

CFC and CHC Reduction at Suppliers

Kansas City Division

R. C. Carter

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CFC AND CHC REDUCTION AT SUPPLIERS

R. C. Carter

Published July 1995

Final Report
R. C. Carter, Project Leader

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Abstract

Alternative cleaning methods and materials were required to reduce the use of ozone-depleting solvents or potentially hazardous materials (chlorofluorocarbons and chlorinated hydrocarbons) at purchased product suppliers. Three groups of printed wiring boards were fabricated by Sparton Technology Inc., the vendor selected to complete the project. These printed wiring boards were evaluated in the Materials Engineering laboratory at the Kansas City Division. Recommendations included using a rosin-based flux and an enhanced cleaning process with Bioact EC-7R as the preferred solvent. Results of the study were included in the Solvent Waste Stream database.

Summary

Chlorofluorocarbons (CFCs) and chlorinated hydrocarbons (CHCs) were required by product definition, drawings, and procedures to be used for cleaning of purchased electromechanical products supplied by vendors to AlliedSignal Inc., Kansas City Division (KCD). Alternative cleaning methods and materials were needed to reduce the use of ozone-depleting solvents (ODS) or potentially hazardous materials (PHM) at purchased product suppliers. Due to environment, safety, and health (ES&H) concerns, it was desired to minimize waste and prevent pollution during the fabrication and cleaning of product manufactured at suppliers. A process development order (PDO) was initiated and initially funded in FY1991, then transferred as a Solvent Waste Stream project into the Production Capability Assurance Program (PCAP) format. WR schedule reductions occurred, which caused changes in the vendors chosen as a vehicle for the study. A succession of five KCD associates helped guide this PDO/PCAP project, and Sparton Technology was the vendor chosen to complete the project.

Three groups of printed wiring boards (PWBs) were fabricated by Sparton Technology and evaluated in the KCD Materials Engineering laboratory. Sparton Technology submitted a final evaluation report. The KCD Materials Engineering summary recommendation, after evaluation of the groups of printed wiring boards, was to use the following:

- 1) a rosin-based flux, and
- 2) an enhanced cleaning process, using
- 3) Bioact EC-7R as the solvent of choice.

The information generated by this project was added to the Solvent Waste Stream database and is being documented by this report.

Discussion

Scope and Purpose

Chlorofluorocarbons (CFCs) and chlorinated hydrocarbons (CHCs) were required by the product definition, drawings, and procedures to be used for cleaning of products procured by AlliedSignal Inc., Kansas City Division (KCD), from suppliers. Some of the legislation leading to this study were the Clean Air Act of 1977 (CAA); the Clean Water Act (CWA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); the Hazardous and Solid Waste Amendments of 1984 (HSWA); the National Emission Standards for Hazardous Air Pollutants (NESHAPs); the Resource Conservation and Recovery Act (RCRA); and the Toxic Substances Control Act (TSCA).

The purposes of this project were to 1) reduce the use of ozone-depleting solvents of the chlorofluorocarbon and chlorinated hydrocarbon types and to 2) eliminate the use of potentially hazardous materials (PHM) and develop environmentally acceptable cleaning processes at purchased product suppliers as directed by the Environmental Protection Agency (EPA) and the Department of Energy (DOE). The scope of the project was reduced to a size that could be accomplished in the developing framework of reduced schedules and closing of existing contracts at our purchased product vendors. What was originally envisioned as a method to involve all of the purchased product vendors was scaled back to two vendors and then to one vendor. The information that was developed by this project has been added to the KCD Process Waste Assessment database.

Activity

Background

CFCs and CHCs were required by the product definition, drawings, and procedures to be used for cleaning of products procured by KCD from suppliers. Formal activity started on identification of vendor cleaning methods, materials that were being cleaned, and contaminants to be removed. The project was later classified as a Solvent Waste Stream project, and the project gained the guidance of KCD Materials Engineering, which was involved in the Process Waste Assessment (PWA) effort at that time.

