NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT INCIDENT REPORT

NORTHWEST AIRLINES 79
McDONNELL DOUGLAS DC-10-40, N143US
LEESBURG, VIRGINIA

JANUARY 31, 1981

NTSB-AAR-81-10

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NTSB-AAR-81-10	PB81-910410	

4. Title and Subtitle Aircraft Incident Report--Northwest Airlines Flight 79 McDonnell Douglas DC-10-40, N143US, Leesburg, Virginia, January 31, 1981

5. Report Date
July 7, 1981

6. Performing Organization Code

7. Author(s)

8. Performing Organization Report No.

9. Performing Organization Name and Address
National Transportation Safety Board
Bureau of Accident Investigation
Washington, D.C. 20594

10. Work Unit No.
3254A

11. Contract or Grant No.

12 Sponsoring Agency Name and Address

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20594

13. Type of Report and Period Covered
Aircraft Accident Report
January 31, 1981

14. Sponsoring Agency Code

15. Supplementary Notes
The subject report was distributed to NTSB mailing lists: 1A, 8A and 8B.

16. Abstract

About 1806 e.s.t. on January 31, 1981, the No. 3 engine failed as Northwest Airlines Flight 79, a McDonnell-Douglas DC-10-40, N143US, was climbing through 6,000 feet after departing Dulles International Airport, Chantilly, Virginia. The flightcrew performed the appropriate emergency procedures, requested an immediate return to Dulles, and dumped 40,000 pounds of fuel. The aircraft, with 10 crewmembers and 43 passengers aboard, landed on runway 12 at 1825 e.s.t. without further incident. No one aboard was injured, and damage to the aircrft was minor. There was no damage to property or injury to persons on the ground.

The National Transportation Safety Board determines that the probable cause of the incident was the high cycle fatigue fracture of the No. 30 fan blade in the No. 3 engine. The origin of the fatigue fracture on the leading edge of the fan blade was a preexisting high temperature arc burn from an undetermined source. Contributing to the damage to the aircraft and the No. 2 engine was the failure of the No. 3 engine nose cowl and fan containment case flanges/fasteners due to aerodynamic loading, fan imbalance, and fan/fan case interaction which resulted in an inflight separation of the nose cowl assembly and the fan containment case.

17. Key Words
Pratt-Whitney JT9D-20 engine; No. 30 fan blade; high cycle fatigue failure; electrical arc burn; nose cowl assembly; fan containment case; "A" flange; "B" flange; foreign object damage.

18. Distribution Statement
This document is available to the public through the National Technical Information Service-Springfield, Virginia 22161
(Always refer to number listed in item 2)

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	22	

NTSB Form 1765.2 (Rev. 9/74)

CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

Adopted: July 7, 1981

AIRCRAFT INCIDENT REPORT
NORTHWEST AIRLINES 79
McDONNELL DOUGLAS DC-10-40, N143US
LEESBURG, VIRGINIA
JANUARY 31, 1981

SYNOPSIS

About 1806 e.s.t. on January 31, 1981, the No. 3 engine failed as Northwest Airlines Flight 79, a McDonnell Douglas DC-10-40, N143US, was climbing through 6,000 feet after departing Dulles International Airport, Chantilly, Virginia. The flightcrew performed the appropriate emergency procedures, requested an immediate return to Dulles, and dumped 40,000 pounds of fuel. The aircraft, with 10 crewmembers and 43 passengers aboard, landed on runway 12 at 1825 e.s.t. without further incident. No one aboard was injured, and damage to the aircraft was minor. There was no damage to property or injury to persons on the ground.

The National Transportation Safety Board determines that the probable cause of the incident was the high cycle fatigue fracture of the No. 30 fan blade in the No. 3 engine. The origin of the fatigue fracture on the leading edge of the fan blade was a preexisting high temperature arc burn from an undetermined source. Contributing to the damage to the aircraft and the No. 2 engine was the failure of the No. 3 engine nose cowl and fan containment case flanges/fasteners due to aerodynamic loading, fan imbalance, and fan/fan case interaction which resulted in an inflight separation of the nose cowl assembly and the fan containment case.

FACTUAL INFORMATION

History of the Flight

On January 31, 1981, Northwest Airlines Flight 79, was being operated as a domestic scheduled passenger flight from Boston, Massachusetts, to Seattle, Washington, with an en route stop at Dulles International Airport, Chantilly, Virginia. The captain stated that the flight from Boston to Dulles was normal and he was impressed with the performance of the aircraft and engines. Flight 79 taxied from the Northwest Airlines ramp at 1755, 1/ received an instrument flight rules (IFR) air traffic control clearance, and was directed to runway 01L for takeoff.

The aircraft departed the airport at 1801, using level two reduced thrust takeoff setting, with the first officer flying the aircraft. Flap and landing gear retraction were normal and Flight 79 was cleared by Dulles Departure Control to turn directly on course to the Martinsburg Very High Frequency Omnidirectional Range (VOR) and to climb to 7,000 feet. The flightcrew stated that, as the aircraft was climbing through 6,000 feet, they heard and felt an explosion, accompanied by heavy aircraft buffeting.

1/ All times are eastern standard, based on the 24-hour clock.

The first officer called out that the No. 3 engine had failed. The flightcrew stated that they also lost the No. 3 electrical system and the No. 3 hydraulic system at the same time. The electrical system failure caused the loss of the first officer's flight instrument panel lighting.

The captain assumed control of the aircraft while the first officer and the flight engineer accomplished the appropriate emergency checklist procedures. The captain requested an immediate return to Dulles and was directed to turn right to a westerly heading. The crew jettisoned 40,000 pounds of fuel to reduce the weight of the aircraft below maximum landing weight. The flight was given vectors to a southerly heading for a landing on runway 12 at Dulles and the crew restored electrical power to the No. 3 bus. Since the No. 3 engine hydraulic system was inoperative, the crew had to make a 360° turn on the base leg to lower the landing gear using the emergency landing gear extension procedure. Flaps and slats were extended normally and the aircraft landed on runway 12 at 1825.

