SDL/91-053 REV B

Conformal Coating, Potting and Staking

of Printed Wiring Boards

Using a Two Part Urethane

Uralane 5750-LV

Uralane 5753-LV

Submitted by:

David E. Cramer

December 1991

Revised

May 1993

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1. OBJECTIVES

This procedure for conformal coating, potting and staking of printed wiring boards (PWB) specifies the materials, equipment, methods, techniques, resin preparation, resin application, and quality requirements for brush and spray conformal coating, potting and staking. The procedure is intended as a guideline for experienced operators as well as those having minimal experience, who must provide quality conformal coating, potting and staking on printed wiring boards for space flight electronics.

2. REFERENCE DOCUMENT

NASA's NHB 5300.4 (3J) April 1985: "Requirement for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies", has been followed in the preparation of this procedure and should be used in resolving conflicting procedures and requirements. It is recommended that all operators obtain and read this document in conjunction with this procedure before any application of coating commences.

3. APPLICABILITY

This document is intended for use by Space Dynamics Laboratory personnel.

4. REQUIREMENTS

The use of this document is intended as a guide for applying conformal coating, potting and staking material for SDL projects. Quality requirements may vary with different projects. Contract requirements may supersede this document.

5. APPROVED MATERIALS

The following list of materials is recommended to perform the work outlined in this procedure.

Materials	Source
3M Scotch #42 Anti-Static High Temperature Masking Tape	Com Kyle Inc, Sunnyvale, CA
Ethyl Alcohol, 200 Proof	USU Chemistry Stores, Logan, Utah
Methyl Ethyl Ketone	USU Chemistry Stores, Logan, Utah
Toluene	USU Chemistry Stores, Logan, Utah
Uralane 5750 LV	E. V. Roberts, Culver City, California
Uralane 5753 LV	E. V. Roberts, Culver City, California
Cab-O-Sil, M-5	E. V. Roberts, Culver City, California
Beaker, polypropylene, 250 cc	VWR Scientific, Salt Lake City, Utah
Syringe, 10 cc	USU Chemistry Stores, Logan, Utah
Syringe Needle, 15 Gauge, Blunt	Technical Devices Inc., Salt Lake City, Utah
Stainless steel spatula	USU Chemistry Stores, Logan, Utah

6. PROCESSING EQUIPMENT

Equipment	Sources
Labline 3470M Oven	VWR Scientific, Salt lake City, UT
Despatch LDB1-38M Oven	Despatch Industries, Lakeville, MN
Ohaus Balance, Model 1650	VWR Scientific, Salt lake City, UT
P-2051 FS Filtered Air Gun	NRD, Inc., Grand Island, NY
Binks Spray Gun, Model 115	S & B Automotive, Logan, UT
Binks Spray Gun, Model 59-10006	S & B Automotive, Logan, UT
Garst Vacuum Pump	Grainger, Inc., Salt Lake City
Wet film Thickness Gauge P/N 790010	Nordson Corp, Amherst, OH
Aerostat XC Benchtop Ionizer	Simco Co., Inc., Hatfield, PA
Kahnetics KDS 824 DVW-D	
Dispensing System	Technical Devices, Inc., Salt Lake City, UT

The facility where the conformal coating work is done should be sufficiently large to contain the necessary equipment and should be isolated from other work areas, which may be sources of contamination. The facility should be a very clean area, preferably a clean or white room, with good ventilation. No smoking or open flames should be allowed in this work area. The temperature of the work area should be 23°C ± 2°C and humidity controlled at 30 to 60 percent RH.

A. A health and safety approved exhaust fume hood must be available to vent fumes and vapor. A minimum of 125-CFM exhaust at the hood face is recommended.

B. A vacuum chamber capable of operating at 50 microns of Hg or less (50 X 10^{-3} torr) must be used.

C. A large convection oven with 25°C minimum operating temperature and having a thermal fail-safe shut down protection must be used.

D. All workstations in the facility must have earth-ground connection for protection against electrostatic discharge.

E. Good lighting intensity of 100 foot-candles minimum (1,076 lumens per square meter) should be available above each coating and staking work surface.

7. QUALITY ASSURANCE REQUIREMENT

7.1. Workmanship

The most important part of the conformal coating, potting and staking procedure is the surface cleaning of the PWB. If the PWB's surfaces are not thoroughly clean the resin will not wet, causing unnecessary problems in the processing. It is important that silicones not come in contact with tools or equipment used in the processing of urethanes. Silicone coatings require special handling, which is not covered in this document.

