



# **Environmentally Friendly Corrosion Protection in Cleaning Systems for United States Coast Guard Aircraft**

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# Outline

- Introduction
- Experimental
- Results
- Discussion
- Conclusions

# **Introduction**

# Scope

- US Coast Guard desired a cleaner incorporating corrosion inhibitors
- To be used as a preventative maintenance product

# The Problem

- Corrosion on Aircraft
  - Caused by contamination
  - Can occur even on painted surfaces

# The Solution

- Development of a Maintenance Cleaner
  - Used to remove various contaminants
  - Should include corrosion inhibitors
  - Must meet specified criteria

# Performance Criteria

- Cleaning Ability
- Corrosion Protection
- Must Meet Mil-C-87973

# Cleaning Properties

- No standardized testing to evaluate cleaning properties
- Field testing implemented based on comparative analysis
  - Rate of removal
  - Foaming properties
  - Water break-free surface

# Cleaning Properties

- Must Remove Contaminants
  - Dirt
  - Grease
  - Oils
  - Exhaust
  - Salts

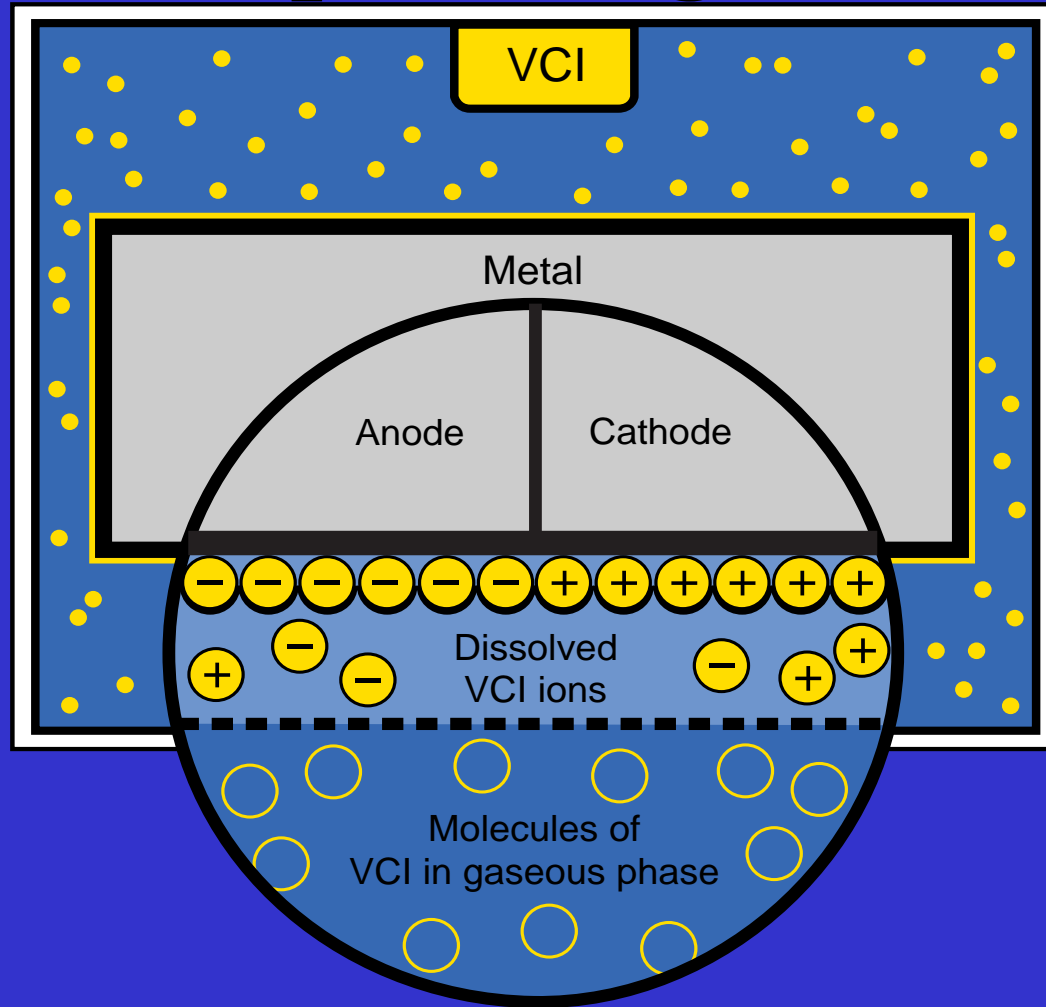
# New VCI Cleaner Tested



# Corrosion Prevention

- VCI Cleaner needs to provide short-term protection
- Part of a preventative maintenance program
- Areas of concern include
  - lap joints
  - flange areas
  - landing gear

# Incorporating VCI's



# Experimental

# Material Compatibility

- Rubber Compatibility Testing
  - ASTM D 2240
  - 25% VCI cleaner solution used
  - Specimens fully immersed for 30 minute interval

# Material Compatibility

- Stress Crazing of Acrylic Plastic
  - ASTM D 484-83
  - Test specimens placed under bending stress
  - Test interval depends on the type of plastic

