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Corrosion Preventative Compound (CPC) Impact on Electrical Wiring and Interconnect System Hardware Evaluation

Aircraft Airworthiness & Sustainment Conference

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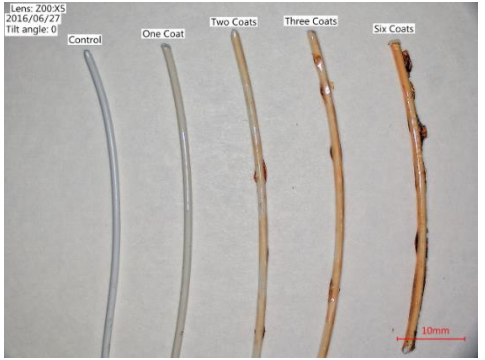
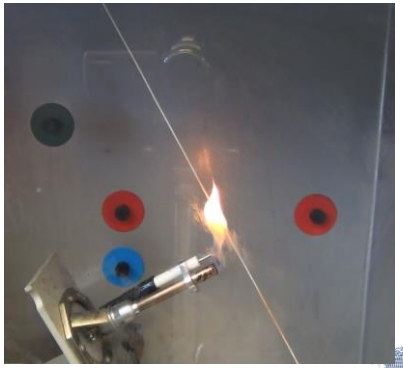
88ABW-2018-2352

CPC Effects on EWIS

- Multi-phase study of effects of CPC on EWIS components
  - Wiring (immersion & spraying)
  - Connector interior (contact mating surface region)
  - Cleaning efficacy of ‘dried’ CPC on wiring
  - …whatever is asked next



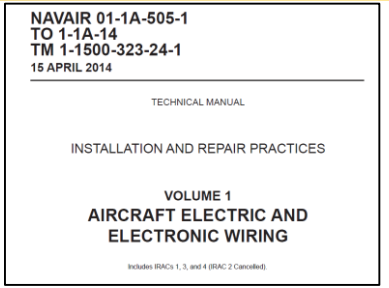
- What is completed?
  - Wiring (immersion & spraying) – *RXS 16-028, RXS 16-060*
  - Connector interior (Group 1, D38999) – *RXS 17-070b*
  - Connector interior (Group 2, D38999) – Report in-process
  - Initial cleaner evaluation – *RXS 17-0XX*



CPC Effects on EWIS

- **The problem**
- DoD wide concern
  - Wiring – unintended coating during application for other reasons
  - Connectors – conflicting guidance on CPC application procedures
  - Both present an unquantified risks
    - **Safety concerns?**
    - **Degraded performance?**
  - Technical data was required

CPC are being applied to wires and connectors with unknown impacts

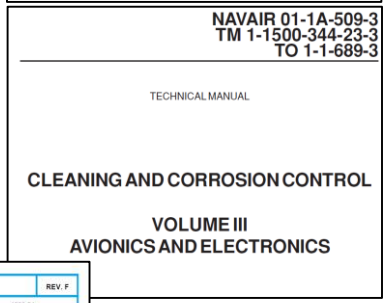

NAVAIR 01-1A-505-1
TO 1-1A-14
TM 1-1500-323-24-1
15 APRIL 2014

TECHNICAL MANUAL

INSTALLATION AND REPAIR PRACTICES

VOLUME 1
AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

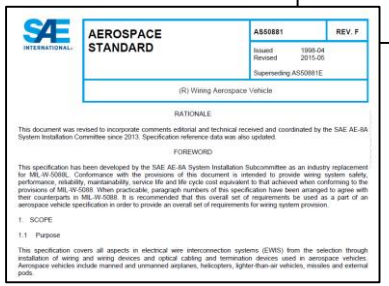
Includes IRACs 1, 3, and 4 (IRAC 2 Cancelled)


NAVAIR 01-1A-509-3
TM 1-1500-344-23-3
TO 1-1-689-3

TECHNICAL MANUAL

CLEANING AND CORROSION CONTROL

VOLUME III
AVIONICS AND ELECTRONICS


SAE INTERNATIONAL

AEROSPACE STANDARD

AS50881 REV. F

Issued 1998-04
Revised 2015-05

Superseding AS50881E

(R) Wiring Aerospace Vehicle

RATIONALE

This document was revised to incorporate comments editorial and technical received and coordinated by the SAE AE-8A System Installation Committee since 2013. Specification reference data was also updated.

FOREWORD

This specification has been developed by the SAE AE-8A System Installation Subcommittee as an industry replacement for MIL-W-5088L. Conformance with the provisions of this document is intended to provide wiring system safety, performance, reliability, maintainability, service life and life cycle cost equivalent to that achieved when conforming to the provisions of MIL-W-5088. When practicable, paragraph numbers of this specification have been arranged to agree with their counterparts in MIL-W-5088. It is recommended that this overall set of requirements be used as a part of an aerospace vehicle specification in order to provide an overall set of requirements for wiring system provision.

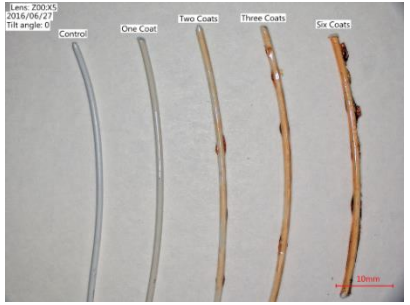
1. SCOPE

1.1 Purpose

This specification covers all aspects in electrical wire interconnection systems (EWIS) from the selection through installation of wiring and wiring devices and optical cabling and termination devices used in aerospace vehicles. Aerospace vehicles include manned and unmanned airplanes, helicopters, lighter-than-air vehicles, missiles and external pods.

