



BCA Aviation Safety & Equipment Quality Analysis

Collaborative Component Examinations

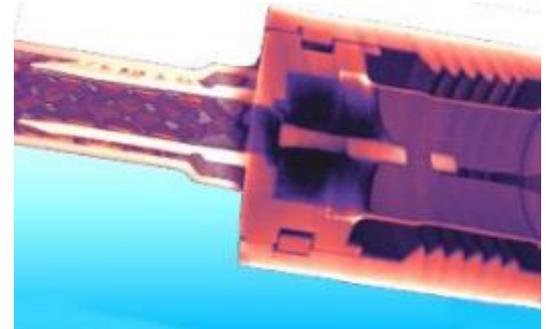
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Boeing Commercial Airplanes

ISASI 16
17 - 20 October 2016
Reykjavík, Iceland

Agenda

Collaborative Component Examinations

- Opening Thoughts
- Equipment Quality Analysis - Examination Processes and Procedures
- Case Studies
- Summary



Opening Thoughts

'Dance of the Unspoken'

The unspoken influences of examination participants can contribute to creation of a competitive or collaborative environment.



Training

Expertise

Experience

Temperament

Culture

Motivation

What is EQA at Boeing?

Boeing Equipment Quality Analysis

Who:

A group of highly professional technical analysts that provide failure and forensic analyses of:

Airplane components

Airplane systems

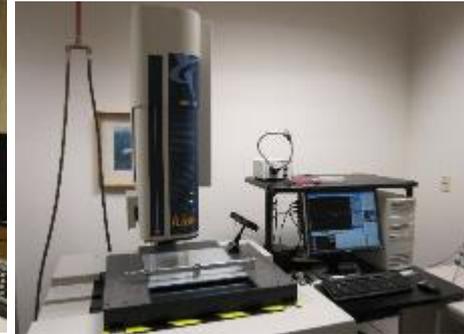
All Boeing models

Why:

To provide a **Safe** & **Reliable** product

Facilities and Equipment

Boeing Equipment Quality Analysis



Chain of Custody

Boeing Equipment Quality Analysis



Locked Room



Customers

Equipment Quality Analysis

- **57%** - Customer Airlines
Includes - Continued Operational Safety Program (COSP)
- **37%** - Boeing Manufacturing & Quality
Includes - Boeing Engineering and Suppliers
- **6%** - Boeing Air Safety Investigations (ASI)

Non-Investigation workload supports Pattern Recognition

Rules of Etiquette

Equipment Quality Analysis

1. If in doubt, always ask the investigator in charge.
2. Always respect the opinions of others. All ideas or suggestions are welcome.
3. Stay to plan but be flexible depending on progressive developments.
4. Any member has the right to put forth suggestions/ideas before the team.

Rules of Etiquette

Equipment Quality Analysis

5. At any time, any member of the team may request a halt or temporary delay in the examination/test to discuss any concerns, proposals, modifications or changes to the originally proposed examination/test prior to continuing with any phase of the analyses. When in doubt, pause and ask others.
6. Try to have only one conversation in the room at a time; avoid side discussions as much as possible.
7. Only the EQA team member will handle the parts under direction of the team to prevent too many people from handling the parts.
8. Testing, if possible, will proceed in the order of non-destructive, starting with the least invasive method to the disassembly analysis, as required.

COPA 737-200 - 06 June 1992

Case Study 1

Background:

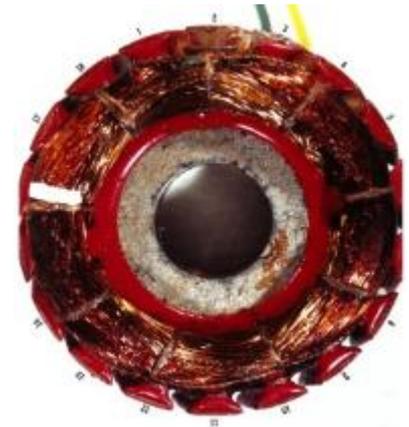
On a flight from Panama City, Panama to Cali, Colombia a 737-200 deviated around a storm and was turning back towards its planned track when all contact with the airplane was lost. The airplane crashed in dense jungle.

