German Federal Bureau
Of Aircraft Accident
Investigation

Investigation Report

Identification

Type of Occurrence:	Accident
Date:	20 January 2015
Location:	Nuremberg Airport
Aircraft:	Transport aircraft
Manufacturer / Model:	Fokker Aircraft B.V. / F28 Mark 0100
Injuries to Persons:	None
Damage:	Aircraft severely damaged
Other Damage:	None
State File Number:	BFU AX001-15

Factual Information

The Auxiliary Power Unit (APU) ingested de-icing fluid during the de-icing procedure on the apron. Subsequently turbine speed increased strongly and the APU ruptured. As a result the aft pressure bulkhead of the airplane was punctured by debris.

History of the Flight

The airplane stood at parking position 30; crew and passengers were on board. The crew stated that the doors were closed, and the APU was running. At about 1050 hrs[1] the de-icing vehicle (Eisbär 6) was requested for de-icing services. The de-

1 All times local, unless otherwise stated.

icing personnel stated that initially the wings and the left side of the tail section were de-iced. Then the de-icing vehicle was positioned on the right side between engine and empennage. The de-icing fluid Type I (Safewing MP I 1938 ECO (80)) was used. After the vehicle had been positioned the right empennage was de-iced. Then the de-icer re-positioned the working basket and wanted to de-ice the right side of the vertical tail. He stated that he had just begun with the leading edge (approximately 0.5 m) when he noticed that the rpm of the APU suddenly increased strongly. He described the noise getting louder and the frequency increasing. Furthermore, the exhaust fumes increased strongly. He then closed the jet tube and ended the de-icing process. At that moment he heard a loud bang and sought cover within the basket. Immediately afterwards there was a second, more intense bang and the APU shut off.

During these events, the driver of the de-icing vehicle noticed that the maintenance door in the fuselage bottom sprang open and an explosive flame of about two meters escaped. He also stated that the blast waves of the two bangs were so intense that the de-icing vehicle rocked.

Both bangs could be heard in the cabin. The crew stated the airplane had rocked. In the cockpit the APU error message illuminated and the APU shut-off automatically.

In the aft part of the cabin a fracture piece of the APU punctured the pressure bulkhead and smoke emitted for a short time.

Initially the passengers were taken to the front of the cabin which was free of smoke and then disembarked. Buses took them back to the terminal.

Personnel Information

Flight Crew

The 33-year-old Pilot in Command (PIC) held an Air Transport Pilot's License (ATPL(A)) with the commensurate class and type ratings issued by the Swiss aeronautical authority. The pilot held a class 1 medical certificate.

The PIC had a total flying experience of 5,580 hours and 3,010 landings; 4,387 hours and 1,900 landings of which were on Fokker 100.

The 37-year-old co-pilot held an Airline Transport Pilot's License (ATPL(A)) with the commensurate class and type ratings issued by the Swiss aeronautical authority. She had a class 1 medical certificate.

She had a total flying experience of 2,970 hours and 2,300 landings; 2,570 hours and 1,300 landings of which were on Fokker 100.

De-Icing Personnel

The de-icing person had been trained in accordance with the requirements (see Chapter Organisations and their Procedures). According to his own statement, he was a trained pilot and worked for de-icing services until his next employment.

Aircraft Information

The Fokker F28 Mk0100 (Fokker 100) is a short and medium range twinjet transport category airplane in all-metal construction. Left and right behind the wings Rolls Royce Tay 650-15 engines were mounted to the fuselage. The airplane had a maximum take-off mass of 45,810 kg.

The APU was located in the tail section behind the aft pressure bulkhead.

The airplane with the serial number 11459 was manufactured in 1993. At the time of the accident it had 51,879 total operating hours and 37,191 total airframe landings.

The aircraft was registered in Switzerland and operated by a Swiss operator.

Meteorological Information

At the time the BFU staff members arrived at the apron, temperatures between zero and minus one degree Celsius prevailed and it was snowing slightly. Ground operations services stated that at the time of the accident the weather conditions had been similar.

Radio Communications

The Cockpit Voice Recorder (CVR) recorded the radio communications between the crew and the de-icing vehicle personnel. The recording was made available to the BFU for evaluation.

Aerodrome Information

Nuremberg Airport's runway is 2,700 m long and 45 m wide. The available runway directions are 099° and 279°. The apron is located north of the terminal.

Flight Recorder

Flight Data Recorder (FDR) and CVR were made available to the BFU for evaluation purposes. The data was not used to determine the course of events.

Wreckage and Impact Information

The airplane stood at the parking position 30 on the apron. Fracture and small metal pieces which could be correlated with the APU and its periphery were found beneath the tail section of the airplane. The maintenance door, which allows access to the APU, was punctured and open (Appendices Image 1).

The APU housing was torn open and allowed a view of the interior (Image 2). The turbine wheel was severely damaged and the compressor wheel shattered. Image 3 shows the area on the right side of the tail section where the air intake for the APU is located and the APU exhaust exits the fuselage.

The area of the air intake was not marked. Smoke residue was found around the closed air intake hatch. The area around the exhaust was clearly silhouetted against the white fuselage surface due to the heat-resistant sheet metal used. In addition, the area to the upper right of the exhaust carried the marking FIRE ACCESS.

The two aft seats for the flight attendants were located at the back wall of the cabin which is also the pressure bulkhead (Image 4). A bin beneath the seats contained the smoke hoods for the flight attendants. A fracture piece of the compressor wheel punctured the area below the right flight attendant seat (Image 5). It left a hole of approximately 100 mm in diameter in the pressure bulkhead. The fracture piece itself had melted into the bottom of the bin. The back wall of the bin had been torn open.

Fire

After the APU had collapsed an explosive flame exited the lower maintenance door at the tail section. There was no subsequent fire.

Organisations and their Procedures

The technical operations department of an operator was responsible for the de-icing service at Nuremberg Airport. The personnel conducting the de-icing was employed with the company and trained prior to each winter season. For the winter season 2014/2015, de-icing personnel was trained in accordance with AEA (Association of

European Airlines) Recommendation for De-/Anti-Icing 29th Edition July 2014 and AEA Training Recommendation 11th Edition August 2014. The AEA was an association of European airlines functioning as interest group. It was not a governmental institution.

Among other things, de-icing personnel must be medically fit, have a valid driver's licence, and command of English.

Additional Information

De-Icing Procedure

During the de-icing process the de-icing fluid has a temperature of up to 70° when it leaves the steel pipe. Fog is the result due to the lower temperatures of the outside air, and the aircraft parts. This fog restricts the field of vision of the de-icing personnel (Image 6).

Documentation of the Aircraft Manufacturer

The manufacturer had stipulated procedures and details concerning de-icing procedures for the Fokker 100 in the Aircraft Operating Manual (AOM), Chapter 7.11.01 and in the Aircraft Maintenance Manual (AMM) TASK 12-31-00-660-833-A. These had to be adhered to during de-icing.

Past Occurrences

In the past there have been similar occurrences with this aircraft type where the APU ruptured due to de-icing fluid intake. The Powerplants Group Chairman's Factual Report of the US American National Transportation Safety Board (NTSB ID-No.: FTW02IA088) (Appendix 1) describes the investigation of the occurrence. The investigation resulted in a safety recommendation (Appendix 2) which the US American Federal Aviation Administration (FAA) addressed in the Airworthiness Directive (AD) 2002-07-03. This AD requires prohibition of APU operation during de-icing. This requirement was incorporated into the American flight manual.

Due to the occurrences, the aircraft manufacturer issued Service Letter 220 (Appendix 4). The service letter contains the factual information of the NTSB investigation report, and a description of the adverse effects on the airplane if the APU is shut down during de-icing. In the service letter the manufacturer recommends airlines to pay attention that only qualified personnel performs de-icing services. The

Airworthiness Recommendations Catalogue (item 12-31-4) (Appendix 5) issued February 2015 due to the occurrence in Nuremberg contains a summary.

In 2005 the aircraft manufacturer, the European Aviation Safety Agency (EASA), and the Dutch aviation authority (CAA-NL) met to discuss the results and actions. The result of the meeting was that no further actions were necessary.

