National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation Report

Preventing Windshield Arcing, Smoke, and Fire on Bombardier DHC-8 Airplanes

Accident Number:	ENG15IA024
Operator/Flight Number:	United Express flight 4776 (operated by CommutAir)
Aircraft and Registration:	Bombardier DHC-8-202, N363PH
Location:	Windsor Locks, Connecticut
Date:	June 5, 2015
Adopted:	March 11, 2016

The National Transportation Safety Board (NTSB) is providing the following information to urge Bombardier, Inc., to take action on the safety recommendations in this letter. These recommendations are intended to prevent the recurrence of windshield arcing, smoke, fire, and overheating on Bombardier DHC-8 airplanes. They are derived from the NTSB's investigation of a June 5, 2015, incident involving United Express flight 4776 (operated by CommutAir) as it approached Bradley International Airport, Windsor Locks, Connecticut. As a result of this investigation, the NTSB is issuing five safety recommendations to Bombardier, Inc.

Background and Analysis

On June 5, 2015, United Express flight 4776, a Bombardier DHC-8-202 airplane, experienced an in-flight fire at the right windshield terminal block while on approach to Bradley International Airport. In written statements, the flight crew reported that the first officer was the pilot flying and the captain was the pilot monitoring for the flight. About 15 to 20 miles from the initial approach fix, the first officer heard a "pop" and noticed arcing at the right windshield terminal block. A fire ensued. The captain declared an emergency to approach control and the crew donned their oxygen masks.

The first officer transferred aircraft control to the captain and attempted to extinguish the fire by discharging the fire extinguisher on the terminal block. The fire was extinguished momentarily but the arcing continued, which re-ignited the fire. The first officer discharged the extinguisher a second time, and the fire was again momentarily extinguished before flaring up and continuing for an unknown amount of time. The fire eventually extinguished while still producing smoke. The crew performed a successful emergency landing without further incident and initiated an emergency evacuation. No injuries to the crew or passengers were reported. Airport fire personnel responded to the incident and confirmed there was no continued fire. The

flight crew did not recall seeing any caution or warning lights during the event and no circuit breakers were popped.[1]

Although postincident examination of the windshield found typical signs of aging (described in more detail below) with evidence of moisture ingression into the laminate around the edges of the windshield, the discrepancies were within the manufacturer's published limits and did not contribute to the failure.[2] The fire damage was concentrated in an area between the upper edge of the terminal block and the lower edge of the windshield gasket where the power wire was routed (see figure). The power wire was melted through in this area but remained soldered to the terminal block, indicating an arcing failure of the power wire. The damage to the power wire precluded investigators from determining whether it was damaged before the incident.

