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CLEANING AND CORROSION CONTROL OF AVIONICS EQUIPMENT AT ALL LEVELS OF MAINTENANCE

W. E. MacKenzie, et al

Naval Air Development Center
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This report covers a survey of cleaning and corrosion problems encountered with avionics systems, the application of a new cleaner for components, and a process for corrosion control of avionics components and systems at the three maintenance levels.

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SUMMARY

INTRODUCTION

Corrosion control of avionics equipment should be applied at two stages; viz., the first and essentially the more important, the design stage, and secondly, in the maintenance of existing equipment. Frequent inspections and corrosion control should be directed to three elements: (1) gross contamination and corrosion of structural parts, (2) electromechanical parts and (3) electronic components, the most critical area. The scope of this investigation was directed to the corrosion control of existing equipment and the establishment of a corrosion control technique that will be applicable to all maintenance levels but is essential for use at squadron and intermediate levels where engineering support is not readily available.

This work was authorized by the NAVAIRSYSCOM (Naval Air Systems Command) (AIR 411B4), and conducted under NAVAIR Project Order P.O. 1-0136, Maintenance Engineering Support - Organization, Intermediate, and Depot Level.

RESULTS

A cleaner for electrical contacts has been successfully demonstrated at NAS (Naval Air Station) Oceana, NAS Norfolk, NAS Miramar, NAS Whidbey and NAS North Island. A more complete list of demonstration sites is included in Appendix B.

Methods for gross contamination removal and corrosion control that can be accomplished at the organizational and intermediate levels have also been demonstrated.

Illustrated guidelines intended mainly for corrosion control at the intermediate but useful at all maintenance levels have been prepared and are contained in Appendix A.

CONCLUSIONS

It is concluded that:

1. Greater consideration must be given to corrosion prevention in the selection of materials at the design stage of future equipment. Points to consider are:

   a. Corrosion resistant materials for construction
   b. Corrosion resistant structural coatings
   c. Better insulating materials
   d. More adequate sealing to minimize moisture damage
   e. More selective plating materials to lessen the damage of specific types of corrosion

2. Most of the corrosion found on avionics equipment could be prevented by more frequent cleaning and inspections, recognition of corrosion and timely corrective action.

3. To reduce the amount of corrosion control work at the depot level there must be guidelines issued for preventive maintenance and corrosion control at the squadron and intermediate levels.

4. Cleanliness and the maintenance of moisture-free surfaces are the two most critical items governing the continued operation of avionics equipment.

RECOMMENDATIONS

It is recommended that:

1. Design requirements for future avionics equipment specify the use of corrosion resistant materials.

2. Existing avionics equipment be maintained clean and timely corrosion control be conducted.

3. Inspections for contamination and corrosion be regular and frequent. At the time of inspections, in-depth work required should be completed and the maintenance cycle retimed.

4. The procedure described in Appendix A be followed for corrosion control.

5. The recommendations of paragraphs 3 and 4 be included in the maintenance requirements cards.

FUTURE ACTION

The next phase proposed for this study will include:

1. Investigation of ultrasonic cleaning procedures with detergents and solvents.

2. Development and standardization of protective coating systems to provide the necessary degree of impermeability, fungus and corrosion resistance.

3. Development and standardization of electroplating techniques on conducting surfaces to obviate in-service metallic migration which results in plating ineffectiveness termed "red and purple plague" by the fleet.

4. Ascertain compatibility of various metallic coatings consistent with the revision to MIL. STD. 889.

5. Development of procedures for the removal and replacement of organic conformal coatings and ascertain electrical compatibility of such coatings.