Due to the occurrence in Nuremberg the above-mentioned parties met again. During the meeting a safety analysis of the occurrence was made. The meeting ended in the notion that marking the intake area could be done with little expense and would attract attention of the de-icing personnel.

Previous EASA Actions

Due to some safety recommendations regarding aircraft de-icing, among others the recommendation BFU 09/2006, EASA has taken action to improve safety during ground de-icing, even though, according to Regulation (EC) No 216/2008 (“on common rules in the field of civil aviation and establishing a European Aviation Safety Agency”), they have no direct oversight responsibilities regarding ground operating service providers. EASA commissioned a study in which the regulations for ground de-icing in member states were examined. In 2011 EASA published the report: EASA 2009/4 Regulation of ground de-icing and anti-icing services in the EASA Member States. Subsequently, in 2012 EASA organised a ground de-icing workshop. In addition, EASA conducted a safety conference concerning de-icing (icing conditions on the ground and in flight). It took place between 15 and 16 October 2013 in Cologne and intended to increase the awareness of all parties involved. The documentation to the study and the information regarding the workshop and the conference are published on the EASA website.

In the course of the policy initiative of the European Commission in regard to aviation safety and the possible revision of Commission Regulation (EC) No 216/2008 EASA has published Opinion No 01/2015. EASA proposes that ground services are included in Commission Regulation (EC) No 216/2008. Currently this proposal is being discussed in the decision-making bodies of the European Union.

Documentation by ICAO

The ICAO Manual of Aircraft Ground and De-Icing/Anti-Icing Operations (Doc 9640-AN/940) describes the procedures and responsibilities during the de-icing of aircraft.

Analysis

Because de-icing fluid was ingested through the APU air intake, the rotational speed of the turbine began to increase. Once the threshold value was reached, the APU shut down automatically, and the fuel supply was cut off. Since the de-icing fluid had ignited and caused the increase of rotational speed, the shut-off fuel supply had no effect. The rotational speed increased further until the APU ruptured.

Subsequently, parts of the compressor wheel penetrated the aft pressure bulkhead in the area beneath the flight attendants' seats. The hot fracture piece was found embedded in the container for the smoke hoods. Smoke in the aft part of the cabin was the result. Passengers and cabin crew were prompted to move to the front part of the airplane. During a similar occurrence in the past almost the same area of the pressure bulkhead was penetrated. The BFU is of the opinion that in case the APU ruptures for other reasons it cannot be ruled out that the same area of the pressure bulkhead would be penetrated again.

The location of the APU air intake, on the right-hand side next to the fuselage and vertical tail fairing, poses the risk of de-icing fluid entering the open APU air intake during operation. The work of the de-icing personnel is made more difficult by the fact that due to the differences in temperatures fog develops which restricts the field of vision of the de-icing personnel. The APU air intake is not marked as other areas are, such as static ports. Europe has not implemented the safety recommendation the NTSB had issued due to a similar case requiring shutting down the APU during de-icing. The manufacturer had described the disadvantages extensively and these were the reasons why the safety recommendation was not implemented. This case shows, however, that the area of the air intake should be clearly marked to remind the de-icing personnel of the hazards. Other manufacturers, where the APU air intake location is comparable to the ones described here, set an example.

The de-icing requirements and the derived personnel and AEA training requirements are very extensive and up-to-date. The de-icing company has implemented the fundamentals and requirements for personnel and training. Certain neuralgic points of the airplane, e.g. air intakes, gaps, and cavities are discussed and pointed out during the theoretical and practical training. The BFU is of the opinion it would improve safety if such areas were clearly marked and it would also make the work of the de-icing personnel easier. In this case the de-icing person had been trained as transport pilot and was aware that the de-icing fluid should not flow into the APU air

intake. Due to non-existent markings it was difficult for him to clearly identify this area.

It has to be noted that AEA was not a governmental authority and the information, which the aircraft manufacturer had published in his aircraft documentation, was not completely included in the AEA documentation. A procedure, where the aircraft manufacturer participates in the compilation of documentation was not defined.

In the past EASA has, even though based on the prevailing regulations it was not responsible, conducted investigations and actions in regard to aircraft de-icing. The BFU is of the opinion, that this approach, surely also prompted by previous safety recommendations, is an active contribution to flight safety. It would be desirable if EASA would continue and expand these actions. The BFU is of the opinion that aircraft de-icing is an important part of the safety of each individual aircraft as well as the entire aviation. Therefore, de-icing should be placed under regulatory authority, similar to maintenance.

Currently the de-icing situation of aircraft is as follows: The aircraft manufacturer defines de-icing procedures for the respective aircraft in the Flight Manual (FM), the Flight Operations Manual (FOM), the Aircraft Maintenance Manual (AMM), etc. These documents or procedures, respectively, are certified by the certification authority during type certification. These manuals are the basis for the aircraft operator to operate the airplane safely. Practice shows that the operator does not de-ice the aircraft, but delegates this service to ground services at the respective airport. The ground services, however, do not refer to the de-icing information in the manuals but to the one from the rules and standards of their association, in this case the AEA. Based on the current Commission Regulation (EC) No 216/2008 EASA is not the supervisory body for airport ground services.

Conclusions

The rupture of the APU and the resulting damage was caused by the ingestion and subsequent ignition of de-icing fluid. Additional factors were the limited field of vision and the insufficient marking.

Safety Recommendations

Safety Recommendation No. 01/2018

The aircraft manufacturer should clearly mark the area around the APU air intake on the aircraft type Fokker F28 Mk0100 (Fokker 100).

Safety Recommendation No. 02/2018

The European Aviation Safety Agency (EASA) should continue and expand the current activities regarding aircraft de-icing. In addition, due to the importance of aircraft de-icing for flight safety, EASA should consider placing aircraft de-icing under regulatory authority similar to aircraft maintenance.

Safety Recommendation No. 03/2018

For the improvement of flight safety the European Commission should establish a legal framework which places ground services and de-icing of aircraft under regulatory approval and supervision of the European Aviation Safety Agency (EASA).

Investigator in charge:	Nehmsch
Field investigation:	Nehmsch, Röstel, Juckl
Assistance:	Ritschel

