Bendix
Aerospace
Systems Division

# Recommendations for Minimizing Green Crud

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## ABSTRACT

The Array A-2 Green Crud problem, the investigation, and resulting recommendations were presented in ATM 1059 of 23 September 1971. With the occurrance of Green Crud in the Array E system in January, 1972 a second investigation of the means to prevent and/or remedy Green Crud was initiated. This ATM describes the results of this latter investigation.

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## INTRODUCTION

A total of 12 instances of Green Crud have appeared on the Array E Qualification and Flight hardware. The location of the Green Crud ranged from beneath components mounted on PC boards, to solder joints of plated copper wire, to solder joints of manganin wire, to beneath the wire insulation several inches from a solder joint. The cause and normal occurrance of Green Crud was reviewed with a number of corporations and NASA representatives. These discussions confirmed the cause documented in ATM 1059 (reference 1).

A review of the practices followed in the manufacturing of the Array E hardware revealed that not all the recommendations of ATM 1059 had been implemented, thus explaining the recurrance of ALSEP hardware Green Crud. The Array E investigation, both laboratory tests and consulation with other companies, lead to recommendations both for minimizing the occurrance of Green Crud and for removing the majority of Green Crud where it has developed. The means of implementation of these recommendations has been documented in BxA Manufacturing Instruction #19.

## EVENTS PRIOR TO ARRAY E GREEN CRUD

The first four ALSEP systems (EASEP, Flight 1, Flight 3 and Flight 4) were manufactured following the requirements of NPC 200-4 (reference 2). The soldering of the A-2 and subsequent systems was in accordance with NHB 5300.4 (3A) (reference 3). Pages pertaining to the soldering specification of these documents are shown in Figure 1. One significant difference appears: the use of liquid flux was very limited on the first 4 ALSEP's. The fact that Green Crud was not apparent on the first 4 systems is attributed to this difference.

As documented in ATM 1059: (1) the Green Crud removed from the A-2 system was non-corrosive and non-conductive in a solid state (reference 4), (2) no corrosion of metals of the A-2 system was observed, and (3) no chemical reaction was observed on the KYNAR sleeving or on the Teflon insulation. Green Crud is a product of metallic oxides removed from the surfaces to be soldered and the acids present in the flux resins. Ionic activity of the flux resins, required to remove the metallic oxides prior to soldering, is induced by the application of heat or by dissolving the resins in alcohol, as a liquid flux. While in a liquid state the flux residues are corrosive and electrically conductive;

FIGURE 1
SOLDERING SPECIFICATION

## SECTION 4: MATERIALS

### 4.1 SOLDER (CORED)

Except where otherwise required by the design, solder shall conform to Federal Specification QQ-S-571, Type RA, composition SN60 or SN63.

### 4.2 FLUX

Only noncorrosive, nonconductive rosin fluxes conforming to Military Specification MIL-F-14256, Type A, and Federal Specification QQ-S-571, Type RA, shall be used. Liquid rosin flux shall be used only for the following applications:

(a) Removal of excess solder from a joint by wicking on to stranded wire; and

(b) Soldering of nickel-plated wire.

When used with flux-cored solder, liquid flux shall be chemically compatible with the solder core flux.

### 4.3 SOLVENTS

Ethyl alcohol, conforming to Federal Specification O-E-760, Grade I, Class A or Class B, or the best grade commercial 99% pure (by volume) isopropyl alcohol shall be used for removal of excess flux, grease or oil.

### 4.4 FLEXIBLE INSULATION TUBING OR SLEEVING

Except as otherwise required by the design, flexible electrical insulation tubing shall be either extruded vinyl plastic, polytetrafluoroethylene or heat shrinkable, as applicable.

4.4.1 EXTRUDED VINYL PLASTIC TUBING. Extruded vinyl plastic tubing conforming to Military Specification MIL-I-7444, Type I, may be used where exposure to temperatures in the range -90° F. to +158° F. will be encountered.

4.4.2 POLYTETRAFLUOROETHYLENE TUBING. Polytetrafluoroethylene tubing which conforms to Military Specification MIL-I-22129 may be used where exposure to high temperatures

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### 3A308 MATERIALS SELECTION

The supplier is responsible for selecting materials suitable for intended use which do not degrade the quality of the solder junction, and metals or parts being joined.