TABLE OF CONTENTS

	Page
SUMMARY	
Introduction	iii
Summary of Results	iii
Conclusions	iii
Recommendations	iv
Future Action	iv
DISCUSSION	
Background	1
Areas Susceptible to Attack	1
Basic Treatments	3
Cleaning Material for Electronic Parts	3
APPENDIXES	
A NADC Procedure No. 30223A, Corrosion Control of Avionics Components	A-1
B List of Avionics Corrosion Control Demonstration Sites	B-1

DISCUSSION

BACKGROUND

A review of naval repair procedures disclosed that a contributing factor in the high maintenance requirements for airborne electronics equipment (avionics) has been the lack of preventive maintenance guidelines and standards. Reduced maintenance is sometimes associated with short service life components but is not applicable for the overall electronics equipment system.

Guidelines for preventive maintenance in corrosion control have not been established during the design stage since emphasis was not directed toward maintainability. This has resulted in considerable repair (due to corrosion damage) being conducted in selective IMA's (Intermediate Maintenance Avionics Repair Facilities). In many instances, major overhauls of malfunctioning equipment could be eliminated by the cleaning of two facing connectors.

To date, there have been no guidelines for corrosion control of avionics equipment at either the organization or intermediate maintenance activities. Most equipment, as designed, is functional until subjected to the operational environment. During development and functional testing stages, the equipment is usually exposed to atmospheric pressure, temperatures of 75 to 80 deg F and a relative humidity of 40 to 60%. Evaluation procedures may simulate extreme conditions but cannot cover all service variables over temperatures from -80 to 165 deg F, relative humidities to 100% and reduced pressures (altitudes ranging to 50,000 feet). Items that appear insignificant during the design stage such as drops of vapor or minute particles of dust can become lodged in critical components and cause failure.

Corrosion control procedures should emphasize clean and moisture-free surfaces. Cleanliness cannot be over emphasized; however, the choice of cleaning agents is critical and damage can also occur from overcleaning. For example, acid cleaning can lead to hydrogen embrittlement of steels and titanium or entrapped acid or alkaline cleaners can lead to galvanic corrosion. Indiscriminate ultrasonic cleaning may be harmful to diodes. Even manual scrubbing can damage printed circuits and insulating coatings. The removal of moisture is critical since it accelerates the corrosive action initiated by contaminants. Moisture also promotes the growth of mildew, which can accelerate corrosion leading to system failures.

AREAS SUSCEPTIBLE TO ATTACK

The areas of corrosive attack can be divided into the following three categories:

Structural

Parts including housings, covers, supports, brackets, cabinets, chassis are required for structural support and although corrosion is not immediately harmful, it should be treated to eliminate long term deterioration. Corrosion is usually of a gross nature and consists essentially of coatings failure and subsequent attack on exposed metal. The corrosion is caused by handling or environmental attack such as moisture and/or microbial contamination. The prime danger from this type corrosion is flaking and susbsequent contamination of more critical parts. Major repair or corrosion control treatment should be performed at the depot level. Preventive maintenance and touch-up procedures may be accomplished at the intermediate level of maintenance with minor assistance from the organizational level. Appendix A outlines a procedure for corrosion control.

Electromechanical

Motion is an integral function of electromechanical switches, relays, potentiometers, motors, generators, and synchro parts. Storage or non-use in less than desirable environments tend to promote corrosion of these parts. The principle causes of malfunction are dust, condensates and resultant corrosion products such as oxides and organic contaminant films. Failure of these parts normally does not occur during operation. The friction tends to keep the critical surfaces clean enough to permit operation. Insulating films form during non-use and prevent start-up of equipment. Once the equipment is activated the insulation is sufficiently removed via friction between surfaces.

Electronic

Electronic systems are susceptible to three major types of corrosion, viz: (1) chemical attack, (2) galvanic action, and (3) pitting associated with externally applied voltage.

1. Chemical attack may occur as

   a. surface contamination
   b. crevice corrosion
   c. porous casting attack
   d. fungi attack

and may lead to:

   (1) dendritic corrosion product formation
   (2) stress corrosion
   (3) hydrogen embrittlement
   (4) intergranular corrosion

The prevention of corrosion in a, b, and c are primary targets of this investigation. Corrosion cited in d and (4) is also under examination. It should be noted that the types of deterioration such as (2), (3), and (4) can be eliminated during the design stage.