Events

Solvent Waste Stream meetings were attended at Sandia National Laboratories/New Mexico, and it became apparent that the issue of purchased product supplier participation in the CFC/CHC study would be a huge endeavor. Cleaning study meetings were set up between Sandia design engineers and KCD materials and purchased product engineers. Of those vendors represented in the Purchased Electromechanical Product Engineering group, EG&G was chosen as the first vendor to participate. EG&G was the approved source for spraytrons and gap tubes. A purchase requisition was initiated with EG&G to request a status report detailing the material and approximate size of parts being cleaned, with how much of what solvents, the cleaning equipment and processes used by the vendor, contaminants being removed, and any special handling concerns or conditions. A matrix for materials/solvents/contaminants was completed from the EG&G report. A cleaning evaluation plan was then initiated for

use at EG&G. The overall plan was to modify the resulting cleaning evaluation plan from EG&G and use it for two more suppliers and thereby develop various cleaning processes that could possibly be used at other purchased material vendors.

In approximately March 1992 it was recognized that interagency coordination on the EG&G cleaning evaluation plan was taking much more time than originally had been budgeted. Parts needed to be purchased from suppliers to allow cleaning process evaluations to proceed, and that activity was dependent on a stable plan. At about that time, the first round of WR schedule reductions occurred, and the overall departmental emphasis was changed to closing out contracts in work. Activity on this Solvent Waste Stream project was to continue; but because the schedules at EG&G were disappearing, a different vendor had to be chosen as a vehicle for the study. In addition, increased emphasis on CFC/CHC reduction and a new timetable for implementation were transmitted by DOE to the various agencies within the complex.

Bell Aerospace and Raymond Engineering were the next vendors chosen as participants in this project under the guidance of J. N. Harrington, also of the Purchased Electromechanical Products Engineering group. Bell Aerospace was the approved source for the FBIA accelerometer, and Raymond Engineering was an approved source for rolamites. On April 1, 1992, Bell and Raymond were requested to quote initial activity costs to identify the solvents being used for cleaning, a description of the parts being cleaned, part material and the approximate part size, and any other CFC, CHC, or PHM used at their facility to produce our purchased material.

CFC, CHC, and PHM usage information was also gathered from several other Purchased Electromechanical Products vendors as part of a telephone survey by the responsible purchased product engineers and buyers. At the same time, work was being done at KCD in studying the effectivity of both air and airless spray cleaning applications of solvents and related solvent cleaning topics. Next, the Raymond Engineering production schedules were canceled and it was realized that, due to the source of their funding, the Bell Aerospace contract did not qualify for this evaluation. Another vendor, Sparton Technology, was requested to make a proposal to support the CFC/CHC PCAP project, and they responded in a timely manner. Sparton Technology was a source of many items, including manual and electromechanical rotary switches, aircraft and ground controllers (both new and repair activity), and special processing in the metal plating area. Sparton had excess material on hand (printed circuit boards and components) that could be used to build the PWBs for the cleaning evaluation.

Accomplishments

The PWBs built by Sparton Technology for this study were submitted to KCD Materials Engineering for evaluation and recommendations. After the first study, additional boards were requested from and supplied by Sparton in support of the cleaning solvent evaluation. As part of their response to the study, Sparton said they were reducing usage of the PHMs on their own initiative and they were glad to see that KCD was promoting environmentally conscious manufacturing. A copy of the final report from Sparton Technology is in the Appendix. Two reports were published by KCD Materials Engineering after they evaluated the three sets of boards received from Sparton. The summary of KCD Materials Engineering

recommendations was to use a rosin-based flux, to use Bioact EC-7R as the solvent of choice, and to use a modified (longer time exposure) cleaning process.

Definitions

CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	Chlorofluorocarbon
CHC	Chlorinated Hydrocarbon
CWA	Clean Water Act
DOD	Department of Defense
DOE	Department of Energy
ECM	Environmentally Conscious Manufacturing
EPA	Environmental Protection Agency
ES&H	Environment, Safety and Health
HSWA	Hazardous and Solid Waste Amendments of 1984
KCD	Kansas City Division
NESHAPs	National Emission Standards for Hazardous Air Pollutants
ODS	Ozone-Depleting Substance
PCAP	Production Capability Assurance Program
PDO	Process Development Order, a predecessor to PCAP
PHM	Potentially Hazardous Material
PWA	Process Waste Assessment
PWB	Printed Wiring Boards
RCRA	Resource Conservation and Recovery Act
TSCA	Toxic Substances Control Act

Appendix
Final Report from Sparton Technology Inc.

