(NHB-5300.4(3J)) REQUIREMENTS FOR CONFORMAL COATING AND STAKING OF PRINTED WIRING BOARDS AND ELECTRONIC ASSEMBLIES (NASA) 44 p

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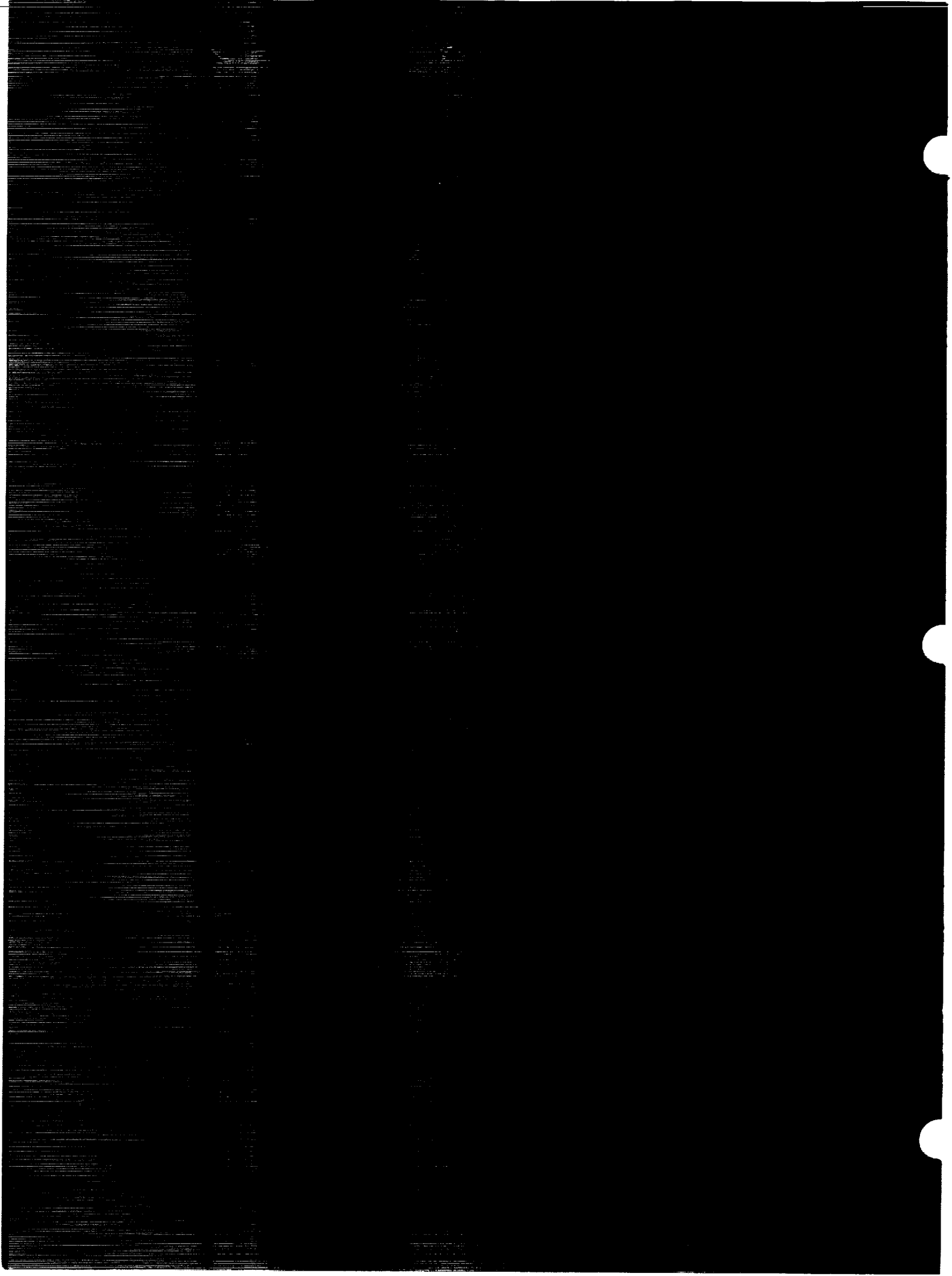


PREFACE

Date: April 1985

In order to maintain the high standards of the NASA conformal coating and staking programs, this publication:

Prescribes NASA's requirements for assuring reliable conformal coating and staking for printed wiring boards and electronic assemblies.

Describes and incorporates basic considerations necessary to assure reliable conformal coating and staking.

Establishes the supplier's responsibility to train and certify personnel.

Provides for supplier documentation of the fabrication and inspection procedures to be used for NASA work, including supplier innovations and changes in technology.

Provides visual workmanship standards to aid those responsible for determining quality conformance to the established requirements.

NASA installations shall:

Invoke the provisions of this publication in procurements involving conformal coating and staking on printed wiring boards and electronic assemblies for aircraft, spacecraft, launch vehicles, mission essential support equipment, and elements thereof as appropriate to design or project requirements. Appendix A contains definitions for terminology used in this publication. Appendix B contains visual aids applicable to the processes contained in this publication. Appendix C explains some problems relating to conformal coating. Appendix D tabulates the advantages and disadvantages of different conformal coatings.

Amend, when timely and within cost constraints, existing contracts to invoke the requirements of this publication.

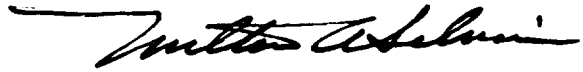
Utilize the provisions of this publication as a basis for in-house conformal coating and staking operations and, as necessary, for training and certifying of in-house personnel.

Assure that NASA contractors invoke the requirements of this publication in their subcontracts and purchase orders.

Make available copies of this publication, in the quantities required, to NASA contractors, subcontractors, and suppliers.

Questions concerning application of this publication to specific procurements shall be referred to the procuring NASA installation or its designated representative.

This publication shall not be rewritten or reissued in any other form.



Milton A. Silveira
Chief Engineer

DISTRIBUTION:

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ORGANIZATION OF THE R&QA MANUAL

OVERALL COVERAGE

The Reliability and Quality Assurance Manual - referred to as the "R&QA Manual" - is the overall generic title which identifies all NASA R&QA management publications published under the basic R&QA subject classification code. The publications are grouped by major subject breakdown and further divided into specific categories identified as Parts. These Parts (not a complete R&QA Manual) are published as individual R&QA publications.

