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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: December 22, 1997

In reply refer to: A-97-121 and -122

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On March 14, 1997, Reno Air flight 153, a McDonnell Douglas MD-87 airplane, N753RA, experienced a partial power loss in both of its Pratt & Whitney (P&W) JT8D-219 turbofan engines during takeoff from Detroit, Michigan. The pilots reported and the digital flight data recorder (DFDR) confirmed that just as the airplane rotated for takeoff, both engines lost power and began to surge.[1] The DFDR data show that the pilots retarded the left and right engine power levers to clear the surging and stabilize the engines about 6 and 16 seconds, respectively, after the surging had begun. The emergency procedures require that the power levers be retarded individually to avoid the potential of a double-engine flameout. The airplane returned to Detroit, and landed without further incident. The airplane was operating on an instrument flight rules flight plan under the provisions of Title 14 Code of Federal Regulations Part 121 as a regularly scheduled passenger flight from Detroit to Reno, Nevada. The 5 crewmembers and 106 passengers on board were not injured.

The examination of both Reno Air engines revealed that almost all of the fan blades had soft body impact damage[2] to the blade tips and leading edges and that the fan rub strips were almost completely rubbed away. The engines were removed from the airplane for disassembly and examination under the direction of the National Transportation Safety Board. A fluorescent penetrant inspection of the high pressure compressor (HPC) blades revealed that 17 8th-stage compressor blades and 1 9th-stage compressor blade from the right engine had transverse cracks on the convex side of the airfoil adjacent to the blade root platform. Several of the cracked 8th-stage compressor blades were further examined at the Safety Board's materials laboratory. The cracks on two of the 0.120-inch thick blades were broken open revealing 0.55-inch long by 0.05-inch wide, crescent-shaped, dark-colored areas, which are characteristic of fatigue fractures. The damage to the fan blades and the fan rub strips caused the airflow into the engines to be

[1] A surge is a disruption of the airflow through the compressors resulting in a stagnation or reversal of the airflow and is typified by loud reports or bangs and flames from the inlet and tailpipe.

[2] Soft body impact damage is characterized by the large radius of curvature of the deformations to the blade, typically a fan blade. Soft body impact damage can result from impact with pliable objects such as birds, ice slabs, tire rubber, wood, and plastic objects.

disrupted, thus causing the compressor to surge. The 8th- and 9th-stage compressor blade airfoils are susceptible to fatigue cracking because they bend from side to side when the engine is continuously surging.[3]

During the Reno Air airplane's inbound flight to Detroit, the air temperature in cruise at flight level 330 ranged from -47 to -55°F. On arrival in Detroit, it was raining and the temperature was 33°F. By the time the pilots began the preflight inspection of the airplane, the rain had changed slightly from moderate to light. The pilots had noted the weather conditions and that the wing tanks were full and considered the potential for wing ice. As required by Airworthiness Directive (AD) 92-03-02,[4] the wings were checked for ice formation. The first officer, who did the external portion of the preflight inspection, stated that he did not find any ice on the upper surface of the wings during an initial inspection when he stood on a ladder and used an ice stick,[5] or during a second inspection (corroborated by witnesses) when he crawled out on the wings to feel for the presence of ice with his hands. The first officer stated that he had observed frost on the lower surfaces of the wings that was 1/16-inch thick. Based on the evidence that was gathered during the investigation, the Safety Board has concluded that ice was present on the wings at that time and subsequently was ingested by the engines. The partial loss of power to both engines just after takeoff, caused by the ingestion of ice from the wings, suggests that the tactile inspection required by AD 92-03-02 does not adequately detect ice on the wings of MD-80s.

The design of the MD-80 series airplane is such that the inboard ends of the fuel tanks in the wings are directly in front of the aft fuselage-mounted engines. The typical fuel load remaining after landing and the cross-sectional shape and dihedral of the wing frequently result in the fuel contacting the upper surface of the tank at the inboard ends. The MD-80 has a fairly long range and can remain at cruise altitudes, where the outside temperature is very cold, for long periods of time. The extended exposure to the extreme cold temperatures causes the fuel in the wing tanks to become very cold. After the airplane lands, and if there is sufficient fuel, ambient temperatures below 50°F, and high humidity or rain, the very cold fuel in the wing tanks can cause ice to form along the upper surface of the wings in front of the engines. Unless the airplane is deiced, the ice will remain on the wing until the airplane takes off. As the airplane rotates for takeoff, the wings flex upward and the ice can break off and be ingested into the engine inlets, damaging the fan blades and rub strips.