**FINAL REPORT ON THE
STUDY TO REPLACE OZONE DEPLETING SOLVENTS**

OCTOBER 26, 1993

**Prepared for:
Allied-Signal, KCD
Contract No. 028A382906
STI Job: 67671**

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FINAL REPORT ON THE STUDY TO REPLACE OZONE DEPLETING SOLVENTS

Ref.: Allied Signal KCD Contract #028A382906
: STI Job # 67671

I Background

Because of a federal mandate, the use of ozone depleting solvents (ODS) and potentially hazardous material (PHM) is to be discontinued. The ODS types of solvents (namely, trichloroethylene, freon and gene-solve) are used at STI to remove rosin flux residue after soldering operations and to remove oil from machined parts. The use of rosin based flux (type RMA or R) is directed on all military programs at STI by specifications cited on associated drawings. The particular specifications are 9913000, Mil-S-45743 and Mil-S-46844. The above solvents remove the residue more readily than isopropyl alcohol and are used to enhance the cleaning operations.

The PHM type material is used in the application of solid film to metal parts; the carrier is dioxane.

In a response to an RFQ from Allied Signal to find a suitable substitute(s) for these solvents, STI proposed testing two organic solvents (Axeral 32 and Bioact EC-7R) which remove rosin flux residue; these two solvents can also be used to remove oil from machined parts. In addition, STI also proposed using water soluble flux instead of rosin based flux, then using de-ionized water and isopropyl alcohol to remove the flux residue.

A. Printed Wiring Assemblies

It was proposed that a group of P.W. Assemblies be soldered using rosin based flux; the assemblies would be representative of the PWAs assembled at STI on the military programs. The assemblies would then be cleaned in a bubbler with each of the two organic solvents mentioned above to be followed by cleaning in a bubbler with isopropyl alcohol. In addition, a group of PWAs would be wave soldered using water soluble flux then cleaned with three rinses of de-ionized (DI) water. The assemblies would be examined carefully with a microscope then tested for cleanliness with the Omega Meter using the criteria required by Mil-P-28809. Samples would also be sent to Allied-Signal for evaluation. Another group of small boards (SMU boards) would be hand soldered using solder with an organic flux core and cleaned with DI water; these boards would be examined carefully under the microscope for contamination. Because of their small size they cannot be checked with the Omega Meter.

B. Rotary Switches

A similar procedure would be followed with Rotary Switches; a particular rotary switch was proposed for use. Because Rotary Switches use machined parts, this would also afford the opportunity to use the organic solvents to remove oil from contaminated machined parts. The manufacture of Rotary Switches also involves the application of solid film to certain machined parts; the carrier for the solid film is dioxane. STI proposed using EM 9000 which is water based. Rotary Switches also use preformed packing ('O' rings) which prior to installation must be dipped in Vydux; Vydux is teflon suspended in freon. STI proposed using teflon suspended in alcohol on one group of switches teflon suspended in DI water in a second group.

On Rotary Switches, the tinning of wires, soldering of decks and cleaning flux residue is controlled by a general process, GP6822. The flux used is type 'R': the solvent used is trichloroethylene. STI proposed following the same GP but substituting the organic solvents where trichloroethylene is called out. In addition, a group of switches would be soldered using water soluble flux. Samples of each of these would be sent to Allied Signal for evaluation. Once Allied-Signal made a determination which solvent was best, STI would assemble 20 switches ten of which would go through D-Test.

II Proposed Solvents

As mentioned above, Two types of organic solvents (described below) were proposed, Axeral 32 and BIOACT EC-7R; both types are readily available. It was also proposed to use DI water and isopropyl alcohol in conjunction with these solvents.