CPC Impact on EWIS Hardware

- **The process**
- Multi-phase study of effects of CPC on EWIS components
  - Wiring (immersion & spraying)
  - Cleaning efficacy of ‘dried’ CPC on wiring
  - Connector interior (contact mating surface region)
  - …whatever may be asked next?



Immersion:

- 13 wire sample types, 7 chemicals
- Electrical, mechanical, chemical tests
- 14 day soak

Sprayed

- 1 CPC
- Repeated flammability testing
- Varying layers of sprayed CPC
- Direct program request

Large Data Set

	WIRE TYPE/SPLICE	M22759/11-20-9 (Thermax)	M22759/16-20-9 (Harbour)	M22759/43-20-9 (RSCC)	M22759/87-20-9 (Thermax)	M5086/2-20-9 (RSCC)	M81044/12-20-9 (Nexans)	M23053/1-101-0 (Sumitomo)	M23053/5-105-9 (Sumitomo)	ASB1824/1-2 (TriStar)	M17/184-00001 (RSCC)	M17/74-RG213 (Coleman)	M22759/4-20-9 (Specialty)	M22759/34-20-9 (Judd)
CPC/TEST														
Control														
Immersion		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Insulation Resistance		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Dielectric Withstand		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Radiant Heat Panel		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	-	Fail	Fail	Pass	Pass
60° Angle Flammability		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	-	Pass	Pass	Pass	Pass
Super Corr A (Electrical Grade)														
Immersion		Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Fail	Fail	Pass	Pass
Insulation Resistance		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Fail	Fail	Pass
Dielectric Withstand		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Radiant Heat Panel		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	-	Fail	N/A	Pass	Pass
60° Angle Flammability		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	-	Fail	Pass	Pass	Pass
So Sure 813 Electrical Grade														
Immersion		Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Fail	Pass	Pass	Pass
Insulation Resistance		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass	Fail
Dielectric Withstand		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Radiant Heat Panel		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	-	Fail	N/A	Pass	Pass
60° Angle Flammability		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	-	Pass	Pass	Pass	Pass
ZC 026 CIC Electrical Grade														
Immersion		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Fail	Pass	Pass	Pass
Insulation Resistance		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass
Dielectric Withstand		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Radiant Heat Panel		Pass	Pass	Pass	Pass	Fail	Pass	Fail	Fail	-	Fail	N/A	Pass	Pass
60° Angle Flammability		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	-	Fail	Pass	Pass	Pass
ACF 50 Electrical Grade														
Immersion		Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Fail	Pass	Pass	Pass
Insulation Resistance		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass
Dielectric Withstand		Pass	Pass	Fail	Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Radiant Heat Panel		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	-	Fail	N/A	Pass	Pass
60° Angle Flammability		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	-	Pass	Pass	Pass	Pass
Ardrox AV-30 Structural Grade														
Immersion		Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass	Pass	Pass	Fail
Insulation Resistance		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass
Dielectric Withstand		Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Radiant Heat Panel		Pass	Fail	Pass	Pass	Fail	Pass	Fail	Fail	-	Fail	N/A	Pass	Pass
60° Angle Flammability		Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	-	Fail	Pass	Fail	Fail
Cor Ban 35 Structural Grade														
Immersion		Pass	Fail	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass	Pass	Pass	Pass
Insulation Resistance		Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass	Pass	Pass
Dielectric Withstand		Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Radiant Heat Panel		Pass	Pass	Pass	Pass	Fail	Pass	Fail	Fail	-	Fail	N/A	Pass	Pass
60° Angle Flammability		Fail	Fail	Fail	Pass	Fail	Fail	Fail	Fail	-	Fail	Pass	Pass	Fail
Cee Bee A CPC Cleaner														
Immersion		Pass	Pass	Pass	Pass	Pass	Fail	Fail	Fail	Pass	Fail	Pass	Pass	Pass
Insulation Resistance		Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass	Pass
Dielectric Withstand		Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Radiant Heat Panel		Pass	Pass	Pass	Pass	Fail	Pass	Fail	Fail	-	Fail	N/A	Pass	Pass
60° Angle Flammability		Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	-	Pass	Pass	Pass	Pass

CPC on Wire

- **CPC on wire results**
- In general, electrical impact was not observed
  - Some exceptions (coaxial wires)
- Significant impact on flammability tests
  - Sprayed samples behaved like immersed after 2 coats

CPC Impact on EWIS Hardware

- **The process**
- Multi-phase study of effects of CPC on EWIS components
  - Wiring (immersion & spraying)
  - Cleaning efficacy of ‘dried’ CPC on wiring
  - Connector interior (contact mating surface region)
  - …whatever may be asked next?

- CPC cleaning
  - Multi-platform request
  - CPC on wiring → additional, ***unnecessary*** risk in wire systems
  - Can CPC be safely removed from wiring

CPC Removal from Wiring

- **CPC cleaner results, revision 1**
- Initial effort:
  - Quickly evaluated *chemicals on hand* → feasibility
  - Distilled water, Isopropyl alcohol, Zip-Strip 125M, Cee-Bee A-952, Dysol DS108
  - Sprayed wires with multiple coats of Cor-Ban 35
- Zip-Strip 125M, Cee-Bee A-952 removed CPC after immersion
  - DS108 removed CPC….*but also the wire marking*
- Later evaluated MIL-PRF-680 degreaser and Novec Plus contact cleaner (509-3 guidance)
  - Neither chemical produced favorable results → unable to remove CPC
- Awaiting customer direction for further analysis

CPC Impact on EWIS Hardware

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<u>Connector evaluation:</u>