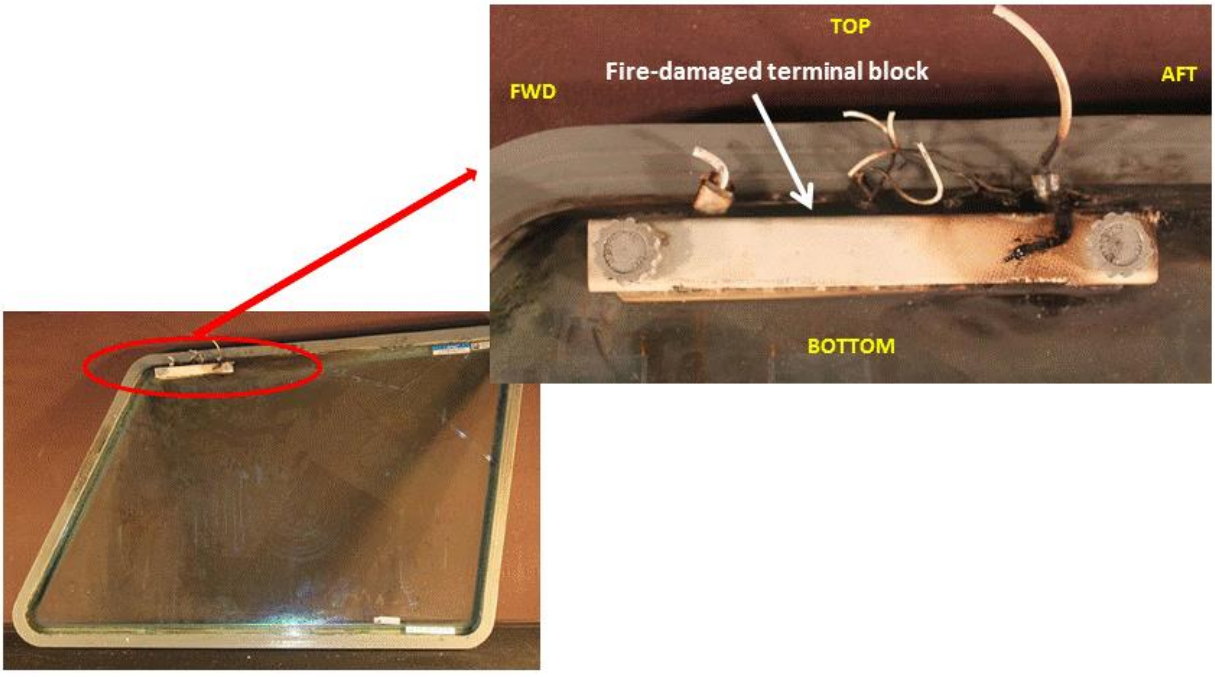

Figure. Photographs showing the damaged windshield and inset of the fire-damaged terminal block.

Postincident examination of the airplane found that the windshield heat switch was in the normal (NORM) position, which would continue to provide power to the windshield heating system. Switching the windshield heat selector to off would have cut power to the circuit, eliminating the arcing and fire. As discussed below, at the time of the incident, neither CommutAir nor Bombardier had flight crew checklists, guidance, or training addressing what to do in the event of windshield arcing, smoke, fire, or overheating. The NTSB determined that the probable cause of the fire was "the arcing failure of the windshield heat power wire on the right windshield due to unknown reasons. Contributing to the severity of the fire was the lack of

[1] More information about this incident, NTSB case number ENG15IA024, is available on our website.

[2] Moisture ingression into the laminate will produce arcing of the heating film, which is distinctly different than the type of arcing failure that occurred in this incident.

training or guidance provided to the crew for selecting the windshield heat to off that would cut power to the circuit."

A search of the NTSB accident database did not find any similar investigations involving DHC-8 windshield arcing, smoke, fire, or overheating; however, a search of several other sources, including the Federal Aviation Administration (FAA) and Transport Canada Service Difficulty Reports databases, yielded 94 additional events from 2000 to the present involving arcing, smoke, fire, or overheating at the windshield terminal block locations on other DHC-8-100/200/300/400 airplanes.[3,4] Of the 94 similar events, only one event (involving the arcing failure of one of the power wires near the terminal block on a left windshield installed on a DHC-8-311 airplane) was subject to a formal safety investigation, which the TSB conducted.[5] As was the case in the NTSB's incident investigation, the TSB's investigation was unable to determine the root cause of the arcing failure due to fire damage. As a result of the investigation, the operator performed an immediate DHC-8 fleetwide check of all windshield terminal block connections for proper torque, hardware, and installation and amended the DHC-8 maintenance schedule to include a torque check of the windshield terminal block connections at each C-check.

Windshield/Heat Power Connection

The current design of the DHC-8 windshields provides for connection of the windshield heat power wires to the terminal block using a ring terminal, screw, and lock washer. These screw connections are susceptible to cross-threading, improper torque, loosening over time due to vibration, and incorrect hardware usage, all of which can lead to arcing at the terminal block. In 2003, Bombardier revised the DHC-8 aircraft maintenance manual (AMM) to provide information on the correct screw and washer part numbers for attaching the power and sensor wires to the windshield terminal blocks and in 2005 revised the AMM to include the proper installation torque values for the terminal block screws. In 2012, Transport Canada issued Civil Aviation Safety Alert 2012-01 recommending detailed inspection of the windshield terminal blocks for security, overheating, and wire routing and re-torqueing of the attaching hardware.[6] Although Bombardier has published several in-service activities report articles over the years on windshield arcing, smoke, fire, or overheating events, these events continue to occur. Where the cause of the arcing, smoke, or fire could be determined, many of the 94 reports found during the NTSB's investigation cited a loose connection at the terminal block or incorrectly installed/missing hardware.