The following list shows the grouping and R&QA publications:

Title

Volume 1 - General Provisions

Title	Number
Reliability Program Provisions for Aeronautical and Space System Contractors	NHB 5300.4(1A) (April 1970)
Quality Program Provisions for Aeronautical and Space System Contractors	NHB 5300.4(1B) (April 1969)
Inspection System Provisions for Aeronautical and Space System Materials, Parts, Components and Services	NHB 5300.4(1C) (July 1971)
Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program	NHB 5300.4(1D-2) (October 1979)
Volume 2 - Government Agency Provisions	
Management of Government Quality Assurance Functions for Supplier Operations	NHB 5330.7 (May 1966)
Quality Assurance Provisions for Government Agencies	NHB 5300.4(2B) (November 1971)
Volume 3 - Standards	
Requirements for Soldered Electrical Connections	NHB 5300.4(3A-1) (December 1976)

Qualified Products Lists Requirements for Microcircuits	NHB 5300.4(3F) (June 1972)
Requirements for Interconnecting Cables, Harnesses, and Wiring	NHB 5300.4(3G) (April 1985)
Requirements for Crimping and Wire Wrap	NHB 5300.4(3H) (May 1984)
Requirements for Printed Wiring Boards	NHB 5300.4(3I) (May 1984)
Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies	NHB 5300.4(3J) (April 1985)

DOCUMENT REFERENCING

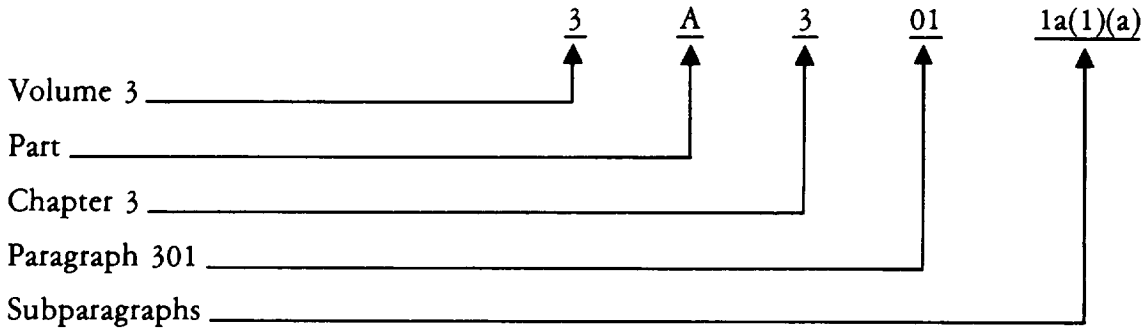
Each R&QA Manual Part is assigned its own identification number within the basic classification code. The numeric-alpha suffix within a parenthesis identifies the grouping of the publication, that is, the volume and part, such as NHB 5300.4(3A): This number indicates that this is the first "Standards" (Volume 3) publication to be issued.

When a part is revised, the suffix identification will be changed to indicate the revision number, such as NHB 5300.4(3A-1).

In referencing or requesting any R&QA publication, the complete specific NHB number must be used.

PARAGRAPH REFERENCING

1. **Within the R&QA Manual.** The following shows the paragraph numbering system applicable to all R&QA publications.



This system provides for referencing any R&QA publication requirement (paragraph) in any other R&QA publication without the need for identifying the NHB number, title, the volume number, or part. However, when referencing a complete Part within another R&QA publication, the specific NHB number must be used.

2. **In Other NASA Documents.** When it is necessary to reference an R&QA publication requirement (paragraph) in any other NASA document, the specific NHB number and paragraph number must be used together as follows: "NHB 5300.4(3A-1), paragraph 3A301-1a(1)(a)," or "paragraph 3A301-2b of NHB 5300.4(3A-1)."

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CHAPTER 1: BASIC PRINCIPLES

3J100 APPLICABILITY AND SCOPE

1. **Applicability.** This publication is applicable to NASA programs involving conformal coating and staking on printing wiring boards (PWB's) and electronic assemblies for aircraft, spacecraft, launch vehicles, mission essential support equipment and elements thereof, and where invoked contractually in procurements. Appendix A contains definitions of terminology used in this publication. Appendix B contains visual aids applicable to the processes discussed in this publication. Appendix C discusses conformal coating problems, and Appendix D furnishes a general comparison of coating materials and processes.

2. **Scope.** This publication sets forth requirements for conformal coating and staking in PWB's and electronic assemblies.

3. **Special Requirements.** Special requirements may exist which are not covered by or are not in conformance with the requirements of this publication. *Design documentation shall contain the detail for such requirements, and they shall take precedence over conflicting portions of this publication when they have been approved in writing by the procuring NASA installation.*

3J101 PURPOSE OF CONFORMAL COATING

1. **Definition.** A conformal coating is a thin, electrically nonconductive protective coating which will conform to the configuration of the board or other assembly to be coated.

2. **Purpose.** Conformal coatings are intended to provide electrical insulation and environmental protection thus minimizing the performance degradation to electronic assemblies by humidity, handling, debris, and contamination.

3J102 PURPOSE OF STAKING

1. **Definition.** Staking is the process of bonding and securing components or parts to PWB's and electronic assemblies by means of an adhesive material.

2. **Purpose.** The main purpose for staking is to protect and support components which may be damaged by vibration, shock, or handling. Thermal transfer factors are not covered by this document.

3J103 PRINCIPLES OF RELIABLE CONFORMAL COATING AND STAKING

1. **Factors Controlling Reliability.** Reliable conformal coatings and stakings result from proper design, control of equipment, materials, work environments, and careful workmanship by trained and certified personnel.

2. **Design Considerations for Conformal Coating.** Conformal coating material shall be specified on the approved engineering drawing. The basic design considerations to assure reliable conformal coatings are as follows:

   a. The conformal coating material and process selected shall be suited to the complexity of the assembly and shall be capable of covering the circuitry.

   b. The coating material selected shall have dielectric properties that will meet the minimum circuit requirements in all anticipated environments. The material shall be noncorrosive and curable under conditions compatible with the components on the boards and assemblies, including their temperature limits.

   c. The coating material shall not cause excessive stress to the PWB and electronic assembly, their piece parts and electrical interconnection during thermal or mechanical tests or exposures.

   d. The coating material shall meet program and contractual outgassing requirements and shall have minimal flammability hazard.

   e. The coating material selected shall have maintainability properties (repair and rework) compatible with the parts and board or other substrate.

   f. The coating material selected shall be compatible with and adherent to all materials used in PWB's and electronic assemblies.

   g. The coating material selected shall be hydrolytically and thermally stable as required.

