# AVIATION INVESTIGATION REPORT
# A02C0227

## COCKPIT FIRE – PRECAUTIONARY LANDING

AIR FRANCE
BOEING 777-228ER F-GSPZ
CHURCHILL, MANITOBA 290 nm NE
17 OCTOBER 2002

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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## Report Number A02C0227

## *Synopsis*

On 17 October 2002, Air France Flight 062, a Boeing 777–228ER, serial number 32310, departed Paris, France, on a scheduled flight to Los Angeles, California, United States, with 172 passengers and 17 crew members on board. At 1459 Coordinated Universal Time, while cruising at flight level 360, the cabin crew smelled an abnormal odour in the cabin. The captain went to the cabin to investigate, and shortly thereafter, a fire started in the area of the left front cockpit windshield. The fire was extinguished by the relief first officer; however, two large cracks developed in the windshield.

The crew diverted the flight to Churchill, Manitoba, and landed and stopped the aircraft on Runway 33, which was snow covered. The aircraft was subsequently moved to the terminal ramp area, and the passengers were deplaned through the aircraft's right front emergency egress slide. No injuries to passengers or crew were reported. The only damage to the aircraft was to the forward left windshield and the forward left glareshield area.

*Ce rapport est également disponible en français.*

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## 5.0 Appendices

# 1.0 Factual Information

## 1.1 History of the Flight

The crew reported for duty at Charles de Gaulle Airport (LFPG) at 0600 Coordinated Universal Time (UTC)[1] to prepare for the extended range twin-engine operations (ETOPS) flight. Pre-flight preparation was normal and the aircraft departed at 0847 for Los Angeles, California, United States, with 3 pilots (the captain, first officer and the relief first officer), 14 flight attendants, and 172 passengers on board.

At 1459, passengers in rows 42 to 44 noticed an unusual smell and notified the cabin crew. The information was relayed to the captain who departed the cockpit to investigate, leaving the cockpit door open. Shortly after the captain's departure from the cockpit, a fire developed at the lower left corner of the captain's forward windshield. The relief first officer, who had been seated in the forward cabin, saw the captain walking to the rear cabin area and went forward. When the relief first officer entered the cockpit, the relief first officer saw the fire and fought it with the cockpit hand-held, Halon fire extinguisher. The entire contents of the extinguisher were discharged onto the fire and the fire was temporarily suppressed, but it recurred after the extinguisher was exhausted. The relief first officer obtained another extinguisher with the assistance of the principal chief of cabin, discharged it onto the fire, and the fire did not recur. The first officer asked the principal chief of cabin to call the captain back to the cockpit. The captain arrived back in the cockpit within a minute, and assumed pilot-not-flying duties.

At the time the fire broke out, the designated ETOPS en route alternate airport for the flight was Winnipeg International; however, the closest available airport with runway and approach aids adequate for a Boeing 777 in an emergency situation was Churchill, Manitoba, directly ahead on the flight planned route. The first officer reviewed the Churchill airport data in an emergency airfields supplement to assist in a decision on diverting the aircraft.

The crew initiated a descent, dumped fuel, and prepared to land at Churchill. The aircraft landed safely and stopped on snow-covered Runway 33 at Churchill. Firefighters from the Town of Churchill inspected the aircraft for fire and none was found. Taxiway A was inspected and sanded, the aircraft engines were restarted, and the aircraft moved to the ramp about three hours after arrival. Passengers deplaned through the aircraft's right front emergency egress slide and were moved to the airport terminal.

## 1.2 Injuries to Persons

| | Crew | Passengers | Others | Total |
|---|---|---|---|---|
| Fatal | – | – | – | – |
| Serious | – | – | – | – |
| Minor/None | 17 | 172 | – | 189 |
| Total | 17 | 172 | – | 189 |

[1] All times are UTC unless otherwise noted.

## 1.3 Damage to Aircraft

The fire originated at an electrical terminal block on the captain's left forward windshield. The major damage was limited to the windshield and the terminal block electrical connectors, which required replacement. There was some minor discolouration to an adjacent interior window post trim cover.

## 1.4 Other Damage

There was no other damage.

## 1.5 Personnel Information

| | Captain | First Officer | Relief First Officer |
|---|---|---|---|
| Pilot Licence | ATPL | ATPL | ATPL |
| Medical Expiry Date | 01 December 2002 | 01 November 2002 | 01 December 2002 |
| Total Flying Hours | 19 647 | 6052 | 2095 |
| Hours on Type | 1253 | 1142 | 1095 |
| Hours Last 90 Days | 146 | 201 | 49 |
| Hours on Type Last 90 Days | 146 | 201 | 49 |
| Hours on Duty Prior to Occurrence | 9 | 9 | 9 |
| Hours Off Duty Prior to Work Period | 40 | 73 | 56 |

Company records indicate that the Chief Cabin Crew had completed initial training on the Boeing 777 aircraft type in May 2002, had completed the required cabin safety training, and had accumulated 683 hours of flight time on the Boeing 777 aircraft type as of the date of the occurrence.

## *1.6 Aircraft Information*

### *1.6.1 General*

| | |
|---|---|
| Manufacturer | Boeing |
| Type and Model | 777-228ER |
| Year of Manufacture | 2002 |
| Serial Number | 32310 |
| Certificate of Airworthiness (Flight Permit) | Issued 18 July 2002 |
| Total Airframe Time | 1359 hours |
| Engine Type (number of) | General Electric GE-90-94B (2) |
| Maximum Allowable Take-off Weight | 646 800 lb. |
| Recommended Fuel Type(s) | Jet A1, Jet B |
| Fuel Type Used | Jet A1 |

### *1.6.2 Windshield Data*

#### *1.6.2.1 Previous Windshield Failure*

The aircraft was delivered new from the factory to Air France on 21 May 2002. The aircraft was put into desert storage for two months and began service on 18 July 2002. On 16 August 2002, after about one month in service, the crew noticed that the black polyethylene cap covering the J5 window heat power terminal on the captain's left forward windshield began to overheat and melt during a routine flight from Shanghai, China, to Paris. There was no smell, warnings or alerts, and after consultation with maintenance personnel, the crew continued the flight to the destination with the window heat shut off. The polyethylene cap is not normally visible to a crew member from most seat positions; it is necessary to lean forward or rise from the crew seat in order to see it. At the time of the occurrence, the windshield had been in service for 456 flight hours and 58.5 cycles.

Once on the ground, maintenance personnel replaced the window heat control unit (WHCU) and tightened the electrical power connector. A replacement electrical power connector and cap were not available and the J5 terminal connector was sealed using a CAF4 silicone sealant. The windshield heat system was tested and found to be serviceable. A full bench check was subsequently carried out on the removed WHCU and no faults were found.

Maintenance control issued a work instruction to replace the windshield electrical power connector by 26 August 2002. The work instruction was queried by maintenance central on 27 August 2002 and the task, having not been completed, was deferred to a scheduled maintenance check of the aircraft scheduled for 09 to 12 October 2002. The task again was not completed during the scheduled maintenance check, and the status of the work instruction remained as DUE. It was later established that the connector and cap had been in stock when the work instruction for the maintenance check was queried, but that the operator's inventory system showed the parts as unavailable. Although the parts were on hand, the inventory system had reserved them for this task. The system did not differentiate between parts that were not in stock and those that had been reserved, and, therefore, indicated to maintenance personnel that the parts were unavailable for this task. The operator's records did not indicate that other cockpit window terminals had been serviced since the aircraft entered service.