- 141 items for examination; reduced to 42
- Further reduced to 16
- Results of initial examinations turned focus onto 3 parts;

Selector panel (*both on VG1*)

Vertical gyro – roll synchro remnant

Standby horizon indicator



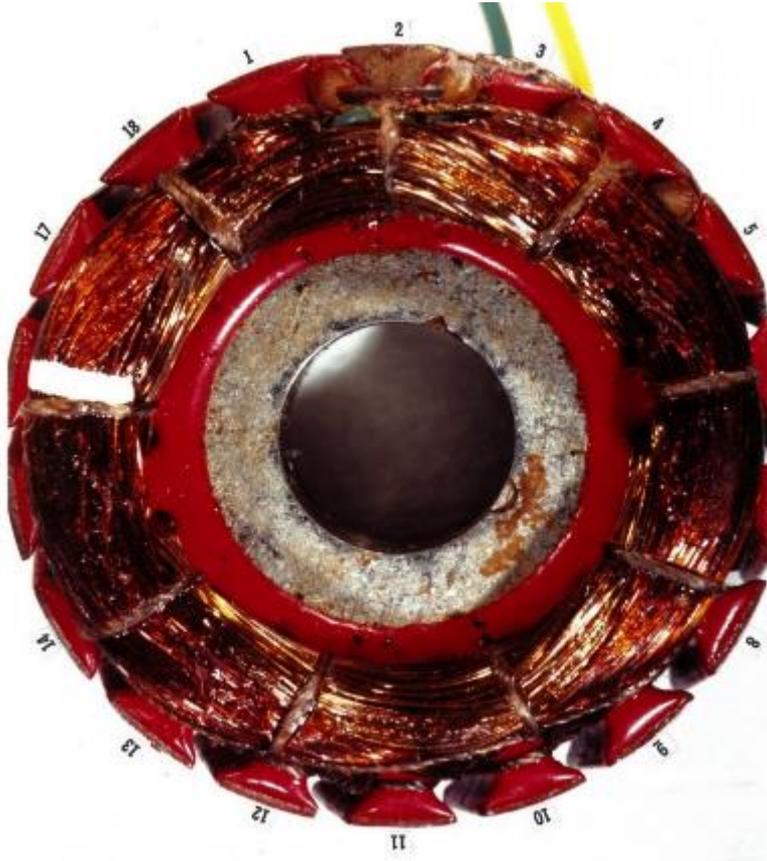
Evolution of an EQA investigation

COPA 737



Found in “BOTH ON VG-1”

COPA 737

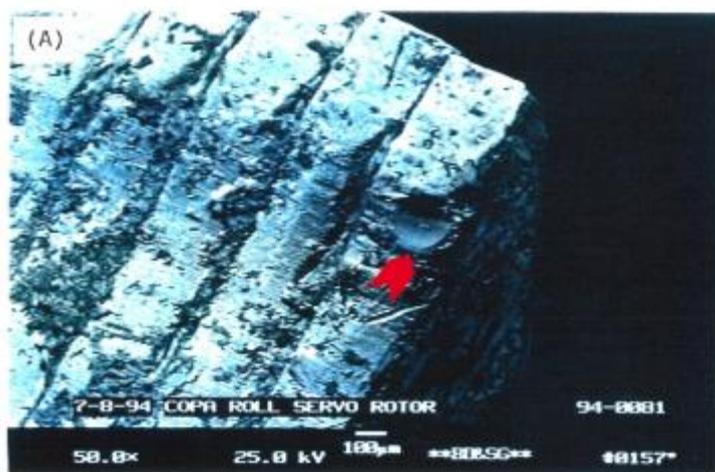
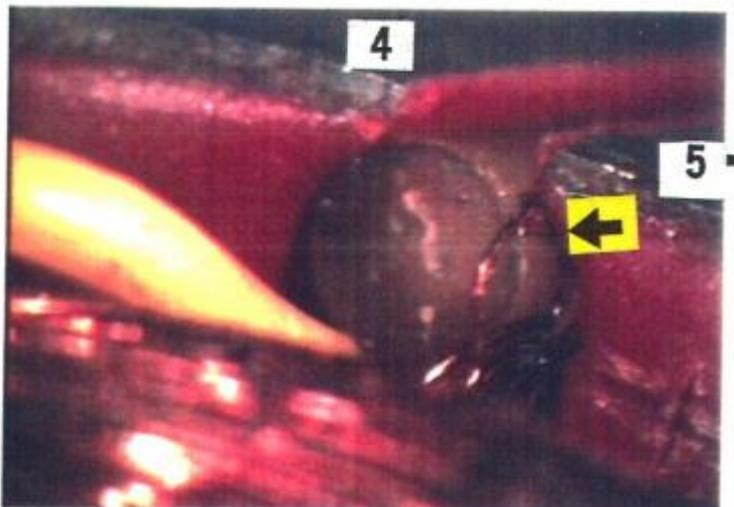
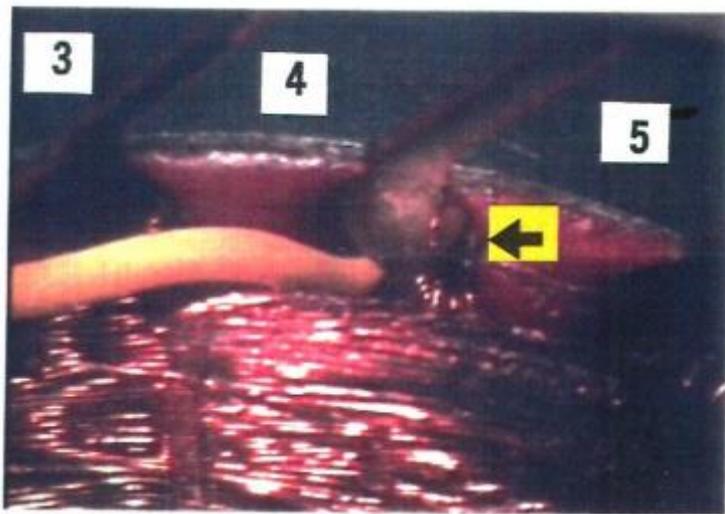


