



# National Transportation Safety Board

Washington, D.C. 20594

## Safety Recommendation

---

**Date:** March 30, 2006

**In reply refer to:** A-06-29 through -35

Honorable Marion C. Blakey  
Administrator  
Federal Aviation Administration  
Washington, D.C. 20591

---

On December 8, 2005, the pilots of Comair Bombardier Canadair Regional Jet (CRJ-200) flight 5029 declared an emergency while climbing through 23,000 feet from Cincinnati International Airport, Cincinnati, Ohio, after temporarily losing use of all electronic flight instrument system (EFIS) displays and smelling smoke in the cockpit. The crew used a battery-powered standby flight reference instrument to continue the flight until a backup source of electrical power was established, and the EFIS resumed operation. The flight landed safely at Port Columbus International Airport, Columbus, Ohio, and no injuries resulted.

Postincident inspection found that a fire had originated at the Ultem 2200<sup>1</sup> base terminal portion of the 1K4XD electrical contactor,<sup>2</sup> manufactured by Tyco Hartman, and spread throughout that portion of the avionics compartment. The contactor was located in the avionics compartment beneath the floor, slightly aft of the captain's seat, and beneath the wall separating the cockpit from the passenger cabin. The fire extensively damaged wire bundles for power supply and airplane systems, caused external damage to other electrical components, and blackened the supply line to the captain's oxygen mask. If the fire had penetrated the oxygen line or if there were leakage from this line, the fire could have been substantially worse.

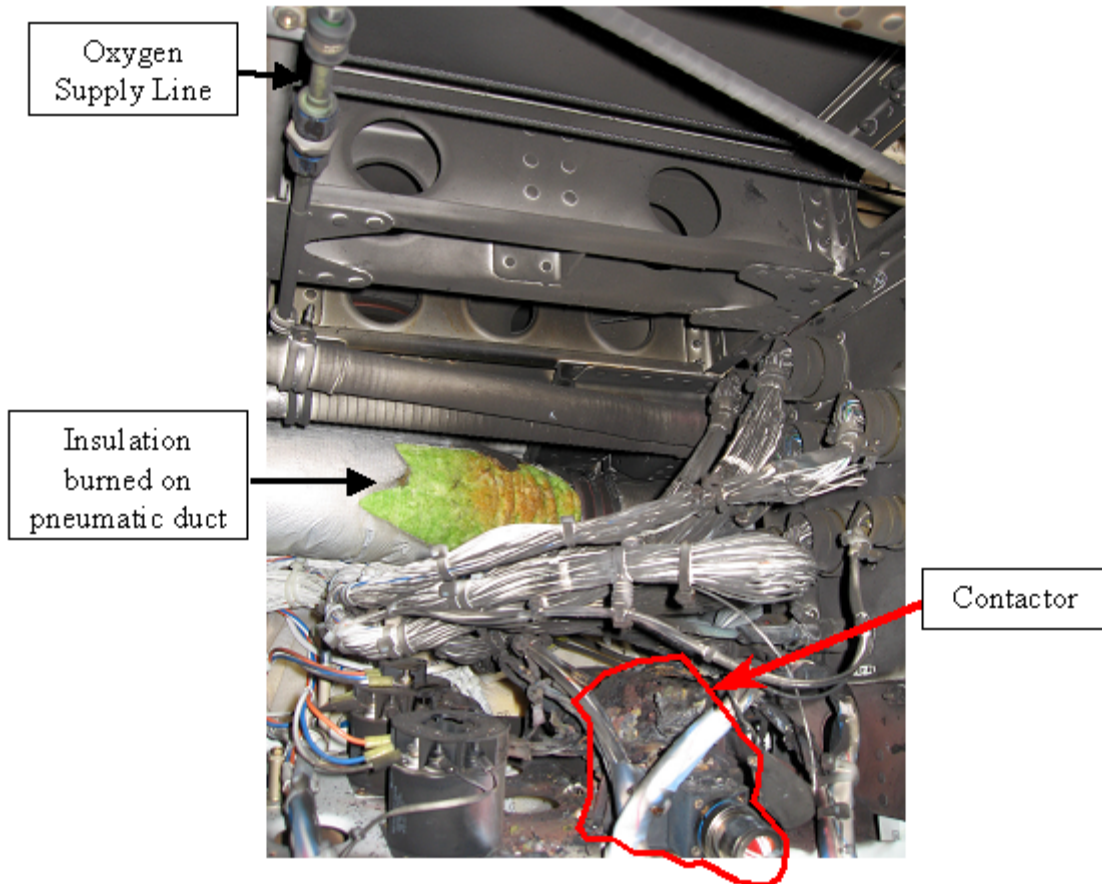
On December 14, 2005, the pilots of Atlantic Southeast Airlines (ASA) CRJ-200 flight 5029 declared an emergency while descending through 24,000 feet into Hartsfield-Jackson Atlanta International Airport, Atlanta, Georgia, when a fire broke out at the 1K4XD contactor in the avionics compartment (see figure 1). The cockpit voice recorder (CVR) transcript revealed that the flight crew was confronted with a cascade of failure events as electrical power from the left, and then right, generator was lost, the smell of electrical smoke entered the cockpit, all EFIS displays were temporarily lost, the cabin temperature temporarily became hot, and the air-driven

---

<sup>1</sup> Ultem 2200 is the tradename of a polyetherimide material manufactured by General Electric.