Braunschweig 31 January 2018

Appendices

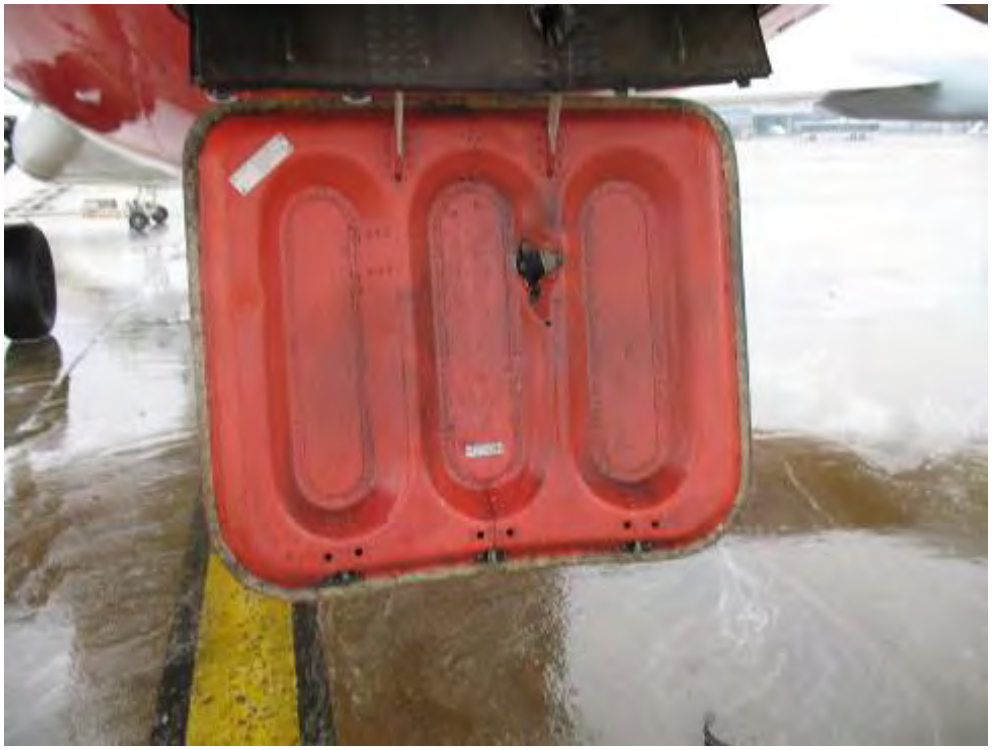

Image 1: Open maintenance door with puncture Photo: BFU

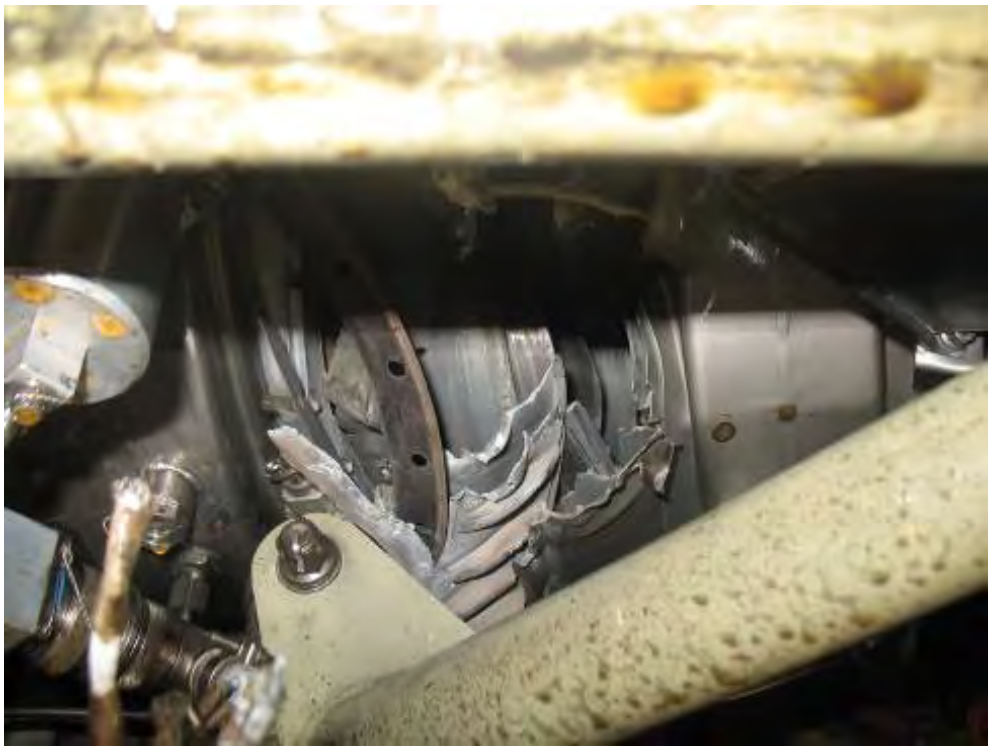

Image 2: Destroyed Auxiliary Power Unit (APU) Photo: BFU

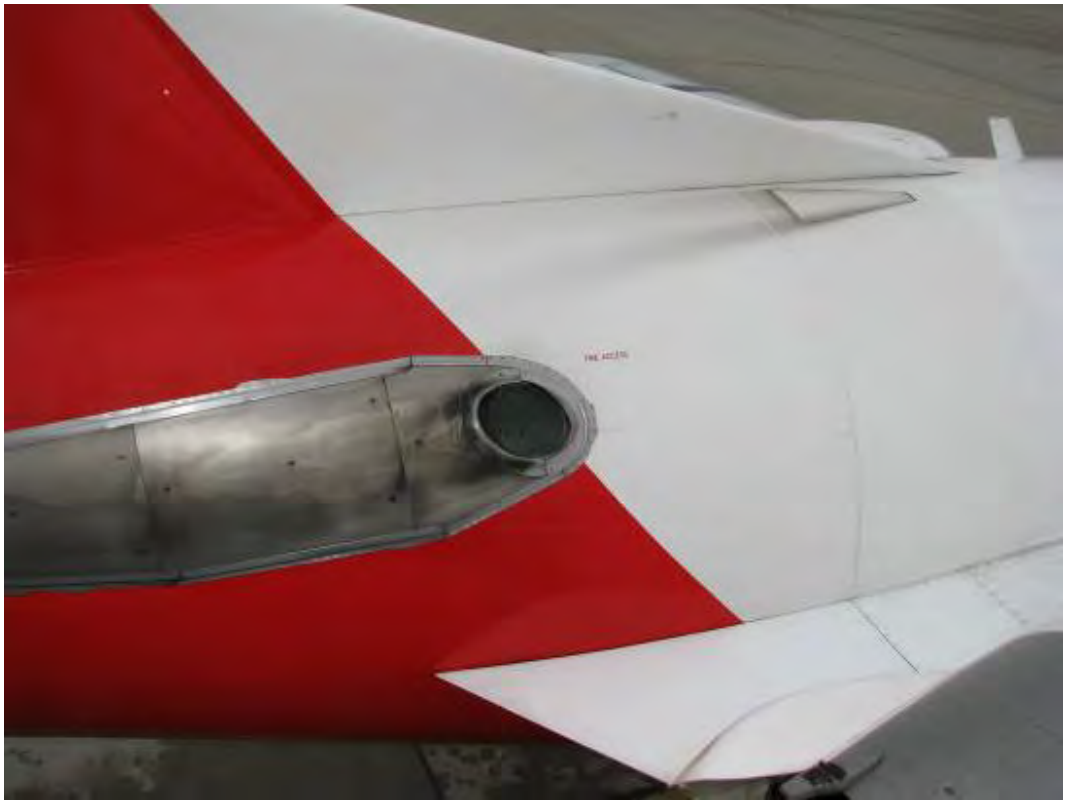

Image 3: Airplane tail section with APU air intake (upper right) and exhaust (centre) Photo: BFU

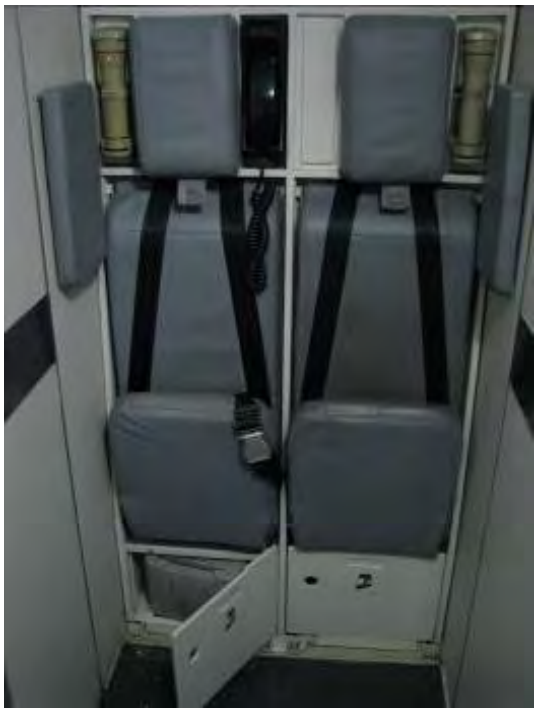

Image 4: Aft flight attendant seats
(viewed from the opposite flight direction) Photo: BFU

