National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: April 29, 2004

In reply refer to: A-04-34 and -35

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

On June 4, 2002, Spirit Airlines flight 970, a McDonnell Douglas MD-82 airplane, experienced a gradual loss of power in both of its Pratt & Whitney JT8D-219 engines and an activation of the aural stall warning and stickshaker while in cruise flight at flight level (FL) 330[1] about 20 miles from Wichita, Kansas.[2] When the stall warning activated, the pilots disengaged the autopilot, turned on the engines' ignition, activated the engines' anti-ice system,[3] and initiated a descent. The pilots reported later that they shut down the right engine when its exhaust gas temperature (EGT) increased to about 600° Celsius (C) and were able to restart it again on the second attempt at about 17,000 feet. They reported that the left engine recovered on its own shortly thereafter. The flight then diverted to the Wichita Mid-Continent Airport, Wichita, Kansas, where it landed safely. The flight was operating on an instrument flight rules flight plan under the provisions of 14 *Code of Federal Regulations* Part 121 as a regularly scheduled passenger flight from Denver International Airport (DEN), Denver, Colorado, to Fort Lauderdale-Hollywood International Airport, Fort Lauderdale, Florida. The 2 pilots, 4 flight attendants, and 105 passengers on board were not injured.

The pilots of flight 970 reported in postincident interviews that the autopilot was in the altitude hold mode and the autothrottle was in the speed hold mode at the time of the incident. Flight data recorder (FDR) data show that, shortly after the airplane leveled off at FL 330, power for the left and right engines decreased from about 2.05 EPR [engine pressure ratio][4] to about

[1] Flight level 330 is an altitude of 33,000 feet mean sea level, based on an altimeter setting of 29.92 inches of mercury.

[2] The description of this incident, CHI02IA151, can be found on the National Transportation Safety Board's Web site at <http://www.ntsb.gov>.

[3] The engine anti-ice system, when activated, uses warm compressor bleed air to prevent the formation of ice on the engine nose cowl and engine's inlet, which includes the inlet guide vanes, nose bullet, and the inlet pressure probes.

[4] Engine pressure ratio (EPR) is a measurement of engine power as a ratio of the total pressure of the gases exiting the engine's exhaust pipe divided by the total pressure of the air entering the engine's inlet. On the JT8D engine, the total inlet air pressure is measured at the dome mounted on the front of the engine.

1.80 EPR, the airplane's indicated airspeed was about 269 knots, and the pitch angle was about 1° nose up, typical for cruise flight. FDR data show that the airplane's speed and pitch angle and the engines' EPR indications remained relatively steady at these values for more than 15 minutes. FDR data then indicate that, over a 5-minute period just before the engines lost power and the stickshaker activated, the indicated airspeed decreased from about 271 knots to 209 knots, the pitch angle increased from 1.34° to 4.91° nose up, and the engines' EPR increased from about 1.68 to about 2.07.[5] The FDR data show that during the 18 seconds after the engines lost power, the airplane slowed to 193 knots and the pitch angle increased to 8.88° nose up before the airplane pitched down and began to descend.[6]

National Transportation Safety Board investigators' examination of the airplane and engines at Wichita following the event did not reveal any damage to the engines or malfunction of an airplane or engine system that could have caused the loss of power. Investigators accomplished a power assurance check on the left engine in accordance with the JT8D-200 Maintenance Manual (MM) and found that the engine was able to attain the target EPR without exceeding its rpm or EGT limits.[7] The airplane's fuel tank boost pumps, engine anti-ice system, and fuel heater system were tested and found to function properly. The airplane was found to have 23,600 pounds of fuel remaining. Jet A fuel samples from the airplane, as well as from the truck that serviced the airplane at DEN, were tested and found to conform to applicable specifications.

According to the pilots, the airplane was nearly at, but not over, the maximum weight limit for operation at FL 330. If the airplane had been over the weight limit for FL 330, its speed would have begun decreasing and its pitch angle would have begun increasing immediately after it leveled off at that altitude. Because the airplane was able to maintain FL 330 for more than 15 minutes before it began to slow and pitch up significantly, it appears that the airplane was not overweight for that altitude. Investigators, therefore, examined other causes for the loss of engine power and the activation of the stall warnings.

Radar weather images of the area that flight 970 was flying in just before the engines lost power show weak weather radar echo intensities at 33,000 feet that are consistent with high altitude ice crystals. According to the Federal Aviation Administration (FAA) National Resource Specialist (NRS) on icing, these ice crystals are not a problem most of the time. The FAA NRS indicated, however, that although high altitude ice crystals do not adhere to the typical areas of an airplane (such as the wings and windshield wipers), they can affect airplanes with engines that use EPR power settings (such as the JT8D-219 engines on the MD-82) because they can occasionally adhere to engine inlet pressure probes, which partially blocks the opening and causes a false high engine power indication. A similar circumstance that demonstrated the effect

[5] The FDR data show that both engines' EPR increased then both dropped suddenly.

[6] In postincident interviews, the pilots stated that when the stall warning and stickshaker activated, they noticed that the low pressure compressor (N1) rotor speed and the EPR for both engines were low. Neither pilot commented on any other engine parameter.