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[3] The JT8D-200 Engine Manual provides specific inspection procedures for 8th- and 9th-stage compressor blades, which were installed in engines that were surging, to check for cracks. P&W conducted testing in support of the Safety Board's investigation of a Midwest Express DC-9 that crashed at Milwaukee, Wisconsin, that showed that severe surging could cause the 8th- and 9th-stage compressor blades to fracture in fatigue. Aircraft Accident Report—Midwest Express Airlines, Inc., DC9-14, N100ME, General Billy Mitchell Field, Milwaukee, Wisconsin, September 6, 1985 (NTSB/AAR-87/01).

[4] AD 92-03-02, which requires the flightcrew to make a tactile (hands-on) inspection of the MD-80 upper wing surfaces, was issued after the crash of Scandinavian Airline System flight 751, an MD-81 airplane, near Stockholm, Sweden, on December 27, 1991, after both engines lost power because of ingestion of wing ice.

[5] An ice stick is a wood pole that is used to feel for the texture of raised axial strips on the upper surface of the wing. The lack of any feeling of the strips with the stick would be indicative of ice being present on the wing, necessitating that the wing be deiced before the airplane could depart.

The Safety Board is concerned about the extent of damage that occurred to the right engine's 8th- and 9th-stage compressor blades during the 16 seconds that the engine was surging. Any further delay in retarding the right engine's power lever could have caused the right engine to experience blade fractures that would have destroyed the HPC and caused a total power loss. If the right engine had lost power, to maintain level flight, the pilots would have had to advance the power on the left engine, possibly inducing further surging that could have fractured the HPC blades. This action could have resulted in a total power loss in both engines that would have necessitated an off-airport emergency landing. This event is a good example of the need for pilots to make a timely reduction of power on engines that are surging to clear the surges and stabilize the engines.

At the request of the Safety Board staff, Boeing's Douglas Products Division (formerly McDonnell Douglas) will publish, in a flightcrew newsletter, the details of this event and the need to reduce engine power to eliminate the surging, which would minimize damage to the engines and ensure a safe return to the airport. However, because flightcrews do not always receive such advisory information, the Safety Board believes that the FAA should also issue a flight standards information bulletin to alert principal operations inspectors, and through them, all affected air carrier flightcrews, of the details of this Reno Air engine ice-ingestion incident and the need to reduce engine power to eliminate surging to minimize damage to the engines and ensure a safe landing.

The Safety Board has learned that overwing heater and ice detection systems are available to MD-80 operators. Also, the Safety Board is aware that American Airlines has completed the installation of such systems on its fleet of MD-80s and that other airlines are also installing these systems on their MD-80s. These systems operate when the airplane is on the ground to warm the wing surfaces above the fuel tanks to prevent ice formation. The systems are also designed to alert the crew if the wing surface is cold enough for ice formation or alert the crew that there is already ice on the wing. By contrast, the tactile inspection of the wing by a flightcrew member has limitations. The use of an ice stick to feel the raised strips on the wing, as the Reno Air first officer did on the first inspection of the wings, may not detect small amounts of ice between the strips. Also, the individual performing the check may miss an area of ice altogether. The flightcrew member crawling out on the wing, as the first officer did on the second inspection of the wings, may not detect the ice because he may not be able to see or touch the ice. The flightcrew members may also be distracted from adequately inspecting the wing surfaces by cold temperatures, inclement weather, darkness, bright lights, or concern for their personal safety on a wet, possibly slippery surface that provides no handholds. Therefore, the Safety Board believes that the FAA should require the installation of an overwing heater and ice detection system on MD-80 and MD-90[6] airplanes to provide a more reliable means of preventing or detecting wing ice before every flight in lieu of the tactile inspection required by AD 92-03-02.

[6] The MD-90 airplane is a derivative of the MD-80 that is slightly longer and has an identical fuel tank configuration in front of the engines, but features International Aero Engines V2500 engines in place of the P&W JT8D-200 engines.

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

> Issue a flight standards information bulletin to alert principal operations inspectors, and through them, all affected air carrier flightcrews, of the details of the Reno Air engine ice-ingestion incident that occurred on March 14, 1997, and the need to reduce engine power to eliminate surging to minimize damage to the engines and ensure a safe landing. (A-97-121)
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> Require the installation of an overwing heater and ice detection system on MD-80 and MD-90 airplanes to provide a more reliable means of preventing or detecting wing ice before every flight in lieu of the tactile inspection required by Airworthiness Directive 92-03-02. (A-97-122)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman