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13. ABSTRACT

Techniques developed ~~previously at NRL~~ for the cleaning and reconditioning of oil- and/or saltwater-contaminated electrical and electronic equipment have been successfully applied to aircraft cockpits and avionics equipment. ~~The F-4B~~ aircraft cockpits, which had been flooded with saltwater, ~~during the fire aboard the FORRESTAL,~~ were filled with a detergent solution and cleaned with the aid of ultrasonic agitation from immersible transducers. The transducers were then placed in tanks and used in the cleaning of avionics equipment from the aircraft, and a dc generator. All equipment was rinsed ultrasonically and dried with a water-displacing fluid and warm air. Procedures have been developed to prevent the corrosion of equipment caused by saltwater contamination from fires or flooding. Equipment can thus be preserved pending cleaning and restoration. This emergency treatment consists essentially of washing with fresh water followed by the application of a water-displacing and rust-inhibiting compound.

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CONTENTS

ABSTRACT

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PROBLEM STATUS

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AUTHORIZATION

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SURFACE CHEMICAL METHODS OF DISPLACING WATER AND/OR OILS AND SALVAGING FLOODED EQUIPMENT

Part 6 - Field Experience in Removing Seawater Salt Residues from Aircraft Cockpits and Avionics Equipment

INTRODUCTION

NRL has previously developed a procedure for removing oily residues and/or seawater from equipment surfaces (1-15). The principle of displacing water with a surface-active agent has reduced drying time on wet equipment from days to hours. This system was used on a large scale to recondition electrical and electronic assemblies damaged by smoke, soot, seawater, and corrosive vapors during the fire on the aircraft carrier CONSTELLATION in December 1960 (5). Modifications of this system have more recently been applied in the cleaning of a tracking radar (11) and by the Coast Guard in the salvage of helicopters after submergence in the ocean (9). The recovery system is being used extensively by government agencies and industry for routine cleaning of electronic equipment, teletypewriters, etc., to remove contamination by oily aerosols, dust, and spreading lubricants, as well as by seawater salt residues. A number of facilities for routine cleaning and emergency salvage employing this system are being established at Pacific Fleet repair bases. The cleaning and salvage system uses a water-base emulsion with ultrasonic agitation or spray application, rinsing, water displacing, and drying.

In July 1967, the aircraft carrier USS FORRESTAL experienced a major fire. During the fire fighting, a number of aircraft were exposed to saltwater from fire hoses and sprinkling systems. Some of the cockpits were completely filled with salt water and remained so for as long as 1 day. Some of the ship's compartments were also flooded, and much wiring and electrical equipment was exposed to saltwater. At the request of the Deputy CNO for Air, NRL personnel went aboard the FORRESTAL in the Philippine Islands to determine the extent to which the salvage process developed by NRL could be used in the recovery of the flooded aircraft and equipment and to advise squadron and ship personnel of corrosion control and cleaning techniques which could be used. The emphasis was placed on temporary preservation until the aircraft and equipment could be overhauled at repair facilities in the eastern United States. Five F-4B aircraft and test equipment with saltwater contamination were received by the Naval Air Rework Facility at MCAS Cherry Point, North Carolina; the Rework Facility at NAS Jacksonville, Florida, received two A-4 and two RA-5C aircraft and mobile electronics testing equipment with saltwater contamination. The cleaning and restoration of these aircraft and their equipment is the subject of this report.

TEMPORARY PRESERVATION

An NRL representative briefed maintenance personnel of the entire air group of the FORRESTAL on the most effective methods of preventing further deterioration of the contaminated equipment. Washing with fresh water followed by spraying with a butyl alcohol-based water-displacing fluid was advised, but since the water-displacing fluid was not available and a shipment from the manufacturer failed to arrive in time, the use of petroleum-based preservatives after drying was recommended as an alternative. All avionics equipment which had been exposed to salt water was to be rinsed thoroughly and coated with preservatives inside and out.

After the aircraft and their avionics equipment had been received by the rework facilities, NRL personnel were requested to assist in the cleaning and recovery phase. On examination of the material received at Cherry Point and Jacksonville, it was found that the equipment that had been properly preserved was in easily salvable condition, with little corrosion. The equipment which had been thoroughly washed with fresh water but not properly preserved was generally in good condition but suffered some corrosion damage. Some aircraft cockpits and their fittings and wiring were in this category. Unfortunately, many items of electrical and electronic equipment had apparently not been rinsed in fresh water and had obviously not been coated with any preservative or had been only externally coated. Extensive corrosion had taken place, particularly on units having magnesium chassis or cases or other active galvanic couples to promote corrosion (16), (Figs. 1 and 4). Corrosion-damaged parts are usually beyond restoration by any cleaning process and require more expensive refinishing or replacement.