CAF4 silicone is rated for use between -65°C to 225°C, up to 250°C for short periods, and it decomposes at about 482°C. The cap material was polyethylene L–P–390, Type l, Class L, which melts at 132°C and ignites at around 355°C.

### *1.6.2.2 Windshield Description*

The left forward windshield, part number 141W7400–1, serial number 02039H8228, was manufactured by PPG Industries Aircraft and Specialty Products in Huntsville, Alabama, in February 2002. The windshield was installed in the newly manufactured aircraft, which, at the time of the 17 October 2002 occurrence, had been in service for 1365 flight hours and 168.5 cycles.

The windshield consists of three plies of glass with exterior surface anti-icing and exterior and interior surface anti-fogging protection. The plies are comprised of chemically tempered glass, separated by interlayers of polyvinyl butyral and urethane. The glass and interlayer materials are bonded together in an autoclave under specific time, temperature and pressure conditions.

The window is designed to withstand fail-safe pressure loads with a single glass ply failed, and normal pressure loads with multiple glass plies failed. The windshield heat system is normally powered whenever the aircraft electrical system is powered.

The anti-ice and anti-fog elements are connected to separate power and sensor terminal blocks located on the upper and lower edges of the windshield. The connectors are numbered J1 through J15 (see Appendix A). The terminal blocks are made of a cast epoxy material with brass blocks embedded into them to allow for the attachment of the window bus bar conductors. The terminal blocks have a cavity to allow for the soldering of the flat-braided copper conductor from the bus bar to the brass blocks. The cavity is then filled with a polysulphide filler/adhesive identified as PR1425. The filler/adhesive contains carbon black as an ultraviolet stabilizer. After the copper conductors are soldered to the terminal block, the block is then glued to the windshield using the PR1425 filler/adhesive.

The electrical power connector consists of a tin/gold-plated beryllium copper alloy insert moulded in an epoxy block with a 12-gauge electrical conductor crimped into the insert. The power connector is attached to the terminal block with a stainless steel screw and lockwasher arrangement, which is torqued to a specified value. The stainless steel screw has a different thermal coefficient of expansion from that of the brass in the terminal block. A silicone rubber O ring is installed around the outer periphery of the power connector to seal the connection at the terminal block. The aircraft maintenance manual (AMM) calls for a torque of 25 to 30 inch-pounds to be applied to the power terminals and a torque of 12 to 15 inch-pounds for the sensor terminals. Once installed, a black plastic cover is snapped into place over the epoxy block to shield the electrical connection.

### *1.6.2.3 Windshield Manufacturing Process*

During the manufacturing process, approximately 2 ½ inches of flat braided copper conductor from the anti-ice and anti-fog elements is left extending from the edge of the inboard ply to enable it to be hand soldered to the brass insert and then rotated for attachment to the edge of the window. The length of copper braid brought out from the window edge is covered with heat shrink insulation. Before the braid is soldered to the terminal, this heat shrink is melted with a soldering gun and removed, exposing ½ to ¾ inch of bare copper braid for soldering purposes. If a braided cable is cut too short, it will be strained when the block is folded into place, if it is cut too long, it will bunch under the block. Neither condition is visible once the block is glued in place.

During the soldering process, the braid is positioned and held in place against the brass block by hand. Ideally, the braid is located in the middle of the brass block. A soldering gun is used to melt the 60/40 (tin/lead) resin core solder and join the two parts. The solder has a melting point of about 190°C. During the soldering process, care must be taken to ensure that the soldered joint is sufficiently heated and that the braid is not moved before solidification of the solder occurs, as either condition could result in a cold-soldered joint. A cold-soldered joint is brittle and may break when moved.

### *1.6.2.4 History of Investigated Window Terminal Incidents*

On 27 September 1993, Boeing issued an All-Operator Message (7240–93–1844), to increase the torque requirement on the electrical power and sensor terminal connector screws on all cockpit windows on Boeing 747 and 767 aircraft. In its message, Boeing said that the original screw torque requirements may have been insufficient to prevent the screws from loosening in service. A loosened screw could cause the current path to be interrupted, which in turn could cause arcing, or power may be transmitted through the terminal screw in lieu of directly from the wire terminal to the terminal block insert. When large amounts of electrical current are transmitted through the screw, it can overheat, becoming red hot, and cause the sealant adjacent to the threaded insert to produce smoke.

During the design of the 777, Boeing was aware of three occurrences of smoke in the cockpit of 767 aircraft caused by arcing or burning at the Number 1 window power terminal. The increased torque requirement was incorporated into the 777 production drawings and the AMM instructions.

In 1996, the Transportation Safety Board of Canada (TSB) investigated a Boeing 767 (report No. A96A0146) involving an arc and smoke at the J5 terminal on the right cockpit window, followed by a brief fire. Because of the extensive damage, the origin of the failure could not be determined; however, it was suspected that the copper braid conductors (near the brass block insert) must have severed to initiate the arc.

In July 2003, a Boeing 777 en route from Rome, Italy, to New York, New York, United States, also experienced a fire at the captain’s windshield J5 terminal. The crew in that occurrence initiated an emergency descent and completed a successful landing at Shannon International Airport, Ireland.

### *1.6.2.5 Flight Deck Airflow*

When both air conditioning packs are operating, the air supply into the flight deck consists of 100 per cent outside air from the left air conditioning pack, with no re-circulated air from the cabin. The air supply to the flight deck is provided in sufficient quantities to maintain a slightly positive pressure in order to exhaust air to the electrical and electronic (E&E) bay under the cockpit and on through to the rest of the aircraft, where it entered the cabin at approximately row 42 to 44. This maintains good ventilation for the flight crew, provides flight deck smoke evacuation, and prevents E&E bay smoke penetration into the flight deck in the event of a fire in the E&E bay.

### *1.6.2.6 Warnings and Alerts*

The Equipment Cooling Override (EQPT COOLING OVRD) and the Window Heat Left Forward Inoperable (WINDOW HEAT L FWD INOP) warning lights appeared in the cockpit while the fire was being extinguished. Both warnings were also displayed as advisory messages on the engine indication and crew alerting system (EICAS). In addition, two aircraft communications addressing and reporting systems (ACARS) maintenance fault messages were generated by the central maintenance computing function (CMCF) at 1503. The flight data recorder (FDR) also recorded an “E&E Bay Smoke Warning” discrete at 1503:22. The discrete remained on for approximately 17 minutes. The crew completed the following checklist procedures in response to the emergency: WINDOW HEAT L FWD INOP (one item is to select the window heat switch to OFF), EQPT COOLING OVRD and WINDOW DAMAGE (un-annunciated).

### *1.6.2.7 Equipment Cooling Override Light*

The EQPT COOLING OVRD light is illuminated by activation of the E&E cooling system remote smoke detector (RSD). The RSD requires optically reflective particles to trigger it. The E&E cooling exhaust system draws air from several locations, including from behind the flight deck forward instrument panel. A small portion of the exhaust air is routed past the RSD. In flight, the E&E cooling system RSD is designed to alarm at a 3 per cent particle obscuration level and, as such, is not designed to detect small amounts of smoldering smoke from overheated equipment or shorted wires.

With the activation of the RSD, the following actions occur:

- The E&E cooling system goes into the override mode and all supply and vent fans are turned off. Cabin pressure differential is used to reverse the airflow and pull the smoke through the system and equipment and discharge it overboard. This prevents smoke in the E&E cooling system from reaching the passenger cabin. The override mode supplies adequate cooling while the aircraft is in cruise flight, but because the airflow decreases as the aircraft descends, due to the decrease in cabin pressure differential, a caution is provided to the crew in the Abnormal Procedures checklist. The caution warns that “after 30 minutes of operation at low altitude and low cabin differential pressure, electronic equipment and displays may fail.”