The NTSB has conducted investigations involving a similar issue of arcing and fire at the windshield heat terminal on Boeing 757 airplanes. During the investigations of two January 2004 events, Boeing indicated that the terminal block on Boeing 747, 757, 767, and 777 airplanes had

[3] Other sources included the Transportation Safety Board of Canada's accident database and information provided by Bombardier and PPG Aerospace Transparencies (the windshield manufacturer).

[4] The search of the data sources yielded many other events that were potentially relevant but the available information was insufficient to conclude that they involved arcing, smoke, fire, or overheating at a windshield terminal block location.

[5] The findings of the TSB investigation are documented in Aviation Investigation Report A09P0351, which can be accessed on the TSB's website (last accessed on March 11, 2016).

[6] This NTSB is not aware of any similar action taken by the FAA on this issue.

been redesigned to incorporate a pin/socket connector, instead of a screw, to connect the airplane electrical system to the windshield heat system. Boeing incorporated the new connector into new production airplanes in mid-2004 and issued service bulletins to retrofit existing airplanes. Incidents of fire near the windshield heat terminal on these airplanes subsequently stopped. Because these types of events continue to occur on DHC-8 airplanes despite revised maintenance instructions and periodic reports from Bombardier, the NTSB concludes that incidents of arcing and fire at the windshield heat terminal on DHC-8 airplanes could be reduced if a different type of windshield/heat power connection were used that precluded the incidence of loose connections. Therefore, the NTSB recommends that Bombardier redesign the windshield heat power connection for all DHC-8 airplanes to provide a mechanically secure, low-resistance electrical connection.

Procedures and Training for Smoke or Fire at the Windshield Terminal Block

The flight crew on the incident airplane reported difficulties in extinguishing the fire during the incident. As mentioned earlier, postincident examination of the airplane found the windshield heat selector switch in the NORM position even though switching it off would have cut power to the circuit and stopped the arcing. CommutAir reported that no specific training is provided to its flight crews for windshield arcing, smoke, fire, or overheating events. Further, none of Bombardier's training materials or checklists currently include any explicit instruction or guidance on this issue. Although the DHC-8-200 Emergency Aircraft Fire or Smoke checklist instructs flight crews to diagnose the source of a fire, it does not specifically mention the windshield heating system or terminal blocks. If an electrical fire is suspected, flight crews are instructed to configure the airplane to use only essential power, which would not include windshield heat; therefore, in the event of arcing or fire at the windshield heat terminal block, following the Emergency Aircraft Fire or Smoke checklist should result in windshield heat being turned off but only as a secondary action.

The NTSB notes that other aircraft manufacturers, such as Boeing and Airbus, have specific checklists for flight crews in the event the windshield heating system fails. Fire and/or smoke in the cockpit is a serious issue that could affect other aircraft systems, lead to a loss of visibility, provide a distraction, or incapacitate the flight crew and possibly lead to an accident. Although turning off the windshield heat may be considered intuitive, explicit guidance on how to respond to windshield arcing, smoke, fire, or overheating would better prepare flight crews to act immediately in such an event. Therefore, the NTSB recommends that Bombardier add an emergency procedure checklist and revise training materials for all DHC-8 airplanes that specifically instruct flight crews, as a memory item, to immediately turn off windshield heat in the event of windshield arcing, smoke, fire, or overheating.

Maintenance Requirements for Bombardier DHC-8 Windshields

Examination of the maintenance records for the incident airplane's windshields showed that CommutAir was in compliance with all Bombardier-recommended inspections as specified in the maintenance task cards (outlined in the following table). The most recent inspection occurred more than 2 years and 3,500 flight hours before the incident with no discrepancies noted. However, as mentioned earlier, postincident examination of the right windshield found typical signs of aging such as an approximately 1-inch wide area of cloudiness and cracking of

the interlayer material (indicating moisture ingression) around the periphery of the windshield. The examination also noted signs of moisture seal erosion along the upper and aft edges of repaired areas of the windshield.