3. **Design Considerations for Staking.** Staking material shall be specified on the approved engineering drawing. The basic design considerations to assure reliable staking materials are as follows:

   a. Staking material shall be noncorrosive, electrically insulative material, with dielectric properties (permittivity and dissipation factor) adequate for the particular application.

b. Staking material shall be strong enough to provide adequate mechanical support. Rigid staking material with low thermal expansion coefficient is generally desirable. For special cases where components sensitive to thermal/mechanical stress are used, application of resilient materials may be required.

c. Staking material must be compatible with and must adhere to the board or substrate and component staked, and to the conformal coating to be applied.

d. The staking material shall meet program and contractual outgassing requirements and shall have minimal flammability hazard.

3J104 GENERAL

1. **Implementation.** NASA quality assurance personnel will advise and assist contractors, suppliers, NASA personnel, and delegated agencies in the proper and effective implementation of the provisions of this publication. Effective implementation includes establishing a system which will identify each inspection point and provide a record.

2. **Changes in Requirements.** When related requirements or changes in requirements are specified, NASA quality assurance personnel will assure that the Government agency delegated to inspect at the supplier's site of fabrication has received full instructions so that the work will be inspected to actual contract requirements.

3. **Nonstandard Processes, Materials, or Parts.** When the supplier intends to use processes, materials, or parts not covered by this publication, the supplier shall document the details of fabrication and inspection, including acceptance and rejection criteria, and shall provide appropriate test data. Such documentation shall be approved by the procuring NASA installation prior to use.

4. **Electrostatic Discharge (ESD) Protection Program.** A program for protecting electrostatic sensitive devices shall be developed and submitted to the procuring installation for approval.

3J105 RELATED DOCUMENTS

1. **Applicable Specifications.** Copies of the following applicable specifications when required in connection with a specific procurement may be obtained from the procuring NASA installation or as directed by the contracting officer:

Military Specifications

MIL-I-46058 "Insulating Compound, Electrical (for Coating Printed Circuit Assemblies)."

2. **Other Publications**

ASTM D 2240	"Standard Method of Test for Rubber Property-Durometer Hardness."
OSHA Standards	29 CFR Part 1910, "Occupational Safety and Health Standards" and state standards as applicable.
NHB 5300.4 (3I)	"Requirements for Printed Wiring Boards."
NHB 8060.1	"Flammability, Odor and Offgassing Requirements and Test Procedures for Materials in Environments that Support Combustion."

Unless otherwise specified, the issue in effect on the date of invitation for bids or request for proposal shall apply.

3J106 DEVIATION AND WAIVER REQUESTS

1. **Approval of Changes.** This publication requires:

   a. Written approval shall be obtained from the cognizant NASA contracting officer or designated NASA representative for technical changes, deviations, or waivers initiated by the supplier.

   b. All deviation and waiver requests shall be supported by objective evidence and data substantiating that quality and reliability will not be compromised.

2. **Responsibility.** The prime contractor is responsible for assuring that any departures from this publication are evaluated, coordinated with, and submitted to the procuring NASA installation for approval prior to use or implementation.

3J107 REWORK

Rework is permissible unless excluded by other provisions of the contract. All rework shall meet the requirements of this publication. Rework is not repair. Repair shall be made only in compliance with applicable contractual requirements.

3J108 DEFINITIONS

For the purposes of this publication, the definitions in Appendix A shall apply.

CHAPTER 2: SUPPLIER COATING AND STAKING PROGRAM

3J200 GENERAL

The supplier is responsible for maintaining a documented coating and staking program that meets the requirements of this publication. Portions of this publication may be abstracted for the supplier's program.

3J201 TRAINING AND CERTIFICATION

The supplier is responsible for:

1. Assuring that design personnel are familiar with the requirements of this publication and other pertinent requirements of the contract or purchase order.

2. Providing necessary training for coating, staking, and inspection personnel in techniques, equipment, and procedures pertinent to the areas of responsibility of each in performance of the duties required of them to fulfill terms of the contract purchase order. Make applicable standards readily available to these personnel and use the standards in the training program.

3. Assuring that each individual who coats, stakes, or inspects processed assemblies is appropriately skilled in the types of processes involved in the assigned work.

4. Certifying that each individual who coats, stakes, or inspects processed hardware is currently qualified to fulfill all requirements of this publication pertaining to the types of processes involved in the assigned work. Demonstration of proficiency is a prerequisite for such certification.

5. Maintaining appropriate records of certification criteria, training, and status of personnel.

3J202 MAINTENANCE OF CERTIFIED STATUS

1. **Proficient Workmanship.** The procuring NASA installation, its designated representative, or the supplier may require that processing personnel demonstrate proficient workmanship on applicable hardware or that they be recertified.

2. **Proficient Inspection.** The procuring NASA installation or its designated representative or the supplier's instructor may require that supplier inspection personnel demonstrate proficient inspection performance and knowledge on applicable hardware or that they be recertified.

3J203 RECERTIFICATION

1. **Causes for Recertification.** Recertification shall be required when:

   a. Proficiency requirements herein are not met. The need for recertification of a certificate holder may be based on observation of the unsatisfactory quality of articles either fabricated by a processor or accepted by an inspector.

   b. New techniques have been developed which require different skills.

   c. A certified person changes employment.

   d. The type of work requiring certification is interrupted for more than 90 days.

2. **Recertification Procedures.** Procedures for recertification shall include sufficient training or retraining to enable the candidate to demonstrate proficiency in performing or inspecting the types of processes involved in the assigned work. A proficiency demonstration shall be required of each candidate.

3J204 REVOCATION OF CERTIFIED STATUS

Certification shall be revoked for operators or inspectors when:

1. Certificate holder requires recertification according to paragraph 3J203 and fails to be recertified.

2. Certificate holder fails to meet the visual acuity requirements of paragraph 3J205.

3. Certificate holder leaves employment.

4. Supplier training program fails to meet requirements set forth herein or set forth otherwise in the contract.

3J205 VISION REQUIREMENTS

1. **Supplier Responsibility.** The supplier is responsible for assuring that all personnel who coat, stake, or inspect meet the following vision test requirements as a prerequisite to training, certification, and recertification. The vision requirements may be met with corrected vision (personal eyeglasses). However, any correction necessary to meet vision requirements shall be documented on the certificate. Where work is performed under a microscope, suitable verification of necessary visual acuity shall be made. The eye tests shall be administered by qualified personnel using standard instruments and techniques. Results of the visual examinations shall be maintained and kept available for review.

2. **Minimum Vision Requirements.** The following are the minimum vision requirements:

   a. Far vision. Snellen Chart 20/50.

   b. Near vision. Jaeger 1 at 14 inches or reduced Snellen 20/20 or equivalent.

3J206 WORKMANSHIP STANDARDS

The supplier shall make applicable standards readily available to personnel involved and shall use these standards in the training program. The supplier shall:

1. Furnish visual standards consisting of satisfactory work samples or visual aids which clearly illustrate the quality characteristics for all types of processes applicable to the contract or purchase order. Standards of unacceptable conditions may also be used for clarification or comparison.

