National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: August 28, 2006

In reply refer to: A-06-60 through -64

Honorable Marion C. Blakey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On June 2, 2006, an American Airlines Boeing 767-223(ER), N330AA, equipped with General Electric (GE) CF6-80A engines experienced an uncontained failure[1] of the high pressure turbine (HPT) stage 1 disk[2] in the No. 1 (left) engine during a high-power ground run for maintenance at Los Angeles International Airport (LAX), Los Angeles, California (see figure 1 for a diagram of a GE CF6-80A engine). The three maintenance personnel on board the airplane as well as the observer on the ground were not injured. Both engines and the airplane sustained substantial damage.[3]

Background

The maintenance personnel who were on board the airplane when the uncontained engine failure occurred stated that they were performing the high-power engine run-up in response to a report from the pilots of the previous flight that the left engine lagged behind the right engine by about 2 percent during the climb from 36,000 to 38,000 feet.[4] The maintenance personnel on board the airplane reported that they performed a series of troubleshooting procedures, including making two rapid excursions with the power levers from idle to maximum power to idle, and that, after the engine had reached maximum power for the second time and was decelerating

[1] An uncontained engine failure occurs when an internal part of the engine fails and is ejected, or results in other parts being ejected, through the engine casing and cowling.

[2] The HPT stage 1 disk consists of separate forgings for the disk and shaft section in front of the disk, which are inertia-welded together to form one integral piece.

[3] The description of this incident, ENG06IA018, can be found on the National Transportation Safety Board's Web site at <http://www.ntsb.gov>. Although the airplane was substantially damaged, the Safety Board has categorized this event as an incident rather than an accident because there was no intention for flight, as defined in 49 *Code of Federal Regulations* (CFR) 830.2, when the HPT disk ruptured.

[4] The climb power setting was 108 percent N1 rpm (N1 is the low pressure rotor speed). The pilots of the previous flight also reported that the left engine operated normally during the takeoff, climb, and initial portion of the flight at cruise altitude and for the remainder of the flight to LAX once they leveled off at 38,000 feet mean sea level.

through 95 percent N1 rpm, they heard a loud explosion that was followed by a fire under the left wing and fuselage aft of the wing. The maintenance personnel stated that they immediately shut down the engines, discharged one fire bottle into the left engine's nacelle, and evacuated the airplane. The fire continued until it was extinguished by airport fire department personnel.