2. Galvanic corrosion occurs when the insulating materials are absent or deteriorated. At present, the maintenance and repair of insulating materials is critical to lessen the danger of attack. The prevention of future galvanic corrosion can best be prevented by the specification of better insulating materials during the design stage.

3. <u>Externally applied voltage</u> corrosion control is essentially a design problem; however, there are several instances where proper and timely maintenance will minimize damage. Careful cleaning to remove soluble salts and the maintenance to establish moisture-free surfaces are two techniques that can be applied to this problem area.

BASIC TREATMENTS

Four basic corrosion treatments for electronic equipment are:

a. Application of materials and finishes not deteriorated by moisture, temperature, salt, fungi, etc.

b. Changing the environment to reduce/eliminate corrosion accelerators, including (1) removing moisture, (2) cooling, and (3) removing fungi.

c. Preventing corrosive media from contacting the surface of materials by (1) sealing assemblies, (2) encapsulating components, and (3) coating parts.

d. Detecting and repairing deterioration prior to serious malfunction by periodic inspection and maintenance.

CLEANING MATERIAL FOR ELECTRONIC PARTS.

During extensive surveys of avionics repair shops it was observed that two solvents were used extensively. The first solvent was 1,1,1 trichloroethane (methyl chloroform). This material has been used as a substitute for (a) flammable napthas and (b) toxic solvents such as carbon tetrachloride. Methyl chloroform has limitations since it may attack certain insulation, potting compounds, seals and sealant materials. This solvent is covered by the requirements of MIL-T-81533 and should be procured in accordance with the requirements of that specification.

The second solvent in widespread use was 1,1,2 trifluoro - 1,2,2 trichloroethane. These materials, as used in aerosol containers, were not in conformance with military specifications. The solvent is covered in bulk by the requirements of MIL-C-81302, Precision Cleaner. A chemically equivalent material has been recommended for use until the specification can be amended. This material is carried in the federal stock system as a cleaning compound, solvent under FSN 6850-105-3084. This solvent, while extremely useful as a precision cleaner, has a major drawback. The rapid evaporation rate produces supercooling and moisture deposition. Two effects may then occur: (a) corrosion can be promoted by the solution of water soluble salts present on the surfaces and in crevices, or (b) moisture formed can turn to ice at high altitudes and low temperatures causing failure of a crucial component.

Evaporation retardants compatible with trichlorotrifluoroethane (MIL-C-81302) were investigated. Methyl siloxanes have been recommended as lubricants for electrical and electronic contacts and are compatible with MIL-C-81302 type cleaning solvent. Siloxane fluids conforming to Federal Specification

VV-D-1078A were evaluated as evaporation retardants. Fluids with a viscosity of 100 centistokes (c St) and above at 25 deg C were eliminated since this group left residual oily, visible deposits.

Fluids of decreasing viscosities were evaluated. The viscosity grade resulting in no visible deposit was 0.65 c St at 25 deg C. Samples were prepared containing 0.2, 0.3, 0.4, and 0.6% siloxane based on the weight of active cleaning solvent. The samples were packaged in aerosol containers using "Freon 12" as the propellant. The cleaner was sprayed on aluminum surfaces and allowed to evaporate. The unretarded MIL-C-81302 solvent evaporated rapidly, cooling the metal and leaving droplets of water condensation. The percentage of siloxane additive that would wet the surface yet evaporate without leaving moisture deposits was in the range of 0.3%.