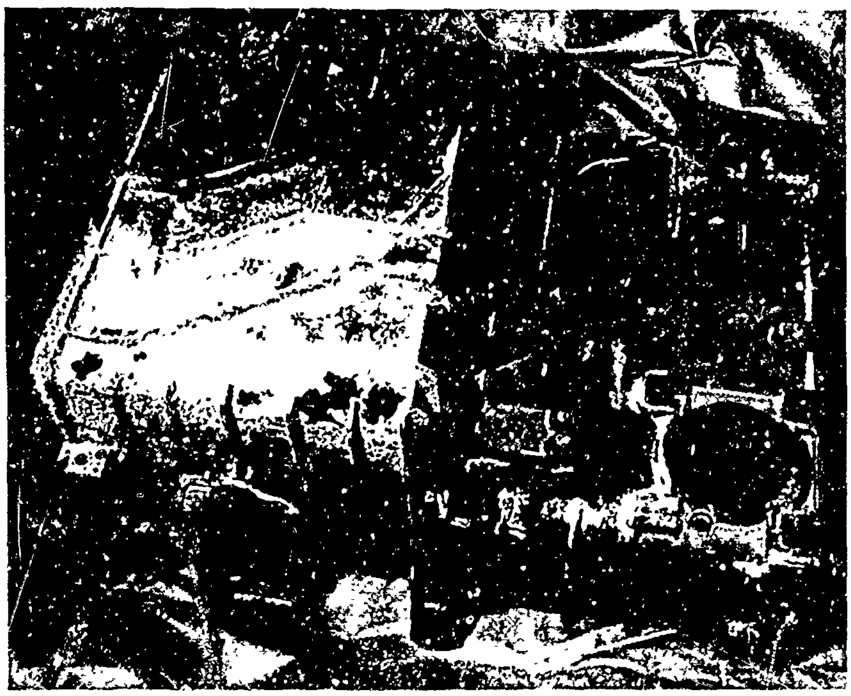

Fig. 1 - Magnesium case severely corroded by saltwater. (Photograph courtesy of Naval Air Rework Facility, Jacksonville, Florida.)

The failure of maintenance personnel to thoroughly carry out the recommendations made by the NRL representatives who visited the FORRESTAL can perhaps be attributed to two misconceptions by the personnel doing the work. They may have felt that electrical and electronic equipment contaminated with salt water was beyond restoration and thus not worth treating or that further immersion in fresh water and coating with preservatives would do more harm than good. It is recommended that instructions and reference manuals be revised to include information on the proper treatment of saltwater-contaminated equipment to facilitate restoration so that maintenance personnel aboard ships and at maintenance facilities ashore will have this information available for training and reference. It should be stressed that saltwater-contaminated equipment can be readily cleaned and restored but only if prompt action has been taken to halt the onset of corrosion.

CLEANING AND RECONDITIONING

The aircraft generally suffered the greatest contamination in their electrical equipment and in all of the wiring and connectors in the cockpits. Most of the major electronic units were in sealed cases, which protected them from the salt water. There were some, however, which were not sealed and were badly contaminated and corroded (Fig. 4). Some units, such as small circuit breakers, were not watertight but did not offer sufficient access to the interior to permit adequate cleaning and flushing. It was recommended that these be discarded and replaced. Most units could be cleaned by the usual technique of immersion in an ultrasonic tank containing a cleaning emulsion or solution.

The greatest problem was the cleaning of the maze of wiring and hundreds of connectors in the cockpits. It has been found that spray cleaning of these connectors is insufficient to remove all of the salt residues. In the cleaning of the fuselage of Coast Guard helicopters (9) a small ultrasonic tank was used to clean the connectors individually or in groups. Due to space limitations in the cockpits, the shortness of the connector leads, and the large number of connectors, this method was not practical for the aircraft from the FORRESTAL. The NRL representatives recommended filling the cockpits with the cleaning solution and providing agitation by the use of immersible ultrasonic transducers. The advantages of this method are that all of the connectors and wiring can be cleaned at once along with the controls, the fittings, and the cockpit structure itself. On completion of the cockpit cleaning, the ultrasonic transducers could be placed in tanks fabricated for the purpose and used to clean avionics units removed from the aircraft and the contaminated test equipment. The ultrasonic cleaning facility would then be available for future use in reconditioning saltwater-contaminated equipment or for routine cleaning of generators, engine parts, and other items now found very difficult to clean properly and economically.

The Naval Air Rework Facility at Cherry Point obtained four Westinghouse 1000-W, immersible magnetostrictive transducers, model I1114, and four 1-kW, solid-state ultrasonic generators. The Jacksonville Rework Facility obtained two units but elected not to clean the entire cockpits by the ultrasonic method, because the A-4's were in relatively good condition and there was doubt about the ability of the RA-5C's to support the weight of the water which would be required to fill their cockpits. The following description of the method therefore concerns its application to four F-4B aircraft at the Cherry Point Rework Facility.

Cockpits

To allow better access by the cleaning solution, the protective coverings on the connectors and wire bundles were removed 4 or 5 in. back from the connectors. The connectors were then positioned or tied so that they faced upward and inboard to prevent the trapping of air bubbles in the connectors and to obtain the most effective penetration of ultrasonic energy into the connectors (Fig. 2). The noses of the aircraft were raised to level the cockpit sills so that the level of the cleaning solution could be as high as possible in the rear cockpits. The cockpit areas were made watertight by the installation of maintenance doors, dummy plates and fittings, rubber plugs, etc. As there was very little oily contamination present, the NRL emulsion cleaner was not used. Instead, a nonionic detergent meeting specification MIL-D-16791 Type 1 was added to tap water, 0.5 oz of detergent per gal of water. To reduce the hardness of the water, 27 oz of Sequestrene Na 4 were added per 100 gal of water. Heating of the water to 120 to 130°F was desired, but facilities for heating the large volume of water required were not available.