The captain stopped the aircraft on the runway, and after the crash rescue crew had inspected the aircraft for damage and leaks and determined that there was no immediate danger, the captain taxied to a regular parking spot. The passengers and flightcrew deplaned normally; no one was injured.

The incident occurred at 1806 during hours of darkness at latitude 39°06'50" N and longitude 77°34'59" W.

Injuries to Persons

Injuries	Crew	Passenger	Other	Total
Fatal	0	0	0	0
Serious	0	0	0	0
Minor/None	10	43	0	53

Personnel Information

The flightcrew consisted of the pilot, the first officer, and the flight engineer. All were properly certificated and qualified for the flight. Seven flight attendants were aboard the aircraft.

Aircraft Information

The aircraft, a McDonnell Douglas DC-10-40, N143US, was certificated, equipped, and maintained in accordance with Federal Aviation Administration (FAA) requirements. Three Pratt and Whitney Aircraft (P.W.A) JT9D-20 engines, which develop 46,300 pounds of static thrust each, were installed on the aircraft.

The gross weight of the aircraft was about 412,275 pounds at takeoff, and the center of gravity (c.g.) was within limits. At takeoff, the aircraft had about 128,700 pounds of Jet A fuel on board.

Meteorological Information

The surface weather observation for Dulles International Airport at 1753, January 31, 1981, was: clear, 20 miles visibility; temperature -- 29° F; dewpoint -- 6° F; wind from 060° at 4 knots; altimeter setting -- 30.13 inHg.

Aerodrome Information

Dulles International Airport is located 26 miles west of Washington, D.C. The airport has three major runways and is surrounded by gently rolling terrain. Land use is a mixture of rural, suburban, and light industry.

All three runways are constructed of concrete. Runway 01R-19L is 11,500 feet long by 150 feet wide; runway 01L-19R is 11,500 feet long by 150 feet wide; runway 12-30 is 10,000 feet long by 100 feet wide. The National Weather Service (NWS) station and the FAA Control Tower operate continuously.

Flight Recorders

The aircraft was equipped, as required, with a cockpit voice recorder (CVR) and a digital flight data recorder (DFDR).

The Fairchild A-100 CVR, S/N 1247, ran for more than 30 minutes after the incident. Elapsed time from the incident to engine shutdown was about 35 minutes. Since the recorder's capacity is 30 minutes, there was no information pertaining to the incident on the recorder tape.

The DFDR was processed at the Safety Board's Flight Data Recorder Laboratory. The recorder indicated the following information just before the incident:

Time:	1805 +	
Altitude:	5,787 feet (mean sea level)	
Indicated Airspeed:	248 knots	
Heading:	332°	
Pitch:	8° nose up	
Roll:	Wings level	
Engine Exhaust Pressure Ratio (EPR):	1.235	No. 1
	1.215	No. 2
	1.236	No. 3

No data were recorded for about 6 minutes following the failure of the No. 3 electrical system, but when power was restored, the recorder worked normally for the remainder of the flight and the EPR on the No. 3 engine was 0.908.

Wreckage and Impact Information

Inspection of the aircraft revealed that the No. 3 engine nose cowl assembly and the fan containment case had separated from the aircraft. The nose cowl was recovered from the yard of a residence in Leesburg, Virginia, on January 31, 1981, with minor ground impact damage on the leading edge of the cowling. The fan containment case was not recovered until February 24, 1981, when it was found in a creek bed, about 3,000 feet northwest of the nose cowl's location. The right wing leading edge slats and the No. 2 engine had experienced foreign object damage (FOD).

The aircraft fuselage was not damaged. The structural integrity of the aircraft was not breeched, and pressurization was maintained. Right wing slats Nos. 1, 2, and 5 were damaged. A 2- by 10-inch cut was found in the leading edge of slat No. 1. Slat No. 2 had a 9- by 14-inch hole in the leading edge and a 2-inch tear on the upper camber surface. The leading edge of the wing was punctured behind slat No. 2. Slat No. 5 had a 10- by 12-inch cut in the leading edge and 45° angle impact scrape marks upward and outward on the leading edge and upper camber surface.

The No. 1 engine was not damaged.

Thirty-two of the forty-six fan blades of the No. 2 engine had FOD. The FOD ranged in size from 0.030-inch nicks to a 2- by 3-inch section of blade which had broken off the airfoil leading edge. Fan blades Nos. 16, 23, 24, and 25 received the most damage. Three 4-inch square areas of acoustic composite material were missing from the intake duct fan shroud.

Stages 2 through 4 of the low pressure compressor sustained minor damage to several blades of each stage. The largest nicks to these blades measured 3/32 inch. Stages 5 through 13 of the high pressure compressor were damaged with nicks as deep as 1/16 inch. Stages 14 and 15 were not damaged.

There was no damage to the lip of the No. 2 engine cowl. A small (1/2 inch) impact mark and two adjoining scrape marks were found 4 feet inside the No. 2 engine inlet at the 10 o'clock position. 2/

No. 3 Engine Examination

Phase I.--The examination of the No. 3 engine was conducted in three phases. Phase I consisted of examination and documentation of the external condition of the aircraft and the No. 3 engine at Dulles International Airport.