Several cans of electronic cleaner (MIL-C-81964, Cleaning Compound, Avionics Components) identified as AML 555 were prepared and included in a corrosion control system. The corrosion control system also includes a water displacing preservative designated MIL-C-81309, Avionics Grade. This system was demonstrated at the NAVAIRSTA (Naval Air Station) Oceana, NAVAIRSTA Whidbey Island, NAVAIRSTA Norfolk, NAVAIRSTA Jacksonville, NAVAIRSTA Pensacola, NAVAIRSTA Brunswick and NAVAIRSTA Miramar. An extensive and successful evaluation program has been conducted at NAVAIRSTA Oceana. This program is being expanded to include a number of additional maintenance activities.

A P P E N D I X A

NADC PROCEDURE NO. 30223A
CORROSION CONTROL OF AVIONICS COMPONENTS

LIST OF FIGURES

Figure		Page
1	Materials for Cleaning and Corrosion Control of Avionics Equipment.	A-5
2	Removal of Contaminants from Switch with Avionics Cleaner	A-5
3	Eraser for Light Tarnish Removal from Contact Points	A-5
4	Cleaning and Rinsing Contact Points with Avionics Cleaner and Special Brush	A-5
5	Soil and Dust Removal from Contact Pins with Special Brush and Avionics Cleaner.	A-6
6	Light Tarnish Removal from Contact Pins	A-6
7	Rinsing Contact Pins with Avionics Cleaner.	A-6
8	Cleaning Electrical Connectors with Avionics Cleaner and Special Brush	A-6
9	Preserving Electrical Connector with Water Displacing Ultra Thin Film Preservative Compound, Avionics Grade	A-7
10	Wiping Excess Preservative Compound from Electrical Connector.	A-7
11	Removal of Light Corrosion from Non Critical Surfaces with Abrasive Mat.	A-7
12	Preserving Exposed Surfaces after Corrosion Removal	A-7

APPENDIX A

NADC PROCEDURE NO. 30223A
CORROSION CONTROL OF AVIONICS COMPONENTS

The procedures detailed herein are illustrated in enclosure (1) and should be used as a guide in the proper selection and application of the materials listed in enclosure (2).

Cleaning

Cleaning of avionics components to remove dust, dirt, and other contaminants is accomplished using AML 555 avionics cleaner (Item 1) and the special spray and brush adapter shown in Figures 2, 4, 5, and 8. Insert tube of special brush adapter into the spray head of the avionics cleaner. Position the avionics component to insure adequate access of the cleaner to all parts including switches, contacts, and pins. Depress spray head, then brush component to be cleaned, using minimum amount of cleaner to assure effective cleaning. Bristle length may be adjusted to suit requirements. When contaminants have been loosened by spraying and brushing, remove the brush and spray the cleaner onto the part to rinse away the loosened contaminants, Figure 7.

Light Corrosion Removal

Light corrosion/tarnish removal is accomplished by rubbing contact points and pins with a ruby red eraser (Item 4) until metal appears bright, Figure 3 and 6. Rinse residual eraser material away by spraying and brushing with cleaner and special brush as in Figure 4 and 7.

Light corrosion should be removed from non-critical surfaces using abrasive mat (Item 7) and rubbing until all traces of corrosion are gone (Figure 11). Light tarnish may be removed using the metal polish (Item 5) and a lintless wiping towel (Item 6).

Preservation

After cleaning and corrosion removal, bright surfaces must be protected to insure that corrosion does not return. On electrical connectors, chassis, dust covers, and exposed surfaces, a light coating of water displacing, ultra thin film preservative compound avionics grade (Item 2) should be used to protect these surfaces from further corrosion. Components should be sprayed with a light film of preservative as in Figures 9 and 12 avoiding excessive application of preservative. If there is an excess it may be wiped off, Figure 10.

Material Notes:

ITEM 1 — Avionics cleaner (AML 555) will be initially supplied in small quantities by NAVAIRDEVCEN, Warminster. Assignment of a federal stock number is in progress.

ITEM 2 — Water displacing, preservative compound, ultra thin film, avionics grade will be initially supplied in small quantities by NAVAIRDEVCEN, Warminster. Assignment of a federal stock number is in progress.