# Material Compatibility

- Effects of VCI Cleaner on Unpainted Surfaces
  - ASTM F 485-90
  - Specimen fully immersed
  - 24 hour testing period

# Material Compatibility

- Effect of VCI Cleaner on Painted Aircraft Surfaces
  - ASTM F 502
  - Measures a change in pencil hardness of the coating
  - Visual inspection for any staining

# Corrosion Testing

- Low-Embrittling Cadmium Plating
  - ASTM 1111-88
  - Specimens totally immersed
  - Evaluated quantitatively by weight loss

# Corrosion Testing

- Sandwich Corrosion
  - ASTM F 1110
  - Specimens sandwiched using saturated filter paper
  - Cyclic test between warm ambient air and warm humid air
  - Seven day testing period

# Corrosion Testing

- Total Immersion Corrosion
  - ASTM F 483
  - 24 hour testing period
  - Evaluated quantitatively by weight loss

# Corrosion Testing

- Half Immersion Corrosion
  - ASTM G 31-72
  - Specimens partially immersed in closed container
  - 30 day testing period
  - Used to test VCI ability of cleaner

# Environmental

- Biodegradation
  - EPA 28-day BOD/COD Test

# Results

# Compatibility Results

- Rubber Compatibility Test (ASTM D 2240)
  - Two types tested
    - AMS 3204
    - AMS 3209
  - No change in Shore A hardness

# Compatibility Results

- Acrylic Plastic Compatibility Test (ASTM F 484-83)
  - Three types tested
    - MIL-P-5425
    - MIL-P-83310
    - MIL-P-25690
  - No crazing evident

# Compatibility Results

- Effects of VCI Cleaner on Unpainted Surface (ASTM F 485-90)
  - Two Alloys Tested
    - Aluminum 7075-T6
    - Titanium 6 Al-V4
  - No Staining
  - No Residue

# Compatibility Results

- Effects of VCI Cleaner on Painted Aircraft Surfaces (ASTM F 502)
  - Test panels done in duplicate
  - No change in pencil hardness was found
    - Rated 4H before
    - Rated 4H after
  - No streaking, discoloration, or blistering

# Corrosion Testing Results

- Corrosion of Low-Embrittling Cadmium Plate (ASTM F 1111-88)
  - Average weight loss of 10.6 mg
  - Within acceptable limits

# Corrosion Testing Results

- Sandwich Corrosion Test
  - VCI Cleaner passes 7 day test
  - No visible corrosion after testing period

# Corrosion Testing Results

- Total Immersion Corrosion (ASTM F 483)
  - Five substrates tested
    - AMS 4037 Bare Al; anodized per MIL-A-8625
    - AMS 4037 Bare Al
    - AMS 4911 Ti (MIL-T-9046)
    - AMS 5045 Grade 120 Steel
    - AMS 5504; 410 SS, silver plated per QQ-S-365

# Corrosion Testing Results

**Table 7**  
**Total Immersion Corrosion (ASTM F 483)**

<b>Alloy</b>	<b>Weight Loss (mg) After 24 hrs</b>	<b>Weight Loss (mg) After 168 hrs</b>	<b>WGT Loss mg/cm<sup>2</sup>/24hrs</b>
AMS 4037 Bare Al; anodized per MIL- A-8625 Type 1	<0.1	+0.2	<0.01
AM 4037 Bare Al	<0.1	<0.1	<0.01
AMS 4911 Ti MIL-T-9046	<0.1	<0.1	<0.01
AMS 5045 Grade 1020 steel	0.1	<0.1	<0.01
AMS 5504; 410 SS, silver plated Per QQ-S-365 Ty II, Grade B	0.6	0.4	0.02

**Note: No visible corrosion on any panel**

# Corrosion Testing Results

- Half Immersion Corrosion(ASTM G 31-72)
  - Two substrates tested
    - 1010 Carbon Steel
    - 3041 Bare Al
- Panels tested with VCI cleaner contained no corrosion during testing period
- Test panels evaluated by visual inspection
- Control fails in less than 24 hours

# Corrosion Testing Results

## Half Immersion Corrosion (ASTM G 31-72)

Alloy	Time Before Corrosion (Days) Control	Time Before Corrosion (Days) VCI Cleaner
1010 Carbon Steel	<1	>30
3041 Bare Al	<1	>30

# Biodegradability Results

- VCI Cleaner Passes 28-day Test
  - Tested undiluted
  - BOD/COD ratio is 0.66

# Discussion

# Discussion

- VCI Cleaner Passes Field Trials
  - Easy-to-use
  - Removes all contaminants
  - Provides corrosion protection

# Discussion

- VCI Cleaner Passes Material Compatibility
  - Rubber compatibility
  - Acrylic plastics
  - Unpainted aircraft surfaces
  - Painted aircraft surfaces

# Discussion

- VCI Cleaner Passes Corrosion Testing
  - Low-embrittling cadmium plating
  - Sandwich corrosion
  - Total immersion
  - Half immersion

# Summary

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- VCI Cleaner Passes Field Cleaning Tests
- VCI Cleaner Provides Desired Corrosion Protection as a Maintenance Product
- VCI Cleaner Conforms to MIL-C-87973

# VCI Cleaner Implemented