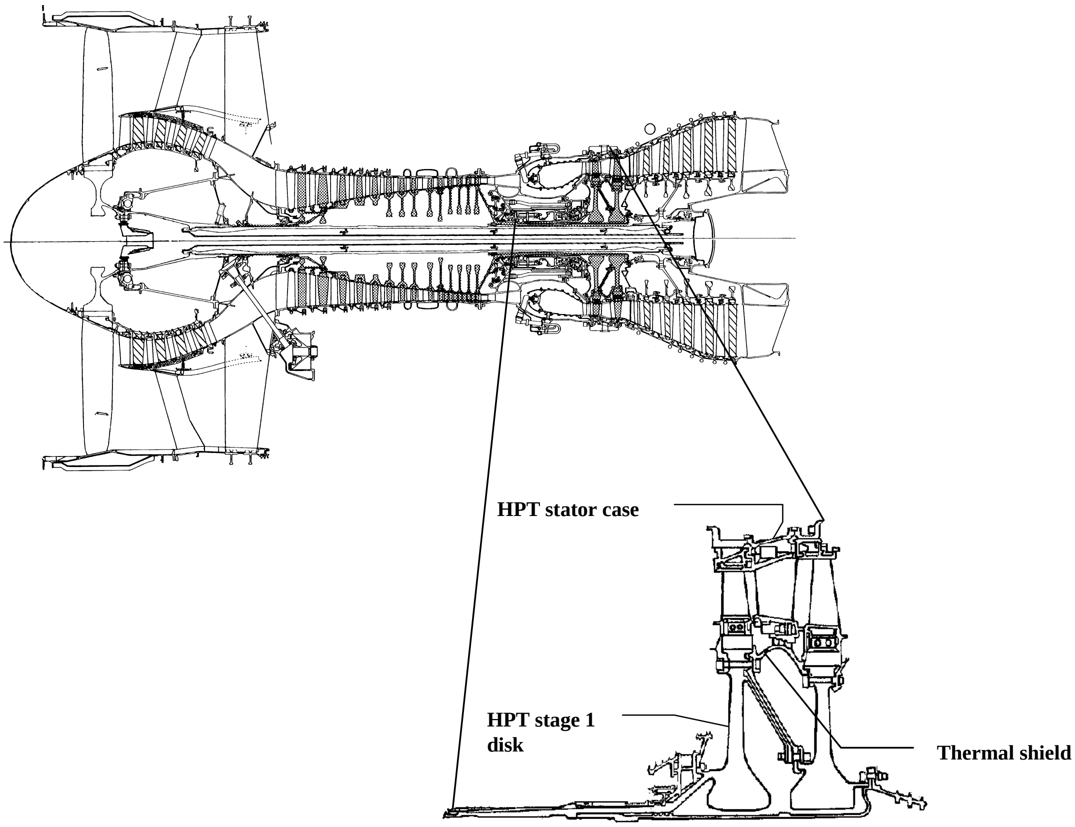

Figure 1. Cross-section of a GE CF6-80A engine and enlarged view of the HPT module

Postincident examination of the No. 1 engine revealed that the HPT stage 1 disk had ruptured and completely split the engine (see figure 2) with the fan, booster, high pressure compressor, and combustor hanging from the forward-engine mount and the low pressure turbine and exhaust hanging from the rear-engine mount. The HPT stage 1 disk separated from the shaft at the conical section of the shaft and was completely missing from the engine. The recovery of the pieces of the ruptured disk revealed that it had broken into three approximately equal-sized pieces, as well as a fourth triangular-shaped piece and several smaller fragments. One piece of the disk, which initially bounced off of the ground before penetrating the airplane, completely severed the airplane's left-hand keel beam and partially severed the right-hand keel beam before exiting the airplane and becoming lodged in the No. 2 engine's exhaust duct. A second piece of the disk was found in the airplane embedded in an air duct. A third piece of the disk was found about 2,500 feet away from the airplane against an airport perimeter fence after crossing two active runways and taxiways.[5] The fourth triangular-shaped piece of the disk was found embedded in the engine pylon.

[5] At the time the engine ruptured and this disk fragment crossed runways 25R and 25L, an Air New Zealand Boeing 747-400 airplane had just landed on runway 25L and was taxiing into the terminal.

Figure 2. View of the left side of the No. 1 engine showing the engine split in two.

Examination of the No. 2 engine revealed that the left side of the engine's nacelle was peppered with holes and impact marks from debris from the No. 1 engine in addition to the piece of the HPT stage 1 disk that had gone through the exhaust duct and was protruding from the right side of the engine (see figure 3). The examination of the airplane revealed numerous holes in the left and right wing's fuel tanks where fuel leaked out, feeding the ground fire that burned the left wing and the fuselage aft of the wing.[6]

The ruptured HPT stage 1 disk, part number (P/N) 9362M58G07,[7] S/N MPOT8749, was machined from an Inconel 718 nickel alloy[8] forging. Metallurgical examination of the pieces of the disk at the National Transportation Safety Board's materials laboratory showed that the material composition, grain size, microstructure, and hardness conformed to the material requirements for Inconel 718 nickel alloy. The examination also revealed that the disk ruptured from a rim-to-bore radial fracture that had originated at a small dent at a blade slot bottom aft corner. Examination of the primary fracture surface with a binocular microscope and at higher magnifications with a scanning electron microscope revealed that its morphology was intergranular fatigue that had propagated about 0.7 inch axially forward and 0.7 inch radially inward before the disk ruptured. The examination also revealed that the aft corner in two other

[6] The fuel leaking from the holes in the right wing's tanks did not ignite.

[7] The disk was originally identified as P/N 9362M58G02. It was reidentified as P/N 9362M58G07 with the incorporation of CF6-80A Service Bulletin 72-639, "Rework of HPT Rotor Stage 1 Disk Bearing Journal with Tribaloy T-400," which increased the disk's life limit to 15,000 cycles. Tribaloy T-400 is a cobalt-based alloy that is a plasma-spray-applied material and is wear- and corrosion-resistant over a wide temperature range.