- 4 groups, 16 connectors per group
- D38999 type, M24308 type
- 4 chemicals
- Thermal, humidity, salt fog exposure
  - Group 1 – 1000 hours at 175 °C, 10 day humidity cycle
  - Group 2 – 1000 hours at 125 °C, 500 hour salt fog

D38999, Group 1 Results

- Across the board degradation in electrical performance, specifically low signal level contact resistance
  - NO failures on any control (4 connectors)
  - **Failures on <u>EVERY</u> connector with CPC applied**

Test	38999M Initial	38999M Max aged
LSLCR (mΩ)	20/31[1]	23/38[1]
Contact resistance max voltage drop (mV) [1]	45[2]	54[2]
Mating force (in-lbs)	16 in-lbs Max.[3]	16 in-lbs Max[3]
Un-mating force	16 in-lbs Max 2 in-lbs min.[3]	16 in-lbs Max 2 in-lbs min.[3]
Insulation resistance (MΩ)	5,000[4]	100[4] (humidity test)
Shell Conductivity (mV)	2.5[5]	5.0[5]

- Failures of the higher power contact resistance (max voltage drop)
- Failures in mate/de-mate torque force
  - Generally confined to first de-mate after temp cycle
  - Significantly lessened after first de-mate

Sample Control

Pin	Baseline (#1)	Pre-CPC Application (#2)	Pre-Thermal (#3)	Post-Thermal (#4)	Pre-Humidity (#5)	Final (#6)
Pre 1Ω 1% resistance	1.0044	0.9961	0.9941	0.9971	0.9980	0.9978
1	0.0123	0.0128	0.0133	0.0149	0.0155	0.0139
2	0.0123	0.0128	0.0127	0.0128	0.0130	0.0128
14	0.0126	0.0128	0.0127	0.0131	0.0142	0.0137
20	0.0112	0.0116	0.0116	0.0122	0.0117	0.0123
21	0.0122	0.0122	0.0125	0.0136	0.0126	0.0146
22	0.0121	0.0122	0.0124	0.0122	0.0129	0.0127
4	0.0195	0.0195	0.0198	0.0200	0.0201	0.0216
16	0.0195	0.0195	0.0196	0.0208	0.0198	0.0200

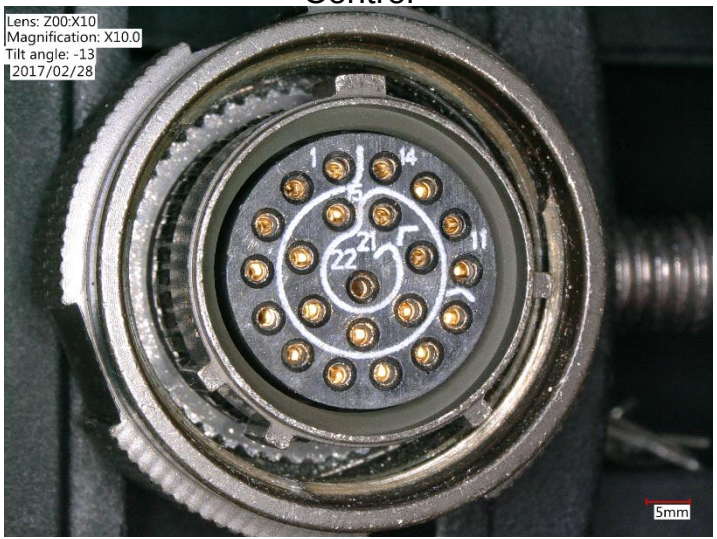
Sample with CPC

Pin	Baseline (#1)	Pre-CPC Application (#2)	Pre-Thermal (#3)	Post-Thermal (#4)	Pre-Humidity (#5)	Final (#6)
Pre 1Ω 1% resistance	0.9961	0.9948	0.9926	0.9965	0.9936	0.9959
1	0.0113	0.0112	0.0114	0.0111	0.0281	0.0230
2	0.0129	0.0130	0.0128	0.1178*	0.0204**	0.0144
14	0.0124	0.0124	0.0128	0.0225	0.2768*	0.0152
20	0.0122	0.0127	0.0124	0.0149	0.0239	0.0286
21	0.0127	0.0128	0.0127	0.0123	0.0174	0.0137
22	0.0124	0.0124	0.0124	0.0158	0.0353	0.0144
4	0.0195	0.0199	0.0201	0.0261	0.0274	0.0214
16	0.0195	0.0197	0.0196	0.0399	0.0366	0.0203

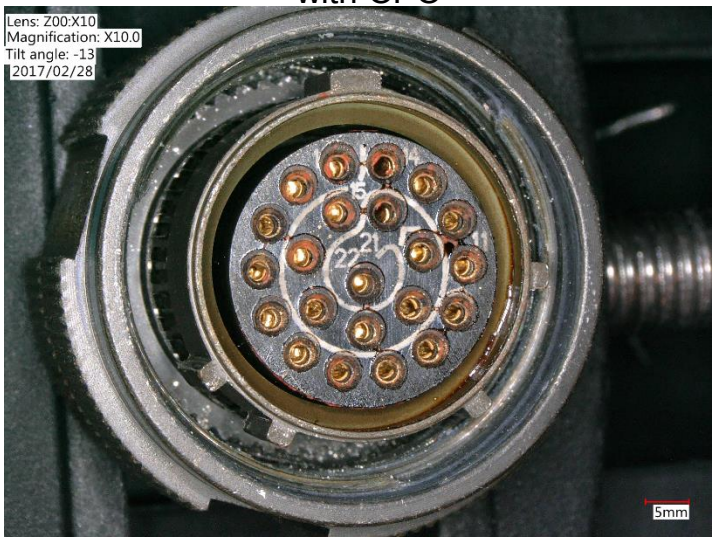
D38999, Group 1 Results

- Pin insert material transfer to socket insert face
  - Note: Control with cleaner also had minor transfer