A. Axeral 32

Du Pont's Axeral 32 (A32) is a petroleum distillate mixture containing 70-90% mixed aliphatic hydrocarbons, 15-20% diisobutyl DBE, and 4.9-9.5 of a surfactant glycol ether. On the NFPA rating system, where 0=no hazard and 4= severe hazard, A32 is rated 2-Health, 1-Flammability, and 0-Reactivity. It is rated as an NFPA Class IIIB combustible Liquid with a Flash Point of 200'-210°F PMCC. OSHA and ACGIH have not established an exposure limit, Du Ponts own acceptable exposure limit (AEL) is 1.5 ppm 8Hr TWA based on an AEL of 1.5 ppm for DBE. Measured exposure of diisobutyl DBE was 0.05 ppm for an open, heated (180°F), non-ventilated tank of A32. Vapor pressure is <0.1 mm Hg at 25°C and evaporation rate is <0.1 (Butyl acetate=1.0). When working with A32 normal splash protection equipment (gloves, safety glasses, faceshield and apron), will provide adequate employee safety. None of the components of this solvent are listed by IARC, NTP, OSHA, or ACGIH as a carcinogen. A32 is an effective cleaning agent at removing ionic contamination, residual rosin, and oxidized rosin from printed wiring assemblies. Enclosed is a product data sheet with test results indicating that A32 cleans better than Freon IMS (equivalent to Genesolve DMS). Also included is a Table of

A32 Compatibilities with plastics and elastomers. The glycol ether component of A32 is listed under SARA Title III Section 313 and TSCA. The product is not regulated by DOT. The waste product is non-hazardous if the lead concentration is below 5 ppm for the TCLP test. Waste disposal costs would be approximately \$175.00/drum in an energy recovery/fuel blending program. Virgin A32 costs approximately \$2000/55 gal. drum.

Conclusions for A32; Advantages include low flammability hazard, cleaning capability, waste classification, low evaporation rate, acceptable solvent under Mil. Spec. 2000, and adaptability to a full aqueous secondary cleaning system. Disadvantages include product cost, exposure limits, secondary cleaning requirement, and listing on TSCA and SARA Title III. A technical data sheet is attached.

B. Bioact EC-7R

Petroferm's Inc. Bioact EC-7R is a natural terpene based hydrocarbon that is biodegradable, non-toxic, non-caustic defluxer and degreaser. NEPA ratings are 1-health, 2-flammability, and 0-reactivity. EC-7R is a Class II combustible liquid with a flash point of 130°F. Based on this flash point Waste EC-7R is classified as hazardous. Disposal costs are the same as for A32, energy recovery/fuel blending at \$175.00/drum. Exposure limits have not been established by OSHA or ACGIH and EC-7R is not a listed carcinogen. Terpene hydrocarbon is described in the Code of Federal Regulations, Title 21 as GRAS (Generally Recognized as Safe). Splash protection equipment is adequate for handling this material. Vapor pressure is 1.6 mm of Hg and evaporation rate is <1 (BUAC=1). EC-7R costs approximately \$2250.00/drum. No component of EC-7R is listed on SARA 313 toxic chemical list or EPA's list of toxic or hazardous substances. It is listed on the TSCA inventory. Petroferm Inc. claims that this solvent is more effective than CFC's at removing rosin based flux residues, but no test data is provided. Enclosed is technical data sheet for this product.

Conclusions for EC-7R; Advantages include low toxicity and exposure hazard, cleaning capability, low evaporation rate, not listed on EPA and SARA, and adaptability to a full aqueous secondary cleaning system. Disadvantages include product cost, flammability hazard, not listed in Mil-STD-2000 secondary cleaning requirement and lack of information on product compatibility and test cleaning results. It should be noted, Petroferm is the only company that can sell terpene based hydrocarbons for defluxing PWA's as they have patented the process and chemical for this specific cleaning procedure. Golden Technologies Inc. a division of Adolph Coors Co. sells the same product for \$1200.00/drum but it cannot be used for this application, only parts and general cleaning. A technical data sheet is attached.