Table. Summary of Bombardier-recommended inspections for DHC-8 windshields.

deHavilland Dash 8 Maintenance Task Card Manual ID	Inspection Type	Inspection Interval	Items to be Inspected
211	Windshield inside (general visual)	Every other C-check (10,000 flight hours)	Unspecified
211E	Windshield outside (general visual)	Every C-check (5,000 flight hours)	Unspecified
211X3	Windshield heater terminal blocks (detailed)	Every 12,000 flight hours or 120 months	Wiring and spiral wrap for damage, chafing, and correct installation; terminal block for damage, corrosion, correct lug installation, and evidence of discoloration or overheating.

Although not specifically identified on the maintenance task cards, inspection of the moisture seals is specified in the Bombardier AMM as a C-check item (every 5,000 flight hours) and refers to the windshield manufacturer's (PPG Aerospace Transparencies) Abbreviated Component Maintenance Manual (ACMM) for damage limits and repair information. However, the ACMM recommends inspection of the moisture seals around the periphery of the windshields at a shorter interval—every 4 months or 1,000 flight hours, whichever comes first. The ACMM also details the inspection of the windshields for delamination, bubbles, discoloration, cracked glass, scratches, and electrical defects and recommends inspection intervals be performed in accordance with standard industry practice. As an example, Boeing and Airbus recommend detailed visual inspections of the windshields at intervals as low as 750 hours and publish detailed task cards to guide maintenance personnel in their inspections.

The NTSB is concerned about the disparity between Bombardier's instructions for inspecting DHC-8 windshield components and recommended maintenance intervals and the detailed instructions and maintenance intervals recommended by the windshield manufacturer. The NTSB concludes that Bombardier's maintenance task cards do not provide enough detail for maintenance personnel to reliably identify discrepant items and that recommended inspections are performed too infrequently to adequately address signs of deterioration and conditions that could lead to arcing, smoke, fire, or overheating. Therefore, the NTSB recommends that Bombardier revise the DHC-8 windshield maintenance task cards to incorporate more specific inspection tasks that focus on the degradation of windshield components known to occur over time. The NTSB also recommends that Bombardier revise the windshield inspection intervals to provide more frequent inspections in accordance with the windshield manufacturer's recommendations.

The NTSB notes that section 56-10-11 in the Bombardier AMM contains permissible damage limits for scratches, delamination, and cracks that are consistent with the published information in the PPG Aerospace Transparencies ACMM. However, the ACMM outlines other damage limits—for bubbles, discoloration, and sensing element failures—that are not contained

in the Bombardier AMM. Additionally, the damage limits in the Bombardier AMM for moisture seal erosion (which was observed on the windshield from the incident airplane) and for discrepancies with the windshield heater terminal block refer maintenance personnel back to the ACMM. Although maintenance departments should have copies of the ACMM, maintenance personnel generally do not have the ACMM on hand while performing maintenance tasks and would primarily refer to task cards and the AMM. The NTSB concludes that omitting information on certain types of damage and referencing a separate document for other types of damage could be confusing to maintenance personnel and lead to inadequate inspections of DHC-8 windshields. Therefore, the NTSB recommends that Bombardier revise the DHC-8 AMM to include detailed permissible damage limits of windshields and windshield components in accordance with the PPG Aerospace Transparencies ACMM.

Recommendations

To Bombardier, Inc.:

Redesign the windshield heat power connection for all Bombardier DHC-8 airplanes to provide a mechanically secure, low-resistance electrical connection. (A-16-3)

Add an emergency procedure checklist and revise training materials for all Bombardier DHC-8 airplanes that specifically instruct flight crews, as a memory item, to immediately turn off windshield heat in the event of windshield arcing, smoke, fire, or overheating. (A-16-4)

Revise the Bombardier DHC-8 windshield maintenance task cards to incorporate more specific inspection tasks that focus on the degradation of windshield components known to occur over time. (A-16-5)

Revise the Bombardier DHC-8 windshield inspection intervals to provide more frequent inspections in accordance with the windshield manufacturer's recommendations. (A-16-6)

Revise the Bombardier DHC-8 Aircraft Maintenance Manual to include detailed permissible damage limits of windshields and windshield components in accordance with the PPG Aerospace Transparencies Abbreviated Component Maintenance Manual. (A-16-7)