

ESS Vibration Failure of a COTS Power Supply

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Introduction

There are several advantages to integrating Commercial Off The Shelf ***"COTS"*** components and sub-assemblies into your product design:

- **COST SAVINGS-** *Volume cost per unit discount.*
- **PERFORMANCE-** *Leverage latest technology and process advancements.*
- **AVAILABILITY-** *Volume production, Multiple suppliers (components).*

Caveats related to COTS items:

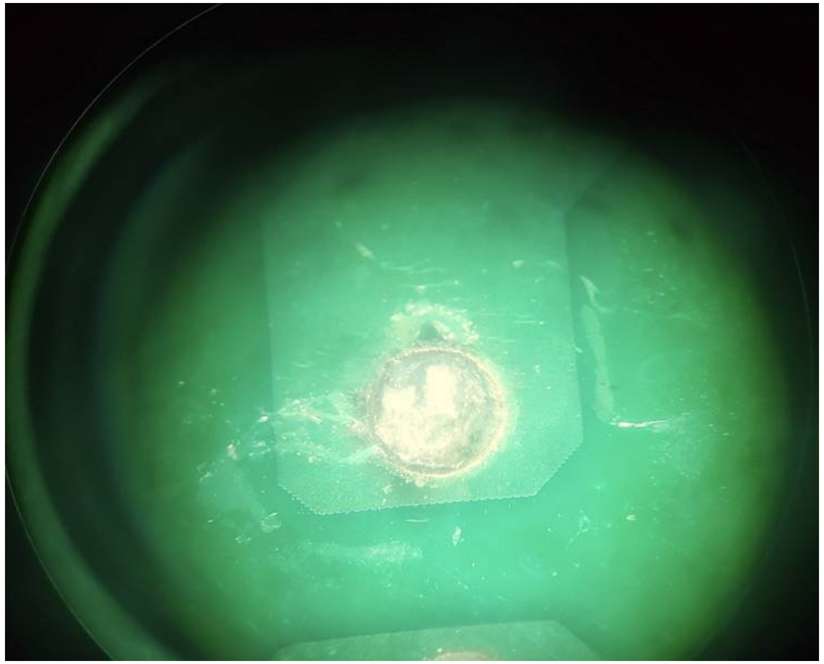
- ✓ **Environmental Limits-** Generally intended to operate in less extreme environments. (Temperature / Vibration / Shock / Humidity / Salt fog / Altitude)
- ✓ Short life cycles, can incorporate significant changes iteratively or new products with little or ***NO*** notice.
- ✓ Board / sub-assembly design ***Should Be*** tolerant to iterative or lifecycle component changes.
- ✓ Sub-assembly / System ***Should Not*** be tied to a qualified platform!

Qualified assemblies & systems >> *Associated with regulated devices and Military/DoD platforms*

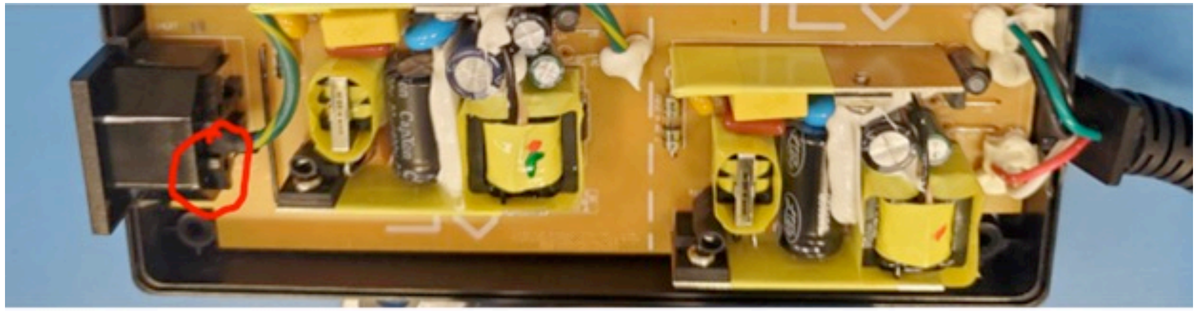
Failure Investigation- *COTS AC/DC Converter; 5 & 12V DC Output*

A switchable (120/240V) portable AC/DC power supply failed following transit case vibration qualification tests.
Preliminary assessments:

1. Portable supply functionally tested before and after testing.
2. No power output from 5VDC or 12VDC outputs, following qualification test.
3. Initial dis-assembly showed there was a failed solder joint on the AC Line connection to the PCB.

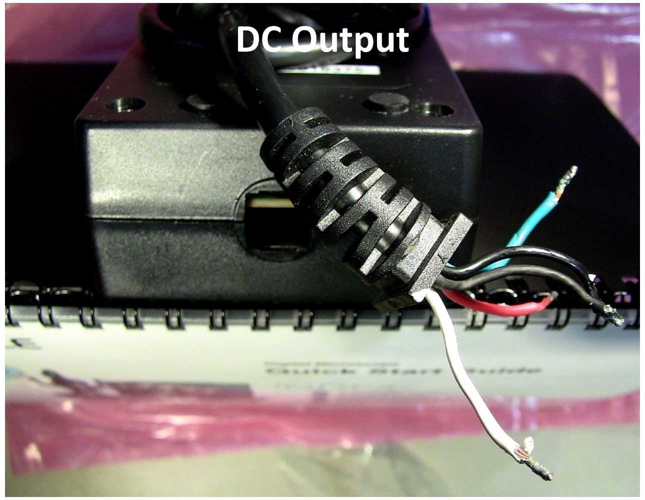


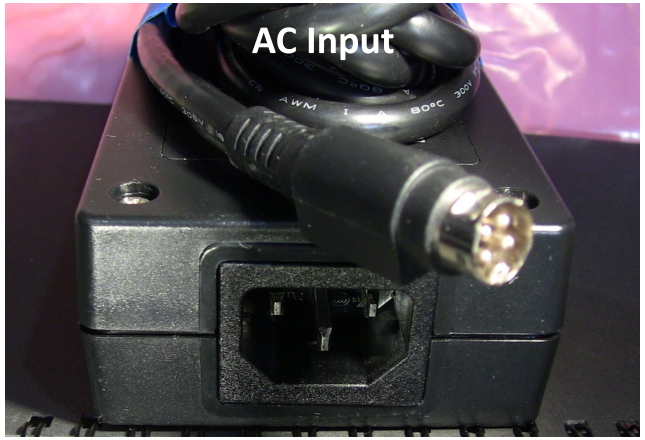
Request- Determine if failure was related to vibration testing