ITEMS 8, 9, 10 — The special cleaner, avionics equipment, spray and brush type is supplied with the kit as a sample. These tools may be manufactured locally following instruction provided in enclosure (3), NADC drawing No. ARP-73-6. Items 8 and 9 are stock items, the plastic extension tubes may be purchased locally.

FIGURE 1
MATERIALS FOR CLEANING AND CORROSION CONTROL OF AVIONICS EQUIPMENT

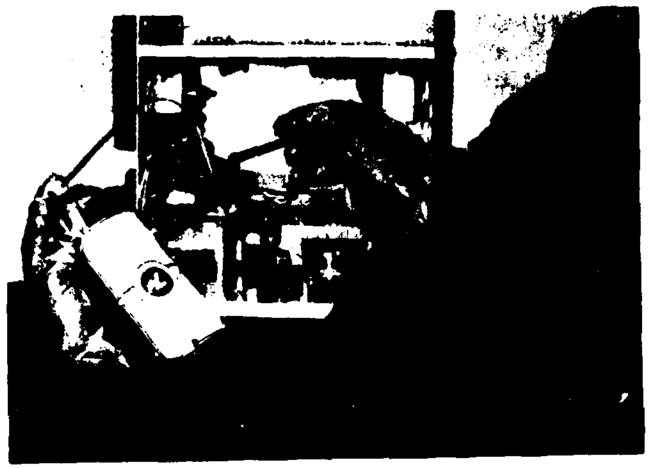


FIGURE 2
REMOVAL OF CONTAMINANTS FROM SWITCH WITH AVIONICS CLEANER

FIGURE 3
ERASER FOR LIGHT TARNISH REMOVAL FROM CONTACT POINTS

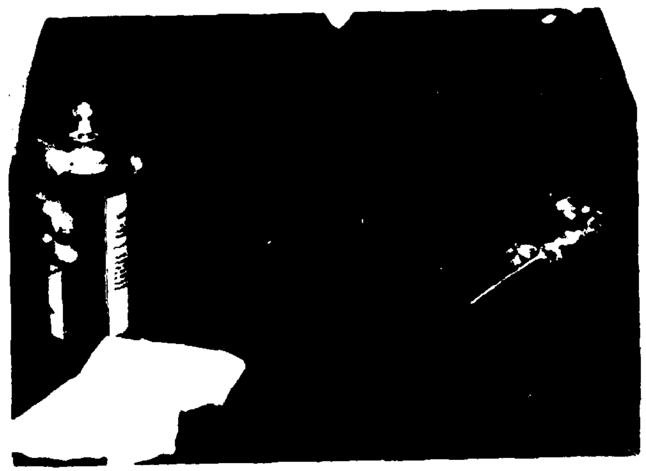


FIGURE 4
CLEANING AND RINSING CONTACT POINTS WITH AVIONICS CLEANER AND SPECIAL BRUSH

ENCLOSURE (1)