Sample Control



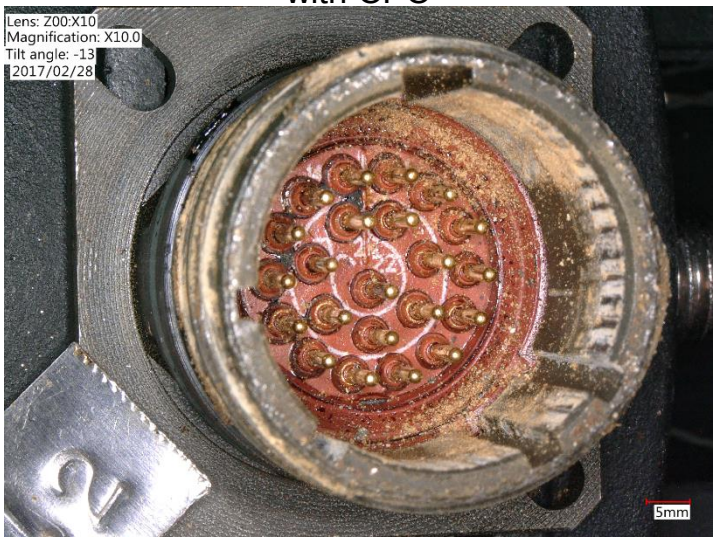
Sample with CPC



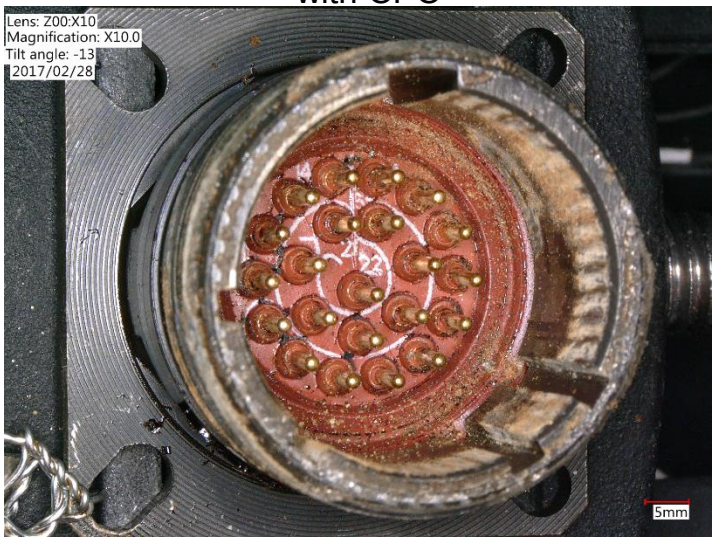
D38999, Group 1 Results

- Gritty material in connectors with applied CPC after thermal exposure

Sample with CPC



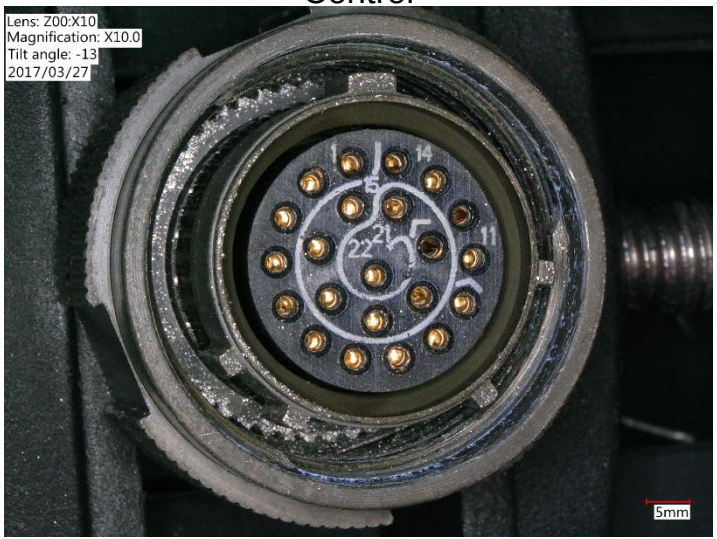
Sample with CPC



D38999, Group 1 Results

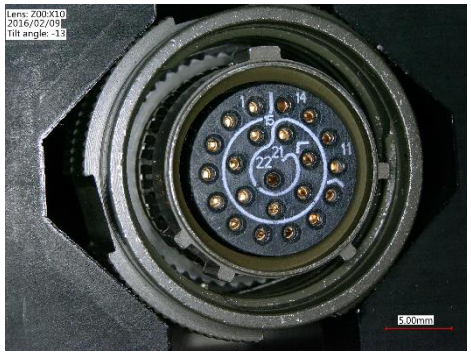
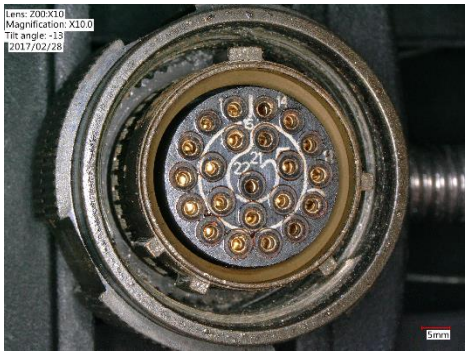
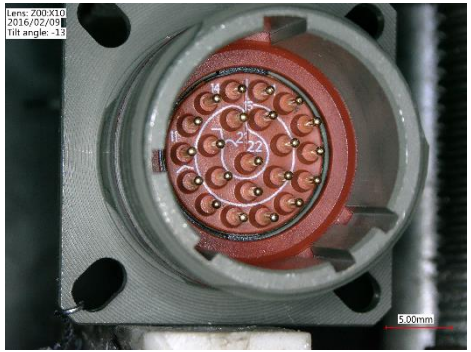
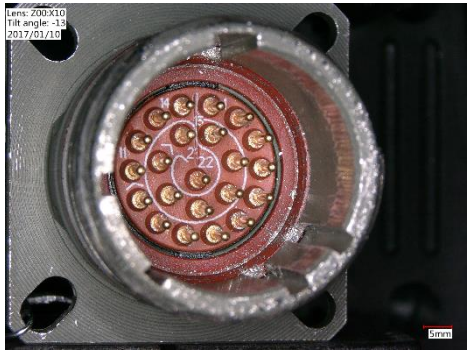