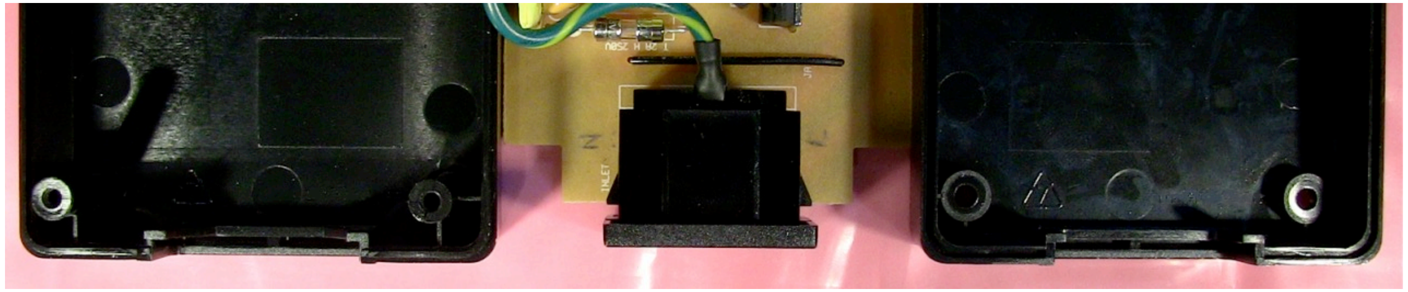
Images Owned by RTX Corporation

Power Supply- *Customer performed initial assessment*





AC/DC Converter as received



Top / Bottom Shell Opened- Issue noted with IEC-320 AC Socket

Serial Number includes embedded date code. Supply built in 2018, approximately ***6 years old***

Old Test asset had to be used *(prior use history!)* Legacy program- NO production units available

Power supply partially dis-assembled during initial assessment

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Power Supply- *CCA overall Top & Bottom, Design attributes*

Top Side- Power Supply

PCB-

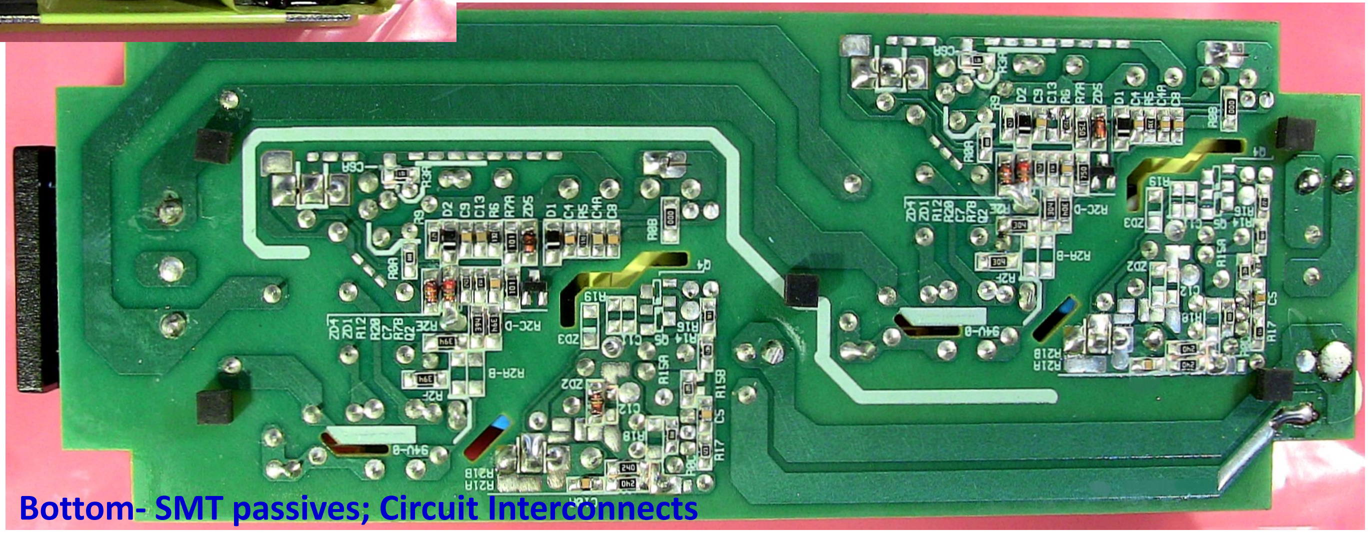
I. Rugged single layer design, no plated thru-holes
II. **Top-** power supply thru-hole components
III. Nickel plated thermal sinks, polyimide tape and RTV used to provide voltage Isolation & Shock/Vibration dampening!
IV. **Bottom-** Logic & Control SMT, connected to topside via leads and wires, solder mask & coatings used for electrical isolation

Designed for

Assembly

Cost

Shock / vibration- Mobile portable device environments, under benign temperatures (0° – 70°C)


Bottom- SMT passives; Circuit Interconnects

Power Pack PCB / Enclosure is ruggedized!

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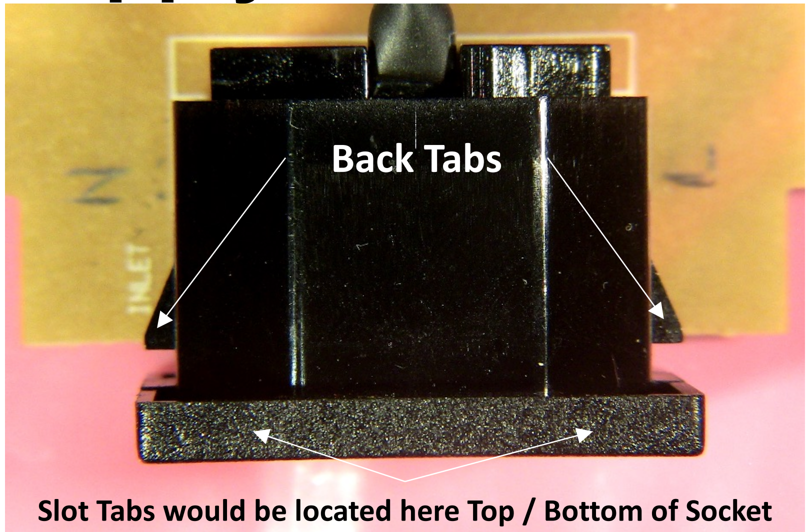
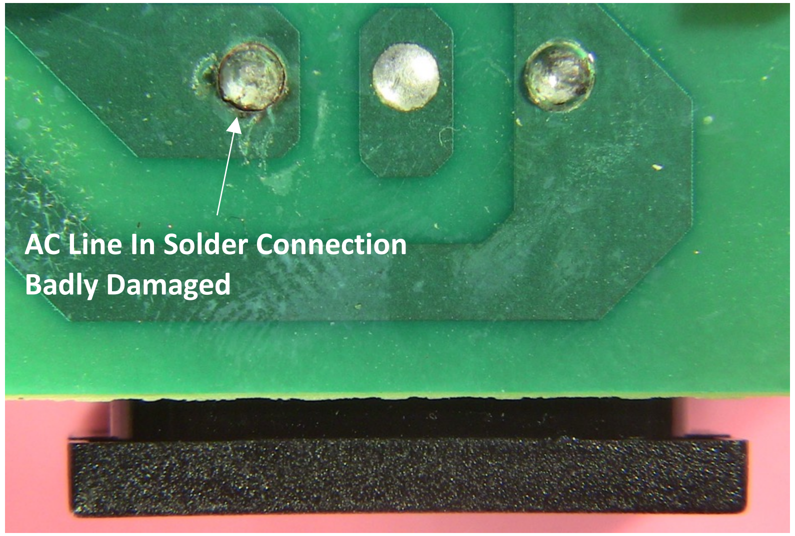
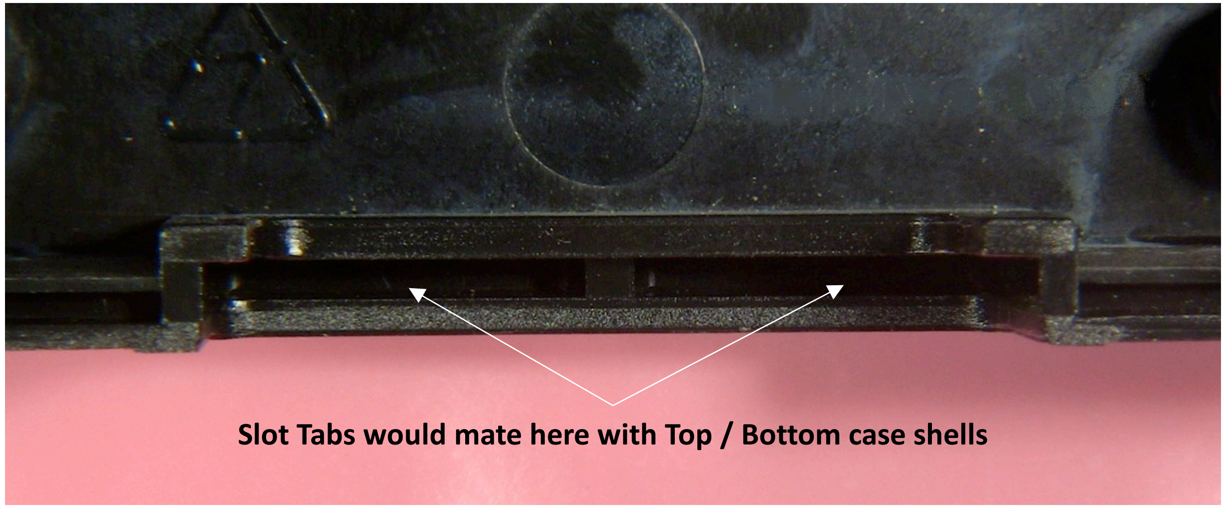
Power Supply- *Back Tab & Slot Tabs, Not Utilized*







