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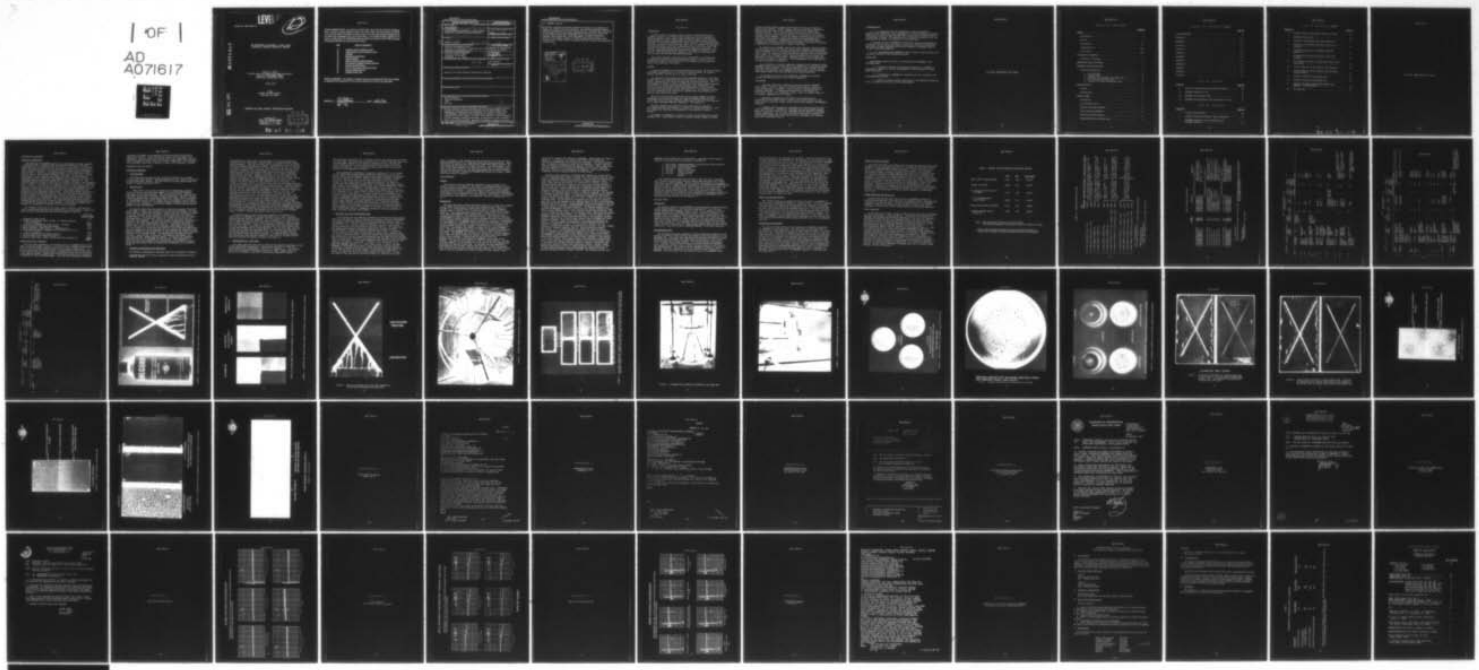

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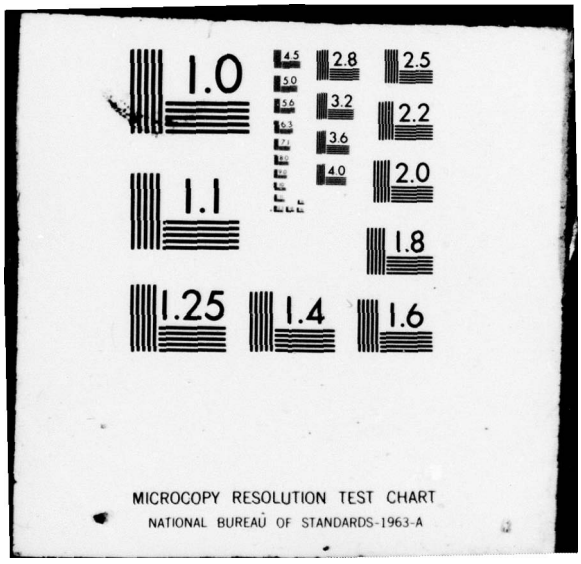
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THE DEVELOPMENT OF AMLGUARD, A CLEAR, WATER DISPLACING, CORROSION PREVENTIVE COMPOUND

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Previous corrosion control treatment used on exposed corrodible surfaces of naval aircraft required the application of two materials: a water displacing, corrosion preventive compound, MIL-C-81309 (a brown, thin film material), followed by the application of corrosion preventive compound MIL-C-16173, Grade 4 (a brown, tacky material). This combination provided adequate corrosion protection, but deposited a rather unsightly brown, dirt attracting film. The need to develop a compound with water

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20. ABSTRACT (cont'd)

displacing, corrosion preventive properties resulting in the deposit of a clear, dry, flexible film was essential. The recently developed compound AMLGUARD, designed with the above characteristics, fulfilled these objectives and performed successfully during laboratory tests and fleet evaluations. Military Specification MIL-C-85054(AS) titled, Corrosion Preventive Compound, Water Displacing, Clear (AMLGUARD) was issued 23 March 1977. National stock numbers, 8030-01-041-1596 and 8030-01-045-4780 have been issued for the 16 ounce aerosol containers and the one quart bulk containers, respectively.

SUMMARY

INTRODUCTION

Exterior surfaces of naval aircraft require constant maintenance to minimize corrosion. MIL-C-81309, water displacing corrosion preventive compound and MIL-C-16173, Grade 4 were extensively used by organizational and intermediate levels of maintenance to protect damaged areas of painted surfaces, but were unsatisfactory for several reasons. Both compounds being soft, pick up corrosive salt particles, dirt, and are unsightly in appearance. There was obviously a need for a compound that would produce a clear, dry, flexible film with water displacing, corrosion preventive properties. The Naval Air Development Center was tasked under AIRTASK WF 54-593-201, Work Unit No. ZM301 to develop such a material. The compound developed which fulfills this need has been designated AMLGUARD.

This report provides a detailed history of AMLGUARD, its formulation, the extensive laboratory testing program undertaken to evaluate the performance and chemical characteristics of the compound and the results of field tests conducted by the fleet.

RESULTS

A compound, AMLGUARD, has been developed which provides the three required performance characteristics; (1) ability to displace water, (2) protect against corrosion, and (3) dry to a clear, hard film.

The compound's water-displacing property depended primarily on the type solvent used in the formulation and its compatibility with other constituents without interfering with corrosion protection and film properties. The displacement or removal of water including salt water from a metallic surface was achieved by using a petroleum base solvent in the formulation. The drying time was controlled to allow water displacement to occur before a film could form over water droplets and entrap them. The compound's drying time was controlled by the selection of solvents used in the formulation based on their evaporation rate.

The use of silicone alkyd resin and silicone resin blended with small percentages of petroleum sulfonate and organic phosphate offer suitable corrosion protection without adversely affecting the required film properties of the newly developed compound, "AMLGUARD." (See Figure 1.)

AMLGUARD combines the properties of both specification compounds MIL-C-81309 and MIL-C-16173, Grade 4 in addition to being clear and dry without cosmetically affecting the appearance of the aircraft as shown in Figure 2.

The removal of AMLGUARD is achieved by wiping the surface with a solvent dampened cloth. Some solvents listed in Technical Manual, NAVAIR 01-1A-509,

Aircraft Weapons Systems Cleaning and Corrosion Control, are suitable for removing the compound. Advance surface analytical techniques conducted at Lehigh University confirm that, AMLGUARD can be totally removed from aluminum surfaces. This is particularly noteworthy since the compound contains silicone resins which are believed to be persistent and to affect subsequent paint adhesion. During the removal evaluation it was noted that MIL-C-43616 specification cleaners removed most of the AMLGUARD from aluminum test specimens. Consequently, where MIL-C-43616 specification cleaners are used during aircraft washing operations, the protective coating of AMLGUARD may be removed after a number of washings.

The evaluation of AMLGUARD conducted by fleet personnel supports results obtained during laboratory testing. Field reports indicate some additional uses of AMLGUARD; e.g., (1) on leading edges of aircraft wings and helicopter blades where the compound provides some erosion resistance for the underlying paint system; (2) on exhaust and gun blast areas where it facilitates the subsequent cleaning of those areas. AMLGUARD coated surfaces release dirt more easily as stated in Appendix A. Fleet endorsement of the compound will be found in Appendices A through F.

The new material, Corrosion Preventive Compound, Water Displacing, Clear (AMLGUARD) under Military Specification MIL-C-85054(AS), is available through the Federal Supply System. The compound packaged in both 16-ounce aerosol containers and one-quart bulk containers can be obtained using the national stock numbers 8030-01-041-1596 and 8030-01-045-4780 respectively.

The procedures for use of MIL-C-85054(AS) (AMLGUARD) for Aircraft Corrosion Prevention/Control can be found in Appendix K.

CONCLUSIONS

1. The water displacing, corrosion preventive compound, AMLGUARD (MIL-C-85054), provides a degree of corrosion protection to exterior aircraft surfaces that is superior to other in-service treatment materials currently available. It combines the properties of MIL-C-81309 and MIL-C-16173, Grade 4 and in addition, is dry, clear, and without effect on the cosmetic appearance of the aircraft.

2. Materials conforming to MIL-C-85054 can be substituted for MIL-C-81309 or MIL-C-16173 Grade 4 except on parts which require a lubricated surface, electrical contact areas, form-in-place gaskets, and removable fasteners.

3. AMLGUARD could be used as a replacement for touch-up paint for aircraft on board ships. AMLGUARD has salt-water displacing properties which MIL-P-23377 and MIL-C-81773 do not. AMLGUARD does not require as elaborate surface preparation. Its use would also permit reduction of inventory of various paint systems and colors during aircraft deployment and eliminate worry about isocyanate toxicity.

RECOMMENDATIONS

1. It is recommended that MIL-C-85054(AS), Corrosion Preventive Compound, Water Displacing, Clear (AMLGUARD), be used on corroded or corrosion prone areas of naval aircraft provided there are no closely fitted moving or sliding parts involved. The characteristic of AMLGUARD to produce a dry film when applied can impede the operation of these type parts.

2. Although the use of AMLGUARD on exterior of electrical connectors is acceptable, its use should be avoided on electrical contacts and connectors where metal to metal continuity and circuit integrity is necessary, due to its good insulating properties.

3. It is recommended that AMLGUARD be used in place of touch-up paint for corrodible surfaces on fleet deployed aircraft.

FUTURE WORK

Consideration should be given to continuing work on AMLGUARD in the following areas:

1. A pigmented compound with equivalent properties to AMLGUARD be developed to enhance its use as a replacement for touch-up paint for shipboard operations.

2. Modifications to AMLGUARD be formulated for use on aircraft with countermeasure coatings.

3. Update the present solvent system used in the AMLGUARD formulation, so as to comply with local air quality requirements.

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INVESTIGATIVE PROCEDURE

Selection of Materials

The composition of AMLGUARD consists of a combination of resins, solvents, a thickening agent, a coupling agent and corrosion inhibitors. The major constituents in the formulation are the silicone alkyd resin and the silicone resins which were selected for their resistance to weathering, corrosion protection and heat stability, those service and performance conditions common to naval aircraft. Basically, the combined resins in the formulation provide a physical barrier from corrosive shipboard stack gases and sea spray. The solvents present in the compound have several functions, they promote water displacement, assist leveling of the compound, aid drying time, solubilize the thickening agent and facilitate compatibility between constituents. The inhibitors provide corrosion protection for the metal substrate. The thickening agent is added to give body to the compound to prevent run off and to achieve a one mil (0.001 in.) (0.025 MM) film thickness with two spray applications. The compound's drying time was controlled by selection of solvents based on their evaporation rate without destroying the water displacement properties and compatibility with formulation constituents. The drying time was controlled to accomplish water displacement before a film could form over water droplets. The early version of the compound being virtually colorless by design made it almost impossible to differentiate where it had been applied on the aircraft surface without close observation. The fleet personnel evaluating the new compound indicated that some coloration would be desirable to distinguish where the AMLGUARD was applied and in what quantity. A blue dye was added to the compound for discernibility (Figure 3) on aircraft surfaces.

The following formulation of the Clear, Water Displacing, Corrosion Preventive Compound was developed with characteristics stated herein to comply with naval aircraft performance and withstand environmental conditions.

	Parts by Weight (Grams)
1. Isopropanol (Navy Stock)	46.0
2. Aromatic Hydrocarbon, Amsco Solvent "G" (American Mineral Spirits Company)	212.0
3. Trichlorotrifluoroethane, Freon TF (E. I. Du Pont)	286.0
4. Ethyl Cellulose T-200 (Hercules Powder)	4.0
5. Barium Sulfonate, NaSul BSN (R. T. Vanderbilt Co.)	40.0
6. Alkyl Ammonium Organic Phosphate, Rust Preventive R.P. No. 2 (E. I. Du Pont)	10.0
7. Silicone Varnish DF-88 (General Electric)	51.0
8. Silicone Resin SR-82 (General Electric)	51.0
9. Silicone Alkyd Resin, Varkyd 385-50E (McCloskey Varnish Co.)	300.0
	1000.0

FORMULATION MIXING PROCEDURE

The first three ingredients, the solvent portion, are added singly in the order stated above while stirring. An Oil Blue A dye is added (2.0 milligrams/100 c.c.) to the blended solvent mixture while stirring, allowing five minutes mixing time to dissolve the dye. Ethyl/Cellulose T-200 is then added to the solvent mixture by slowly sifting the powder into the mix while stirring, if no lumps are evident, approximately 15-20 minutes mixing time is necessary to dissolve the ethyl cellulose powder. Once the ethyl cellulose is dissolved

ingredients are added in the sequence listed above while the mixture is continuously stirred. Allow five minutes mixing time after adding each ingredient. After the five minute mixing time of each ingredient, the batch shall be checked for weight loss due to solvent evaporation. Add trichlorotrifluoroethane (Freon TF) as required to make up the difference in weight.

LABORATORY TESTS AND RESULTS

Protection Properties

1. Test Specimens

AISI 1010 steel was used for most of the test work due to its rapid corrosion rate which enables a quick determination of the corrosion protection of each experimental formula. The 1010 steel is aircraft quality grade conforming to specification MIL-S-7952.

2. Humidity Test

ASTM D1748-70 * was used to determine the experimental compound's ability to protect 1010 steel when exposed to a sustained 100% humidity environment for prolonged periods. This simulates a climatic condition that some naval aircraft will experience during a deployment. The test utilizes a humidity chamber where a condensing condition at +120°F (49°C) is produced by air bubbling through diffuser stones which are submerged in water heated to +140°F (60°C) (Figure 4). A constant rotating specimen holder is used to suspend the test specimens in the humidity chamber to assure uniform moisture deposit on each test specimen.

The compound under test was applied to a 1010 steel specimen (2"x4"x1/8" thick) (50mm x 101mm x 3mm) using one of two application methods. The first method employs a Fisher-Paye Dip Coater, whereby, the test specimen is dipped in the test compound and is withdrawn at a slow uniform rate of 4"/minute (101mm/minute). This method deposits a thin uniform film on the test specimen approximately one tenth mil (0.0001 in.) (0.0025 mm) thick when dry using this type compound. The alternate method of application consisted of spraying a 1010 steel test specimen with the test compound from either an aerosol can or a MIL-S-22805 aerosol spray kit. This method deposited a heavier less uniform film on the test specimen, approximately five tenth's of a mil (0.0005 in.) (0.0125 mm) thick when dry, with a one-coat application. After the compound air dried overnight the test specimen was subjected to the humidity chamber with the polished side of each specimen facing the rotational direction of the specimen holder. The specimens were observed daily for corrosion. After 65 days of exposure to the humidity environment, the test specimens were removed from the chamber. To indicate the compound's protective ability, the AMLGUARD film was removed. When compared to a blank 1010 steel test specimen with no protection and exposed for 24 hours in the same environment there was significant difference as can be noted in Figure 5.

3. Sulfurous Acid/Synthetic Sea Water Test

The Sulfurous Acid/Synthetic Sea Water Spray Test is depicted in Figure 6.