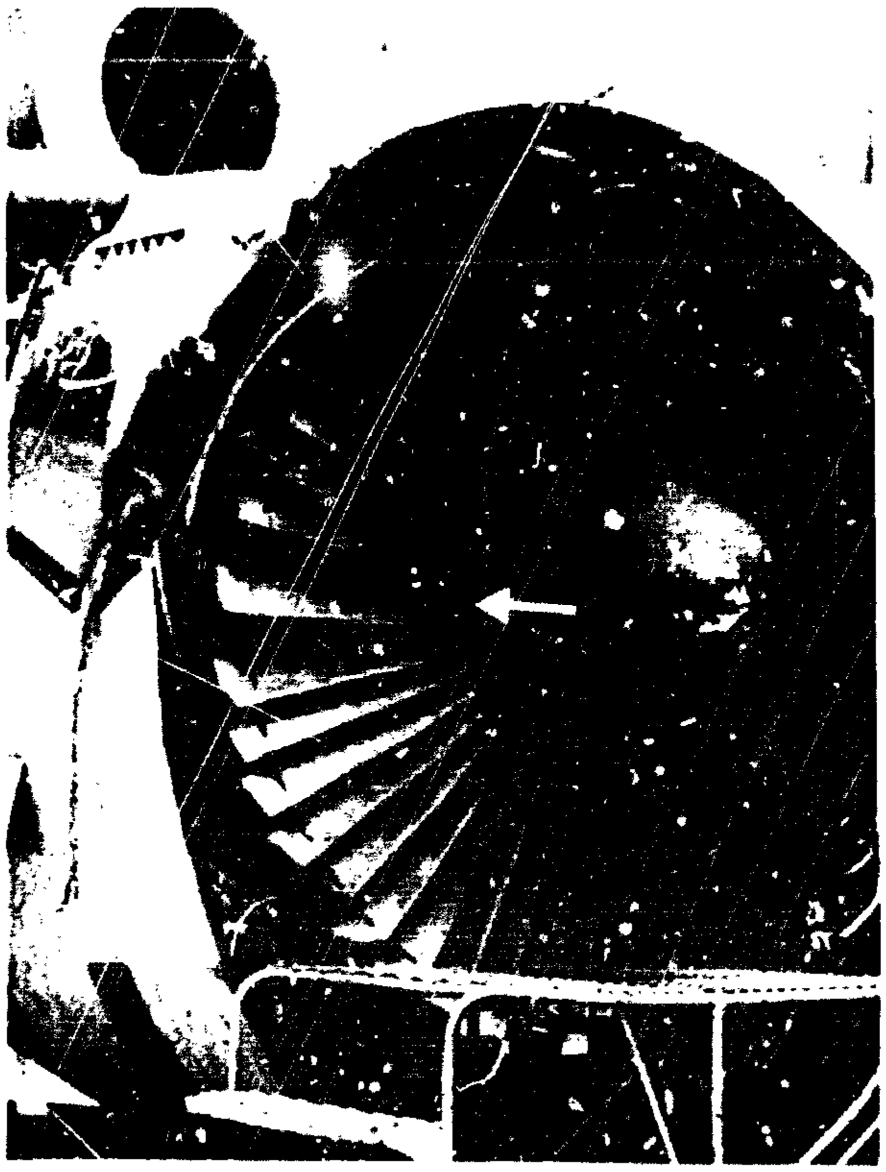
The nose cowl assembly, the fan containment case forward of the B-flange, and their associated fixtures and components were missing from the aircraft. (See figure 1.) The rear of the nose cowl and the front of the fan case are mated at A-flange. The rear of the fan case and the front of the fan exit case are mated at B-flange. The fan exit case was torn and crushed around its leading edge. The compressor blades were damaged, all fan blades were damaged at the tips, and the No. 30 blade was missing.

The No. 30 blade had separated at a point about 1 inch outward from the blade platform. Two pieces of blade, representing about 80 percent of the blade area, were recovered. One piece was imbedded in the fan exit case stators and the other was found on the runway after the aircraft landed. The critical areas of the leading edge of the remaining 45 fan blades were inspected with a 10-power magnification lens and were found to exhibit no cracks or other significant anomalies. Minor in-service and typical FOD nicks were present in the areas examined. A 1/2-inch outward bulge was found in the trailing edge of the fan spinner in front of the No. 35 fan blade. There was no other damage to the spinner. A 1/4- by 7/16- by 3/8-inch section was missing from the convex side of the No. 35 blade slot in the fan disk forward surface.

The No. 30 fan blade root and pieces were removed for metallurgical examination, and the damaged engine was removed for shipment to the Minneapolis Northwest Orient Airlines facility for disassembly and inspection.

The No. 30 blade assembly, serial number BU9913, was manufactured as P.W.A. blade detail 736001 described as a faired tip airfoil. The airfoil had been glass bead peened per P.W.A. Service Bulletin (SB) 4060. Alert Service Bulletin (ASB) 4124, notifying operators of a minimum edge thickness requirement on service blades, had been complied with. SB 4262 requiring a 0.033- to 0.039-inch maximum tolerance of the leading edge from root to tip also had been complied with. Another bulletin increased

2/ All clock positions concerning engine damage are as viewed from aft of the engine.



NO. 3 ENGINE AFTER INCIDENT. ARROW DENOTES SEPARATED NO. 30 FAN BLADE.