- The EQUIP COOLING OVRD advisory light illuminates and an EQUIP COOLING OVRD advisory message is displayed on the EICAS.

- The FDR records the “E&E Bay Smoke Warning” discrete.

- The CMCF records “26 Cargo Smoke Detection System Fault,” which appears as an ACARS maintenance fault message.

### *1.6.2.8 Window Heat Left Forward Inoperable Light*

The WINDOW HEAT L FWD INOP light is illuminated by the WHCU when a window overheat is detected or a system fault has occurred and the WHCU has automatically turned off the window heat. The WHCU regulates the windshield temperature from 30.55°C to 35°C and monitors a current range of between 13.6 and 27.8 amperes while in flight. When a system fault is detected, the WHCU will also display an advisory message on the EICAS, indicating that the primary window heat for the affected window is OFF.

### *1.6.3 Aircraft Navigation Systems*

The flight crew of Air France Flight 062 (AFR062) used the aircraft flight management system (FMS) as the primary navigational aid to manage the aircraft's lateral and vertical flight paths. The FMS consists of two flight management computers (FMC) and three control display units (CDUs). The crew used the FMS to display the lateral position of the aircraft during the approach to Churchill. The FMC determines the present position from the global positioning system (GPS), the air data inertial reference system (ADIRS), and the navigation radios. The FMC automatically tunes the very high frequency omni-directional range (VOR), the distance measuring equipment (DME), and the instrument landing system (ILS) radios. The aircraft also is equipped with automatic direction finder (ADF) radios, which the crew must manually tune, using the CDUs, and which will display bearing pointers on the navigation displays. The FMC does not process data from the ADF radios.

The FMC contains a navigation database with most data on navigation charts approach plates. As a customer option, the navigation database in use on the occurrence aircraft did not include non-directional beacon (NDB) approaches.

### *1.6.4 Flight Deck Door*

The aircraft door is hardened against intrusion. In accordance with industry practice, the operator's policy is that the door remain closed and locked during normal operations. In responding to the smell in the cabin, the captain left the door open while departing the cockpit, and the relief first officer was able to enter the cockpit quickly.

## *1.7 Meteorological Information*

When the captain left the cockpit at approximately 1500, the first officer made a weather request on the aircraft ACARS system for Churchill, which was the closest emergency airport with a runway adequate to land the Boeing 777. At 1500, the weather at Churchill was observed to be as follows: wind from 360° true (T) at 7 knots, visibility 15 statute miles, scattered clouds at 2400 feet, broken clouds at 4400 feet, temperature -2°C, dew point -4°C. When the fire broke out, AFR062 was approximately 290 nautical miles (nm) northeast of Churchill, operating in day visual meteorological conditions (VMC) at flight level (FL) 360.

At 1600, the Churchill weather was observed to be as follows: wind from 020° T at 7 knots; visibility 15 statute miles, with showers in the vicinity; scattered clouds at 2300 feet; broken clouds at 22 000 feet; temperature -1°C, dew point -5°C. AFR062 landed at Churchill at 1602 in day VMC conditions. Recent snowfall had left about ½ inch of snow on the runway.

## 1.8 Aids to Navigation

### 1.8.1 Churchill

On the date of the occurrence, NAV CANADA radar coverage did not extend into the area northeast of Churchill, and the air traffic control service provided was based on procedural separation.

The Churchill Airport was served by a combined VOR and DME (YYQ), three NDBs, and an ILS for Runway 33. The published instrument approaches for Runway 15/33 at the Churchill Airport consisted of a Localizer/NDB for Runway 15, an NDB for Runway 33, and an ILS for Runway 33. In addition, there are VOR, VOR/DME and NDB approaches for Runway 07/25. The ILS approach has the lowest approach minima of all the approaches at Churchill. Notice to Airmen (NOTAM) 020207, issued at 1938 on 16 October 2002, was in force for the Churchill Airport and advised operators that the ILS to Runway 33 was unserviceable until 2359 on 17 October 2002.

Air France includes NOTAM information for emergency airports in flight crew briefing packages for the following events: airport shutdown, runway closures or restrictions, and change of communication frequencies. NOTAM 020207 was available in the Air France computer flight planning system, but was not included in the briefing package for the crew of AFR062 because emergency airport approach aid unserviceability is not one of the criteria for inclusion.

### 1.8.2 Company Information

Air France provides company-approved aeronautical information publications to its flight crews.

The first officer had available, at his crew position, an emergency airfields supplement that contained basic information about emergency airport location and elevation, runway size and orientation, communication frequencies, and airport services. The information listed in this supplement for Churchill was current.

Detailed information on airport facilities and instrument approaches is required when instrument meteorological conditions (IMC) prevail. In the Boeing 777, approach plates and aerodrome charts for emergency diversion airports were kept in a binder in a compartment behind and to the left of the captain. The relief pilot retrieved this binder while the captain and first officer performed other tasks. The plastic binder cover was held closed by a metal wire and lead seal. The relief pilot was unable to break the wire or seal and had to tear the binder cover away from the wire to gain access to the documents in the binder.

The Churchill documents in the binder were as follows: approach plates for the ILS to Runway 33, the NDB to Runway 33, and the ILS (Back Beam) and the NDB to Runway 15; the minima for these approaches; and an aerodrome chart.

The responsibility for the dissemination of Canadian aeronautical information has been delegated to NAV CANADA by the Minister of Transport. Advance notice of changes to information for locations within Canadian Domestic Airspace is disseminated by NAV CANADA to producers of aeronautical information databases and publications by the weekly Aeronautical Information Regulation and Control (AIRAC) Canada document.

A number of revisions to information about the Churchill Airport and navigation aids occurred from 1999 to 2002, and were disseminated via the AIRAC. These included the redesignation of the Y (Yankee) NDB to ZCH (Beluga), an advisory that the ILS 33 glide path was unreliable below 323 feet above sea level (asl) rather than 260 feet asl, an increase of the ILS 33 decision height above the threshold from 200 to 250 feet, the decommissioning of Apron 1 and Taxiway A north of Runway 25, the commissioning of the new Apron 1 between Runway 15 and Runway 07, and the redesignation of Taxiway B as Taxiway A.

On 13 March 2001, Air France deleted Churchill from the company list of emergency airfields and removed Churchill from the register of current documentation to be included in the emergency binder. The Churchill documents had not been removed from the binder carried in the occurrence aircraft; however, they were no longer in the register of current documentation, and none of the above revisions had been incorporated by normal company amendment processes.

## *1.9 Communications*

### *1.9.1 Internal Communications*

The first communication to the flight crew regarding a burning odour was directly from a flight attendant who entered the cockpit at approximately 1500 and reported a smell of smoke in the vicinity of row 44. The flight attendant was instructed to report back within 10 minutes. Within a couple of minutes, a flight attendant again entered the cockpit and requested that the captain come to the cabin to assess the smell. The captain went aft to the cabin and was seen by the relief pilot, who then went forward to the cockpit. After the captain had left but before the relief pilot arrived, the first officer observed smoke and flames coming from the left windshield area and donned his oxygen mask. At 1502, the first officer had the principal chief of cabin recall the captain via the interphone. Seconds later, the relief first officer arrived in the cockpit, donned the observer station oxygen mask and used the cockpit hand-held fire extinguisher to fight the fire. The relief first officer directed a flight attendant to bring another fire extinguisher from the cabin, and this second extinguisher was then used to put out the fire. At about the same time, the captain returned to his seat in the cockpit and donned an oxygen mask.