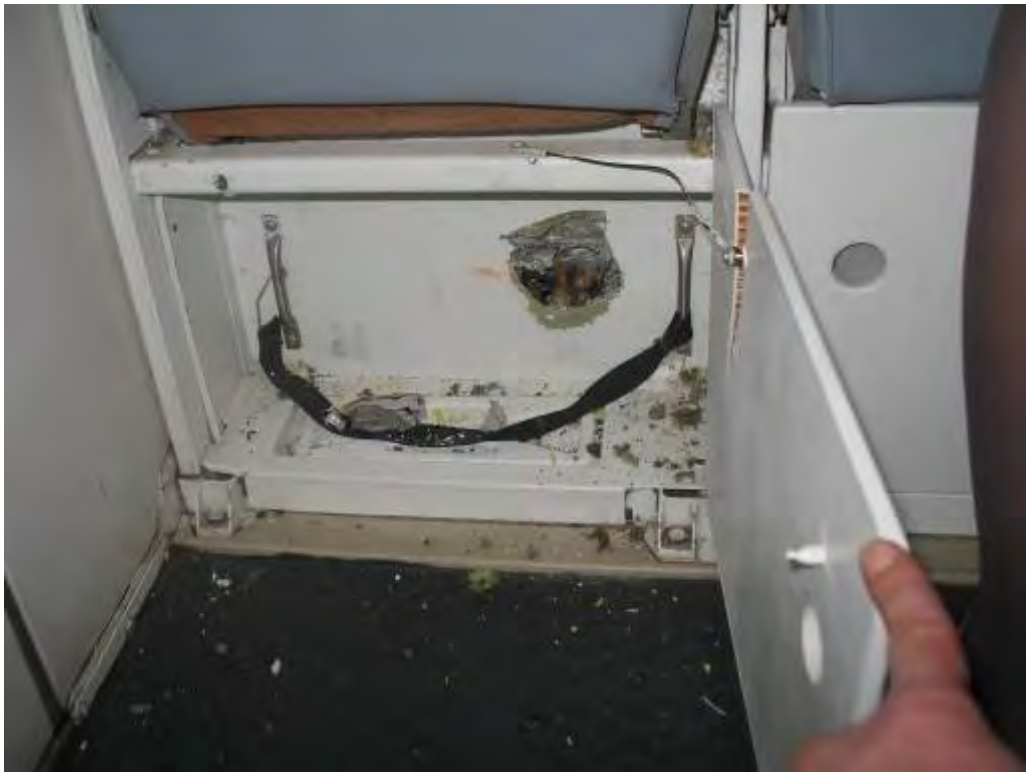

Image 5: Punctured bulkhead below the right aft flight attendant seat Photo: BFU

Fracture piece of the compressor wheel in the bottom of the bin

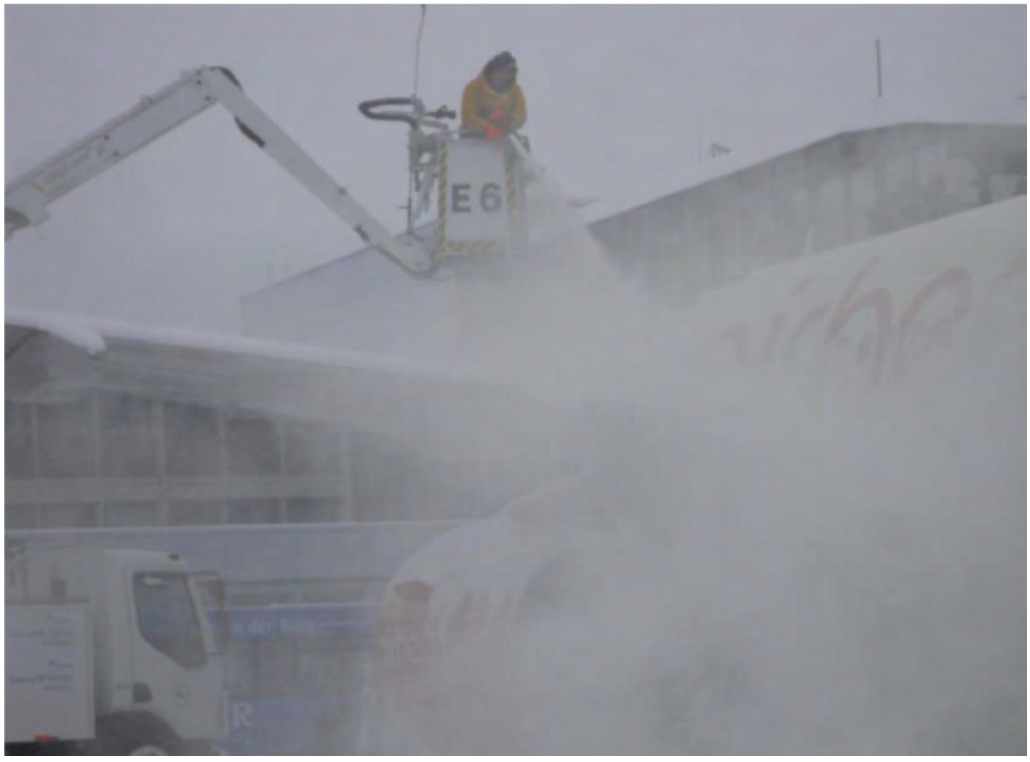

Image 6: Fog development during de-icing Photo: De-icing company

Appendix 1

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C. 20594

April 14 2003

POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT

NTSB ID No.: FTW02IA088

A. INCIDENT

Location:	Dallas-Fort Worth International Airport, Texas
Date:	March 2, 2002
Time:	0730 central standard time (CST)
Aircraft:	Fokker F.100, N1425A, American Airlines flight 334

B. POWERPLANTS GROUP

Group Chairman:	Gordon J. Hookey National Transportation Safety Board Washington, D.C.
Member:	Mark Deckard American Airlines Tulsa, Oklahoma
Member:	Jason W. Field American Airlines Tulsa, Oklahoma
Member:	John E. Smith Honeywell Anniston, Alabama

C. SUMMARY

On March 2, 2002, at about 0730 CST, American Airlines flight 334, a Fokker F.100, N1425A, had an uncontained rupture of the AlliedSignal[1] GTCP 36-150RR auxiliary power

[1] The engine's data plate listed AlliedSignal as the manufacturer. AlliedSignal merged with Honeywell and the new company is known as Honeywell.

unit's (APU) turbine wheel while the airplane was being deiced at the Dallas-Fort Worth International Airport (DFW), Texas. The APU was operating at the time the airplane was being deiced. Examination of the airplane revealed damage in the tailcone. Additionally, a fragment of the turbine wheel penetrated the aft pressure bulkhead and was found embedded in the first aid kit under the flight attendant' jump seat at the rear of the cabin. The airplane was being deiced prior to departing DFW for Nashville, Tennessee, as a regularly scheduled domestic passenger flight on an instrument flight rules flight plan under the provisions of 14 Code of Federal Regulations Part 121. There were no reported injuries to the 2 pilots, 2 flight attendants, and 30 passengers on board Flight 334.

The APU was removed from the airplane and shipped to American Airlines' APU facility, Tulsa, Oklahoma where it was examined by members of the Powerplants Group on March 6, 2002. The examination revealed the compressor case, which contains the APU's turbine, was ruptured in the plane of the turbine wheel. The turbine wheel was broken into several pieces, all of which were examined by Honeywell's Materials Laboratory, Phoenix, Arizona. The metallurgical examination of the turbine wheel did not reveal any evidence of fatigue. Additionally, the containment ring was broken into three pieces.

The APU's electronic control unit (ECU) was removed from the APU and shipped Honeywell's Anniston, Alabama facility to interrogate the ECU's non-volatile memory (NVM) and perform a diagnostic test. The APU's ECU was tested in the presence of members of the Powerplants Group on March 19, 2002. The NVM showed an overspeed fault and the diagnostic test showed that there were no discrepancies with the ECU.

D. DETAILS OF INVESTIGATION

1.0 Auxiliary power unit information

The APU is a small gas turbine engine that drives a compressor and generator to supply compressed air and electrical power, respectively, to the airplane when the engines are not operating or as a backup if one of the engine-driven systems is inoperative. The APU installed in N1425A was an AlliedSignal Model 36-150RR that features a centrifugal compressor, an annular reverse-flow combustor, and a turbine wheel that drives the compressor. The APU has an ECU that meters fuel to the APU while it is in operation. Additionally, the ECU monitors the rotor speed and will shut off fuel to the APU if it senses an overspeed, which is 107 percent.

The APU was serial number (SN) P-101C. 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.

2.0 Auxiliary power unit examination

2.1 Turbine wheel

The turbine wheel was broken up into at least four major pieces. All of the vanes were broken off. The pieces of the turbine wheel were forwarded to Honeywell for metallurgical examination in the Materials Laboratory.