[8] Inconel 718 is a high-strength, heat-resistant nickel alloy.

slot bottoms each contained a crack that coincided with a small dent.[9] Although small, randomly located areas of classical fatigue striations were observed, intergranular fatigue fractures (which made up the bulk of the area of the progressive fracture on the ruptured disk) do not have striations; thus, it was not possible to determine how fast the fatigue fracture had been propagating before the disk ruptured. The aft face of the disk and blade slot bottom surface were dimpled, which is indicative of these surfaces having been shotpeened.[10]

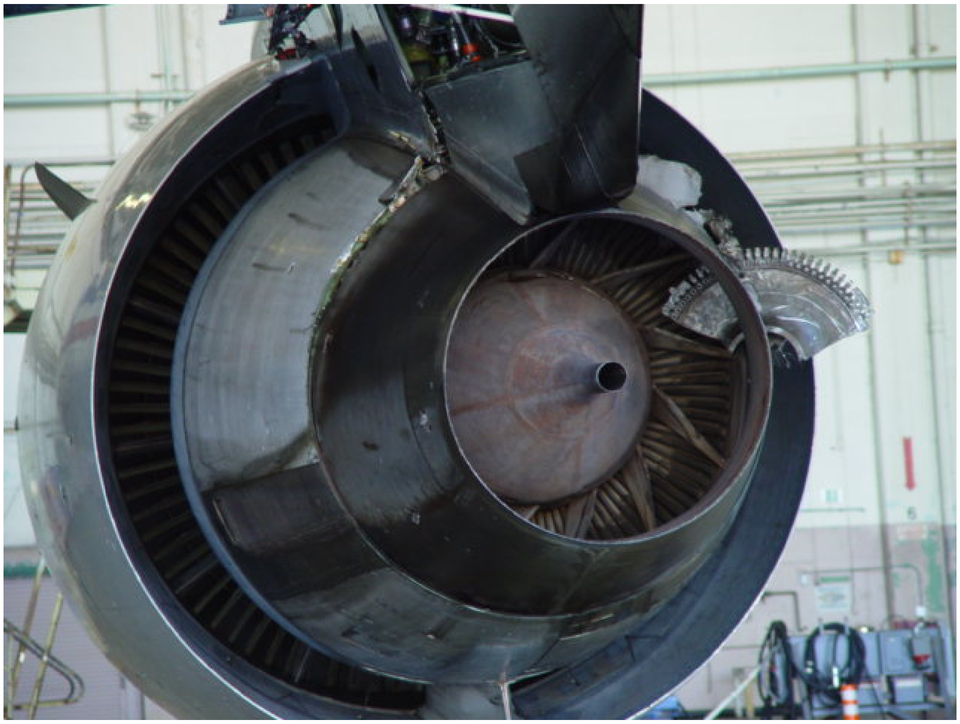

Figure 3. View of the exhaust of No. 2 engine showing piece of HPT stage 1 disk protruding from the right side of the engine exhaust duct.

According to American Airlines' maintenance records, the HPT stage 1 disk had accumulated 48,429 hours since new and 9,186 cycles since new (CSN), with 5,814 cycles remaining for the disk's 15,000 CSN life limit. The maintenance records also indicated that the HPT stage 1 disk had last been overhauled at American Airlines' Maintenance & Engineering Center, Tulsa, Oklahoma, in 2001, when the disk had 43,354 hours and 8,057 CSN.[11] The engine had operated 4,895 hours and 1,129 cycles since the 2001 overhaul. The records from the 2001

[9] These cracks were subsequently broken open in the Safety Board's materials laboratory for examination, which confirmed that they were also intergranular fatigue fractures that were propagating axially forward and radially inward.

[10] Shotpeening is a metallurgical surface treatment to improve resistance to cracking wherein the surface to be treated is bombarded with air-propelled steel shot.

[11] The HPT stage 1 disk was installed in the incident engine following the overhaul. The incident engine was installed on an American Airlines 767, N312AA, in the No. 1 position, on March 26, 2002. While the engine was installed on N312AA, the airplane was placed in storage. The engine was removed from N312AA when the airplane was sold and was installed on N330AA in the No. 1 position at LAX on April 5, 2006. The engine had operated 604 hours and 128 cycles between the time it was installed on N330AA and the time of the incident.

overhaul show that the disk passed a fluorescent penetrant inspection (FPI) at that time.[12] The records from the 2001 disk overhaul did not make any reference to the blade slot bottoms. According to American Airlines' maintenance records, the disk was also overhauled in 1991 when the disk had 14,696 hours and 3,296 CSN. The Safety Board's investigation of this incident is ongoing.