Supply Chain Issue: Mis-application of IEC-320 Socket to slot tab enclosure design

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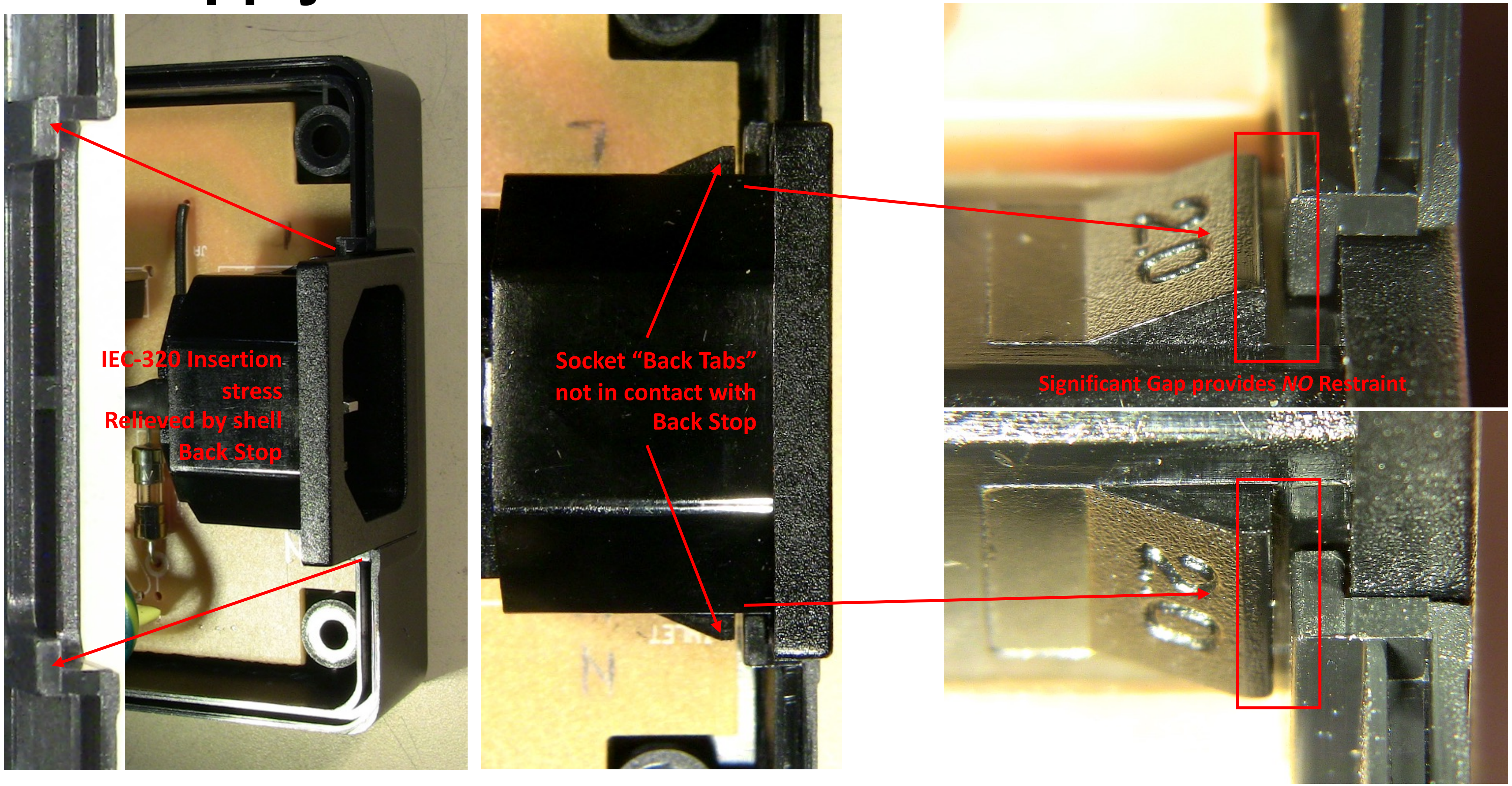
Power Supply- *Board & Socket fit in relation to outer enclosure*



Mis-application *ALLOWS* mechanical stress transfer to AC Line solder joints. No board Staking OR retention features