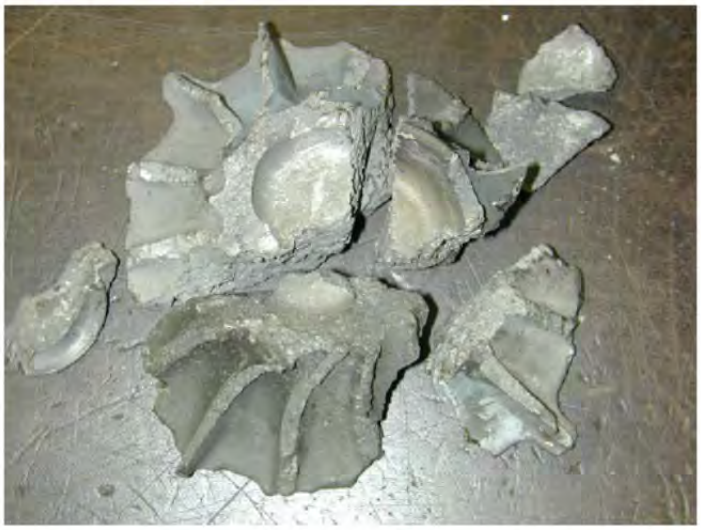

Photo 1: Turbine wheel broken into several pieces (American)

The results of Honeywell's Materials Laboratory examination of the APU's turbine wheel were reported in Materials Analysis report No. 229723. The report stated that the examination revealed the turbine wheel had separated due to overload caused by the overspeed. There was no evidence of fatigue on any of the fracture surfaces. The examination also did not detect any evidence of the deicing fluid. Energy dispersive x-ray analysis identified several areas on the fracture surfaces that were rich in tantalum that is indicative of unbonding. The report stated that the unbonded areas would have provided a path for the fracture, but was not the primary cause of the fracture.

For further details, refer to Honeywell Materials Laboratory Report No. MA 229723, Attachment 1.

2.2 External examination

The compressor case was ruptured with two 3-inch wide holes at 1 to 6 and 10 to 12 o'clock.[2] The remainder of the exterior of the engine was intact and there was no evidence of a fire or any other uncontainments.

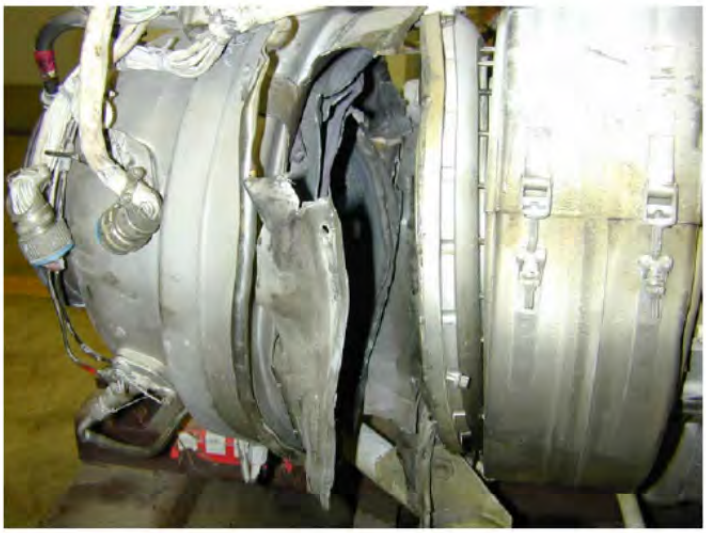

Photo 2: External view of APU showing ruptured compressor case (American)

2.3 Compressor impeller

The compressor impeller was intact except for a 4-inch long section of the rim up to ¾-inch deep that was missing. The impeller vane leading edges had nicks and gouges and were bent opposite the direction of rotation.

[2] All locations on the engine, or directions, as referenced to the clock, will be as viewed from the aft looking forward (ALF), unless otherwise specified.

5

Photo 3: Compressor impeller (American)

2.4 Containment ring

The containment ring was broken into three pieces that were 13-, 10 ¾-, and 14 ¾- inches long.

3.0 Electronic control unit

3.1 Electronic control unit information

The ECU was part number 2118802-5, serial number 82-G0009. The ECU recorded that it had operated 3,469 hours and 2,471 cycles.

3.2 Shutdown history

The ECU records the last six shutdown events. The shutdown events are displayed on an LED [light emitting diode] display on the front of the ECU. The test operator can scroll down through the events by pressing the button on the left side of the ECU. The ECU did not show any line replaceable unit (LRU) faults. The ECU had five events listed as follows:

Shutdown History	Fault	Code	Symptom
Present	Auto shutdown	Overspeed	27
1	No start	Slow speed	264
2	Auto shutdown	Door circuit	269
3	Auto shutdown	Door circuit	269
4	Auto shutdown	Door circuit	269

A copy of the test data sheet listing the ECU's event history is attached, Attachment 2.

3.3 Diagnostic test

A full diagnostic test was performed on the ECU in accordance AlliedSignal Component Maintenance Manual No. 2118802 Section 49-61-48 Page 107 Automatic Test. The ECU was hooked up to APU Automatic Test Station No. 5 STE 4202309-2. The automatic test showed that the ECU passed all of the tests.

A copy of the test print out is attached, Attachment 3.

4.0 Deicing of airplane

At the time of the event, the airplane was being deiced. American Airlines conducted a Board of Inquiry (BOI), where the personnel who deiced the airplane, the checker, drivers of the deicing trucks, and the bucket operators, were questioned by local management. A copy of the BOI's summary was provided to the Safety Board.

4.1 Ambient conditions

According to the BOI's summary, the airplane was parked at the deicing area on taxiway EK. The engines were shutdown, but the APU was operating. The weather at the time was reported to be freezing rain and ice pellets, overcast, temperature 23 degrees F, and wind 20 knots and gusting.

4.2 Deicing operation

Two trucks were used to deice the airplane. The five-person crew consisted of a checker, a driver for each truck, and a spray bucket operator for each truck. According to the BOI summary, the drivers of the two trucks had agreed in advance to start at opposite ends of the airplane to prevent the wind from blowing the deicing fluid back onto each of the bucket operators. Truck No. 1 would deice the right side of the airplane from nose to tail and truck No. 2 would deice the left side of the airplane from tail to nose. The airplane was being deiced with Type 1 deicing fluid.[3]

[3] Deicing fluid is combustible when compressed.

Bucket operator No. 1 stated that he had deiced the nose and right wing of the airplane. After he had finished deicing the fuselage and wings, he deiced the horizontal stabilizer. When he had finished the horizontal stabilizer, the bucket operator stated that he started to deice the vertical stabilizer when he heard a noise and then stopped deicing and saw what he thought to be an APU fire. The bucket operator stated that he knew where the F.100 airplane's APU inlet was located and that he had not sprayed any deicing fluid into the APU inlet. Bucket operator No. 2 stated that he had deiced the horizontal stabilizer and tail [vertical fin] and part of the fuselage. After the truck had been repositioned, he had just started to deice the left wing when he noticed that the checker had discovered a fire.

Bucket operator No. 1 stated that he knew where the APU inlet was located, but that he could not always see it because of the spray blowing back on him. Bucket operator No. 2 stated that he could not see the APU inlet because of his position on the left side of the airplane, and the APU inlet was located on the right side of the airplane on the other side of the tail from his position.

4.3 Experience

The personnel who deiced the airplane stated their experience with deicing airplanes as follows:

Checker	14 years
Bucket operator No. 1	13 years. He estimated he had probably deiced at least 100 F.100s.
Driver, truck No. 1	14 years
Bucket operator No. 2	15 years. Although he had deiced many airplanes that included 757s, Super 80s, 737s, and 727s, he stated that N1425A was first F.100 he ever deiced
Driver, truck No. 2	17 years

For further details, refer to American Airlines' Board of Inquiry Summary, Attachment 4.