* Standard Test Method for Rust Protection by Metal Preservatives in the Humidity Cabinet

The significance of this test was to determine the corrosion protection capability of the experimental compound under a simulated aircraft carrier deck environment. This test was used for the development of the forerunner Corrosion Preventive Compound MIL-C-81309. Basically, the test is a cycling of sulfurous acid/synthetic sea water solution atomized for one hour by air pressure to produce a fog or mist (Figure 7) and air dried for three hours. Sulfurous acid is the acid produced when carrier stack gases containing sulfur dioxide (combustion products of bunker C fuel) combine with water vapor from the sea spray. Reagent grade sulfurous acid was added to the synthetic sea water in the percentage necessary to achieve corrosion equivalent to that obtained with the combustion products of bunker C fuel. Synthetic sea water used in the test simulates natural sea water. The synthetic sea water consists of chemical salts and their percentages approximating those existing in a composite of natural sea water. Details concerning the test procedure are explained in Naval Air Development Center report No. AML 2436 titled, "Development of Environment Wet Test Chamber for Simulating Carrier Deck and Other Corrosive Environment", dated 11 May 1966. Test specimens consisting of 1010 steel measuring 2-1/8 inches (54 mm) in diameter by 1/16 of an inch (1.5 mm) thick were used for this test. The test specimens were coated in the same manner used to prepare the humidity chamber test specimens, by either the Fisher Payne Dip Coater method and/or the spraying method, from either the aerosol package or the MIL-S-22805 aerosol spray kit. The test specimens, spray coated and air dried overnight, were subjected to the simulated carrier deck environment (H_2SO_3/Sea Spray Test). Comparatively, Figure 8 shows the specimens treated with AMLGUARD and exposed for 10 cycles were adequately protected from the corrosive environment, whereas, the untreated specimen when exposed for one cycle, severely corroded. Figure 9 depicts a typical salt deposit after five cycles.

A dissimilar metal corrosion test was conducted to demonstrate the effectiveness of AMLGUARD on a magnesium-cadmium plated steel coupling on both painted and unpainted specimens. The test consisted of a specification QQ-M-44 magnesium disc two inches (51 mm) in diameter by 1/4" inch (6.3 mm) thick, with a countersunk hole in the center to accommodate a cadmium-plated steel aircraft fastener. A pair of disc assemblies were painted and another pair were left bare. A painted disc assembly and a bare disc assembly were treated with AMLGUARD and air dried overnight. The four discs were subjected to the SO_2/salt spray test mentioned above. The untreated specimens both painted and unpainted were exposed for one hour to the corrosive environment and showed severe corrosion or attack. The AMLGUARD treated specimens both painted and unpainted were exposed for four hours to the same environment and displayed no evidence of attack, see Figure 10.

4. Five Percent Salt Spray Test

Salt spray tests were also used to evaluate the corrosion protection ability of the experimental formulations. One test was conducted in a salt fog cabinet meeting the requirements of ASTM B117-73 Appendix I. five percent salt fog was constantly discharged, seven days a week. Ideally, many test panels can be exposed at one time to obtain quick comparative results.

1010 steel panels measuring 3" x 6" (76 mm x 152 mm) were painted and air dried for seven days. The panels were scribed with an X on their long axis down to the substrate metal. One half of the panel was treated with the corrosion preventive compound and air dried overnight before being exposed in the five percent salt cabinet. To illustrate the effectiveness of the test and the protection of the AMLGUARD see Figure 1.

Early experimental formulation testing was conducted on 3" x 6" (76 mm x 152 mm) 7075 alclad aluminum panels coated with Specification MIL-P-23377, Primer Coating, Epoxy Polyamide, Chemical and Solvent Resistant and topcoated with Specification MIL-C-81773, Coating, Polyurethane, Aliphatic, Weather Resistant. Two panels were used per test, both were scribed with an X through the paint system down to the aluminum substrate. One panel was treated with the experimental preservative, the other left untreated. Both were subject to five percent salt/SO_2 spray, in a cabinet meeting the requirements of ASTM B117-73 Appendix I. The environment in the cabinet is a continuous five percent salt spray fog where sulfur dioxide gas is injected at a flow rate of 1 c.c./min./cu.ft.(1 cc/min./0.03 m^3) of cabinet, for 1 hr/6 hr cycle (four times daily). This again simulates the environment of an aircraft carrier with stack gases and sea spray. Details of the test procedure is presented in Naval Air Development Center report No. NADC-77252-30 titled, Accelerated Laboratory Corrosion Test for Materials and Finishes used in Naval Aircraft. A 90 day exposure to that environment produced results which clearly demonstrated the protective quality of the preservative. Results are displayed in Figures 11 and 12. The painted aluminum test specimens were not further used due to the length of time required to obtain significant results . Subsequent testing was conducted primarily on 1010 steel which produced faster results.

5. Synthetic Sea Water Displacement Test

The following test was conducted simulating a corrodible aircraft surface laden with sea spray in order to evaluate the synthetic sea water displacement and corrosion protection capabilities of the experimental formulas. Steel test panels, 2" X 4" (50 mm X 101 mm) conforming to FS 1010 of MIL-S-7952, were used for this test. The test panel was placed so that one 2-inch (50 mm) end was raised one inch (25 mm) above a horizontal surface. The entire panel was sprayed with synthetic sea water consisting of: 50 grams of sodium chloride (NaCl); 22 grams of magnesium chloride ($MgCl_2 \cdot 6H_2O$); 3.2 grams of calcium chloride ($CaCl_2 \cdot 2H_2O$) and 8.0 grams of sodium sulfate (Na_2SO_4) added to a litre of distilled water. Within one minute after spraying the sea water one milliliter of the test compound was poured along the upper two-inch (50 mm) edge of the panel and allowed to run slowly down the specimen so as to completely cover the test panel. To illustrate AMLGUARD's water displacing ability, the synthetic sea water was tinted red. In Figure 13 the mid portion of the panel had AMLGUARD applied to it. Even at the outset, it can be seen that AMLGUARD is displacing the sea water. After one minute from the initial application, a second milliliter of the test compound was poured and allowed to run down the panel in the same manner. After waiting an additional minute, the panel was hung in a vertical position for one minute. A photo was taken at this time and as depicted by Figure 14, almost all of the sea

water is displaced. The specimen was then placed flat (test side up) above distilled water @ 72°F in a closed desiccator (100% static humidity). After four hours, the panel(s) were removed and cleaned with mineral spirits, and then evaluated for presence of visible corrosion. The effectiveness of the test is best demonstrated by the corrosion on the blank or untreated specimen in four hours versus the sea water displacement and corrosion protection provided on specimens treated with AMLGUARD and exposed for 40 days. These effects are noted in Figure 15.

FILM PROPERTIES

Clarity

Two criteria of the new compound requested by fleet personnel were clarity and dry film properties. The clarity of AMLGUARD relative to other military corrosion preventive compounds, MIL-C-81309 and MIL-C-16173 Grade 4, is illustrated by Figure 2. Evaluation sheets returned by fleet personnel requesting a tint or dye be added to the compound for application discernibility, attests to the compound's effective clarity. The dryness of the material is exhibited by its inability to be removed by rubbing or wiping after it is dry.

Removability

The newly developed corrosion preventive compound is removed with solvents such as methyl ethyl ketone, TT-M-261; dry cleaning solvent, Type II, P-P-D-680; 1,1,1 trichloroethane, MIL-T-81533; toluol TT-T-548; aliphatic naphtha, Type II, TT-N-95. All of these solvents are authorized for shipboard use. The solvent emulsion type aircraft cleaners such as MIL-C-43616 could remove the AMLGUARD film depending upon the concentration of the cleaning compound used to clean aircraft surfaces. The surfaces from which the AMLGUARD is removed requires no special preparation other than the usual surface preparation for standard aircraft painting or touch-up. To demonstrate the completeness of the AMLGUARD removal and the non-interference with primer or paint adhesion to substrate, a test was conducted on an untreated 7075 alclad aluminum flexural test assembly, simulating that of an aluminum aircraft skin. The assembly was cleaned by wiping with an acetone dampened cloth. One half of the assembly was left blank or untreated; the other half was treated with AMLGUARD and allowed to air dry at room temperature for three days. The AMLGUARD film was removed by wiping with a toluene dampened cloth, then the entire assembly was sprayed with epoxy primer MIL-P-23377 and air dried overnight. Masking tape was applied across the fastener areas on both the untreated and AMLGUARD treated sides of the assembly. The tape was then removed as a test for paint adhesion. No loss of primer adhesion to the substrate on either side of the test assembly was noted when the tape was pulled away. The assembly was then immersed in distilled water for 24 hours, removed and wiped dry. Within five minutes after removal from the water the tape test was repeated. The primer on both sides of the test assembly was partially removed in equal amounts, again

indicating no change in the adhesion of AMLGUARD. These effects are shown in Figure 16. In a similar test, specification MIL-P-23377 primer was applied over AMLGUARD and the dry tape test performed. The results indicate that the adhesion between the primer and the AMLGUARD is greater than the adhesion between the AMLGUARD and the metallic substrate. Thus, these tests show that AMLGUARD can be effectively removed with no residue remaining behind to interfere with subsequent paint adhesion. This is particularly noteworthy since the compound contains silicone resins.

Advanced surface analytical techniques were conducted at Lehigh University to establish whether solvent cleaning will totally remove silicone resins present in AMLGUARD from metallic surfaces. They are Auger Electron Spectroscopy (AES) and the Electron Spectroscopy for Chemical Analysis (ESCA). In brief, Auger Electron Spectroscopy is a nondestructive method of surface chemical analysis which is accomplished by performing an energy analysis of the electrons ejected from a specimen while bombarding the specimen with a beam of electrons. Electron Spectroscopy for Chemical Analysis (ESCA) is a analytical technique which can be used for quantitative and qualitative studies of the oxidation states of atoms in chemical compounds. The analysis is obtained by measuring energy of electrons that are emitted during irradiation of the sample with X-rays. The tests were conducted on 7075 alclad aluminum coupon specimen measuring 1/2" x 1/2 " x .020" (12.5 mm x 12.5 mm x 0.500 mm) thick. An untreated set of specimens was analyzed to establish a base line on the spectrograms of the elements present in 7075 alclad aluminum. AMLGUARD treated and solvent cleaned specimens were analyzed qualitatively and quantitatively for extraneous (contaminating) elements and elements in excess of those present in the base metal analysis. The treated specimens were sprayed with AMLGUARD, air dried four days and the coating removed by wiping with a solvent dampened cloth. Five different solvents were evaluated. The silicon content on the surface of the specimens after cleaning was determined using the above described methods. Any increase in silicon content of the AMLGUARD treated and cleaned specimens above that of the untreated specimens would be considered due to the silicone residue from the AMLGUARD not being completely removed. Quantitative results of the tests are presented in Table I. The spectrograms corresponding to the determinations below are presented in Appendices G and H. The test results indicate that all traces of silicone were removed with specification solvents, TT-T-548, toluene and TT-T-95, Aliphatic Naphtha, Type II. The specification solvents, MIL-T-81533, 1,1,1, trichloroethane and P-D-680, Dry Cleaning Solvent, Type II removed all but insignificant amounts of silicone. It is believed that quantities found would have been removed with a second solvent wipe. The AMLGUARD treated specimens, solvent cleaned with specification TT-M-261, methyl ethyl ketone appeared to be visibly clean, although, a trace amount of silicon was found. Since highly sensitive spectroscopic procedures were used in this study and no significant amounts of silicon were found, there is no concern for residual silicone causing an adhesion interference when surfaces are properly cleaned with appropriate solvents. Further, Auger Electron Spectroscopy studies at Lehigh University were conducted on 7075 alclad aluminum specimens coated with AMLGUARD and removed with fleet available solvents listed in NAVAIR 01-1A-509. The solvents used for this

AMLGUARD removal evaluation are listed below. The Auger Electron Spectrograms of the solvents used are presented in Appendix I.

1. MIL-C-43616 Cleaning Compound, Aircraft Surface (20% Solution)
2. MIL-T-81772 Polyurethane Thinner
3. MIL-T-19554 Lacquer Thinner
4. TT-M-261 Methyl Ethyl Ketone
5. TT-I-235 Isopropyl Alcohol
6. TT-T-291 Mineral Spirits
7. Acetone

Test conditions performed were identical to the first set of specimens sent to Lehigh University for analysis, except these specimens were solvent wiped twice to remove AMLGUARD. Results confirm the findings of the initial test work, that is, proper solvent cleaning will thoroughly remove AMLGUARD from metallic surfaces, including methyl ethyl ketone which initially showed trace amounts of silicon remaining on the metal surface with one solvent wipe. During this second surface analysis it was found that MIL-C-43616 solvent emulsion cleaner did not adequately remove AMLGUARD for subsequent refinishing and should not be used for this purpose, see Naval Air Development Center, Warminster message R122301Z May 78 (Appendix J).

PHYSICAL TESTS

Flexibility

The flexible quality of the AMLGUARD film was evaluated by tests performed using varying conditions. The tests were conducted on 3" x 6" (76 mm x 152 mm) anodized 2024 aluminum, 0.020" (0.5 mm) thick, annealed to produce greater ductility for subsequent mandrel tests. The tests consisted of an AMLGUARD coated test panel subjected to various thermal conditions and bent around various size mandrels. The thermal conditions, film thickness, size of mandrels and test results are listed in Table II. The test results indicate that under extreme bending or flexing conditions the AMLGUARD displays good flexibility properties. The AMLGUARD film did develop some very fine cracks, barely visible to the naked eye. These cracks appeared under the most extreme conditions. There was no loss of AMLGUARD adhesion to the metal substrate.

Oil Resistance Test

The following tests were performed to obtain background information on the effects of hydraulic fluids (natural and synthetic) and lubricating oil on the AMLGUARD film. The tests were conducted using specification hydraulic fluids MIL-H-5606 and MIL-H-83282, and specification lubricating oil MIL-L-23699, those in common use on naval aircraft. The test essentially consisted of 3" x 6" (76 mm x 152 mm) 2024 aluminum alclad panels coated with AMLGUARD under conditions listed in Table 3, prior to being subjected to the run-off and immersion tests. The run-off test was designed to simulate a spillage of hydraulic fluids or lubricating oil on an aircraft surface treated with AMLGUARD. The fluid and/or oil was poured over part of an AMLGUARD coated

panel and allowed to run down and off the panel. After four hours dwell time at room temperature, the AMLGUARD film was observed for discoloration or signs of attack from the fluid or oil used. The immersion test utilized an AMLGUARD coated panel whereby one-half of the panel was immersed in the fluid or oil for four hours at room temperature then removed and observed for AMLGUARD film deterioration. The test conditions used during the evaluation and the results obtained are presented in Table III. The hydraulic fluids MIL-H-5606 and MIL-H-83282 had no effect on the AMLGUARD film after the run-off tests at room temperature. The immersion tests performed at room temperature caused the AMLGUARD film to pick up a slightly red tint from the fluids and to display some spotty film removal. The tests conducted at room temperature with the engine lubricating oil MIL-L-23699 did affect the AMLGUARD film considerably. After the run-off test, the lubricating oil had discolored and softened the AMLGUARD film. The immersion test in the lubricating oil caused the AMLGUARD film to be softened so that it could easily be removed with slight rubbing. A four hour immersion test in each of the hydraulic fluids and lubricating oil at 250°F was conducted on AMLGUARD coated panels. At the end of this immersion test both hydraulic fluids and the lubricating oil had caused the AMLGUARD film to wrinkle and permitted its easy removal from the panel in a sheet-like form.

Effects on Painted Surfaces

The following test was performed to measure the effect of AMLGUARD on aircraft paint. AMLGUARD was applied to a painted panel. The Pencil Hardness Test used in Military Specification MIL-C-43616 was conducted on the paint initially before the application of AMLGUARD and at intervals one-half hour, one hour, and 24 hours after the AMLGUARD application. The pencil hardness taken on the paint film one hour after the compound had been applied was the only interval where the value decreased one pencil hardness. However, the paint film recovered to its original hardness within a 24 hour period. The effect of AMLGUARD on polyurethane paint is comparable to that obtained with specification MIL-C-43616 aircraft washing compounds used at the recommended dilution.

Flash and Fire Properties

The flash and fire point tests were conducted on AMLGUARD to establish its flammability characteristics. The flash point test was performed in accordance with ASTM method #D56 using the Tag Closed Cup Tester. The flash point could not be obtained on AMLGUARD with this method, each time the test flame was induced into the cup it was extinguished by boiling or evaporation of the Freon TF (trichlorotrifluoroethane) which is a non-flammable solvent contained in the compound. In a similar test conducted in accordance with the ASTM method D92 which specifies the Cleveland Open Cup Tester the flash point again could not be obtained due to the volatility of the Freon solvent which extinguished the test flame. However, the fire point of AMLGUARD was determined using the Cleveland Open Cup method and found to be 125°F (52°C). This temperature must be attained before ignition or fire of AMLGUARD is possible. Based on these tests, the AMLGUARD compound is considered safe for shipboard use.

Effects on Acrylic Plastic

Tests were performed in accordance with Military Specification MIL-C-43616 paragraph 4.4.10, to evaluate the effects of AMLGUARD on MIL-P-5425 Acrylic Plastic. The AMLGUARD when tested as specified in MIL-C-43616 did in fact cause craze cracks to form on MIL-P-5425 acrylic plastic test specimens. The testing procedure utilizes a flannel cloth placed at the fulcrum of the test specimen loaded as a simple beam and kept moist with the material for six hours. In a similar test where nothing is placed over the fulcrum the AMLGUARD was applied from an aerosol can on the acrylic plastic test specimens. A total of six coats (one coat per day) and a total dwell time of seven days, showed no evidence of crazing or attack on stressed acrylic plastic test specimens. Based on this evaluation the use of AMLGUARD is safe if an accidental discharge or overspray on acrylic plastic canopies is experienced. However, if large amounts of AMLGUARD are permitted to run off and collect at crevices or like areas damage to acrylic plastic canopies or windshields could result.