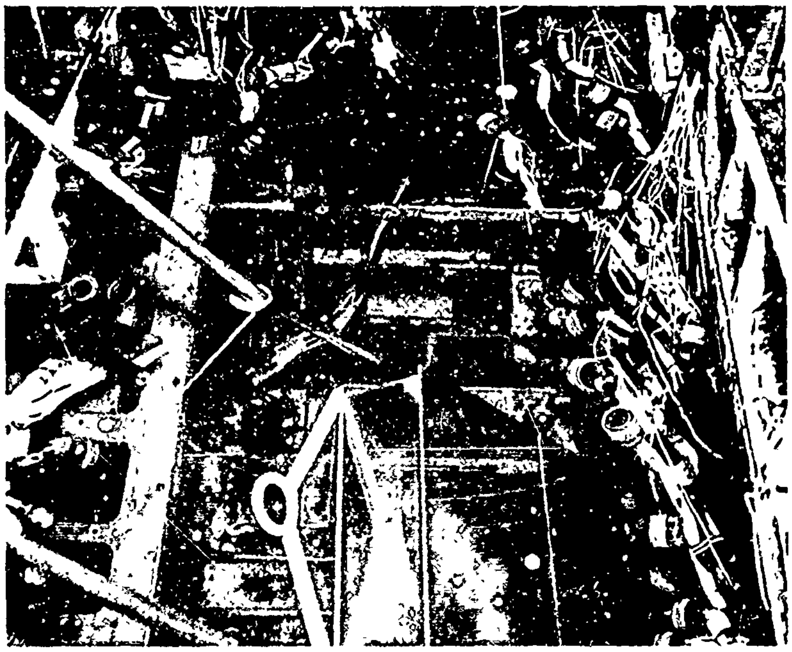

Fig. 2 - Forward end of rear cockpit during cleaning, with ultrasonic transducers immersed in detergent solution. (Photographs courtesy of Naval Air Rework Facility, Cherry Point, North Carolina.)

After the cockpits were filled with the cleaning solution, the transducers were placed in the cockpits and energized (Fig. 2). Note that the transducers were mounted in pairs on frames with lifting eyes for easier handling and positioning. The assemblies were near neutral bouyancy under water. The transducers were ordered with the power lead conduits connected to them by right-angle fittings so that they could be arranged horizontally with one above the other to form an array 14 in. wide and 22 in. high. The transducers were moved about in the cockpits so that the ultrasonic energy, which is emitted only from the transducer faces opposite the supporting framework, was applied to all areas of the cockpits. During the time when ultrasonic energy is being absorbed by the gases dissolved in the water, the intensity of energy at the surfaces to be cleaned is low. Cleaning was therefore continued for 15 min beyond the time when the degassing action diminished. After the cleaning solution had been pumped out, the cockpits were sprayed with fresh water, filled with water, and rinsed with ultrasonic agitation. This step is necessary to remove the cleaning solution which has been driven deep into crevices. The rinse water was then pumped out and sucked from nondraining pockets.

To rapidly displace moisture from the connectors, wiring, and metal surfaces and to prevent corrosion Spray-Dri (Type II, Moisture Control for Electronics) was sprayed thoroughly over everything in the cockpits. Air at 130°F was then blown into the cockpits by a hot-air integral fuel cell blower. The doors and plates which had been used to make the cockpits watertight were removed to allow air to exhaust, and plastic film was taped over the canopy openings (Fig. 3).

Fig. 3 - Drying the cockpits with warm air

Avionics Units

On completion of the cockpit cleaning and rinsing the transducer assemblies were placed in tanks fabricated so that the assemblies covered one end of the tanks below the level of the liquid, and the length was sufficient to accommodate the largest units to be cleaned. One tank was used for cleaning and one for rinsing. The same detergent solution was used for cleaning as was used in the cockpit cleaning. After cleaning and rinsing, the units were sprayed with Spra-Dri (Type II) and placed in an oven at 125°F to dry. The equipment was then bench checked, corroded parts were replaced, and necessary repairs were made. An electronic unit, shown in Fig. 4 contaminated with salt water and badly corroded, is shown in Fig. 5 after having been cleaned ultrasonically for about 5 min, rinsed, and dried.