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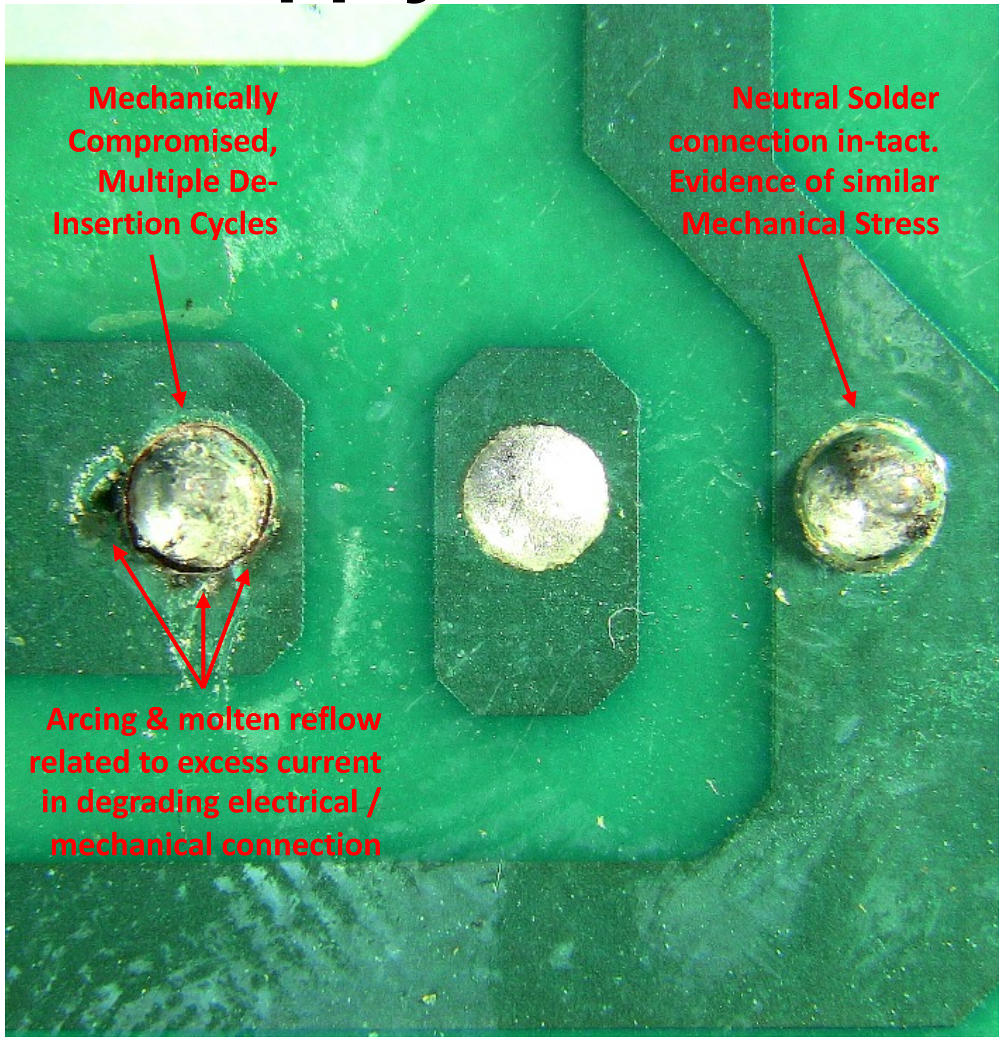
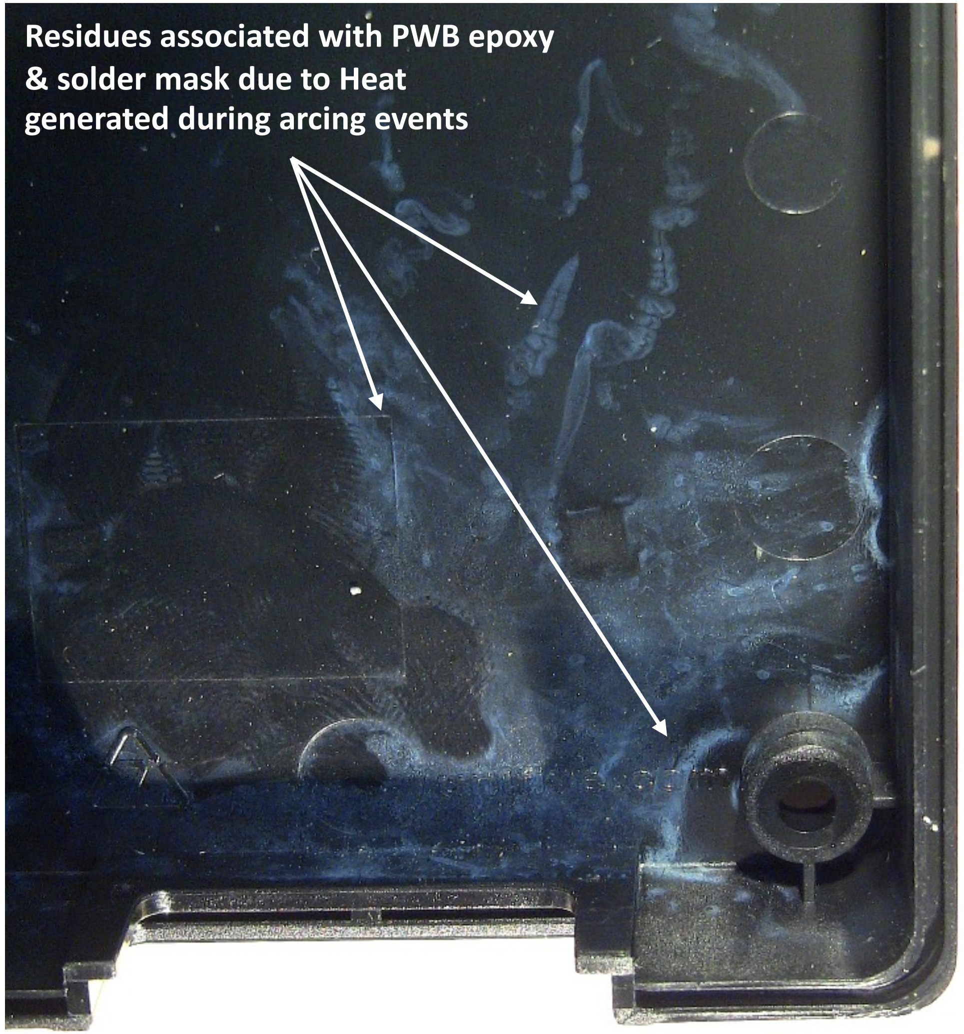
Power Supply- *AC Line In Solder Interconnect*