JT9D-20 TURBOFAN ENGINE

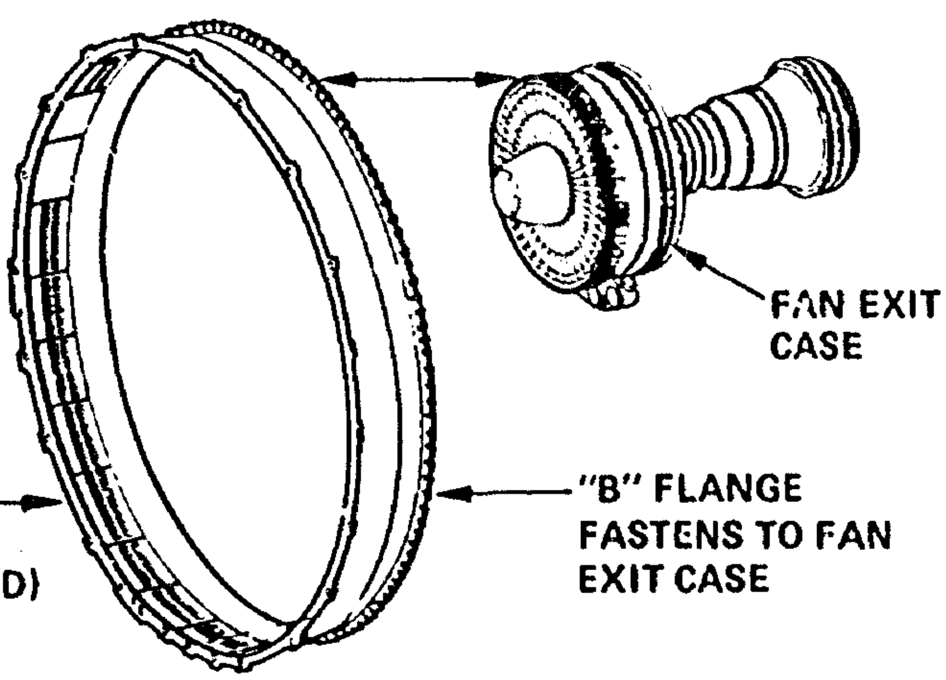


Figure 1.--No. 3 engine after incident.

the first 4 inches of the critical area of the leading edge and the first 9 inches above the platform on the trailing edge to a minimum thickness between 0.050 and 0.060 inch to enhance the blade's resistance to FOD.

The No. 30 blade had 14,864 hours of use and had recorded 9,699 cycles. It was reworked by TRW Compressor Components Division of TRW, Inc., Cleveland, Ohio, in November and December 1979. At that time, the following operations were accomplished:

1. P.W.A. Service Bulletin 4060; glass bead peening
2. Routine blending and overhaul instructions
3. Hardface strip
4. Rehardfaced (Linde Division of Union Carbide)
5. Flourescent dye penetrant inspected

Northwest Airlines' records indicated that the fan assembly had been removed on April 29, 1980, to replace the low compressor assembly and inspect the fifth stage compressor blades.

The records also indicated that the fan blades had been inspected, per NWA-OM38 Routine Work Card, on November 21, 1980, and December 9, 1980. During the inspection conducted on November 21, 1980, 16 nicked blades were discovered and blending was required. After the blending was completed, the blades received an eddy current inspection. Indentification of the blended blades was not required. No discrepancies were noted during the December 9, 1980, inspection. The fan assembly was removed from the engine on February 13, 1981, and was measured for balance. The assembly measured 2,600 ounce/inches out of balance.

Phase II.--Phase II consisted of a detailed examination and documentation of the damage to the No. 3 engine and portions of the No. 2 engine at the Northwest Airlines' facility in Minneapolis, Minnesota.

The fan case assembly, P/N 72709B, was eliptical in shape and in one piece when recovered. The case was buckled about 12 inches at the bottom. There are 23 scalloped flanges/lugs on the A-flange of the fan case. Twenty are used to fasten the nose cowl to the fan case. The 20 lugs, nut plates, bolts, and lock wires indicated varying degees of damage. Some lugs were deformed, some nut plates contained portions of sheared bolts, some bolts were fastened in position, other bolts evidenced random shear, and the lockwires were randomly pulled and damaged. Lug Nos. 2, 3, 4, 7, 8, and 9 displayed a similar shear pattern.

The B-flange has 120 lugs/bolts that fasten the fan case to the fan exit case. Fifty-four attachment bolts were still atttached to the fan case and 66 bolts were missing. The attached bolts exhibited random shear failures. The flange was torn inward and then forward at the 6-o'clock position. The fan exit case was also damaged on the bottom portion and numerous random scratches were found inside the fan exit case.

The nose cowl attachment flange was separated from the inner structural members from the 7- to 10-o'clock position. All of the 1-inch spaced flange attachment rivets were sheared in this area. The inner barrel skin was peeled away from its honey comb subsurface between the 8- and 12-o'clock positions.

There was a scrape mark beginning at the 6-o'clock position and extending to the 8-o'clock position where an 8- by 10-inch portion of inside cowl skin was missing. The honey comb substructure was gouged over a rectangular area approximately 4.5 by 14.0 inches; the gouge was 0.75 inch in depth. A fan blade fragment measuring 1.0 by 2.75 inches was found inside the gouge at the 8-o'clock position.

There were two scrape marks in the inner surface beginning at the 12-o'clock position and terminating at the 3-o'clock position where the Tt2 probe was mounted. The Tt2 probe was sheared off flush with the inner surface. There was an inner skin puncture measuring approximately 2 inches in diameter at the 1-o'clock position approximately 2 inches forward of the A-flange. A 14-inch tear in the direction of rotation was found 4 inches forward of the A-flange, on the inner surface.

The nose cowl outer surface had a 3-inch deep buckle between the 12- and 4-o'clock positions. It also had a 1-inch-deep buckle between the 7- and 12-o'clock positions, 16 inches aft of the front inlet lip. There was a deep buckle and tear puncture between the 6- and 12-o'clock positions 10 inches forward of the A-flange surface. The A-flange surface was buckled forward at a 45° angle between the 7- and 11-o'clock positions. The left hand fairing strake had a 6-inch compression tear at the trailing edge on the surface of the cowling outer skin. The right hand strake was not damaged.

Under the direction of the Safety Board, the remainder of the engine was completely disassembled and inspected. There were no preexisting discrepancies. All damage occurred during the incident sequence.

Phase III.--Phase III consisted of an inspection of the manufacturing and repair facilities of TRW Corporation Compressor Components Division, Cleveland, Ohio, and the Minneapolis Northwest Airlines facility by the investigation team to determine whether the fan blades were being repaired in accordance with applicable directives. No discrepancies were noted either at TRW or at Northwest Airlines.