Vertical Gyro #1
Roll Synchro Rotor

EQA found:

- Broken wire in the selector panel (may have been overload from impact)
- Compromised winding in the rotor from VG1- resulting in intermittent short to ground manufacturing flaw

COPA 737



Case Study 1 Summary

COPA 737

The collaborative investigative process narrowed down the list of relevant components to be considered for examination.

Willingness of participants to take new suggestions into account such as the looking for shorts to core/ground on VG-1 instead of focusing on open circuit between lead wires found during initial continuity checks.

Experience of participants utilized to recognize patterns during physical examination to determine damage caused by manufacturing flaw and not impact.

737 Oxygen Mask Examination

Case Study 2

Background

- During pushback an oxygen fire erupted
- All passengers and crew safely evacuated
- Left side cockpit mostly destroyed by fire
- “Flame holder” traced to oxygen mask storage box
- Mask found outside storage box



Component Examination Focus

- Looking at possible oxygen leakage scenarios
- Mask selector supports one scenario
- When mask on “Emergency” oxygen flows when storage doors are opened

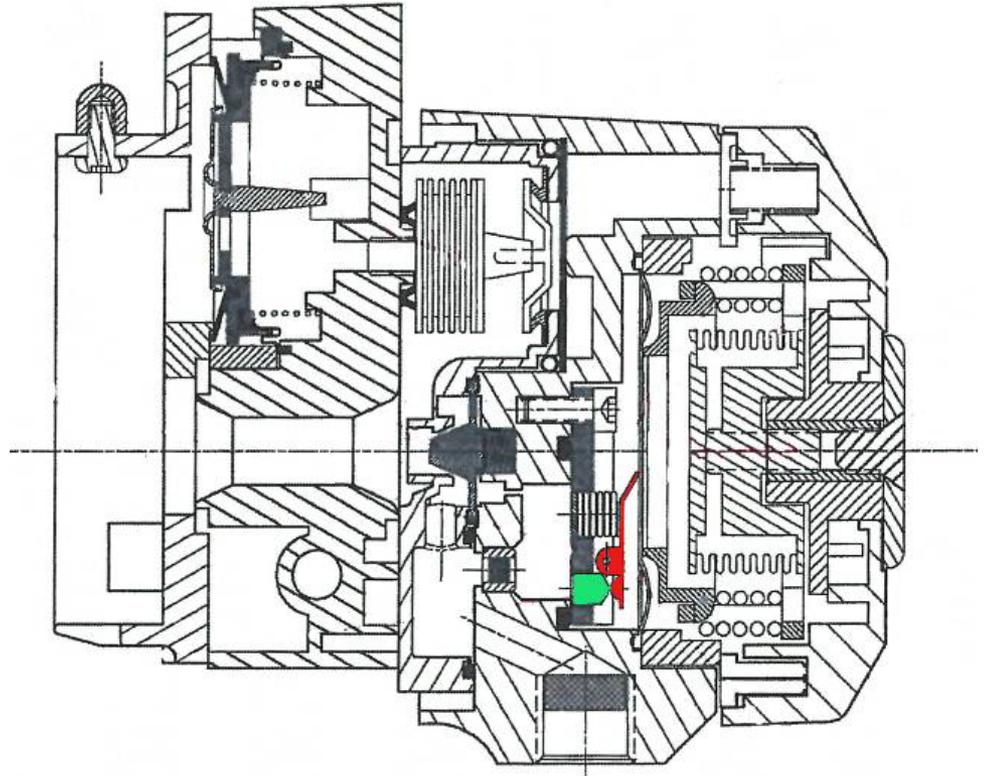
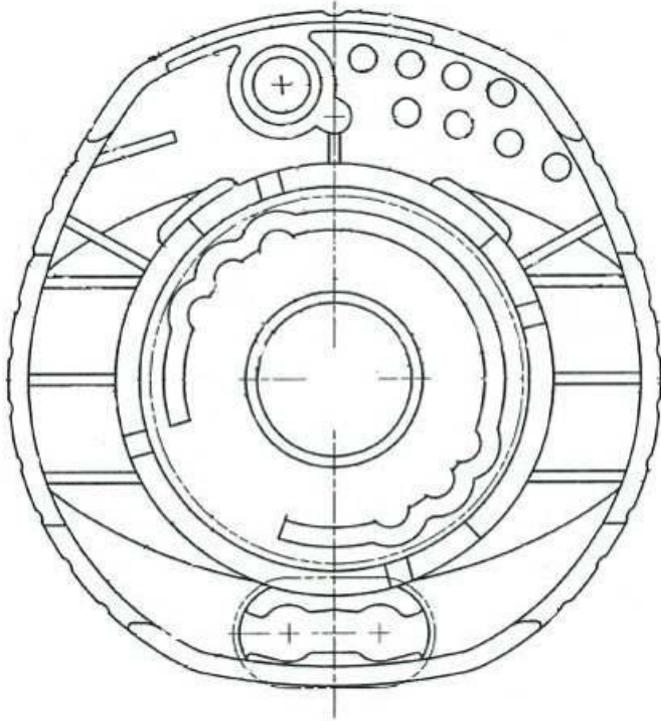
Evolution of an EQA investigation