<sup>2</sup> Tyco Hartman identifies the part number as D-18ZZA and Bombardier refers to the part as the 1K4XD AC Utility Bus 1 contactor. The contactor is a switching device for three-phase AC electrical power generated by each of the two engine-mounted 30KVA electrical generators. The purpose of the contactor is to provide power to a utility bus, primarily during ground operation.

generator (ADG) deployed.<sup>3</sup> The crew only had use of the single standby flight reference instrument when the surrounding EFIS displays began to flicker. The CVR transcript indicated that the flight crew had difficulty prioritizing which checklists to use to respond to the numerous visual and aural alerts and warnings, and the flight crew did not completely follow any single checklist. Similar to the December 8 event, postincident inspection of the airplane found that the captain's oxygen supply line was blackened.



**Figure 1.** Burned area beneath the left forward cabin floor of the ASA CRJ-200.

These incidents represent two of the seven fires<sup>4</sup> that have occurred involving the Ultem 2200 surface of the 1K4XD contactors in CRJ-200 airplanes; six of the seven fires occurred in the last 6 months. The fires resulted in destruction of the contactor and, in most cases, a significant fire in the avionics compartment. Although these fires have not resulted in

<sup>3</sup> The ADG is an air-driven electrical generator located adjacent to the first officer's seat that deploys from a stowed position into the airstream. Deployment creates a loud bang, followed by a continuous loud buzzing or vibrating sound in the cockpit.

<sup>4</sup> Four fires, including the two described above, resulted in almost identical damage. Two fires resulted in significantly lesser damage to the contactor and area. The fire in one airplane was so localized that only the contactor was destroyed.

loss of life to date, the potential exists for an uncontained fire to compromise the oxygen line, which could develop into an even more critical situation. Further, four of the fires have resulted in at least temporary loss of all EFIS information, preventing the pilots from using their primary flight instruments and increasing their workload during an emergency situation.

On December 22, 2005, Bombardier issued All Operator Message 941 to notify operators that a minor wiring modification could provide separation of electrical power sources. This change was designed to mitigate failure effects of the 1K4XD contactors and allow continued operation of at least one pilot's EFIS should a failure occur. On February 24, 2006, Bombardier reported to National Transportation Safety Board investigators that most operators had not yet performed this modification. The Safety Board notes that although this change would not prevent contactor failures and possible fires, it would reduce the resulting pilot workload if a fire occurred. The Board also notes that all operator messages do not have the same level of authority as airworthiness directives issued by the Federal Aviation Administration (FAA), which are more effective in requiring operators to make safety-critical changes. Therefore, the Safety Board believes that the FAA should immediately require operators to provide separation of electrical power sources in CRJ-200 airplanes to prevent the potential loss of EFIS displays that may result from contactor failures.

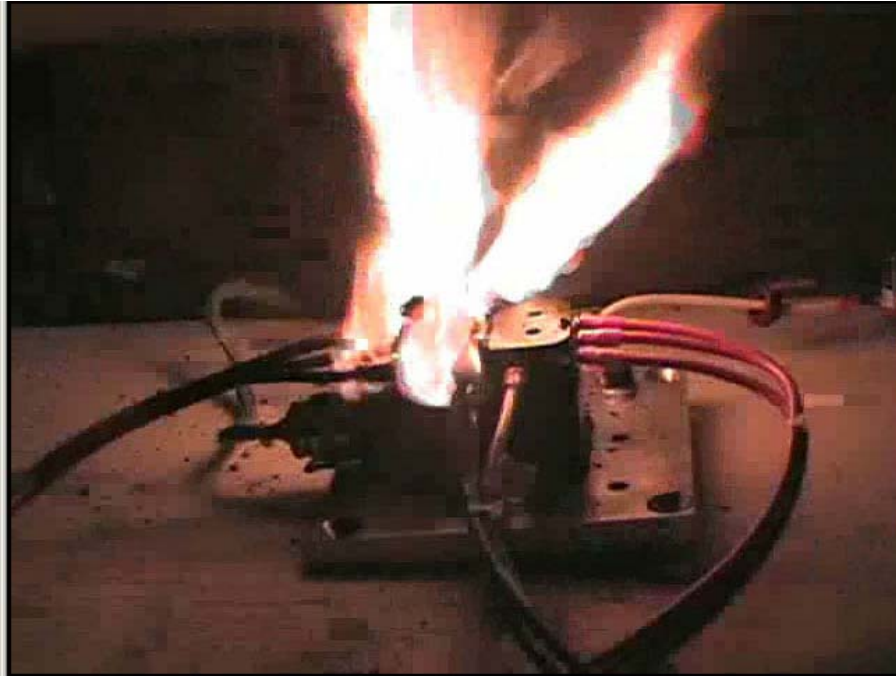
### **Contactor Failure Mode and Testing**