Subsequent communications between the flight crew and the cabin crew were handled by the relief first officer either directly or using the interphone, and involved coordination for the impending arrival at Churchill.

### *1.9.2 External Communications*

At the time of the occurrence, AFR062 was about 290 nm northeast of Churchill, over Hudson Bay, and had been communicating with Arctic Radio via high frequency radio. The crew had been advised to contact the Winnipeg Area Control Centre (ACC) on very high frequency (VHF) 123.9 MHz when they passed 90° west longitude. The transmitter for that frequency was located at Churchill.
One characteristic of VHF radio emissions is that the transmitted radiation does not follow the curvature of the earth or bend around obstructions; VHF propagation is via line of sight. At an altitude of FL 360, the useful line of sight distance would be about 200 nm, and at 6000 feet it would be about 80 nm.

Shortly after the fire started, the first officer made a MAYDAY transmission on the emergency frequency 121.5 MHz, and another aircraft responded and relayed the call to the Edmonton ACC. The MAYDAY call was also received by the Rankin Inlet Flight Service Station, and AFR062 was advised to contact the Winnipeg ACC on 123.9 MHz.

The crew and the Winnipeg air traffic controller were initially unable to establish direct controller-pilot communications on 123.9 MHz because the aircraft was beyond the useful line of sight range. The crew commenced descent from FL 360 at 1508 when they were 224 nm from Churchill. During their descent the controller used another aircraft to relay transmissions to and from AFR062, and for a short period was able to communicate directly. The crew levelled off at 6000 feet at 1524 when they were 134 nm from Churchill, again below the line of sight. At 1535, they once again established direct communications with the controller at a distance of 90 nm from Churchill and remained in contact with the controller until 1549 when they switched to 122.2 MHz and established contact with Churchill Radio.

The controller provided air traffic control (ATC) clearances and instructions to the crew, obtained information from them regarding the aircraft's status, and provided information needed by the crew to prepare for the arrival at Churchill. The *Air Traffic Control Manual of Operations* required that landing information be issued to the crew; the crew received all of the required information from the controller, except for the approach aid in use. The controller was aware that the Churchill ILS was unserviceable, but did not immediately provide this information because of the communications problems experienced as AFR062 descended below the line of sight. The controller also assumed the ILS information was of relatively low importance to the crew because the weather was suitable for a visual approach. The information that the Churchill ILS was not available was transmitted on 123.9 MHz from another aircraft to the controller at 1514. This transmission was recorded on the AFR062 cockpit voice recorder (CVR); however, it was not heard by the crew.

At 1549, the crew switched to 122.2 MHz and established direct contact with Churchill Radio. The *Flight Service Station Manual of Operations* required that advisory information be issued to the crew; AFR062 received all of the required information from the Churchill flight service specialist, including the unavailability of the ILS.

## *1.10 Aerodrome Information*

The Churchill aerodrome is operated by Transport Canada. The aerodrome has two runways; only Runway 15/33 was adequate for Boeing 777 operations. Runway 15/33 is 9200 feet long by 160 feet wide and has an asphalt surface. The aerodrome elevation is 94 feet asl.

A series of runway surface condition NOTAMs for the Churchill aerodrome had been issued. On the day of the occurrence (17 October), the runway surface condition had been observed at 1310 and indicated that Runway 15/33 was 100 per cent covered with loose snow up to ½ inch in depth. There were windrows 10 feet inside the runway lights, up to 4 inches high and 8 feet wide. The flight crew did not have any difficulty in braking or steering the aircraft on landing.

The *Canadian Aviation Regulations* designate a number of airports that are required to provide an airport rescue and firefighting (ARFF) service. The Churchill aerodrome is not so designated and is not required to provide this service. Firefighters from the Town of Churchill, located about 4 nm from the airport, responded to the occurrence and inspected various areas of the aircraft after it had landed. The firefighting service provided by the Town of Churchill is not considered by Transport Canada to meet the ARFF criteria.

The ETOPS guidance material contains standards that must be met for an airport to be considered an adequate ETOPS en route alternate. In particular, an airport must have ARFF capabilities to be considered an adequate en route alternate airport. Due to the fact that Churchill does not provide an ARFF service, it is not adequate to be designated as a flight-planned ETOPS en route alternate. Air France uses Churchill as an emergency airport, not as an ETOPS alternate. Winnipeg and Goose Bay were the designated ETOPS alternates for the occurrence flight.

## *1.11 Flight Recorders*

### *1.11.1 General*

The aircraft was equipped with a Honeywell (Allied Signal) solid state FDR and a Honeywell (Allied Signal) solid state CVR. The recorders were forwarded to the TSB Engineering Branch for playback and analysis.

Approximately 26.9 hours of flight data, including the incident flight, were recovered from the FDR. The CVR recording was from approximately 28 minutes prior to the fire and ended on the ground in Churchill, 79 minutes later, when the aircraft was shut down. While on the ground, approximately 2 hours 23 minutes after the initial shutdown, aircraft electrical power was restored and the CVR powered up briefly, recording the final 14 minutes of the 2-hour recording.

### *1.11.2 CVR Recording Quality*

The transcription of the internal crew communications, using the two-hour mixed audio channel, was hampered by an imbalance in channel input levels. The levels of the incoming VHF radio transmissions were considerably higher than the crew's hot microphone levels, effectively masking the crew's internal communications in a significant number of areas of the recording. In an attempt to improve the speech intelligibility, signal processing techniques were used; however, these attempts were of limited success.

France's Bureau d'Enquêtes et d'Analyse (BEA) had encountered similar problems before this occurrence and had worked with an aircraft manufacturer to test a complete radio transmission line, including a ground station and a number of different VHF transceivers. Testing of nine VHF transceivers from three different suppliers indicated that all of the transceivers tested had output levels of varying degrees above nominal values. This suggested that there were procedure variations in the pre-setting of the transceivers by the suppliers prior to their installation, which may explain the imbalance in the radio channel levels on the occurrence CVR recording.

The European Organisation for Civil Aviation Equipment (EUROCAE) publishes technical standards for avionics, including both functionality, testing and form fit standards. Today, EUROCAE documents are considered by Joint Aviation Authorities (JAA) to be referenced by the JAA Joint Technical Standard Orders and other regulatory documents. The main European administrations and the main aircraft and equipment manufacturers are members of EUROCAE and actively participate in the Working Groups that prepare these specification documents. EUROCAE ED specifications contain standards for products. Amendments to the EUROCAE ED56a specifications *(Minimum Operational Performance Requirements for Cockpit Voice Recorder Systems*) were proposed in 2000 to ensure adequate CVR performance. These amendments, which specified that the radio signals be pre-set to levels lower than the hot microphone levels, were later incorporated into ED112 (*Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems*) and published in March 2003.

## *1.12 Aircraft Damage and Examination*

### *1.12.1 General*

The aircraft was examined in Churchill after the occurrence and none of the window heat power or backup power control circuit breakers was found tripped. The damaged left front cockpit window and its associated window heat control unit were removed for examination.

### *1.12.2 Terminal Screw Torque*

Prior to the removal of the damaged window, the power and sensor terminal connector screws were checked for proper torque as specified in the AMM (see Appendix A for a list of the recorded torque values). Three of the five power terminal connector screws were checked, and two of these were found to be well below the desired torque requirements. The torque on the remaining two power terminal connector screws, J5 and J13, was not checked in order to leave the burnt connectors undisturbed until laboratory examination. However, they were determined to be at least finger tight. One of the six sensor terminal connector screws was marginally below the required torque values.