Oxygen Mask Examination



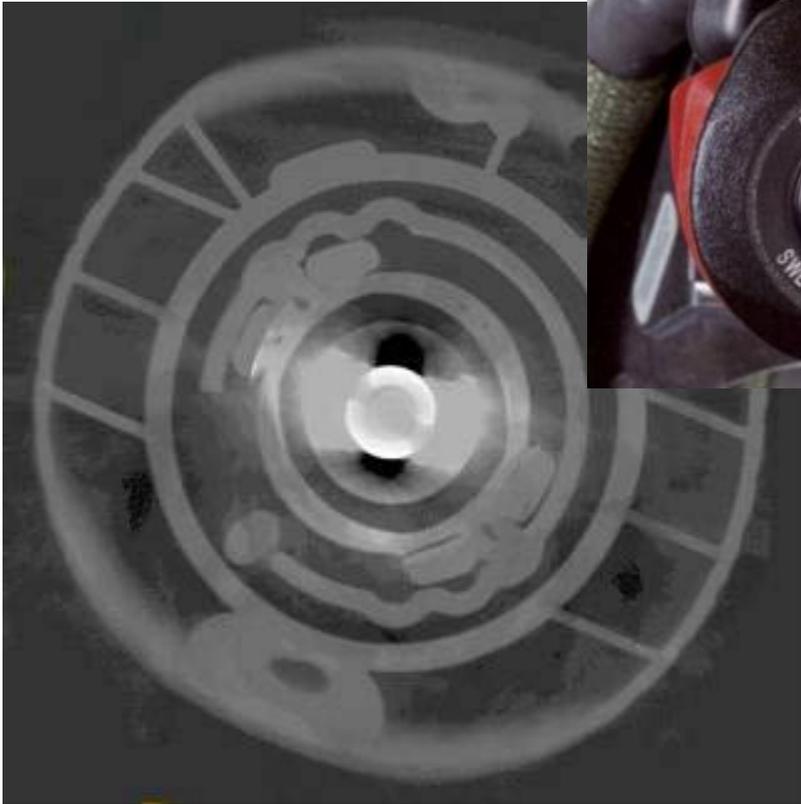
Drawing Review

Oxygen Mask Examination

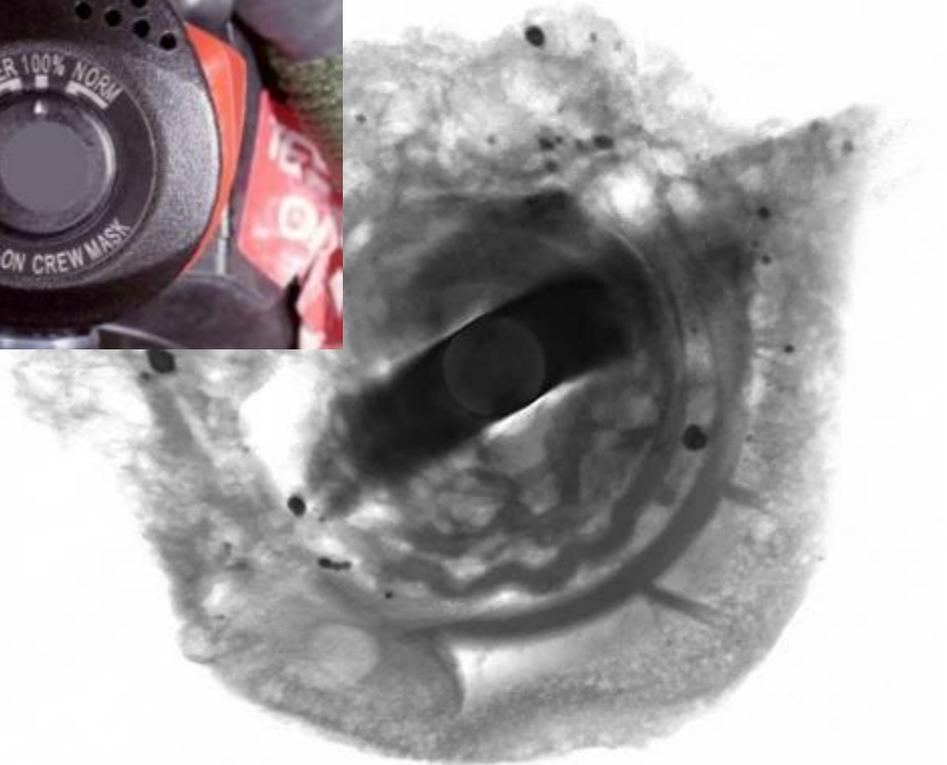


Comparative Analysis

Oxygen Mask Examination



