AVIATION INVESTIGATION REPORT
A01A0030

MULTIPLE ENGINE FLAME-OUTS

AIR CANADA REGIONAL AIRLINES
DE HAVILLAND DHC-8-100 C-GANS
SYDNEY, NOVA SCOTIA
03 APRIL 2001

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Aviation Investigation Report

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Summary

The Air Canada Regional Airlines DHC-8-100 aircraft with 35 passengers and a crew of three was on a flight from Sydney, Nova Scotia to Halifax, Nova Scotia. The flight took off at 1547 Atlantic daylight time, and during the climb out at about 6000 feet, the first officer observed ice in the air inlet duct of the right engine (Pratt & Whitney 120A). About five seconds later the right engine flamed out. The aircraft was being operated with the engine ignition on and the engine recovered almost immediately. Approximately two minutes after the engine had recovered, the right engine flamed out and recovered again. After completing the required checklist procedures, the first officer checked the air inlet duct and observed that the ice had disappeared. The captain then checked the left engine and saw that ice was also present in the left air inlet duct. A few minutes later, as the aircraft was reaching its cruise altitude at 14 000 feet, the left engine went through a similar flame-out and recovery sequence. The aircraft continued to its destination without further incident.

Ce rapport est également disponible en français.

Other Factual Information

The aircraft had arrived in Sydney the previous evening and was scheduled to depart the next morning. On approach at Sydney there were traces of light rime icing with no appreciable accumulation, and aircraft anti-ice and de-ice systems were used. The wing and tail leading edges were clean on arrival at the ramp. The Sydney weather was blowing snow with a temperature of minus 1°C and a dew point of minus 4°C. A short time after arrival in Sydney, the aircraft was placed in an unheated hangar, where the temperature was slightly above freezing.

Due to a snow storm in the area, all morning flights out of Sydney were canceled. The occurrence aircraft was removed from the hangar and positioned on the ramp, into the wind, at 1450 Atlantic daylight time (ADT)[1] on the day of the occurrence. The weather was reported to be as follows: wind 340° true at 22, gusting to 31, knots, visibility 1 mile in light snow and blowing snow, temperature -1°C, and dew point -5°C.

The first officer completed the pre-flight inspection at 1500. This included a tactile inspection of the engine plenum areas through each by-pass door; no contamination was found. A visual inspection of the engine air inlet ducts was conducted from the ground. However, the lower portion of the inlet ducts would not be visible from this vantage point. Immediately after the pre-flight inspection, the ground handler installed the engine air intake plugs to prevent snow from accumulating inside the engine air inlets. He gained access to the air inlets by standing on the baggage cart and examined the air inlet ducts visually and by running his hand inside them before installing the plugs and again after they were removed (at 1520) for the start of the right engine to warm the aircraft cabin prior to passenger boarding. The ground handler did not see or feel any contamination during the installation and removal of the inlet plugs. The flight crew carried out visual inspections of the engine air inlets from the cockpit during the de-icing operation, prior to engine start, and just prior to the start of the take-off roll and no contamination was observed.

The *Bombardier Aerospace Engine Lower Cowl Intake Icing Inspection Training Guide* outlines the precautions and inspections recommended to be carried out on the aircraft during overnight parking, prior to departure and take-off during inclement weather. At the time of the occurrence, the guide contained the following recommendation on engine inlet inspection:

Check inside the engine inlet with a flashlight for any signs of ice, snow or slush. This should include visual and tactile inspections of all areas below the intake heater adapter, plenum chamber and diffuser areas. Any ice, snow or slush must be removed with a

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[1] All times are Atlantic standard time (Coordinated Universal Time [UTC] minus three hours) unless otherwise noted.

snow-brush or similar tool. If necessary pre-heat lower cowl to remove ice.

The training guide did not contain a specific recommendation to perform a tactile inspection of the inlet duct area.