8

5.0 F.100 auxiliary power unit installation

The F.100's APU is installed transversely in the tail compartment just aft of the aft pressure bulkhead. 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 inlet duct intake is equipped with a rectangular shaped, electrically operated door that is hinged at the forward end. When the APU switch is ON, the ECU supplies electrical power to the air intake door actuator via the air intake open door relay to open the intake door. When the door opens, the air intake door actuator pulls the aft edge of the door inward. The APU can be operated on the ground and in flight. When the airplane is on the ground, the door opens to an angle of 15 degrees, and when the airplane is in flight, the door opens to an angle of 10 degrees. When the APU switch is turned OFF, the ECU supplies power to air intake door actuator via the air intake door close relay to close the APU intake door. The F.100 airplane does not have a flow diverter strip over the APU air inlet similar to what is installed over the cabin doors to divert rain water so it does not it does not drip down on the people using the doors.

For further details, refer to F.100 APU inlet duct sketch, Attachment 5.

Gordon J. Hookey
Powerplants Group Chairman

Appendix 2

National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: March 29, 2002

In reply refer to: A-02-05

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

On March 2, 2002, American Airlines flight 334, a Fokker F.28 Mark 100,[1] experienced an uncontained rupture of the turbine wheel in the AlliedSignal model GTCP36-150RR auxiliary power unit (APU) after deicing fluid entered the APU while the airplane was being deiced at the Dallas-Ft. Worth International Airport, Texas. The interior of the airplane's tailcone sustained damage from the liberated turbine wheel fragments. One fragment of the turbine wheel penetrated the aft pressure bulkhead and became embedded in the first aid kit that is stored directly beneath the flight attendant's aft jump seat in the rear of the airplane's cabin. The event occurred as the airplane was preparing to depart Dallas-Ft. Worth as a scheduled domestic flight to Nashville, Tennessee, in accordance with 14 *Code of Federal Regulations* Part 121. There were no injuries to the passengers and crewmembers.

Generically, APUs are small jet engines equipped with generators and bleed air ports to provide electricity and air to the airplane while it is on the ground. The APU normally operates at 100 percent rpm, but under some circumstances it can quickly accelerate beyond this value, resulting in a hazardous situation. The GTCP36-150RR APU is equipped with an electronic control unit (ECU) that will, among other things, shut down the APU by closing off its supply of fuel if it senses that the speed of the APU rotors is greater than 107 percent rpm. In the F.28 Mark 100, the APU is mounted in the tailcone transversely across the fuselage and directly behind the aft pressure bulkhead. Air for the APU is supplied through an inlet duct on the upper right side of the fuselage just forward of the vertical fin's leading edge.

Examination of the APU by the National Transportation Safety Board at the American Airlines facility in Tulsa, Oklahoma, revealed that the compressor case was ruptured in the plane

[1] The airplane is certificated as the "F.28 Mark 100," but it is commonly called the "F.100."

7453

of the turbine wheel.[2] The turbine wheel was broken into numerous small fragments. The fragments are to undergo a metallurgical examination to determine if fatigue was a factor; however, no evidence of fatigue has been found at this time. Interrogation of the ECU's nonvolatile memory showed that an overspeed had occurred.

On March 6, 2001, an event that was similar to the Dallas-Ft. Worth event occurred on American Airlines flight 581, an F.28 Mark 100, at Dorval International Airport, Montreal, Canada. As in the Dallas-Ft. Worth event, the airplane was being deiced while the APU was operating. The ECU nonvolatile memory showed that the ECU sensed an overspeed and cut off fuel to the APU. However, the rotor continued to accelerate until the turbine wheel burst.

The Type I deicing fluid being used to deice American Airlines flight 334 is an ethylene glycol solution that is combustible when compressed. If deicing fluid enters the APU inlet, it will augment the combustion process. If the APU ingests enough deicing fluid, it will sustain combustion even if the ECU senses an overspeed and cuts off the fuel to the APU. Because the ECU no longer has command of the rotor speed, the APU will continue to accelerate unabated until the turbine wheel bursts.

In February 2001, American Airlines issued a "Winterization Bulletin" for the F.28 Mark 100 airplane, advising that deicing fluid should not be allowed to enter into the APU inlet. Additionally, the F.28 Mark 100 Maintenance Manual, Section 12-31-00, page 301, states, "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."

Although its investigation into the event at Dallas-Ft. Worth event is ongoing, the Safety Board is concerned that deicing fluid could inadvertently enter the APU inlet of another F.28 Mark 100, resulting in an uncommanded acceleration of the APU rotors and another turbine wheel rupture. The Board is further concerned that turbine wheel fragments liberated by such an event could penetrate the cabin of the F.28 Mark 100 and injure passengers and crew. The Federal Aviation Administration has advised the Safety Board that the Fokker F.28 Mark 4000 has the same APU and air-inlet configuration as the F.28 Mark 100.

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

> Immediately issue an airworthiness directive for the Fokker F.28 Mark 100 and F.28 Mark 4000 airplanes that prohibits auxiliary power unit operation during deicing operations. (A-02-05) (URGENT)

[2] The turbine wheel and compressor impeller are mounted back-to-back within the compressor case.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT and BLACK concurred in this recommendation. Member GOGLIA disapproved this recommendation and filed the enclosed dissent.

Original Signed

By: Marion Blakey
Chairman

Enclosure

DISSENTING STATEMENT

Notation 7453

Member Goglia, Dissenting;

The safety recommendation to the FAA that an airworthiness directive be issued to prohibit APU operation "during deicing operations" misses the mark. First, it does not address the importance of effective training in deicing and anti-icing applications. We know the critical importance of deicing and anti-icing because there have been numerous accidents related to this activity, the lack of it, or its improper application. Safety would be far better served by a directive that addresses the issue from a broader perspective that holds the prospect of an ongoing higher standard of training for all deicing crews across all fleet types, rather than the correction of a specific shortcoming for a particular aircraft type.

Second, prohibiting the use of the APU during "deicing operations" may have significant unintended consequences.

Again, safety would be better served by having a well-trained deicing crews that are fully trained and comprehend all aspects of this important activity and the consequences of any deviation from approved procedures.

John Goglia, Board Member

Appendix 3

[Federal Register: April 4, 2002 (Volume 67, Number 65)]
[Rules and Regulations]
[Page 16011-16013]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr04ap02-2]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 39

[Docket No. 2002-NM-94-AD; Amendment 39-12697; AD 2002-07-03]

RIN 2120-AA64

Airworthiness Directives; Fokker Model F.28 Series Airplanes

AGENCY: Federal Aviation Administration, DOT.

ACTION: Final rule; request for comments.

SUMMARY: This amendment adopts a new airworthiness directive (AD) that is applicable to all Fokker Model F.28 series airplanes. This action requires revising the Airplane Flight Manual to prohibit operation of the auxiliary power unit (APU) during deicing. This action is necessary to prevent ingestion of deicing fluid into the APU, which could cause uncontained failure of the turbine wheel of the APU, and result in failed and uncontained parts penetrating the aft cabin pressure bulkhead, and consequent possible injury to the cabin crew or passengers. This action is intended to address the identified unsafe condition.

DATES: Effective April 19, 2002.

Comments for inclusion in the Rules Docket must be received on or before May 6, 2002.

ADDRESSES: Submit comments in triplicate to the Federal Aviation Administration (FAA), Transport Airplane Directorate, ANM-114, Attention: Rules Docket No. 2002-NM-94-AD, 1601 Lind Avenue, SW., Renton, Washington 98055-4056. Comments may be inspected at this location between 9:00 a.m. and 3:00 p.m., Monday through Friday, except Federal holidays. Comments may be submitted via fax to (425) 227-1232. Comments may also be sent via the Internet using the following address: 9-anm-iarcomment@faa.gov. Comments sent via fax or the Internet must contain "Docket No. 2002-NM-94-AD" in the subject line and need not be submitted in triplicate. Comments sent via the Internet as attached electronic files must be formatted in Microsoft Word 97 for Windows or ASCII text.

The information concerning this amendment may be obtained from or examined at the Federal Aviation Administration (FAA), Transport Airplane Directorate, 1601 Lind Avenue, SW., Renton, Washington 98055-4056.