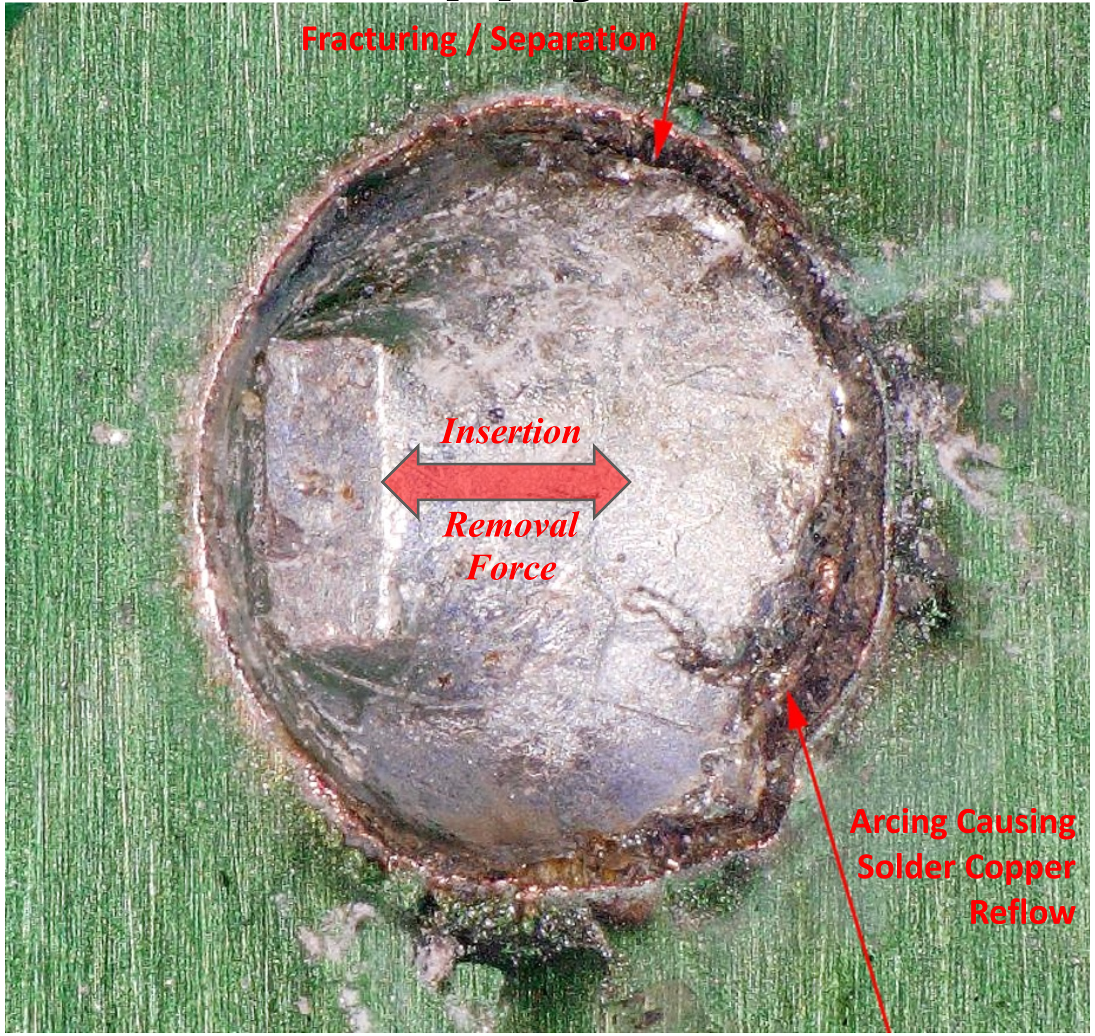


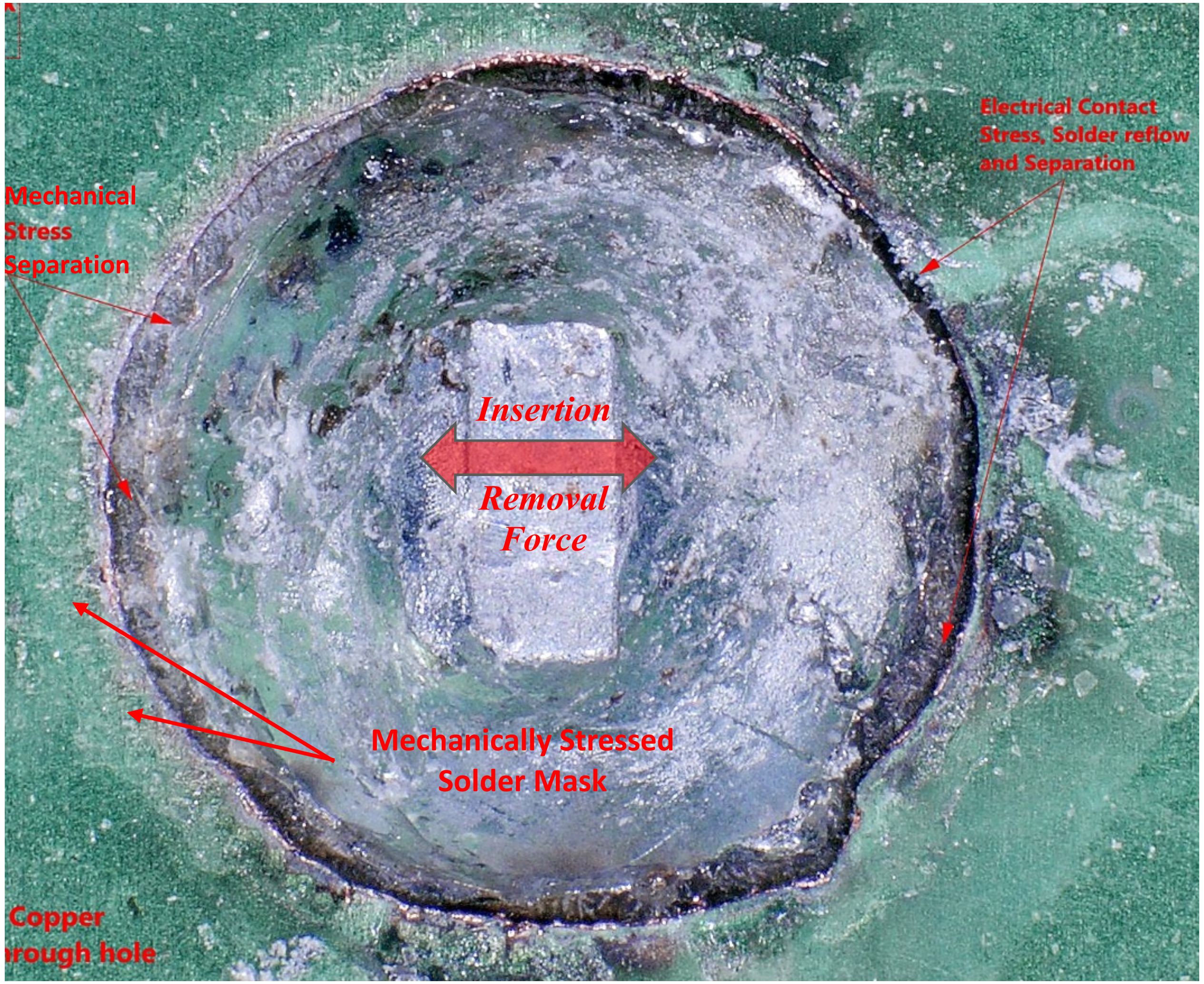


Solder connection- Mechanical / thermal degradation due to cyclical use, residues are from interconnect arcing