2. Use applicable illustrations found in this publication for visual aids (see Appendix B). The illustrations of this publication shall be supplemented as necessary.

3J207 DOCUMENTATION

1. **Applicable Documents.** Documents required herein shall be submitted to the procuring NASA installation or its designated representative as required by the contract or purchase order. Applicable supplier coating and staking program documents, or portions thereof, accepted on other NASA contracts shall be included to avoid duplication of effort.

2. **Training and Certification Programs.** The supplier shall describe the training and certification program proposed in order to satisfy the requirements herein for the types of coating and staking to be performed. This description shall include the following, as applicable:

   a. Qualification of instructors.

   b. Procedures for training, including who will be trained and for what function, e.g., fabricator, inspector, or other personnel.

   c. Lesson plan(s).

   d. Hours of instruction.

   e. Procedures for certification and recertification.

f. Procedures for recording of training, recertification, and method of identifying trained personnel.

g. Certification criteria.

3. **Process Methods and Procedures.** The supplier shall document the methods and procedures proposed to incorporate the requirements of this publication into the design, fabrication, and inspection of processes involved in the contract or purchase order.

CHAPTER 3: FACILITIES, EQUIPMENT, AND MATERIALS

3J300 SAFETY

> CAUTION!
>
> ALL SOLVENTS AND CHEMICALS MAY PRESENT HEALTH AND SAFETY PROBLEMS. FOLLOW OSHA PRECAUTIONS AND GUIDELINES FOR HANDLING.

1. **Protective Gloves.** Conformal coating and staking materials may affect skin; hence, protective gloves should be worn during processing. Rubber protective gloves shall be free of plasticizers; cloth gloves shall be lint free.

2. **Protective Glasses.** Protective glasses shall be worn during processing.

3. **Handling of Solvent-Containing Coatings.** All coating and staking materials, except polyxylylene, may contain flammable or harmful solvents. There shall be no smoking or open flame within 25 feet (7.6 meters) of the coating operation area.

4. **Exposure to Solvents.** Personnel exposure to solvents and vapor of solvents shall be controlled in accordance with imposed safety standards. Exposure of personnel to solvents and vapors of solvents shall be kept to a minimum.

5. **Exposure to Toluene Diisocyanate (TDI).** Some polyurethane coatings may contain free TDI. OSHA restriction on TDI exposure shall be followed. Free TDI affects breathing and eyes.

3J301 FACILITY CLEANLINESS

The supplier is responsible for maintaining processing areas in a clean, orderly condition. Smoking, eating, and drinking in the work area shall not be permitted.

3J302 ENVIRONMENTAL CONDITIONS

1. **Controlled Environment.** The coating and staking area shall have a controlled environment which limits entry of contamination. This area shall be continuously maintained as follows:

   Temperature . . . . . 75° ±9°F (24° ±5°C)

   Relative humidity . . . . . 30 to 60 percent

   Parts, materials, or equipment being processed that require more critical environmental conditions than the preceding shall have such requirements identified and specified in the design documentation. Such requirements will have precedence over the established general environments. Parts and assemblies not sensitive to electrostatic charge (ESD) may be processed below 30 percent Relative Humidity (RH) unless coating requires a higher RH to achieve proper cure. For some coating materials, high humidity may retard the completion of cure.

2. **Ventilation.** The coating and staking facility shall be provided with adequate ventilation to accommodate the volume of compounds, solvents, and primers used. Fumes shall be drawn away from the operator and vented to the outside or to a scrubber, as applicable.

3J303 LIGHTING REQUIREMENTS

Light intensity shall be a minimum of 100 foot-candles (1076.4 lumens per square meter) at the work surface being used for coating and staking operations.

3J304 TOOL AND EQUIPMENT CONTROL

The supplier shall:

1. Select appropriate tools and equipment for coating and staking.

2. Establish procedures to properly clean, maintain, and check equipment and tools at regular intervals to assure proper function, control, and safety.

3. Maintain records of calibration and verification of tools and equipment.

3J305 COATING MATERIAL SELECTION

Coating material requirements, selection, and quality assurance inspection shall be specified by the procuring NASA installation. For general information and reference, Appendix D of this publication or the appropriate Qualified Products List (QPL) may be consulted. To facilitate examination and quality control, coating material with fluorescent indicators may be desirable.

> **CAUTION!**
>
> COATING MATERIALS WITH FLUORESCENT INDICATORS SHALL NOT BE USED IN THE VICINITY OF OPTICAL ASSEMBLIES.

3J306 MATERIAL STORAGE

1. **Shelf Life Stickers.** Material storage shall be controlled by shelf life stickers attached to each material container.

2. **Purchase Date Recording.** Records of manufacturing date, lot number, and receiving date of each material shipment shall be maintained.

3. **Solvents.** All cleaning and diluent solvents shall be stored in accordance with imposed safety regulations.

4. **Coating and Staking Materials.** Materials shall be stored in accordance with the manufacturer's recommendations. All stored containers shall be sealed.

5. **Moisture Sensitive Material.** Many materials are hygroscopic or moisture sensitive. Their storage shall be such as to minimize moisture exposure. The isocyanate part of urethane material shall be stored in a dry nitrogen atmosphere whenever possible.

6. **Expired Shelf Life.** If material with an expired shelf life date is tested in accordance with the material specification or approved test procedure and found to be in acceptable condition, the expiration date may be extended provided the extension is less than one-half the original shelf life.

7. **Order of Use.** Material shall be used on a "first in, first out" basis.

3J307 IN-PROCESS STORAGE AND HANDLING

1. **Establishment of Damage-Prevention Criteria.** The supplier shall be responsible for the development and implementation of requirements and procedures necessary to prevent damage to hardware, ESD damage, and to control conditions that could degrade its reliability.

2. **Handling and Storage Between Cleaning and Processing.** Lint-free gloves shall be employed for the handling of assemblies between cleaning and further processing. The hardware shall be stored in a manner that will minimize exposure to debris and dust.

3. **Handling and Storage After Coating.** After coating, particularly when the coating is still wet and tacky (during the curing cycle), hardware shall be handled and stored in a manner which minimizes exposure to particulate or other contaminants.

CHAPTER 4: PREPARATION FOR COATING AND STAKING

3J400 CLEANING

1. **Criteria.** The surface to be coated and staked shall be cleaned by an approved suitable method which will assure that the assemblies are free of solder flux and other ionic, oily, or particulate contaminants. Any contaminants trapped under the coating could interfere with the performance of the coating and might degrade the function of the coated assemblies. After cleaning and prior to coating, the PWB or electronic assembly shall be thoroughly dried to remove all residual solvents and moisture. The parts to be coated shall be kept clean and dry until coating. Maximum time period between drying and coating shall be specified and approved.