Aircraft Dc Generator

As a demonstration of the uses of ultrasonic cleaning with emulsion cleaners in routine maintenance work at Cherry Point, a dc aircraft generator (Type 30E02-E-G) was cleaned using the same tanks and ultrasonic equipment which were used for the avionics equipment. The cleaning tank was filled with 70% water with water softener and 30% NRL

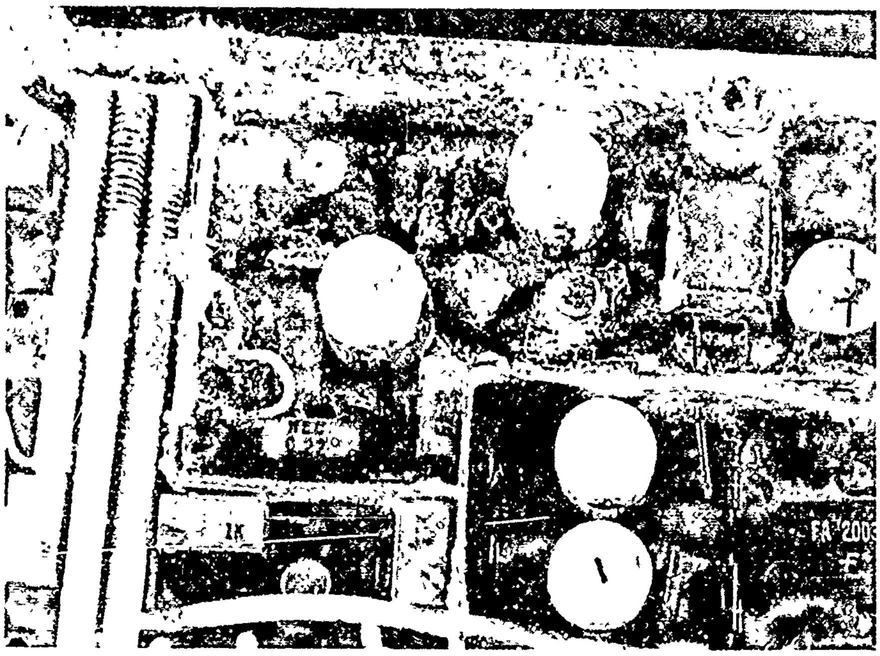

Fig. 4 - Electronic unit, showing salt residue and corrosion products before cleaning. (Photographs courtesy of Naval Air Rework Facility, Jacksonville, Florida.)

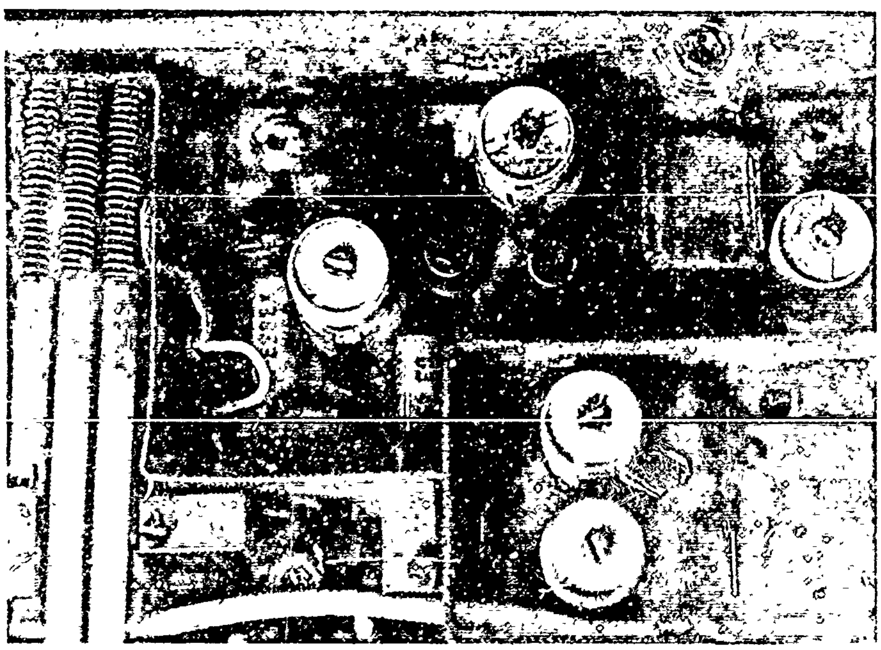

Fig. 5 - Unit shown in Fig. 4, after ultrasonic cleaning

emulsion cleaner concentrate. After cleaning, rinsing, and drying, the insulation resistance measured at 500 V was 500 to 600 megohms in the field coils and 1600 to 1800 megohms in the armature. The emulsion cleaner is preferred to halogenated solvents for this type of work for several reasons. It is much cheaper, it will remove water-soluble contaminants, it is more aggressive in removing oxidized oil and solid contaminants, and it cavitates more forcefully, making the ultrasonic agitation more effective.

RESULTS AND CONCLUSIONS

1. The Naval Air Rework Facility at Cherry Point reported (16) that the cleaning technique applied to the cockpits and avionics equipment was very effective in removing salt residues and minor corrosion products, and numerous items which initially failed to pass bench check and test requirements were found to be acceptable after cleaning and drying. Eight months after the cleaning and restoration, the four F-4B aircraft showed no signs of corrosion in the cockpits and did not have excessive electrical or electronic failures. The technique for cleaning cockpits is summarized in Appendix A.

