**Federal Department of the Environment,
Transport, Energy and Communication** **No. 1824**

Final Report by the Aircraft Accident Investigation Bureau

on the incident

of the aircraft Embraer EMB-145LU, HB-JAX
on 30 November 2002
at Zurich Airport

Bundeshaus Nord, CH-3003 Berne, Switzerland

Ursache

Der Vorfall wurde durch eine überhitzte Leiterplatte (PCB) in der *„Tuning back-up control head"* aufgrund eines kurzgeschlossenen Transistors verursacht.
Erschwerend bei der Abwicklung des Vorfalls wirkte sich das ungenügend funktionierende Sauerstoffmaskensystem aus.

Seither getroffene Massnahmen

Im Zusammenhang mit den Maskenproblemen hat das Flugbetriebsunternehmen die folgenden Massnahmen eingeleitet:

- Maskenscheiben mit verringerter Durchsicht:

  Das Problem wurde als Verschmutzung beim Herstellungsprozess lokalisiert. Die Masken wurden ausgetauscht und die Kontrollintervalle auf 400 Std. reduziert.

- Aussetzen der Maskenmikrofone:

  Das Problem wurde in einem Schalter lokalisiert. Dieser Schalter wurde durch eine Modifikation des Herstellers überbrückt (174250-SIL-2).

- Beibehalten des aufgeblasenen Zustands des Mask Harness:

  Das Problem wurde in einer Feder mit ungenügendem Federdruck lokalisiert. Die Feder wurde im Rahmen einer Modifikation durch den Hersteller ersetzt (SB 174690-35-1).

- Zu lange Zeit zum Aufsetzen der Maske:

  Dieses Problem ist bedingt durch die geringe Grösse des Aufbewahrungsbehälters und den Ort seiner Unterbringung. Durch regelmässiges Entnehmen der Masken nach dem letzten Flug des Tages wird die Besatzung im Umgang mit dieser Maske trainiert. Danach wird die Maske von geschultem Personal nach einem entsprechenden Verfahren wieder eingepackt.

Sicherheitsempfehlung Nr. 286

Das BFU empfiehlt dem Bundesamt für Zivilluftfahrt, eine Überprüfung des Sauerstoffmaskensystems einschliesslich der Mikrofone und der dazugehörenden Schalter, der Checklisten und der Positionierung und Grösse der Behälter zu veranlassen, dies unter Einbezug des Flugbetriebunternehmens, des Herstellers und der Bewilligungsbehörde.

Final report

This report has been prepared fort he single purpose of accident / incident prevention. The legal assessment of accident / incident causes and circumstances is no concern of the accident investigation (article 24 of the Air Navigation Law)

AIRCRAFT	Embraer EMB-145LU				HB-JAX
OPERATOR	Swiss International Air Lines				
OWNER	Swiss International Air Lines				

PILOTS	PIC:	New Zealand citizen, born 1967			
	COPI:	German citizen, born 1959			
LICENCES	ATPL (PIC) and CPL (COPI)				
FLIGHT EXPERIENCE	**Total**	5240	**In the previous 90 days**	115	
(PIC)	**On accident type**	633	**In the previous 90 days**	115	
FLIGHT EXPERIENCE	**Total**	1200	**In the previous 90 days**	146	
(COPI)	**On accident type**	831	**In the previous 90 days**	146	

PLACE	over RILAX		
COORDINATES	---	**ALTITUDE**	---
DATE AND TIME	30 November 2002, 18:30 UTC [1]		

TYPE OF FLIGHT	Commercial scheduled flight / CRX 759
PHASE OF FLIGHT	Holding and approach
TYPE OF INCIDENT	Strong electrical smell in cockpit

INJURIES TO PERSONS

	Crew	Passengers	Others
Fatal	---	---	---
Serious	---	---	---
Minor or none	4	21	

DAMAGE TO AIRCRAFT	---
OTHER DAMAGE	---

[1] All times are in UTC (LT= UTC + 1)

History of Flight

The crew had started their rotation of this day together at 13:55 and flew the following legs:

LX 1579 Vienna to Zurich

LX 758 Zurich to Luxemburg

LX 759 Luxembourg to Zurich (Incident Flight)

On the last leg of the day from Luxembourg to Zurich as LX 759, the flight departed Luxembourg at 17:47 with 21 Passengers on board.