7.2. Final Inspection

After completion of the conformal coating each PWB assembly shall be inspected by the operator and a quality assurance person (as required). A lighted magnifier, having four to ten power magnification should be used to inspect the PWB. An ultra-violet lamp should be used to inspect the fluorescent cured urethane to ensure that all the surfaces and electrical components are well coated.

7.3. Acceptance Requirement

An acceptable coated PWB shall meet the following requirements for both sides of the board.

A. Coating shall be fully cured and tack-free to the touch.

B. Coating shall have good adhesion to the PWB and electrical components with no visible lifting or peeling of the coating.

C. Coating shall be uniform in thickness and shall be in the range of 0.003 to 0.005 inches. Allowance must be made for the non-uniformity of brush coating.

D. Coating shall be smooth and free of air bubbles.

E. Coating shall not contain any dust, dirt, or brush hair embedded in it.

F. Coating shall have no excessive resin build-up on the PWB's surface and the electrical component stress relief wires must be free of resin.

G. Coating shall have no thin or dry spots.

H. Coating shall not be allowed to bridge between ceramic-bodied dual-in-line components and the PWB's surface.

I. Coating shall not be allowed to coat male/female IC component terminals. (i.e. sockets).

J. Excessive amounts of staking compounds used in the staking of electrical components shall not be used. Refer to NHB 5300.4 (3J), chapter six, for guidance in staking components and wires.

8. COATING PROCEDURE

Caution: It is important that any PWB containing "sensitive-to-damage" parts be protected against electrostatic discharge (ESD). ESD protection procedures must be

followed when handling and processing PWB's. All personnel and workstations shall be well grounded to prevent any damage during the entire processing of the electronics.

Caution: OSHA precautions and guidelines shall be followed when handling chemicals and/or organic resin materials.

8.1. Cleaning the Printed Wiring Board

All PWBs should be visually inspected on both sides for unusual or excessive surface contamination prior to the cleaning. Cleaning shall be done to assure that the surfaces are free of oil films, greases, fluid residue and any other contamination. By use of a small soft natural bristle brush, together with the proper approved solvents, gently brush the front and back surfaces of the PWB to loosen any contamination. The proper solvent will depend upon the degree of contamination and the component tolerance.

The following steps are provided to assist the operator:

Start with a mild solvent such as ethyl alcohol . A stronger solvent, such as acetone should be used only if necessary to loosen stubborn contamination.

NOTE: Operators involved in conformal coating should wear protective clothing and polyethylene gloves at all times when handling the boards. It is important that everyone involved in the coating process must maintain and observe strict cleanliness procedures.

A. Using a spray gun (Binks Model 115), spray clean all PWB surfaces with 200 proof ethyl alcohol. During the spray cleaning, the boards should be held by a gloved hand or by a clamping device such that the board is at an angle of 10 to 20° from the vertical, with the topside closest to the operator. Solvent spray one side of the board, working small sections at a time from left to right and from top to bottom to allow contaminates to travel downwards.

B. Rotate the PWB a full 360° in steps of 90°. On each 90° rotation, spray as in step A. This will ensure that all electrical components have been spray cleaned.

C. Remove excess solvent by blow drying all surfaces with dry, clean nitrogen. The nitrogen gas should be 99.99% pure and the pressure should not exceed 5 PSIG (for ESD reasons). A higher pressure may be used if the P-2051-FS ionizing filtered air gun is used.

D. The opposite side of the board should then be spray cleaned as in steps A, B, and C.

E. The cleaned boards should be re-inspected for cleanliness and excess contamination. If any deposits are noted, they should be removed and the board re-cleaned, as indicated above.

F. Place the board in a clean convection oven and dry at 60 to 65°C for a minimum of 30 minutes to completely evaporate all cleaning solvents.

G. Remove the PWBs from the oven and store in a clean, dry cabinet or in an approved conductive bagging material until needed for the conformal coating application. Ideally, perform the conformal coating immediately.

H. If the PWB is stored for a period of time, it should be re-dried as in step F prior to the conformal coating.

8.2. Staking Electronic Components On Printed Wiring Board (PWB)

Electrical components such as large resistors, capacitors, chokes, small wire, coils, etc. which are attached to the boards, may be subject to high vibrational stress levels. To ensure that none of these electrical components become detached from the PWB, a thixotropic mixture of curing agent Uralane 5753 LV-A and prepolymer resin Uralane 5753 LV-B, filled with Cab-O Sil, is used for staking. Properly applied staking compound will firmly hold components in place. (Note: This resin has a short pot life and should not be used after one hour.)