After the passengers were boarded, the aircraft was de-iced, and, at 1536, the engines were started for departure. The engine ignition was selected “ON” after engine start in accordance with the DHC-8-100 *Aircraft Flight Manual* (AFM), which requires that engine continuous ignition must be turned to the “ON” position when the aircraft is operating in icing conditions. The engine anti-ice systems were also selected “ON” after engine start and operated continuously throughout the flight. After engine start and while taxiing to position for take-off on Runway 01, the crew turned the heat up in the cabin, which resulted in a lot of condensation and vapor in the cabin. The lavatory smoke alarm then activated, and, while this problem was being resolved, the aircraft continued to taxi for position for the take-off. After arriving in position for take-off at the end of the runway, the crew stopped the aircraft momentarily until the problem was rectified. The airport ramp condition at the time of departure was reported as 95 per cent bare and wet, 5 per cent bare and dry. The aircraft began its take-off roll at 1547, eleven minutes after the engines were started. Airframe de-icing systems were not used during the departure and climb to cruise altitude because no airframe icing was observed by the crew. Propellor heat was turned on during the climb-out.

When the right engine flamed out the first time, the right engine control unit (ECU) reverted to “MANUAL”. After the engine recovered, the crew re-selected the ECU to “NORMAL” and about 30 seconds later, the right engine flamed out again with the ECU again reverting to “MANUAL”. Following the second flame-out of the right engine, the crew did a complete review of their options, including returning to Sydney; however, due to the weather conditions in Sydney and the published AFM limitations with one ECU inoperative, the crew elected to continue to Halifax. The crew then consulted with company maintenance personnel who suggested that the ECU circuit breaker be cycled. The crew elected to wait until after top of climb to do this. However, just as they were reaching their cruise altitude, the left engine went through a flame-out and restart sequence with the left engine ECU reverting to “MANUAL”. With both ECUs now in “MANUAL”, the crew cycled the ECU circuit breakers and re-selected the “NORMAL” position one engine at a time. With the aircraft clear of cloud, operating normally, and with no further sign of ice in the inlet ducts, the crew did not deem it necessary to declare an emergency.

The crew described the ice that they observed in the engine air inlet ducts before the engines flamed out. The ice started three to four inches aft of the intake lip, it spread aft along the bottom and side as far aft as they were able to see, and it was very white, with a consistency similar to that of rime ice.

A special weather observation taken three minutes after the take-off was as follows: wind 340° true at 24, gusting 29, knots, visibility 1½ mile in light snow and blowing snow, overcast ceiling at 700 feet, temperature -1°C, and dew point -5°C. The temperatures remained the same throughout the afternoon. The upper wind charts predicted the following temperatures, in degrees Celsius: 6000 feet, -7; 9000 feet, -7; and 12 000 feet, -12. The significant weather charts valid for the time of departure indicated that there would be moderate mixed icing from the surface to 11 000 feet for the Sydney area.

As a result of the delay in the reporting of this incident to the TSB, the flight data recording associated with the occurrence flight was overwritten and was not available for investigation purposes.

There have been other DHC-8 in-flight engine flame-outs attributed to ice ingestion and/or airflow disruption due to the dislodging of an ice sheet. Two of these flame-outs (TSB/CASB reports A87O4219 and A88A0039) have been attributed to ice accumulation during ground operations. There are indications that another flame-out event, TSB Report A99A0160, could have been related to in-flight ice accumulation in the aft plenum of the engine air inlets; however, the incident was not investigated thoroughly. In an attempt to prevent further occurrences, modified procedures were developed for the 2000/2001 fall/winter/spring seasons to ensure that the engine air inlets were free of contamination on the ground. These procedures were distributed to operators by Bombardier Aerospace through a service letter dated 20 September 2000 and a revised CD ROM training guide. Highlights of the information are as follows:

> Service Letter - Pre-taxi Precautions
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> *Through the icing experience of one operator it has been discovered that ice can build in the engine air intake, immediately ahead of the bypass door. If this ice accumulation is not removed it can build forward of the nacelle plenum and potentially cause an engine power interruption. As a result of these events, the operator has implemented the following procedures:*
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> *Tactile inspections of the engine intakes must be completed during all station stops when icing conditions exist. If icing conditions are encountered in-flight or icing conditions exist or have existed on the ground, an inspection to ensure that the engine air intakes are clear, must be performed. A visual inspection of the intake may **NOT** identify ice that has formed in the nacelle plenum. With the intake bypass doors "OPEN", reaching inside the plenum chamber will identify any ice, slush or "other" contaminant build-up. This area **MUST** be clear before flight.*
>
> Service Letter - Taxi Precautions
>
> *During icing conditions, open by-pass doors and select ignition to **MANUAL** immediately after engine start (Series 100, 200, and 300 not incorporating Auto Relight Systems MODSUM 8Q100813/ Service Bulletin 8-74-02).*
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> *During taxi, avoid using reverse thrust on snow or slush covered runways, taxiways or ramps unless absolutely necessary. Reversing on snow/slush covered ground can cause slush and water to become airborne and be drawn into the engine intakes and onto the wing surfaces. Using reverse to aid in gate push back in freezing conditions is not recommended.*

Training Guide

Check inside the engine inlet with a flashlight for any signs of ice, snow or slush.

