AIRCRAFT ACCIDENT REPORT No 2/2009

This report was published on 16 April 2009 and is available on the AAIB Website www.aaib.gov.uk

REPORT ON THE ACCIDENT TO BOEING 777-222, N786UA AT LONDON HEATHROW AIRPORT ON 26 FEBRUARY 2007

Operator:	United Airlines Incorporated
Aircraft Type and Model:	Boeing 777-222
Registration:	N786UA
Location:	London (Heathrow) Airport, UK Latitude: N 051° 29' Longitude: W 000° 28'
Date and Time:	26 February 2007 at 1000 hrs All times in this report are UTC

Synopsis

The aircraft operator's duty manager at Heathrow notified the Air Accidents Investigation Branch (AAIB) of the accident at 1140 hrs on 26 February 2007 and the investigation commenced the next day. The AAIB investigation team comprised:

Mr K Conradi	(Investigator-in-Charge)
Mr N Dann	(Operations)
Mr S Hawkins	(Engineering)
Mr R James	(Flight Recorders)

A preliminary report on the initial findings from the accident was published in AAIB Special Bulletin S2-2007 on 17 April 2007. This formal report contains the final findings and Safety Recommendations from the investigation.

The accident occurred during engine start after pushback from the stand. After the right generator came online an electrical failure occurred in the right main bus. The failure resulted in severe internal arcing and short circuits inside the two main power contactors of the right main bus. The heat generated during the failure resulted in the contactor casings becoming compromised, causing molten metal droplets to fall down onto the insulation blankets below. The insulation blankets ignited and a fire spread underneath a floor panel to the opposite electrical panel (P205), causing heat and fire damage to structure, cooling ducts and wiring. The flight crew responded to the bus failure and a burning smell by shutting down the right engine and taxiing to a nearby stand. The Airfield Fire Service attended the aircraft when it arrived on stand and entered the Main Equipment Centre where they discovered significant smoke but no fire. The passengers were evacuated uneventfully via steps.

The investigation identified the following causal factors:

1. An internal failure of the Right Generator Circuit Breaker or Right Bus Tie Breaker contactor on the P200 power panel inside the Main Equipment Centre resulted in severe internal arcing and short-circuits which melted the contactor casings. The root cause of contactor failure could not be determined.

2. The open base of the P200 power panel allowed molten metal droplets from the failed contactors to drop down onto the insulation blankets and ignite them.

3. The aircraft's electrical protection system was not designed to detect and rapidly remove power from a contactor suffering from severe internal arcing and short-circuits.

4. The contactors had internal design features that probably contributed to the uncontained failures.

Five Safety Recommendations were made.

Findings

1. The aircraft was serviceable and there were no indications of any problems until the right Integrated Drive Generator (IDG) came online after engine start.

2. Within five seconds of the 'No Break Power Transfer', the Bus Power Control Unit (BPCU) detected a fault with the Right Generator Circuit Breaker (RGCB), a Right Main Bus under-voltage was detected, and an unusual 'growling' noise was heard by the flight crew which emanated from the region near the P200 power panel.

3. An 'ELEC AC BUS R' failure caution message appeared on the Engine Indication and Crew Alerting System (EICAS) and the flight crew carried out the checklist items for this message.

4. The RGCB and Right Bus Tie Breaker (RBTB) suffered from severe internal arcing and short circuits which generated temperatures in excess of 1,000°C, and resulted in uncontained failures. The RGCB was probably the first to fail.

5. Molten copper and silver droplets from the failed contactors dropped down through the open base of the P200 panel and ignited the insulation blankets below.

6. The insulation blanket fire spread underneath a floor panel to the opposite P205 power panel, causing heat and fire damage to structure, cooling ducts and wiring.

7. The Main Equipment Centre (MEC) smoke detector was triggered 42 seconds after the electrical failure event.

8. The detection of smoke in the MEC triggered the 'Equipment Cooling Override' mode and displayed a 'EQUIP COOLING OVRD' advisory message to the flight crew but no 'smoke' message.

9. The flight crew first became aware of the smoke four and a half minutes after the

failure event, when the tug driver noticed smoke emanating from one of the MEC vents and notified the flight crew via the interphone.

10. The flight crew decided to shut down the right engine and taxi to a nearby stand in order to evacuate the passengers using the steps.

11. The Airfield Fire Service attended the aircraft when it arrived on stand, entered the MEC and discovered significant smoke but no fire.

12. The insulation blankets had self-extinguished and tests revealed that the insulation had similar flame retardant properties to new insulation of the same type.

13. The RGCB and RBTB contactors had suffered such severe internal damage that it was not possible to determine the initiating point of failure or the root cause of failure.

14. A number of possible causes of contactor failure were considered, but there was insufficient evidence to select a most probable cause of failure.

15. The most likely causes of contactor failure included a debris induced short-circuit, a debris induced fouling of the armature, a loss of over-travel due to heat build-up, erosion and/or assembly errors, and arc tracking across the unprotected region of the stationary contact support block.

16. A number of modifications to the contactor design have been carried out that should make the contactor more resistant to failure and more resistant to an uncontained failure.

17. The electrical protection system was not designed to detect and rapidly remove power from a contactor suffering from severe internal arcing and short-circuits.

18. Since the accident a containment tray modification to the power panel has been developed which could have prevented the molten metal droplets from igniting the insulation blankets.

Safety Recommendations

The following Safety Recommendations have been made:

Safety Recommendation 2009-021

Boeing Commercial Airplanes should consider implementing differential current fault protection of main power contactors when designing future electrical systems.

Safety Recommendation 2009-022

The Federal Aviation Administration, in conjunction with the European Aviation Safety Agency, should consider mandating the replacement of ELM 827-1 contactors with ELM 827-3 contactors on all Boeing 777 aircraft, to reduce the risk of a contactor breakdown that results in uncontained hot debris.

Safety Recommendation 2009-023

Tyco Electronics Corporation should introduce mitigating action to reduce the risk of auxiliary contact

blade failure in ELM 827 and ELM 828 contactors, in order to prevent a broken blade from causing a short-circuit failure.

Safety Recommendation 2009-024

The Federal Aviation Administration, in conjunction with the European Aviation Safety Agency, should mandate that all Boeing 777 aircraft be equipped, at the earliest opportunity, with a software update that will generate a caution message to alert flight crew of the presence of smoke in the Main Equipment Centre.

The aircraft manufacturer responded to this Safety Recommendation by stating:

'Boeing is undertaking a review of system architecture, smoke detection, flight deck indications, and flight crew procedures across all of our production models to ensure a consistent approach to fireworthiness and flight crew indication, and identify safety enhancements that may be warranted. This work will include a review of the "SMOKE EQUIP COOLING" message for 777 passenger aircraft.'

Safety Recommendation 2009-025

The Federal Aviation Administration, in conjunction with the European Aviation Safety Agency, should mandate that all Boeing 777 aircraft be equipped, at the earliest opportunity, with a containment tray below the open base of the P100, P200 and P300 power panels, to prevent any hot debris from a failed contactor from falling on to insulation blankets or other components and causing heat and fire damage.