2. Action is being taken by ComNavAirLant to provide more information on aircraft corrosion control to maintenance personnel. Reference 17 is a summary of current corrosion control techniques. Comments (18) on this summary and on the Handbook for the Preservation of Naval Aircraft have been forwarded by NRL to ComNavAirLant. Some of the appendices to Ref. 18 have been included as the appendices to this report. Appendix B gives the recommended contents and instructions for an emergency corrosion control kit for shipboard use on saltwater-contaminated equipment. This information was prepared at the request of ComServPac. Appendix C describes the equipment and procedures suitable for use in cleaning contaminated equipment at a shipyard or rework facility. The ultrasonic cleaning facilities being established at western Pacific bases are to be equipped and operated as described in this appendix.

3. A clear distinction must be drawn between the preservation of operational equipment to protect it from the environment during storage or transit and the preservation of saltwater-contaminated equipment to prevent deterioration until cleaning and restoration can be accomplished. Removing the accessible salt residues from the contaminated equipment is insufficient, and sealing the exteriors of units or aircraft is ineffective (unless a very low relative humidity can be maintained inside continuously). The salt residues must be washed off with fresh water, preferably by immersion, and that which remains trapped in crevices must be displaced or rendered harmless by the application of Spra-Dri (Type I, for Moisture and Rust Control, Interim Federal Specification O-W-001284 of July 24, 1967). If this material is not available, the equipment should be dried and then coated with any available preservative. As a last resort, even petroleum-base lubricating oil can be used. The equipment must be thoroughly sprayed inside and out with the preservative or coated by immersion. The temporary preservation treatment is described in Appendix B.

4. Ultrasonic cleaning with the NRL emulsion cleaner could be profitably used in many routine cleaning jobs, as exemplified by the cleaning of the dc aircraft generator. This technique has been used to clean motors contaminated with fuel oil and seawater (4). Adequate ultrasonic energy intensity (5 to 10 W/sq in.) is essential for cleaning motors and generators. Motors up to 40 hp have been recovered by this process (19).

ACKNOWLEDGMENTS

The authors acknowledge with pleasure the cooperation of personnel of the USS FORRESTAL and the Naval Air Rework Facilities at Cherry Point, North Carolina, and Jacksonville, Florida.

REFERENCES

1. Baker, H.R., and Zisman, W.A., "Water-Displacing Fluids and Their Application to Reconditioning and Protecting Equipment," NRL Report C-3364, Oct. 1948

2. Baker, H.R., and Zisman, W.A., U.S. Patent 2,647,839 (1953)

3. Baker, H.R., and Leach, P.B., "Salvage of Flooded Electrical Equipment," NRL Report 5316, June 1959

4. Baker, H.R., Leach, P.B., Singleterry, C.R., and Zisman, W.A., "Surface Chemical Methods of Displacing Water and/or Oils and Salvaging Flooded Equipment, Part 1 - Practical Applications," NRL Report 5606, Feb. 1961

5. Baker, H.R., Leach, P.B., and Singleterry, C.R., "Surface Chemical Methods of Displacing Water and/or Oils and Salvaging Flooded Equipment, Part 2 - Field Experience in Recovering Equipment Damaged by Fire Aboard USS CONSTELLATION and Equipment Subjected to Salt-Spray Acceptance Test," NRL Report 5680, Sept. 1961

6. Baker, H.R., U.S. Patent 3,078,189 (1963)

7. Baker, H.R., and Singleterry, C.R., U.S. Patent 3,138,558 (1964)

8. Baker, H.R., U.S. Patent 3,167,514 (1965)

9. Baker, H.R., and Leach, P.B., "Surface Chemical Methods of Displacing Water and/or Oils and Salvaging Flooded Equipment, Part 3 - Field Experience in Recovering Equipment and Fuselage of HH 52A Helicopter after Submersion at Sea," NRL Report 6158, Oct. 1964

10. Baker, H.R., and Leach, P.B., "Surface Chemical Methods of Displacing Water and/or Oils and Salvaging Flooded Equipment, Part 4 - Aggressive Cleaner Formulations for Use on Corroded Equipment," NRL Report 6291, June 1965

11. Baker, H.R., and Leach, P.B., "Surface Chemical Methods of Displacing Water and/or Oils and Salvaging Flooded Equipment, Part 5 - Field Experience in Removing Seawater Salt Residues, Sand, Dust, and Soluble Corrosive Products from AN/FPS-16-(XN-1) Missile- and Satellite-Tracking Radar," NRL Report 6334, Oct. 1965

12. Bernett, M.K., and Zisman, W.A., "Surface Chemical Displacement of Organic Liquids from Solid Surfaces," NRL Report 6354, Dec. 1965

13. Baker, H.R., Singleterry, C.R., and Zisman, W.A., "Factors Affecting the Surface-Chemical Displacement of Bulk Water from Solid Surfaces," NRL Report 6368, Feb. 1966

14. Baker, H.R., Leach, P.B., Singleterry, C.R., and Zisman, W.A., Ind. Eng. Chem. 59 (No. 6):29 (1967)

15. "Reconditioning of Flooded Equipment," Naval Ships Technical Manual, NavShips 0901-919-0000, Chapter 9190, Section X

