



NASA Electronics Parts and Packaging Program
2021 Electronics Technology Workshop

Red Plague Control Plan
VS
Hydrofluoric Acid Corrosion Mitigation

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Wire – Cable - Connectors

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Work performed for GSFC Code 562

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Acronyms



- Cu: symbol for the chemical element copper
- DSCC: Defense Supply Center Columbus (Ohio)
- ESCC: European Space Components Coordination
- ETW: Electronics Technology Workshop
- GIDEP: Government – Industry Data Exchange Program
- GSFC: Goddard Space Flight Center
- JSC: Johnson Space Center
- NASA: National Aeronautics and Space Administration
- MD: Maryland
- NEPP: NASA Electronics Parts and Packaging Program
- O: symbol for the chemical element oxygen
- Pb: symbol for the chemical element lead
- pH: Logarithmic scale, Power of Hydrogen, acidity or basicity of aqueous solutions
- RP: Red Plague
- S&MA: Safety & Mission Assurance
- vs: versus
- XL-ETFE: Cross-linked Modified Ethylene Tetra Fluoro Ethylene

Wire Disease

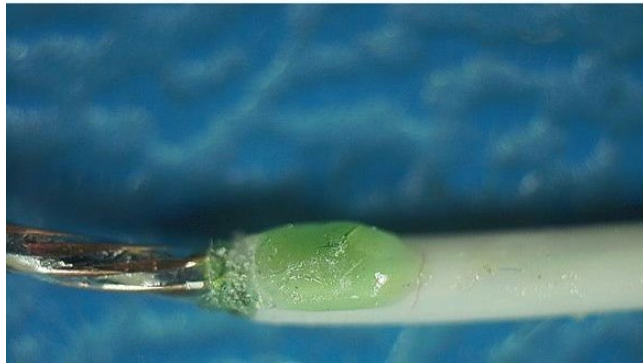


- Electrical wires can develop infectious conditions that affect their function
- Exposure to artifacts in the environment
 - Oxygen
 - Water: liquid or vapor
 - Hydrogen Sulfide (atmospheric)
 - Sulfur Dioxide: Sulfur + immersion silver = creep corrosion on Pb-free conductors
 - Esters & Mineral oil (attack copper oxide)
 - Excessively high plenum temperature during tape wrap sintering
- Exposure to artifacts in the wire's construction
 - Fluorine gas released from wire insulation forms corrosive compounds
 - Examples of fluorinated compounds in wire insulation:
 - Polytetrafluoroethylene, Fluorinated ethylene propylene, Perfluoroalkoxy
- Operational or handling failures
 - Fracture through mechanical fatigue, flexing, over-crimping
 - Wire fusing due to high current
 - Notch propagation
- Manufacturing
 - Improper processing of pellets prior to extrusion

Conductor Plagues

- White Plague: gold-aluminum intermetallic formation
 - In the case of a wire bond, forms in a high temperature environment
 - Resulting alloy is a semiconductor
- Purple Plague: gold-aluminum intermetallic formation
 - In the case of a wire bond, forms in a high temperature environment
 - Resulting alloy is a brittle semiconductor
 - Volume reduction in the joint & creates voids in surrounding conductors
- Green Plague: copper oxide migrates into a resin solder flux
 - Common after soldering a bare copper alloy, like phosphor bronze, manganin or yellow brass; less common on silver and tin plated wire
 - May not clean with IPA when it settles on insulation, but considered a cosmetic defect
- Black Plague: cupric oxide (CuO)
 - A form of copper corrosion, appears black: copper + silver + oxygen + water
- Red Plague: cuprous oxide (Cu₂O)
 - A form of copper corrosion, appears red-brown: copper + silver + oxygen + water
 - Corrosive galvanic cell is maintained when moisture is present and water is a byproduct of this cell, so the corrosion can occur indefinitely in the atmosphere