### 3A309 SOLDER

Solder shall conform to Federal Specification QQ-S-571, Type RA or RMA for cored solder; and type S, form B or I for solid solder, and shall be composition Sn60 - Sn63, unless otherwise required by a NASA-approved design.

### 3A310 FLUX

1. TYPES AND USAGE. The supplier's process documentation shall describe the types of fluxes, where each is used, and necessary precautions.

2. LIQUID ROSIN FLUX. Liquid rosin flux shall conform to MIL-F-14256, Type A, except that the copper mirror test (par. 3.5) is not required, and that the resistivity of water extract (par. 3.2.6) shall be at least 45,000 ohm-centimeters. Liquid flux used with flux-cored solder shall be chemically compatible with the solder core flux and with the materials with which it will come in contact.

### 3A311 SOLVENTS

1. Solvents and processes proposed by the supplier for cleaning and flux removal shall be submitted for review. Solvents shall be nonconductive, noncorrosive, and shall not dissolve or degrade the quality of parts or materials.

CAUTION!

Solvents shall not be used in any manner which will carry dissolved flux residue on to contact surfaces such as those in switches, potentiometers, or connectors.

2. The following solvents are acceptable when properly used for cleaning in soldering operations:

   a. Ethyl alcohol, ACS grade, 99.5% or 95% by volume.

   b. Isopropyl alcohol, best commercial grade, 99% pure.

   c. Trichlorotrifluoroethane, clear, 99.8% pure.

   d. Any mixtures of the above.

CAUTION!

Ultrasonic cleaning, if used, shall be employed with caution to prevent damage to parts.

however, after solidifying (evaporation of the solvents) the flux and flux residues which contain the Green Crud are non-active. The residue can be reactivated with solvents as alcohol or with heat sufficient to liquify the resins of the residue. Green Crud beneath the insulation of wire adjacent to solder joints is a result of wicking the residue beneath the insulation by use of excessive liquid flux or by alcohol used as a cleaning solvent following the soldering operation.

Based on the above definition of the cause of Green Crud, BxA ALSEP Quality Directive (AQD) -63 (reference 5) was issued to minimize recurrance. AQD-63 and its 3 revisions covering 21 July to 7 October of 1971 established the following:

1. Use of liquid flux shall be eliminated except in cases where soldering (tinning) is extremely difficult without its use.

2. When liquid flux must be used:
   a. To minimize the flux residue, just touch the end of the wire with flux when tinning.
   b. When tinning the wire attempt to stop the solder flow within one wire diameter (of the stranded bundle) from the end of the insulation. Thermal shunts shall be utilized to aid in preventing solder from wicking under the insulation except where space limitations prohibit their use.

3. Excess flux and flux residues shall be removed with tri-chloro-tri-fluro-ethane (freon TF). Isopropyl alcohol shall not be used.

4. Each tinned wire shall be examined after cleaning with a 5X or greater eye-loop to verify that all liquid flux and flux residues have been removed from the tinned wire.

CAUTION

a. Do not attempt to solder to non-tin-dipped connector terminals.
b. Flux solvents will readily carry flux residues under the insulation, therefore extreme care must be exercised to prevent wicking of dissolved residues when attempting to remove the flux residues.
c. Care must be exercised to prevent flux solvents from carrying flux residues onto contact surfaces of connectors.

## ARRAY E GREEN CRUD

In December of 1971 and January of 1972, a total of 12 instances of Green Crud were found on the Array E hardware, qualification and flight systems. The matrix of Figure 2, which identifies the 12 cases, the wire type, operator, etc., was compiled to examine possible correlations; none are evident. However, an on-the-floor investigation revealed that the instructions of AQD-63, noted above, had not been implemented. The use of liquid flux and alcohol was found, thus explaining the incidence of Green Crud. Actions were taken immediately to restrict the use of alcohol and liquid flux (reference 6) and additional investigations were conducted to determine methods to: (1) minimize the occurrance of Green Crud and, (2) remove the maximum amount of Green Crud where deposits are formed.

A number of discussions were held with J. Claus and D. Venier of the Kester Solder Company, E. Swantek of the Tensolite Wire Company, A. Stripens of North American-Downey, P. Marran of NASA/MSC who was associated with the North American activities, V. Friebel of Ball Brothers Corporation (reference 7) and R. Tannehill of NASA/MSFC (reference 8).

In summary,

1) Cause - the general conclusions stated above and in ATM-1059 regarding the formation of Green Crud were confirmed. Green Crud is a product of copper oxides and solder flux. However, with the chlorides present in the activated flux, there are two types of Green Crud which can be produced, copper abetate and copper chloride. Copper abetate is inert and in a solid state is non-corrosive and non-conductive. Copper chloride, however, is soluable in water and can result in a corrosive process and be electrically conductive. Measures must be taken to minimize the latter type of Green Crud.

2) Properties - the corrosive and conductive properties of solidified Green Crud were not agreed to by all individuals contacted. Definitive tests reports have been requested but not yet received. It appears the disagreeme can be answered by the fact that there are two types of Green Crud.

3) Cleaning flux residues - the method of cleaning, i.e., bathing in organic solvent following soldering and purging in vacuum to reach confined locations were confirmed; however, two cleaning solvents have been suggested: 1, 1, 1-Trichloroethane and AP-20.

Figure 2

## GREEN DISCOLORATION DATA ARRAY E

| ITEM | NEXT ASSY. NAME | NEXT ASSY P/N & S/N | MODEL (QUAL. OR FLIGHT) | D.R. NUMBER | W.O./Q.C. CONTROL NUMBER | OPERATION NUMBER | OPERATOR NO. & DATE | INSPECTOR NO. & DATE | SOLDER OR CRIMP(C) | JOINT RWK'D (X) TIMES | OPERATOR NO. & DATE REWORK | INSPECTOR NO. & DATE REWORK | WIRE TYPE (MANGANON, SILVER PLATED, ETC. | WIRE NO. OR R/R NO. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P/N 2362209<br>NAME Mother Board Assy. PDU<br>S/N 2 | PDU | 2362200<br>S/N 1 | Qual. | AC3642 | 28355 | #30 | #64<br>10-2-71 | #87<br>10-2-71 | S | 1 | #166<br>12-6-71 | #29<br>12-11-71 | MIL-W-16878/6<br>ET-24 | G2027 | Stranded copper 246A Silver Coated Teflon Ins. |
| P/N 2368110<br>NAME Mother Board Assy. PCU<br>S/N 2 | PCU | 2368101<br>S/N 12 | Flt. | AC3787 | 28396 | #60 | None (Final) | #130<br>12-1-71 | S | 0 | Open<br>-- | -- | MIL-W-16878/6<br>ET-24 | L3192 | Stranded copper 246A Silver Coated Teflon Ins.<br>DR Waiting Disp. |
| P/N 2362852<br>NAME Harness<br>S/N 14 | Central Station | 2362900<br>S/N 10 | Qual. | AC3905 | 29650 | #151 | #122<br>11-19-71 | #46 & 122<br>11-19-71 | S | 0 | DR, LIMITED HOLD | | MIL-W-16878/4<br>ET-24 | G0920 | Manganin Stranded and Stranded Copper silver Coated Teflon Ins. |
| P/N 2362183<br>NAME PC Board #3<br>S/N 2 | LSG Elect. Pkg. | 2362198<br>S/N TBD | Flt. | AC3937 | 31903 | #40 | #88<br>1-10-72 | #107<br>1-10-72 | S | 0 | DR CLOSED<br>Freon Cleaned<br>N/A | #107 | Oper. Amps. | N/A | DR Closed |
| P/N 2348370<br>NAME Explosive Package Elect.<br>S/N 18 | Base Plate Assy. | 2348552<br>S/N TBD | Qual. | AC3594 | 27180 | #20 | #73<br>12-9-71 | #46<br>12-9-71 | S | 0 | Limited Hold | | MIL-W-16878/4 | G6966 | Stranded Copper Silver Coated Teflon Ins. |
| P/N 2348393<br>NAME Firing Circuit Assy.<br>S/N 23 | Explosive Package Elect. | 2348370<br>S/N TBD | Qual. | AC3765 | 29970 | #100 | #22<br>10-25-71 | #64<br>10-26-71 | S | 0 | DR Closed<br>N/A | #11 | MIL-W-16878/4 | H6604 | Stranded copper silver coated Teflon Ins.<br>"USE AS IS" |
| P/N 2348393<br>NAME Firing Circuit Assy.<br>S/N 25 | Explosive Package Elect. | 2348370<br>S/N TBD | Qual. | AC3766 | 29972 | #100 | #56<br>10-20-71 | #64<br>10-20-71 | S | 0 | "USE AS IS" Disposition | | MIL-W-16878/4<br>E | H6604 | Stranded Copper Silver Coated Teflon Ins.<br>DR Closed "D" Stamped on Final. |