Storage Stability and Shelf Life

Storage stability and shelf life tests on the AMLGUARD compound are currently being conducted at the Naval Air Development Center. They have been in progress for over two years. To date, no deterioration of the AMLGUARD compound is indicated in either the bulk one quart (0.946 liters) glass containers or the 16-ounce (0.476 liters) aerosol or pressurized containers.

FLEET EVALUATION

To date over 2500 16-ounce ($47.36 \times 10^{-5} m^3$) aerosol containers of AMLGUARD have been distributed to fleet activities. The pressurized containers of AMLGUARD were packaged and distributed generally in case lots (12 cans/case). Enclosed with each case were six evaluation forms. The input from fleet activities by means of the evaluation forms provided the Naval Air Development Center with the information necessary to determine the quality of the compound and the needs or changes required to meet fleet needs.
The consolidated results from the evaluation is presented in Table IV. The U.S. Marines and the U.S. Coast Guard evaluated AMLGUARD primarily as a corrosion preventive on helicopter aircraft. Both services have expressed complete satisfaction and a strong need for the compound as indicated by the recommendation letters and naval messages in the appendices. Aerospace firms are currently evaluating AMLGUARD for use on production F-18 aircraft where MIL-C-16173 Grade 4 is used. The Naval Aircraft Materials Laboratory in Gasport Hamshire, United Kingdom, has expressed an interest in this type of corrosion preventive compound for use on their Sea King helicopters. Several aerosol packages of AMLGUARD were sent to to that foreign facility for their evaluation.

TABLE I. RESULTS OF AUGER ELECTRON SPECTROSCOPY ANALYSIS

	Si*	Al*	Si:Al Ratio
Blank (7075 Alclad Aluminum)	0.072	1.89	0.0380
Toluene (TT-T-548)	0.076	2.03	0.0374
Dry Cleaning Solvent Type II (P-D-680)	0.091	1.96	0.0464
1,1,1, Trichloroethane (MIL-T-81533)	0.086	2.11	0.0407
Methyl Ethyl Ketone (TT-M-261)	0.49	1.65	0.2969
Aliphatic Naphtha Type II (TT-N-95)	0.064	1.66	0.0385

Note: 7075 Aluminum Si (Silicon) content 0.4% max.
7075 Alclad Aluminum Fe (Iron) and Si (Silicon) content 0.7% max.

* Above values obtained from peak to peak deflections measured in inches from the Auger Electron Spectroscopy analysis spectrograms.

TABLE II. AMLGUARD FLEXIBILITY TEST

	Film Thickness	Bend Over 1/8" Mandrel	Bend Over 1/4" Mandrel
A. 1 coat air dried 24 hrs. @ R.T.	.0004"	Good, no adhesion loss, no cracking, spalling, or crazing of film	Not tested (1/8" test more severe)
B. 2 coats air dried 24 hrs. @ R.T.	.00085"		
C. 1 coat baked @ 240°F/1 hr.	.00045"	Mild lateral cracking along entire length of bend, no adhesion loss	Two mild cracks on one end of bend, no adhesion loss
D. 2 coats baked @ 240°F/1 hr.	.0007"		
E. 1 coat baked @ 240°F/24 hrs.	.0004"	Good, no cracking, no adhesion loss	Not tested (1/8" test more severe)
F. 2 coats baked @ 240°F/24 hrs.	.0007"		
G. 1 coat air dried R.T. 24 hrs. flexed @ -60°F	.0007"	Mild lateral cracking along entire length of bend, no adhesion loss	Mild lateral cracking along entire length of bend, no adhesion loss
H. 2 coats air dried R.T. 24 hrs.flexed @ -60°F	.0009"		
I. 1 coat baked @ 240°F/1 hr. flexed @ -60°F	.00045"	Fine cracking of film along entire length of bend, no adhesion loss	Fine cracking of film along entire length of bend, no adhesion loss
J. 2 coats baked @ 240°F/1 hr.flexed @ -60°F	.0007"		
K. 1 coat baked @ 240°F/24 hrs.flexed @ -60°F	.0004"		
L. 2 coats baked @ 240°F/24 hrs.flexed @ -60°F	.0007"		

R.T. - Room Temperature
All tests conducted @ R.T. unless otherwise indicated.

AMLGUARD application:
1 coat from aerosol can
2 coats from aerosol can 1 hr. after first coat.

TABLE III. AMLGUARD OIL RESISTANCE TEST

	Film Thickness	Run Off Test	Immersion Test
		MIL-H-5606 Results after 4 hr. subjected @ R.T.	
1 coat air dried @ R.T./24 hrs.*	.0002"	No effect on AMLGUARD film	Slight softening of AMLGUARD film
2 coats air dried @ R.T./24 hrs.*	.0006"	No effect on AMLGUARD film	Slight softening of AMLGUARD film
1 coat baked @ 240°F/1 hr.*	.00015"	No effect on AMLGUARD film	Some spotty removal of AMLGUARD film
2 coats baked @ 240°F/1 hr.*	.0006"	No effect on AMLGUARD film	No effect on AMLGUARD film
1 coat baked @ 240°F/24 hrs.*	.00035"	No effect on AMLGUARD film	
2 coats baked @ 240°F/24 hrs.*	.0005"	No effect on AMLGUARD film	
		MIL-L-23699 Results after 4 hrs. subjected @ R.T.	
1 coat air dried @ R.T./24 hrs.*	.0003"	Slightly brown discoloration of AMLGUARD film, easily removed	AMLGUARD film completely removed during wiping of oil from panel
2 coats air dried @ R.T./24 hrs.*	.0006"	Slightly brown discoloration of AMLGUARD film, slight softening of film	AMLGUARD film softened greatly, film not removed
1 coat baked @ 240°F/1 hr.*	.0002"	Brown discoloration of AMLGUARD film, film softened	Film easily removed after completion of test
2 coats baked @ 240°F/1 hr.*	.0006"	Brown discoloration of AMLGUARD film, film softened	ALMGUARD greatly softened and wrinkles with some cracking of film
1 coat baked @ 240°F/24 hrs.*	.0003"	Brown discoloration of AMLGUARD film, film softened	Film easily removed after completion of test
2 coats baked @ 240°F/24 hrs.*	.0007"	No effect on AMLGUARD film	No effect on AMLGUARD film
		MIL-H-83282 Results after 4 hrs. subjected @ R.T.	
1 coat air dried @ R.T./24 hrs.*	.0002"	No effect on AMLGUARD film	AMLGUARD film softened slightly, no removal evident, film picked up slight tint of red from hydraulic fluid
2 coats air dried @ R.T./24 hrs.*	.0006"	No effect on AMLGUARD film	
1 coat baked @ 240°F/1 hr.*	.0003"	No effect on AMLGUARD film	No effect on AMLGUARD film
2 coats baked @ 240°F/1 hr.*	.00055"	No effect on AMLGUARD film	No effect on AMLGUARD film
1 coat baked @ 240°F/24 hrs.*	.0004"	No effect on AMLGUARD film	No effect on AMLGUARD film
2 coats baked @ 240°F/24 hrs.*	.00065"	No effect on AMLGUARD film	No effect on AMLGUARD film

R.T. - Room Temperature

*Oil Resistance Test Run on Test Panels 4 hr. Immersion @ 250°F - The AMLGUARD film on all specimens were attacked by the above fluids and oil. AMLGUARD film wrinkled and lost adhesion on panel, film could then be removed in a skin form.

AMLGUARD Application:
1 coat from aerosol can
2 coats from aerosol can 1 hr. after first coat.

TABLE IV. AMLGUARD FIELD EVALUATION DATA

	(1) Aircraft Type	(2) Areas Applied	(3) Cleaning Procedure Prior to AMLGUARD Application	EVALUATION CRITERIA (4) General Appearance S-Satisfactory U-Unsatisfactory	(5) Dye Desirable Yes/No	(6) Frequency of Application	(7) Effectiveness of Preservative E-Excellent G-Good F-Fair U-Unsatisfactory	(8) Conditions during Exposure H-Humid D-Dry T-Tropical S-Shipboard LB-Landbased	(9) Activity	
1.	EA-6B	Port MLG Strut Buno 158800	None	Unsat/Lack of Dye, Impossible to Tell Where Applied	Yes	Once	E	H/LB	VAQ-129	
2.	A-6E	Springs & Hinges on 7 Day Insp.	Wipe Down Before Application	S	Yes	-	G	-/LB	VA-52	
3.	A-6E	Hinges & Springs, Bare Metal Areas	Washed	S	Yes	Every 7 Days	G	H/-	VA-52 NAS Whidbey Island	
4.	E-2C	Hyd.B-Nuts & Hdwe in Wheel Wells & Wing Butts	A/C Washed, Old Grade IV Removed w/P-D-680	Unsat/In Clear Form Hard to Tell if Entire Area is Covered	Yes	14 days	E	-/LB	VAW-122	
5.	E-2C	Wing Butts, Landing Gear	Removal of Grade IV w/P-D-680	S	Yes	One Time in 90 Days	E	-/LB	VAW-125	
6.	S-3A	Bare Screws, Hinges Ordnance Hdwe	Entire A/C Wash Job, Removal of Corr. & Specific Area Cleaned w/Alcohol	S	Yes	Only the One Time	E	H/LB	VS-33	
7.	CH-46	Fwd Head & Trans., Battery & Camlocks., Free Air Gauge on Windshield	A/C Washed where AMLGUARD applied Cleaned w/mild Cleaning Solvent	S	-	According to Directions on Can Lable on a One Time per A/C Recorded for this Evaluation	Unsat/Leaves a Tacky Film on Hinge Areas	H/LB	HC-3 NAS North Island	
8.	S-3A	Wheel Wells	Normal Fresh Water Wash	S	No	20-30 Days	E	H/S	VS-29 on Board U.S.S. Enterprise	Would like to see this compound in pint or quart cans for brush application.
9.	S-3A	4" Square of Bare Metal on Str'd Mid Fuselage on A/C 706 159386	Removed Paint Feathered Edges Cleaned with Aliphatic Naphtha	S	No	Checked every 15 days Reapplied at 30 days	E	H/S	VS-29 on Board U.S.S. Enterprise	Would like to see this compound in pint or quart cans for brush application.
10.	P-3C	Piano Hinges, Hi Loc Fasteners Tail Area Anchor nuts - Tail Section	Wiped with A Dry Rag	S	Yes *	Every 28 Days	G	H/LB	VP-31 Buno 159505	* Dye would allow an easy lube audit however it is apparent with close examination that AMLGUARD has been applied.

TABLE IV. AMLGUARD FIELD EVALUATION DATA

	(1) Aircraft Type	(2) Areas Applied	(3) Cleaning Procedure Prior to AMLGUARD Application	(4) General Appearance S-Satisfactory U-Unsatisfactory	(5) Dye Desirable Yes/No	(6) Frequency of Application	(7) Effectiveness of Preservative E-Excellent G-Good F-Fair U-Unsatisfactory	(8) Conditions during Exposure H-Humid D-Dry T-Tropical S-Shipboard LB-Landbased	(9) Activity	EVALUATION CRITERIA
11.	P3C 157325 QE-2	C/P Flapwells, Wheel Wells, AFT Fuselage	Wiped Heavy Deposits of Oil and Grease Away	S	Yes	1st Time 4/28/76 2nd Time 5/20/76	G	1st Time H/B 2nd Time D/LB	UP-40 NAS Moffet Field	Needs a Dye Bad, You Can't See It
12.	P3C Buno 159326 QE-6	QE-6 Port Wheel Well Down Lock, Nose Wheel Well Chipped Paint Stbd Inbd M/M Lip Bolts, QE-2 Heat Exch Access Lips	Wiped Heavy Deposits of Oil and Dirt off 4/28/76	S	Yes	1st Time 4/28/76 2nd Time 5/18/76	G	H/LB	UP-40 NAS Moffet Field	Needs a Dye Bad, You Can't See It
13.	P3C 158226	All Hinges	Regular A/C Wash Cycle	S	Yes	-	E	-/LB	VP-48 Air-Frames NAS Moffet Field	
14.	P3C 158221	All Hinges	Regular A/C Wash	S	Yes	-	E	D/LB	VP-48 Air-Frames NAS Moffet Field	
15.	P3A	Piano Hinges & Fasteners, Hi-Lock Fasteners, Anchor Nuts in Tail Area	Wipe w/Dry Rag on Piano Hinges, None on Anchor Nuts or Hi Lock Fasteners	S	Yes	28 Days	G	H/LB	VP-31 Buno 150511	
16.	-	Tail Section & All Hinges & Cables	Applied after A/C was Washed	S	Yes	-	E	-/LB	VP-19 NAS Moffet Field	
17.	-	Hinge Pins, Screws	Dry Cleaning Solvent	S	No	14 Days	E	D/LB	VMFA-314	
18.	A4M	Fuel Probe, Cables	Cleaned with Abrasive Webbing & A/C Washing	S	No	14 Days	E	D/LB	VMA-214	
19.	A4M	Slat Tracks & Rollers Piano Hinges	None	S	No	Twice Monthly	G	D/LB	UMA-311 Metal Shop	
20.	S3A Viking	Hdwe in Wheel Wells, Wing Butts, Fasteners, Cables, Finfold & Wing Panels	Removed all Dirt, Salt Spray & Old Preservative with Toluene	S	No	On every 56 & 112 Day Inspection & Touchup When Needed	E	-/S	AIRANTISUBRON-31 on USS Independence CV62	
21.	A4M TA4F	Hinges, Slat Track Rollers	Wash	S	No	Twice Monthly	G	D/LB	HEMS-13 Flight Line	
22.	F14, F4, TA-4, C-1A & US-2	All Skin Surfaces & Landing Gear	Some Areas were Cleaned & Dried, Some were left Wet & Dirty or Just Wiped Off. AMLGUARD under both Conditions Covered Well	S*	Yes**	-	E Displaces Water Very Well	H/LB Sub-Tropical	VX-4 NAS Pt. Mugu, CA	*Very satisfied with the appearance that is left when dry. ** The amount of dye in AMLGUARD at present is sufficient to know how well area is being covered.

TABLE IV. AMLGUARD FIELD EVALUATION DATA

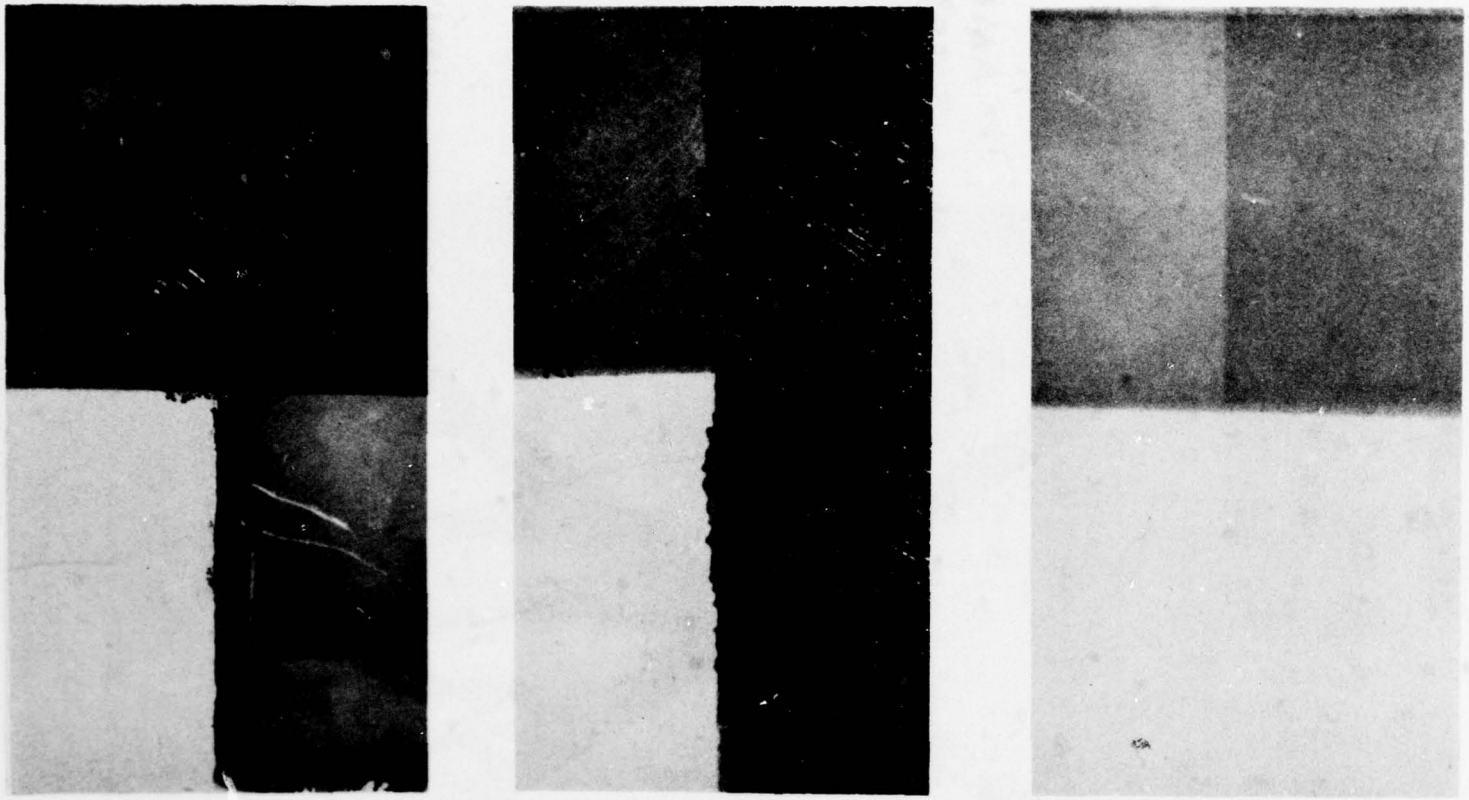
					EVALUATION CRITERIA					
	(1) Aircraft Type	(2) Areas Applied	(3) Cleaning Procedure Prior to AMLGUARD Application	(4) General Appearance S-Satisfactory U-Unsatisfactory	(5) Dye Desirable Yes/No	(6) Frequency of Application	(7) Effectiveness of Preservative E-Excellent G-Good F-Fair U-Unsatisfactory	(8) Conditions during Exposure H-Humid D-Dry T-Tropical S-Shipboard LB-Landbased	(9) Activity	
23.	Helicopter HH-52A	●	Complete Soap & Solvent Cleaning Prior to First Application, Local Cleaning as Needed for Subsequent Application	Very S	Yes	Once before Deployment and as Needed during 4 Month Deployment (Reapplied Twice)	E	-/S	USCG Aviation Training Center Prime Unit, Mobile, Alabama	● Exterior of all electrical connectors, all areas of bare metal, gear boxes, rotor heads, tail drive shaft, bare screws, bolts, clamps, and etc.