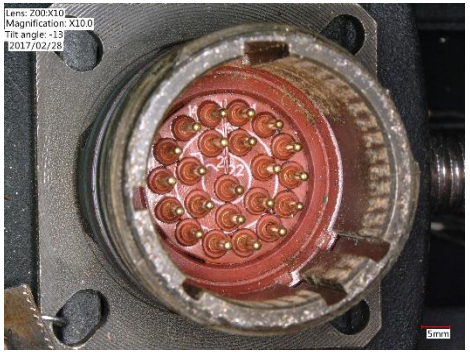
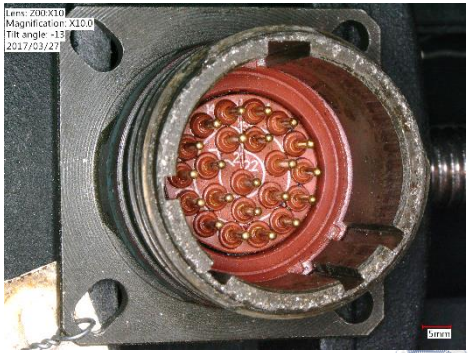
- Severe gunk present in connectors with applied CPC after humidity exposure

Sample Control



Sample with CPC

D38999, Group 1 Results

Initial baseline	Post 500 mate/de-mate cycles	Post 1000 hours at 175 °C	Final (Post Humidity)
			
			

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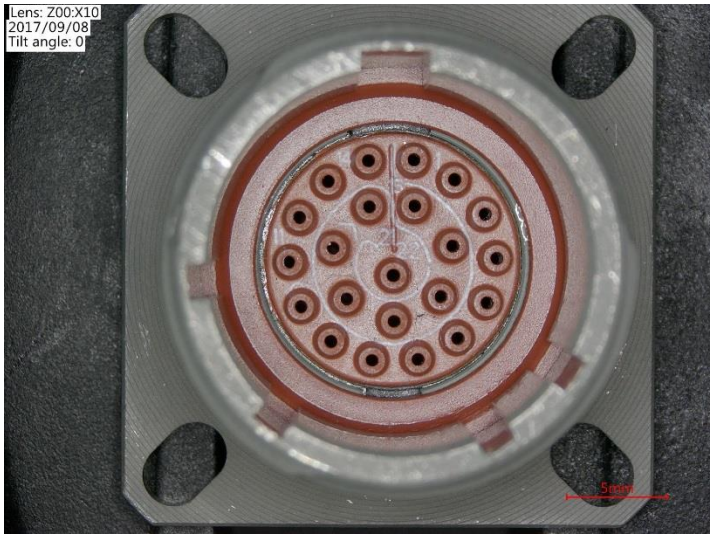
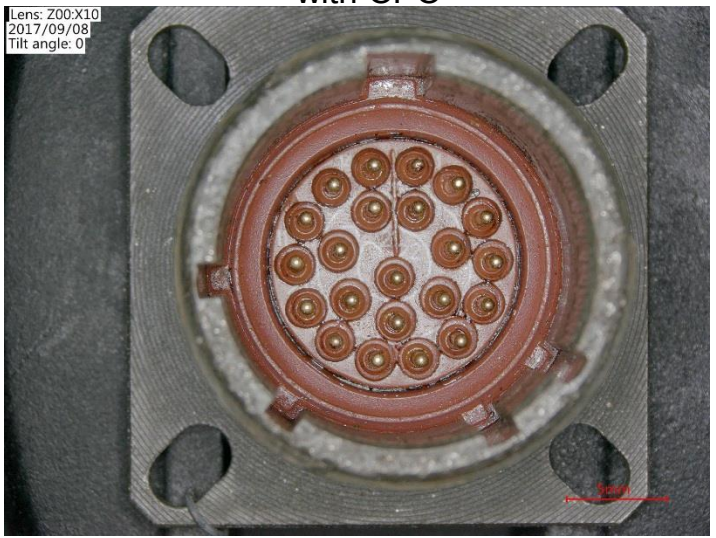
D38999, Group 1 Results

