National Transportation Safety Board
Aviation Accident Final Report

Location:	Dallas, TX	**Accident Number:**	FTW02LA088
Date & Time:	03/06/2002, 0715 CST	**Registration:**	N1425A
Aircraft:	Fokker F-28 MK-100	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	34 None
Flight Conducted Under:	Part 121: Air Carrier - Scheduled		

Analysis

The F-100 commercial passenger airplane experienced an uncontained rupture of the auxiliary power unit's (APU) turbine wheel while standing during de-icing procedures. Approximately ten minutes after de-icing began, the Captain reported that he heard and felt a "thud-like" noise from outside the aircraft. At the same time, the APU shutdown. One of the de-icing crewmembers on the ground stated he saw a flame come from the APU exhaust and had activated the ground APU fire bottle discharge switch. Examination of the APU revealed two large holes in the APU's compressor case in line with the turbine wheel's plane of rotation. The turbine wheel was broken into several pieces. A fragment of the turbine wheel was found embedded into a first aid kit that was mounted inside the cabin on the aft wall directly in front of the aft pressure bulkhead. Metallurgical examination of the fractured pieces of the turbine wheel were confirmed that the APU had experienced an overspeed. Further examination did not reveal evidence of fatigue on any of the fracture surfaces. The APU's electronic control unit (ECU) was removed from the engine to interrogate the ECU's non-volatile memory (NVM) and perform a diagnostic test. The NVM indicated that the APU had experienced an overspeed, which is a rotor speed of 107 percent or greater, and had commanded a shutdown. The diagnostic test showed that there were no discrepancies with the ECU. The Automated Surface Observing Station for DFW at 0700 reported winds from 320 degrees at 20 knots gusting to 27 knots. The members of the de-icing crew stated that at the time they were de-icing the airplane, the wind was blowing at 20 knots and gusting. Due to the windy conditions, the drivers of the de-icing trucks had coordinated prior to de-icing the airplane to start at opposite ends of the airplane so the bucket operators would not be spraying each other as they de-iced the airplane. According to company records, all 5 members of the de-icing crew were trained and experienced, and were aware not to spray de-ice fluid in the area of the F-100's APU inlet.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The ground crew inadvertent application of deicing fluid in the auxiliary power unit resulting

in an overspeed and turbine wheel burst. A contributing factor was the gusty wind.

Findings

Occurrence #1: MISCELLANEOUS/OTHER
Phase of Operation: STANDING

Findings
1. (C) FLUID,ANTI-ICE ADDITIVE - INGESTED
2. ICE/FROST REMOVAL FROM AIRCRAFT - INADVERTENT USE - GROUND PERSONNEL
3. (C) AUXILIARY POWER UNIT - OVERSPEED
4. (C) TURBINE ASSEMBLY,TURBINE WHEEL - BURST
5. (F) WEATHER CONDITION - GUSTS

Factual Information

On March 6, 2002, at 0715 central standard time, a Fokker F-28 MK-100 turbojet airplane, N1425A, operating as American Airlines Flight 334 (AAL 334) experienced an uncontained rupture of the auxiliary power unit's (APU) turbine wheel while operating during de-icing procedures at the Dallas/Fort Worth International Airport (DFW), Dallas, Texas. AAL 334 was being operated by American Airlines, Inc., of Fort Worth, Texas under 14 Code of Federal Regulations Part 121, as a scheduled domestic passenger flight from DFW, to the Nashville International Airport (BNA), near Nashville, Tennessee. The two airline-transport pilots, two flight attendants, and thirty passengers were not injured. Instrument meteorological conditions prevailed, and an instrument flight rules (IFR) flight plan was filed. The flight was in preparation for departure to BNA at the time of the accident.

AAL 334 departed gate Alpha 14 at 0633, and taxied to ramp spot 22 for de-icing. The aircraft was parked at a northeast direction. The ground de-icing crew notified the flight crew to prepare for de-icing. Approximately ten minutes after de-icing began, the Captain reported that he heard and felt a "thud-like" noise from outside the aircraft. At the same time, the APU shutdown. One of the de-icing crewmembers on the ground stated he saw a flame come from the APU exhaust and discharged the ground APU fire bottle. Approximately the same time, the #2 flight attendant who was seated in the jumpseat at the rear of the cabin, phoned the Captain via the intercom and informed him that the emergency first aid kit sustained damage in the form of a three-inch hole in the back of the kit. The flight attendant stated that an apparent impact on the first aid kit had propelled it from the stowed position into the center aisle of the aircraft. The rear cabin jumpseat was located directly in front of the aft pressure bulkhead. The emergency first aid kit was stowed directly onto the aft wall of the cabin underneath the rear cabin jumpseat.