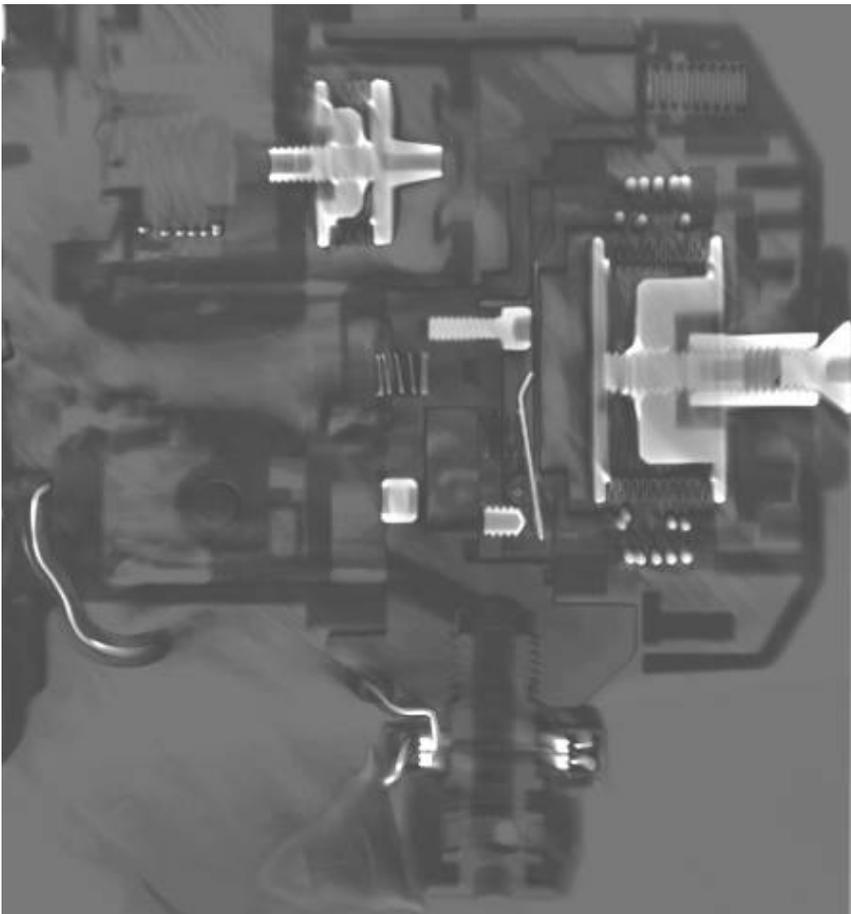
Exemplar



Event Mask

Comparative Analysis

Oxygen Mask Examination



Case Study 2 Summary

Oxygen Mask Examination

Chain of custody maintained with local investigative agency partnership.