2. **Monitoring.** Effectiveness of the cleaning will depend on the proper execution of the approved cleaning procedure and the consistent use of fresh and residue-free solvent for the final cleaning step. To assure the effectiveness, the approved cleaning method, which may be vapor degreasing, ultrasonic immersion, solvent spray, solvent dip, brush, pulsating spray, or a combination of these, shall incorporate a monitoring procedure. The purity of the cleaning solvents may be examined by chemical analysis and/or by the determination of evaporation residue. In vapor degreasing, the solvent shall be periodically checked and replaced whenever in doubt. The residual ionic contamination of the PWB's may be monitored quantitatively by resistivity measurement in accordance with NHB 5300.4 (3I).

3. **Compatibility of Solvent With Hardware.** Many desirable cleaning solvents (e.g., trichloroethane, acetates, or some proprietary cleaning solvents) used for removing flux residues may be too harsh for some hardware surfaces. Assemblies containing silicone compounds, or those that have been previously coated, may require the use of benign cleaning solvents like isopropanol to minimize degradation caused by solvent. The cleaning procedure shall be compatible with the hardware so that there is no damage to the hardware.

> **NOTE**
>
> As a minimum, the assemblies shall be cleaned with both a polar solvent (e.g., isopropanol) and a nonpolar solvent (e.g., trichlorotrifluoroethane).

4. **Protection of Unsealed Components.** Unsealed components shall not be completely immersed in cleaning solvent. Hardware containing unsealed components shall be immersed in solvent only after these components have been sealed or masked prior to cleaning.

5. **Rework Cleaning.** The rework area shall be cleaned and dried prior to application of rework coating material.

3J401 STAKING

Staking, when required, shall be performed in accordance with the appropriate engineering document to the requirements of Chapter 6 herein. Staking shall be performed prior to conformal coating.

3J402 PRIMING

1. **Coatings Requiring Primer.** Silicones and polyxylylenes usually require a primer, whereas most other coatings may not.

2. **Silicone and Polyxylylene Coating Requirements.** For those silicone and polyxylylene coatings requiring priming, the priming shall be applied in an approved manner to obtain a generally uniform thin primer coat. Any excess buildup must be removed.

3. **Repriming Requirements.** Most primers are effective only for a specified period of time with well-protected storage. If, after priming, subsequent conformal coating has not been applied within the manufacturer's recommended elapsed time, repriming is mandatory.

3J403 MASKING

1. **Material.** Areas to be kept free of coating shall be masked with tape, covers, or other suitable masking material or devices.

2. **Masking Methods.** The method of conformal coating application may dictate completeness of masking. Dip application requires more thorough masking than brush application, which in turn requires better masking than spray application.

3. **Masking for Polyxylylene Coating.** Unsealed parts and areas not to be coated shall be properly masked to prevent polyxylylene vapors from penetrating minute openings. In addition, masking materials must be compatible with vacuum deposition. Many nonmetallic materials outgas or emit contaminants in vacuum.

> **CAUTION!**
>
> PRECAUTIONS MUST BE TAKEN TO ASSURE THAT NO HARMFUL RESIDUES ARE LEFT WHEN THE MASKING MATERIAL IS REMOVED AFTER COATING.

CHAPTER 5: COATING

3J500 GENERAL

Conformal coating materials may include solvents (diluents), fillers and catalysts and/or accelerators, in addition to the basic resin and curing agent. Some coating materials come in single-component form. Vacuum deposition material, including polyxylylene, requires a special coating chamber.

3J501 MATERIAL PREPARATION

Coating material shall be mixed and prepared according to the manufacturer's instructions or the appropriate process document. It must be verified, prior to usage, that coating materials have not exceeded their shelf life. Following are general information and requirements:

1. **Single-Component Coatings.** Coatings that are supplied as a single component may require stirring because of settling of fillers or other ingredients in the system.

2. **Multicomponent Materials.** Multicomponent materials shall be thoroughly mixed until the mixture is smooth and homogeneous and shall be used within the pot life limit. Frozen premixes do not need mixing, but will have pot life limits after being thawed.

3. **Premixing of Fillers.** If filler is to be added (e.g., silicas or talc), it shall be premixed into the less moisture-sensitive coating component before final mixing (e.g., in urethane, fillers shall be premixed into the polyol portion and not into the isocyanate).

4. **Moisture Removal.** Fillers are normally hygroscopic and should be oven baked to remove absorbed moisture before being added to resins.

5. **Order of Mixing.** When used, accelerators (or catalysts) shall be mixed in last to extend pot life as much as possible. Mixing shall be carefully conducted to minimize entrapped air. High-solids materials or high-viscosity material may be deaerated to remove trapped air. Be aware of the possibility of losing the volatile ingredients, if any, in the process of deaeration.

6. **Mix Record.** A record of each mix batch date and procedure shall be maintained.

7. **Spray Applications.** In spray application, viscosity of coatings shall be closely observed and controlled by addition of solvent as necessary to preserve the best sprayable viscosity.

8. **Containers.** In all mixing operations, nonabsorbent plastic, glass, or metal containers and stirrers shall be used. Containers with seams and crevices that will trap unmixed coating components shall not be used. Wooden sticks and tongue depressers shall not be allowed as stirrers.

9. **Material Condition.** Materials shall not be used that exhibit any evidence of surface skinning or gelling.

10. **Silicones.** Silicone mix/spray operations shall be segregated from other material operations.

3J502 COATING APPLICATION

Conformal coating shall be applied using a method that will yield complete coverage without excessive filleting or runs. Common coating application methods include spraying, brushing, dipping, pouring, or a combination thereof. Vacuum deposition is used particularly for polyxylylene. For a general comparison of coating materials and processes, see Appendix D.

1. **Spraying.** The coatings shall be sprayed onto the assembly using clean dry gas at a pressure sufficient to provide good atomization. One pass shall be sprayed across the entire surface of the assembly holding the spray gun at an angle of approximately 45° to the assembly. The assembly shall be rotated 90° after each pass, and spraying repeated, so that all four directions are sprayed. See Figure 5-1.

   The four-direction spraying shall be repeated, as necessary, to cover incompletely coated areas. Particular attention shall be paid to surfaces such as lead wires, lead wire tips, and other conductor areas. Additional solvent may be needed from time to time to adjust spray viscosity.