The flight progressed normal along the planned route and reached the Swiss controlled airspace via RILAX at Flight level (FL) 150.

The copilot (COPI) was the flying Pilot (PF) and the commander (CDR) had the task of the pilot non flying (PNF).

The flight LX 759 entered the holding over RILAX. During the holding he was cleared down to FL 120.

At this time, both flight attendants (FA) were in the galley area when they realized an electrical smell.

FA 1 informed the flight crew about the smell, which had realized as well this smell. The cockpit door remained closed during this time.

After he had received this information, the CDR ordered the oxygen masks .

The COPI donned his mask within about 5 seconds without any problem. He did not smell the electrical smell any more after he had his mask applied. The supply of oxygen and the communication was working properly.

The CDR declared an emergency (MAYDAY, MAYDAY) and requested landing priority.

Air traffic control (ATC) immediately handled the flight LX 759 with priority and instructed the remaining traffic with vectors and holding instructions.

The CDR transferred the radio communication to the COPI and wanted to apply his oxygen mask as well. It took him about 15 seconds, because the removal of the mask out of the storage box was restricted. He could still realize the electrical smell after he had applied the mask.

ATC cleared the flight to FL 70 and advised the crew that they will land on runway 16 and about their distance to the runway.

At this time the communication via the intercom between the crewmembers was established and checked.

ATC recleared the flight down to 5000 ft QNH and later for the ILS approach to runway 16 advising them about the remaining track miles and offering more track miles if required. The flight crew confirmed that the track miles as stated would be sufficient.

During the approach the CDR informed the cabin about the intention to proceed for a rapid disembarkation once landed but to be prepared for an emergency evacuation.

During the approach after approximately 7 NM the flight crew experienced some intercom difficulties due to intermittend operation of the COPI mask microphone.

The CDR carried out the final check, but got no reply from the COPI. The COPI moved the oxygen mask and was able to reestablish communication.

ATC issued the landing clearance for runway 16 and instructed the flight to change to the frequency 118.10 after landing.

The landing was normal and during the landing run, the CDR asked the flight attendants if there was any sign of smoke or fire. FA 1 confirmed that the smell was still present in the forward galley area and FA 2 stated that there was no smell in the back of the aircraft.

The CDR decided that after leaving the runway they would stop the aircraft on the taxiway and carry out a rapid disembarkation.

After stopping the aircraft, the COPI went out to assist the passengers leaving the aircraft. The passengers left the aircraft without their hand carried baggage and were picked up by bus and brought to the terminal.

The aircraft was then towed to the hangar and electrical power was removed. The Cockpit voice recorder (CVR) and the Flight data recorder (FDR) as well as both oxygen masks were removed for investigation.

The source of the electrical smell was later located by maintenance in the tuning back up control head (TBCH).

Findings

- The crew held the required licenses.
- The aircraft was admitted to traffic.
- The aircraft HB- JAX had no story of earlier smell/ smoke incidents.
- The flight from Luxembourg to Zurich was without any unusual event until the entering of the RILAX holding.
- The crew was on the third leg of the rotation and a fourth leg from Zurich to Manchester was planned.
- The flight crew had flown together already four legs the day before.
- On the incident flight the COPI was PF and the CDR assisted as PNF.
- During the holding in RILAX both FA were in the forward galley area and realized the electrical smell.

- FA 1 informed the CDR via interphone about his observation. This communication was hardly readable for the flight crew, therefore the CDR had to ask back to understand. A problem with intercom/public address had happened before; on November 24, 2002 this is six days before the incident, a work order was opened (WO 1227141).