FIGURE 1. PARTIALLY PROTECTED 1010 STEEL PANEL EXPOSED TO 5% SALT SPRAY ENVIRONMENT FOR SEVEN DAYS

MIL-C-81309 DRY

MIL-C-81309 DRY
MIL-C-16173, (GRADE 4)
OVERCOAT

EXPERIMENTAL CLEAR
PRESERVATIVE



RIGHT SIDE OF EACH PANEL TREATED WITH MATERIAL IDENTIFIED ABOVE IT, LEFT SIDE UNTREATED

FIGURE 2. LIGHT/DARK GRAY PAINTED PANELS TREATED WITH AIRCRAFT CORROSION PREVENTIVE COMPOUNDS

FIGURE 3. PARTIALLY PROTECTED 1010 STEEL PANEL EXPOSED TO 5% SALT SPRAY ENVIRONMENT FOR SEVEN DAYS

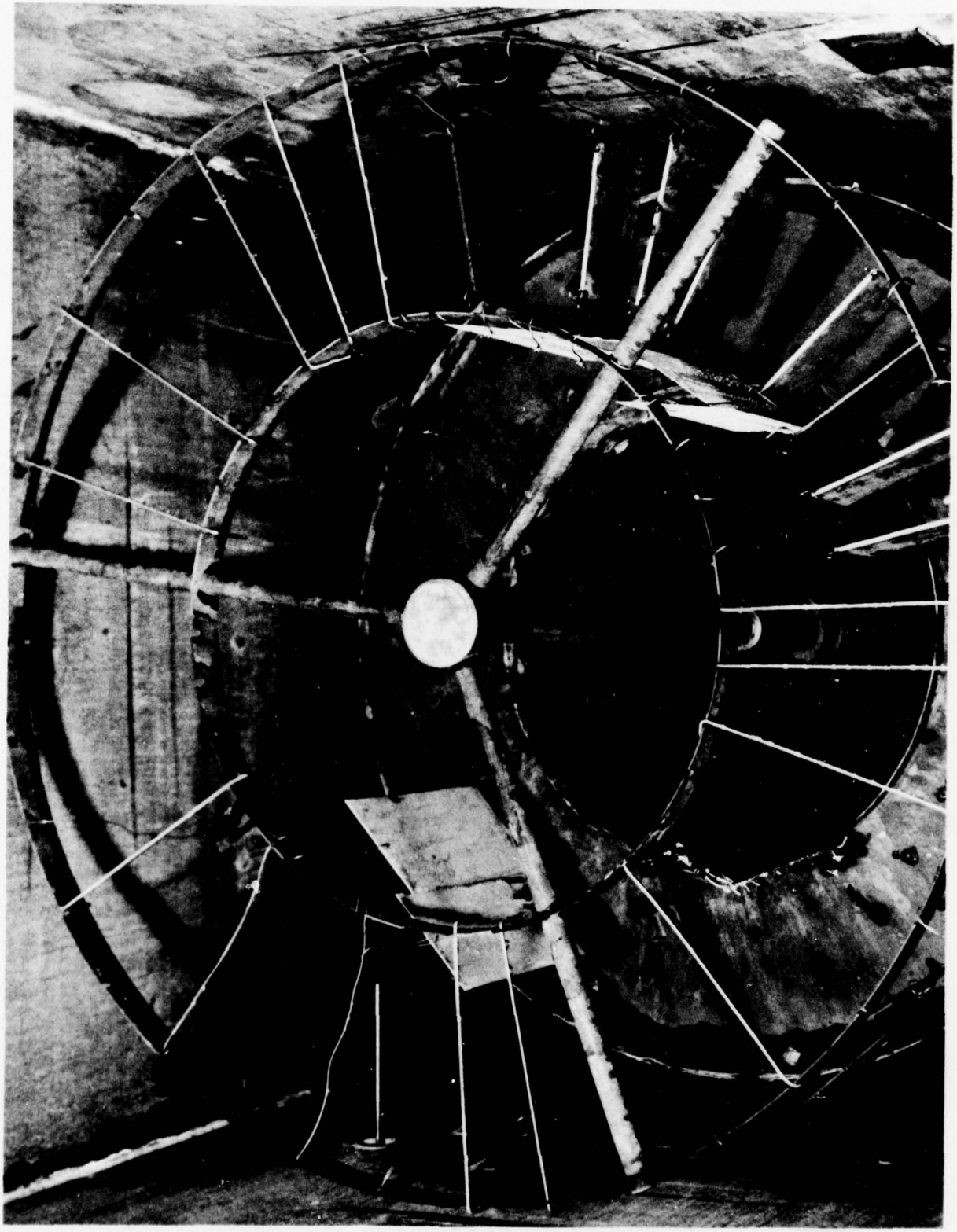


FIGURE 4. HUMIDITY CABINET 100% RELATIVE HUMIDITY @ 120°F

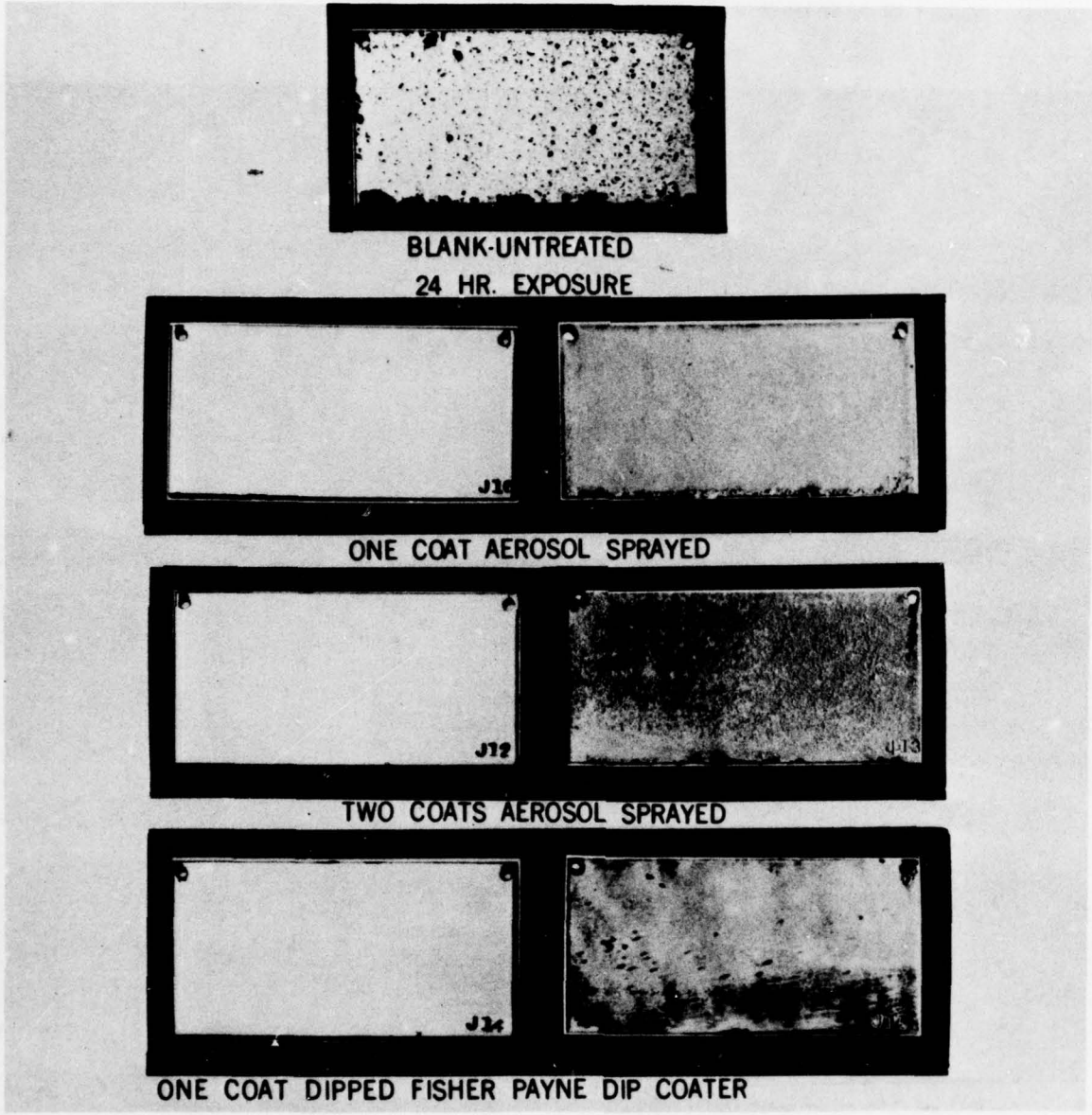


FIGURE 5. 1010 STEEL TREATED WITH "AMLGUARD," SUBJECTED TO 100% RELATIVE HUMIDITY @ 120°F FOR 65 DAYS. "AMLGUARD" REMOVED WITH MINERAL SPIRITS FROM PANELS ON LEFT SIDE TO SHOW PROTECTION AFFORDED.