The terminal connector screw torque on the undamaged right front cockpit window was checked and all five of the power terminal connector screws were found to be well below the desired torque requirements, with two of the five having no torque reading at all. Three of the six sensor terminal connector screws were marginally below the desired torque value.

After the occurrence, Air France conducted a fleet inspection of its 25 Boeing 777 aircraft to check the security of the J5 and J13 power terminal connector screws. Each aircraft is equipped with two J5 and two J13 terminals, and Air France found that on four of the aircraft, 11 of the 16 terminal connector screws showed torque values lower than those specified in the AMM. On one of the four aircraft, F-GSPC, the J5 connector on the left front windshield showed traces of overheating and melting of the black plastic cover. The electrical power connector was replaced; during the pre-flight check of the aircraft the next day, the connector was again found to be overheated. The window and its J5 connector were removed and examined at PPG Industries, Inc. (TSB Engineering Laboratory Report LP 105/2002). The power terminal connector screw was found to be cross-threaded in the brass block, resulting in a poor electrical connection and overheating of the terminal connector. It could not be determined whether the screw had been cross-threaded during or prior to the replacement of the electrical power connector.

### *1.12.3 Window Examination*

The window was examined at PPG Industries in December 2002. The terminal block in the area of the J5 brass connector was damaged due to the intense heat of the event, and the polysufide filler/adhesive was consumed by fire; the brass block insert was lying free but was still attached on one end to the J5 power connector lead wire. The terminal block in the area of the J13 brass connector was intact. The breaking torque on the J5 and J13 power terminal connector screws was checked and determined to be less than 5 inch-pounds.

The ganged J5/J13 terminal block was folded back from the window to expose the J5 and J13 braid wires. Approximately 0.6 inch of J5 braid wire from the edge of the glass to the terminal block base was intact, with the remainder of the braid either destroyed or melted. The J13 braid wire was intact with no indication of straining or bunching of the braided cable. The soldered connection at the J13 terminal was intact with no signs of a cold-soldered joint.

A blob of solder from the J5 brass connector was found in a thermal cavity in the glass surface beneath the J5 terminal block area with two parallel cracks, each about 35 inches across the length of the windshield, emanating from the cavity. The thermal cavity was created when an area of glass beneath the J5 terminal block was untempered due to exposure to localized extreme heat, and fragments of the untempered glass were dislodged during disassembly. The damage to the terminal block indicated that the heat had been sufficient to ignite the polysulphide filler/adhesive, creating the fire. The temperatures associated with resistive heating could account for the melting of the solder but would not account for the thermal untempering of the glass. Such temperatures are usually associated with arcing, which can easily reach temperatures in excess of 2760°C. As such, the melting of the solder and the detachment of the braid from the brass connector would likely have led to an electrical arcing event, as power from the WHCU was still being applied to the terminal.

With the disintegration or melting of the J5 braid wire, it was not possible to establish the condition of the braid or its soldered connection prior to the fire. The J5 solder joint appeared to be high on the brass terminal, but whether the soldering position had stretched the braid wire during installation could not be determined. The J5 connector/terminal block inserts were
broken apart and foreign material was present on both mating surfaces; no pitting was observed. This material was not identified. Debris was also noted on the threads inside the terminal block.

### *1.12.4 Window Heat Control Unit Testing*

The WHCU was tested at the manufacturer's facility in France, under the supervision of investigation staff from the BEA. The unit has a self-test feature that displays fault messages on the EICAS; however, the unit is not equipped with an electronic memory that stores fault data once power has been removed. A full bench acceptance test was carried out and no faults with the control unit were found. It was believed that the arcing, which occurred at the J5 window terminal, did not induce current variations beyond the specified values; therefore, no alarm signal was sent to the EICAS until after the fire was established.

## *1.13 Fire*

### *1.13.1 General*

The fire was limited to the immediate area surrounding the J5/J13 terminal block on the left forward windshield as the fire burnt up along the windshield in a high narrow flame emanating from the terminal block. Crew flight planning papers lying on top of the instrument panel glare shield caught fire, but the papers were quickly removed by the first officer and the flames extinguished. Other loose paper in the cockpit was gathered and removed by the principal chief of cabin to minimize the fire hazard. The sustaining fuel source for the fire was the polysulphide filler/adhesive used in the construction and installation of the windshield terminal block. The fire burned for just over two minutes from approximately 1502 to 1504, until it was extinguished.

### *1.13.2 Extinguishing the Fire*

Bringing the fire under control required the repeated full use of the single hand-held, cockpit mounted, one-kilogram Halon 1211 fire extinguisher, as well as the partial use of a second identical fire extinguisher that had to be brought into the cockpit from the cabin area.

Halon 1211 is a streaming agent that vaporizes to a gas as it is discharged. The Halon gas does not quench a fire, but reacts chemically with the fire to disrupt its chain reaction. Because of this, the burning material can flame up again after the Halon is dissipated, necessitating repeated use of the extinguisher. The aircraft's E&E exhaust system would have been ventilating the Halon gas rapidly, reducing the concentration of the Halon at the site of the fire. As such, repeated use of the extinguisher would have been required as long as combustible materials remained, power was present at the terminal, and the temperature at the connector remained hot enough to re-combust the materials.

The crew flight deck procedure for SMOKE/FUMES/FIRE ELEC source identified is to remove the electrical power from the affected equipment as soon as possible (Boeing 777 Quick Reference Handbook (QRH) 00.21). If the source is not identified, the crew will work with the cabin attendants to turn off galley power, cabin lights, the main in-flight entertainment system and passenger cabin power, and land at the nearest suitable airport.

### *1.13.3 Location of Fire Extinguishers*

A single cockpit fire extinguisher is mounted in a cabinet behind the captain's seat, along with a crash axe and gloves. At this location, the fire extinguisher was out of the reach of a seated first officer. Air France policy is that at least one pilot be seated at the controls with the restraining belts fastened during flight.

## *1.14 Survival Aspects*

No airstair or other passenger-handling equipment is available at Churchill. The policy of Transport Canada is that passenger-handling equipment is to be provided by airline companies using the aerodrome, based on market need. The aircraft's emergency slides are designed to evacuate passengers rapidly in an emergency. They are not designed for normal egress, and their use may result in passenger injury.

# 2.0 Analysis

## 2.1 Warnings and Alerts

The EQPT COOLING OVRD and the WINDOW HEAT L FWD INOP warnings appeared in the cockpit at 1503, approximately 1 minute and 15 seconds after the start of the fire and 10 to 15 minutes after the onset of an odour in the back of the aircraft. The crew indicated that the alerts appeared in close succession to one another after the use of the fire extinguisher, with the WINDOW HEAT L FWD INOP appearing first. It is possible that the cool Halon 1211 streaming agent and the dynamic pressure of the gas hitting the wires and terminal block (especially if the terminal insert was loose due to the burning of the polysulphide filler/adhesive) could have caused a thermal shock causing the WHCU to detect a current interruption and turn on the warning. The fault detection functions built into the WHCU did not pick up the overheating at the J5 connector early on in the occurrence and gave no system protection or advance warning of a problem until after the fire began, nor is the system designed to do so. The fire extinguished when the electrical power to the system was interrupted and the polysulphide filler/adhesive was consumed.

The EQPT COOLING OVRD light appeared about 14 seconds after the crew's first use of the fire extinguisher. The use of the extinguisher likely produced enough condensed vapour (steam) and decomposition by-products, to cause the air that was being drawn from behind the flight deck forward instrument panel to activate the RSD, thereby turning on the light.