Safety Board investigators found the cause of the contactor failure and fires on CRJ-200s. The investigation noted that various forms of precipitation were present before the departure of each incident flight and that when the main cabin door is open on a CRJ-200, the forward cabin floor is exposed to the weather. Water on the floor can then seep into the avionics compartment below, where the 1K4XD contactor is located. Pulling the main entry door into the closed position may also result in water draining into the cabin area and subsequently into the avionics compartment.

Two versions of the 1K4XD contactors are approved to be installed on in-service CRJ-200 airplanes: the originally certified version, which uses NP509 woven glass fabric, melamine resin laminate (also known as G-9) as an insulator for the contactor's plastic base and a newer version (approved for use on March 16, 2000, by Tyco Hartman<sup>5</sup>), which uses the Ultem 2200 material. Safety Board investigators conducted tests at Tyco Hartman on both versions of the contactor in February 2006. The tests revealed that when drops of water were placed on the contactor that contained the Ultem 2200 material to bridge the electrical terminals, the Ultem 2200 material gradually turned to a carbon char for the duration of power application. After the water evaporated due to the short circuit, the carbon char provided a semiconductive path between terminals, and intense flames and arcing extended more than a foot from the contactor (see figure 2). The duration of the breakdown of the base material, short-circuiting, and fire lasted for more than 100 seconds in one test before a wire fell away, disconnecting the power supply. Similar tests on the contactor containing the melamine insulator material resulted in the water steaming off with no material breakdown and no fire.

---

<sup>5</sup> Tyco Hartman indicated that it stopped using the G-9 melamine material because it created manufacturing difficulties and because the release of fibers posed an environmental threat to manufacturing personnel.



**Figure 2.** Arcing and flames rising from the contactor base with the Ultem 2200 material after water bridged two electrical terminals. Continuous short-circuiting and fire, along with occasional arcs, such as shown above, lasted for 100 seconds in this test.

Electrical components can be protected from moisture-induced short circuits. The Safety Board has learned that similar contactors in some military airplanes have sealant applied to the electrical terminals, eliminating the potential for water to create short-circuit paths. One commercial airline has installed, on CRJ-200s, a piece of sheet metal above the avionic component adjacent to the 1K4XD contactor to redirect water flow from cabin floor leaks. Although permanent replacement of the Ultem 2200 material is the desired long-term action, immediate action is required to prevent water from reaching 1K4XD contactors with Ultem 2200 material and creating short circuits that may result in fire. Therefore, the Safety Board believes that the FAA should immediately require Bombardier to develop a means of protecting electrical terminals on Tyco Hartman 1K4XD contactors fitted with Ultem 2200 (polyetherimide) terminal bases from moisture-induced short circuits. Once Bombardier has developed a means to protect electrical terminals on Tyco Hartman 1K4XD contactors fitted with Ultem 2200 (polyetherimide) terminal bases from moisture-induced short circuits, the Safety Board believes that the FAA should require operators to install the protection as soon as possible.

### **Material Properties**

The Safety Board notes that although earlier CRJ-200 1K4XD contactors use G-9, 1K4XD contactors with Ultem 2200 currently can be used as replacement parts on any CRJ-200. Only CRJ-200 airplanes equipped with the Ultem 2200 contactors have experienced the type of in-flight fires discussed in this letter. Contactors that contain G-9 material were shown during testing not to be adversely affected when exposed to water. Although reducing the possibility of the contactors coming into contact with water and better isolating the electrical connections (as

previously recommended) will provide some degree of protection, the risk for moisture-induced short circuit and fire remains. These recommended actions, therefore, are considered only an interim solution until replacement contactors are installed. Accordingly, the Safety Board believes that the FAA should require Bombardier to expedite the replacement of 1K4XD contactors on CRJ-200s with contactors that are not susceptible to short circuit.