2. **Brushing.** The material shall be evenly applied, using a brush, without forming excessive fillets and thickness. Particular attention shall be paid to undersides of components and lead wires. The brush selected shall provide adequate control for appropriate coverage and shall be cleaned in a nonreactive solvent and thoroughly dried before use.

3. **Dipping.** The entire assembly shall be dipped. The extraction rate shall be such as to obtain uniform thickness. The coated assembly shall be allowed to drain until the coating stops running and minimum component filleting is achieved.

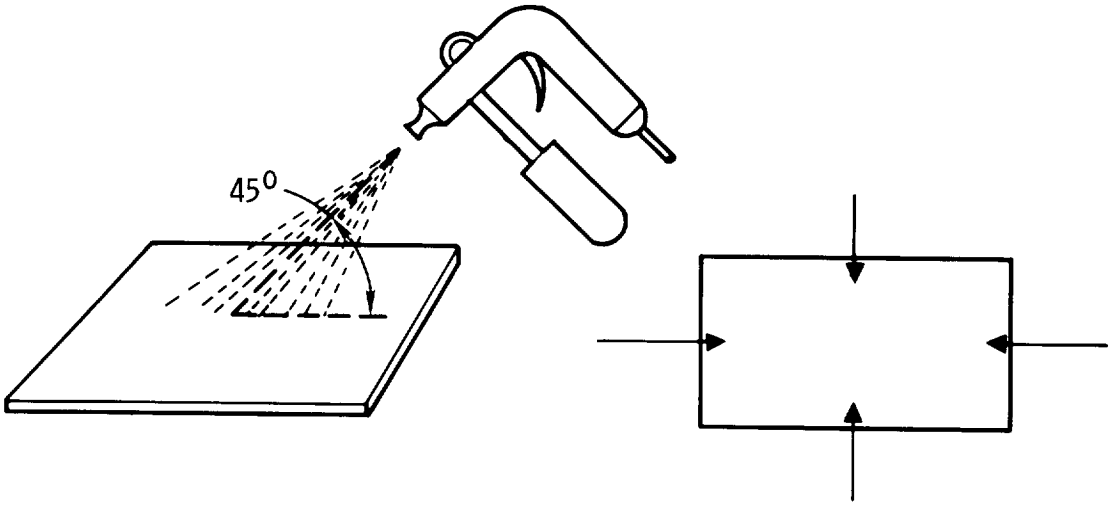
4. **Pouring.** Sufficient material shall be poured or flowed onto the assembly so that it will cover and spread outwardly and down without entrapping air. If necessary, a soft bristle brush shall be used for spreading and draining to reduce excessive buildup. The coated assembly shall be allowed to drain in the most appropriate orientation to reduce air entrapment, excessive filleting, and excessive thickness.

5. **Vacuum Deposition.** Polyxylylene coating shall be applied using a special vacuum deposition chamber. The coating shall be thin, uniform, and fillet free.

6. **Excessive Fillet Removal.** In the dip and brush application methods, excessive filleting may occur. If the spray application method produces excessive filleting, the spray parameters are improper and must be changed. Excessive filleting shall be removed using a soft bristle brush to push excessive material out and away. Determination of whether or not filleting is excessive shall be based on such factors as coating flexibility and thickness, component sensitivity, and circuit configuration.

CAUTION!

AVOID NEGATING THE STRESS RELIEF DESIGNED INTO THE ASSEMBLY OR INTRODUCING ADDITIONAL STRESSES ESPECIALLY WHEN RIGID GLASS- OR CERAMIC-BODIED COMPONENTS ARE INVOLVED. COATING SHALL NOT BE ALLOWED TO BRIDGE STRESS RELIEF LOOPS OR BENDS AT TERMINATIONS IN PART LEADS OR CONNECTING WIRES, AND ALSO SHALL NOT BE ALLOWED TO BRIDGE BETWEEN THE BOTTOM OF CERAMIC-BODIED DUAL-IN-LINE PACKAGES (DIP's) AND THE PRINTED WIRING BOARD SURFACE.



A. ANGLE OF SPRAY

B. ALL FOUR SPRAYING DIRECTIONS

FIGURE 5-1
SPRAY APPLICATION

7. **Bubble and Air Entrapments.** Immediately after material application, the uncured coating shall be examined for bubbles and air entrapments. These defects shall be broken by vacuum or with a sharp probe or other tools.

3J503 CURING

1. **Cure Schedule.** The coating material shall be cured in accordance with a specified cure schedule which is compatible with the thermal limitations of the hardware.

2. **Multiple Coatings.** When multiple coatings of the same material are employed, each coat may be partially cured before the next coat is applied.

3. **Curing Silicones.** Ovens used for curing silicones shall not be used for curing other materials.

> **CAUTION!**
>
> SOME SILICONE COATING CURES ARE INHIBITED BY VARIOUS CONTAMINANTS SUCH AS SULFUR OR SULFUR-CONTAINING CHEMICAL COMPOUNDS, AMINES AND CERTAIN OTHER NITROGEN-CONTAINING COMPOUNDS, ACIDIC MATERIALS (USUALLY ORGANIC ACIDS), AND ROOM TEMPERATURE VULCANIZING (RTV) SILICONE RUBBER CATALYSTS.

4. **Humidity Requirements.** While high humidity may retard the completion of curing, some materials specifically require a higher-than-ambient relative humidity to cure properly. Where necessary, an enhanced humidity environment shall be provided.

3J504 CLEANUP

The coated assembly shall be cleaned to remove any maskant, loose debris, or material which may damage or degrade its performance.

3J505 TOUCHUP

Coated assemblies may be touched up or reworked provided there is no deviation from the original engineering callout.

CHAPTER 6: STAKING

3J600 SURFACE PREPARATION

1. **Cleaning.** Surfaces to be staked shall be free of dirt, grease, and other contaminants. Prior to application of the compound, the surfaces to be joined shall be cleaned with a solvent compatible with the surface material, and then dried.

2. **Priming.** Priming, when required, shall be done in accordance with the manufacturer's recommendations.

3J601 MATERIAL PREPARATION

Material Preparation. Staking material shall be mixed and prepared according to the manufacturer's instructions or the appropriate process document. It must be verified, prior to mixing, that staking materials have not exceeded their shelf life. Following are general information and requirements.

1. **Single-Component Materials.** Materials that are supplied as a single component may require stirring because of settling of fillers or other ingredients in the multiple ingredient system.

2. **Multicomponent Materials.** Multicomponent materials shall be thoroughly mixed until the mixture is smooth and homogeneous and shall be used within the pot life limit. Frozen premixes do not need mixing, but will have pot life limits after being thawed.