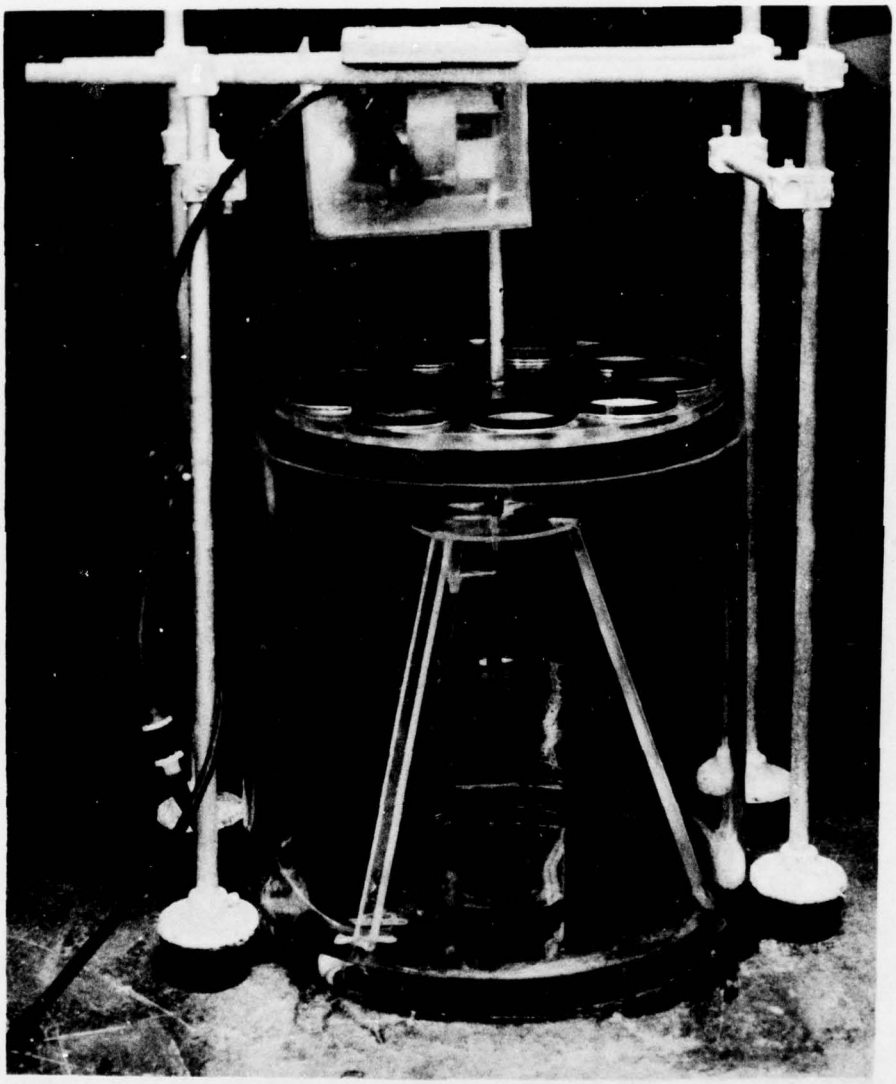


FIGURE 6. EQUIPMENT FOR SULFUROUS ACID/SYNTHETIC SEA SPRAY TEST

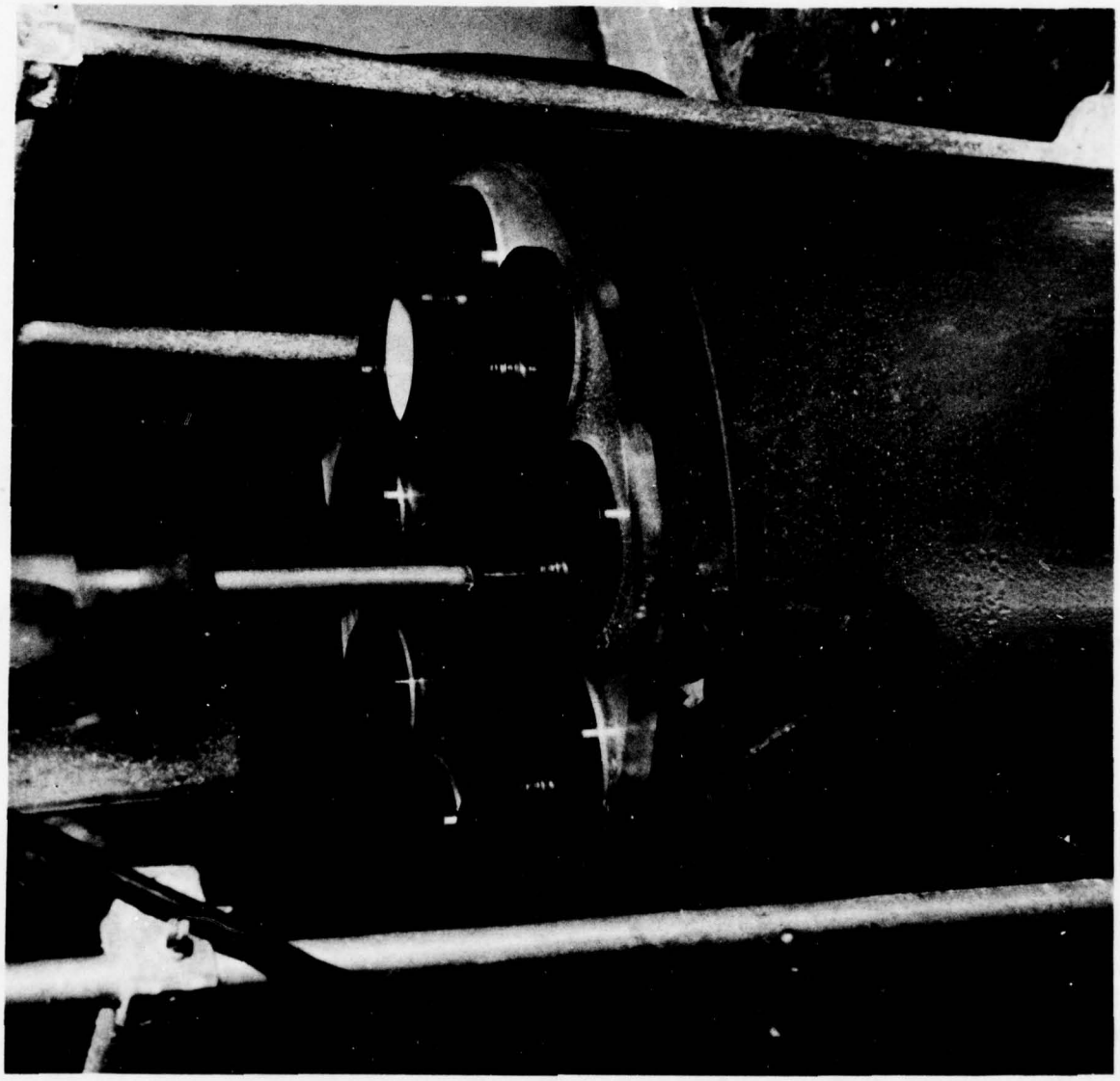


FIGURE 7. SULFUROUS ACID/SYNTHETIC SEA SPRAY TEST IN OPERATION

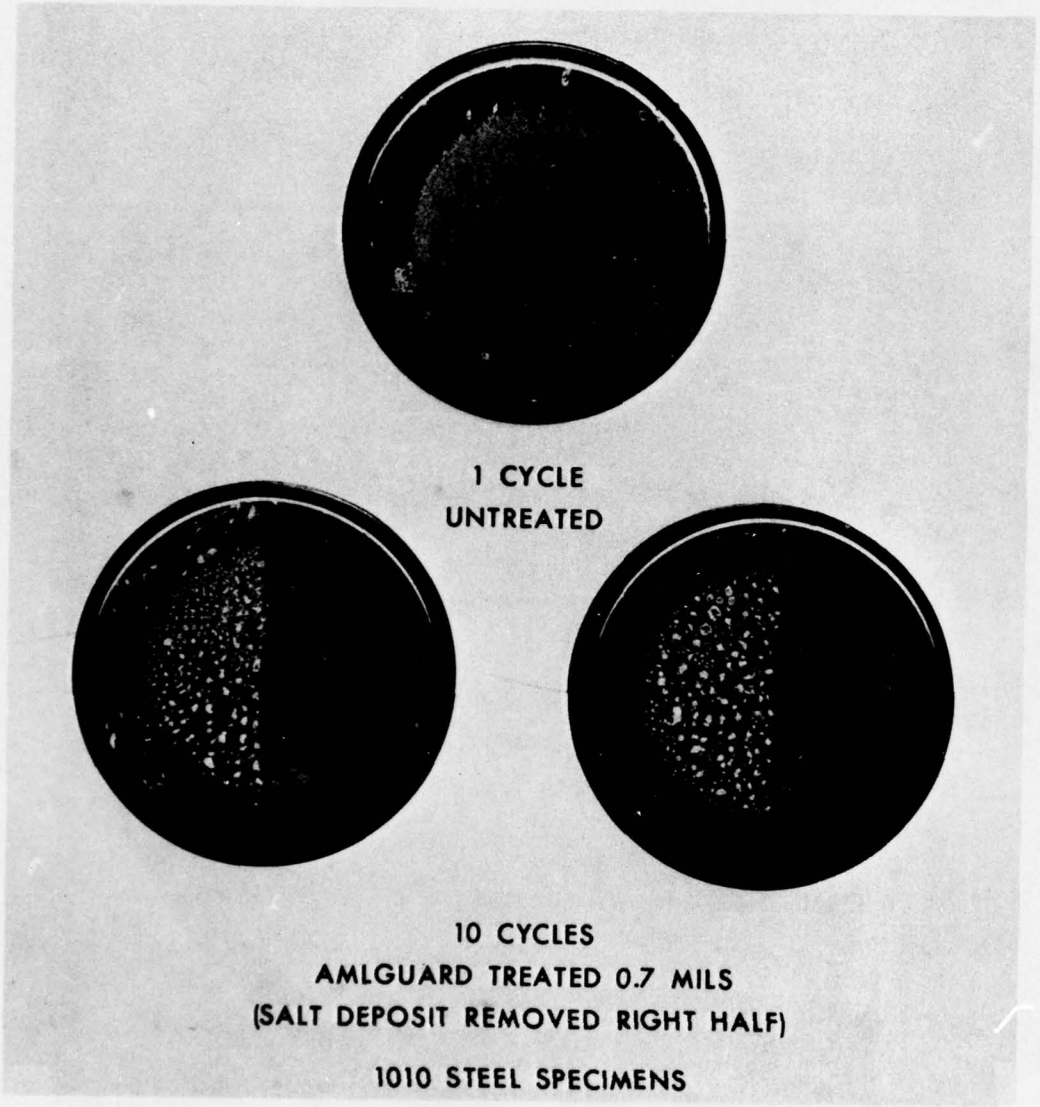
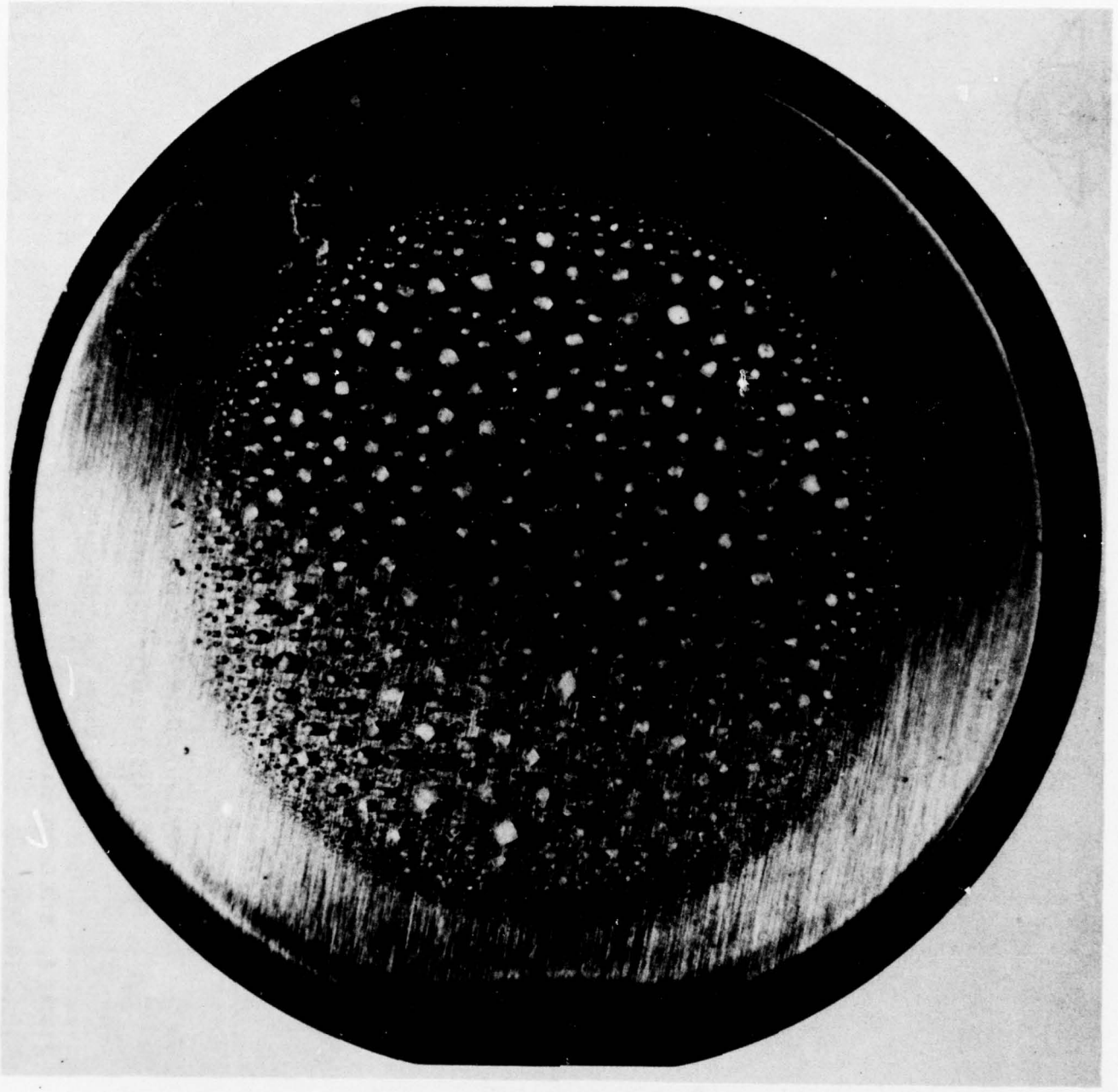


FIGURE 8. SIMULATED CARRIER DECK ENVIRONMENT H_2SO_3/SEA SPRAY TEST



SPECIMEN TREATED WITH AMLGUARD DEPICTING TYPICAL SALT DEPOSITS AFTER 5 TEST CYCLES

FIGURE 9. SULFUROUS ACID SYNTHETIC SEA WATER SPRAY TEST SPECIMEN

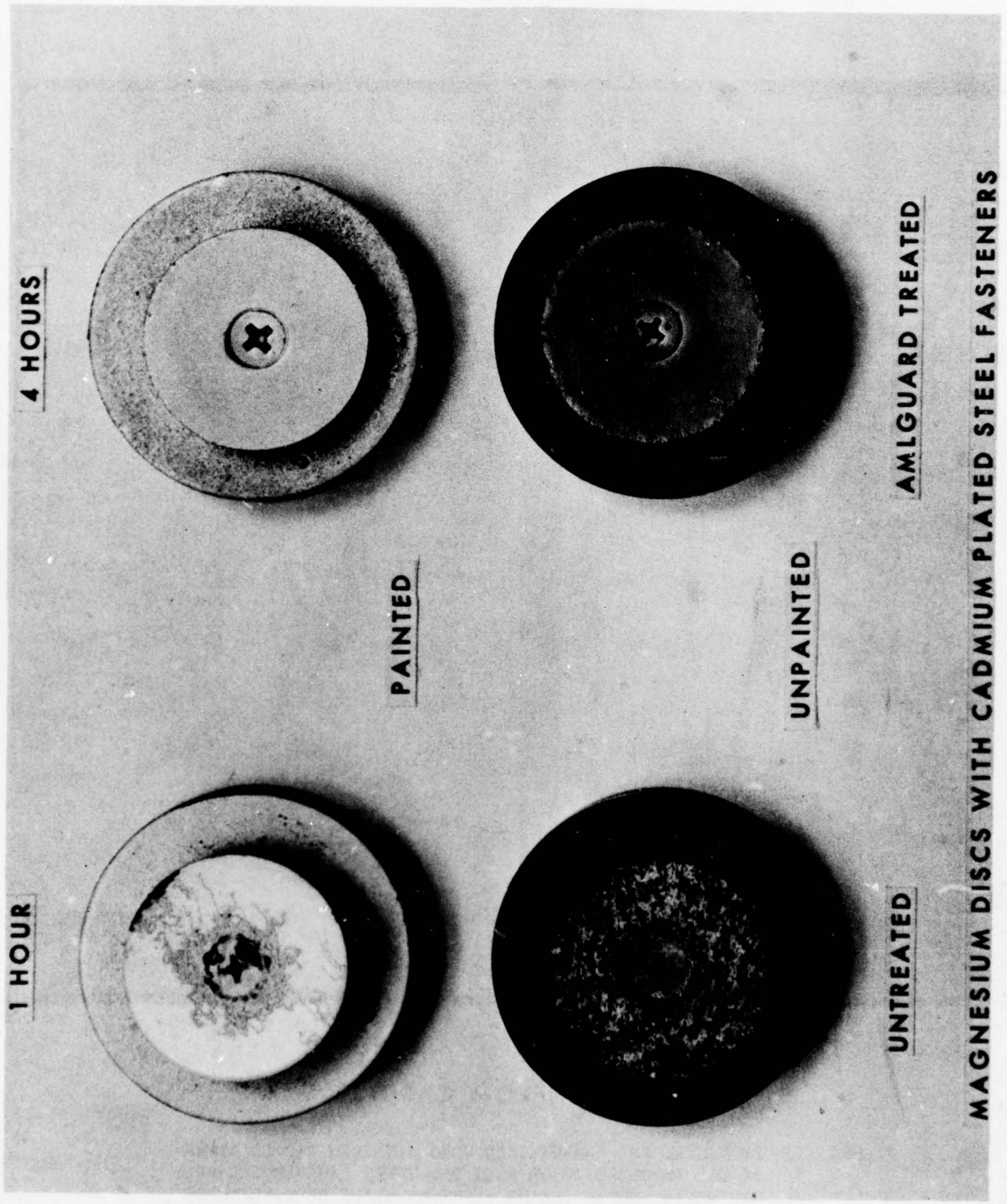
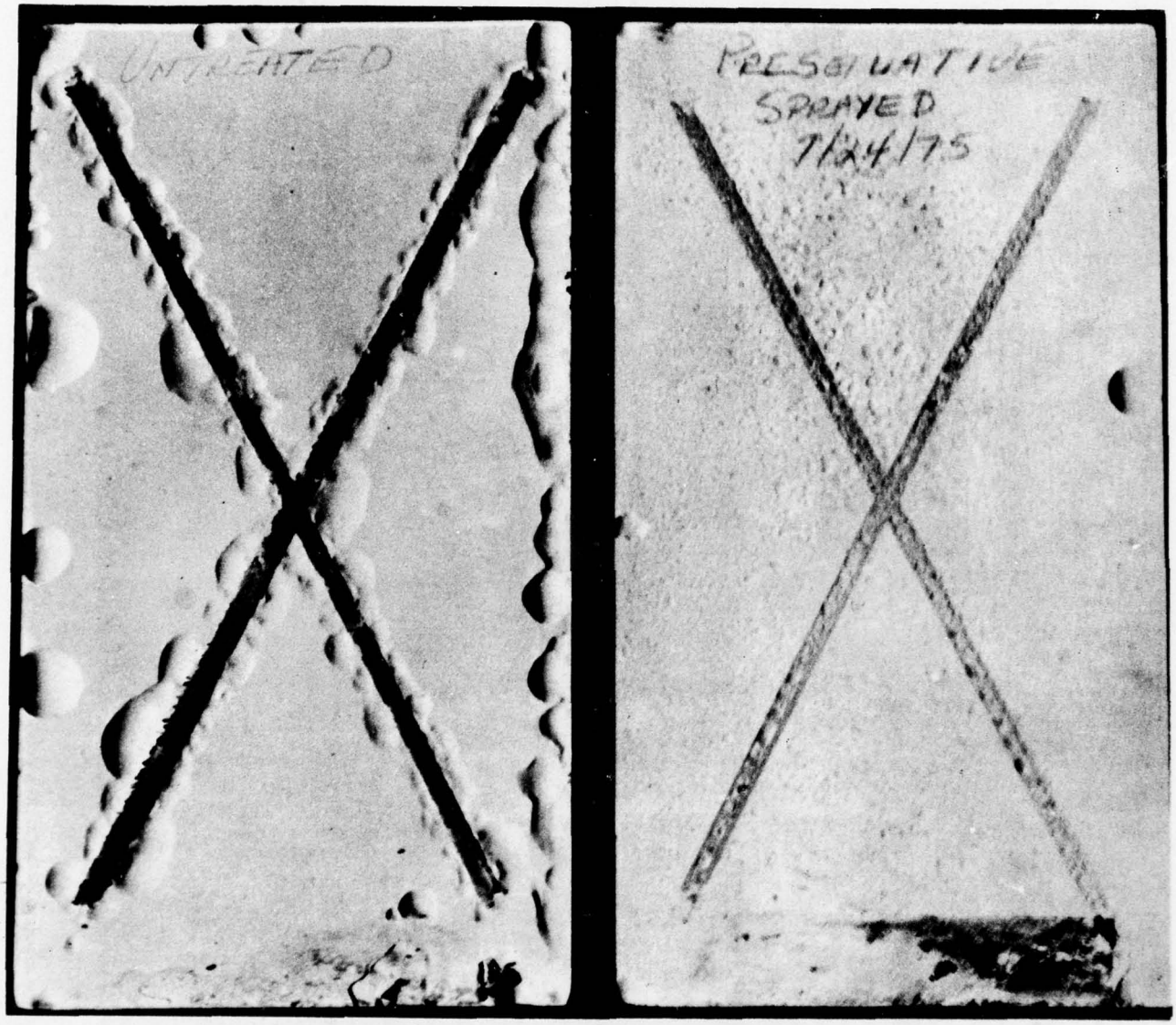


FIGURE 10. ACCELERATED LABORATORY TEST SIMULATED CARRIER DECK ENVIRONMENT



AS REMOVED FROM CABINET

FIGURE 11. PROTECTED AND UNPROTECTED 7075 ALUMINUM PANELS AFTER 90 DAY EXPOSURE TO 5% SALT/SO_2 SPRAY (AS REMOVED FROM CABINET). NOTE: PAINT BLISTERS ALONG SCRIBED MARKS ON UNPROTECTED (LEFT) PANEL.