16. NavAiReworkFac CherPt letter 34200/GGG:mr 10360 of Feb. 13, 1968

17. Frazier, E.L., Digest of U.S. Naval Aviation Weapon Systems - NavAir 08-1-503, 27 (No. 10):12 (1968)

18. NRL letter 6170-199:HRB:PBL:eb, Ser. 5217 of July 1, 1968, "Avionics Corrosion Control of Electrical and Electronic Equipment, comments on"

19. NRL letter 6170-41:RNB:eb, Ser. 1789 of Feb. 28, 1966, "Cleaning of Electrical Equipment on USS ALAMAGORDO (ARDM-2) Following Salt-Water Immersion"

Appendix A

PROCEDURE FOR CLEANING COCKPITS OF F-4B AIRCRAFT

The wiring, electrical connectors, and interior of the cockpits should be cleaned as follows:

1. Remove all cable ties.

2. Remove boots and/or tape covering on connector plugs.

3. Electrical plugs, receptacles, and parts with internal voids shall be manipulated during immersion to allow all air to escape from the parts.

4. Components which had been treated with preservative compounds should be degreased by spraying with Type I dry-cleaning solvent, Fed. Spec. P-D-680, prior to ultrasonic cleaning.

5. Inflate the nose strut to maximum height and jack the nose of the aircraft to level the sills of the cockpit.

6. Make the cockpits watertight by installing applicable maintenance doors, dummy plates and fittings, rubber plugs, etc., as necessary.

7. Fill the cockpits with water to the level of the sill. Monitor the water added to the cockpits of the first aircraft to determine the approximate volume.

8. Add 1 fl oz of detergent, Mil-D-16791, Type I, for each gallon of water. Mix the detergent thoroughly by stirring. (Solution of the detergent can be hastened by premixing the detergent with isopropyl alcohol in the ratio of 1 part detergent to 2 parts alcohol. If this is done, then use 3 fl oz of the concentrate for each gallon of water.)

9. Immerse the ultrasonic transducers completely below the liquid surface and turn on the power.

10. Move transducers slowly around the cockpits to degas the solution. A noticeable increase in the ultrasonic hum and the level of agitation should occur when the solution is degassed.

11. To clean the cockpit and contents, slowly move the transducers along the side, front, back, and bottom surfaces of each cockpit. The rate of movement should be such that all surfaces are exposed to the ultrasonics for approximately 15 min.

12. Drain the detergent solution from the cockpits.

13. Spray rinse all surfaces of the cockpits with fresh water.

14. Refill both cockpits with fresh water and rinse ultrasonically as described in paragraphs 9 and 10. (Do not add detergent.)

15. Drain the rinse water. Vacuum suction may be used to remove the water from the floor, voids, and pockets which will not otherwise drain.

16. Apply the water-displacing compound (Spra-Dri for Electronics, Moisture Control, Type II, Fed. Spec. O-W-001284 of July 24, 1967).

Due to the noxious odor of the n-butyl alcohol in the Spra-Dri, a suitable respirator shall be worn when spraying this material in confined spaces.

17. Allow the excess liquid to drain and/or use vacuum to remove the excess liquid from voids and recesses.

18. Dry the cockpit interior with warm air at a temperature of 120 to 130°F.

Appendix B

EMERGENCY KIT TO MINIMIZE CORROSION DAMAGE FROM SEAWATER CONTAMINATION DURING TRANSIT TO A REPAIR BASE

CONTENTS OF KIT

Two square 5-gal cans of Spra-Dri, Type I, Moisture and Rust Control (Spra-Dri, Type II, is not designed for use in the preliminary preservation).

Two manually operated sprays - (all-metal construction) such as are used for applying insecticides. The tank type which is pumped up to operating pressure before use is more convenient and effective.

INSTRUCTIONS FOR USE

Step 1 - Spray wash or submerge the seawater-contaminated equipment in fresh water to remove as much seawater as possible (this should be done before seawater has dried on the equipment, if practicable). Contaminated equipment should be washed inside as well as outside with the fresh water, if there is any possibility that seawater has penetrated. It will be necessary to open the cases to gain access to the interior.

Step 2 - Blow as much fresh water as possible from the interior and exterior of the washed equipment with clean, dry compressed air.

Step 3 - Using the insecticide sprayer, spray the washed equipment inside and outside with "Spra-Dri, Type I, Moisture and Rust Control." Ventilation adequate to remove the butyl alcohol vapors is necessary.

Step 4 - Dry the equipment as thoroughly as possible, by hot-air blowers, if available, or by placing in a heated and ventilated space.

Step 5 - Since some seawater will remain in crevices after the simple spray or immersion washing, it is wise to store the equipment in the driest available space with adequate ventilation. The drier the treated equipment is kept in transit to the repair facility, the less the corrosion that will result from crevice-held seawater.

Spra-Dri, Type I, can be obtained through General Services Administration in 12-oz aerosol cans or 1 and 5 gallon cans by referring to the Interim Federal Specification Water Displacing Compound O-W-001284 of July 24, 1967. Specify square cans if desired.