Images Owned by RTX Corporation

Power Supply- *AC Line In Solder, Higher Magnification*

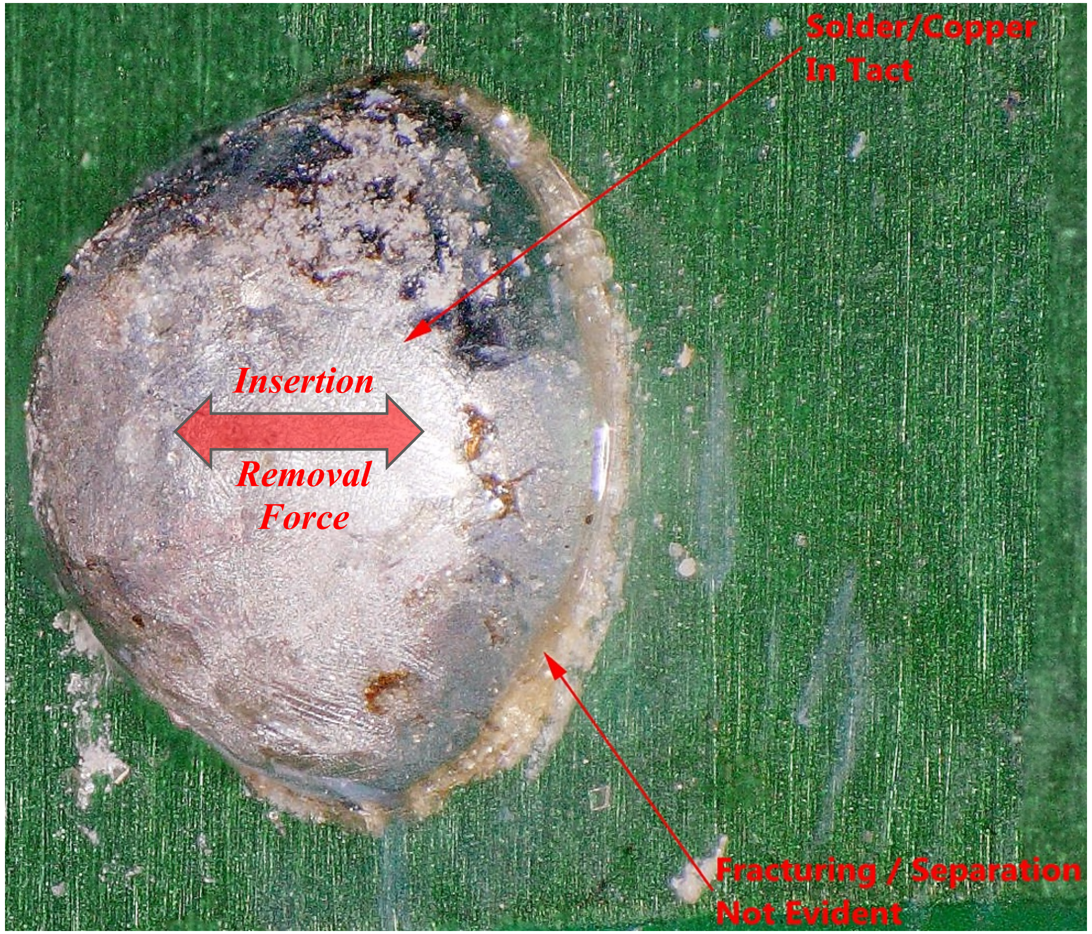


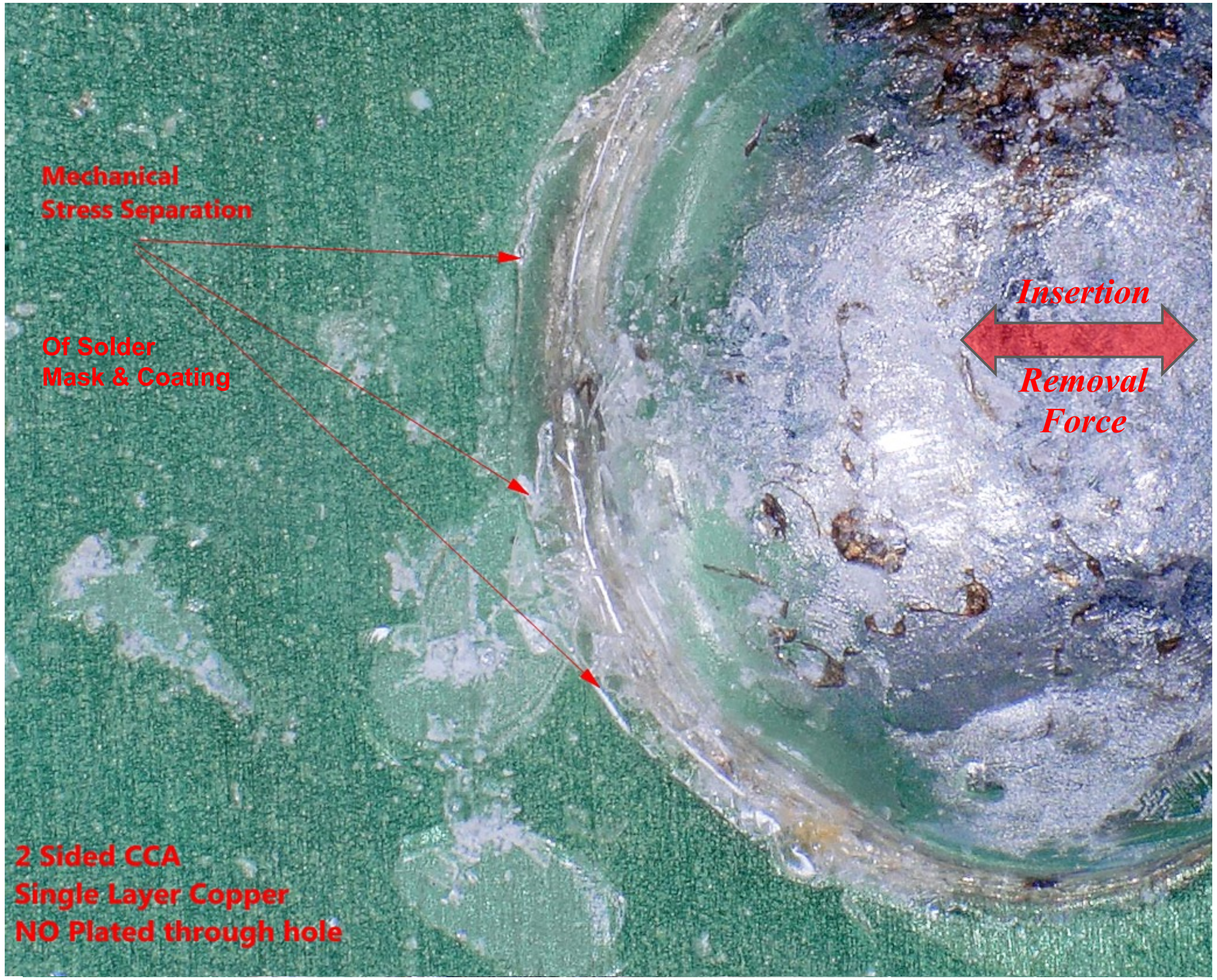


Solder connection- Mechanical / thermal degradation due to cyclical use, residues are from interconnect arcing

Images Owned by RTX Corporation

Power Supply- *AC Neutral Solder, Higher Magnification*





Solder connection is in-Tact, though not ideal. Electrical connection is not compromised

