IPC-WP-113A

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

Developed by the Wire Harness Design Task Group (7-31k)
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Supersedes:
IPC-WP-113 -
December 2015

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

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TECHNICAL BACKGROUND

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.

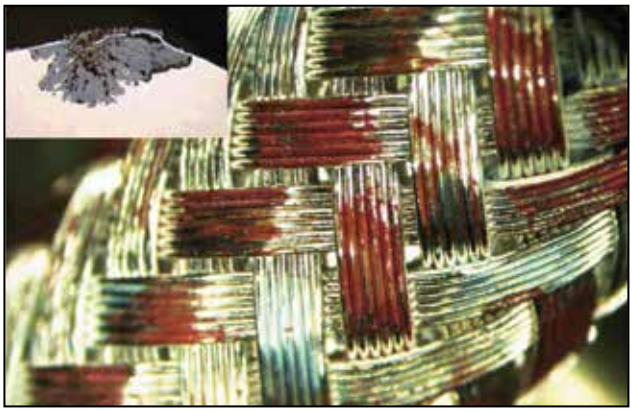

Figure 1-1 Red Plague (Cuprous Oxide Corrosion) on Braided Shield
Inset: Microsection of Single Strand (400X)

Mechanical Damage

The primary initiator of Red Plague is mechanical damage of the silver coating during wire manufacturing (e.g., drawing, stranding, application of insulation jackets) 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 (e.g., excessive flexing. improper bend radius).

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 (e.g., oxygen, sulfur compounds, salt) may result in corrosion and corrosion by-products that attack and compromise the mechanical integrity of the silver coating. Common “green” packaging materials, paper wrapping materials, rubber bands, and cardboard boxes should be avoided because such materials often outgas small amounts of sulfur. Exposure to atomic oxygen (AO) in spaceflight applications has been shown to tarnish and pit exposed silver coatings.

Note: *Although it is normally assumed that there is no moisture in the vacuum of space, the recent claim of evidence of algae growth on the outer surfaces of the International Space Station suggests that there may be sufficient water and oxygen present to make AO damage a concern for development of Red Plague in Low Earth Orbit (LEO) inclinations.*

1 GENERAL REQUIREMENTS

1.1 Scope This document introduces design concepts, guidelines, procedures, practices, process attributes, and recommendations for the control and mitigation of performance and reliability risks associated with the use of silver-coated copper conductors and technology in the manufacture of electrical and electronic assemblies, including optical and metallic cable and wiring harness assemblies, and elements thereof.

1.2 Purpose The intent of this document is to provide guidelines and a template for the development and implementation of a Red Plague Control Plan (RPCP).

For purposes of this document:

- The Designer is the design agent for the User.
- The User is the individual, organization, company, contractually designated authority, or agency responsible for the procurement or design of electrical / electronic / electromechanical (EEE) hardware, and having the authority to define the class of equipment and any variation or restrictions to the requirements of this document (i.e., the originator / custodian of the contract detailing these requirements). The User is considered the Design Authority.
- The Supplier is considered the individual, organization or company which provides the Manufacturer (assembler) components (electrical, electronic, electromechanical, mechanical, printed boards, etc.) and/or materials (solder, flux, cleaning agents, etc.).
- The Manufacturer is considered the entity that provides a service or product to the User.

1.3 Applicability This document is targeted for applications where exposure to assembly processes, environmental conditions, and contamination may promote the development of cuprous oxide corrosion (Red Plague) in silver-coated copper wire, cable, and harness assemblies, and is applicable to all organizations involved in the design, manufacture, and installation of silver-coated copper wire, cable, and harness assemblies.

a. The design concepts, guidelines, and procedures presented in this document are for guidance ONLY, and are not requirements. As such, the use of the words "**must**", "**should**" and "**shall**" (and derivations thereof) have no special meaning in this document, and they do not indicate a binding criterion.
b. This document is not binding, unless separately and specifically included by the applicable contract, approved drawing(s), or purchase order.

1.4 Commercial Off-The-Shelf (COTS) This document does not apply to Commercial-Off-The-Shelf (COTS) items. Designers considering the use of COTS hardware for applications described above are responsible for identifying and managing risks associated with hardware that was built without a control plan to reduce the harmful effects of Red Plague.

1.5 Existing or Previously Approved Designs The implementation of a Red Plague Control Plan (RPCP) should not constitute the sole cause for the redesign of previously approved designs. When drawings for existing or previously approved designs undergo revision, they should be reviewed and changes made that allow for compliance with the requirements of the imposed Plan.

Figure 1-2 - Red Plague (Cuprous Oxide Corrosion)
Photo Courtesy of NASA

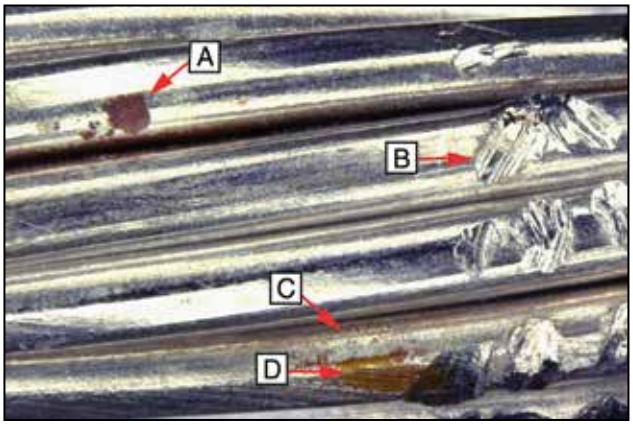

Figure 1-3 - Close-Up View AS22759 Stranded, Silver-Coated, Copper Wire Showing Varying Stages of Red Plague Damage *Photo Courtesy of NASA*
A. Damaged Plating Site (Red Plague)
B. Mechanical Damage (Recent)
C. Porosity Sites with Red Plague
D. Exposed Copper with Red Plague