Two spray trucks were used to de-ice the airplane with Type 1 de-icing fluid. The five-person crew consisted of a checker, a driver for each truck, and a spray bucket operator for each truck. The members of the de-icing crew stated that at the time they were de-icing the airplane, the wind was blowing at 20 knots and gusting. Due to the windy conditions, the drivers of the de-icing trucks had coordinated prior to de-icing the airplane to start at opposite ends of the airplane so the bucket operators would not be spraying each other as they de-iced the airplane. The bucket operators both stated that at times, the wind was whipping the stream of de-icing fluid such that they could not even see the airplane, let alone where the de-icing fluid was being sprayed. Bucket operator #1stated that he had completed de-icing the nose, right wing, and right horizontal stabilizer of the airplane, and had just started to de-ice the right side of the vertical fin, when he heard a noise and saw that the APU was on fire. Bucket operator #2 stated that he had de-iced the left horizontal stabilizer, the left side of the vertical fin, and aft fuselage, and after the truck was repositioned, he had started to de-ice the left wing when the checker discovered the APU fire. The bucket operators stated that they knew where the F-100's APU air inlet was located, and were aware that de-icing fluid should not be sprayed into the APU inlet.

The Automated Surface Observing Station for DFW at 0700 reported winds from 320 degrees at 20 knots gusting to 27 knots, visibility 2.5 statute miles in freezing rain and ice pellets, overcast skies at 2,500 feet, temperature minus 4 degrees Celsius, dew point minus six degrees Celsius, and an altimeter setting of 30.01 inches of Mercury. The Investigator-In-Charge calculated the density altitude to be approximately minus 1,586 feet.

The AlliedSignal (Honeywell) GTCP 36-150RR APU is transversely mounted in the tail compartment directly behind the aft pressure bulkhead. According to American Airlines, the APU had a total time of 19,637 hours and 15,674 cycles since new. The APU had operated 1,764 hours and 1,167 cycles since its last overhaul. Air for the APU is supplied through an intake duct. The APU intake duct inlet is located on the upper right side of the fuselage adjacent to the vertical stabilizer, just aft of where the leading edge of the vertical stabilizer attaches to the crown of the fuselage. The APU's air inlet door, which is hinged at the front, opens inward to an angle of 15 degrees when the airplane is on the ground and the APU is operating. The F-100 does not have a flow diverter strip over the APU air inlet, similar to what is installed over the cabin doors, to divert the flow of any fluids away from the doors.

Examination of the airplane revealed APU damage, which was located inside the tailcone. The turbine wheel was found fractured into five pieces. The fracture surfaces were coarse and grainy, with no evidence of fatigue. The impeller was found intact and the impeller vane leading edges had nicks and gouges and were bent opposite the direction of rotation. Ridges on the rear face of the impeller were in line with the vanes on the front face. A fragment of the turbine wheel penetrated the aft pressure bulkhead, and was found embedded in the first aid kit that was stored directly underneath the flight attendant's aft jump seat located at the rear of the cabin. Examination of the APU was conducted at American Airlines' maintenance facility in Tulsa, Oklahoma. The examination revealed two large holes in the APU's compressor case in line with the turbine wheel's plane of rotation. The turbine wheel was broken into several pieces. The broken pieces of the turbine wheel were submitted to Honeywell's Materials Laboratory for a metallurgical examination that confirmed the APU had experienced an overspeed. Further examination did not reveal evidence of fatigue on any of the fracture surfaces. Additionally, the containment ring was broken into three pieces.

The APU has an electronic control unit (ECU) that meters fuel to the APU while it is in operation. The ECU monitors the rotor speed and will shut off fuel to the APU if it senses an overspeed, which is 107 percent. The ECU was removed from the engine and shipped to Honeywell's Anniston, Alabama facility to interrogate the ECU's non-volatile memory (NVM) and perform a diagnostic test. The NVM indicated that the APU had experienced an overspeed, which is a rotor speed of 107 percent or greater, and had commanded a shutdown. The diagnostic test showed that there were no discrepancies with the ECU.