The American Airlines incident raises serious safety concerns because, if it had occurred during flight rather than on the ground during maintenance, the airplane may not have been able to maintain safe flight. The Safety Board investigated another uncontained failure of an HPT stage 1 disk that raised similar concerns. On September 22, 2000, a US Airways Boeing 767-2B7(ER) airplane, N654US, equipped with GE CF6-80C2B2 engines, experienced an uncontained failure of the HPT stage 1 disk in the No. 1 engine during a high-power ground run for maintenance at Philadelphia International Airport, Philadelphia, Pennsylvania. The uncontained failure caused a fire under the left wing of the airplane. The mechanics involved were not injured, and the No. 1 engine and the airplane sustained substantial damage.[13] At the time of the failure, the disk had accumulated 7,547 CSN. The Board is also aware of an uncontained HPT stage 1 disk rupture that occurred on an Air New Zealand Boeing 767-219(ER), ZK-NBC, equipped with GE CF6-80A engines while the airplane was climbing through 11,000 feet on a flight from Brisbane, Australia, to Auckland, New Zealand, on December 8, 2002.[14] A section of the disk's rim and web separated and, after penetrating the engine's case and nacelle, damaged the left wing's leading edge. The airplane was able to return to Brisbane for a safe landing, and none of the 10 crewmembers and 190 passengers on board were injured. At the time of the incident, the ruptured Air Zealand HPT stage 1 disk had accumulated 12,485 CSN.

As a result of its investigation of the US Airways event, the Safety Board issued Safety Recommendations A-00-121 through -124, which were all closed in either an acceptable or acceptable alternate status following the Federal Aviation Administration's (FAA) actions in response. Although some of the issues identified thus far in the Board's investigation of the American Airlines event were previously addressed by these recommendations and the FAA's corrective actions, the fact that an uncontained failure of an HPT stage 1 disk recurred indicates that further actions are necessary.

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[12] FPI is a nondestructive inspection method of detecting cracks and other surface anomalies. The inspection consists of applying or immersing the part in a low viscosity penetrating fluid containing fluorescent dyes and allowing the fluid to penetrate into any surface defects. Excess penetrant is removed and a "developer" is applied that acts as a blotter to draw the penetrant out from any surface defects that will luminesce when viewed under a blacklight.

[13] The incident number for this event is DCA00IA090.

[14] The Australian Transport Safety Bureau conducted the investigation of the Air New Zealand event. The Safety Board participated in the investigation as a representative of the State of Manufacture in accordance with the provisions of Annex 13 to the Convention on International Civil Aviation.

Service Bulletins and Airworthiness Directives Regarding Rework/Enhanced Inspection of CF6-80 Series High Pressure Turbine Stage 1 Disks

Safety Recommendations A-00-121 and -123 asked the FAA to do the following:

> Require operators of General Electric (GE) CF6-80C2 engines to review their engine maintenance records for any high pressure turbine (HPT) stage 1 disks with blade slot bottoms that have been blend repaired. Any CF6-80C2 engines that are found to have an HPT stage 1 disk with a record of having had a blade slot bottom blend repaired should be removed from service and inspected at appropriately less than 1,675 cycles since the blend repair was accomplished and at appropriate intervals thereafter. (A-00-121) Urgent
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> Require implementation of the eddy current inspection procedure being developed by General Electric for CF6-80C2 HPT stage 1 disk blade slot bottoms. (A-00-123)

On October 13, 2000, GE issued CF6-80C2 Alert Service Bulletin (ASB) 72-A1024, which implemented the enhanced inspection of the CF6-80C2 HPT stage 1 disk referenced in Safety Recommendation A-00-121. Although the entire disk, including the blade slot bottom corners, would be examined during an FPI, the enhanced FPI included an etch to clean the blade slot bottom corners, which was intended to improve the probability of detecting cracks. GE issued CF6-80C2 ASB 72-A1026 on January 17, 2001, which added an eddy current inspection, referenced in Safety Recommendation A-00-123, to the enhanced visual inspection previously detailed in ASB 72-A1024. On October 24, 2002, GE revised the ASB to require a double etch and FPI, which was intended to further enhance the probability of detecting cracks. On May 18, 2001, the FAA issued Airworthiness Directive (AD) 2001-10-07, requiring the initial and repetitive inspections called for in ASB 72-A1026 Revision 1.

On March 20, 2002, GE issued CF6-80A SB 72-0779, which implemented the enhanced visual inspection and the eddy current inspection for HPT stage 1 disks in CF6-80A series engines, as well. On January 28, 2003, following the Air New Zealand event, the FAA issued AD 2003-01-05 to mandate the initial and repetitive inspections recommended in SB 72-0779. On January 22, 2004, GE issued SB 72-0779 Revision 1 and Alert SB 72-A1026 Revision 2 for CF6-80A and CF6-80C2 HPT stage 1 disks, respectively, to require a double etch and FPI, as well as an eddy current inspection of the blade slot bottoms. These bulletins also established CSN limits for when HPT stage 1 disks should be removed from service for the initial inspection.