3. **Premixing of Fillers.** If filler is to be added (e.g., silicas or talc), it shall be premixed into the less moisture-sensitive component before final mixing (e.g., in urethane, fillers shall be premixed into the polyol portion and not into the isocyanate).

4. **Moisture Removal.** Fillers are normally hygroscopic and shall be oven baked to remove absorbed moisture before being added to resins.

5. **Order of Mixing.** When used, accelerators (or catalysts) shall be mixed in last in order to extend pot life as much as possible. Mixing shall be carefully conducted to minimize entrapped air. High-solids material or high-viscosity material may be deaerated to remove trapped air. Be aware of the possibility of losing the volatile ingredients, if any, in the process of deaeration.

6. **Mix Record.** A record of each mix batch date and procedure shall be maintained.

7. **Containers.** In all mixing operations, nonabsorbent plastic, glass, or metal containers shall be used. Containers with seams and crevices that will trap unmixed coating components shall not be used.

3J602 STAKING

1. **Application.** In addition to spatulas and brushes, syringes, with or without pressure-controlled pneumatic dispensers may be used to apply the material. An appropriate amount shall be applied to the components and areas specified by engineering document to wet and join the intended surfaces. Some typical staking methods are shown in Figures 6-1 through 6-5.

> **CAUTION!**
>
> MATERIAL SHALL NOT BE ALLOWED TO BRIDGE BETWEEN THE BOTTOM OF CERAMIC BODIED DUAL-IN-LINE PACKAGES (DIP's) AND THE PRINTED WIRING BOARD SURFACE.

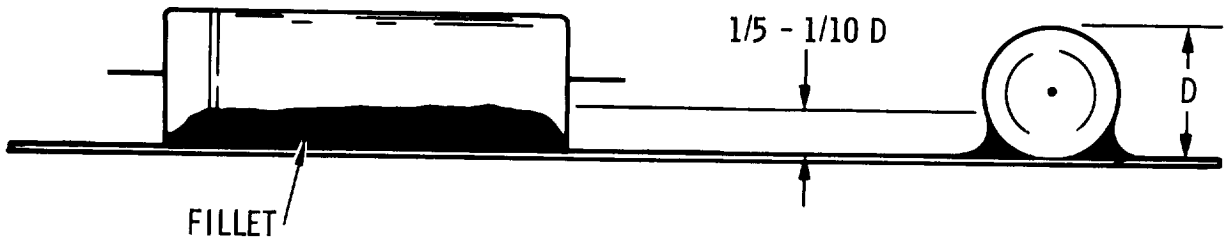
2. **Flexible Materials.** Flexible staking materials with high thermal expansion coefficient shall not be applied where excessive stress may be damaging (e.g., under DIP integrated circuits).

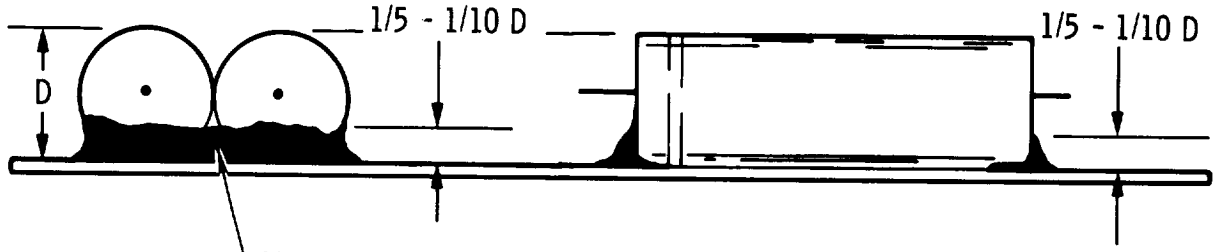
3. **Rigid Materials.** Caution must be taken to assure that the staking compound does not negate stress relief of parts and joints. Glass bodied components shall be covered with resilient material prior to staking with rigid material.

4. **Mandatory Staking.** Some components must be staked (e.g., solid tantalum capacitors). Jumper wires should be staked every inch, at a minimum, and at every change of direction.

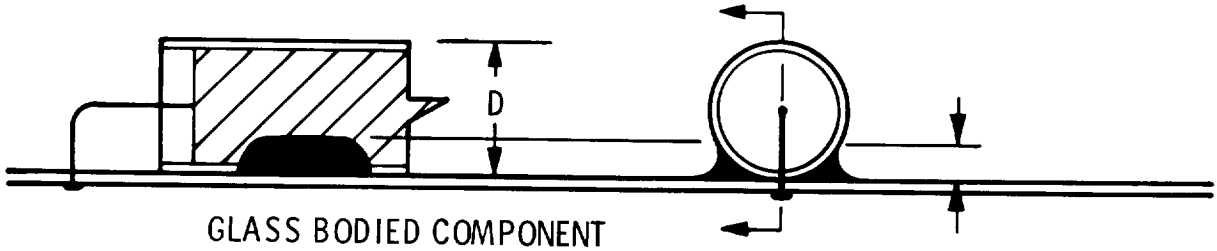
5. **Curing.** Staking material shall be cured in accordance with the cure schedule specified for the material.

6. **Cleanup and Preparation for Coating.** All residue and contaminants shall be removed or cleaned off.