GREEN DISCOLORATION DATA ARRAY 2

| ITEM | NEXT ASSY. NAME | NEXT ASSY P/N & S/N | MODEL (QUAL. OR FLIGHT) | D.R. NUMBER | W.O./O.D. CONTROL NUMBER | OPERATION NUMBER | OPERATOR NO. & DATE | INSPECTOR NO. & DATE | SOLDERED OR CRIMP (C) | JOINT RWK'D (X) TIMES | OPERATOR NO. & DATE REWORK | INSPECTOR NO. & DATE REWORK | WIRE TYPE MANGANON. | SILVER PLATED, ETC. | WIRE P.O. OR R/R NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P/N 2348393<br>NAME Firing Ckt. Assy.<br>S/N 28 | Explosive Pkg. Elect. | 2348370 S/N TBD | Qual | AC3767 | CN29975 | #100 | N/A (Final) | #46 12-17-71 | S | 1 | N/L (DR) | #18 1-8-72 | MIL-W-16878/4 E | H6604 | Stranded Copper Silver Coated Teflon Ins. Final Disp. "USE AS IS" Closed |
| P/N 2348393<br>NAME Firing Ckt. Assy.<br>S/N 30 | Explosive Pkg. Elect. | 2348370 S/N 27 | Qual. | AC3768 | P/N 2348370 C/N 27189 (29962) | #10 | None | #46 12-18-71 | S | 0 | N/A | #114 1-11-72 | MIL-W-16878/4 | H6604 | Stranded Copper Silver Coated Teflon Ins. "USE AS IS" Closed |
| P/N 2362291-502<br>NAME Up-Link Relay Module PDU<br>S/N 2 | PDU | 2362200 S/N 1 | Flt. | AC4097 | 27628 | #75 | N/L | #48 1-12-72 | S | 1 | Open Disposition | | Component Leads | N/A | DR Open |
| P/N 2349485<br>NAME Sequencer<br>S/N 1 | Data Processor | 2349400 | Pre-Flt. | 4319 | 31135 | #20 | N/L | #73 1-27-72 | S | 0 | --- | --- | | N/A | |
| P/N 2349485<br>NAME<br>S/N 2 | Data Processor | 2349400 | Pre-Flt. | 4320 | 31136 | #20 | N/L | #73 1-27-72 | S | 0 | --- | --- | | N/A | |
| P/N<br>NAME<br>S/N | | | | | | | | | | | | | | | |
| P/N<br>NAME<br>S/N | | | | | | | | | | | | | | | |

## TESTS CONDUCTED

A number of tests were conducted to determine the means of obtaining a good solder joint with the minimum amount of Green Crud residue. The matrix of Figure 3 summarizes the test, the results and conclusions reached.

In examination of the incidents of Green Crud, it was obvious that that which appeared under wire insulation would be the most difficult to prevent and to remove. The first 2 tests of the Figure 3 matrix were conducted to verify that soldering of plated wire could be performed without liquid flux. The results of the test were affirmative, thus overcoming the most significant Green Crud problem.

In addition to plated copper wire, the manganin wire of the ALSEP harness showed Green Crud deposits. The oxides present on manganin prohibit soldering without liquid flux, thus minimization of Green Crud was the goal. The tests conducted, 3 thru 5, to determine the degree of Green Crud prevention possible indicated a minimum amount would result if anti-wicking tools were used and a very controlled amount of liquid flux was applied. Removal of the Green Crud on exposed wire by dipping solvent AP-20 was demonstrated by test #6; however, that under the wire insulation was not affected. The wire, as removed from the spool, was examined to verify the Green Crud was not present in new wire.