No. 30 Fan Blade Metallurgical Examination

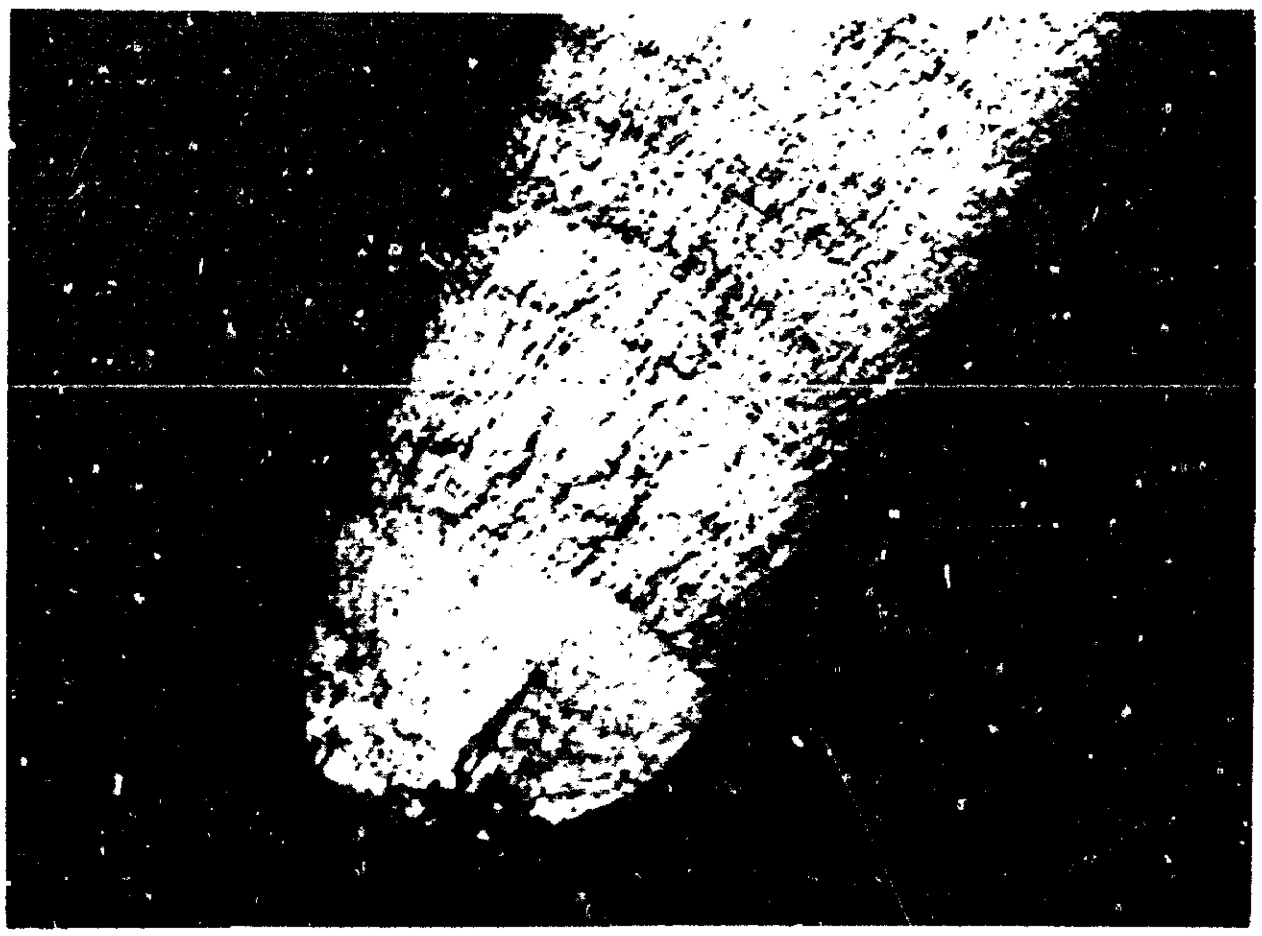
The fan blade was broken into three pieces--two pieces of blade and the blade root. The fracture surfaces of the pieces of blade were obliterated because of post fracture mechanical peening.

The root section of the blade was examined at magnifications up to 70X with the aid of a stereomicroscope. Examination of the fracture surface disclosed progression marks typical of fatigue emanating from a small discolored area at the leading edge of the blade. (See figures 2 and 3.)

After initial examination at the Safety Board's metallurgical laboratory, the root section was taken to the Pratt and Whitney research and engineering laboratory in East Hartford, Connecticut, for further examination under the direction of a Safety Board metallurgist. Detailed color and black and white photographs were taken, and then the section root was submitted to the Pratt and Whitney metrology laboratory for dimensional measurements. Of special interest was the geometry of the leading edge of the blade adjacent to the fracture. This area had been reworked, apparently to remove surface irregularities. Another objective of the dimensional measurement was to determine if the trailing edge of the blade had been reworked in accordance with Pratt and Whitney SB No. 4573. Traces of the leading edge of the blade, made with a New

Figure 2.--Side view of the fan blade root. The fracture origin is indicated by arrow "O."

8X



21X

Figure 3.--Closeup view of the fatigue crack origin area. The discolored area at the tip of the blade was confirmed to be the fatigue crack origin.

England profilier, indicated the geometry of the blade was in accordance with specifications outlined in that service bulletin.

Scanning electron microscope (SEM) examination of the fracture surface confirmed that the fatigue crack had originated at an oxide-discolored area. The fracture mode in this area appeared to be quasi-cleavage which is an indication of brittle fracture in titanium alloys.