C. Isopropyl Alcohol

Isopropyl alcohol (IPA), anhydrous CAS #67-63-0 with synonyms: 2-propanol, dimethyl carbinol and IPA. NEPA ratings for IPA are 2-Health, 3-Fire, 0-Reactivity. It is rated as a class 1B flammable liquid with a flash point of 53° F TCC and a boiling point of 160.07° F. Upper and lower explosive limits are 12.0% and 2.0% respectively. Vapor pressure at 20° C is 33mm Hg. Evaporation rate is 2.88 (butyl acetate=1). Percent volatiles is 100% and IPA is not photochemically reactive. DOT hazard class is Flammable Liquid UN1219. Used IPA is classified as a hazardous waste EPA Code D001 and disposal costs are \$120.00 per 55 gal drum for energy recovery. Disposal costs for Axeral 32 and Bioact EC-7R have also decreased to \$120.00/drum. Exposure limits are 400 ppm 8hr TWA and 500 ppm STEL, OSHA and ACGIH. Air concentrations of 12,000 ppm are Immediately Dangerous to Life and Health, IDLH. IPA is not listed as a carcinogen by NTP, IARC and IARC. The recommended personal protection is aprons, gloves, safety glasses and face shields. Due to the high fire hazard and evaporation rate increasing personal exposure, a chemical hood should be used to evacuate fumes from open containers. All dispensing should be conducted with bonded and grounded containers. IPA costs \$120.00/drum.

Conclusions: IPA is not an aggressive cleaner. However, it is typically used in conjunction with other more aggressive cleaners. It's utility is twofold: one, as a rinsing agent to remove already solubilized or suspended contamination from PWAs or machined metal parts and two, clean IPA evaporates without leaving a residue. Other advantages include low cost, higher exposure levels than PHMs, non-ODS, non-VOC pollutant and not listed on CERCLA or SARA Title III, section 313. Disadvantages include Fire hazard, cleaning capability and primary cleaning requirement.

III Cleanliness Test Methods

The PWAs used are from the Weapon Storage and Security System built for the Air Force and from the SMU105 also built for the Air Force; these boards are representative of boards built for the Ground and Air Controllers and the AN/GWM-9. The assembly and soldering criteria for all these boards are covered by Mil-S-45743; this specification, in turn, defers to Mil-P-28809 for cleanliness criteria. The resistivity of the test solution must be greater than 2 MΩ and the allowable contamination is 10 μgm of NaCl; however, if an Omega Meter is used, the maximum ionic contamination limit is 14 μgm NaCl/in². STI uses an Omega Meter 500 to make these measurements. The time in test solution is covered by the manual for this instrument and in this case it is 5 minutes.

IV Solvent Tests

A. Axeral 32

1. Large PW Assemblies

Four PWAs (part# deleted) were soldered using Axeral 32 solvent; these assemblies are from the Weapon Storage and Security System built for the Air Force. The assemblies were serialized 1AH through 4AH ('A' indicating Axeral and 'H' indicating hand soldered). The assembly and soldering specifications which apply are Mil-S-45743 and Mil-S-46844; these cover the hand soldering and wave soldering of components onto PC Boards. Both defer to Mil-P-28809 for cleanliness. These specifications are used on the Air Controllers, AN/GWM-9 and SMUs. The solder used was Sn63 per Mil-S-571 with rosin core flux, type RMA. The boards are 10"x4.4" and moderately populated with a mix of two lead devices, ICs, transistors and an edge board connector. As the components were being soldered, the assembly was dipped frequently in pan containing Axeral 32; this is to remove most of the rosin flux residue quickly before it crystallizes and is more difficult to remove. This is standard procedure; normally freon or Genesolve is used. When the assembly was finished, it was cleaned for five minutes minimum in a bubbler containing Axeral 32 then drained. It was then cleaned for 3 minutes minimum in bubbler containing alcohol/DI water, 75%/25% then drained. Finally, it was cleaned for 3 minutes minimum in a bubbler containing pure alcohol then allowed to dry. The boards were examined with a 10 power microscope; there was no visible contamination. The assemblies were also examined under ultra violet light; the residue from rosin flux shows up under UV light. No residue could be seen. The boards were then tested with the Omega Meter for cleanliness; they passed. A sample was sent to Allied-Signal.