Tests 8, 9 and 10 were performed to confirm the manufacturer's position that the use of AP-20 was not detrimental to PC boards or components. Flat packs, transistors, resistors, conformal coating, ink markings and the PC board itself were not damaged in a 30 minute AP-20 bath. The mylar sheet with adhesive used to hold flat packs in place during soldering operations was not damaged, although some of the adhesive became soft during the 30 minute test.

Since formation of Green Crud is inhibited by solidifying the flux residues, a bake dry process immediately following soldering was tested, test #11. Some improvement was noted; however, the amount of Green Crud present was not considered acceptable.

The elimination of the use of liquid flux on PC board operations, and thus the elimination of Green Crud, was investigated with tests 12 thru 16. It was determined that components and PC boards are oxidized when received by Bonded Stores. To achieve acceptable solder joints and to minimize the need for liquid flux, pre-cleaning should be used. Liquid flux can be minimized but not eliminated. A minimum amount of liquid flux, assumed 1.0% in an AP-20 solution, will not yield a Green Crud wicking under wire insulation. This test, #17, was performed to verify the acceptability of the use of liquid flux on a PC board which has insulated wiring attached.

FIGURE 3

ARRAY E GREEN CRUD INVESTIGATIONS

| No. | Operation | Conditions | Results | Conclusions |
|---|---|---|---|---|
| 1. | Solder Plated Wire to Terminal | a. No, Liquid Flux<br>b. Clean Terminal | a. Good Solder Joint<br>b. No Apparent Green | Plated Wire can be soldered well without liquid flux and no Green Crud will be produced. |
| 2. | Rework #1 | a. No Liquid Flux<br>b. Copper Dri-wick | a. Good Solder Joint<br>b. No apparent Green Crud | |
| 3. | Tin Manganin Wire | a. Activated Flux (Wrap)<br>b. No Liquid Flux | a. Difficult Operation<br>b. Inadequate Tinning | Liquid Flux must be used in soldering Manganin wire. Green Crud will be produced but can be minimized by use of anti-wicking tools and limited amount of liquid flux. |
| 4. | Tin Manganin Wire | a. Activated Flux (Wrap)<br>b. Liquid Flux (1544) | a. Good Tinning<br>b. Green Crud on Exposed Wire & under insulation (1/4" ave) | |
| 5. | Tin Manganin Wire | a. Activated Flux (Wrap)<br>b. Limited Liquid Flux (1544)<br>c. Anti-wicking Tool | a. Good Tinning<br>b. Wicking Limited<br>c. Green Crud on Exposed Wire & to Some Degree Under Insulation (1/8" Ave) | |
| 6. | Cleaned #5 With AP-20 | a. Dipped in 2 baths ≃ 1 Min each | a. Green Crud Greatly Reduced on Exposed Wire. Green Remained under Insulation | Exposed Green Crud can be removed by AP-20. No Apparent removal of Green Crud from under insulation by AP-20 bath. |
| 7. | Examined Plated Wire on Spool | | a. No Green Under Insulation | Green under insulation is Green Crud produced in soldering |
| 8. | Bathe PC Board & Components in AP-20 | a. Boards Carried Flat Packs, Transistors, Resistors, Conformal Coating, 73X ink markings<br>b. Bath was for 30 min. | a. No Detrimental Effect on Boards or Components.<br>b. Adhesive of Mylar Tape under Flat Pack was softened and removed at exposed edges<br>c. Ink markings not affected<br>d. Conformal coating not affected. | PC Boards markings, conformal coating, and components are not effected by AP-20 |
| 9. | Bathe PC Board with Flat Packs in one of 2 solvents: AP-20 or 20%/80% mixture of isopropyl alcohol and 1, 1, 1-trichloroethane. | a. Baths were for 3 min. in one of 2 solvents | a. No apparent removal of Mylar tape adhesive in either solvent. | Mylar tape adhesive not removed if bath is limited to 3 minutes. |
| 10. | Bathe Mylar strip in AP-20 | a. Bath was for 12 hrs. | a. Mylar not affected | Mylar tape used under flat packs will not be affected. |