A longitudinal metallographic section was taken through the fracture origin and polished and etched. The microstructure corresponded to the discolored area and was acicular alpha or alpha prime martensite. This structure typically forms in Ti-6A1-4V alloy, the specified blade material, when the material is heated above the melting point and rapidly cooled in air or water. The adjacent area was predominantly stabilized alpha or acicular alpha which typically occurs when Ti-6A1-46 alloy is heated to high temperatures below the melting point and cooled quickly in air. The remainder was composed of equiaxed alpha in a beta matrix and is considered normal microstructure for this Ti-6A1-4V alloy forging.

The heated areas exceeded hardness specifications when measured by a Rockwell Hardness Test. Hardness measurements taken at three points in the discolored area were Rockwell C 58, 43, and 34. The maximum specified hardness for fan blade alloy is Rockwell C 39.

No. 2 Engine Fan Blades

The damaged fan blades from the No. 2 engine were examined at the Safety Board's metallurgical laboratory to determine what materials struck the blades. A sample of the FOD deposit was examined in the scanning electron miscroscope and the results analyzed by X-ray. The deposit was composed of silicon, iron, and nickel. The blade is composed of aluminum and titanium. The fan case and the fan exit case are made of stainless steel, which is composed of iron and nickel.

FAA Regulations

Title 14 CFR 33 pertaining to airworthiness standards for aircraft engines states:

> Section 33.19 Engine design and construction must minimize the development of an unsafe condition of the engine between overhaul periods. The design of the compressor and turbine rotor cases must provide for the containment of damage from rotor blade failure.

Title 14 CFR 25 pertaining to airworthiness standards for transport category airplanes in effect at the time of certification of the aircraft states in part:

> Section 25.903 (b) The powerplants must be arranged and isolated from each other to allow operation, in at least one configuration, so that the failure or malfunction of any engine, or of any system that can affect the engine, will not—
> (1) Prevent the continued safe operation of the remaining engines.
>
> * * *

Additionally, the certification basis for the DC-10-40 also required compliance with Special Conditions No. 25-18-WE-7 dated January 7, 1970 and Amendment 1 to the special conditions dated July 9, 1971. The document stated in part:

Special Condition No. 6 Fault Analysis -

In addition to the requirements of 14 CFR 25.901, it must be established by fault analysis, component tests, or simulated environmental tests that no single failure or likely combination of failures of any powerplant system will jeopardize the safe operation of the aircraft, except that failures of structureal elements need not be considered when the probability of such failures is extremely remote.

ANALYSIS

The Aircraft

The aircraft was properly certificated and had been maintained in accordance with approved procedures. There was no evidence of preincident failure or malfunction of the aircraft structure, flight controls, or systems that was not related to or caused by the failure of the No. 3 engine.

The Flightcrew

The flightcrew was properly certificated and qualified for the scheduled passenger flight. They all held current medical certificates.

No. 30 Fan Blade Failure

The separation of the No. 30 fan blade resulted in the failure of the No. 3 engine and the inflight separation of the inlet cowl and the fan containment case. The fan blade, SN BU9913, which had a total operating time of 14,864 hours and had been cycled 9,699 times, fractured about 1 inch above the root platform. The fracture was caused by high cycle fatigue originating at a small oxide-discolored area on the blade leading edge, which was identified as an arc burn. Hardness in the heat affected zone at the fatigue origin was increased, while hardness away from the arc-burn area was typical of titanium fan blade material. Composition of blade material conformed to specification requirements. The source of the arc burn was not determined; however, the arc burn apparently had occurred before the most recent blending of the leading edge. Appearance of the microstructure at the fatigue origin suggested that portions of melted and heat affected areas associated with the arc burn had been partially removed by a blending operation. The most recent blending on this fan rotor occurred in November 1980; however, it is not known whether the No. 30 blade was one of the 16 blades reported to have been blended since records of individual blade maintenance operations are not required.

Inflight Separation of Cowl and Fan Case

The loss of the nose cowl and fan case was the result of the separation of the No. 30 fan blade and the subsequent dynamic interreaction of the fan case, nose cowl, fan blades, and the out-of-balance condition of the fan assembly.

When the fan blade fractured, it struck the fan case and the inner nose cowl near the [illegible]-o'clock position, causing the loss of two to five A-flange inlet cowl retention bolts in the area of the impact. The impact loads may have also caused the B-flange bolt fractures or the 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. The bolts sheared in a sequential circumferential (unzipping) manner until only fasteners between the 1- and 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 nut plates, 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 the leading edge Nos. 1 and 2 slats on the right wing. (See figure 4.)

Fourteen JT9D fan blade failures including N143US, 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. This incident was the only instance of inflight separation of the nose cowl assembly and the fan case.

No. 2 Engine Damage

Although the flightcrew had no indication of damage to the No. 2 engine because it continued operating until shutdown after landing, there was substantial damage to the fan and compressor section of the engine. A sample of the impact material on the No. 25 fan blade from the No. 2 engine was examined and analyzed. The sample had a high iron content that was not consistent with the titanium alloy composition of fan blades. The fan case and the fan exit case are made of stainless steel, which has a high iron content. Therefore, the Safety Board concludes that the No. 2 engine was damaged by material from the No. 3 engine fan case and/or the fan exit case.

It should also be noted that when the engine nose cowl and the fan case separated from the aircraft, they struck the leading edge of the wing on slats Nos. 1, 2, and 5. The slats, flaps, and gear were retracted at the time and the aircraft was climbing. There is the possibility that if the aircraft had been configured differently or had been at a different speed or attitude, the aircraft structure may have been substantially damaged by the separated components.