Resin Formulation for Staking

Material	Function	Amount
Uralane 5753 LV-A	Curing Agent	6.0 grams
Uralane 5753 LV-B	Prepolymer Resin	30.0 grams
Cab-O-Sil, M-5	SiO_2 Thickener	2.1 grams

A. Cab-O-Sil must be heated to 125 - 130°C for a minimum of 48 hours prior to use to assure removal of moisture. This is normally done in a wide shallow stainless steel or Pyrex glass tray to provide maximum surface area. Keep the Cab-O-Sil covered with aluminum foil at the recommended drying temperature.

B. The manufacturer's warranty for the use of Uralane 5753 LV-A and Uralane 5753 LV-B is 6 months from date of shipment. It is the SDL policy that this material not be used for processing space flight hardware after the 6 months expiration date unless a sample of the outdated material is prepared and properly cured to demonstrate it's acceptability.

C. Weigh the correct amounts of the Uralane 5753 LV-A and Uralane 5753 LV-B, into a small (250 ml) glass or polypropylene beaker. (Note: Do not use paper.) Mix well for 3 to 5 minutes with a stainless steel spatula. (Note: Do not use wood.) Add the Cab-O-Sil and again slowly mix well until the Cab-O-Sil is thoroughly blended into the resin mixture.

D. De-aerate the resin mixture by placing the beaker into a vacuum chamber and evacuate at a pressure of 50 microns of Hg (50 X 10^{-3} torr) or less for 5-8 minutes; or until most of the entrapped air is removed from the thixotropic mixture.

E. Transfer the de-aerated resin mixture to a syringe, being careful not to trap air bubbles. Install a large bore, blunt needle onto the syringe. The syringe works well for staking all electronic components and wires.

F. Place a sufficient amount of mixed resin onto the electrical components to form fillets between the components and the PWB only on the sides of the components. Refer to NHB 5300.4 (3J) for proper staking applications of electrical components, wires, etc.

G. Do not vacuum de-aerate the thick staking resin mixture after it has been applied to the electronic component. Allow the resin to stand at ambient temperature overnight, or until resin is firm enough not to be disturbed by the brushing or spraying application, before applying conformal coating.

H. This staking resin formulation will cure tack-free at ambient temperature in 24 hours. An 8-hour cure is normally sufficient as an intermediate cure prior to proceeding with conformal coating. Complete cure requires 5 to 7 days at room temperature. Complete cure can also be achieved by exposing the resin to a temperature of 60-65°C for 24 hours or 75° C for 12 hours.

8.3. Potting

Potting is defined as the complete encasement of a component or a module within a resin using a can, shell, or other container, which remains as an integral part of the product after the resin, has cured. Embedment is the same process except that a removable mold is used. For this procedure, except for mold preparation and removal they will be considered as being the same process and the term potting will be used.

A. If a removable mold is to be used it should have an interior surface as smooth as possible. The mold may be made from any of several materials as long as they do not react with the potting material. Teflon is an excellent material which will minimize the need for a mold release and in most cases eliminate the need completely. The use of a mold release such as Miller-Stephenson MS-136 Release Agent is needed for most molds.

Resin Formulation for Potting

Material	Function	Amount
Uralane 5753 LV-A	Curing Agent	6.0 grams
Uralane 5753 LV-B	Pre-polymer Resin	30.0 grams

B. Weigh out the correct amounts of the Uralane 5753 LV-A and Uralane 5753 LV-B into a glass or polypropylene container with a volume 4 to 5 times that of the material being mixed. Mix well for 3 to 5 minutes with a stainless steel spatula. (Note: Do not use wood.)

C. De-aerate the resin mixture by placing the beaker into a vacuum chamber and evacuate at a pressure of 50 microns of Hg (50 X 10^{-3} torr) or less for 5-8 minutes; or until most of the entrapped air is removed from the thixotropic mixture.

D. The de-aerated resin may be poured into the mold cavity directly or transferred to a syringe. Care should be taken to allow the material to flow rather than "splash" so that a minimum of air is trapped. It may be desirable to fill the mold in steps rather than completely at one time since the level of the material will rise during de-aeration of step E.

E. De-aerate the resin filled cavity to remove entrapped air.

F. Allow the Potted assembly to stand overnight at room temperatures. The resin will be dry and tack-free after twenty-four hours and completely cured in five to seven days. An elevated cure at 65°C for 24 hours (or 75° C for 12 hours) can be done after an overnight stand. Note: A longer cure at a lower temperature will result in less stress being placed on the assembly.