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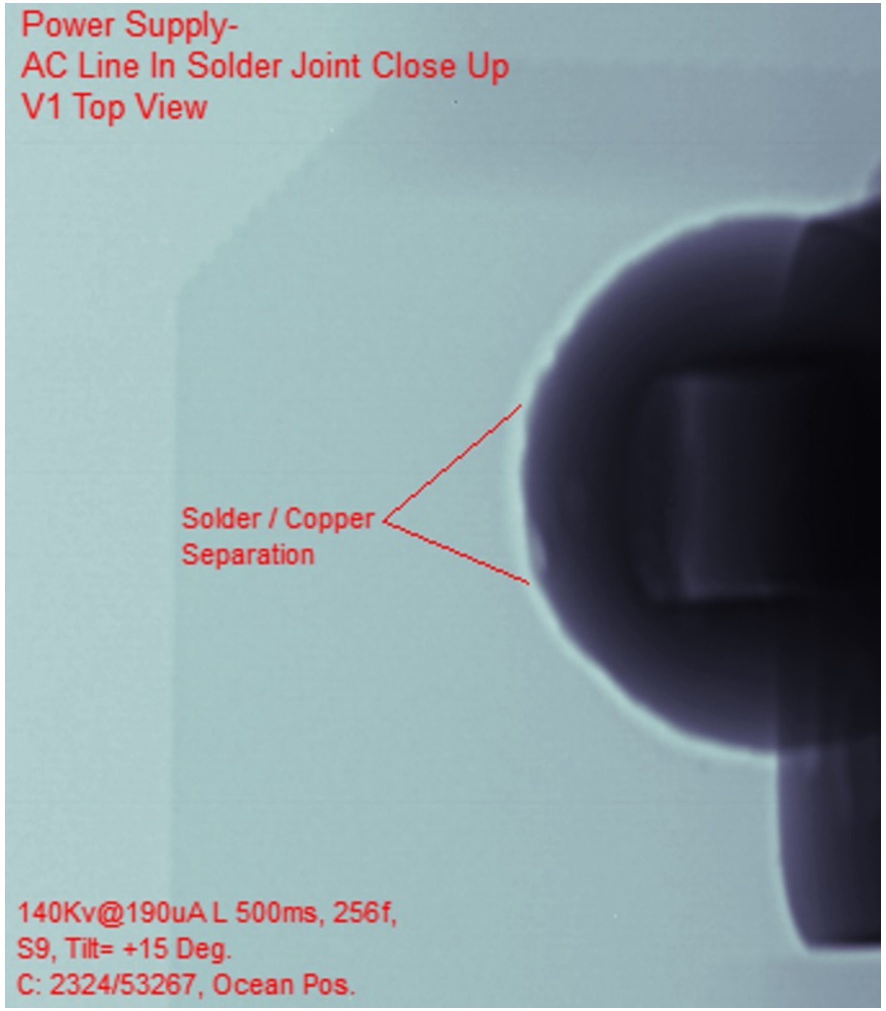
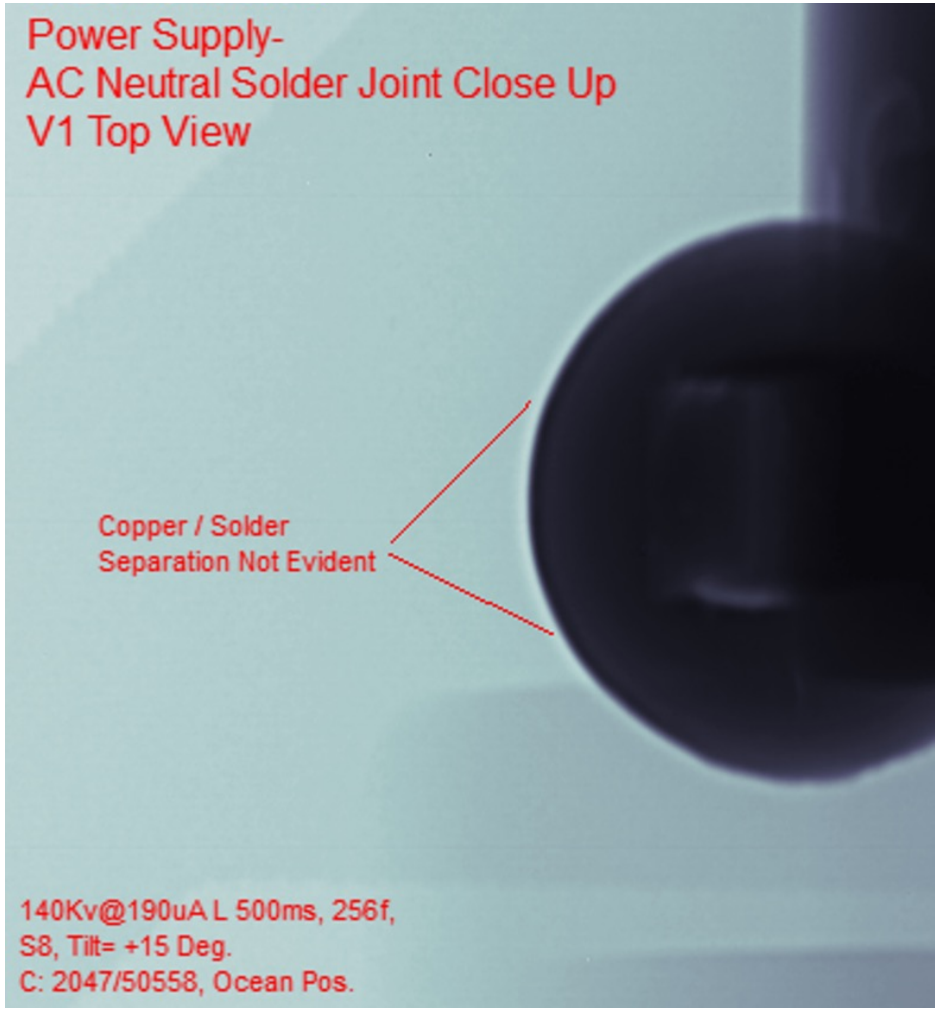
Power Supply- *AC Line & Neutral X-Ray Assessments*

