



SUMMARY OF EXAMINATIONS

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Aviation Accident Investigator
Central Region

NTSB Accident Number: CEN10IA535
Subject: Summary of NTSB IIC's Examinations

This is a summary of the incident site visit and several follow-up examinations by the NTSB investigator in charge (IIC) regarding the incident involving an Embraer EMB-500 (*Phenom 100*), N226CP, at the Brenham Municipal Airport (11R), Brenham, Texas, on the afternoon of Friday, September 10, 2010.

September 14 and 15, 2010 on-site visit at Brenham, Texas

Examination Observers:

Tom Latson	NTSB
Daniel Marimoto	Embraer Aircraft
Claret Rodrigues	Embraer Aircraft
Mike Fadok	Meggitt Aircraft Braking

An examination of the asphalt surface of runway 16 and found numerous tire marks in the touch down zone area, but the investigation team was not able to correlate any of those tire marks with the incident airplane. At a point just north of taxiway C, and about 1,900 feet from the landing threshold, there were skid marks which led to the final resting location of the incident airplane. The skid marks continued almost uninterrupted, roughly centered about on the runway center line, until a point about 3,000 feet from the landing threshold when the skid marks began to curve toward the east side of the runway, curving more steeply in the last 100 feet of movement. The skid marks on the runway led to ground scars in the grass where the incident airplane came to rest about 3,400 feet from the landing threshold. Measurements at the scene showed the left main gear came to rest in the dirt about two feet to the east of the edge of the runway, with the nose gear and the right main gear further away from the runway. Measurements of the ground scars showed that the airplane came to rest with the nose oriented on a heading of about 45 degrees magnetic.

When the investigation team arrived the incident airplane had been moved from the edge of the runway and it was examined on the paved ramp area in front of the airport terminal building. The right (R) main landing gear (MLG) tire was blown out. The R MLG gear strut was damaged and partially collapsed. The R wing was resting on an aircraft jack. The R MLG gear lock actuator was bent and partially separated. The R MLG gear door, lock actuator fitting, and right wing tip light lens were damaged. The R wing upper and lower skins were examined for obvious damage such as skin deformation, rivets pulled out, distortions, etc., and no damage was detected. The R flap and R aileron were not damaged.

The left (L) MLG tire was blown out but no other damage was observed. The L MLG assembly and L wing upper and lower skins were examined for obvious damage such as skin deformation, rivets pulled out, distortions, etc., and no damage was detected. The L flap and L aileron were not damaged.

The nose landing gear compartment and nose tire were examined for obvious damage such as skin deformation, rivets pulled out, distortions, etc., and no damage was detected.

The fuselage, empennage, vertical fin and tail surfaces were examined for obvious damage such as skin deformation, rivets pulled out, distortions, etc., and no damage was detected.

In the cockpit the Flap selector handle was found in the Flaps 0 position.

The IIC, after consultation with and concurrence from all members of the investigation team, then removed several components from the airplane and took possession of them for subsequent examination. Those components included the cockpit voice data recorder (CVDR); the brake control unit (BCU); emergency/parking brake valve; and the shut off valve (SOV). Also removed were the following matching components from both sides: two steel brake assemblies; two wheel speed transducers; two main brake pressure transducers; two brake control valves (BCV); two weight-on-wheels (WOW) proximity sensors; and two pedal position transducers.

The wreckage of the incident airplane, minus the removed components, was released to the owner for retrieval.

October 5 and 6, 2010 follow-up examinations at Akron, Ohio, at Circle Prime Manufacturing

Principal Examination Observers:

Tom Latson	NTSB
Daniel Marimoto	Embraer Aircraft
Oswaldo Barthel Monteiro	Embraer Aircraft
Jade Angerami	Embraer Aircraft
Dennis Ciccone	Meggitt Aircraft Braking
Kevin Kurko	Meggitt Aircraft Braking

Several other technically qualified persons from Embraer Aircraft, Meggitt Aircraft Braking, and Circle Prime Manufacturing were also present to assist.

The NTSB investigator-in-charge (IIC) opened the sealed box containing the brake control unit (BCU). The BCU was photo documented and connected to the manufacturer's test bench. On power up the unit displayed errors BRK Fail and Breaking CPU Fail. A Functional Test Instruction (FTI) was performed and the unit was opened and the flex print board was removed. The fault was isolated to the U205 area. The U205 op amp was replaced and the FTI was repeated. The error flags went away.

The IIC took physical custody of the removed U205 op amp and the investigation team concurred with plans to perform a component level failure analysis of the U205 op amp.

October 6 and 7, 2010, follow-up examinations at Akron, Ohio, at Meggitt Aircraft Braking

Principal Examination Observers:

Tom Latson	NTSB
Daniel Marimoto	Embraer Aircraft
Oswaldo Barthel Monteiro	Embraer Aircraft
Jade Angerami	Embraer Aircraft
Dennis Ciccone	Meggitt Aircraft Braking
Kevin Kurko	Meggitt Aircraft Braking

Several other technically qualified persons from Embraer Aircraft and Meggitt Aircraft Braking were also present to assist.

The left and right brake assemblies were individually installed on the manufacturer's test apparatus and were tested in accordance with the manufacturer's test data sheet with PASS results for both.

The left and right main brake pressure transducer were individually installed on the manufacturer's test apparatus and were tested in accordance with the manufacturer's test data sheet with ACCEPT results for both.