Check for ice accumulation inside the nose cowl through engine bypass doors.

If frozen contaminant is discovered, ensure that the lower cowl intake is clear prior to engine start.

Air Canada Regional Airlines (ACR) adopted these modified procedures and incorporated them into their flight crew and ground handler Standard Operating Procedures (SOPs) and training programs. Both flight crew members and the ground handler were trained in these procedures prior to the occurrence.

Subsequent to this occurrence, personnel from Bombardier Aerospace, ACR, Pratt & Whitney Canada, Transport Canada (TC), and the TSB undertook a systematic fault analysis process called Relentless Root Cause Analysis (RRCA) to establish why the engines had flamed out. This process involved identifying the factors that may have contributed to the event and then analyzing each factor to determine what, if any, role it played. One of the factors that was identified as being a possible contributing factor was that three of the four drain holes (two in each inlet duct area just forward of the "ski jump") were completely blocked with green paint and the fourth was partially blocked with paint. It is probable that the holes were painted over during cowling refurbishment by the operator. During the process it was agreed that the engine flame-outs were caused by ice in the engine air inlet ducts lifting up as a solid sheet, interrupting the airflow to the engines and causing them to flame-out. As a result of the RRCA, two possible scenarios were postulated which could have created the conditions which led to the engine flame-outs. The first scenario was that there was ice in the inlet ducts prior to engine start and the second scenario was that ice accumulated in the inlet ducts after engine start. In the first scenario, it was hypothesized that ice/snow, which had accumulated in the intakes on the previous flight, melted while the aircraft was in the hangar overnight and then pooled due to blocked drain holes. This residual water went undetected by the flight and ground crews and froze as a sheet of ice on the bottom of each intake after the aircraft was removed from the hangar. After the aircraft was airborne, these sheets of ice broke free and lifted up as a solid sheet, momentarily interrupting the airflow to the engines and causing them to flame-out.

A National Transportation Safety Board (NTSB) report on a Grumman G-159 (G-1) accident that occurred on 19 July 2000, in which engine icing was discussed, contained the following excerpt from the *G-1 Flight Manual*, Appendix A, Adverse Weather/Abnormal Atmospheric Conditions section, which stated in part:

> Engine/propeller icing can occur without wing icing. A turbine engine operating in an air mass with an ambient temperature below 8 degrees C may experience engine icing; this is caused by the temperature drop associated with the reduction in pressure between that of the air mass and the pressure at the propeller disk and/or first stages of the compressor. As air is drawn past the propeller or into the engine, moisture condenses into droplets. Theses droplets, due to their inertia, cannot follow the airflow around the propeller, guide vanes, or compressor blades. Instead, they strike the metal parts and freeze...

The excerpt from the *G-1 Flight Manual* raised the question as to whether the same thing could have occurred in the DHC- 8-100 inlet. In response to this question, Bombardier Aerospace carried out a Computational Fluid Dynamic (CFD) analysis (second scenario). Two different type nacelle inlet installations were analyzed and compared, the "pitot" nacelle inlet

(DHC-8-100) and an "annular" nacelle inlet (similar to the type found on the G-1) using ISA standard atmosphere conditions at 9000 feet altitude and a temperature of -3°C. The findings of this comparative analysis were as follows:

- The temperature rise across the propeller disk is small, approximately 1°C, for both applications.

- The temperature increase due to flow deceleration between the propeller and the inlet is significantly larger than that imparted by the propeller, approximately 4°C, compared to the annular inlet where there is a slight decrease in temperature.

- There is a slight drop in temperature as the air enters the DHC-8-100 inlet and then the temperature increases a slight amount over the length of the inlet before entering the engine compressor. In the annular inlet, there is a sharp decrease in temperature of approximately 10°C as the air enters the inlet and then the temperature climbs approximately 7°C over the length of the inlet before entering the engine compressor.