- Swelling was noted on the pin insert material

As-new example



Sample with CPC



D38999, Group 1 Results

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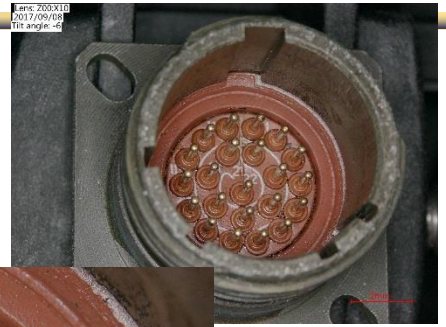
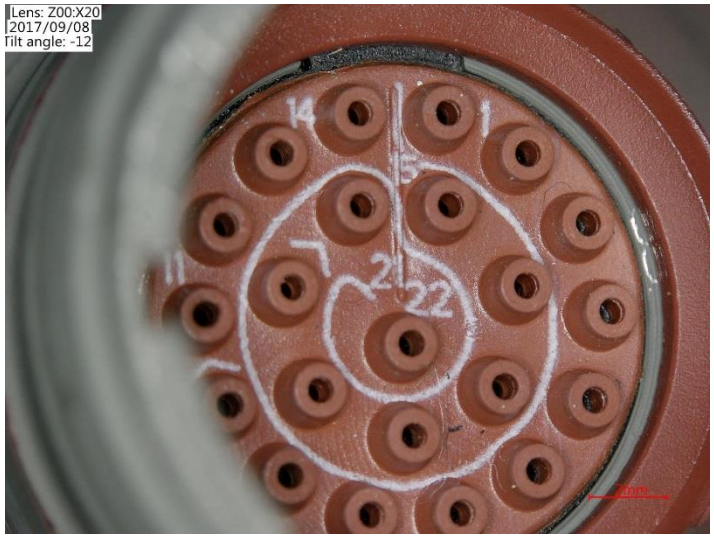
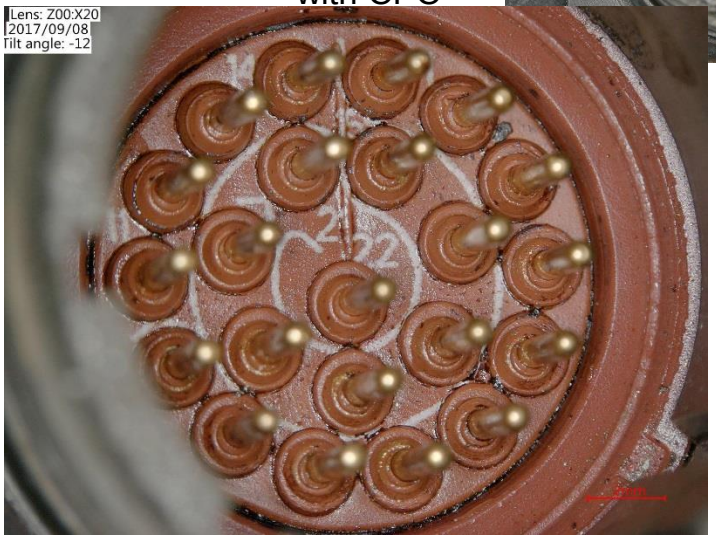


As-new example

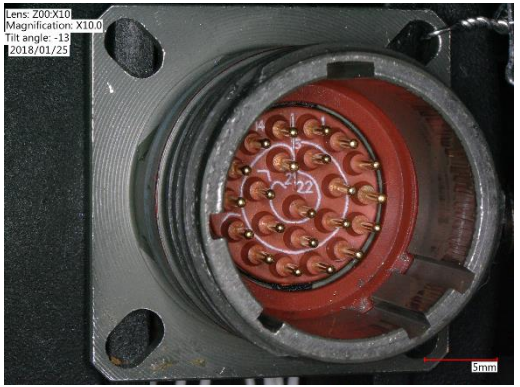


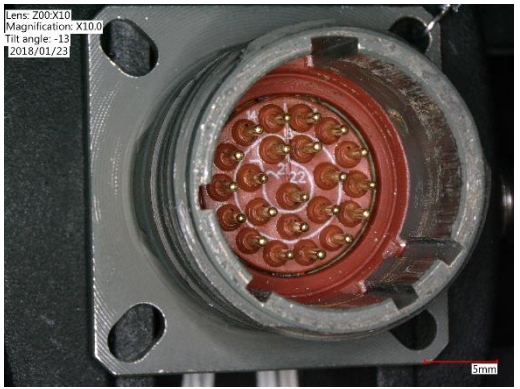
Sample with CPC



D38999, Group 2 Results

- Electrical performance problems much less prevalent
  - Isolated to a few connectors, more random behavior
- Visual examination showed swelling of insert materials
- Post thermal condition was less granular and gritty, more “gunky”
- Notable deformation of pin seals