## 2.2 Manufacturing Issues

The soldering of the braid conductor from the anti-ice and anti-fog elements to the window terminal brass insert is a hand-operated process with no means of mechanically holding the braid before or after the soldering process. Good soldering practices for electrical connections require a physical connection such as clenching, followed by soldering to fill the spaces and provide low resistance. A clenched and soldered joint results in a stronger connection and reduces the likelihood of a cold-soldered joint. Solder has a relatively low melting point. Where high-current windshield de-icing circuits depend on solder alone for the physical security of the electrical connection, there is a risk of electrical arcing if the terminal screw connection overheats and the solder melts.

## 2.3 Window Failure

Due to the extent of the burn damage, it could not be determined whether the overheating of the J5 terminal occurred as a result of a manufacturing defect, such as a poor solder connection, or because of resistive heating caused by a loose terminal connector screw.

Debris was noted on the J5 connector and brass block mating surfaces, as well as on the threads inside the terminal block. The debris could be indicative of heated foreign material entering the contact area due to a gap provided by a loose connection. A tight connection would probably not allow the ingestion of foreign material during heating, unless the material was already present during assembly. Boeing issued an All-Operator Message (7240-93-1844), indicating that insufficient torque on the connector screw may lead to a loosening of the screw in service. As a number of other terminal screws on the aircraft were found undertorqued, the possibility of the J5 connector also being initially undertorqued is strong. As the connector loosens in service, the O ring protecting the mating surfaces, normally in compression, relaxes, effectively separating the mating surfaces and causing the electrical power to be transmitted through the terminal screw. Once large amounts of electrical current are directed through the terminal screw, overheating of the connection can occur.

The damage to the J5 connector probably occurred during the earlier 16 August 2002 occurrence. The connector cap melted at that time, but did not ignite, indicating a terminal temperature of between 132°C, the melting point, and 355°C, the ignition point. As the melting point of the solder is around 190°C, the most likely scenario is that the solder joint degraded as a result of resistive heating at an undertorqued terminal during this occurrence. The terminal connector was tightened as a remedial fix and silicone sealant was applied. The connector and its cap were ordered for the aircraft, but not installed on the aircraft because of the anomaly in the operator's stores inventory system, whereby parts that were reserved for a task were shown as unavailable in inventory. Re-tightening of the connector would have little effect on the integrity of the terminal because of the degraded soldered connection. As a reheating of the terminal occurred from the effects of a degraded soldered connection, the visual indications of heating would likely have been masked by the significantly higher melting temperature of the silicone sealant over that of the protective black cap. The effect of the masking would have been to prevent the early identification of the overheating by the flight crew.

The untempering of the glass is indicative of temperatures higher than those that would normally be associated with resistive heating. However, once the solder connection was compromised by resistive heating, electrical arcing would have occurred, resulting in temperatures sufficient to ignite the polysulphide filler/adhesive, untemper the glass, and produce the cracks.

## *2.4 Quality Control*

The August 2002 windshield heat terminal incident, which likely damaged the J5 connector involved in this occurrence, took place after the aircraft had been in service for about one month. An inspection of the other terminal connection screws, after this occurrence, showed that many were undertorqued. Because no maintenance action had been taken on the connectors, they were likely undertorqued on delivery of the aircraft to the operator, indicating that manufacturing quality control was inadequate in this area.

## *2.5 Recorders*

The CVR audio quality was sufficient to record the crew's conversations on individual audio channels. However, when incoming VHF transmissions were recorded at the same time as hot microphone sounds, the incoming transmissions overpowered the hot microphones and made them unintelligible. Amendments to the EUROCAE ED56a specifications were incorporated into the ED112 specification, which describes the requirement for compatible audio levels between the different audio streams.

## *2.6 Crew Response*

Although the initiation site of the fire was in a visual range directly in front of the captain, the first indications of an odour appeared in the cabin area of the aircraft due to the designed slight positive pressure in the flight deck and the effects of the cabin airflow. When made aware of the electrical odour, the captain left his seat to assess the severity of the situation. The first officer was alone in the cockpit when the fire broke out, and because of the location of the fire extinguisher, he was not in a position to reach the single cockpit fire extinguisher, or to fight the fire when it appeared. The intervention of the relief first officer in coming forward from the cabin to the cockpit and the assistance of the principal chief of cabin provided the timely resources required to suppress the fire while the first officer continued to fly the aircraft and initiate MAYDAY calls.

Although it is the operator's policy to keep the cockpit door locked in flight, the smell of smoke in the cabin necessitated a crew response, and the captain's response would have been slower had he stopped to close and lock the cockpit door. The opened door also allowed the quick intervention of the relief first officer and cabin crew to fight the fire. Had the door been locked, the first officer would have faced a more difficult situation.

The crew's coordination was effective and in accordance with the QRH in responding to the fire and organizing a safe diversion to an alternate destination. At the onset of the occurrence, the principal chief of cabin assisted the first officer and recalled the captain. The relief first officer responded from the cabin, without being called, to provide support to the first officer in the absence of the captain, and took action to extinguish the fire while the first officer flew the aircraft and initiated a response to the emergency. The captain returned shortly thereafter and carried on with the organization of the occurrence response, assisted by the first officer, who continued the flying duties, and the relief first officer, who provided support for the diversion and approach at Churchill.

## *2.7 Diversion Issues*

The emergency airfields supplement used by the first officer provided accurate, though limited, information regarding the Churchill runway for the initial decision to divert to Churchill.

The operator's airport and approach information was not as useful as it could have been. The diversion binder was difficult to open, the information was out-of-date, and it did not include all the approaches available at Churchill or the revisions to the ramp and taxiway information. The Churchill documents in the binder were no longer required to be carried on the aircraft, and were present only because they had not yet been removed from the binder. Because the documents were no longer required to be carried on board, there was a risk that the crew would not have had any Churchill airport or approach information other than the limited airport information in the emergency airports supplement. Although the FMC navigation database was not designed to include NDB approaches, the aircraft was equipped with ADF radios with which the crew can fly an NDB approach by manually tuning the CDUs and using the bearing pointers displayed on the NDB. The NDB approach was the only usable instrument flight rules approach available at the time of the flight's arrival. Because the weather was VMC, the crew did not have to use the more work-intensive, manual NDB procedure at a time of elevated mission stress. The crew was assisted during the approach by the prevailing VMC and the FMS ground mapping display capability.

## *2.8 Communication Issues*

External communications involving AFR062 were generally effective in that the crew members received and transmitted their emergency status and the information required to arrange the flight's diversion to Churchill. During the descent, the crew received all required airport information from Winnipeg ACC, except the status of the ILS. That information was not communicated initially, but when the crew received it from Churchill FSS, they reverted to a visual approach, which had no effect on the aircraft's operation. The Churchill FSS-to-aircraft communications were timely and effective.

## *2.9 Churchill Facilities*

The unserviceability of the Churchill ILS did not hamper the arrival, because the FMS was capable of ground mapping the aircraft's position based on GPS and ADIRS information, and because VMC prevailed. In more adverse weather conditions, the unserviceability would have made the approach more difficult; the FMS could not fly a coupled approach, as there were no NDB approaches in the database. An NDB approach could have been flown if necessary, but the crew would have had to fly the approach manually, and its higher approach minima would have reduced the chances of success.

Firefighting services provided by the Town of Churchill were of assistance to the flight, in that firefighters stood by during the flight's arrival and checked the aircraft after it had come to a stop, to assure the crew that no fire hazard existed.