## FIGURE 3 (Cont.)

## ARRAY E GREEN CRUD INVESTIGATIONS

| No. | Operation | Conditions | Results | Conclusions |
|---|---|---|---|---|
| 11. | Bake Manganin Solder Joints | a. Liquid Flux<br>b. Bake 1 hr @ 150°F<br>c. Bake immediately following soldering | a. Green Crud present but somewhat reduced from non-baked samples | Quick dry of flux residue reduces amount of Green Crud but significant amount is still produced. |
| 12. | Examine PC Boards and Components from Bonded Stores | | a. Gold Plated leads, good condition.<br>b. A number of other plated leads, oxidized and apparently unsatisfactory for soldering.<br>c. In some cases solder on PC board, oxidized and apparently satisfactory for soldering. | PC Boards and Components should be cleaned properly prior to soldering and/or liquid flux must be used. |
| 13. | Solder Flat Pack to PC Board | a. Board not Cleaned<br>b. No Liquid Flux | a. Difficult Operation<br>b. No Green Crud | |
| 14. | Solder Flat Pack to PC Board | a. Board Cleaned, 1544<br>b. No Liquid Flux | a. Operation Easier than #13<br>b. No Green Crud | |
| 15. | Solder Flat Pack to PC Board | a. Board not Cleaned<br>b. Liquid Flux | a. Operation Easier than #14<br>b. No Green Crud | |
| 16. | Solder Flat Pack to PC Board | a. Board Cleaned, 1544<br>b. Liquid Flux | a. Operation Easier than #15<br>b. No Green Crud | |
| 17. | Wick 1% Solution, 1544 Flux in AP-20, Under Insulation of Copper Wire | | a. No Green Crud | Liquid Flux can be used in vicinity of plated wire (as on PC board), be cleaned with AP-20 and not cause Green Crud under plated wire insulation. |
| 18. | Vacuum Clean Plated Wire with AP-20 | a. Plated wire with Green Crud<br>b. Clean per AP-20 Vacuum Procedure, Figure 4. | a. Green Crud reduced by 75% under insulation<br>b. No apparent Green Crud on exposed wire. | Green Crud still apparent under wire insulation. Additional vacuum cycles may further reduce amount of Green Crud. Degree of cleaning by 3 solvents appeared approximately equal. |
| 19. | Vacuum Clean Manganin Wire with AP-20 | a. Manganin Wire with Green Crud<br>b. Clean per AP-20 Vacuum Procedure, Figure 4. | Same as 18. | |

## FIGURE 3 (Cont.)

## ARRAY E GREEN CRUD INVESTIGATION

| No. | Operation | Conditions | Results | Conclusions |
|---|---|---|---|---|
| 20. | Vacuum Clean Plated Wire with 1, 1, 1 Trichloroethane | a. Plated Wire with Green Crud<br>b. Clean per Trichloroethane Vacuum Procedure, Figure 4 | Same as 18 | |
| 21. | Vacuum Clean Manganin Wire with 1, 1, 1 Trichloroethane | a. Manganin Wire with Green Crud<br>b. Clean per Trichloroethane Vacuum Procedure, Figure 4 | Same as 18 | |
| 22. | Vacuum Clean Plated Wire with 20%, 80% mixture of Isopropyl Alcohol & 1, 1, 1 - Trichloroethane | a. Plated Wire with Green Crud<br>b. Clean per Mixture Vacuum Procedure, Figure 4 | Same as 18 | |
| 23. | Vacuum Clean Manganin Wire with 20%, 80% Mixture of Isopropyl Alcohol & 1, 1, 1 - Trichloroethane | a. Manganin Wire with Green Crud<br>b. Clean per Mixture Vacuum Procedure, Figure 4 | Same as 18 | |
| 24. | Clean Soldered Terminal Boards | a. Manganin Wires Soldered to Terminal Board<br>b. Green Crud Present<br>c. 2-Bath cleaning in AP-20, 1 minute each. | a. Trace of Residue on Terminal Board | AP-20 is more effective solvent. |
| 25. | Clean Soldered Terminal Boards | a. Manganin Wires Soldered to Terminal Board<br>b. Green Crud Present<br>c. 2-Bath cleaning in 20%, 80% mixture, 1 minute each. | a. Small Amount of Residue on Terminal Board | |
| 26. | Compare Solubility of AP-20 and 20%, 80% mixture and 1, 1, 1 - Trichloroethane | a. Visual observation of drops of 1544 in the 3 Solvents | a. Rapid Dissolving of 1544 in AP-20<br>b. Slower Dissolving of 1544 in 20/80.<br>c. Slower Dissolving of 1544 in 1, 1, 1 | AP-20 is more effective solvent. |