As part of the CFD analysis, Bombardier Aerospace also looked at the impact on snow/ice development in the DHC-8-100 inlet by calculating the length of time required for snow in the inlet flowfield to melt, the length of time a particle takes to travel from the inlet to the compressor face, and determining what effect the temperature/dew point spread on 03 April 2001 may have had. The findings from this analysis were as follows:

- Time to melt ice crystal/snowflake is approximately 12 seconds.

- The residency time of a particle in the inlet is 20 milliseconds.

- The air temperature and the dew point on 03 April 2001 were -1°C and -5°C, respectively. Because the temperature of the air increases as it enters the inlet, the temperature would have been about 6 degrees Celsius higher than the dew point.

The conclusions from the above analysis were that snow/ice would not have sufficient time to melt before being ingested in the engine compressor and due to the spread between the temperature and dew point in the inlet, any water vapour in the airstream would not have precipitated out in the form of fog or snow.

In another CFD analysis, Bombardier Aerospace conducted a particle trajectory analysis for the DHC-8-100 inlet for in-flight operations, on the ground with engines at idle power, and on the ground with engines stopped. The conclusions from this analysis were as follows:

- Significant impingement of ice particles can occur on the bottom of the inlet duct on the ground when the aircraft is pointed into the wind during a snow storm with the engines off.

- There is no impingement of snow/ice particles on the bottom of the inlet duct on the ground when the aircraft is pointed into the wind during a snow storm with the engines at idle power.

- There is no impingement of snow/ice on the bottom of the inlet duct in flight when the duct is free of ground ice.

- Impingement of snow/ice particles can occur on the bottom of the inlet duct in-flight when a forward facing step is created by the breaking of a pre-existing sheet of ice.

- Some ice accretion can occur on the forward facing step of a pre-existing sheet of ice.

Based on the CFD analysis, Bombardier Aerospace offered the following to explain the observation of an ice build-up in the inlet duct during the flight: The ice sheet may have broken just aft of the de-icing boot because of activation of the de-icing boot or because of high normal and shearing stresses in the thin edge (wedge) of the ice sheet. After the ice sheet broke away there would be a forward facing step which could cause a localized change in air pressure and flow angle, resulting in a small amount of observable ice accretion which would not affect engine performance.

Applying the lumped-capacity heat transfer analysis and forced convection principles, Bombardier Aerospace computed that the time required for water on the bottom of the inlet duct to freeze is approximately 30 minutes under the conditions of 03 April 2001. The assumptions used for this computation were: drain holes blocked, water had a depth of 0.6 inch (about half of the maximum possible depth), water was assumed to be at 1°C, outside air temperature at -1°C, and air blowing in inlet at 10 knots due to the wind.

During the winter of 2001/02 ACR reported 12 incidents in which ice accumulated in the engine inlets during flight. One of these incidents was on 05 December 2001. In this incident, the aircraft had been parked on the ramp overnight in Charlottetown, Prince Edward Island, with the engine air inlets protected. The crew completed a pre-flight inspection of the aircraft and an engine intake inspection in accordance with the latest procedures. The engine air inlets and airframe were reported to be dry and free of any form of contamination.

The 0600 Charlottetown weather was as follows: wind 120° at 5 knots, visibility 15 statute miles, temperature minus 2°C, dew point minus 5°C, ceiling 3000 feet scattered and 7000 feet overcast. The aircraft departed at 0628 and at 3100 feet entered cloud and encountered light snow. At 11 700 feet, light rime ice was observed and as the aircraft leveled at 12 000 feet, both the airframe and engine de-icing boots were selected on (ice was observed in the engine air inlet ducts at this time). The boots were selected on again during cruise and just prior to the start of descent into Halifax; the de-icing boots were clean at the end of each cycle. The aircraft landed in moderate snow at 0655.

Because of the icing conditions encountered, the engine air inlets were inspected 10 minutes after landing, and ¼ inch of ice was found on the 'ski ramp' areas of the air inlet ducts, just aft of the drain holes. One-half inch of ice was also observed on the radome. The 0700 Halifax weather was as follows: wind 130° at 6 knots, visibility 1½ statute miles in snow showers, temperature and dew point minus 1°C, and ceiling 2800 feet overcast. On 03 January 2002, the airline sent a letter of concern to the manufacturer regarding the icing noted in the intakes following the 5 December 2001 flight. In a response to the airline, on 28 January 2002, Bombardier stated that it would not anticipate that the icing noted would cause any operating anomalies.