The passenger-handling equipment at Churchill was not adequate to accommodate the flight, which necessitated the operation of the forward emergency slide to deplane the passengers. Although no passengers were injured during the deplaning, the slides were not designed for normal egress and passenger injury was a possibility.

# 3.0 Conclusions

## 3.1 Findings as to Causes and Contributing Factors

1. An electrical arc occurred at the J5 connector on the left front windshield leading to the ignition of the polysulphide filler/adhesive in the terminal block and the cracking of the windshield.

2. It is likely that an undertorqued terminal connector screw contributed to the overheating of the J5 terminal. The overheating of the terminal likely caused the solder at the J5 terminal brass insert to melt and the braided conductor to separate, resulting in the electrical arcing.

3. Repairs to address a prior overheating problem of the J5 connector on 16 August 2002 were deferred by Air France and remained as due at the time of the occurrence. A temporary repair was conducted on the terminal, using material that likely masked the reheating of the terminal, preventing early identification of the problem by crew members.

4. The aircraft was likely delivered by the manufacturer to the operator with a number of the window power terminal connector screws undertorqued.

## 3.2 Findings as to Risk

1. The hand-soldered braid connection on the brass block in the window terminal does not employ a means of mechanically holding the braid during assembly, creating the risk of producing a poor solder connection.

2. In high-current windshield de-icing circuits that depend on solder alone for the physical security of the electrical connection, there is a risk of electrical arcing if the terminal screw connection overheats and melts the solder.

3. The fault detection functions built into the window heat control unit (WHCU) did not pick up the overheating at the J5 connector; there was no system protection or advance warning to the crew of a system problem.

4. With both crew members seated, the single, hand-held, cockpit fire extinguisher would only be accessible by the captain; it was out of the reach of the first officer.

5. The size and volume of the single, hand-held, cockpit fire extinguisher was not sufficient to fully extinguish the fire; a second unit from the cabin was required.

6. Passenger handling equipment at Churchill was inadequate for the Boeing 777 aircraft type; the passengers were deplaned via an emergency slide.

7. The operator's diversion information binder was sealed so securely as to be difficult to use, and the information that it contained was incomplete and out of date. There was a risk that, had the documents been removed from the binder as intended, the crew would not have had any Churchill airport and approach information other than the limited airport information in the emergency airports supplement.

8. The crew's flight management system (FMS) approach data, containing only instrument landing system (ILS) information, was of limited assistance during the approach.

9. The operator's maintenance inventory system indicated an out-of-stock condition for a windshield heat terminal that was, in fact, in stock, which made the part unavailable for use in the repair required by a previous windshield occurrence.

## *3.3 Other Findings*

1. The cockpit voice recorder (CVR) recording on the occurrence aircraft was of poor quality when incoming radio transmissions at high audio levels masked the crew's hot microphone inputs. Prior to installation, there were variations in the pre-setting of the transceivers by the suppliers, which could have led to an imbalance in the radio channel levels on the occurrence CVR recording.

# 4.0 Safety Action

## 4.1 Action Taken

### 4.1.1 Boeing

Boeing has undertaken a program to redesign the window terminal block to eliminate the screw connection. The new window blocks were scheduled to be incorporated into Boeing 777 aircraft, Line Number 471 (delivery date February 2004). The new design incorporates a locking pin/socket, which will address issues concerning loose or cross-threaded screws and inset ferrules. All Boeing 747, 757, 767 and 777 windows delivered thereafter, either on new aeroplanes or as spares, will have the new terminals installed. Boeing intends to deliver spares in kit form with the new wire end terminals included. The operator will have to remove the existing wire end terminal and splice in the new one when replacing windows on existing aircraft. The intent is to eliminate concerns with arcing at the window power terminals.

Boeing released a Fleet Team Digest article to B757 operators in May 2003, discussing terminal arcing and overheating. The article detailed actions to incorporate re-designed terminals into the affected cockpit windows.

### 4.1.2 Air France

Air France issued several internal communiques to highlight and address issues raised during the incident. One internal communique, Flash Qualité B777, Issue 02–02, was issued to the Air France maintenance department. The communique highlighted the problems encountered with an overheated window terminal screw and reminded maintenance staff members of the importance of properly securing and torquing the window terminal screw(s), in accordance with the instructions contained in the aircraft maintenance manual.

A second communique, OA IV, was issued to the Air France 777 flight department, to provide clarity to flight crews on the intent of the un-annunciated Window Damage L, R, checklist and the annunciated Equipment Cooling Override checklist.

Air France completed a comprehensive internal investigation of this occurrence and provided a report to the TSB. The occurrence is used as a “lessons learned” case study during training.

### 4.1.3 European Organization for Civil Aviation Equipment

Amendments to the EUROCAE (European Organization for Civil Aviation Equipment) ED56a specifications (*Minimum Operational Performance Requirements for Cockpit Voice Recorder Systems*), were proposed in 2000 to ensure adequate cockpit voice recorder (CVR) installed performance. These amendments, which specified that the radio signals be pre-set to levels lower than the hot microphone levels, were incorporated into ED112 (*Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems*) and published in March 2003.

### *4.1.4 Aeronautical Radio Incorporated*

Aeronautical Radio Incorporated (ARINC) was chartered to coordinate radio communication standards and compliance with such standards. Major avionics manufacturers participate in the formation of, and comply with, ARINC standards. As a result of the Air France occurrence, the Bureau d'Enquêtes et d'Analyse (BEA) requested assistance from Airbus to conduct tests on the output levels of a number of different VHF transceivers. The tests indicated that the audio output levels of all the transceivers were above the specified nominal level. The audio output levels are pre-set by the suppliers prior to aircraft installation, as set out in ARINC Characteristic 716. Above nominal output levels of the VHF transceiver could exceed the microphone levels, with the result that crew speech is masked. Based on these results, Airbus forwarded a modification request to ARINC to refine Characteristic 716, concerning audio output specifications. Following industry consultation concerning the proposed changes, Supplement 11 to Characteristic 716 was adopted by ARINC and published in June 2003.

### *4.1.5 International Air Transport Association*

The International Air Transport Association has offered to supply passenger-handling equipment sufficient to accommodate the Boeing 777 aircraft type at the Churchill Airport, provided the airport is designated as being airport rescue and firefighting (ARFF) capable. The designation would allow flight planning for long-range aircraft to use the airport as a diversion alternate for emergency purposes. The Town of Churchill has offered the services of its fire department for use at the airport in case of aircraft emergencies. However, Transport Canada is unable to designate any ARFF category for Churchill, because it does not consider that the Town of Churchill fire department capability meets the minimum ARFF requirements.