Examples

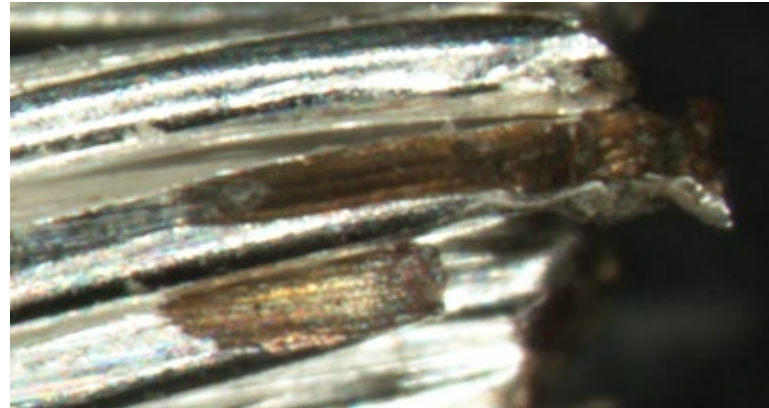
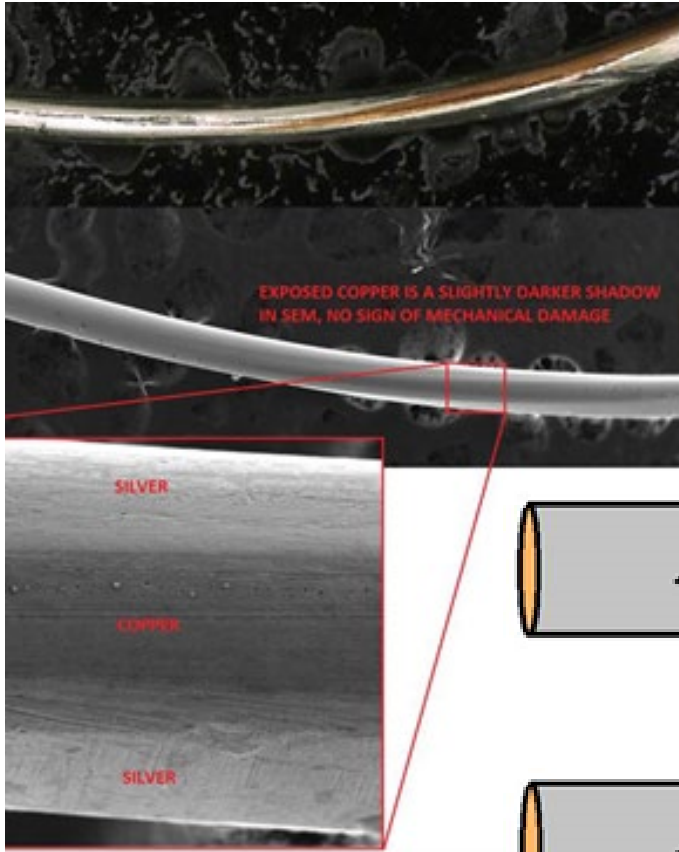


Green Plague



Red Plague

Copper Corrosion from Fretted Silver Not an Example of Red Plague



Bare strand (1 out of 19 showing bare copper region)



Bare strand (simplified view, without "twisting")

Red Plague Control Plan

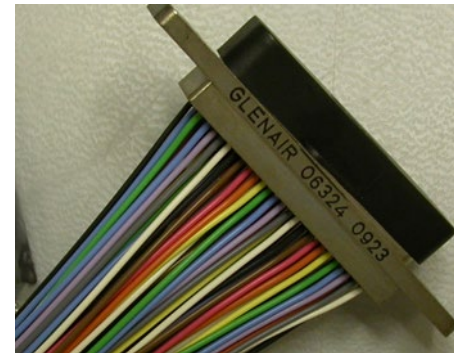
- JSC 64647
 - Robert Cooke, S&MA Quality & Flight Equipment Division
- ECSS-Q-ST-70-20
 - European Space Agency's document on Red Plague corrosion
- GSFC has a draft dated 04-28-2021
 - Ayyaz Tufail, GSFC Code 373
 - Scope: Prescribes the minimum requirements for the control of cuprous oxide corrosion (Red Plague) for silver-coated copper wires, cables and harness assemblies
 - Purpose: To address operations where assembly processes, environmental conditions and contamination may promote the development of Red Plague in silver-coated copper wires, cables and harness assemblies
 - Silver-plated copper wire shall be shipped and stored in sealed water-vapor-proof packaging
 - Desiccant, moisture-barrier bags, humidity indicator, nitrogen dry box (option), heat-shrinkable end caps or dipped encapsulant
 - Wire & cable shall not be stored in paper wrapping or cardboard boxes
 - After kitting, store in less than 70% relative humidity & monitored environment, and cap wire ends