FIGURE 5
SOIL AND DUST REMOVAL FROM CONTACT PINS WITH SPECIAL BRUSH AND AVIONICS CLEANER

FIGURE 6
LIGHT TARNISH REMOVAL FROM CONTACT PINS

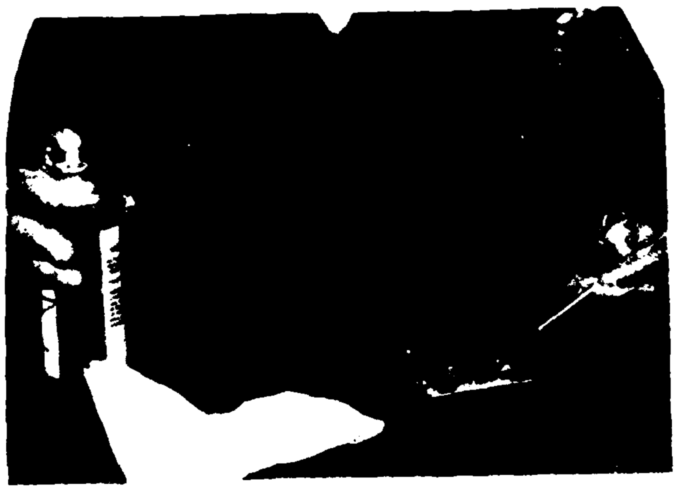


FIGURE 7
RINSING CONTACT PINS WITH AVIONICS CLEANER

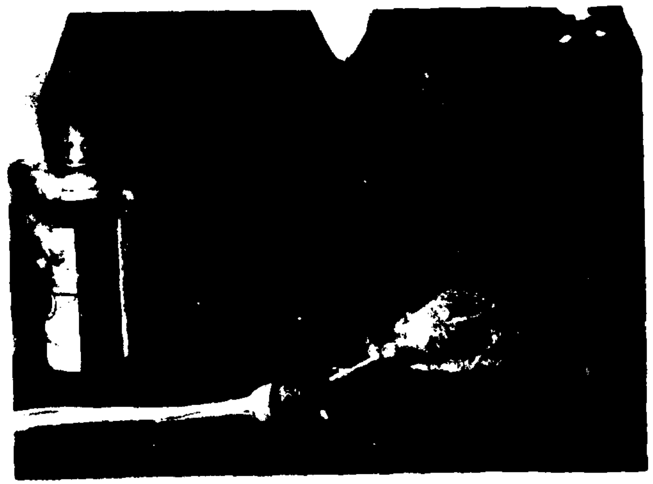


FIGURE 8
CLEANING ELECTRICAL CONNECTORS WITH AVIONICS CLEANER AND SPECIAL BRUSH

ENCLOSURE (1)

FIGURE 9
PRESERVING ELECTRICAL CONNECTOR WITH WATER DISPLACING ULTRA THIN FILM PRESERVATIVE COMPOUND, AVIONICS GRADE

FIGURE 10
WIPING EXCESS PRESERVATIVE COMPOUND FROM ELECTRICAL CONNECTOR

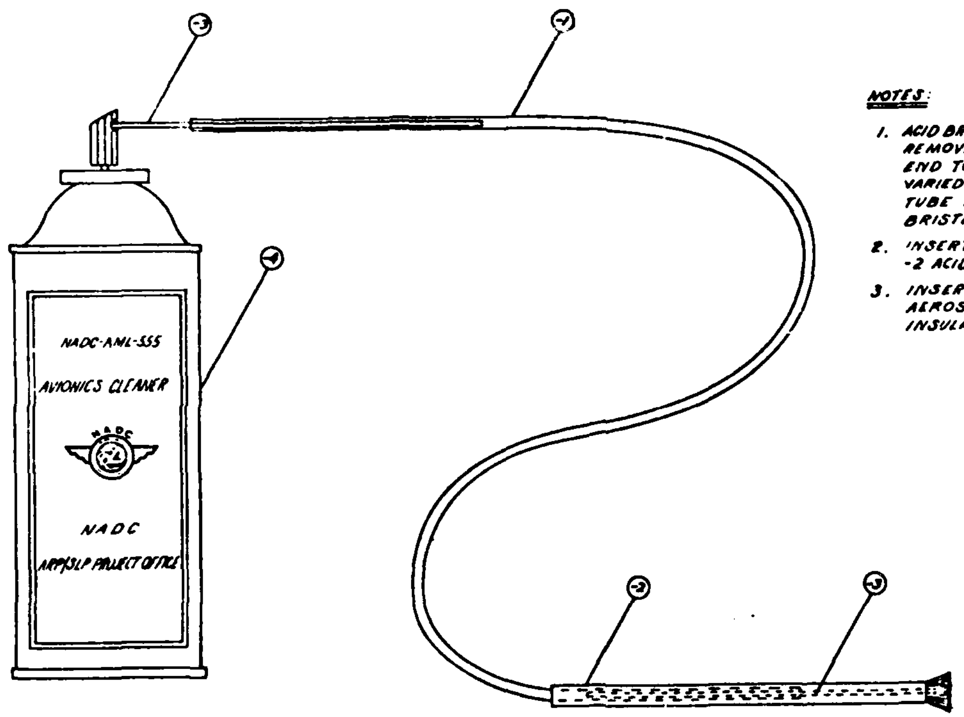
FIGURE 11
REMOVAL OF LIGHT CORROSION FROM NON CRITICAL SURFACES WITH ABRASIVE MAT