FAA Regulations

Title 14 CFR 25.903(b) and 33.19 specify that no single failure or malfunction will prevent the continued safe operation of the other engines and that the design of the compressor and turbine rotor cases must provide for the containment of damage from rotor blade failure. The failure of a single fan blade and subsequent interactions resulted in the inflight loss of major engine components, FOD to the No. 2 engine, and structural damage to the right wing leading edge slats. With regard to the JT9D engine and its installation on DC-10 aircraft, the engine manufacturer is responsible for compliance with 14 CFR 25.903(b) and the aircraft manufacturer is responsible

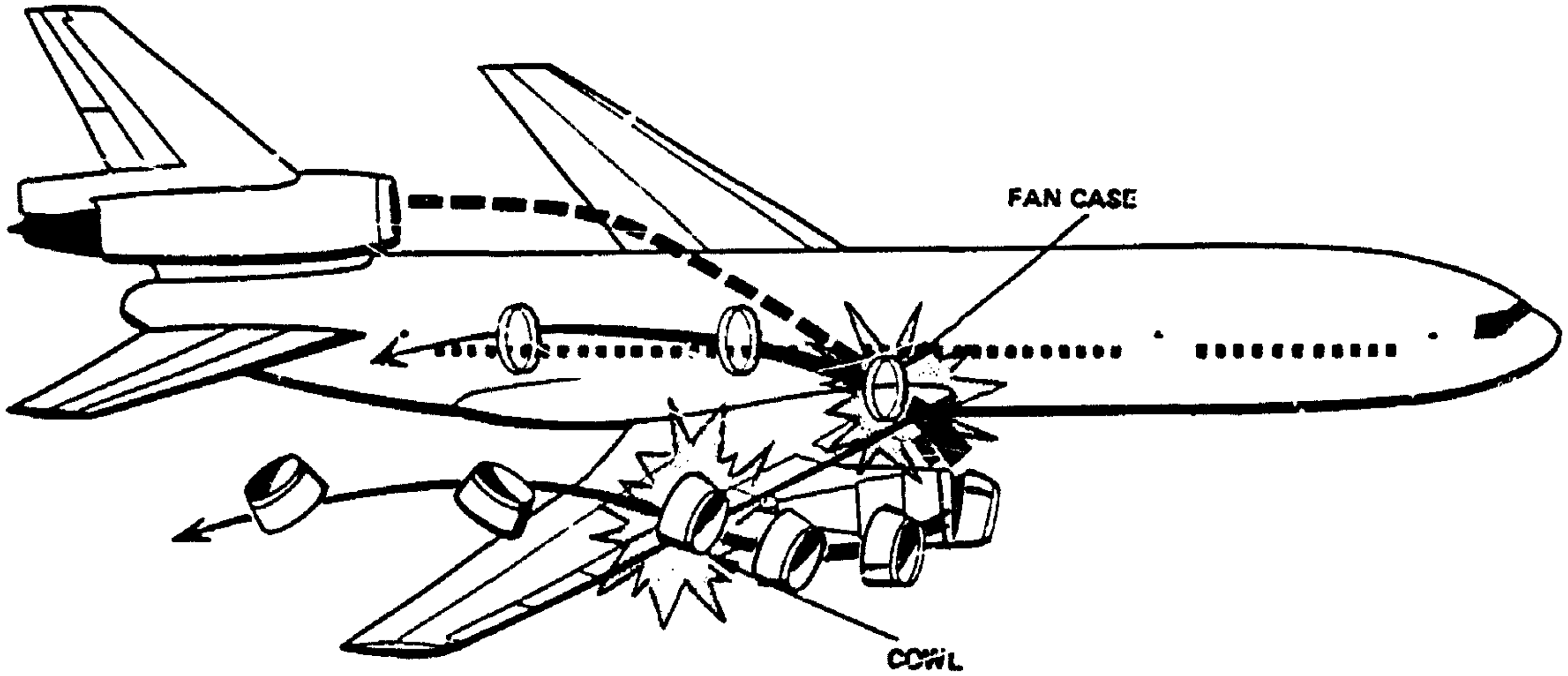


Figure 4.--Graphic analysis of the loss of the nose cowl and fan case.

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, FOD to the No. 2 engine, and structural damage to leading edge devices. Although we recognize that this was the only occurrence of this type of failure of this engine installations, 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. As a result, we have recommended 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 provisions of airworthiness requirements provided in 14 CFR 33 and 14 CFR 25 are satisfied.

CONCLUSION

Findings

1. The aircraft was certificated and had been maintained in accordance with approved procedures.

2. The flightcrew was properly certificated and medically qualified for the flight.

3. There was no evidence of preincident failure or malfunction of the aircraft structures, flight controls, or systems.

4. Fan blade No. 30 on the No. 3 engine separated 1 inch from the fan blade platform because of a high cycle fatigue fracture.

5. The origin of the fatigue was a preexisting high temperature arc burn from an undetermined source on the leading edge of the blade.

6. The separated fan blade caused aerodynamic loading and fan imbalance which resulted in the shearing and overloading of the A-flange fasteners.

7. The nose cowl, which separated upward and outward, struck and damaged slat No. 5.

8. Increased aerodynamic loading and fan blade tip/fan case interaction caused shearing and overloading of the B-flange fasteners.

9. The fan case, which separated upward and inward, struck and damaged slats Nos. 1 and 2.

10. The No. 2 engine was damaged by material from the fan case and/or fan exit case.

11. The intent of Federal aviation regulations pertaining to airworthiness standards for transport category aircraft and engines may not have been met in the DC-10/JT9D aircraft engine configuration since fracture of a

single fan blade led to inflight separation of major engine components which caused damage to the aircraft wing leading edge slats and FOD to the No. 2 engine.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the incident was the high cycle fatigue fracture of the No. 30 fan blade in the No. 3 engine. The origin of the fatigue fracture on the leading edge of the fan blade was a preexisting high temperature arc burn from an undetermined source. Contributing to the damage to the aircraft and the No. 2 engine was the failure of the No. 3 engine nose cowl and fan containment case flanges/fasteners due to aerodynamic loading, fan imbalance, and fan/fan case interaction which resulted in an inflight separation of the nose cowl assembly and the fan containment case.