The test results were as follows;

1-A-H ---- 14.2 MΩ; 10 µgm NaCl
2-A-H ---- 17.5 MΩ; 8.8 µgm NaCl
3-A-H ---- 17.5 MΩ; 8.8 µgm NaCl
4-A-H ---- 18.0 MΩ; 8.8 µgm NaCl

The boards and the assemblies were stored in anti-static polyethylene bags. After the boards had passed the cleanliness test they were examined; they were not handled with any special care. Allied-Signal then informed STI that they would like to have the remainder of the boards plus one more for evaluation and to ship them in mylar bags. STI complied.

2. Small Printed Wiring Assemblies

The same procedure as above was followed using four PC Boards (part# deleted). This PWA is used in the SMU 105; it is a dense assembly with the axial components mounted vertically. It is 2.4" x 1.8". The assemblies were examined under UV light and under a 10 power microscope; there was no visible contamination. As mentioned above, because the assemblies are small a cleanliness test with the Omega Meter could not be done; the area, even with all the boards being cleaned at once, was not large enough. The boards were carefully examined under a 10 power scope for contamination; there was no visual contamination.

B. Bioact EC-7R

The same procedures in IV A, 1 and 2 above were followed using Bioact. The same type of PW Assemblies were used and the lot sizes were the same. The assemblies were serialized 1BH through 4BH ('B' indicating Bioact; 'H' indicating hand solder). The test results were as follows:

1BH ---- 17.5 MΩ; 8.8 μgm NaCl
2BH ---- 17.5 MΩ; 8.8 μgm NaCl
3BH ---- 19.3 MΩ; 7.3 μgm NaCl
4BH ---- 15.1 MΩ; 10 μgm NaCl

PWAs 5AH and 5BH were sent to Allied-Signal before cleaning for evaluation of the contaminants prior to cleaning.

The boards and the assemblies were stored in anti-static polyethylene bags. After the boards had passed the cleanliness test they were examined; they were not handled with any special care. Allied-Signal then informed STI that they would like to have the remainder of the boards plus one more for evaluation and to ship them in mylar bags. STI complied.

C. Water Soluble Flux

1. Six large PWAs (part# deleted) were wave soldered using water soluble flux. The boards were serialized 1 WS W through 6 WS W, ('WS' indicating water soluble and 'W' indicating wave soldered).

The cleaning and drying procedures are an integral part of the wave soldering. When the PWAs come off the wave they pass through a cleaning tank containing DI water at 160°F with saponifiers added to aid in removing the flux residue. The boards then pass through a rinse tank containing DI water at 150°F and a second rinse tank containing DI water at 140°F. The rinses are at an elevated temperature for two reasons; 1) the assembly, as it comes off the wave, is very hot and having the rinse at an elevated temperature prevents damage that might result from temperature shock; 2) having the rinse at an elevated temperature increases the evaporation rate of the water.

Five of the PWAs were tested on the Omega Meter; the sixth PWA (S/N 5WSW) was sent to Allied-Signal without cleaning for evaluation. The results were:

1WSW----9 MΩ; 12.2 μgm NaCl/in²
2WSW----9 MΩ; 12.2 μgm NaCl/in²
3WSW----11 MΩ; 13 μgm NaCl/in²
4WSW----10 MΩ; 10.5 μgm NaCl/in²
6WSW----5.4 MΩ; 27.2 μgm NaCl/in²*
7WSW----9.5 MΩ; 11.5 μgm NaCl/in²

* S/N 6WSW was over heated while going through the drying cycle; the board was badly discolored. We believe this caused some material breakdown which, in turn, caused the failure. A replacement board was assembled - S/N 7WSW.