### *4.1.6 Transport Canada*

Canadian Aviation Regulation 308 came into force in June 2002, requiring airports that met the specified criteria to provide Aircraft Emergency Intervention (AEI) service by June 2004. In May 2004, the Minister of Transport approved an extension to the implementation date until 31 December 2005. AEI service provides limited emergency capabilities but does not meet the International Civil Aviation Organization Category 4 ARFF requirements. Churchill Airport met the criteria for the provision of AEI service and has plans in place to satisfy the ARFF requirements.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 14 July 2004.*

*Visit the Transportation Safety Board's Web site (www.tsb.gc.ca) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.*

# *Appendix A – Windshield Terminals*

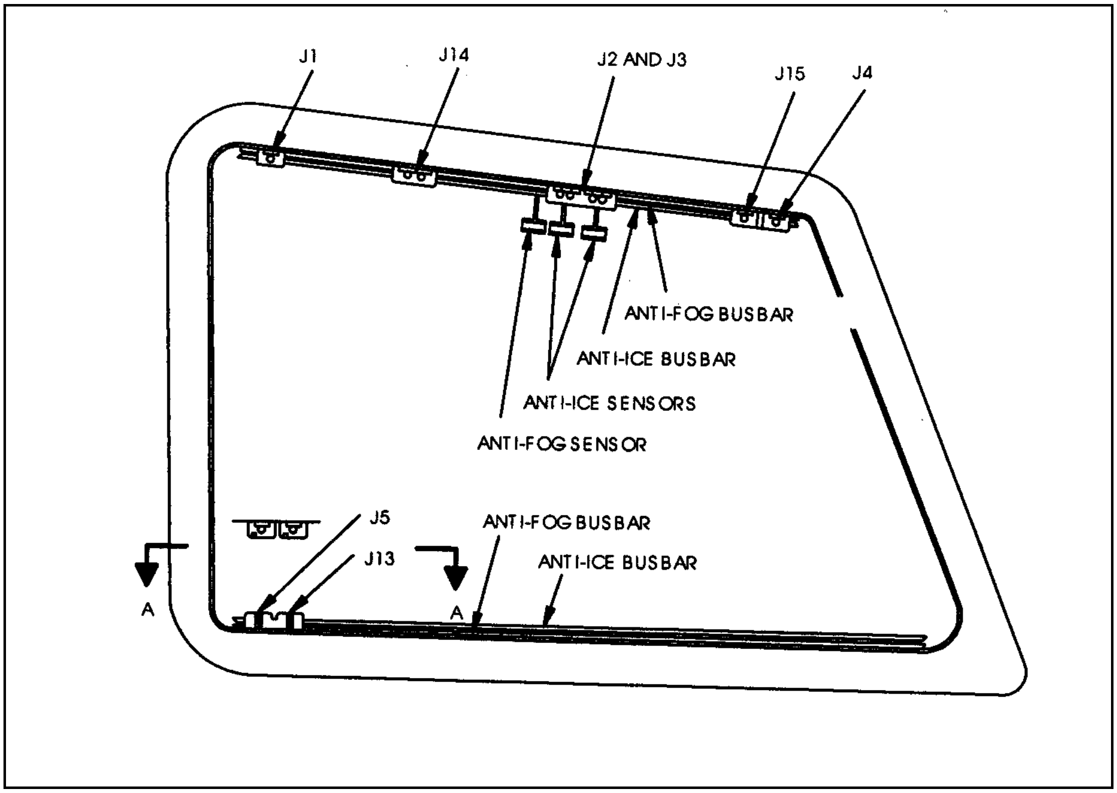
| *Windshield Location* | *Terminal Number* | *Terminal Type* | *Terminal Torque* | | |
|---|---|---|---|---|---|
| | | | *Target* | *Actual* | *Difference* |
| Left Fwd | J1 | Power | 25–30 in/lbs | See Note 1 | |
| | J4 | Power | 25–30 in/lbs | 8 in/lbs | -68% |
| | J5 | Power | 25–30 in/lbs | Burnt<br>See Note 2 | |
| | J13 | Power | 25–30 in/lbs | Burnt<br>See Note 2 | |
| | J15 | Power | 25–30 in/lbs | 12 in/lbs | -52% |
| | | | | | |
| Left Fwd | J2 A | Sensor | 12–15 in/lbs | 15 in/lbs | Good |
| | J2 B | Sensor | 12–15 in/lbs | 12 in/lbs | Good |
| | J3 A | Sensor | 12–15 in/lbs | 10 in/lbs | -17% |
| | J3 B | Sensor | 12–15 in/lbs | 15 in/lbs | Good |
| | J14 C | Sensor | 12–15 in/lbs | See Note 3 | |
| | J14 D | Sensor | 12–15 in/lbs | 5–10 in/lbs | -17 to -58% |
| | | | | | |
| Right Fwd | J1 | Power | 25–30 in/lbs | Loose | -100% |
| | J4 | Power | 25–30 in/lbs | Loose | -100% |
| | J5 | Power | 25–30 in/lbs | 8 in/lbs | -68% |
| | J13 | Power | 25–30 in/lbs | 8 in/lbs | -68% |
| | J15 | Power | 25–30 in/lbs | 5 in/lbs | -80% |
| | | | | | |
| Right Fwd | J2 A | Sensor | 12–15 in/lbs | 8 in/lbs | -33% |
| | J2 B | Sensor | 12–15 in/lbs | 5 in/lbs | -58% |
| | J3 A | Sensor | 12–15 in/lbs | 15 in/lbs | Good |
| | J3 B | Sensor | 12–15 in/lbs | 10 in/lbs | -17% |
| | J14 C | Sensor | 12–15 in/lbs | 15 in/lbs | Good |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | J14 D | Sensor | 12–15 in/lbs | 15 in/lbs | Good |

Note 1: The initial breaking torque on J1 was measured at 10 in/lbs. The terminal was re-tightened to 25 in/lbs and the breaking torque was again measured at 10 in/lbs. Other than terminal J14C, all other torque values were at tightening torque value, the torque it took to move the screw by tightening it.

Note 2: In order not to disturb the terminal prior to laboratory examination, the terminal torque was not checked, but determined to be at least finger tight. During the laboratory examination, the breaking torque was measured at less than 5 in/lbs.

Note 3: The initial breaking torque on J14C was measured at 2–5 in/lbs.




J1, J4, J1, J13, J15: Power Terminals
J2, J3, J14: Sensor Terminals
Note: J13 and J15 are Anti-Fog (back-up) Power Terminals

Note: Image taken from Air France AMM 56–11–01, page 27, revision 2002/05/05.

Torque values taken from Air France AMM 56–11–01, page 20, revision 2002/05/05.

# *Appendix B – Glossary*

| | |
|---|---|
| ACARS | aircraft communications addressing and reporting system |
| ACC | Area Control Centre |
| ADF | automatic direction finder |
| ADIRS | air data inertial reference system |
| AEI | Aircraft Emergency Intervention |
| AFR062 | Air France Flight 062 |
| AIRAC | Aeronautical Information Regulation and Control |
| AMM | aircraft maintenance manual |
| ARFF | airport rescue and firefighting |
| ARINC | Aeronautical Radio Incorporated |
| asl | above sea level |
| ATC | air traffic control |
| ATPL | Airline Transport Pilot Licence |
| BEA | Bureau d'Enquêtes et d'Analyse (France) |
| C | Celsius |
| CDU | central display unit |
| CMCF | central maintenance computing function |
| CVR | cockpit voice recorder |
| DME | distance measuring equipment |
| E&E | electrical and electronic |
| EICAS | engine-indicating and crew-alerting system |
| EQPT COOLING OVRD | Equipment Cooling Override |
| ETOPS | extended range twin-engine operations |
| EUROCAE | European Organization for Civil Aviation Equipment |
| FDR | flight data recorder |
| FL | flight level |
| FMC | flight management computers |
| FMS | flight management system |
| FSS | Flight Service Station |
| GPS | global positioning system |
| ILS | instrument landing system |
| in/lbs | inch pounds of torque |
| MHz | megahertz |
| NDB | non-directional beacon |
| nm | nautical miles |
| NOTAM | Notice to Airmen |
| QRH | Quick Reference Handbook |
| RSD | remote smoke detector |
| T | true |
| TSB | Transportation Safety Board of Canada |
| UTC | Coordinated Universal Time |
| WINDOW HEAT L FWD INOP | Window Heat Left Forward Inoperable |
| VMC | visual meteorological conditions |
| WHCU | window heat control unit |
| VHF | very high frequency |
| VOR | very high frequency omni-directional range |