The Safety Board notes that operators of CRJ-200s have found that the proximity of the avionics compartment to the forward cabin door combined with the lack of a water-tight seal in the floor above this area make it likely that components underneath may occasionally be subjected to moisture. When Tyco Hartman changed the insulator material used on 1K4XD contactors, the company judged it to be interchangeable with the original material in form, fit, and function based on Bombardier-specified requirements for the contactor and did not notify Bombardier of the change. Further, Bombardier's design specification did not require that the contactor be capable of operating under full electrical load while exposed to moisture or that it be tested to demonstrate this capability.

The Safety Board is concerned that Bombardier's design requirements may not adequately represent the potential for exposure to fluids in the installed environment for electrical components or ensure that such exposure does not pose a safety hazard. Therefore, the Board believes that the FAA should require Bombardier to demonstrate the capability of electrical components to safely tolerate exposure to moisture or conductive fluids under full electrical load when such components may be inadvertently exposed to such conditions.

Further, despite the similarity of Ultem 2200 to aromatic polyimide electrical wire insulation,<sup>6</sup> Tyco Hartman was unaware of the arc-tracking susceptibility of Ultem 2200 when its use was specified in this electrical application. The Safety Board is concerned that other manufacturers may also be unaware of this characteristic of the Ultem 2200 material or materials with similar arc-tracking properties and that electrical components containing Ultem 2200 or similar material may be used on other airplanes in locations that are subject to fluid exposure. Further, airplane manufacturers may not be fully aware of the resulting fire risk. Therefore, the Safety Board believes that the FAA should require all airplane manufacturers to determine whether any electrical components on their aircraft are manufactured with Ultem 2200 or similar material with arc-tracking characteristics and require removal or protection of these components to prevent potential fires.

### **Flight Crew Information**

During the investigation of the two incidents discussed earlier, investigators found that the flight crew was presented with multiple visual and aural alerts and warnings and noticed the smell of smoke. However, it is unclear in the other four events that led to extensive fires in the avionics compartment whether or not such warnings were immediately accompanied by the smell of smoke. No fire or smoke detection system is in proximity to the subject contactors and the electrical system cautions or warnings may be the flight crew's only indication that a short-circuit-induced fire has begun. As a result, the Safety Board is concerned that flight crews may be unaware that in-flight electrical emergencies precipitated by arc-tracking failures of the

---

<sup>6</sup> Kapton is one example of this material, which is widely recognized as being susceptible to arc-tracking.

1K4XD contactor are accompanied by a fire hazard. The Board notes that in the ASA incident, the crew exhibited confusion over which checklists to use to address the multiple warnings. The Board also notes that it may take months to completely purge the CRJ-200 fleet of the subject contactors. Therefore, the Safety Board believes that the FAA should require Bombardier to immediately evaluate existing abnormal and emergency procedures for the CRJ-200 airplane to determine whether they adequately address the fire hazard presented by the failure of the 1K4XD contactor and provide flight crews with additional guidance as needed.

As has been discussed, the failure of 1K4XD Ultem 2200 contactors and ensuing fires are initiated by exposure to moisture. The Safety Board notes that on any given day, CRJ-200 airplanes may be operated in a variety of weather conditions that involve precipitation, providing an opportunity for the contactors to be exposed to moisture and the imminent possibility of another event. Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Immediately require operators to provide separation of electrical power sources in CRJ-200 airplanes to prevent the potential loss of electronic flight instrument system displays that may result from contactor failures. (A-06-29) Urgent

Immediately require Bombardier to develop a means of protecting electrical terminals on Tyco Hartman 1K4XD contactors fitted with Ultem 2200 (polyetherimide) terminal bases from moisture-induced short circuits. (A-06-30) Urgent

Once Bombardier has developed a means to protect electrical terminals on Tyco Hartman 1K4XD contactors fitted with Ultem 2200 (polyetherimide) terminal bases from moisture-induced short circuits, as recommended in Safety Recommendation A-06-30, require operators to install the protection as soon as possible. (A-06-31) Urgent

Require Bombardier to expedite the replacement of 1K4XD contactors on CRJ-200s with contactors that are not susceptible to short circuit. (A-06-32)

Require Bombardier to demonstrate the capability of electrical components to safely tolerate exposure to moisture or conductive fluids under full electrical load when such components may be inadvertently exposed to such conditions. (A-06-33)

Require all airplane manufacturers to determine whether any electrical components on their aircraft are manufactured with Ultem 2200 (polyetherimide) or similar material with arc-tracking characteristics and require removal or protection of these components to prevent potential fires. (A-06-34)

Require Bombardier to immediately evaluate existing abnormal and emergency procedures for the CRJ-200 airplane to determine whether they adequately address the fire hazard presented by the failure of the 1K4XD contactor and provide flight crews with additional guidance as needed. (A-06-35) Urgent

Acting Chairman ROSENKER and Members ENGLEMAN CONNERS, HERSMAN, and HIGGINS concurred with these recommendations.

*[Original Signed]*

By: Mark V. Rosenker  
Acting Chairman