- The CDR and the COPI realized the electrical smell at the same moment and the CDR ordered the disposal of the oxygen masks on for the flight crew.

- The CDR declared an emergency using the standard phraseology “MAYDAY, MAYDAY, MAYDAY”.

- The COPI could apply his oxygen mask within about 5 seconds and established communication.

- The CDR had difficulties to remove the oxygen mask from its container and it took about 15 seconds until the mask was properly applied. The communication was established. Due to the hair styling, the mask was not properly fitting and therefore a small leak was remaining. Therefore the CDR noticed still a weak smell even with the mask applied.

- The source of electrical smell was located as the tuning back-up control head (TBCH) CD 850 P/N 7513000-835 S/N 01102103 (Fig. 1).

- The investigation of the burnt area showd, that the electrical smell was produced by the disintegration (burning process) of printed circuit board material and flex board material.

- Damage was found in three areas:

  - SMD resistors on the 7516359-910 power supply printed circuit board (PCB)

  - burnt flex print connecting the power supply circuit board with the multilayer main PC board

  - heat damage on the multilayer main PC board, were on the top side the resin is burnt away until the glass fiber layer (Fig. 2 & Fig. 3).

- Some copper tracks were melted away. The temperature necessary to melt copper is approximately 1100 °C. This composite material starts to disintegrate at temperatures of approximately 330 °C.

- Toxic gases are already emitted at temperatures of 330 °C. The area of heat damage is of minor size, so that the toxic fumes have not constituted a danger. Nevertheless the smell has been annoying.

- Analysis from the unit manufacturer stated the following: “The root cause of this failure was found to be the failure of the Q401 transistor. The Q401 transistor on the power printed circuit board (PCB) failed (random part failure) which in turn shorted the 28 VDC power to ground. This caused excessive current to flow through the 28 VDC traces on the power PCB. This excessive current caused the traces to burn along with R418 and the flex connector. The short circuit could have persisted for several seconds and resulted in the emission of smoke ...”.

- Both oxygen masks P/N 174690-93 Rev.D S/N 12763 (LH) and S/N 12767 (RH) were investigated and both had intermittend microphone failures caused by the internal reed switch, who should mute the microphone during the oxygen inhalation. Immediately after inhaling, the switch should make communication possible again.

- The reed switch in the RH oxygen mask during subsequent tests was operating intermittend because of the actuating lever was not moving freely all the time.

- The maintenance was of the opinion that the communication problem was due to an incorrect setting of the microphone selector.

- During the investigation some shortcomings on the labeling of the switches on the audiopanel for switching between mask and boom microphone were noticed.

Analysis

The electrical smell observed by the FA's and the flight crew originated from the burning PCB and flex board in the TBCH. This has resulted from a too high current flowing in the circuits due to a shortened transistor Q401.

The identification of the electrical smell by the crew was correct. There was no possibility of the crew in flight to further locate or isolate the source.

The communication between cabin- and cockpitcrew was adapted to the situation. Never the less the quality of the intercom was insufficient. This problem had been reported before on 24 November 2002 on WO 1227141. The trouble could not be reproduced on ground

The decision to declare an emergency was appropriate, as the situation was one of "smoke/smell" of unknown origin. The emergency/abnormal procedures ask in case of AIRCONDITIONING SMOKE; CABIN FIRE OR SMOKE or ELECTRICAL SYSTEM FIRE OR SMOKE always for the same item to be done as memory items. They are:

Crew Oxygen Masks	DON, 100%
Smoke Goggles	DON
Crew Communication	ESTABLISH
Recirculation Fan	OFF
Diversion	CONSIDER

The coordination between the crew members was appropriate and the passengers were informed in time about the intensions of the flight crew.

After the handover between COPI and CDR and back during the period of the donning of the oxygen masks, a communications check was done which confirmed the operation of the intercom. Therefore the statement of maintenance that the communication problem was due to an incorrect setting of the mask switch is not appropriate.