RECOMMENDATIONS

On May 15, 1981, the Safety Board adopted the following recommendations to the Federal Aviation Administration:

> Issue an airworthiness directive which requires a visual inspection for arc burns before and after each rework operation on titanium alloy fan blades from Pratt and Whitney Aircraft JT9D turbofan engines and requires replacement of arc burn-affected blades. We further recommend that a description of arc burn in titanium be included in the airworthiness directive. (Class II, Priority Action) (A-81-63)

> Issue an air carrier maintenance bulletin urging operators and maintenance personnel to use extreme caution with any electrical equipment in the vicinity of titanium alloy fan blades to minimize the possibility of arc burn. This bulletin should also describe the appearance of arc burn in titanium and point out the nature of damage caused by such burns and the possible consequences of this damage. (Class II, Priority Action) (A-81-64)

On July 7, 1981, the Safety Board adopted the following recommendation to 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)

The Safety Board has been informed that Pratt and Whitney Aircraft and Northwest Airlines have taken internal actions to preclude recurrence. Pratt and Whitney Internal Engineering Notice 302213 was issued and a cautionary note providing expanded warnings relative to using electrical equipment in the vicinity of fan blades was added to the applicable alert service bulletins. These warnings are also being incorporated in applicable Engine, Repair, and Maintenance Manuals as they are revised. An Engine Manual temporary revision was issued March 16, 1981, for D-3A/7/20 models and on March 12, 1981, for D-59A/70A/7Q models.

Northwest Airlines has accomplished a one-time fleetwide inspection of its JT9D-20 engine fan blades in accordance with Alert Service Bulletin 4573.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PATRICIA A. GOLDMAN
Member

/s/ G.H. PATRICK BURSLEY
Member

July 7, 1981

APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The Safety Board was notified of this incident at 1900 on January 31, 1981, and investigators proceeded immediately to Dulles International Airport to initiate the investigation. Working groups were established for powerplants, maintenance records, metallurgy, and flight data recorder.

Parties to the investigation were the Federal Aviation Administration, Northwest Airlines, Pratt and Whitney Aircraft Corporation, McDonnell Douglas Aircraft Company, and Air Line Pilots Association.

2. Public Hearing

A public hearing was not held; and depositions were not taken.

APPENDIX B

PERSONNEL INFORMATION

Captain Boyd Roger Lofgren

Captain Lofgren, 49, holds Airline Transport Pilot Certificate No. 1395062, with ratings for airplane multiengine land, McDonnell Douglas DC-10, Boeing 707, 720, Convair 240, 340, and 440. His first class medical certificate with no limitations was issued on November 18, 1980. Captain Lofgren had about 16,790 total flying hours with 1,414 hours in the DC-10 at the time of the incident.

First Officer Patrick T. Donlan

First Officer Donlan, 43, holds Airline Transport Pilot Certificate No. 1649319, with ratings for airplane multiengine land, Boeing 727 and 747. He also has commercial privileges for single engine land aircraft. His first class medical certificate with no limitations was issued on October 9, 1980. First Officer Donlan had about 3,754 total flying hours with 981 hours in the DC-10 at the time of the incident.

Second Officer Duane Jean Hoff

Second Officer Hoff, 40, holds Flight Engineer Turbojet Certificate No. 1822941. He also holds Commercial Pilot Certificate No. 1668293, with airplane single/multiengine land, instrument and Lockheed 188 ratings. His first class medical certificate with no limitations was issued on December 8, 1980. Second Officer Hoff had about 4,300 total flying hours with 2,500 in the DC-10 at the time of the incident.

APPENDIX C

AIRCRAFT INFORMATION

1. Aircraft

The aircraft, a McDonnell DC-10-40, Serial Number (S/N) 46752 was obtained from the manufacturer on November 10, 1972, by Northwest Airlines, and has been owned and operated by Northwest since acquisition. On January 31, 1981, the aircraft total time was 18,820:43 hours.

The aircraft received its last heavy maintenance check, No. 2, on May 9, 1980, at a total time of 17,296 hours. The aircraft received service checks Nos. 1 and 3 on January 14, 1981.

2. Engines

The aircraft was equipped with three Pratt and Whitney Model JT9D-20 engines.

(a) Statistical Data No. 3 Engine

Engine Serial No.-686165
Date Installed - March 15, 1980
Total Time - 13,186 hours as of 1-31-81
Total Cycles - 7,678 as of 1-31-81
Total Time Since Installation - 1,835 hours
Total Cycles Since Installation - 966

(b) Fan Module, S/N 6-1-6139

Total Time - 16,706 hours as of 1-31-81
Total Cycles - 9,802 as of 1-31-81
Blade No. 30 Serial No.-BU9913
Blade No 30 Part No.-771821E
Blade Total Time - 14,864 hours as of 1-31-81
Blade Total Cycles - 9,699 as of 1-31-81

The No. 30 blade total time is lower than the fan module total time because it was not one of the module's original blades.

(c) Nose Cowl

Installed - March 15, 1980
Time Since Installation - 1,835 hours as of 1-3-81
Cycles Since Installation - 966 as of 1-31-81

Total time on nose cowl was not obtained because it is only changed on condition.

(d) General

All engine modules (except the No. 10 gearbox) had received heavy maintenance checks on March 15, 1980.

3. Airworthiness Directives

A review of the Airworthiness Directives (AD's) did not reveal any outstanding AD's pertaining to the nose cowl, fan blade containment ring, or fan blades installed on the No. 3 engine.

The FAA had issued AD 76-24-03 that pertained to fan blades used in early JT9D engines. The part numbers of the fan blades in the No. 3 engine at the time of the incident were not included in the AD. However, Northwest Airlines inspected the No. 3 engine fan blades in accordance with the AD procedures. The records indicated that the No. 3 engine had been continuously maintained in accordance with Northwest Airlines' maintenance programs and FAA rules and regulations.

U.S. GOVERNMENT PRINTING OFFICE: 1981-0-341-828/45