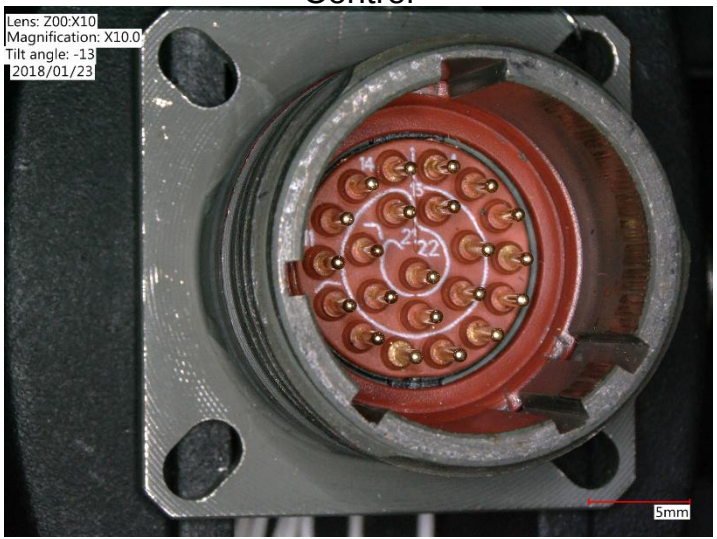




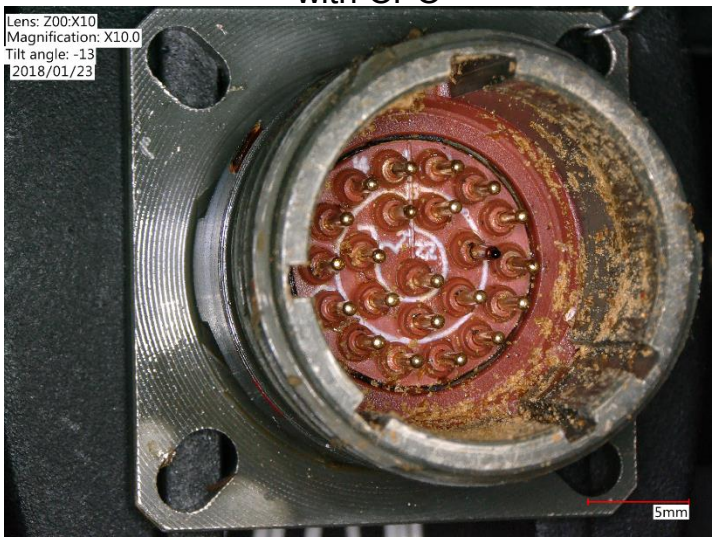
D38999, Group 2 Results

- Residue material present in connectors
  - Less gritty than Group 1, more moisture present