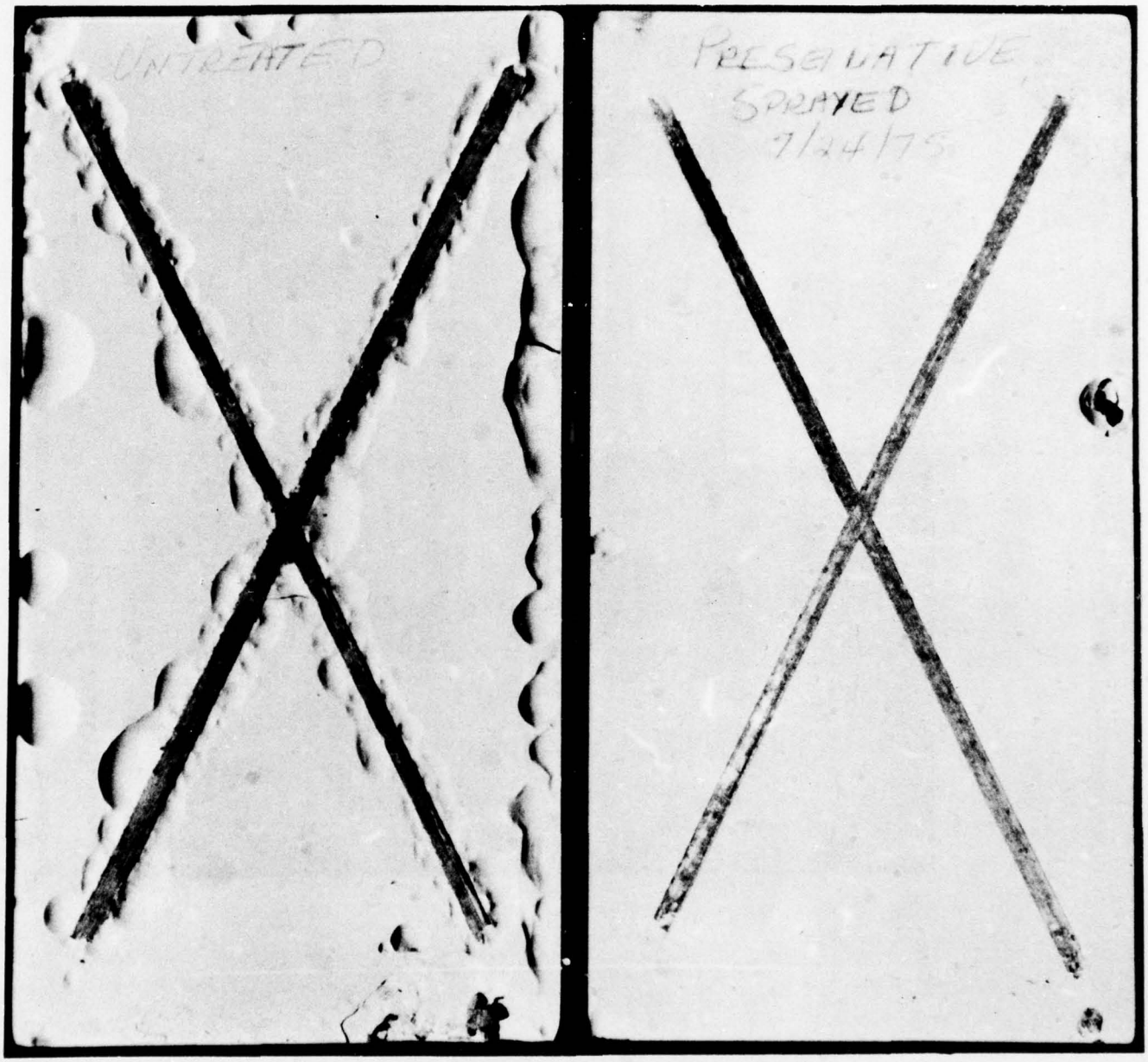


FIGURE 12. PANELS PICTURED IN FIGURE 11 AFTER SOLVENT WIPING. PROTECTED AND UNPROTECTED 7075 ALUMINUM PANELS AFTER 90 DAY EXPOSURE TO 5% SALT/SO_2 SPRAY (AS REMOVED FROM CABINET) AFTER SOLVENT WIPE.

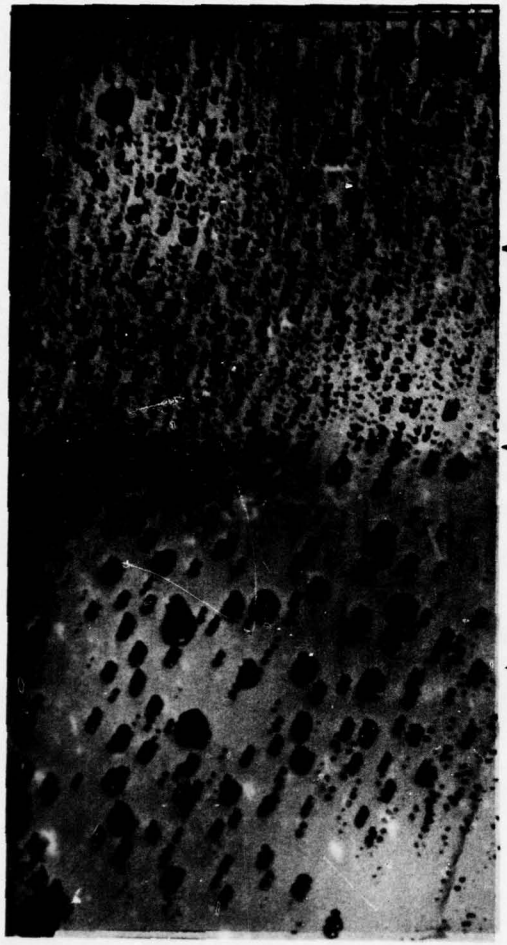


FIGURE 13. SYNTHETIC SEA WATER DISPLACEMENT TEST

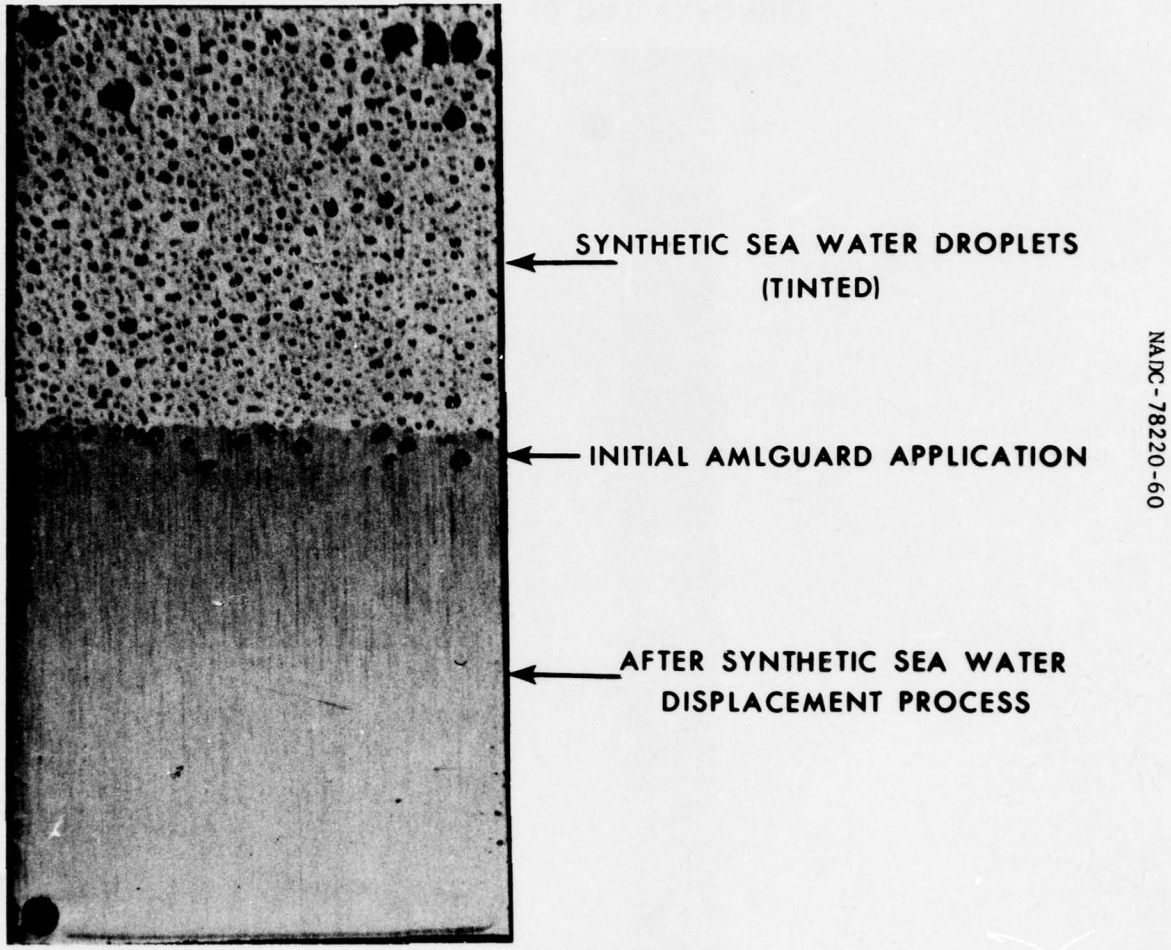


FIGURE 14. SYNTHETIC SEA WATER DISPLACEMENT TEST

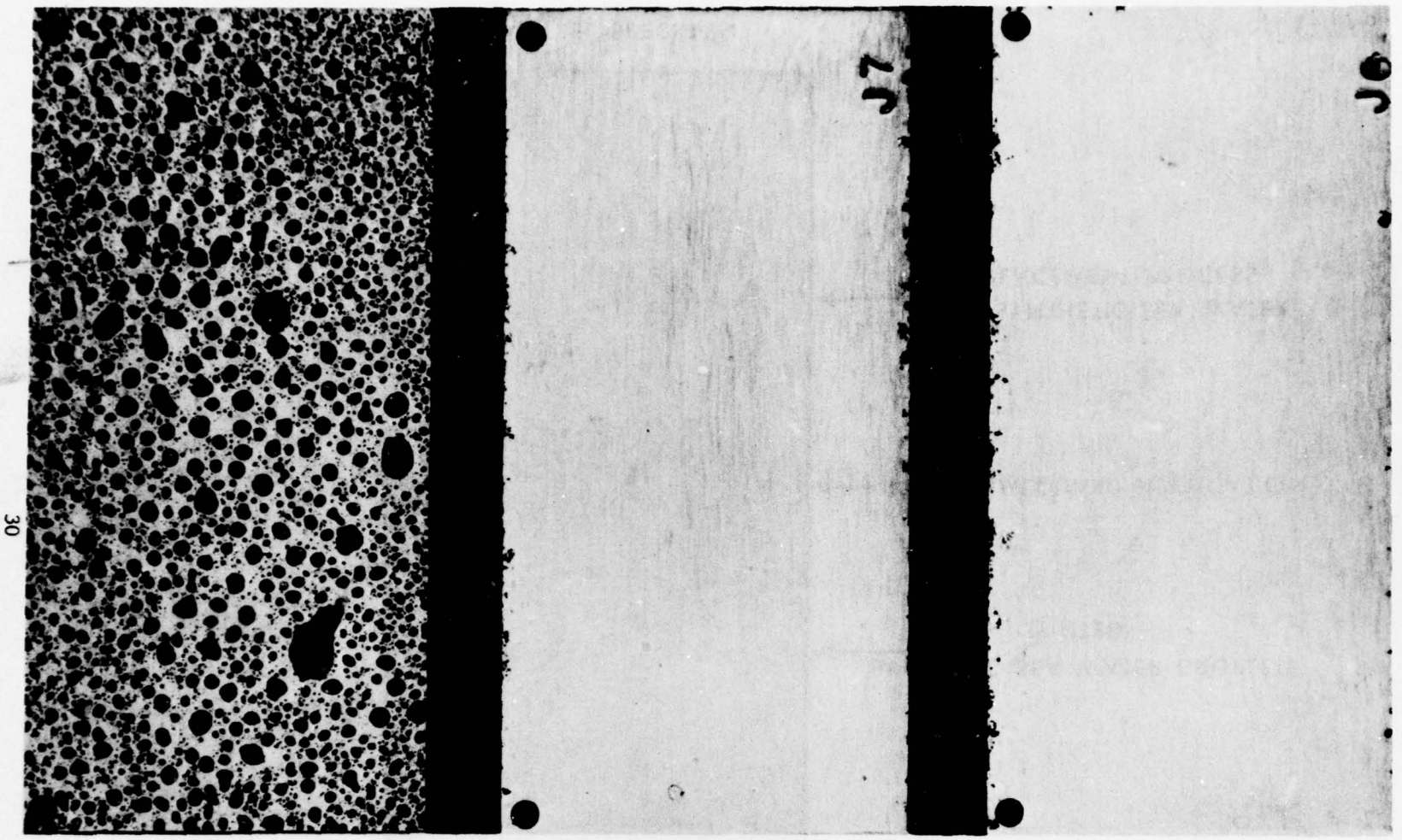
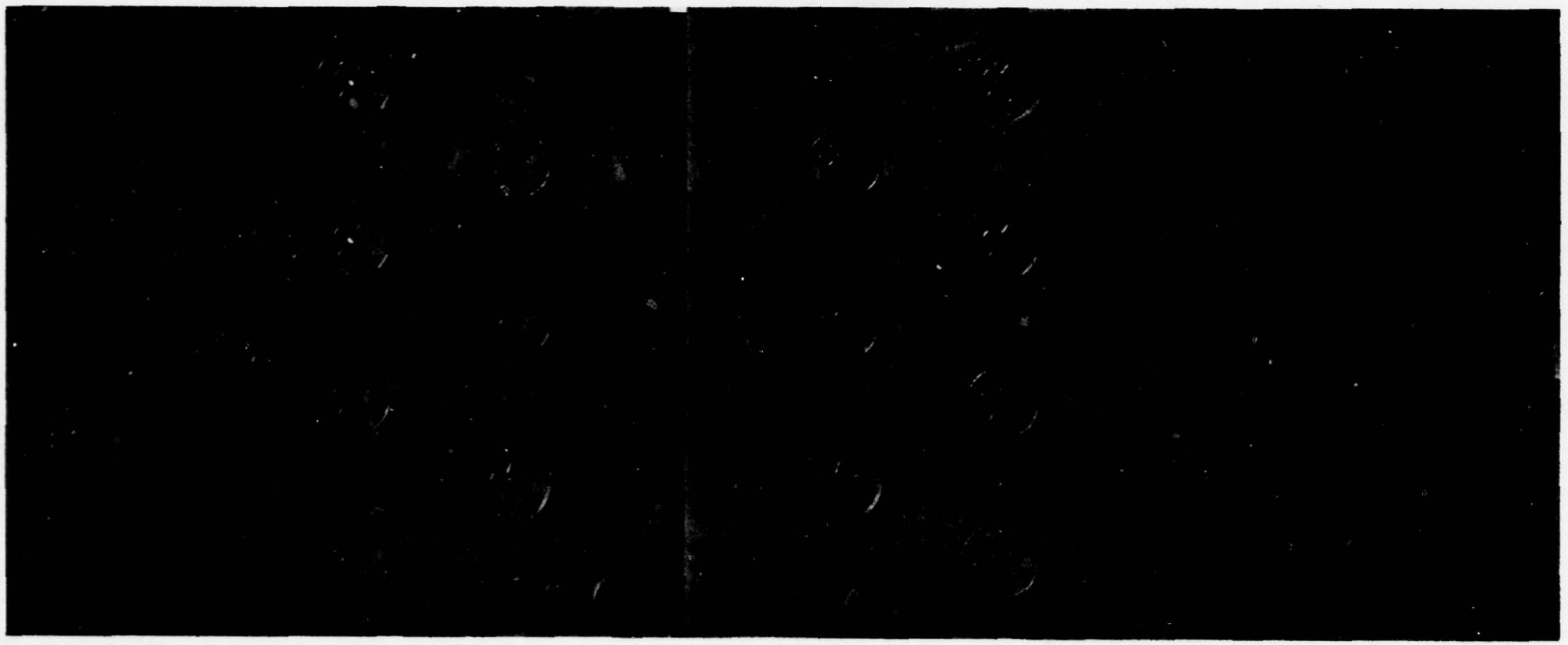


