IPC-WP-113

Guidance for the Development and Implementation of a Red Plague Control Plan (RPCP)

Developed by the Wire Harness Design Task Group (7-31k) and IPC-HDBK-620 Handbook Task Group (7-31h) of the Product Assurance Committee (7-30) of IPC

Users of this publication are encouraged to participate in the development of future revisions.

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TECHNICAL BACKGROUND (Figures 1-1 and 1-2)

Red Plague (cuprous oxide corrosion) can develop in silver-coated soft or annealed copper conductors (component leads, single and multi-stranded wires and PCB conductors) when a galvanic cell forms between the copper base metal and the silver coating in the presence of moisture (H_2O) and oxygen (O_2). Once initiated, the sacrificial corrosion of the copper base conductor can continue indefinitely in the presence of oxygen, progressively reducing the electrical and mechanical integrity of the conductor (the degradation is particularly acute in thin conductors). The color of the corrosion by-product (cuprous oxide crystals) may vary depending on the different levels of oxygen available, but is commonly noted as a red/reddish-brown discoloration on the silver coating surface.

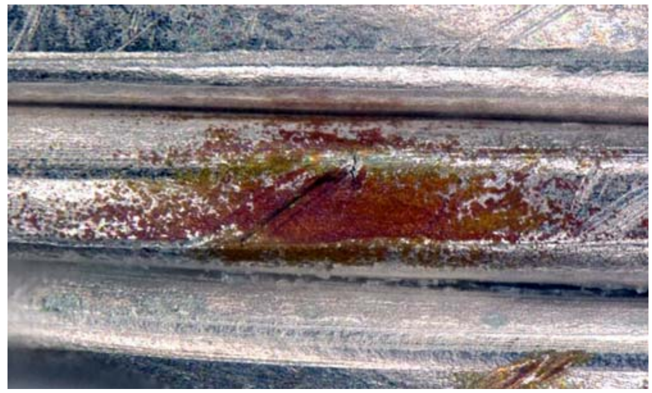

Figure 1-1 Red Plague (Cuprous Oxide Corrosion)
Photo Courtesy of NASA

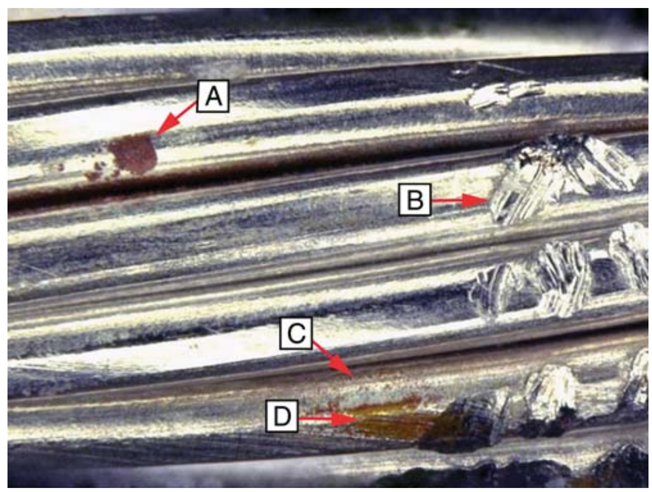

Figure 1-2 Close-Up View
AS22759 Stranded, Silver-Coated Copper Wire Showing Varying Stages of Red Plague, Damaged Plating, Mechanical Damage, Porosity, and Exposed Copper
Photo Courtesy of NASA
A. Damaged Plating Site (Red Plague)
B. Mechanical Damage (Recent)
C. Porosity Sites with Red Plague
D. Exposed Copper with Red Plague

Mechanical Damage The primary initiator of Red Plague is mechanical damage of the silver coating during wire manufacturing (i.e., drawing, stranding, application of insulation jackets, etc.) resulting in exposure of the copper-silver interface to atmospheric moisture and oxygen. Other common sources of mechanical damage include improper assembly and installation practices (i.e., excessive flexing. improper bend radius, etc.).

Environmental Conditions In order for Red Plague to develop, a galvanic cell must form between the copper base metal and the silver coating in the presence of water (H_2O) and oxygen (O_2). Since only a small amount of water is required, protection from high humidity and oxygen and other contaminants such as aqueous solvents and cleaning systems is considered the greatest significant mitigation against Red Plague.

Inadequate Silver Coating Thickness Porous, discontinuous, and thin silver coatings are more likely to develop Red Plague since a greater number of sites for galvanic cells to form between the copper base metal and the silver plating are possible. Silver coating thicknesses below 1 µm [40 µin] are more easily damaged during manufacturing and handling, thus increasing susceptibility. Increasing the silver coating thickness to 2 µm [80 µin] has shown improved resistance to corrosion.

High Temperature Though the upper continuous operating temperature rating of most silver-coated wiring is +200 °C [+392 °F], exposure to temperatures approaching +200 °C [+392 °F] or higher induces migration of the copper base metal through the silver coating. This may reduce the silver coating thickness and create porosity sites for cuprous/cupric oxide corrosion to occur. This effect is typically experienced in instances where the wiring is exposed to excessive heat during test or highly accelerated burn-in.

Chemical Attack Exposure to chemicals present in the environment (oxygen, sulfur compounds, salt, etc.) may result in corrosion and corrosion by-products that attack and compromise the mechanical integrity of the silver coating. Common