[7] The airplane's right engine was not tested because of damage that was discovered on numerous 7th stage compressor blades (the first stage of the high pressure compressor) during a borescope examination of the engine. Although the damage was minor, it exceeded the JT8D-200 MM's limits. However, the damage was insufficient to have caused the loss of engine power.

of ice blocking the JT8D engines' inlet pressure probes was the January 13, 1982, crash of Air Florida flight 90, a Boeing 737 that crashed into the Potomac River after taking off from Washington National Airport.[8] In addition to ice and snow contaminating the wings, the JT8D engines' inlet pressure probes were partially blocked by ice and snow, giving the flight crew an erroneous EPR indication.[9]

Although FDR data from Spirit Airlines flight 970 suggest that engine power was increasing just before the engines rolled back, the loss of airspeed and increase in pitch indicates that engine power was actually decreasing. According to a note in the MD-80 Flight Crew Operating Manual (FCOM), icing of the engine inlet pressure probes may cause the throttles to retard when the autothrottle is in the EPR limit mode.[10] The investigation concluded that because the engine anti-ice system was not activated when flight 970 entered the icing conditions, the ice crystals were able to adhere to and partially block the inlet air pressure probes, causing the EPR indication to increase until reaching the autothrottle EPR limit. Meanwhile, engine power and airspeed were actually decreasing and the airplane was pitching up, resulting in a stall condition.

The Safety Board is concerned that the pilots failed to activate the engine anti-ice system earlier. Specifically, they should have activated it before the airplane began transiting an area that, according to the Safety Board's meteorological analysis, would have had visible moisture present and in which the temperature was less then 6ºC.[11] The pilots' actions are contrary to the guidance in the MD-80 FCOM, which directs flight crews to use the engine anti-ice system whenever the outside air temperature is less than 6°C and visible moisture is present.

Further, the pilots apparently failed to recognize the signs that the engines' inlet probes were accreting ice despite the guidance in the MD-80 FCOM. The pilots of flight 970 had numerous visual cues in the cockpit that should have alerted them to the progressive loss of engine power and impending airplane stall: the loss of almost 90 knots of airspeed, the increase of engine EPR from about 1.7 to 2.07 even though the engines' low and high pressure rotor speeds, EGT, and fuel flow were actually decreasing concurrent with the engine throttles continually moving rearward, and the increase of the airplane's pitch attitude from about 1.4° nose up to 6.68°. The Safety Board is concerned that despite the guidance provided in the MD-80 FCOM, the infrequency with which high altitude ice crystals impact engine operation may result in flight crews not fully understanding the risk associated with high altitude ice

[8] The airport has since been renamed Ronald Reagan Washington National Airport.

[9] See National Transportation Safety Board, *Collision with 14th Street Bridge Near Washington National Airport, Air Florida Flight 90, Boeing 737-222, N62AF, Washington, D.C., January 13, 1982*, Aircraft Accident Report NTSB/AAR-82-8 (Washington, DC: NTSB, 1982).

[10] On the MD-80 series airplane, the autothrottle EPR limit mode is intended to prevent the autothrottle system from increasing the engine power to a point that might exceed the engines' temperature or rpm limits. If the engines' EPRs reach the EPR limit, then the autothrottle system will retard the engines' power levers as necessary to prevent the EPRs from exceeding the limit. FDR data from flight 970 show that the autothrottle system was switching in and out of the EPR limit mode when the EPR had increased above 2.0.

[11] Although the pilots stated the airplane was clear of any clouds at the time of the event, the Safety Board's meteorological analysis indicated that the airplane would have been in and out of clouds for the preceding 50 miles. The pilots stated in their postincident interviews that the ram air temperature was -29ºC.

crystals and how they can affect flight operations. Therefore, the Safety Board believes that the FAA should issue a flight standards information bulletin to principal operations inspectors to alert all affected air carrier flight crews about the icing situation encountered by Spirit Airlines flight 970 and to emphasize the need to maintain vigilance for the signs of high altitude icing conditions, the effect these conditions can have on airplane and engine performance, and the need for the appropriate use of the engine anti-ice system.

The Safety Board notes that because icing that occurs as a result of an encounter with high altitude ice crystals does not appear in places that pilots would typically look for ice accretion (such as the windshield wipers, windshield wiper attachment bolt, wings, etc.), there is no verifiable way for pilots on many turbojet airplanes to know if there may be an ice buildup on the engine inlet pressure probes. Such awareness is important to the timely activation of the engine anti-ice system. The Safety Board is aware that the Boeing MD-11 airplane is equipped with an ice detector in the engines' inlet that alerts pilots to activate the engine anti-ice system. Because the position of an engine on an airplane and the configuration of the inlet duct vary from airplane to airplane, the Board recognizes that the MD-11 inlet ice detector may not necessarily be usable on other turbojet airplanes. However, the Board is concerned that there may be additional instances of power losses and aerodynamic stalling if pilots of turbojet airplanes are not vigilant for or are not able to see (such as at night) the conditions that can cause engine inlet probe icing and, as a result, fail to activate the engine anti-ice system. Therefore, the Safety Board believes that the FAA should actively pursue research with airplane and engine manufacturers and other industry personnel to develop an ice detector that would alert pilots of inlet pressure probe icing and require that it be installed on new production turbojet airplanes, as well as retrofitted to existing turbojet airplanes.

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

> Issue a flight standards information bulletin to principal operations inspectors to alert all affected air carrier flight crews about the icing situation encountered by Spirit Airlines flight 970 and to emphasize the need to maintain vigilance for the signs of high altitude icing conditions, the effect these conditions can have on airplane and engine performance, and the need for the appropriate use of the engine anti-ice system. (A-04-34)

> Actively pursue research with airplane and engine manufacturers and other industry personnel to develop an ice detector that would alert pilots of inlet pressure probe icing and require that it be installed on new production turbojet airplanes, as well as retrofitted to existing turbojet airplanes. (A-04-35)

Chairman ENGLEMAN CONNERS, Vice Chairman ROSENKER, and Members GOGLIA, CARMODY, and HEALING concurred in these recommendations.

Original Signed

By: Ellen Engleman Conners
Chairman