After the investigation of the US Airways incident noted that the disk's blade slot bottom aft corner radii did not conform to engineering drawing requirements,[15] GE issued SBs 72-0788 (applicable to CF6-80A engines) in December 2002 and 72-1089 (applicable to CF6-80C2 engines) in May 2003 to modify HPT stage 1 disks by chamfering the blade slot bottom aft corners. This modification is intended to restore the geometry of the blade slot bottom aft corners

[15] The Safety Board noted its concern in the letter that transmitted Safety Recommendations A-00-121 through -124 that out-of-tolerance radii may negatively affect the fatigue life of CF6-80C2 HPT stage 1 disks.

to the desired dimensions. Whereas the geometry of a chamfered blade slot bottom aft corner is accurately controlled from part to part, the radii that resulted from the manual finishing process known as benching during manufacture were found to vary from part to part and blade slot bottom to blade slot bottom, often not conforming to the engineering drawing requirements. In addition to being accomplished on existing CF6-80A, -80C2, and certain -80E1 HPT stage 1 disks, the chamfer is being applied to the blade slot bottom corners on new production HPT stage 1 disks.

In February 2004, the FAA issued AD 2004-04-07 (effective March 12, 2004), which superseded ADs 2001-10-07 and 2003-01-05, to retain the initial and repetitive inspections required in the previous ADs, as well as require the modification outlined in SBs 72-0788 and 72-1089. The compliance times outlined in AD 2004-04-07 for all affected HPT stage 1 disks are provided in table 1.

Table 1. AD 2004-04-07 Compliance Times

HPT Stage 1 Disk CSN on the AD Effective Date	Compliance Time for Inspection and Rework
10,000 or more CSN	At the next engine shop visit or within 1,000 cycles-in-service (CIS) after the AD effective date, whichever occurs first
5,000 or more CSN but fewer than 10,000 CSN	At the next engine shop visit or within 2,400 CIS after the AD effective date, whichever occurs first, but before accumulating 11,000 CSN
Fewer than 5,000 CSN	At the next engine shop visit or within 3,500 CIS after the AD effective date, whichever occurs first, but before accumulating 7,400 CSN

In a June 29, 2006, meeting with Safety Board investigators, GE stated that the majority of in-service CF6-80A and -80C2 HPT stage 1 disks had already been subjected to the enhanced inspection process outlined in SB 72-0779 Revision 1 and ASB 72-A1026 Revision 2. GE also stated that a large number of the CF6-80A and -80C2 HPT stage 1 disks had undergone the rework of the blade slot aft corner in accordance with SBs 72-0788 and 72-1089. GE also indicated that as of the June 29, 2006, meeting, about 200 HPT stage 1 disks had not yet undergone either the enhanced inspection process or the blade slot bottom aft corner rework.[16] The disk from the incident American Airlines 767 had not been subject to the enhanced inspection process or the blade slot bottom aft corner rework before the uncontained engine failure occurred.

The Safety Board is concerned that disks that have not yet been inspected or reworked present a significant risk for another uncontained HPT stage 1 disk rupture. The Board notes that the HPT stage 1 disks from the American Airlines, US Airways, and Air New Zealand events all ruptured several thousand cycles short of the disks' 15,000 CSN life limit (9,186, 7,547, and 12,485 CSN, respectively). The Board also notes that CF6-80A and -80C2 HPT stage 1 disks with as few as 5,144 CSN have been found with propagating cracks that were detected during

[16] GE stated that the number of engines that have not yet had the enhanced inspection or the rework may increase because not all operators had reported to GE at the time of the meeting.

routine inspection.[17] Historically, establishing an inspection or rework schedule would require using a factor of two or three below the time to failure. However, in this case, it is unknown when the cracks initiated or how many cycles elapsed from crack initiation to failure. Therefore, to establish a conservative margin for these disks, inspection and rework should occur well before the 5,144 CSN threshold where fatigue cracks were found or the 7,547 CSN threshold where the US Airways disk failed. Additionally, because HPT stage 1 disks in CF6-80A, -80C2, and a small number of -80E1 engines are identical in the area of the blade slot bottom aft corners (although they have different part numbers), any actions taken should be accomplished to all three engine models.

Because the Safety Board is concerned that another failure may be imminent if immediate action is not taken, the Safety Board believes that the FAA should require that all CF6-80A and -80C2 HPT stage 1 disks and applicable -80E1 HPT stage 1 disks that have more than 3,000 CSN and have not been reworked in accordance with GE SBs 72-0788 or 72-1089 or have not yet been inspected in accordance with SB 72-0779 or ASB 72-A1026 be immediately removed from service for inspection and rework in accordance with these SBs. Those CF6-80A and -80C2 HPT stage 1 disks and applicable -80E1 HPT stage 1 disks that have fewer than 3,000 CSN and have not been reworked or inspected in accordance with these SBs can remain in service until reaching the 3,000 CSN threshold, at which time they should also be removed from service for inspection and rework. The Board also believes that the FAA should require that all CF6-80A and -80C2 HPT stage 1 disks and applicable -80E1 HPT stage 1 disks that have not been reworked in accordance with SBs 72-0788 or 72-1089 but have been inspected in accordance with SB 72-0779 or ASB 72-A1026 and have more than 3,000 cycles since the inspection be immediately removed from service for reinspection and rework in accordance with these SBs. Those CF6-80A and -80C2 HPT stage 1 disks and applicable -80E1 HPT stage 1 disks that have not been reworked in accordance with SBs 72-0788 or 72-1089 but have been inspected in accordance with SB 72-0779 or ASB 72-A1026 and have fewer than 3,000 cycles since the inspection can remain in service until reaching the 3,000 cycles-since-inspection threshold, at which time they should also be removed from service for reinspection and rework.

Compliance Schedules for Engine-Related Airworthiness Directives

The Safety Board notes that the inspection timetable provided in GE SB 72-1026 called for the enhanced and focused visual inspection and eddy current inspection of applicable HPT stage 1 disk blade slot bottom aft corners to be accomplished whenever the disks were removed from the engine and disassembled to the piece-part level. However, despite the discovery of additional HPT stage 1 disks with propagating cracks in the blade slot bottom aft corner (including one from a CF6-80A engine),[18] the FAA did not accelerate this inspection timetable when it issued AD 2001-10-07 requiring the inspections. The Safety Board also notes that despite GE's issuance of SB 72-0779 implementing the enhanced visual inspection and eddy current inspection on CF6-80A engines and the discovery of a CF6-80A HPT stage 1 disk with a

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[17] During the investigation of the US Airways incident, the Safety Board learned of two other CF6-80C2 HPT stage 1 disks that had cracks emanating from the blade slot bottoms. One was installed on an airplane operated by Thai Airways International and had 5,144 CSN at the time the cracks were detected. The other was installed on a Gulf Air airplane and had 9,532 CSN.

[18] This disk was from an engine installed on an All Nippon Airways airplane.

propagating crack, the FAA did not issue AD 2003-01-05 mandating the inspections for CF6-80A engines until after the Air New Zealand event had occurred. As with AD 2001-10-07, the inspections for the CF6-80A HPT stage 1 disks required by AD 2003-01-05 were to be accomplished whenever disks were disassembled to the piece-part level, and, as with AD 2001-10-07, AD 2003-01-05 did not accelerate the inspection timetable for the CF6-80A engines. The FAA did not revise this schedule until 2004 when it issued AD 2004-04-07, which mandated the enhanced inspections for CF6-80A and -80C2 HPT stage 1 disks through an age-driven compliance schedule.

GE indicated that it developed its age-driven compliance schedule using a combination of damage tolerance and safety risk analysis. The Safety Board notes that although these methods can be useful in establishing safe compliance timelines, they were not effective in preventing the Air New Zealand or American Airlines uncontained engine failures. Although the American Airlines engine failure occurred on the ground and did not result in any injuries, the potential outcome of a catastrophic uncontained failure of a high-energy rotating component was demonstrated by the accident involving United Airlines flight 232, which crashed at Sioux City, Iowa, on July 19, 1989, after a fan disk in the center GE CF6-6 engine burst in flight and disabled all of the DC-10's hydraulic systems.[19]

The Safety Board is concerned that the history of two uncontained engine failures and five HPT stage 1 disks with intergranular fatigue cracks should have prompted the FAA to establish a more aggressive inspection schedule. The uncontained engine failures occurred at 7,547 and 12,485 CSN and fatigue cracks were observed at 5,144; 9,532; 9,359; 9,058; and 9,495 CSN. The American Airlines HPT stage 1 disk failed at 9,186 CSN. The CSN threshold at which the uncontained engine failures occurred and when fatigue cracks were discovered in HPT stage 1 disks should have dictated an inspection interval well below the 9,186 CSN threshold at which the American Airlines disk failed rather than the 11,000 CSN schedule provided in the AD. The objective of setting AD compliance times for potentially catastrophic events should be to prevent any further occurrences[20] over the life of the affected engine model. If the FAA had implemented a more aggressive inspection schedule to address the increasing number of HPT stage 1 disks that were found with propagating cracks, the uncontained engine failure that occurred on the American Airlines 767 at Los Angeles may have been averted. Therefore, the Safety Board believes that the FAA should revise the engine-related AD process to ensure that the compliance timelines are appropriately established.