FIGURE 12
PRESERVING EXPOSED SURFACES AFTER CORROSION REMOVAL

ENCLOSURE (1)

MATERIALS LIST

ITEM	
1	Avionics Cleaner (AML555) (MIL-C-81964)
2	Water displacing, preservative compound, ultra thin film, avionics grade
3	Plastic gloves, disposable (FSN 6515-051-1950)
4	Rubber eraser, ruby-red, soft (FSN 7510-579-8551)
5	Metal polish MIL-P-6888 (FSN 7930-267-1224)
6	Towel, wiping, lintless (FSN 7920-965-1709)
7	Abrasive mat MIL-A-9962, very fine (FSN 5350-967-5089)
8	Brush, acid (FSN 9QC 7920-514-2417)
9	Insulation (.085 X 26" plastic tubing) 90-5970-543-1098
10	Plastic extension tube, open purchase



NOTES:

1. ACID BRUSH -2 TO BE MODIFIED AS FOLLOWS: REMOVE BRISTLES AND INSERT IN OPPOSITE END TO DESIRED LENGTH (LENGTH CAN BE VARIED TO SUIT). INSERT ONE -3 PLASTIC TUBE INTO OPEN END AND DOWN INTO BRISTLES.
2. INSERT -1 INSULATION INTO OPEN END OF -2 ACID BRUSH AND OVER -3 PLASTIC TUBE.
3. INSERT ONE -3 PLASTIC TUBE INTO -4 AEROSOL CAN NOZZLE AND SLIP INSULATION -1 OVER OPEN END OF TUBE.

BILL OF MATERIAL

PART NO.	MATERIAL	NO. REQUIRED
-1	9Q5970-543-1098 INSULATION .085 x 26" LONG	1
-2	9QC-7920-514-2417 ACID-BRUSH	1
-3	PLASTIC TUBE .085 O.D. x 5" LONG	2
-4	AEROSOL CAN - AVIONICS CLEANER NADC-AML-SSS	1

DO NOT SCALE THIS DRAWING

NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA. 18974

CLEANER - AVIONICS - EQUIPMENT
SPRAY & BRUSH TYPE

SIZE C | CODE IDENT NO 80206 | NADC DWG NO ARP-73-6

SCALE FULL | SHEET 1 OF 1

APPENDIX B

LIST OF AVIONICS CORROSION CONTROL DEMONSTRATION SITES

The Naval Air Development Center has supplied limited quantities of materials for corrosion control of avionics components and/or demonstrated the procedure at the following locations:

1. CONUS Naval Air Rework Facilities

2. AIMD's located as follows:

   a. Brunswick, ME
   b. Norfolk, VA
   c. Oceana, Virginia Beach, VA
   d. Cherry Point, NC
   e. Cecil Field, FL
   f. Pensacola, FL
   g. Glenview, IL
   h. Miramar, CA
   i. North Island, San Diego, CA
   j. Moffett Field, Mountain View, CA
   k. Alameda, CA
   l. Whidbey Island, WA
   m. Lakehurst, NJ
   n. Patuxent River, MD
   o. Jacksonville, FL
   p. Albany, GA

3. USS AMERICA (evaluation underway)

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