Spra-Dri, Type I, Moisture and Rust Control, is also commercially available from the Perfecting Service Plant, Cleco Pneumatic Division, G.W. Murphy Industries, Inc., 332 Atando Avenue, Charlotte, N.C. (P.O. Box 1949) 28206.

Appendix C

RECLAMATION OF OIL - AND/OR SEAWATER-CONTAMINATED EQUIPMENT

The following equipment is recommended for a complete facility for the removal of oil and seawater from flooded or contaminated equipment.

ULTRASONIC EQUIPMENT

Three stainless-steel (304L or 316L) tanks, 4 by 4 by 4 ft, should be provided. These tanks should be constructed of 12-gauge or heavier sheet and have adequate reinforcement to support double the weight of water required to fill them. A stainless-steel valve and piping should be installed on each tank in a location which assures complete draining by gravity. A stainless-steel steam coil should also be installed on the bottom of each tank to maintain the desired operating temperature. One of these tanks is to be used for ultrasonic cleaning of the equipment, one is to be used for rinsing the equipment in fresh water, and the third is to be used as a presoak tank in case smoke-contaminated equipment is encountered.

Each of the two ultrasonic tanks used for cleaning and rinsing should be equipped with nine 1000-W magnetostrictive immersible transducers 10-5/16 by 13-11/16 by 4-1/2 in. in size. Racks to hold the transducers are available from the supplier of the ultrasonic equipment. The tanks could be constructed at the respective shipyards, or they could be purchased from the supplier of the ultrasonic equipment.

A solid-state generator or a bank of solid-state generators capable of 9-kW total output should be provided for each of the two ultrasonic tanks. If it should become necessary to clean equipment which is too large to fit into the 4-by-4-by-4 ft ultrasonic tanks, a larger tank could be constructed, and if necessary all eighteen immersible transducers could be used in that tank.

SPRAYING EQUIPMENT

Equipment that cannot be dismantled for cleaning in ultrasonic tanks can often be cleaned by spraying with the NRL cleaning emulsion followed by fresh-water spray rinsing and drying. Both a Binks Spray Gun 140B (manufactured by the Binks Manufacturing Co., 3118 Carrol Avenue, Chicago, Ill.) and an ordinary steam jenny have been found satisfactory for such spray cleaning. In the Binks Spray Gun the NRL cleaning concentrate is emulsified with the desired amount of water before spraying, while with the steam jenny the NRL cleaning concentrate is used in the cleaner tank, and water is mixed with it at the time of use.

If the equipment is contaminated with seawater only (no oil, grease, or preservative), a solution of Detergent General Purpose, Military Spec. Mil-D-16791, Type I, Water Soluble, Nonionic, can be used at a concentration of 1 oz per gallon of fresh water. It can be applied with either the Binks Spray Gun or the steam jenny.

DRYING EQUIPMENT

Forced-draft ovens with accurate temperature control large enough to accommodate the equipment being cleaned are preferable for final drying of the cleaned equipment. If ovens are not available, a small room equipped with an exhaust fan and heaters can be used. Either electric, gasoline, or kerosene (fuel-oil) heaters are satisfactory for heating such a room. A portable parachute drying tower, Federal Stock 2 RM 8340-276-3341-S030, can be used to heat the room or can be used to construct and heat a temporary enclosure. Dehumidifiers could also be used to remove the moisture from the room. The temperature in these drying facilities should be between 120 and 160°F depending on the temperature sensitivity of the equipment being dried. If a heated room is used for drying, its temperature should be at least 30°F above the ambient temperature.

COMPRESSED AIR

If compressed air is not available, any type of compressor that will deliver clean dry air at 80 psi will be adequate to furnish air for spray cleaning and for blowing as much water as possible from the wet equipment before using the water-displacing fluid.

SUPPLIES NEEDED

There is no Federal Stock number for the NRL cleaning concentrate. The cleaning concentrate can be formulated as follows:

Dry Cleaning Solvent, Type II, Federal Spec. P-D-680 (formerly P-S-661) Navy Stock W6850-285-8011 (55-gal drums) Navy Stock W6850-274-5421 (5-gal cans)	94 vol-%
Fuel Oil, Diesel Marine, Type I, Military Spec. Mil-F-16884F	5 vol-%
Polyethylene Glycol 400 monooleate, S1006, a product of Glyco Products Co., Inc., Empire State Building, New York, N.Y. 10001 or Surfactant nonionic (oil soluble), such as Detergent, General Purpose, Military Spec. Mil-D-16791C-ANI-Type II, Navy Stock 7930-531-9716 (5-gal cans)	1 vol-%

The shelf life of this cleaner concentrate is in excess of 1 year.

The water-displacing fluid Spra-Dri is available in pressurized aerosol cans or in drums from GSA. It is supplied as Spra-Dri, Moisture and Rust Control, Type I, and as Spra-Dri, for Electronics, Moisture Control, Type II, by referring to the Interim Federal Specification, Water-Displacing Compound O-W-001284 of July 24, 1967.

