



AEROSPACE RECOMMENDED PRACTICE

ARP6229™

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Fluoride Offgassing in Fluoropolymer Insulations

RATIONALE

This report provides information to the user community on the potential of fluoride offgassing from fluoropolymer wire insulation and recommendations to protect against potential effects. Although there have been some published advisories related to this subject, no publication existed prior to this ARP which pulls together current knowledge for communication to industry OEMs and end-users.

1. SCOPE

This SAE Aerospace Recommended Practice (ARP) shall be limited to information about corrosion caused by fluoride offgassing of fluoropolymer-based wire insulation. It reviews published reports of corrosion caused by this phenomenon, describes scenarios where this may be a concern, mitigation options, and references a test method which can be used to evaluate wire insulations where needed.

1.1 Purpose

This document provides basic information to wire manufacturers, OEMs, and end users about fluoride offgassing from wire insulation, including effects, applications of concern, test methods, and recommendations.

2. REFERENCES

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS4373	Test Methods for Insulated Electric Wire
AIR5717	Mitigating Wire Insulation Damage During Processing and Handling
ARP6400	Recommended Practice for Processing and Handling Wire and Cable with Silver Plated Conductors and Shields
AS22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy

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2.2 Other Publications

“Fluoropolymer degradation resulting in corrosion of packaged pre-wired connector assemblies”, FSFC NASA Advisory #: NA-GSFC-2003-03, April 15, 2003

“Cause and effects of fluorocarbon degradation in electronics and opto-electronic systems” Predmore, Roamer E.; Canham, John S. Ph.D; NASA Goddard Space Flight Center, Materials Engineering Branch; 2003

“A corrosion puzzle of pre-wired connectors in sealed storage bags” by June Cabourne, Senior Project Manager at Cristek Interconnects, Inc. c. 1998

GIDEP EA-P-98-02 Problem Advisory “Wire outgassing” 1998

“ISS Fiber Optic Failure Investigation Root Cause Report”, NASA GSFC, August 1, 2000

“Effect of Insulation on Red Plague Corrosion in Silver-Plated Wire”, Steven Gullerud, Peter Ibarra, Steve Zingheim, and Richard Reimer, TE Connectivity, AEISS Presentation, October 12, 2011

3. BACKGROUND

3.1 Definition and Mechanism

During processing of fluoropolymers, exposure to high temperatures can cause the polymer to degrade in the presence of air and water to produce carbonyl fluoride end groups. These end groups remain in the polymer and can later hydrolyze in the presence of moisture to produce carbon dioxide and hydrofluoric acid. This reaction can occur over a long period of time, at a rate limited by the diffusion of water into the fluoropolymer material. In wire insulation, this phenomenon is referred to as either fluoride offgassing or fluoride outgassing.

The total potential of fluoride offgassing from a fluoropolymer insulation is finite, and limited by the amount of carbonyl fluoride groups present within the polymer. Observed parts per million (ppm) of extractable hydrogen fluoride in wire insulation ranges from 10 to 1000.

3.2 History

Insulation off-gassing is a known issue in the satellite manufacturing industry since the late 1990s. The issue was first publically reported by Cristek Interconnects, Inc. in mid-1997 concerning corrosion on pre-wired connectors in sealed bags that were terminated to AS22759/33 insulated wire. This resulted in a subsequent Government Industry Data Exchange Program (GIDEP) Problem Advisory in 1998 regarding the offgassing of XL-ETFE insulated wire. A second GIDEP was published by Goddard Space Flight Center in 2003, again observing corrosion on connector assemblies caused by fluoride offgassing in wire assemblies stored in sealed bags for 2 years.

While the instances above involved XL-ETFE wire, other fluoropolymers have been shown to generate fluoride offgassing and cause corrosion-related failures. FEP jacketed fiber optic cables were found to have etched pits in the fiber caused by HF released by the FEP insulation layer.

3.3 Effects

Hydrogen fluoride is highly corrosive, and will etch glass and corrode plating surfaces of connectors and other components. As a vapor, it is able to penetrate porous coatings and react with underlying materials. Although there are considerable health risks associated with hydrogen fluoride, the potential amount released by a fluoropolymer wire insulation is quite small and unlikely to present an actual health hazard.

An investigation has shown evidence that hydrogen fluoride is capable of penetrating the plating of a silver-plated copper conductor and reacting with the underlying copper to form copper fluoride. If there is enough available hydrogen fluoride, the volume increase caused by this reaction is able to breach the silver plating and expose the underlying copper. The presence of white to bluish-white crystals on a conductor surface may indicate that some copper fluoride has formed, but does not necessarily mean that the underlying plating has been compromised.