1

FOR FURTHER INFORMATION CONTACT: Tom Rodriquez, Aerospace Engineer, International Branch, ANM-116, FAA, Transport Airplane Directorate, 1601 Lind Avenue, SW., Renton, Washington 98055-4056; telephone (425) 227-1137; fax (425) 227-1149.

SUPPLEMENTARY INFORMATION: The FAA has received reports indicating that uncontained failure of the auxiliary power unit (APU) has occurred on three Fokker Model F.28 Mark 0100 series airplanes. In all cases, the overspeed of the APU caused uncontained failure of the turbine wheel of the APU with consequent penetration of the aft pressure bulkhead. Investigation revealed that deicing fluid was ingested into the APU inlet. The deicing fluid acted as an additional fuel source, which resulted in runaway acceleration, leading to failure of the turbine wheel. The deicing fluid entered into the APU through the intake air inlet on the upper fuselage surface. This intake air inlet is open only during operation of the APU. Subsequent to the first two occurrences of APU overspeed and turbine wheel failure, operators took actions to abate the occurrences of deicing fluid getting into the APU inlet through additional warnings to flight crews and the personnel performing the deicing. With the most recent event, the FAA has determined that those actions have not been totally effective and additional actions are warranted. Ingestion of deicing fluid into the APU could cause uncontained failure of the turbine wheel of the APU due to overspeed, and result in failed and uncontained parts penetrating the aft cabin pressure bulkhead, and consequent possible injury to the cabin crew or passengers.

Similar Design of the Intake Air Inlet

The APU intake air inlet operation and location on Fokker Model F.28 Mark 0100 series airplanes is the same on Fokker Model F.28 Mark 0070, 1000, 2000, 3000, and 4000 series airplanes; therefore, all these models may be subject to this same unsafe condition.

U.S. Type Certification of the Airplane

These series airplanes are manufactured in the Netherlands and are type certificated for operation in the United States under the provisions of Sec. 21.29 of the Federal Aviation Regulations (14 CFR 21.29) and the applicable bilateral airworthiness agreement.

Explanation of Requirements of Rule

Since an unsafe condition has been identified that is likely to exist or develop on other airplanes of the same type design registered in the United States, this AD is being issued to prevent ingestion of deicing fluid into the APU, which could cause uncontained failure of the turbine wheel of the APU and result in failed and uncontained parts penetrating the aft cabin pressure bulkhead, and consequent possible injury to the cabin crew or passengers. This AD requires revision of the Limitations Section of the Airplane Flight Manual to prohibit operation of the APU during deicing.

Determination of Rule's Effective Date

Since a situation exists that requires the immediate adoption of this regulation, it is found that notice and opportunity for prior public comment hereon are impracticable, and that good cause exists for making this amendment effective in less than 30 days.

Both major airlines operating the F.28 Mark 0100 series airplanes have voluntarily applied the restriction to their operations procedures to prohibit operation of the APU during deicing. In consideration of that information, the FAA has determined that telegraphic notification of this action to those operators is not necessary, since all operators are currently in compliance. However, the

issuance of this immediately adopted rule is necessary to ensure that any affected airplane that is imported and placed on the U.S. Register in the future will be required to be in compliance as well. Issuance of this rule will ensure that the AFM is revised accordingly in all affected airplanes, prior to the time it is permitted to operate in the U.S.

Comments Invited

Although this action is in the form of a final rule that involves requirements affecting flight safety and, thus, was not preceded by notice and an opportunity for public comment, comments are invited on this rule. Interested persons are invited to comment on this rule by submitting such written data, views, or arguments as they may desire. Communications shall identify the Rules Docket number and be submitted in triplicate to the address specified under the caption ADDRESSES. All communications received on or before the closing date for comments will be considered, and this rule may be amended in light of the comments received. Factual information that supports the commenter's ideas and suggestions is extremely helpful in evaluating the effectiveness of the AD action and determining whether additional rulemaking action would be needed.

Submit comments using the following format:

- Organize comments issue-by-issue. For example, discuss a request to change the compliance time and a request to change the service bulletin reference as two separate issues.
- For each issue, state what specific change to the AD is being requested.
- Include justification (e.g., reasons or data) for each request.

Comments are specifically invited on the overall regulatory, economic, environmental, and energy aspects of the rule that might suggest a need to modify the rule. All comments submitted will be available, both before and after the closing date for comments, in the Rules Docket for examination by interested persons. A report that summarizes each FAA-public contact concerned with the substance of this AD will be filed in the Rules Docket.

Commenters wishing the FAA to acknowledge receipt of their comments submitted in response to this rule must submit a self-addressed, stamped postcard on which the following statement is made: "Comments to Docket Number 2002-NM-94-AD." The postcard will be date stamped and returned to the commenter.

Regulatory Impact

The regulations adopted herein will not have a substantial direct effect on the States, on the relationship between the national Government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, it is determined that this final rule does not have federalism implications under Executive Order 13132.

The FAA has determined that this regulation is an emergency regulation that must be issued immediately to correct an unsafe condition in aircraft, and that it is not a "significant regulatory action" under Executive Order 12866. It has been determined further that this action involves an emergency regulation under DOT Regulatory Policies and Procedures (44 FR 11034, February 26, 1979). If it is determined that this emergency regulation otherwise would be significant under DOT Regulatory Policies and Procedures, a final regulatory evaluation will be prepared and placed in the Rules Docket. A copy of it, if filed, may be obtained from the Rules Docket at the location provided under the caption ADDRESSES.

List of Subjects in 14 CFR Part 39

Air transportation, Aircraft, Aviation safety, Safety.

Adoption of the Amendment

Accordingly, pursuant to the authority delegated to me by the Administrator, the Federal Aviation Administration amends part 39 of the Federal Aviation Regulations (14 CFR part 39) as follows:

PART 39--AIRWORTHINESS DIRECTIVES

1. The authority citation for part 39 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701.

Sec. 39.13 [Amended]

2. Section 39.13 is amended by adding the following new airworthiness directive:

AIRWORTHINESS DIRECTIVE

Aircraft Certification Service
Washington, DC

U.S. Department
of Transportation
Federal Aviation
Administration

We post ADs on the internet at "www.airweb.faa.gov/rgl"

The following Airworthiness Directive issued by the Federal Aviation Administration in accordance with the provisions of Title 14 of the Code of Federal Regulations (14 CFR) part 39, applies to an aircraft model of which our records indicate you may be the registered owner. Airworthiness Directives affect aviation safety and are regulations which require immediate attention. You are cautioned that no person may operate an aircraft to which an Airworthiness Directive applies, except in accordance with the requirements of the Airworthiness Directive (reference 14 CFR part 39, subpart 39.3).

2002-07-03 Fokker Services B.V.: Amendment 39-12697. Docket 2002-NM-94-AD.

Applicability: All Model F.28 series airplanes, certificated in any category.

Compliance: Required as indicated, unless accomplished previously.

To prevent ingestion of deicing fluid into the auxiliary power unit (APU), which could cause uncontained failure of the turbine wheel of the APU, and result in failed and uncontained parts penetrating the aft cabin pressure bulkhead, and consequent possible injury to the cabin crew or passengers; accomplish the following:

Revising the Airplane Flight Manual (AFM)

(a) Within 14 days after the effective date of this AD, revise the Limitations Section of the FAA-approved AFM to include the following statement (this may be accomplished by inserting a copy of this AD into the AFM): "APU operations during deicing is prohibited."

Alternative Methods of Compliance

(b) An alternative method of compliance or adjustment of the compliance time that provides an acceptable level of safety may be used if approved by the Manager, International Branch, ANM-116, Transport Airplane Directorate, FAA. Operators shall submit their requests through an appropriate FAA Principal Maintenance Inspector, who may add comments and then send it to the Manager, International Branch, ANM-116.

Note 1: Information concerning the existence of approved alternative methods of compliance with this AD, if any, may be obtained from the International Branch, ANM-116.

Special Flight Permits

(c) Special flight permits may be issued in accordance with Secs. 21.197 and 21.199 of the Federal Aviation Regulations (14 CFR 21.197 and 21.199) to operate the airplane to a location where the requirements of this AD can be accomplished.