2. Because the test samples sent to Allied-Signal were not handled with any special care at STI after the cleanliness tests had been made and the test results at Allied-Signal showed high contamination, an additional five boards were wave soldered, cleaned and sent to Allied-Signal for evaluation. The same procedure was followed as before, however, handling of the assemblies was kept to a minimum and mylar bags were used. The assemblies (part# deleted) were from the WSSS; there were no edge board connectors available so these were not included. The assemblies were sent Friday, Sept. 24. The results of the STI cleanliness tests were:

11WSW----10.9 MΩ; 11 μgm NaCl/in²
12WSW----10.5 MΩ; 12 μgm NaCl/in²
13WSW----10.5 MΩ; 12 μgm NaCl/in²
14WSW----10 MΩ; 13 μgm NaCl/in²
15WSW----9.1 MΩ; 14 μgm NaCl/in²

3. Six small PWAs (part# deleted) were assembled, hand soldered, using water soluble flux. The assemblies were cleaned in three rinse of DI water, each rinse at 150° F. The assemblies were examined with a 10 power microscope and under UV light; there was no visible contamination. The assemblies could not be tested with an Omega Meter.

D. Allied-Signal Tests on PWAs

After Allied-Signal received the above samples, they requested that the remaining boards which STI had tested for each of the solvents and water based flux be sent to them for evaluation; they requested that the boards be stored in mylar bags. Up to that point, the assemblies had been stored in anti-static polyethylene bags. Also, after the boards had been through the cleanliness test and passed, they were handled extensively as they were examined with a microscope and under UV light. STI complied and put them in mylar bags and sent them to Allied-Signal for evaluation.

1. Cleanliness Measurement Results

The following is taken from their report which accompanies this report.

"--- Meseran data indicate that the rosin flux samples cleaned with Bioact EC-7R were the cleanest; the rosin flux samples cleaned with Axeral 32 were the next cleanest; the water soluble flux samples cleaned with DI water were the most contaminated. Board type large PWAs exhibited lower Meseran numbers than board type WSSS assys. for the Axeral 32 and Bioact EC-7R cleaned rosin flux samples and similar Meseran numbers for the DI water cleaned water soluble flux samples. Omega Meter 700 data indicate that both the rosin flux contaminated samples cleaned with Axeral 32 and Bioact EC-7R are sufficiently clean, but the water soluble flux contaminated samples cleaned with DI water are not acceptably clean."

The Meseran test checks for organic contaminants. STI cannot run this test; it is not a requirement of Mil-S-45743. The Omega Meter test checks for ionic contamination; this is required by Mil-S-45743 and STI runs this test on an Omega Meter 500.

E. Rotary Switch

The assembly of Rotary Switches has several areas of concern. One area concern is the cleanliness of the switch deck after the wires have been soldered; all traces of flux residue must be removed. Another area is the migrating of flux residue up beneath the wire insulation when the wires are tinned; if too much residue gets under the insulation, at a later stage this material will bleed back onto the switch deck and cause CLR (Contact Loop Resistance) failures. This can occur after the switch has been accepted. A third area is the cleaning of machined parts; in the past this has been done with freon which is an ODS. A fourth area is the application of solid film to certain metal parts; the current material contains dioxane, a carcinogen. Lastly, Vydax, a lubricant, is applied to 'O' rings used in rotary switches; it is teflon suspended in freon.

The parts used for the switch were supplied by Allied-Signal.

1. Axeral 32

Two sets of switch decks (eight decks/set) were soldered using Axeral 32; the wires were tinned also using Axeral 32. The procedures followed are those set forth in GP6822, 'Cleaning and Handling of Printed Circuit Switches' Axeral 32 was substituted where trichloroethylene was called out as the cleaning agent. Rosin based flux, type 'R', was used.

2. Bioact EC-7R

The above procedures were followed using Bioact EC-7R

3. Water Soluble Flux

Two sets of switches were soldered using water soluble flux. The cleaning agent was DI water; it was substituted for trichloroethylene just as in steps 1 and 2 above.

Because the Omega Meter cannot be used to test these switch decks, the above assemblies were sent to Allied-Signal for evaluation.

F. Allied-Signal Tests on Switch Decks

The tests run by Allied-Signal were to detect how far the flux residue migrated beneath the insulation. The best results were with the wires which were soldered with water soluble flux; a small quantity of residue was detected in the first inch of wire. Using Bioact, residue was detected up to 12 inches; Using Axeral, residue was detected up to 15 inches. Tests were run on decks which had been soldered using the standard method (rosin flux and trichloroethylene); flux residue was detected up to 15 inches. As a result of Allied-Signal's findings, the procedures for assembling the switches detailed in V below were followed.