8.4. Masking the Printed Wiring Board (PWB)

A. All masking shall be done per verbal instructions and/or drawing requirements. 3M Scotch #42 tape is recommended for the masking of all specified areas to be protected from the resin. Connectors can be masked, front and rear with this tape. The tape should be applied with firm finger pressure to ensure a uniform surface free of air bubbles.

B. All male/female contacts (i.e. socketed IC's) must be covered prior to spray coating. The covering for these contacts can be the staking compound described in section 8.3.

Note: 3m Scotch #42, although classed as an anti-static tape, will generate a low static voltage as it is removed from the roll or board. Because of this, masking and unmasking of PWB's should be done with the aid of an air ionizer such as the Aerostat XC Benchtop Ionizer.

8.5. Brush Conformal Coating Resin Preparation

The two component, solvent based, room temperature curing Uralane 5750-LV provides an excellent conformal coating when properly applied. This urethane resin contains a fluorescent material which will provide an optical confirmation of the resin coverage of the PWB.

Resin Formulation for Brush Coating

Material	Function	Amount
Uralane 5750 LV-A	Curing Agent	5.4 grams
Uralane 5750 LV-B	Pre-polymer	30 grams
Toluene (70 pbv)/		
Methyl Ethyl Ketone (30 pbv)	Diluent	20 grams

A. Weigh the appropriate amounts of Uralane 5750 LV-A and Uralane 5750 LV-B, as indicated in the table, into a clean glass or polypropylene beaker. Stir well with a stainless steel spatula (not wood) for three to five minutes.

B. Immediately add the diluent to the mixed Uralane and again stir until well blended. The diluent will thin the mixed resin and provide better leveling by extending solvent evaporation time. Caution: Do not vacuum de-aerate this mixture, as it will remove all the solvents.

C. The mixed Uralane resin is then ready for application to the PWB.

8.6. Brush Conformal Coating Resin Applications

During the brushing application, solvents will evaporate from the resin. It may be necessary to add additional solvents to the resin mixture.

A. Prior to the resin application blow the PWB surfaces with clean dry nitrogen, 5 PSIG maximum, to remove any dust and/or dirt particles. The P-2051 FS ionizing air gun may be used at higher pressures.

B. With a clean camel hair or sable brush approximately one quarter to three eighths inch diameter, begin brush coating the front (electrical component) side first. Brush coat from left to right, approximately a one-inch wide area. Continue from top to bottom until the front side has been completed, making sure that all electrical components have been coated. Care must be taken to ensure that the resin be carefully applied around IC components such that none touches or flows by capillary action into the male/female (socket) interface. (These sockets should be covered by the staking compound prior to start of the coating procedure.) The thickness of the wet coating should be measured with the thickness gauge in several areas. Add or remove resin as necessary to obtain a thickness between 0.003 to 0.005 inches. The edges of the PWB are usually not coated, but can be coated if desired.

C. Excess resin buildup beneath and around electrical component stress wires must not be allowed. Excess resin can be removed by brush or by blowing the resin from the components with a jet stream of clean, dry nitrogen, 5 PSIG maximum, combined

with vacuum pick-up of excess resin. Measure the thickness of the wet resin and add or remove as necessary to provide thickness between 0.003 and 0.005 inches.

D. If possible, brush coat the backside of the PWB immediately after finishing the front. Brush coat the backside of the PWB in the same manner as the front side, being sure that all electrical components have been coated. Normally it is not possible to coat the second side of the PWB at this time. Go to step E, F, and the overnight cure of step G. The next day, coat the second side starting at step A.

E. After completion of the brush coating, check the surface of the PWB for complete resin coverage and any contamination, such as brush hair, and then place the PWB into a vacuum chamber. Vacuum de-aerate for a period sufficient to break entrapped air bubbles, approximately one to two minutes. The finished PWBs should exhibit a smooth uniform coating without bubble entrapment or dry spots. If any touch-up work is necessary it should be done at this time.

F. Upon completion of the vacuum de-aeration, place the PWB in a horizontal position upon sharp pointed Teflon (or other suitable plastic) supports, in a clean area with the electronic components at the topside for resin curing.

G. Allow the PWB to stand overnight at room temperatures. The resin will be dry and tack-free after twenty-four hours and completely cured in five to seven days.