## FIGURE 4

## PROCEDURE FOR CLEANING WITH SOLVENT IN VACUUM

1) Immerse item in an open container of solvent.
2) Place container in bell jar.
3) Evacuate to four inches of Mercury for three minutes.
4) Repeat two additional times.
5) Remove container and flush item with clean solvent.
6) Place item in bell jar, and evacuate to one inch of Mercury for five minutes.
7) Immerse item in solvent for one minute.
8) Oven dry at 140° ±10°F for 15 to 30 minutes.
9) Reinspect

NOTE: Solvents tested were

a) AP-20
b) 1, 1, 1 - Trichloroethane
c) Mixture of Isopropyl alcohol (20%) and 1, 1, 1-Trichloroethane (

Three cleaning solvents were tested for capability to remove Green Crud and to dissolve liquid flux. This series of tests, including #18 thru 26, indicates that AP-20, a mixture of 20% isopropyl alcohol and 80% 1, 1, 1-trichloroethane, and pure 1, 1, 1-trichloroethane all are effective in removing Green Crud. Green Crud on the exposed wire was apparently 100% removed, that beneath the insulation was approximately 75% removed by means of washing by vacuum purging. A quantative evaluation was not possible; the three solvents removed approximately equal amounts of Green Crud. Tests 24, 25 and 26 were a direct measure of flux solubility in solvent rather than a measure of Green Crud removal. Soldered terminal boards were cleaned in AP-20 and the 20-80 mixture solvent. After drying the AP-20 board showed slight traces of flux residue, the 20-80 mixture board had small spots of flux residue indicating AP-20 the superior solvent. Test #26, in which liquid flux was added to the three solvents tested, provided the same results: the flux dissolved more readily in AP-20, the other two being approximately equal.

## RECOMMENDATIONS

Recommendations resulting from this investigation are:

1) P. C. boards should be cleaned upon release from Bonded Stores.

2) Established procedures for soldering temperatures and calibration of irons should be followed.

3) Plated copper wire should be soldered using activated solder (WRAP) with no liquid flux.

4) Manganin wire should be tinned using activated solder (WRAP) and liquid flux (1544). Tinning should be no closer than one wire diameter from insulation. Anti-wicking tools should be used.

5) At completion of manganin tinning operation, the wires should be cleaned with AP-20, using the vacuum purge procedure if possible. Liquid flux and AP-20 should be bake dried.

6) Tinned manganin wire should be soldered in place using activated solder with no liquid flux.

7) At completion of soldering manganin wire in place, bathe clean with AP-20 and bake dry.

8) Soldering of components on PC board should be done using activated solder (WRAP) and liquid flux (1544).

9) At completion of soldering on PC board, the entire board should be cleaned in AP-20 solution using successive baths and bake dried.

10) Where Green Crud does appear on exposed surfaces, clean with successive baths of AP-20 and bake dry.

11) Where Green Crud does appear beneath insulation, under components, etc., clean with AP-20 utilizing a vacuum purge technique.

12) Where solder reflow is required, use of liquid flux should be limited to degree possible. Area should be bathed in AP-20 and bake dried.

13) Following completion of soldering operations (including reworked if required), no alcohol should be used for cleaning (modify conformal coating processes as required).

## REFERENCES

1) ATM 1059; Results of A-2 Schjeldahl Connector "Green Crud" Investigation; 23 Sept. 71.

2) NPC 200-4; Quality Requirements for Hand Soldering of Electrical Connection; August 1964.

3) NHB 5300.4 (3A); Requirements for Soldering Electrical Connections; May 1968.

4) Letter to T. W. Fenske ; 22 June 1971.from Dr. R. D. Pehlke, University of Michigan.

5) ALSEP Quality Directive No. 63, Rev. A, B and C; 21 July, 5 August, 22 September and 7 October 1971.

6) ALSEP Quality Directive No. 63, Addendum #1; 10 January 1972.

7) Corrosion problems on silver-plated copper wire; wire and wire products magazine; V. R. Friebel, Ball Brothers Research Corporation; May, 1969.

8) IN-R-Qual-66-44; Corrosion of Silver-plated Copper Conductors; 30 September-1966.