Sample Control



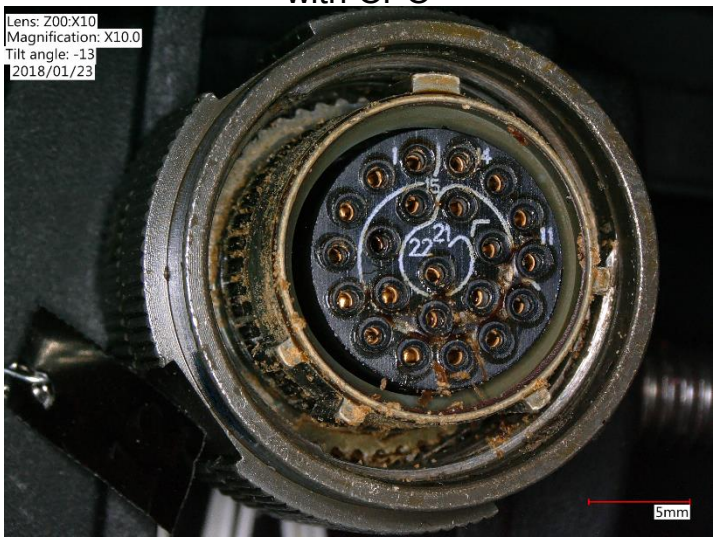
Sample with CPC



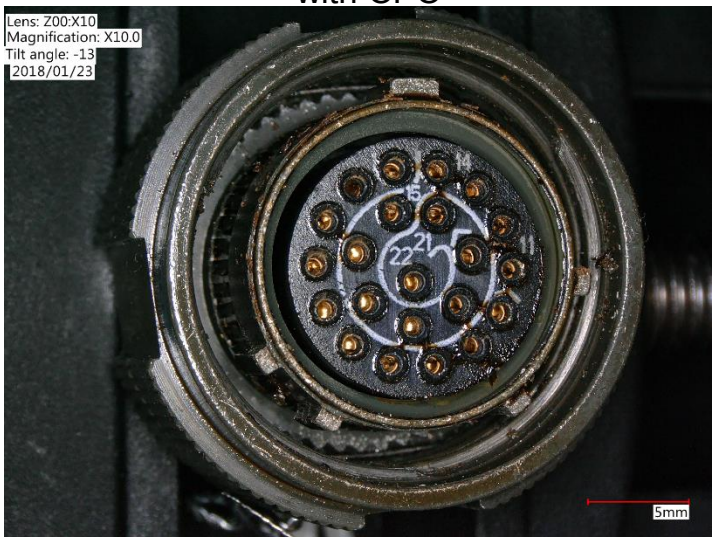
D38999, Group 2 Results

- Severe gunk present in connectors with applied CPC

Sample with CPC



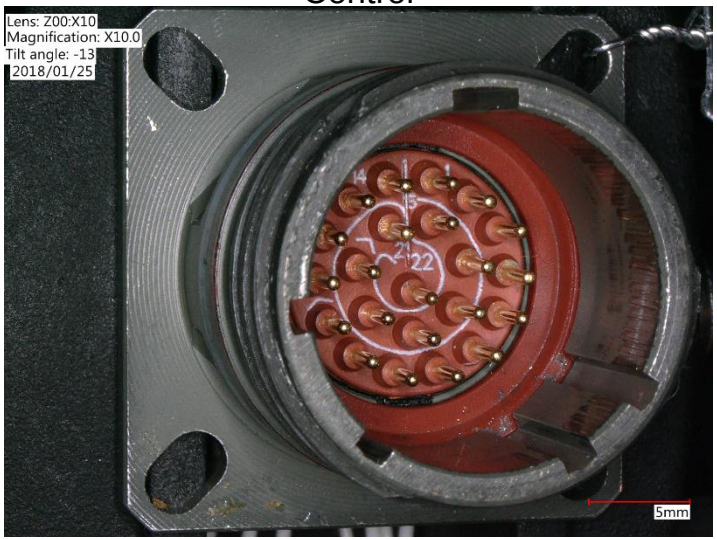
Sample with CPC



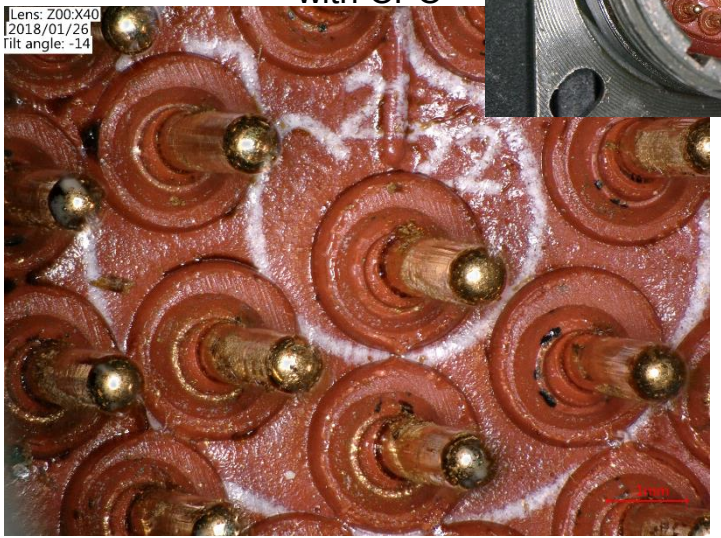
D38999, Group 2 Results

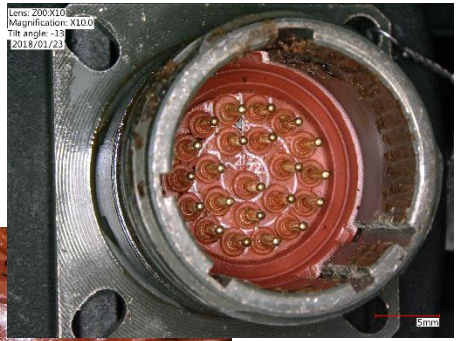
- Swelling causes permanent deformation of pin seal geometry
- Also note swelling of outer and inner inserts/grommets

Sample Control



Sample with CPC

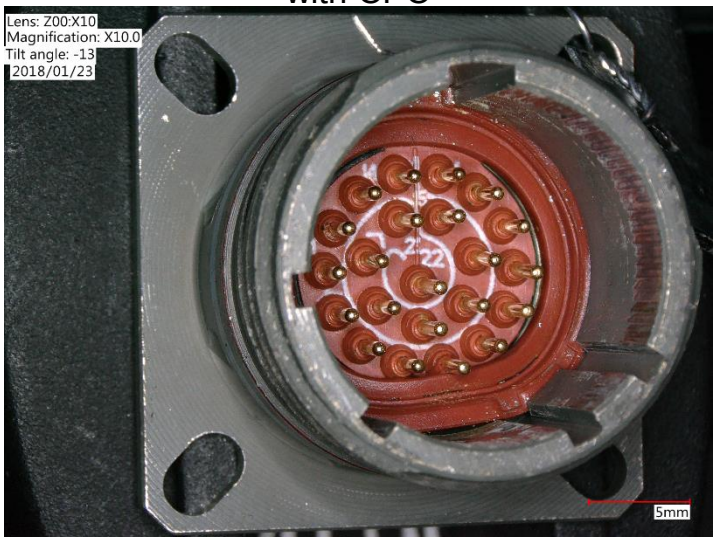




D38999, Group 2 Results

- Special finding – pin pierced through outer grommet material

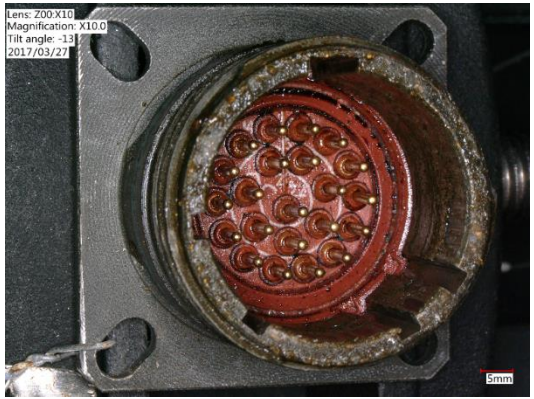
Sample with CPC



Sample with CPC

CPC Effects on EWIS

- What's next?
  - Insert fluid compatibility test (swell) completed (UDRI) – report soon
    - Novec Plus, Navguard, So-Sure 813 all increase in volume
    - Stabilant 22, Super Corr A initially increase, but then revert (net volume loss)
    - Volatiles trapped in connector, will not freely evaporate
  - Group 2 connectors have completed 1000 hour temp exposure (125 °C) and 500 hour salt fog
    - Awaiting final electrical characterization
  - M24308 – two groups of similar testing



CPC Impact on EWIS Hardware

- Navy helicopters submitted IRAC for standard application methods
- Aircraft SPOs re-wrote tech manuals
- Modifications to T.O. 1-1A-14
- Proposed modifications to T.O. 1-1-689
  - Major culture change w.r.t. connector maintenance
- Joint service wide awareness, buy-in
- Lowered risk → increase in safety, mission readiness

- QUESTIONS?

INTERIM RAPID ACTION CHANGE

Date: 12 May 2015

Category: Priority

From:

To:

Subj:

WARNING

Do not apply Corrosion Preventive Compound, MIL-PRF-81309, Type III, to internal sections of connectors and receptacles. Serious damage to equipment, possibly resulting in system failure, fire and personnel injury may occur.

a. Do not apply any CPC to insulation of any wire or cable type. For maximum effectiveness, wires and cables shall be clean and dry. Contamination with fluids and debris, degrades the wire insulation and wiring system operation.

Thank You