No. 3 engine had failed at a point where it had been subjected to an electrical arc burn, the Safety Board adopted Safety Recommendations A-81-63 and -64 to the Federal Aviation Administration addressing the need for caution in conducting maintenance and inspection of titanium fan blades on the Pratt and Whitney JT9D-20 high-bypass turbofan engines. As the investigation continued, problems regarding the structural design of the nose cowl assembly, the fan case, the fan exit case, and their attaching mechanisms became evident.

Examination of the aircraft revealed that the No. 3 engine nose cowl assembly and the fan case had separated from the engine. The No. 30 fan blade had separated from the fan disc about 1 inch above the blade platform as a result of a chordwise fatigue crack and overload fracture, which initiated at the arc burn point. Of the 20 nose cowl-to-engine fan case attachment bolts on A-flange, 13 were missing, 6 had failed in shear, and 1 had pulled out of its nutplate. There were indications that some of the missing bolts had pulled out of their nutplates and that five of the fan case attachment lugs had failed laterally in bearing load.

The Safety Board determined that when the fan blade fractured, it struck the fan case and the inner nose cowl near the 6-o'clock position causing the loss of 2 to 5 A-flange nose cowl retention bolts in the area of the impact. The impact loads may have also caused B-flange bolt fractures and B-flange breakout in an area corresponding to the A-flange failures. The engine dynamic imbalance and the aerodynamic loads on the engine nose cowl loaded the remaining A-flange fasteners beyond their tensile strength and the flange joint began to separate.

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The bolts sheared in a sequential circumferential (unzipping) manner until only fasteners between the 1- and the 3-o'clock positions remained. Aerodynamic forces then lifted the cowl away from the engine, pivoting about the remaining bolts, stripping the bolts from their nutplates, and bending the flange backward and outboard. The cowl separated upward and outward and struck right wing slat No. 5. As the A-flange fasteners progressively separated, additional aerodynamic loading caused interaction between the fan blade tips and the fan case, and caused increased loading on the B-flange. The torsional loads imposed by fan blade tips striking the fan case and the additional aerodynamic loading caused failure of the B-flange fasteners. The unrestrained fan case moved in and out of the fan exit case and struck the fan exit guide vanes at random locations. The fan case was driven forward and was radially swung away from the engine, striking the fan exit case. The impact caused the fracture of a small section of the fan exit case B-flange and bent it backward and inboard. The fan case departed upward and inward and struck leading edge Nos. 1 and 2 slats on the right wing. The nose cowl and fan case from the No. 3 engine came to rest in a populated area.

Postincident examination also revealed that the Nos. 1, 2, and 5 leading edge slats on the right wing, and the No. 2 engine, had been damaged by foreign objects from No. 3 engine components and debris. Visual inspection of the No. 2 engine fan rotor revealed that 32 of the 46 fan blades had received such damage, which ranged from 0.030-inch nicks to 2- to 3-inch sections missing from the blades' leading edges at blade station 23.5, just below the outboard shroud. Six damaged blades from the No. 2 engine were examined metallurgically in an attempt to determine the composition of the material that the No. 2 engine had ingested. A test sample of material deposited on the No. 25 blade contained significantly higher quantities of iron than the titanium alloy of the fan blades. The fan case and fan exit case are made of stainless steel, which contains iron; consequently, fragments from these two components of the No. 3 engine probably damaged the No. 2 engine. With regard to the JT9D engine and its installation on DC-10 aircraft, the engine manufacturer is responsible for compliance with 14 CFR 33 and the aircraft manufacturer is responsible for compliance with 14 CFR 25. The nose cowl and fasteners for attachment to the JT9D engine are provided by the aircraft manufacturer but the cowl is fastened to the A-flange of the engine fan case which is provided by the engine manufacturer. It appears in this incident that the broken fan blade damaged the A-flange and fasteners (and probably the B-flange and fasteners) which allowed the nose cowl and fan case to separate from the engine in response to dynamic imbalance loads, aerodynamic loads, and fan-fan case interaction loads. We conclude that the failure of a single blade resulted in the loss of major engine components, foreign object damage to the No. 2 engine, and structural damage to leading edge devices. Although we recognize that this was the only failure of this type of engine installation, the Safety Board is concerned that these regulations as they existed for certification may not have been met with regard to the JT9D engine and its installation on the DC-10 aircraft.

The No. 30 fan blade from the No. 3 engine, serial No. BU9913, had accumulated 14,864 flight-hours and 9,699 cycles. It had been last inspected on December 9, 1980, and no discrepancies were noted. Since that time, the engine had been operated 306 hours and had accumulated 134 cycles. The blade had been reworked by TRW Components Division of TRW, Inc., Cleveland, Ohio, in November and December 1979. At that time, the following were accomplished: (1) Service Bulletin No. 4060, glass bead peening; (2) routine blending and overhaul; (3) hardface strip/removal; (4) rehardfacing; and (5) fluorescent dye penetrant inspection. As part of the incident investigation, the Safety Board observed both fan blade rework and overhaul processing procedures at the facilities of TRW, Inc., in Cleveland, and at Northwest Airlines' facilities in Minneapolis, Minnesota. No discrepancies in rework and processing procedures were identified.

Fourteen JT9D fan blade failures have been reported to the manufacturer since the engine went into service. Six failures have occurred on JT9D engines installed on DC-10 aircraft, and eight failures have occurred on JT9D engines installed on Boeing 747 aircraft. Damage to the 13 previous aircraft involved has varied from minor internal engine damage to engine nose cowl or fan case penetration to thrust reverser separation.

In the incident investigated, the Safety Board believes that the safe operation of the aircraft was jeopardized by the damage to the No. 2 engine and the leading edge devices, which resulted from the failure to contain the damage to the No. 3 engine. Therefore, the Safety Board recommends that the Federal Aviation Administration:

> Review the design of the flanges and fasteners on the forward and aft faces of the fan case of the JT9D turbofan engine to insure that the intent of airworthiness requirements provided in 14 CFR 33 and 14 CFR 25 are satisfied. (Class II, Priority Action) (A-81-70)

KING, Chairman, DRIVER, Vice Chairman, McADAMS, GOLDMAN, and BURSLEY, Members, concurred in this recommendation.

By: James B. King
Chairman