FIGURE 15. SYNTHETIC SEA WATER DISPLACEMENT PANELS AFTER EXPOSURE TO 100% HUMIDITY



SUBSTRATE UNTREATED

SUBSTRATE AMLGUARD TREATED
AND REMOVED BEFORE PRIMING

PRIMER ADHESION COMPARISON RESULTS

FIGURE 16. WET TAPE TEST

A P P E N D I X A

FITRON THREE TWO Message
120303Z Aug 76

RECEIVED

1976 AUG 12 [illegible] 01

[illegible]

RTTEZYUW RULYSGG8259 2250304-EEEE--RUEODOA;
ZNY EEEEE
R 1213372 AUG 76
FM FITRON THREE TWO
TO RUEOALL/COMNAVAIRLANT NORFOLK VA
INFO ZEN/COMCARAIRWING ONE
ZEN/USS JOHN F KENNEDY
RUEBEDA/COMFITWING ONE OCEANA VA
RULSAA/COMNAVAIRSYSCOM WASHINGTON DC
RUEODOA/NAVAIRDEVCEN WARMINSTER PA
RUEOALL/NAVAIRREWORKFAC NORFOLK VA
RUEBEDA/FITRON THREE TWO DET OCEANA VA
BT
UNCLAS E F T O //N13000//
COMNAVAIRSYSCOM FOR AIR-52032B; NAVAIRDEVCEN FOR CODE 302B;
COMNAVAIRLANT FOR CODE 526B;
AML-GUARD EVALUATION
A. COMNAVAIRLANT NORFOLK VA 111352Z JUN 76
1. REF A DESIGNATED FITRON THREE TWO TO CONDUCT EVALUATION
OF AML-GUARD CORROSION PREVENTIVE;
2. EVALUATION CONDUCTED 9 JULY TO PRESENT IN CARRIER OPS/
MARITIME ENVIRONMENT; AML-GUARD APPLIED TO BROKEN AND

PAGE 02 RULYSGG8259 UNCLAS E F T O
CHIPPED PAINT ON ALL AREAS OF F14A INCLUDING INTAKES,
WINGS, SPEED BRAKES, AND TURTLEBACK; ALSO APPLIED TO GUN
BLAST DEFLECTOR AND TO LEADING EDGES OF WINGS AND BOTH
HORIZONTAL AND VERTICAL STABILIZERS;
3. WHERE AML-GUARD APPLIED TO BROKEN/CHIPPED PAINT, CORROSION
IS DRASTICALLY REDUCED; AML-GUARD ON LEADING EDGES DECREASES
MAINTENANCE TIME BY 90 PERCENT OF THAT PREVIOUSLY DEDICATED
TO UPKEEP OF LEADING EDGES; AML-GUARD SHOULD BE REAPPLIED
AFTER AIRCRAFT WASHING AND AT APPROX 12 DAY INTERVAL ON
LEADING EDGES; SPOT PEELING OCCURS DUE AERODYNAMIC FRICTION
AND ABRASION FROM WASHING PADS, GUN BLAST DEFLECTOR ONLY
AREA WHERE AML-GUARD DOES NOT PERSIST DUE BURN-OFF; HOWEVER,
CLEANING OF DEFLECTOR GREATLY FACILITATED WHERE PORTIONS OF
AML-GUARD REMAINED;
4. RECOMMEND THAT AML-GUARD BE ACCEPTED FOR FLEET USE AND
PROCURED IN ONE GALLON QUANTITIES AS WELL AS 16 OUNCE AEROSOL
CANS;
BT
#8259

TOR: 120601Z/EB/JM
COS: 30
REF A: SAME SUBJECT

14 AUG 1976

R 120303Z AUG 76

A P P E N D I X B

COMNAVAIRLANT Message
170952Z Dec 76

RECEIVED

1976 DEC 17 23 55

NAVAIRDEVCEN
MSG CNTR

PTTEZYUW RUEOALA5953 3522240-EEEE--RUEODQA;
ZNY EEEEE
P R 172952Z DEC 76
FM COMNAVAIRLANT NORFOLK VA
TO RULSSAA/COMNAVAIRSYSCOM WASHINGTON DC
INFO RULSSAA/CHNAVMAT WASHINGTON DC
RUMAPH/COMNAVAIRPAC SAN DIEGO CA
RUEODQA/NAVAIRDEVCEN WARMINSTER PA
RUEBHGA/GSA WASHINGTON DC
RUEBAGB/ASO PHILADELPHIA PA
RUEOLFA/CG FMFLANT
RUEOAIJ/CG SECOND MAW
RUEBNMA/MAG TWO SIX
RUEBFDA/COMFITWING ONE OCEANA VA
RUEBFDA/FITRON THREE TWO
RT
UNCLAS E F T O //N13220//
COMNAVAIRSYSCOM FOR AIR 5272281 NAVAIRDEVCEN FOR 3029
AML GUARD PROCUREMENT
A, FITRON THREE TWO 120363Z AUG 76 NOTAL
B, MAG TWO SIX 162155Z DEC 76 PASEP
1, IN VIEW OF FAVORABLE EVAL INDICATED REFS A AND B REQUEST

PAGE 2 RUEOALA5953 UNCLAS E F T O //N13220//
EXPEDITIOUS PROCUREMENT SUBJ MATERIAL. AML GUARD IS SUPERIOR TO
ANY CORROSION PREVENTIVE COMPOUND CURRENTLY UTILIZED ON LAND/SEA
BASED AIRCRAFT;
2, RECOMMEND SUBJ MATERIAL BE PROCURED IN ONE QUART CONTAINER AND
16 OZ AEROSOL CANS;
BT
#5953

NNNN

TOR: 172355Z/JM/JP/PP
REF A: NOT HELD
B: SAME SUBJ
COS: 30
-I-: 12 198

20 DEC 1976

P R 172952Z DEC 76

A P P E N D I X C

COMNAVAIRPAC Speedletter
FF7-11/N71A/DRR:ps 10320
ser 1539 of 6 Oct 1976

NADC-78220-60

X

OCT 6 1976

VS7-11/W71A/DRR:ps
10320
Ser 1539

Commander Naval Air Force
U.S. Pacific Fleet (Code 74F)
Naval Air Station, North Island
San Diego, CA 92135

Subj: AMLGUARD Corrosion Preventive Compound Evaluation; report of

Ref: (a) COMNAVAIRPAC 211804Z APR 76

Encl: (1) VS-33 spdltr EPD:jdb 2857 ser 267 of 1 JUL 76
(2) AMLGUARD Evaluation Report Form, NC-3

1. Reference (a) directed evaluation of the AMLGUARD Corrosion Preventive Compound. In accordance with reference (a), enclosures (1) and (2) are forwarded.

2. AMLGUARD is considered to be excellent as a temporary film for surfaces where the paint has been damaged, and immediate repainting cannot be accomplished. The addition of a tint would be advantageous for identifying surfaces coated with the protective film.

G. C. SKEZAS
By direction

COPY TO

Commander Anti-Submarine Warfare Wing
U.S. Pacific Fleet
Naval Air Station, North Island
San Diego, CA 92135

ADDRESS REPLY AS SHOWN AT LEFT; OR, REPLY HEREON AND RETURN

CLASSIFICATION

A P P E N D I X D

CG Aviation Training Center Letter
(PH: FTS 534-9209) 13081
of 18 October 1977

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
COMMANDING OFFICER
U.S. COAST GUARD
AVIATION TRAINING CENTER
MOBILE, ALABAMA 36608
(PH: FTS 534-9209)

13081
18 October 1977

From: Commanding Officer, CG Aviation Training Center
To: Naval Air Development Center, Aero Materials Lab (code 606) Warminster, Pennsylvania 18974

Subj: AMLGUARD (MIL-C-85054); evaluation of

1. During a recent helicopter deployment on board a Coast Guard Icebreaker AMLGUARD was substituted for MIL-C-16173D. This substitution provided an evaluation of subject material while exposed to a corrosive environment. Subject material was used extensively on one helicopter while MIL-C-16173D was used on the other.

2. Upon return from deployment the helicopter was thoroughly inspected for any corrosion. There was no corrosion found that could have been caused by a lack of protection provided by AMLGUARD. The transparency of AMLGUARD made this inspection an easy task.

3. The advantages of AMLGUARD are that it will provide the necessary protection, will not collect dust and other contaminants, and is transparent, so that any corrosion, cracks, or other defects can be detected without removal of subject material.

4. Request you advise when subject material becomes available through normal supply channels. We intend to recommend that Commandant (G-EAE), U. S. Coast Guard approve AMLGUARD for use on all U. S. Coast Guard Aircraft.

W. P. KOZLOVSKY

Encl: Evaluation Report

Copy to:
COMDT G-EAE/63
CO
AVENGDIV
AR&SC

A P P E N D I X E

COMNAVAIRPAC Letter
10360 WPC B14892
Ser 74F/5137 of 7 Sep 1976

COMMANDER NAVAL AIR FORCE
UNITED STATES PACIFIC FLEET
NAVAL AIR STATION, NORTH ISLAND
SAN DIEGO, CALIFORNIA 92135

10360
WPC B14892
Ser 74F/ 5137
7 SEP 1976

FIRST ENDORSEMENT on CG THIRD MAW ltr 49:SAC:rem 10322 of 18 Aug 1976

From: Commander Naval Air Force, U.S. Pacific Fleet
To: Commander Naval Air Development Center

Subj: Service Evaluation of AMLGUARD Corrosion Preventive Compound

1. Forwarded, recommending acceptance of the subject material for fleet use.

2. Field evaluation reports received thus far have been unanimous in their conclusion that the material designed as "AMLGUARD" is highly satisfactory for applications that normally require frequent application of MIL-C-81309 water displacing preservative.

J. S. MALLORY
By direction

A P P E N D I X F

3D Marine Aircraft Wing, FMFPAC Letter
49:SAC:rem 10322
of 18 Aug 1976

UNITED STATES MARINE CORPS
3D MARINE AIRCRAFT WING, FMFPAC
MCAS, EL TORO
SANTA ANA, CALIFORNIA 92709

IN REPLY REFER TO:
49:SAC:rem
10322

AUG 18 1976

From: Commanding General
To: Commander, Naval Air Developement Center (Code 30222)
Via: Commander, Naval Air Force, U. S. Pacific Fleet (Code 74F)

Subj: Service Evaluation of AMLGUARD, a clear water displacing corrosion preventive compound

Ref: (a) NAVAIRDEVCEN ltr 3022/2857 dtd 7 April 1976
(b) COMNAVAIRPAC 211804Z APR 76

1. In accordance with reference (a) request, modified by reference (b), this activity has completed an evaluation of AMLGUARD.

2. Evaluation was conducted by several squadrons with A-4M, TA-4F, and F-4N aircraft. All personnel connected with the evaluation were highly satisfied with the product and desire that it be placed in the supply system and all hands be notified of National Stock Number assigned when available.

3. Areas to which AMLGUARD was applied included fuel probes, cables, piano-type hinge pins, slat tracks and rollers, screws, etc.. In every case, AMLGUARD was as good as to better than MIL-C-81309.

4. Squadron evaluation sheets are attached.

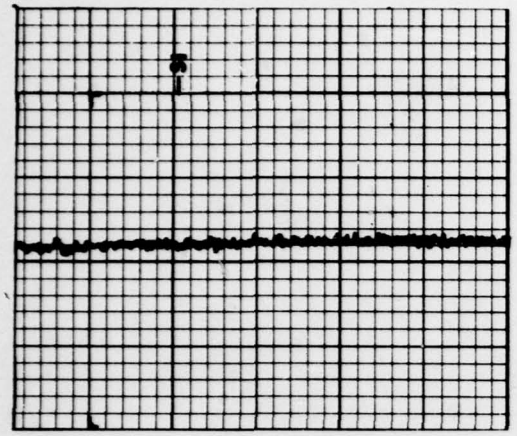
G. A. Porter
G . A . PORTER
By direction

A P P E N D I X C

Auger Electron Spectroscopy

AUGER ELECTRON SPECTROSCOPY

SPECTROGRAMS OF 7075 ALCLAD ALUMINUM AFTER AMLGUARD APPLICATION AND SOLVENT WIPE REMOVAL TREATMENT



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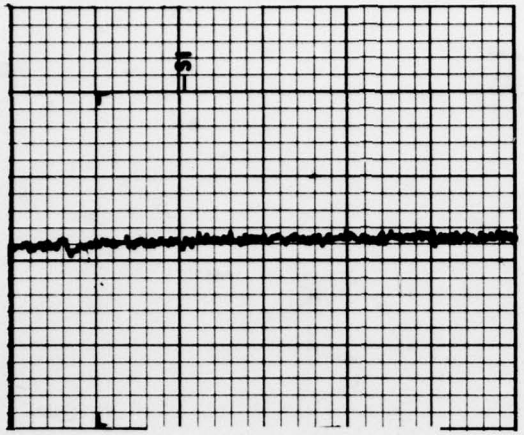
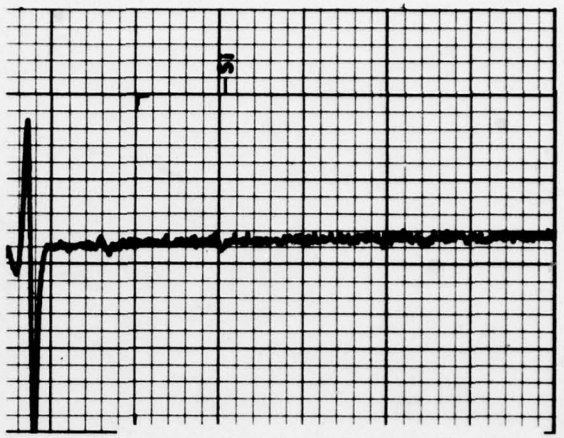
7075 ALCLAD ALUMINUM



REMOVED W/TOLUENE
TT-T-548



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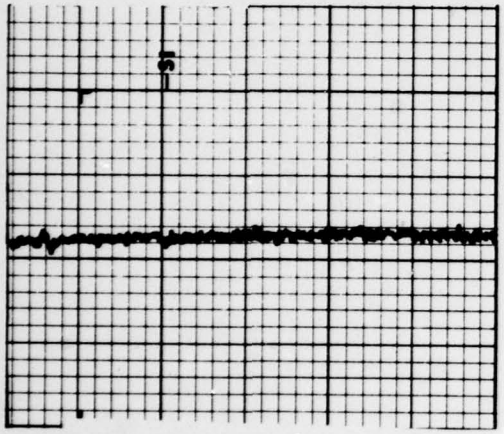
TYPE II P-D-680



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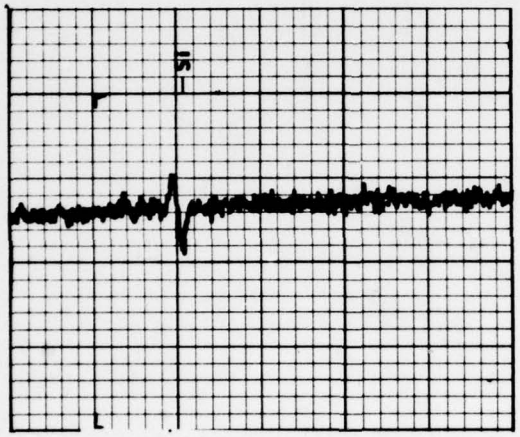
MIL-T-81533



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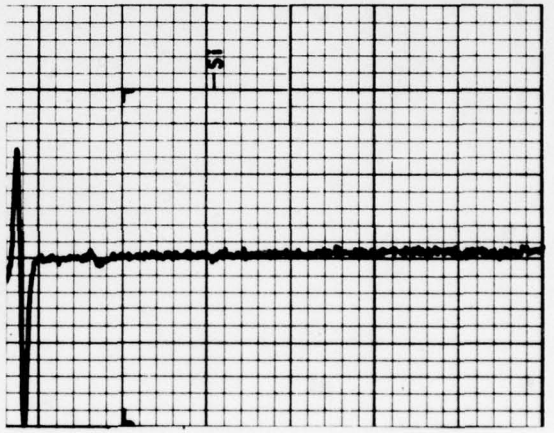
TT-M-261



REMOVED W/ALIPHATIC NAPHTHA
TYPE II TT-N-95

G-2

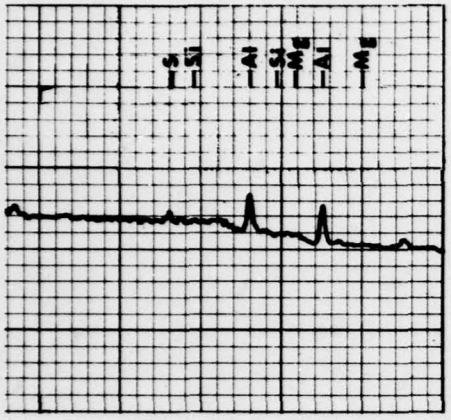
NADC-78220-60

A P P E N D I X H

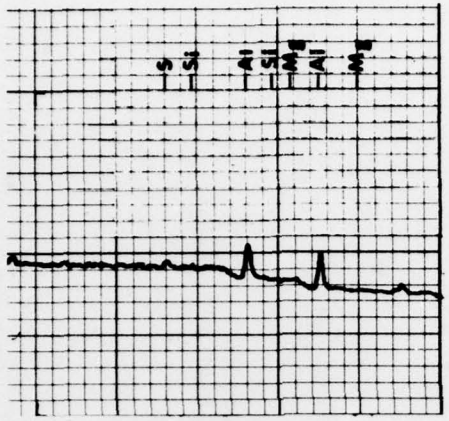
ESCA (Electron Spectroscopy Chemical Analysis)