Adequacy of the Design of CF6-80 Series High Pressure Turbine Stage 1 Disks

Safety Recommendation A-00-124, which was issued following the Safety Board's investigation of the US Airways uncontained engine failure in Philadelphia, requested, in part,

[19] The description of this accident, DCA89MA063, can be found on the Safety Board's Web site at <http://www.ntsb.gov>.

[20] Title 14 CFR 25.1309 establishes that an inverse relationship should exist between the probability of occurrence of a failure condition and the severity of its effect on the airplane and/or its occupants. The qualitative safety goal for a failure condition that is potentially catastrophic is that the condition should not occur during the entire operational life of all airplanes of one type. The quantitative goal for a catastrophic failure condition is an average probability per flight hour of $1x10^{-9}$ or less.

that the FAA conduct a design review of the CF6-80C2 HPT stage 1 disk to include a stress analysis evaluating the adequacy of the design. In a March 7, 2001, response, the FAA stated that, after conducting a preliminary design review, it did not expect that "fatigue cracks would initiate in the [disk blade slot bottom] before the published life limit" and that the HPT stage 1 disk blade slot bottom is "sensitive to potential damage sustained due to mishandling or improper processes during new part manufacture or maintenance." In a February 1, 2002, response, the FAA indicated that it had completed the design review of the CF6-80C2 HPT stage 1 disk and determined that, with the modification that was eventually promulgated in SB 72-1089, no further design changes were necessary. The FAA also stated its belief that "when the prescribed manual procedures and limitations are followed, the disk integrity remains intact." The Board classified Safety Recommendation A-00-124 "Closed—Acceptable Action" on May 28, 2002.

Although the Safety Board concurs with the FAA's determination that mishandling or improper processes used during new manufacture or maintenance of CF6-80 series HPT stage 1 disks can lead to damage from which a crack could originate,[21] the Board also notes that cracks in the US Airways and the Air New Zealand disks originated in the blade slot bottom aft corners from no apparent defect or tool mark (similar cracking was observed in five other disks that had cracks but did not rupture).[22] Because handling damage to the disk could happen randomly around the disk, it could be expected that any resultant cracks might also occur randomly around the disk. The presence of cracks in the blade slot bottom aft corners from no apparent defect would suggest that the operating stresses in this area of the disk are near the limits for the Inconel 718 nickel alloy and that the disk, particularly in the area of the blade slot bottom aft corner radius, has limited, if any, tolerance to damage. Although GE has issued SBs to chamfer the slot bottom aft corners on CF6-80 series HPT stage 1 disks to ensure conformity to engineering drawing requirements, the Safety Board remains concerned that the stresses in the CF6-80 series HPT stage 1 disk blade slot bottom aft corner continue to remain high and could possibly exceed the material properties for Inconel 718 nickel alloy. Therefore, the Safety Board believes that the FAA should require a design review of CF6-80 series HPT stage 1 disks that incorporate chamfered blade slot bottom aft corners that includes a stress analysis and finite element model emphasizing the blade slot bottom aft corner to determine whether sufficient material property margin exists to ensure that cracks do not occur. If the design review of chamfered HPT stage 1 disks finds that this design does not provide sufficient material property margin, then a redesign or material change should be implemented.

Disabling Cockpit Voice Recorders During Ground Tests of an Airplane and/or its Engines

Following the June 2, 2006, uncontained engine failure in Los Angeles, the flight data recorder (FDR) and cockpit voice recorder (CVR) were removed from the airplane and shipped to the Safety Board for playback and analysis. The playback of the FDR provided good accurate data of the engine failure event on the ground, as well as the engine performance problem reported by the flight crew of the previous flight. However, the playback of the CVR revealed

[21] During the investigation of the US Airways event, the Safety Board learned of two CF6-80C2 HPT stage 1 disks on airplanes operated by Thai Airways and Gulf Air that were found with cracks that originated from tool marks and propagated from the blade slot bottom aft corners.

[22] GE reported that one of these disks was found to have a crack that originated from a tool mark on the front face of the disk adjacent to a blade slot.

that only information from the in-bound flight was captured and that neither the engine failure event nor any segment of the ground operation at LAX was recorded. According to the maintenance personnel on board the airplane at the time of the failure, it was their normal practice to pull the CVR circuit breaker whenever they were going to run the engines for a ground test.

The Safety Board has long advocated that CVRs be disabled as soon as possible upon landing after a reportable incident or accident to preserve important data that can be used to assist with the investigation of the event. However, in situations such as at Los Angeles in which an arriving airplane has a maintenance report that requires a ground engine run, maintenance personnel should not intentionally disable a CVR before conducting ground tests of the engines. The Safety Board notes that when the US Airways 767 experienced an uncontained engine failure during ground testing at Philadelphia, the CVR captured valuable information that contributed to the investigation of the event because the maintenance personnel had not disabled the CVR before conducting the ground test. Although the maintenance personnel involved in the Los Angeles event were able to provide Safety Board investigators with information about what was occurring in the cockpit leading up to and at the time of the failure, the additional data that would have been recorded on the CVR during this time would have been very beneficial to the investigation.

The Safety Board is concerned about the potential for losing valuable data if an event occurs during an engine ground test and the CVR has been intentionally disabled. However, in a situation in which an airplane has been involved in a reportable event and maintenance personnel have to test the engines, the CVR should be disabled to preserve the event data until a replacement CVR can be installed for an engine ground test. Therefore, the Safety Board believes that the FAA should require that maintenance personnel ensure that an aircraft's CVR is operating before conducting any engine ground tests. If an airplane has been involved in a reportable event, the incident CVR should be removed to preserve the event data and any subsequent ground test should be delayed until a suitable replacement CVR can be installed in the aircraft.

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

> Require that all CF6-80A and -80C2 high pressure turbine (HPT) stage 1 disks and applicable -80E1 HPT stage 1 disks that have more than 3,000 cycles since new (CSN) and have not been reworked in accordance with General Electric Service Bulletins (SB) 72-0788 or 72-1089 or have not yet been inspected in accordance with SB 72-0779 or Alert Service Bulletin 72-A1026 be immediately removed from service for inspection and rework in accordance with these SBs. Those CF6-80A and -80C2 HPT stage 1 disks and applicable -80E1 HPT stage 1 disks that have fewer than 3,000 CSN and have not been reworked or inspected in accordance with these SBs can remain in service until reaching the 3,000 CSN threshold, at which time they should also be removed from service for inspection and rework. (A-06-60) Urgent

Require that all CF6-80A and -80C2 high pressure turbine (HPT) stage 1 disks and applicable -80E1 HPT stage 1 disks that have not been reworked in accordance with General Electric Service Bulletins (SB) 72-0788 or 72-1089 but have been inspected in accordance with SB 72-0779 or Alert Service Bulletin (ASB) 72-A1026 and have more than 3,000 cycles since the inspection be immediately removed from service for reinspection and rework in accordance with these SBs. Those CF6-80A and -80C2 HPT stage 1 disks and applicable -80E1 HPT stage 1 disks that have not been reworked in accordance with SBs 72-0788 or 72-1089 but have been inspected in accordance with SB 72-0779 or ASB 72-A1026 and have fewer than 3,000 cycles since the inspection can remain in service until reaching the 3,000 cycles-since-inspection threshold, at which time they should also be removed from service for reinspection and rework. (A-06-61) Urgent

Revise the engine-related airworthiness directive process to ensure that the compliance timelines are appropriately established. (A-06-62)

Require a design review of CF6-80 series high pressure turbine (HPT) stage 1 disks that incorporate chamfered blade slot bottom aft corners that includes a stress analysis and finite element model emphasizing the blade slot bottom aft corner to determine whether sufficient material property margin exists to ensure that cracks do not occur. If the design review of chamfered HPT stage 1 disks finds that this design does not provide sufficient material property margin, then a redesign or material change should be implemented. (A-06-63)

Require that maintenance personnel ensure that an aircraft's cockpit voice recorder (CVR) is operating before conducting any engine ground tests. If an airplane has been involved in a reportable event, the incident CVR should be removed to preserve the event data and any subsequent ground test should be delayed until a suitable replacement CVR can be installed in the aircraft. (A-06-64)

Chairman ROSENKER, Vice Chairman SUMWALT, and Members HERSMAN and HIGGINS concurred with these recommendations.

[Original Signed]

By: Mark V. Rosenker
Chairman