Participation by component manufacturer aided in identifying key characteristics utilizing exemplar unit.

Ability to evaluate and perform iterative comparative analysis of internal component position using on site digital radiography (DR) and computed tomography (CT) technology and expertise.

Consensus was reached amongst participants that regulator was in “Emergency” position.

Contact Dendrite Growth

Case Study 3

Multiple similar microswitch failures were observed by supplier.

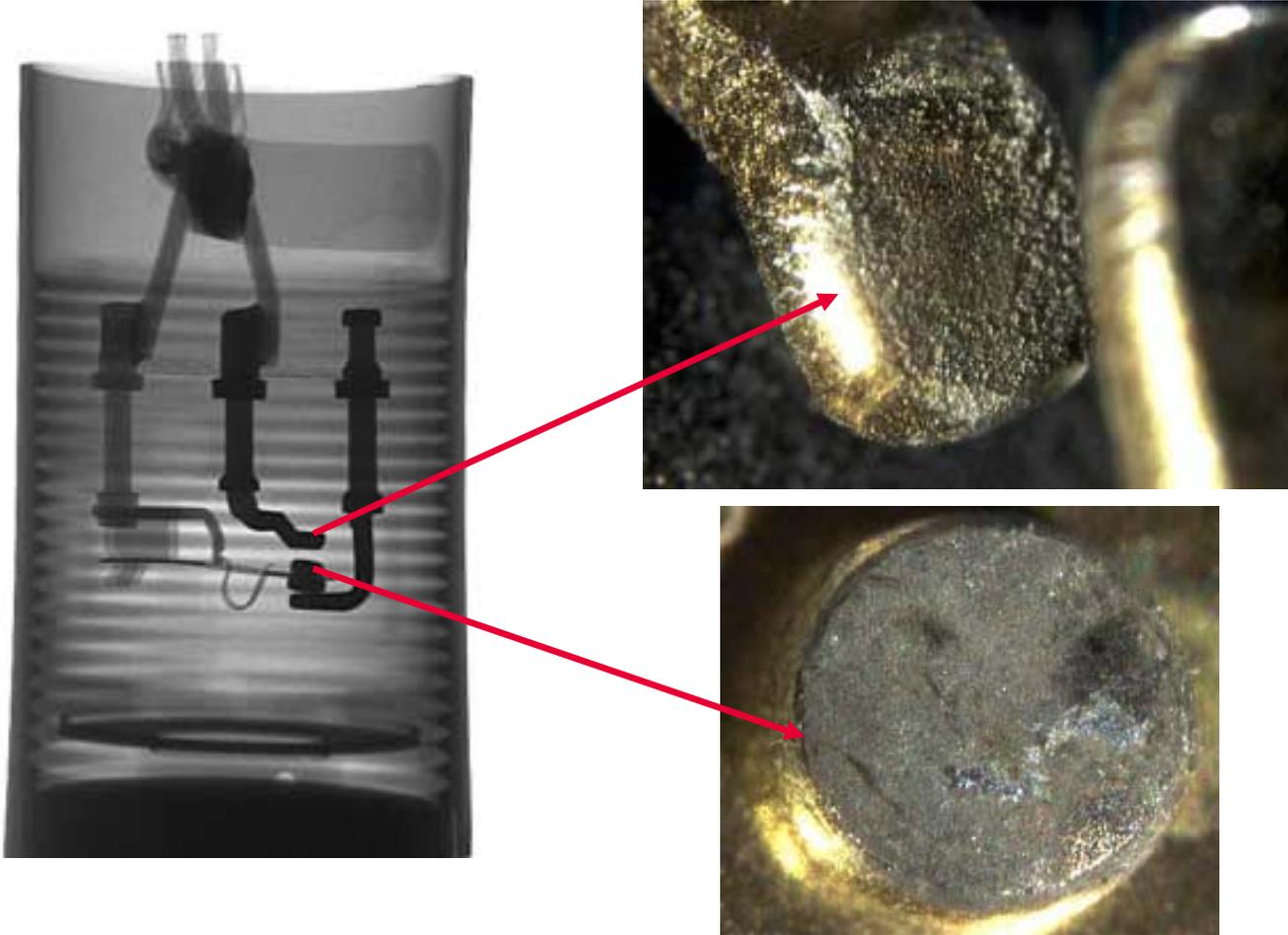
The circuit between normally open contacts internal to switch were determined to be shorted together by external examination of connector pins.