H. An elevated cure at 65°C for 24 hours (or 12 hours at 75° C) can be done after an overnight stand.

8.7. Spray Conformal Coating Resin Preparation

Spray coating PWB is the preferred method of coating. It will require more preparation and clean-up time, however.

Resin Formulation for Spray Coating

Material	Function	Amount
Uralane 5750 LV-A	Curing Agent	5.4 grams
Uralane 5750 LV-B	Pre-polymer	30 grams
Toluene (70 pbv)/		
Methyl Ethyl Ketone (30 pbv)	Diluent	36 grams

A. Weigh the appropriate amounts of Uralane 5750 LV-A and Uralane 5750 LV-B into a clean glass or polypropylene beaker (250 cc). Stir well with a stainless steel spatula (not wood) for a minimum of three to five minutes.

B. Add the diluent to the mixed resin and again stir until thoroughly blended. Allow this mixture to stand for five to eight minutes to permit air bubbles to escape.

C. The resin is now ready for spray application to the PWB by use of the Binks spray gun model 59-10006.

8.8. Spray Conformal Coating Resin Application

The spray coat application is fast and is accomplished with a minimum amount of resin material. Special attention must be given to obtain proper resin coverage on the electrical components. It is difficult to spray coat both sides of the PWB at one time without disturbing the wet resin sprayed onto the first side. It is recommended that only one side be coated, then allowed to cure overnight before doing the second side.

A. Prior to the resin application, blow the surface of the PWB with clean dry nitrogen, 5 PSIG maximum to remove dust and/or dirt particles. The P-2051 FS ionizing air gun may be used at higher pressures.

B. The PWB should be placed on a flat platform with Teflon (or other approved plastic) stand-offs holding the PWB approximately three fourths inch or greater from the flat surface. A rotating table works well to turn the PWB in 90° increments during the spraying procedure.

C. If any IC's are present on the PWB, some of the mixed resin should be placed in a syringe and flowed under the IC to cover the bottom of the IC and the board under the IC. The excess resin mix should be removed from under the part by the combined use of low-pressure nitrogen gas, 5 PSIG maximum, and vacuum pick-up.

D. Place the mixed resin into the spray gun's reservoir and pressurize with clean dry nitrogen to provide good atomization of the mixed resin.

E. At one side of the PWB a clean one-inch wide by four-inch long aluminum plate may be affixed. This may be used as a witness sample and as a flat surface to measure the wet resin. Do not measure the resin on the PWB when spraying as it will leave marks in the resin coating. It is recommended that the component side of the PWB be coated first.

F. With the Binks spray gun, model 59-10006, at a 45° angle to the PWB and approximately three to five inches from the board, begin spraying from left to right, being sure to spray approximately one inch beyond the edge of the board. This prevents overlap and excess resin build-up. Spray from top to bottom until the board has been covered, being careful to minimize the overlap of each resin spray pass. Rotate the assembly 90° and repeat so that all four directions are well sprayed. For each direction sprayed, the wet resin thickness should be approximately 0.001 inches. Touch-up any area of the PWB as necessary to cover thin or dry spots and carefully blend the touch-up resin with the coated board. It has been found that the spray coating does not need vacuum de-aeration after spraying. Inspect the PWB for bubbles or any other contamination under four to ten-power magnification.

G. Place the PWB into a clean, dry cabinet and allow to stand overnight at ambient temperature. (The convection oven, unpowered, will work well for this purpose.) It should be tack-free with-in 24 hours. Normally this ambient cure will be sufficient to allow the continuation of the conformal coating process. An elevated cure can be done at 65°C for 24 hours (or 75°C for 12 hours) after overnight standing.

H. Spray coat the other side of the PWB after overnight cure. Follow the above steps A, B, D, E, F and G.

I. After the coating of the second side of the PWB, followed by 24-hour ambient cure, the masking material may be removed either prior to or after the 24 hour 65°C (or 12 hour 75°C) cure.

8.9. Cleaning The Printed Wiring Board After Final Resin Curing

A. All masking material shall be removed, followed by cleaning the non-coated surface where tape may have left some residue or adhesive. Use a urethane swab, lightly dampened with cleaning solvent, to remove any contamination. A non-scratching tool of wedge-sharpened wood or nylon works well to remove any urethane material. A sharp scalpel or razor blade may be used to cut the cured coating material so as to prevent lifting of the conformal coating adjacent to the masked area.

Caution must be exercised so as not to damage the circuitry or conformal coating during clean up.

B. This final cleaning may be done prior to or after the elevated cure of 60-65°C (or 75°C). It would best be performed as the final step.