The shut off valve (SOV) was installed on the manufacturer's test apparatus and was tested in accordance with the manufacturer's test data sheet with an ACCEPT result.

The left and right wheel speed transducers were individually installed on the manufacturer's test apparatus and were tested in accordance with the manufacturer's test data sheet with ACCEPT results for both.

The left and wheel brake control valves (BCV) were individually installed on the manufacturer's test apparatus and were tested in accordance with the manufacturer's test data sheet with ACCEPT results for both.

October 13, 2010 follow-up examination at Spokane, Washington, at Hi-Rel Laboratories

Principal Examination Observers:

Tom Latson	NTSB
Kevin Kurko	Meggitt Aircraft Braking

The IIC had custody of the U205 op amp and physically brought the component for the examination. The op amp was identified by the part number 1013DM and was manufactured by Texas Instruments. A radiographic inspection was performed using a Fein Focus 160.24 Radiographic Inspection System. There was no evidence of damage or defects noted.

Electrical testing of the device was performed using a curve tracer and was cycled three times over a temperature range of minus 55 degrees C up to 70 degrees C. The device functioned normally with no defects noted.

Hi-Rel Laboratories reported on their report that based on their analysis it was not likely that the device tested was the cause of the malfunction of the application circuit (*the Brake Control Unit*).

December 15, 2010 follow-up examination at the Air Force Research Laboratory (AFRL) at Wright-Patterson Air Force Base, in Dayton, Ohio

Principal Examination Observers:

Tom Latson	NTSB
Steven Gerken	AFRL
David Johnson	AFRL
Steven Wead	FAA
Matthew Ford	FAA
Oswaldo Barthel Monteiro	Embraer Aircraft
Jade Angerami	Embraer Aircraft
Dennis Ciccone	Meggitt Aircraft Braking

Several other technically qualified persons from AFRL were also present to assist.

The suspect op amp, previously tested at Hi-Rel Laboratories, was again tested by AFRL using an oscilloscope and was determined to be functional.

The brake control unit (BCU) was photo documented, disassembled, and the rigid-flex wheel control assembly containing the replacement op amp was removed. The flexible board had been manufactured by Printed Circuits, Inc. (PCI). It consisted of three rigid 10-layer sections with layers 4 through 7 being a flexible board that connected the three sections.

The board was severed to isolate the three rigid sections and a computed tomography (CT) scan was performed on the section in the area around U205 which exhibited a registration error. Evaluation

revealed circumferential cracks in the copper barrel and solder layer in a via that led to an open circuit within the ground connection to a BCU op amp. The open circuit caused the BCU to fail eventually. Investigators concluded that registration errors of the annular rings between layers of a rigid-flex printed wiring assembly most likely caused the cracks in the vias. Investigators recommended locating and conducting radiography on printed wiring assemblies retrieved from the field to ensure registration errors do not exist in other fielded BCUs. They also recommended analysis of thermal expansion properties of rigid and flex portions of the printed wiring assembly to ensure compatibility.

February 18, 2011, letter from an independent third party review

The third party reviewer examined the coupons associated with BCU's FEB09-0061 and MAR09-0085 and confirmed several anomalies. The rigid-flex (flex print) boards associated with both BCU's were manufactured by Printed Circuits, Inc. (PCI), and came from production lot WC 070. Three boards were produced per panel and the third board from that panel was rejected during manufacturing by PCI. Therefore, all BCU's produced with boards from PCI's production lot WC 070 are now out of service.

Boards were also evaluated from PCI's production lots WC 074, WC 085, WC 091, WC 094, and WC 095. There were minor annular ring shifts that were within drawing specifications. There was a marginal misalignment of the flex layer to via interface that was within drawing specifications.

Boards were evaluated from PCI's production lots WC 055, WC 056, WC 064, WC 068, and WC 070. Some of the vias displayed solder mask and a lack of solder coating within the via. Identification of the solder mask did not affect via integrity or the annular ring misregistration, which met drawing requirements.

The independent third party review of a board manufactured by Colonial Circuits from BCU unit JAN09-0056 was conducted and noted an acceptable layer to layer annular ring misregistration which met drawing requirements. There were no manufacturer process or material anomalies identified within the micro section that could confirm the root cause of the failed unit JAN09-0056.

The independent third party took a new 90005225-1 flex print board manufactured by Cosmotronic and subjected it to thermal cycling and solder reflow. During continued examination at higher power, two minor anomalies were uncovered with a minor void in one of the metal runners exiting the via. A second anomaly was minor undercutting near one of the metal runner to via interfaces. The examination also identified a flex area that appeared to be delaminated. In conclusion the third party reviewer found good quality and workmanship in accordance with specifications and recommended that the minor anomalies should be discussed during a process audit at Cosmotronic. That process audit was completed.

November, 2010 follow-up examination at Liverpool, New York, at Tactair Fluid Controls, Inc.

Examination Observer:

Robert Fortune

FAA

The emergency parking brake valve was installed on the manufacturer's test apparatus and tested in accordance with the manufacturer's acceptance test procedure with ACCEPT test results.

December 7, 2010 follow-up examinations at Farmingdale, New York, at Curtiss Wright Integrated Sensing, Co.

Examination Observers:

John Harris

FAA

Gregg Behonick

FAA

Alejandro Serrano

FAA

The left and right pedal position transducers were individually installed on the manufacturer's test apparatus and were tested in accordance with the manufacturer's final inspection report with ACCEPT results for both.

The two weight-on-wheels (WOW) proximity sensors were not tested and were returned to the owner.