ESCA (ELECTRON SPECTROSCOPY CHEMICAL ANALYSIS)

SPECTROGRAMS OF 7075 ALCLAD ALUMINUM AFTER AMLGUARD APPLICATION AND SOLVENT WIPE REMOVAL TREATMENT



BLANK (UNTREATED)
7075 ALCLAD ALUMINUM



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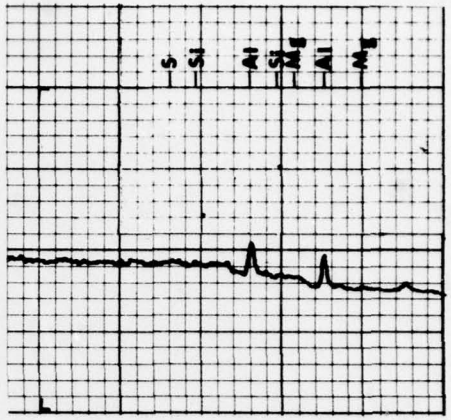
TT-T-548



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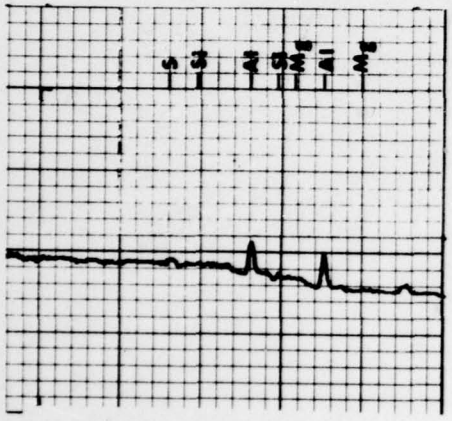
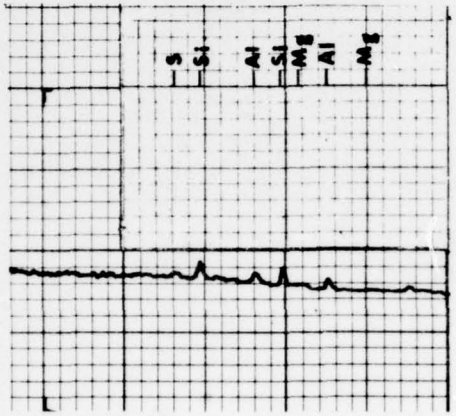
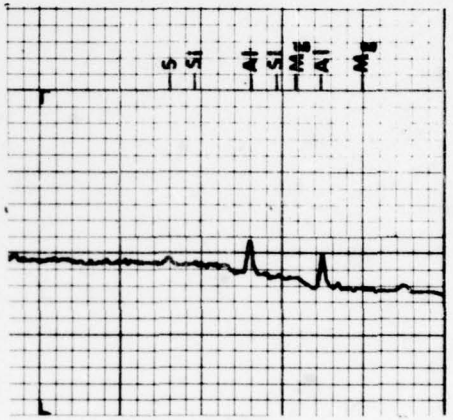
TYPE II P-D-680



REMOVED W/1,1,1, TRICHLOROETHANE
MIL-T-81533



REMOVED W/METHYL ETHYL KETONE
TT-M-261



REMOVED W/ ALIPHATIC NAPHTHA
TT-N-95

BINDING ENERGY

H-2

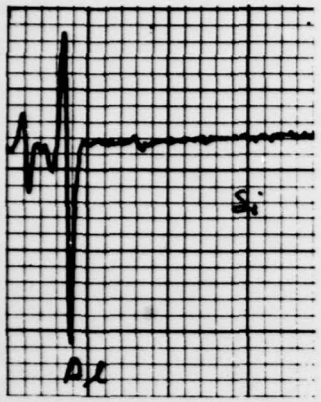
NADC-78220-60

A P P E N D I X I

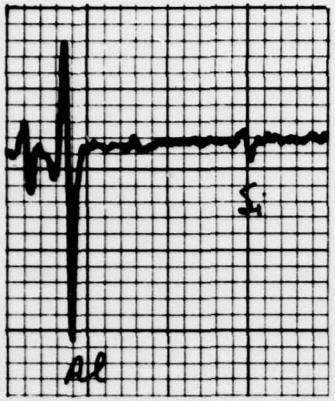
Auger Electron Spectroscopy

AUGER ELECTRON SPECTROSCOPY

SPECTROGRAMS OF 7075 ALCLAD ALUMINUM AFTER AMLGUARD APPLICATION AND SOLVENT WIPE REMOVAL TREATMENT



BLANK (UNTREATED) 7075 AL AD ALUMINUM



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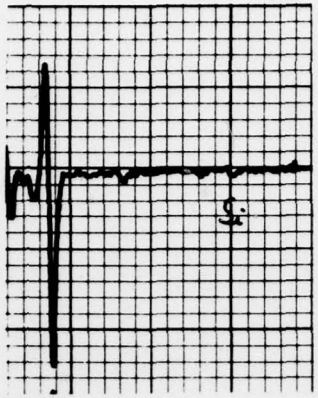
MIL-C-43616 (20% SOLUTION-AEROSOL PACKAGE)



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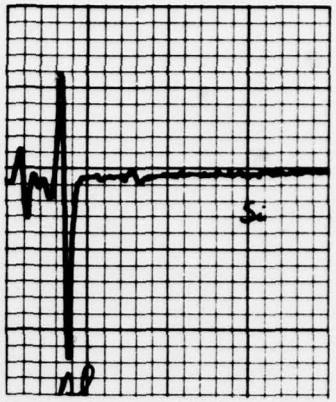

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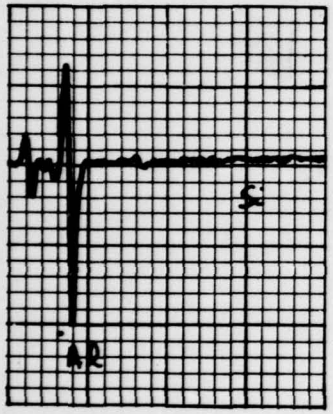

(RETEST)
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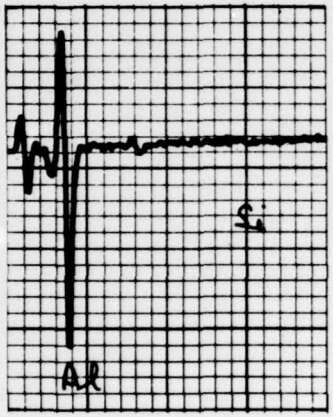
TT-M-261



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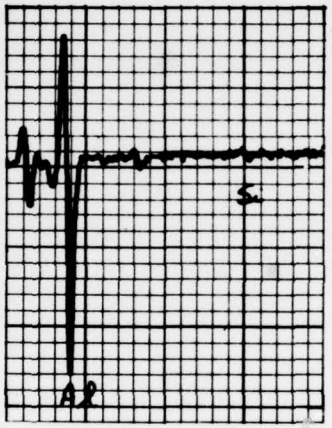
TT-I-735A



REMOVED W/MINERAL SPIRITS
TT-T-291

REMOVED W/ACETONE

A P P E N D I X J

NAVAIRDEVCEN Message
122301Z May 78

RTTUZYUW RUEODQA2505 1322301-UUUU--RUEOAIG RUEOALL RUWJELC RULSSAA
RUEBRDA RUWMBFA RUCLEKA RUEOALA RUWJELA RUCLMHA.
ZNR UUUUU
R 122301Z MAY 78
FM NAVAIRDEVCEN WARMINSTER PA
TO RUEOAIG/NAVAIREWORKFAC CHERRY POINT NC
INFO RUEOALL/COMNAVAIRLANT NORFOLK VA
RUWJELC/COMNAVAIRPAC SAN DIEGO CA
RULSSAA/COMNAVAIRSYSCOM WASHINGTON DC
RUEBRDA/NAVAVNLOGCEN PATUXENT RIVER MD
RUWMBFA/NAVAIREWORKFAC ALAMEDA CA
RUCLEKA/NAVAIREWORKFAC JACKSONVILLE FL
RUEOALA/NAVAIREWORKFAC NORFOLK VA
RUWJELA/NAVAIREWORKFAC NORTH ISLAND CA
RUCLMHA/NAVAIREWORKFAC PENSACOLA FL
BT

ROUTINE OUTGOING

UNCLAS //N10360//
COMNAVAIRLANT FOR CODE 528; COMNAVAIRPAC FOR CODE 74;
COMNAVAIRSYCOM FOR AIR-5203; NAVAVNLOGCEN FOR CODE 310;
NAVAIREWORKFACS FOR CODE 340
MIL-C-85054 CORROSION PREVENTIVE COMPOUND REMOVAL
A. NAVAIREWORKFAC CHERRY POINT NC 271954Z APR 78
B. NAVAIRDEVCEN WARMINSTER PA 071900Z MAR 78
C. NAVAIR 01-1A-509
1. IAW REF A, INFORMATION PROVIDED IN REF B MAY HAVE BEEN MISINTERPRETED SINCE REF A CITES PARTIAL REMOVAL OF SUBJ MATERIAL BY METHYL CHLOROFORM AND DRY CLEANING SOLVENT. IN EACH CASE, AN INSIGNIGICANT AMOUNT WAS DETECTED ONLY BY HIGHLY SENSITIVE SPECTROSCOPIC PROCEDURES. THE SOURCE OF THE SI DETECTED COULD HAVE BEEN DUE TO ATMOSPHERIC CONTAMINATION. NORMAL CLEANING WITH THESE SOLVENTS AS WELL AS TOLUENE AND ALIPHATIC NAPHTHA WILL PROVIDE A SUBSTRATE SUITABLE FOR APPLICATION OF COATINGS OR ADHESIVES. THESE SOLVENTS/THINNERS ARE LISTED IN REF C. AVAILABILITY TO FLEET CONFIRMED BY TYCOMS.
2. AS REF B INDICATED, ADDITIONAL SOLVENTS/THINNERS WERE TESTED FOR REMOVABILITY OF SUBJ MATERIAL. THE FOLLOWING WERE FOUND TO THOROUGHLY REMOVE THE SUBJ MATERIAL FROM THE TEST SURFACES: MIL-T-19544 THINNER, MIL-T-81772 THINNER, ACETONE, ISOPROPYL ALCOHOL, MINERAL SPIRITS, AND METHYL ETHYL KETONE. THE METHYL ETHYL KETONE WAS FOUND TO BE SATISFACTORY UPON FURTHER CHECK. PAINT ADHESION TESTS CONFIRMED THE ANALYTICAL RESULTS. ALL MATERIALS ARE LISTED IN REF C. MIL-C-43616 SOLVENT EMULSION CLEANER DID NOT REMOVE THE SUBJ MATERIAL ADEQUATELY FOR REFINISHING AND FLEET UNITS ARE ADVISED NOT TO USE IT FOR THIS PURPOSE. ALL SOLVENTS/THINNERS LISTED HEREIN ARE RECOMMENDED FOR REMOVAL OF SUBJ MATERIAL.
BT
#2505

TOD: 122340Z MAY 78/JG/EB/JB
RELEASED BY: P.M. STURM
DRAFTED BY: J. CARROLL
CC. 60

R 122301Z MAY 78

A P P E N D I X K

Procedures for Use of MIL-C-85054(AS) (AMLGUARD) for Aircraft Corrosion Prevention/Control

PROCEDURES FOR USE OF MIL-C-85054(AS) (AMLGUARD) FOR AIRCRAFT CORROSION PREVENTION/CONTROL

A. Description

Mixtures of corrosion inhibitors and water displacing compounds in an organic resin vehicle dissolved in suitable solvents which produce a transparent, water displacing, flexible, non-tacky corrosion preventive film. This material is usually tinted to increase the detectability of resultant films on aircraft surfaces without adversely affecting its properties.

B. Material Forms Available

Type I
16 ounce aerosol can
NSN: 8030-01-041-1596

Type II
1 quart (bulk) can
NSN: 8030-01-045-4780

C. Methods of Application

Brush, dip, spray
For spray application, do not thin (dilute) bulk material.

D. Application Instructions

For best results:

1. Wipe off dirt and excess moisture from surface to be protected prior to applying the corrosion preventive compound.
2. Apply a thin, uniform coat of corrosion preventive compound directly on area to be protected.
3. Allow to dry for one-half hour.
4. Apply a second uniform coat of corrosion preventive compound and allow to dry.
5. Application by wiping is not recommended.
6. After application of each coat of material by aerosol spray can, clear the spray tip (nozzle) of entrapped material by inverting the can and spraying.

E. Removability

These materials are easily removed by the following solvents and will not leave a residue:

Methyl ethyl ketone	TT-M-261
Aliphatic naphtha	TT-N-95
Mineral spirits	TT-T-291
Dry cleaning solvent	P-D-680
Isopropyl alcohol	TT-I-735
Acetone	O-A-51
Thinner	MIL-T-19544
Thinner	MIL-T-81772

CAUTION:

Do not use synthetic wiping cloths with these solvents to remove MIL-C-85054 films.

F. Intended Uses

Materials conforming to MIL-C-85054 can be substituted for MIL-C-81309 or MIL-C-16173, (Grade 4) except on parts which require a lubricated surface, electrical contact areas, form-in-place gaskets, and removable fasteners as described in Table I.

Specific areas on which these materials have been satisfactorily used are:

Wing butts, wheel wells, wheels, leading edges, access panels, exterior of electrical connectors, exterior of gear boxes, rotor heads, bolts, clamps, landing gear, cables, accessory gearbox of power plants, installed permanent fasteners, seams, chipped/damaged paint metal surfaces, chassis, mounting racks, hardware, bus bars, and terminal boards.

G. Endurance

MIL-C-85054 is a short term preservative and must therefore be reapplied more frequently in an outdoor sea environment.

TABLE I

EXPLANATION OF RESTRICTED AREAS OF APPLICATION

PARTS/AREA	MIL-C-85054	MIL-C-81309	MIL-C-16173 Grade 4
Lubricated surface	NO	*YES	NO
Electrical Contacts			
Friction/Sliding	NO	YES	NO
Stationary (points)	NO	NO	NO
Form in Place Gaskets	NO	*YES	NO
Removable Fasteners (thread area)	NO	YES	YES

* Where lubrication is essential, VV-L-800 is used. MIL-C-81309 shall be used where corrosion protection and water displacement are primary considerations.

D I S T R I B U T I O N L I S T

REPORT NO. NADC-78220-60

AIRTASK NO. WF54-593-201
WORK UNIT NO.ZM301

	No. of Copies
COMNAVAIR (AIR 954).	10
2 for retention	2 for AIR 516
1 for AIR 03	1 for AIR 530
1 for AIR 320	1 for AIR 4114D
2 for AIR 5163D1	
COMNAVAIRLANT (Code 528)	12
COMNAVAIRPAC (Code 74F).	12
COMNAVAVNLOGCEN, NAS Patuxent River, MD 20670.	1
CONAVAIREWORKFAC, Alameda (Codes 120, 300, 340, 940)	1
Jacksonville (Codes 120, 300, 340, 940). .	1
Norfolk (Codes 120, 300, 340, 940)	1
North Island (Codes 120, 300, 340, 940). .	1
Pensacola (Codes 120, 300, 340, 940) . . .	1
Cherry Point (Codes 120, 300, 340, 940). .	1
CONRL (Codes 6313 and 6120), Washington, DC.	2
WPAFB (AFML), Dayton, Ohio 45433	1
WRAMA (Code MMETC), Robins AFB, Georgia 31098	1
CO, Army Materials Engineering R&D Center, Ft. Belvoir, VA .	1
CO, Army Aviation Systems Command, St. Louis, MO 63100. . .	1
DDC.	12
Commandant (G-EAE/63) U. S. Coast Guard Headquarters, 400 Seventh St. S.W., Washington, DC 20590.	6
CO, U.S.C.G. Aviation Training Center (Prime Unit), Mobile, AL 36608.	2
Fleet Analysis Center (Code 8613), Naval Weapons Station, Seal Beach, Corona Annex, Corona, CA 91720.	1
COMNAVAIRENGCEN (Code 91222), Lakehurst, NJ 08733.	2
COMNAVAIRSHIPENGCEN (Code 6101C), Washington, DC 20362 . . .	1
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CG, 2nd Marine Division (Attn: Major Sahno (G-4) Camp Lejeune, North Carolina 28542.	1

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