Boeing contacted supplier to assist in examination and root cause as part of quality management system corrective action process.



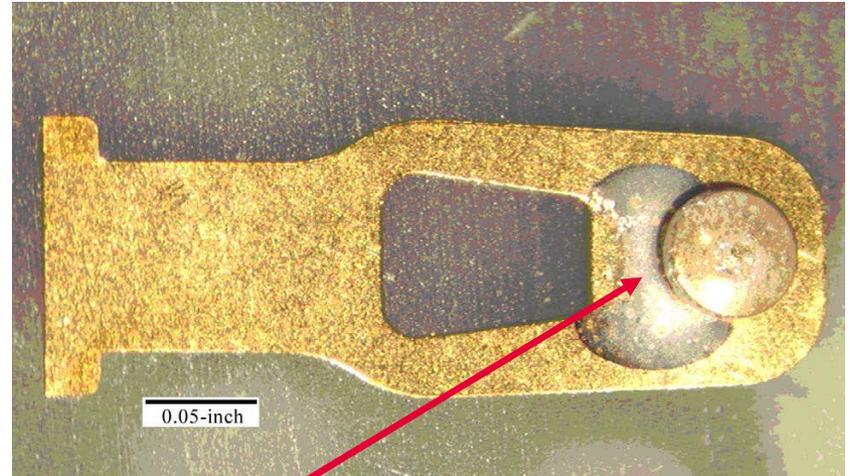
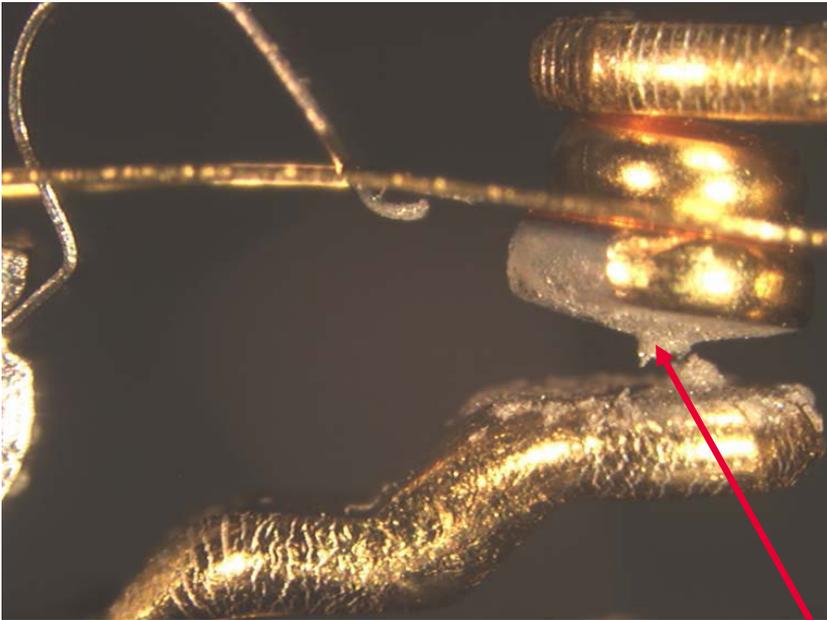
Digital Radiography Examination