A review of American Airlines' de-icing training program showed that each of the 5 had completed annual refresher training in de-icing procedures for the F-100. During de-icing training, personnel are advised not to spray the F-100 APU inlet area, and crews are furnished diagrams of each type of airplane that higlight prohibited spray areas. According to company records the following is a summary of de-icing experience for the crew:

Checker 14 years

Driver #1 14 years

Driver #2 17 years

Bucket Operator #1 13 years

Bucket Operator #2 15 years

In February 2001, American Airlines issued a 'Winterization Bulletin' for the F-100 advising that de-ice spray should not be sprayed into the APU inlet. Additionally, the F-100

maintenance manual section 12-31-00, page 301 specifically advises, "Do not let de-icing and/or anti-icing fluid/water mixture go into the APU inlet. Injury to persons and/or damage to equipment can occur." American Airlines' policy had been to operate the APU during de-icing. As a result of this event, pilots were instructed to not operate the APU during de-icing operations, and to refer to the operating manual and follow procedures for de-icing with an inoperative APU. De-icing crews were also informed of the change in de-icing procedures, regarding the operation of the APU.

As a result of this event, on March 29, 2002, the National Transportation Safety Board issued Safety Recommendation A-02-05 that recommended the Federal Aviation Administration (FAA) immediately issue an airworthiness directive (AD) for the Fokker F-28 MK-100 and F-28 MK-4000 airplanes that prohibits APU operation during deicing operations. The FAA issued AD 2001-07-03 that prohibits the operation of the APU during deicing operations for all series of the F-28 airplane.

Pilot Information

Certificate:	Airline Transport	**Age:**	37, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--w/ waivers/lim.	**Last Medical Exam:**	11/19/2001
Occupational Pilot:		**Last Flight Review or Equivalent:**	03/30/2001
Flight Time:	13644 hours (Total, all aircraft), 5033 hours (Total, this make and model), 2121 hours (Pilot In Command, all aircraft)		

Co-Pilot Information

Certificate:	Airline Transport	**Age:**	34, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	None	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 2 Valid Medical--no waivers/lim.	**Last Medical Exam:**	11/28/2000
Occupational Pilot:		**Last Flight Review or Equivalent:**	07/15/2001
Flight Time:	3700 hours (Total, all aircraft), 500 hours (Total, this make and model), 1600 hours (Pilot In Command, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	Fokker	**Registration:**	N1425A
Model/Series:	F-28 MK-100	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Transport	**Serial Number:**	11408
Landing Gear Type:	Retractable - Tricycle	**Seats:**	111
Date/Type of Last Inspection:	02/22/2002, Continuous Airworthiness	**Certified Max Gross Wt.:**	100971 lbs
Time Since Last Inspection:	33 Hours	**Engines:**	2 Turbo Jet
Airframe Total Time:	22818 Hours	**Engine Manufacturer:**	Rolls-Royce
ELT:	Installed, not activated	**Engine Model/Series:**	TAY650-15
Registered Owner:	AMR Corporation	**Rated Power:**	15100 lbs
Operator:	AMR Corporation	**Air Carrier Operating Certificate:**	Flag carrier (121)
Operator Does Business As:	American Airlines	**Operator Designator Code:**	AALA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	DFW, 607 ft msl	**Observation Time:**	0700 CST
Distance from Accident Site:		**Direction from Accident Site:**	
Lowest Cloud Condition:	Scattered / 1500 ft agl	**Temperature/Dew Point:**	-4°C / -6°C
Lowest Ceiling:	Overcast / 2500 ft agl	**Visibility**	2.5 Miles
Wind Speed/Gusts, Direction:	20 knots/ 27 knots, 320°	**Visibility (RVR):**	
Altimeter Setting:	30.01 inches Hg	**Visibility (RVV):**	
Precipitation and Obscuration:			
Departure Point:	Dallas, TX (DFW)	**Type of Flight Plan Filed:**	IFR
Destination:	Nashville, TN (BNA)	**Type of Clearance:**	None
Departure Time:	0633 CST	**Type of Airspace:**	Class B

Airport Information

Airport:	Dallas/Ft Worth Intl (DFW)	**Runway Surface Type:**	Asphalt
Airport Elevation:	607 ft	**Runway Surface Condition:**	Wet
Runway Used:	NA	**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	4 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	30 None	**Aircraft Fire:**	On-Ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	34 None	**Latitude, Longitude:**	32.885278, -97.040278

Administrative Information

Investigator In Charge (IIC):	Alexander Lemishko	**Adopted Date:**	06/30/2004
Additional Participating Persons:	Clayton B Titus; Flight Standards District Office (SW21); Ft. Worth, TX		
Publish Date:			
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		

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