Effective Date

(d) This amendment becomes effective on April 19, 2002.

Issued in Renton, Washington, on March 28, 2002.
Kalene C. Yanamura,
Acting Manager, Transport Airplane Directorate, Aircraft Certification Service.
[FR Doc. 02-8172 Filed 4-3-02; 8:45 am]
BILLING CODE 4910-13-P

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Appendix 4

STORK Fokker

Service Letter
Fokker 70/100

ATA ch. 49-00

220

AIRBORNE AUXILIARY POWER

GENERAL - AUXILIARY POWER UNIT (APU) FAILURE DUE TO THE INGESTION OF DE- OR ANTI-ICING FLUIDS.

Reason for revision:

This service letter was initially issued to inform you about the risk of an APU failure in case the APU is kept running during de-/anti-icing of the aircraft. It is now revised to incorporate information with respect to operational consequences that may occur when shutting down the APU during de-/anti-icing of the aircraft. The entire content of the SL has been revised, therefore no revision bars are present.

History:

Fokker Services received three reports of APU auto shutdowns while de-icing the aircraft. The APU was severely damaged and sent to the shop for investigation. Damage to the surrounding aircraft structure was experienced.
Shop investigation of the first occurrence revealed, amongst others, an APU turbine rotor rim separation and a broken containment ring. The investigation revealed that the APU failed due to the ingestion of a steady stream of de-icing fluid in the inlet. This happened in sufficient quantity that, once the fluid reached its flash point, it ignited causing the rotational speed of the APU to increase past the overspeed threshold of 107 percent where the Electronic Control Unit cuts off the fuel supply. The ignition of the de-icing fluid caused the rotational speed to increase uncontrolled to approximately 147 percent speed. At that speed the turbine rotor experienced a rim separation.

Shop investigation of the two other APU's revealed similar damage and it was concluded that both APU's had also failed due to overspeed caused by the ingestion of de-icing fluids.

After the third event the FAA issued AD 2002-07-03 (Docket No. 2002-NM-94-AD) on the subject of F28, Fokker 70 and Fokker 100 APU operation during de-/anti-icing. According the AD, within 14 days after the effective date (19 April 2002) of the AD, the Limitations Section of the FAA-approved AFM should be amended to include the following statement:
"APU operations during deicing is prohibited."

Recommendation:

Based upon the first experience AlliedSignal has revised the APU Maintenance Manual adding a strong caution about APU overspeeds due to de-icing fluid ingestion. AlliedSignal also issued Field Service note GTCP36-49-20-00-06 about this subject.
At that time Fokker already had cautions and notes in all manuals not to spray de-icing fluids in the APU intake, therefore no significant manual revisions were considered necessary. For instance, the Fokker 100 AMM section 12-31-00 (Snow and ice removal) had the warning: "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." Nevertheless, as part of the June 01, 2003 AMM revision Fokker Services has further clarified the concern with respect to possible overspeed of the APU. Fokker Services is of the opinion that in case the operator can make sure that during de-or anti icing of the aircraft no fluid can enter the APU air intake system the APU can be kept running. If the operator can not make sure that this does not happen, it is advised to select the APU off during de- or anti-icing procedures.

If the operator decides to switch off the APU during the de-/anti icing procedures he must be aware of the possibility of the following adverse effects:

1. Loss of IRS position data
2. Hold-over time exceedances
3. Low bleed pressures for On-Ground Wing Leading Edge Heating System (OGWLEHS)

Ad. 1:

In case the operational practice is involving a remote de-icing position (off-gate), the following scenario is possible. When the crew shuts down the engines and APU then within one minute, the IRS and (possibly) the FMS will loose all of the programmed and verified data. Once the aircraft de-/anti-icing procedures have been completed, the APU and the engines will be started again. Next the pilots will have to re-programme the IRS and FMS. Note that the IRS re-alignment times are a function of type (10 MCU or 4 MCU) and latitude as follows:

IRU	HG2001BC02 4 MCU	HG1050AD04/04 10 MCU
Time after IRU data entered will be lost	1minute	1 minute
Alignment time	Varies from 2,5 min at 0 deg latitude to 15 minutes between 70 deg and 78.25 N or S latitude	10 minutes

Ad. 2:

When the APU and Engines have to be shut down due to de-/anti icing procedures of the aircraft, the hold over time may not be sufficient to properly start the APU, engines and re-program the IRS and FMS before take-off.

Ad. 3:

For aircraft with the On Ground Wing Leading Edge Heating System (OGWLEHS) the APU is recommended to be ON during taxi-out and take-off to provide sufficient bleed air and avoid low capacity alerts. Notwithstanding the fact that there is an AFM procedure for such alerts, it requires increasing engine thrust, which may not be desirable due to e.g. slippery taxiways, and may not even be possible due to e.g. other traffic behind. Where it is possible to increase thrust to avoid low pressure warnings, it will still lead to (at least) a 2 minute delay due to the requirements of the AFM procedure. According the AFM procedure a 2 minutes duration of OGWLEHS operation with bleed air pressure of at least 16 psi within 5 minutes prior to take-off is required.

Conclusion:

In view of the above history, information and all precautions that have already been taken by the APU manufacturer and by Fokker Services, Fokker Services is of the opinion that it is not necessary to prohibit application of de-/anti-icing fluid with a running APU. Instead Fokker Services recommends that airlines tighten their control over the qualified de-/anti-icing facilities and that the airlines and qualified de-/anti-icing facilities increase the awareness of the personnel involved with respect to the application of de-icing fluids into the intake of a running APU (and any other critical points/areas during de-icing) on any aircraft, not only Fokker aircraft. Please also note in this respect that it requires a substantial flow of de-/anti-icing fluid into the APU intake to get the overspeed condition that caused these occurrences.

Appendix 5

STORK Fokker

Airworthiness Recommendations Catalogue
Fokker 70/100

Ground De-icing and Anti-icing
Recommendations on the use of the APU during de-icing

Effectivity

All F28 Mk0070/0100 aircraft serial numbers.

Background

Fokker Services received 3 reports of an uncontained APU turbine rotor rim failure during aircraft de-icing. The ingestion of a steady stream of de-icing fluid into the APU inlet near the dorsal fin ultimately resulted in an uncontrolled APU overspeed until separation of the APU turbine rotor rim. Following the third occurrence, the FAA issued Airworthiness Directive 2002-07-03 to include the statement 'APU operations during de-icing is prohibited' into the FAA AFM of the Fokker 70/100 and the FAA FH of the F28 aircraft.
Fokker Services reviewed the available information on all 3 occurrences and is of the opinion that the APU can be kept running during de-icing if some recommendations are adhered to. These recommendations were already contained in the AMM prior to the above mentioned occurrences. Nevertheless, Fokker Services has further clarified the concern with respect to possible overspeed of the APU per Manual Change Notification (MCNM) F100-073.

Recommendations

Incorporate the changes of Manual Change Notification (MCNM) F100-073 (which is distributed free-of-charge to all operators).
Adhere to the recommendations and precautions contained in the AMM as changed by the incorporation of MCNM F100-073. For that purpose also tighten your control over the qualified de/-anti-icing facilities to ensure that all personnel involved are fully aware of the importance of prevention of de-icing fluids entering the intake of a running APU.

Dutch/EASA Airworthiness Directive (AD)

None.

Other References

FAA Airworthiness Directive 2002-07-03.
Service Letter 220 (which also contains the possible adverse effects of switching off the APU during de-icing).
Airworthiness Recommendations Catalogue item 12-31-3.

apr 01/04	ATA100:	12-31
Technical Services	Subject:	4
Fokker Services BV	Issue:	1

This investigation was conducted in accordance with the regulation (EU) No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and the Federal German Law relating to the investigation of accidents and incidents associated with the operation of civil aircraft (Flugunfall-Untersuchungs-Gesetz - FlUUG) of 26 August 1998.

According to the law the sole objective of the investigation shall be the prevention of future accidents and incidents. It is not the purpose of this activity to assign blame or liability or to establish claims.

Published by:

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