It was determined that during initial aircraft certification, the DHC-8-100 met or exceeded the certification criteria for intake induction icing. These criteria state that, ". . . each engine, with all icing protection systems operating, must operate throughout its flight power range (including idling) without the accumulation of ice on the engine components that adversely affects engine operation or that causes a serious loss of power or thrust in continuous maximum and intermittent maximum icing conditions . . . " On the 03 April 2001 flight, the aircraft was operating well within (below) the maximum icing conditions threshold when the engines flamed out.

Since the 1999 occurrence, Transport Canada Continuing Airworthiness has been actively monitoring the

DHC-8-100 engine air inlet icing issue. Following the 03 April 2001 occurrence, TC has closely followed the RRCA process, operator actions, and the response and actions of the aircraft manufacturer. TC has also conducted a formal risk assessment considering at least three scenarios. TC concluded that the probability of a double engine flame-out and failure to restart at least one engine due to in-flight ice contamination to occur was improbable/unlikely, because over the total flying hours of the entire global DHC-8-100 fleet (more than 10 million flight hours) there has been no such occurrence. By combining the hazard severity and the hazard probability TC's Risk Assessment determined the risk to be low.

Risk determination would usually require that the duration of exposure to a hazard be factored with the severity of the event under consideration and with the probability of that event. In this type of occurrence, the exposure to the hazard (in-flight ice contamination in the air inlet ducts) can only occur when icing conditions exist and an aircraft is flying through or in such conditions. Therefore, determining the duration of exposure to conditions that would result in ice accumulation and possible engine failure is virtually impossible.

Analysis

It was established that the engine flameouts were caused by ice in the engine air inlet ducts lifting up as a solid sheet interrupting the airflow to the engines and causing them to flame-out. Two possible scenarios were established for the ice built up in the engine air inlet ducts. One scenario is that there was water in the engine air inlet ducts when the aircraft was removed from the hangar. This water went undetected during the inlet inspections and then froze into a solid sheet. The other scenario is that the engine air inlet ducts were clean when the engine inlet plugs were removed for engine start and that a sheet of ice formed in each engine inlet duct after engine start.

The first scenario postulates that because the aircraft had arrived in Sydney in blowing snow conditions, snow/ice accumulated in the inlet duct before the aircraft was placed in the unheated hanger. Although this is likely, (either from in-flight accumulation or from after landing accumulation, or a combination of both) it was not verified that snow/ice was present. If snow/ice had accumulated, it would have melted because the temperature inside the hangar was slightly above freezing and the residual engine heat in the inlets would have raised the inlet temperature after the aircraft engines had been shut down. Water from the melted ice that would have normally drained out the inlet duct drain holes would have remained in the inlet because of the drain hole blockages. When the aircraft was removed from the hangar the next day, the water in the bottom of the inlet ducts froze. This water and/or ice went undetected by the flight crew or the ground handler when he installed and removed the inlet plugs.

Thirty minutes after the aircraft was removed from the hangar the right engine was started and run for five minutes to heat the aircraft. Both engines were started 46 minutes after the aircraft was out of the hangar. Of the total period outside the hangar before both engines were started, the plugs were estimated to have been in place for 20 minutes, leaving the inlets exposed to the wind and blowing snow for 26 minutes, with the right engine running for 5 minutes of that. The heat transfer analysis concluded that, in conditions similar to those on the ramp on the day of the occurrence (temperature -1°C, wind 10 knots), ½ inch of water could freeze in 30 minutes. Given that any water in the inlet ducts would have been exposed (plugs removed) to the wind prior to engine start for approximately 10 minutes with respect to the right engine, and slightly less than 30 minutes for the left engine, the heat transfer analysis conclusion may not be completely appropriate for both engines. The left engine, however, would have been exposed to the -1°C temperature for about 46 minutes.

Heat transfer analysis also concluded that the conditions on 03 April 2001, after engine start, were not conducive to inlet duct icing and consequently, the inlet icing could not have occurred as described by the crew unless there was a pre-existing, ground-accumulated ice sheet. Previous occurrences where it has been concluded that inappropriate ground handling procedures resulted in an ice/snow build-up in the engine inlets were also used to support the first scenario.