V Rotary Switch Assembly

A. Machined Parts

Parts were taken from stock (Job 67434) and returned to the Machine Shop. They were contaminated with shop oils now in use and then cleaned in alcohol as are other parts which are made in the shop. The Bases (part# deleted) and the Detent and Shaft Assembly (part# deleted) were honed to remove the old solid film. They were then contaminated with the shop oils. All parts were cleaned using Bioact EC-7R.

B. Solid Film

The Bases (part# deleted) and the Shaft and Detents Assemblies (part# deleted) were prepared for solid film per KCD procedure except Bioact EC-7R was used in place of trichloroethane. The solid film used was EM9000, a water based dry film manufactured by EM Corp. (A specification sheet is enclosed) The solid film seemed to go on well. It had a different luster and the burnishing took more time and pressure than before.

All parts were then cleaned per the steps described in the procedure except Bioact EC-7R was used in place of trichloroethane.

C. 'O' Rings

There were two types of Vydux used. The serial number 1 through 10 used a water based Vydux and serial numbers 11-20 used an alcohol based Vydux. The Vydux in alcohol left a thinner film

than did that of the Vydux in water. Both were applied undiluted and then the excess rubbed off using fingers in gloves. For the environmental tests, five switches using each type of Vydux will be used.

D. Potting

The units were potted using the new Ethacure instead of the Z-hardener. It was noted by the person doing the potting operation that there were more bubbles in the potting and that the bubbles were more difficult to remove.

E. Life Tests

Twenty switchassys. were tested at room ambient for Contact Loop Resistance (CLR) and the rotational torque. Ten of these switches which included 5 of the two different types of Vydux were submitted to D-testing per procedure. Test data is attached and includes high and low temperature shock, post temperature ambient, post vibration, post shock, and life test.

The first 2 units that were started through life test failed torque at less than 700 cycles. The units were taken apart and examined visually. The solid film on the detent had broken down and considerable metal was worn off the detent causing the torque to go up. The next two units were hand life tested and torque readings made every 100 cycles until failure occurred. One failed at 100 cycles and the other at 200 cycles. The units were tested for CLR and HI-POT and they passed, then taken apart and analyzed. The solid film was beginning to break down. The printed circuit boards and contacts showed minimum wear. The rotation torque for the printed circuit boards was good being around 30 inch-ounces.

VI Conclusions

A. PWAs

The Axeral and Bioact organic solvents did a good job of removing ionic contamination. As shown above, the large PWAs easily meet the limits for resistivity and contamination set by Mil-P-28809. The test results from Allied-Signal bear this out. As shown by the Meseran Tests conducted by Allied-Signal, the organic contaminants were much less when using the organic solvents. Because of these data Allied-Signal recommended Bioact EC-7R to be used with rosin based flux.

The results with wave soldering using the water soluble flux are not as good. The resistivity readings are well beyond the minimum 2 MΩ requirement, but the contamination rates are consistently near the upper end of 14 μgm/in² allowed by Mil-P-28809. The results of the second group of assemblies which were handled more carefully were the same as the first. Again, the test results from Allied-Signal bear this out. The Meseran Tests showed high organic contamination. It may be that an additional cleaning step using isopropyl alcohol is all that is needed. Allied-Signal recommended not using water soluble flux.

B. Rotary Switches

Using water soluble flux for the tinning of the wires showed the best results; according to the Allied-Signal tests, the flux residue migrated only 1 inch from the solder joint. When using rosin based flux, the residue migrated 4-12 inches and neither organic solvent would remove the residue. The water based flux was also used to solder the wires to the switch deck. Bioact will be used to remove oil residue from the metal parts.

More study will be necessary to determine a suitable replacement for Electro film lubricant 4396BX if the Dioxane is unacceptable. The cleaning as tested should be acceptable as a replacement for the old chemicals used per KCD procedure.