The communication problem between COPI and CDR was reproducible during the following tests of the masks on a different aircraft (HB-JAY).

Earlier incidents which necessitated the use of oxygen masks already showed similar problems.

The cause of incident is considered an isolated case. No other occurrence is known of burnt BUTU that would have caused electrical smell.

It is a fact that the use and disposal of oxygen masks in Embraer 145 aircraft is causing further stress and distraction due

- to a much to long time to remove the mask from its container
- to the intermittend operation of the microphone hindering the crew communication in a critical phase.

It therefore is imminent, that the type of mask microphone and the mechanical storage (size and location) should be examined with respect to their size and location.

The approval of the individual components is not sufficient, as the interaction of the components, location, procedure and test procedures have to be adapted as to give a completely working system.

Cause

The incident was caused by a overheated PCB in the tuning back up control head due to a shortened transistor.

Aggravating in the handling of the incident was the insufficient operation of the oxygen mask system.

Actions taken since

With respect to the problems with oxygen masks, the operator has taken the following actions:

- Glass with reduced opacity:

  The problem was localized as a contamination during the manufacturing process. The masks have been replaced and the interval of inspection has been reduced to 400 hrs.

- Intermittend operation of mask microphones:

  The problem was localized in the muting switch. This switch was bypassed by a modification of the manufacturer (174250-SIL-2).

- Maintaining the inflated condition of the mask harness after releasing the lever:

  The problem was localized in an insufficient pressure of a spring. This spring was replaced through a modification of the manufacturer (SB 174690-35-1).

- Too long time to don the mask:

  This problem is due to the small size of the storage container and the location, were he was installed. Through a regular donning of the mask after the last flight of the day, the crew is trained in the use of these masks. Thereafter the mask is repacked by specially trained maintenance personnel in accordance with the relevant procedure.

Safety Recommendation No. 286

The Swiss aircraft accident investigation bureau recommends to the federal office for civil aviation tol initiate a review of the oxygen mask system including the microphone and associated switching, checklists and container location and size together with the operator, manufacturer and certification authority.