The second scenario postulates that the inlet ducts were clear of water and ice prior to engine start and that ice developed in the inlet ducts after the engines were running. In this scenario, there is agreement that any ice present on arrival the night before would have likely melted after the aircraft was put in the hangar. There is disagreement, however, regarding the presence of ice or water in the inlet ducts prior to engine start, because the ground handler's direct visual and tactile inspection of the inlets showed them to be clear. Further, ice formation in flight is supported by the pilots' observations from the cockpit of ice forming in the inlet ducts after take-off, and the fact that there was no ice visible in the inlet ducts after the flame-outs. The incident of 05 December 2001 and other ACR in-flight-icing reports confirm that inlet duct icing can occur.

Theoretical modeling was used to develop the conclusions in the first scenario. The second scenario relies on ACR personnel statements that no ice was present before engine start and that the proper ground and flight procedures were followed. While it is not possible to determine conclusively which scenario is accurate, the implications of either possibility are serious.

To deal with the first scenario and ensure that inlet ice contamination on the ground will not result in an engine flame-out, the manufacturer introduced additional ground handling safety defenses. These procedures have been implemented by ACR.

The second scenario, that the multiple in-flight engine flame-outs may have been caused by ice accumulation after the engines were started, cannot be discounted as a possibility. Therefore, even though engine ignition successfully re-started the engines on this occasion, appropriate follow-up action is required to ensure that the risk of significant in-flight ice accumulation causing flame-outs is adequately assessed.

Findings as to Causes and Contributing Factors

12. It was determined that the engine flame-outs were caused by ice in the engine air inlet ducts lifting up as a solid sheet interrupting the airflow to the engines and causing them to flame-out. It could not be determined conclusively how the ice formed in the inlet ducts.

Findings as to Risk

1. Three of the four drain holes in the right engine inlet duct were completely blocked and the fourth was partially blocked, which increased the risk that water could pool and freeze in the duct.

Safety Action Taken

Bombardier Aerospace published a revised ground procedure training guide in September 2001. The main difference in this guide compared to the previous version (September 2000) is that it contains a more detailed description of the areas to be inspected (tactile inspection of inlet duct area is added) and cleaned, and it suggests tools and methods for carrying out the inspections and cleaning procedures. Bombardier Aerospace has also provided instructions, Customer Special Installation (CSI) 826930, on enlarging the drain holes in the engine air inlet ducts.

ACR has incorporated the revised procedures into their training program and SOPs. In addition, ACR has developed, for data collection purposes, an “Engine Intake Ice Survey” form. Flight crew complete this form anytime ice is detected in the engine air inlets. In conjunction with this program, ACR and Environment Canada have entered into a program which provides real-time monitoring of in-flight atmospheric conditions. Data from this program will be correlated with data from the ice surveys in an attempt to understand the conditions which lead to engine air inlet duct ice formation in order to develop appropriate icing avoidance procedures.

As of 31 December 2001, the operator has received several completed “Ice Survey” forms and it was this survey that resulted in detection of the icing incident on the flight of 05 December 2001. ACR has commenced the installation of splitter angles, (designed by Bombardier Aerospace at the request of ACR [to install some kind of device in the inlet duct so that any ice sheet, regardless of how it got there, would not lift as a solid sheet] and provided to ACR as CSI 44022) in the engine nacelle lower cowl. ACR has installed this device in all of their DHC-8 aircraft. The purpose of the splitter angles is to prevent a single, solid sheet of ice from forming in the engine lower cowl. The company has also completed a program to enlarge the drain holes in the engine inlet ducts in accordance with CSI 826930.

A TSB Aviation Safety Advisory was sent to Transport Canada on 17 August 2001 suggesting that this and previous occurrences involving DHC-8-100 engine flame-outs be reviewed to validate that the aircraft and engines (Pratt & Whitney 120A) were performing acceptably under conditions for which they are certified.

On 23 October 2001 Transport Canada responded to the safety advisory. Stated in the response were the following:

- Bombardier has developed extensive ground procedures for the upcoming winter 2001/2002 and they will assist Air Canada Regional (ACR) to implement them [This activity was completed].

- Bombardier will station a Field Service Representative in the Atlantic region this winter to ensure that the procedures are understood and to collect data in the ACR operating environment.

- TC Civil Aviation staff members are satisfied that ACR, Bombardier, and Pratt and Whitney Canada are working collaboratively to ensure that there is not a recurrence of the event experienced by ACR on 03 April 2001.

- TC is satisfied with the progress to date and will continue to monitor and support these efforts until the issue is resolved.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 03 June 2003.

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