Examples

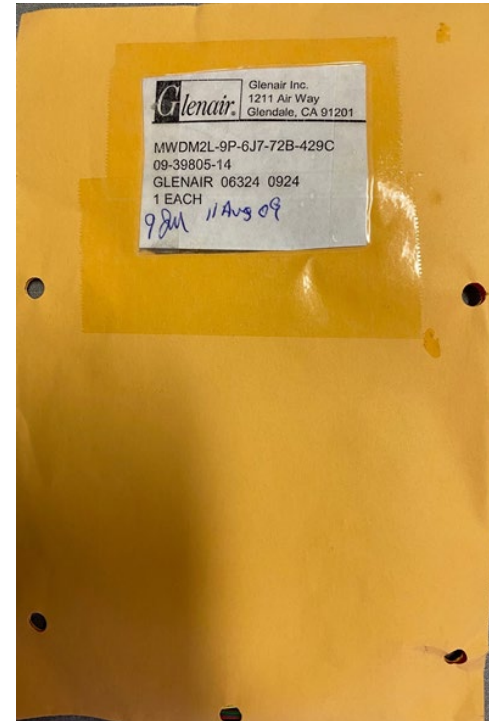
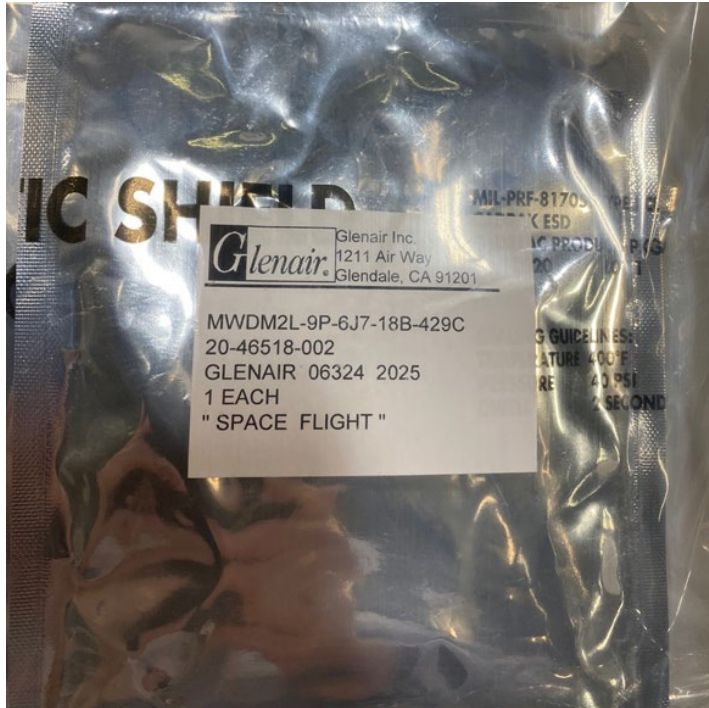


Hydrogen Fluoride Threat to Metals

- GIDEP EA-P-98-02B
 - DSCC noted in 1998, hydrofluoric gas was affecting the nickel plating on Cristek micro-D connectors
- Cross-linked Modified Ethylene Tetra Fluoro Ethylene (XL-ETFE) insulation was the culprit
- After the insulation is extruded on a conductor, ionizing radiation hardens the polymer, but fluorine can leach from the XL-ETFE, mix with moisture to form hydrofluoric acid gas, and attack nickel (as shown below) and copper if the top coatings are porous



Glenair Connector Packaging with XL-ETFE Pigtails



Glenair tried dry nitrogen-sealing baked-out, pigtailed micro-D connectors but hydrofluoric acid attack was still discovered after four months. Vented manila envelopes were the standard after the GIDEP and have returned to this method. Other suppliers use vented plastic bags.

Glenair Micro-D w/ Pigtails Storage Method at GSFC



At their factory, Glenair covers micro-D shell with Teflon tape. No corrosion detected > 5 years storage.

Comments

- If red plague is seen on freshly made product, the cause is likely damage to the silver plating while drawing, spooling, stranding or braiding. The silver-plating processes of the copper monofilaments are tightly controlled.
- Based on Code 562 experiences with manufacturers, no evidence of red plague forming fast enough that it would be detected prior to shipment; however, RP corrosion was noticed by distributors or customers later on, and typically on the braided shields when it occurs.
- Desiccants in sealed bags may not prevent hydrofluoric acid gas formation.
- **How can hydrofluoric gas venting be incorporated into a Red Plague Control Plan?**
- **Based on personal & project experiences, GSFC will balance corrosion mitigation techniques between the Red Plague Control Plan and a future Hydrofluoric Acid Corrosion Control Plan.**



End of Presentation