Berne, 02 December 2004 Aircraft Accident Investigation Bureau

Annex 1

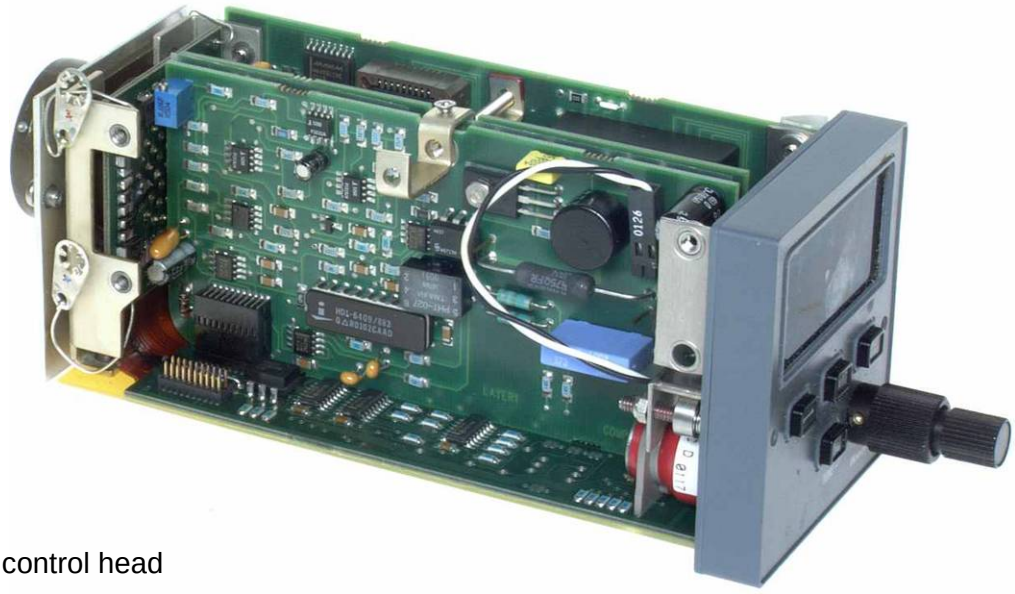

Fig.1

Tuning back up control head

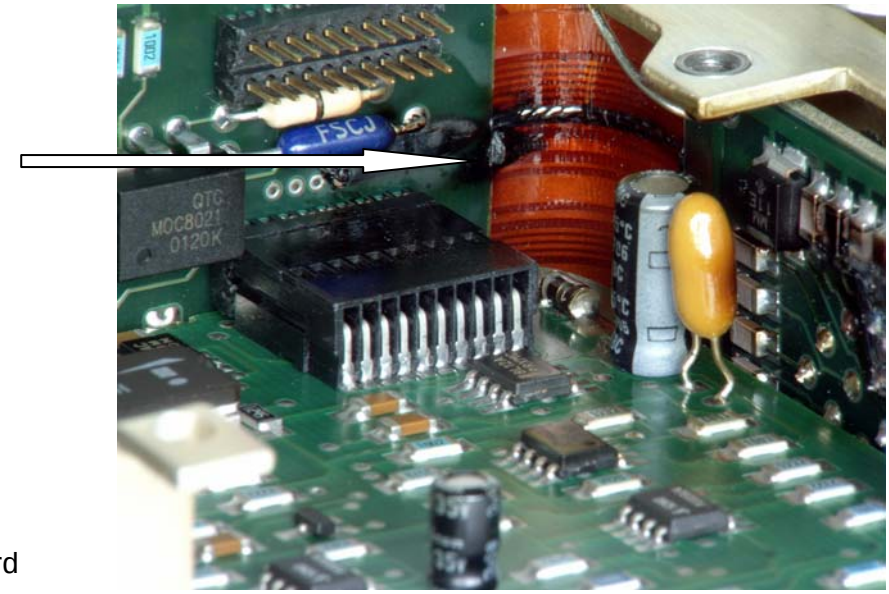

Fig.2

Damage on Flexboard

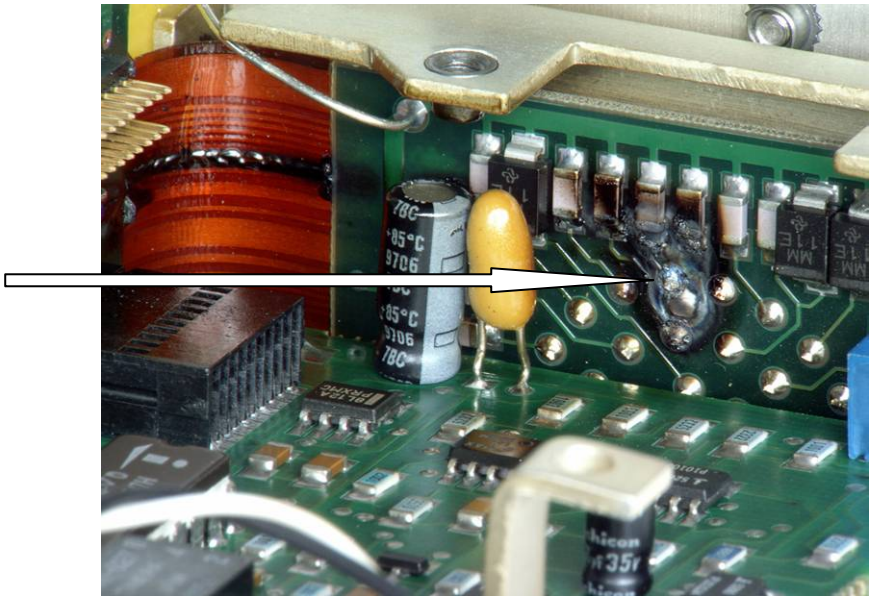

Fig.3

Damage on PCB