Contact Dendrite Growth



Physical Examination

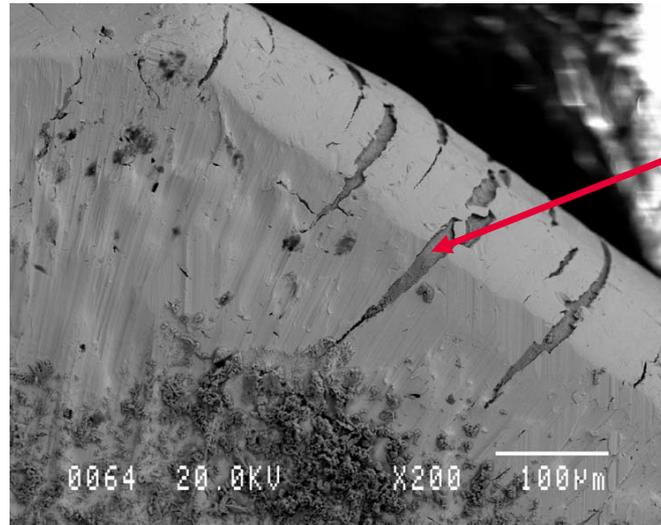
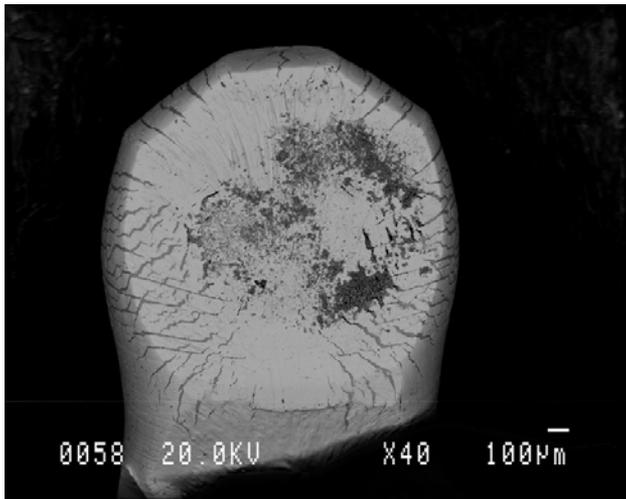
Contact Dendrite Growth



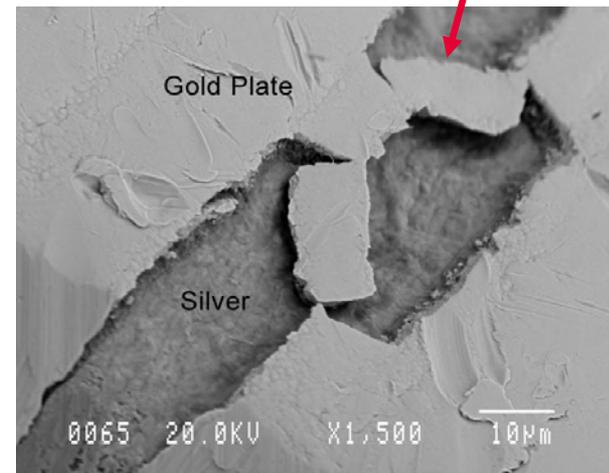
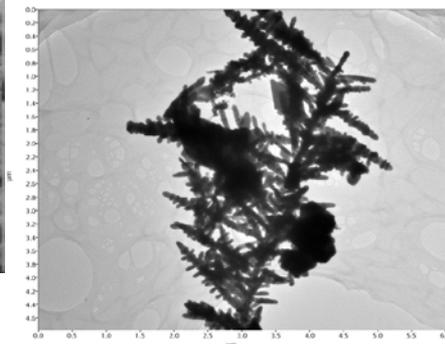
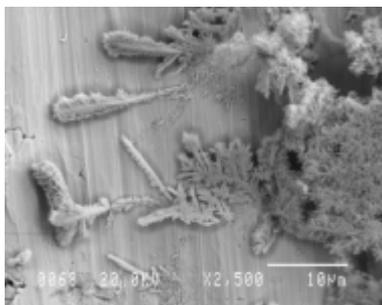
Silver crystalline material bridged normally open contacts completing the circuit

Microscopic Examination

Contact Dendrite Growth



Cracks in gold plating exposing silver substrate



Silver dendritic formations

Case Study 3 Summary

Contact Dendrite Growth

Professionalism and trust initiated internal discussion and examination activities.

Highly skilled resources and analytical capabilities were shared and leveraged to perform detailed analysis to fully characterize unusual contaminant.

Results were shared between parties to enhance product quality and reliability.

Observations

'Dance of the Unspoken'

The unspoken influences of examination participants can include:

- Training, experience, and abilities
- Expertise and competency in areas being examined
- Personal, professional, and political motivations
- Ability to remain impartial

Aspects of a Competitive Environment

- I win
- Logistical barriers and limited resources
- Information withheld, concealed, or selectively released
- Misconceptions of parties' interests in an examination
- Misuse of position, knowledge or power

Benefits of a Collaborative Environment

- Shared and expanded resources
- Open and transparent information disclosure and flow
- Keeping an open mind and building relationships, trust, and mutual respect amongst participants
- Processes used are agreed upon by participants while allowing some flexibility
- We all win

Successful Collaboration

The case studies reviewed show what can be accomplished in a collaborative environment when:

- Highly experienced resources and their capabilities are shared
- Trust, mutual respect, and openness reinforce consensus results and help build relationships amongst participants
- Important links within investigations are uncovered that enhance product safety and reliability