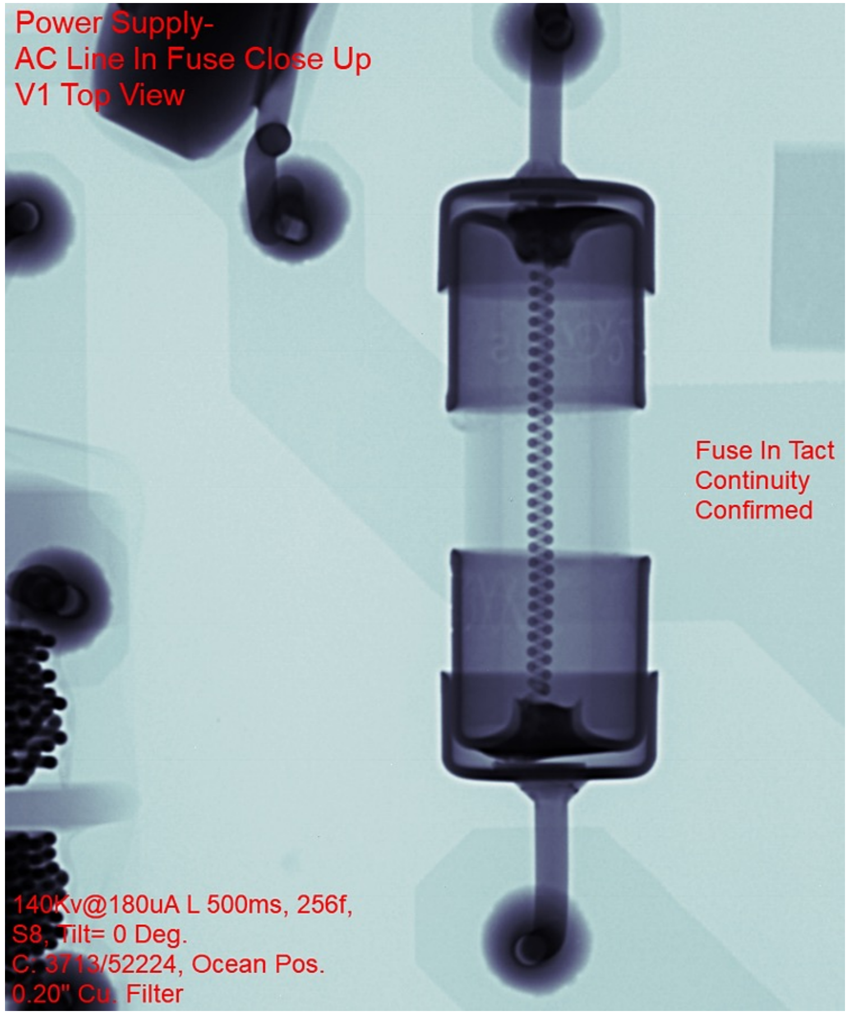


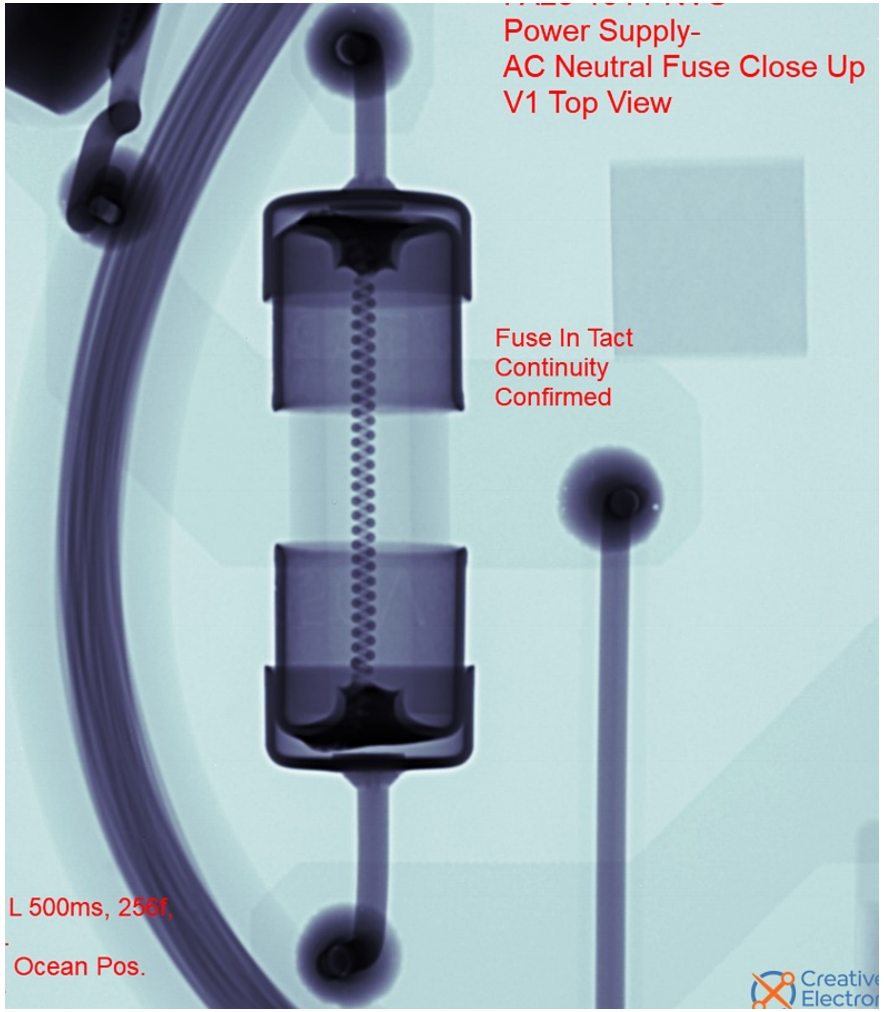


IEC-320 main board solder attach- ***X-Ray confirms compromised AC Line In solder joint***

Images Owned by RTX Corporation

Power Supply- *AC Line & Neutral X-Ray Assessments*





AC Line & Neutral Fuses. Elements have electrical continuity and are *in-tact*

Images Owned by RTX Corporation

Observations & Findings

Power supply received partially dis-assembled from initial assessments-

It was confirmed with offset lighting that the AC Line in solder joint was badly damaged. The board was charred around the un plated thru-hole. Copper separation and solder melted away from the AC line pin a full 360 degrees.

AC Line Input Degradation:

1. Input connections were probed with a multi-meter confirming an electrical open from the solder joint to power in. Line AC In & Neutral fuses were also tested and confirmed to be in-tact.
2. AC Neutral In solder was probed to the inputs, electrical continuity to this and the ground pin were confirmed.
3. Mechanical / Electrical Breakdown- Copper damage with multiple arc locations indicate that the connection suffered from end use cyclical power cord insertion / removal fatigue stress, leading to a compromised electrical connection. This increased current density, resulting in excess heat and solder reflow. This led to connection degradation and eventual failure.
4. X-rays of the solder connections and the fuses confirmed the findings in Items 1-3 above.
5. The enclosure assembly bottom, contains multiple smoke emission trails from where the AC Line In solder connection is. This is a result of multiple instances of arcing, which burned the board material, solder mask and coatings, depositing localized residues.
6. Items 3-5, are consistent with mechanical-electrical degradation effects noted in power supplies with IEC-320 power cord socket mis-application issues.

Findings & Recommendations

AC line Input Design: *IEC-320 Power cord socket*

7. Top & bottom enclosure has IEC-320 retention tab slots for socket strain relief, preventing mechanical force impingement onto the socket solder connections.
8. An alternate (available) IEC-320 socket was integrated that ***DOES NOT*** contain mating retention tabs. The alternate socket ***DOES*** contain an inner shell "back tab", but is designed for a thicker wall dimension. The tab ***Does NOT*** achieve contact with this feature to restrain the socket during power cord insertion/removal cycles.
9. IEC-320 sockets have multiple retention features: Tab slots, Back tabs, Through hole stakes, Board fasteners & Epoxy bead (between board surface and socket), to prevent mechanical stress on the solder joints.
10. While The IEC-320 socket applied to this enclosure Provides a mechanical back-stop (insertion force), the back tab is not providing mechanical restraint, when un-plugging the AC Cord.
11. Mechanical damage on one side of the solder joint, with Arcing leading to an eventual open on the other side is consistent with the orientation and direction to which the AC power cord is inserted, then pulled out.
    - Based on observations, electrical / x-ray analysis and review of the AC Line input CCA design, the root cause of the failure is related to prior use Mechanical / Electrical fatigue leading to AC Line solder joint failure.
    - While the AC Line in pin had continuity prior to the vibration testing, the solder joint was compromised from prior use. Lack of retention features allowed what was left of the electrical contact to open following test.
    - In this instance, the failure is **NOT** a result of the vibration test.

If possible, use NEW assets for Qual Tests! Perform mechanical / electrical construction analyses to confirm asset viability prior to test!

Abstract:

COTS components and assemblies offer several benefits including market availability, volume production cost savings and performance advantages when developed and manufactured by companies with core competencies in various technology sectors. The challenge in integrating COTS is not just ensuring it can operate in the intended environment but that that the system design can be tolerant of material and process variances often found in high volume COTS devices. This presentation will focus on an environmental test failure of a COTS Power supply. In this instance the power supply subjected to transportation qualification test was determined to be a used asset, complicating the failure analysis. We will review the general construction and ruggedized mechanical characteristics of the assembly, then review the physical analyses utilized to determine the root cause of the failure.