In case smoke or soot is encountered on the equipment a presoak in water containing 2 to 4 oz per gallon of one of the following polyphosphate-type alkaline cleaners is recommended prior to routine ultrasonic cleaning, etc. (a) Sonex 20, supplied by Chemtrex Corp., 491 West Street, New York, N.Y. 10014, or (b) Spray Altrex, supplied by Chemical Corp., Wyandotte, Michigan 48192.

The presoak tank should be maintained at 120 to 160°F depending on the temperature sensitivity of the contaminated equipment. The temperature of the presoak tank should be kept as high as possible to insure better removal of contaminant.

METHOD OF SALVAGE

1. Immediately after the removal of the equipment from seawater, flush thoroughly with fresh water.

2. Follow with a spray of water-displacing rust-inhibiting composition (Spra-Dri, Moisture and Rust Control. Type I). (This protects the equipment during necessary inspection or inquiry and during transport to repair base.) Failure to apply steps 1 and 2 promptly may render later salvage impossible or useless.

3. When the equipment arrives at salvage installation, disassemble the electronic equipment to units of a size permitting immersion in an ultrasonic bath and allowing better access of the cleaning solutions.

4. Remove the oily contamination, seawater, and salt with the emulsion cleaning composition in the ultrasonic tank. Use 20 to 50 vol-% of concentrate in fresh water (with a hardness of less than 10 ppm), depending on the amount of oily residue to be removed. (Pressure spraying or immersion in an air-agitated tank may be substituted for ultrasonic treatment if circumstances require but are less efficient.) If the oil contamination is heavy, the equipment should be sprayed with emulsion cleaner (50 vol-% NRL concentrate and 50 vol-% water) to remove as much oil as possible before disassembly. This will facilitate handling and avoid overloading the ultrasonic cleaning tank with oil residues. (This emulsion should be kept well mixed while spraying.) If no oily contaminant is present, use 1 oz/gal of Surfactant Nonionic (water-soluble) General Purpose Detergent, Specification Mil-D-16791, Type I, Navy Stock 7930-282-9701, 5-gal pail.

5. Rinse in the ultrasonic tank of fresh water or spray rinse with fresh water.

6. Blow the rinse water off the equipment with clean, compressed air and follow with a spray of water-displacing composition (Spra-Dri, Moisture Control, for Electronics, Type II, or Spra-Dri Moisture and Rust Control, Type I, for rugged electrical or mechanical equipment).

7. Dry in an oven (or equivalent) for several hours. The drying temperature should be 120 to 160°F depending on the heat tolerance of the equipment.

8 Electrical or electronic equipment should be checked for proper operation, defective components replaced, and adjustments made before returning the equipment to service.

NOTES

1. Experience at this laboratory indicates that dc motors and generators that have been flooded in seawater cannot be satisfactorily reconditioned by spray cleaning. However, units have been satisfactorily reconditioned when ultrasonically cleaned and ultrasonically rinsed in fresh water and then dried as described.

2. The water used for preparing the emulsion cleaner should not have a hardness greater than 10 ppm. If it is harder than this, a water softener should be added as follows:

For a water hardness of 20 ppm add 10 oz of the recommended water softener per 100 gal of water, and for a hardness of 40 ppm add 20 oz of water softener per 100 gal of water. The chemical compound designated as tetrasodium ethylenediaminetetraacetate dihydrate is recommended. This compound is available commercially under several trade names, two of which are Sequestrene NA4 (supplied by Geigy Industrial Chemicals, Saw Mill Road, Ardsley, N.Y. 10502) and Nullapon BF 78 (a product of Antara Chemicals, 435 Hudson Street, New York, N.Y. 10014).

3. Of the two ultrasonic tanks recommended, one should be used for cleaning and the other other for fresh-water ultrasonic rinsing. When a tank is first filled, it is recommended that the ultrasonic units be turned on and allowed to operate while the steam-heating coil brings the tank temperature up to 190°F. The steam should then be turned off, and the tank contents allowed to cool down to the desired operating temperature (130 to 135°F for the NRL emulsion cleaner). This heating to 190°F assists in degassing the liquids; effective degassing is necessary to get good ultrasonic cleaning.

4. If meters are not hermetically sealed and have been submerged in seawater, they should be replaced.

5. Care should be taken when placing electronic equipment, which contain transistors in the circuit, into the ultrasonic tank as described in Ref. 9, page 2.

6. Electron tubes do not have to be removed from equipment while being cleaned in the ultrasonic tank (Ref. 11, page 5).

7. The cleaning emulsion will remove the lubricant from bearings, gear trains, etc., thus all bearings and moving parts will need relubrication (Ref. 5).

8. Experience has shown that from 3- to 5-min immersion in each ultrasonic tank is sufficient for cleaning and rinsing electronic gear. From 10- to 20-min immersion in each ultrasonic tank is often needed for seawater-soaked motors and generators.

9. To facilitate the solubility of Detergent General Purpose, Specification Mil-D-16791, Type I, (water soluble, nonionic) in water, a gel can be made by mixing in the ratio of 1 part detergent to 2 parts isopropyl alcohol. This concentrate should then be used in a concentration of 3 oz/gal of fresh water.