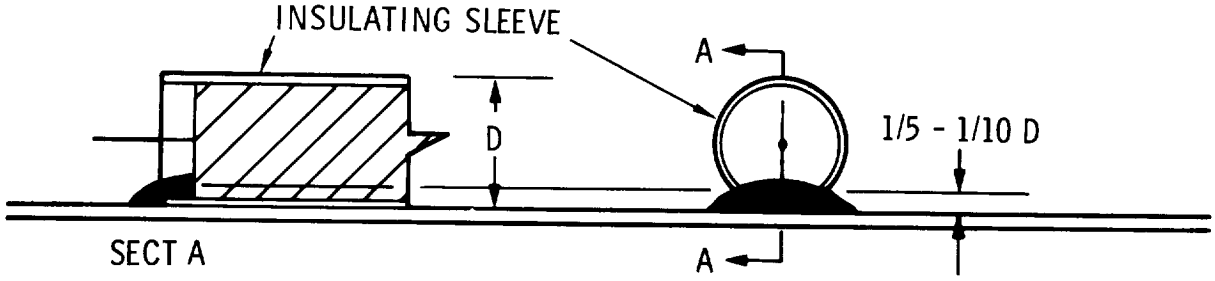




ALTERNATE FILLET WHEN BOTH
SIDES NOT ACCESSIBLE



GLASS BODIED COMPONENT
WITH INSULATED SLEEVE



FILLET USED WHEN METALLIC CASE
COMPONENT IS COVERED WITH
INSULATING SLEEVE

FIGURE 6-1
TYPICAL STAKING OF RESISTORS, CAPACITORS
AND SIMILAR ELECTRONIC COMPONENTS

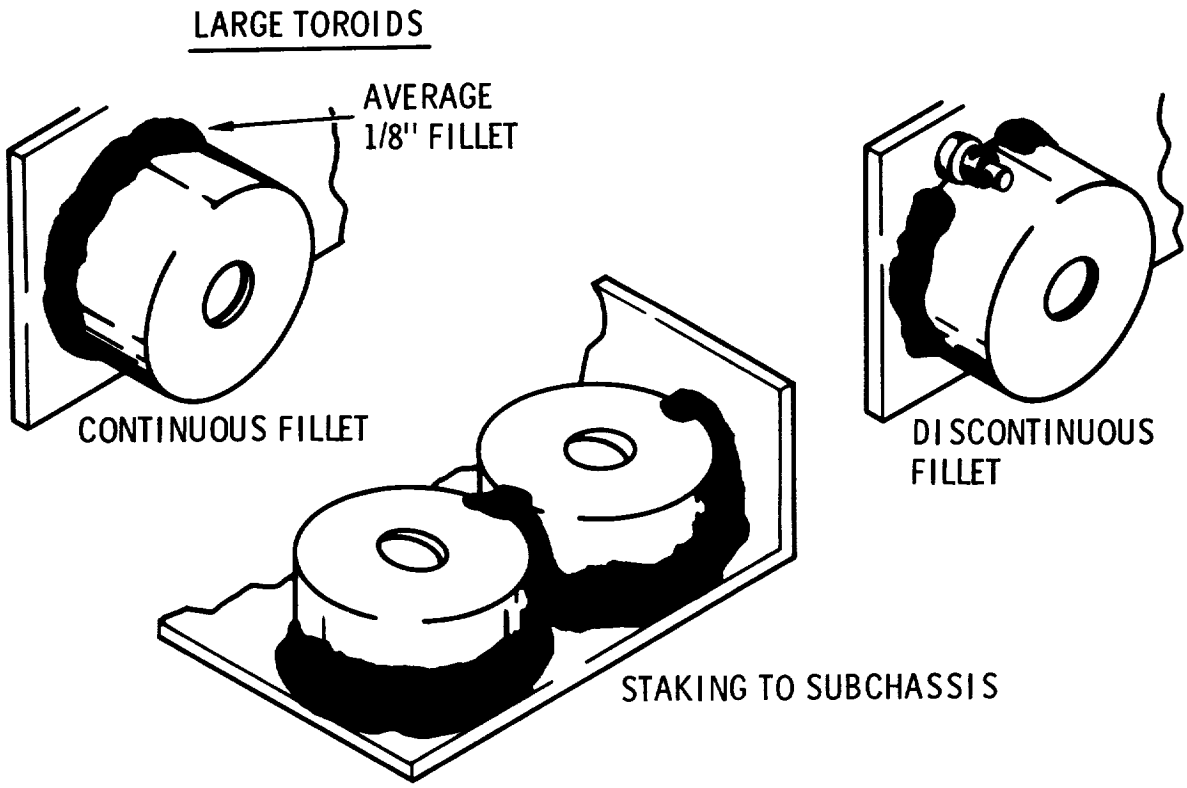


FIGURE 6-2
TYPICAL STAKING OF TOROIDS

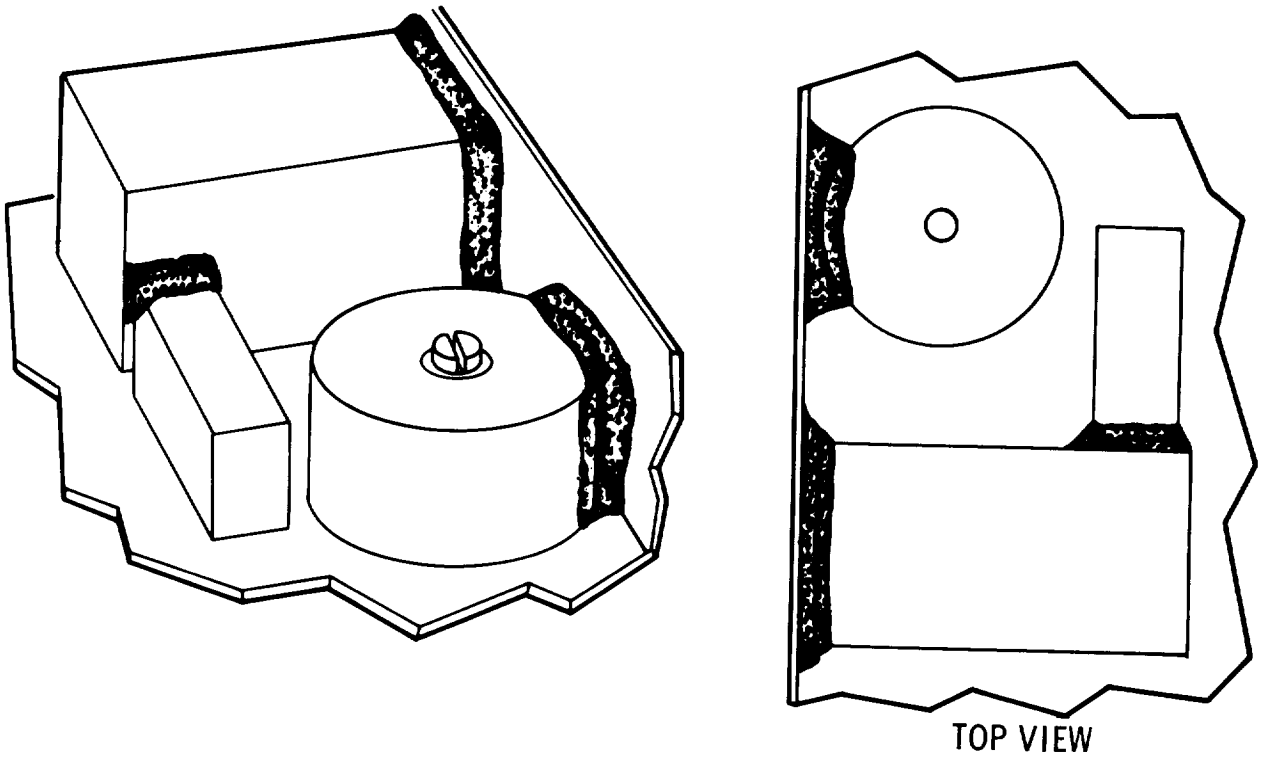


FIGURE 6-3
TYPICAL STAKING

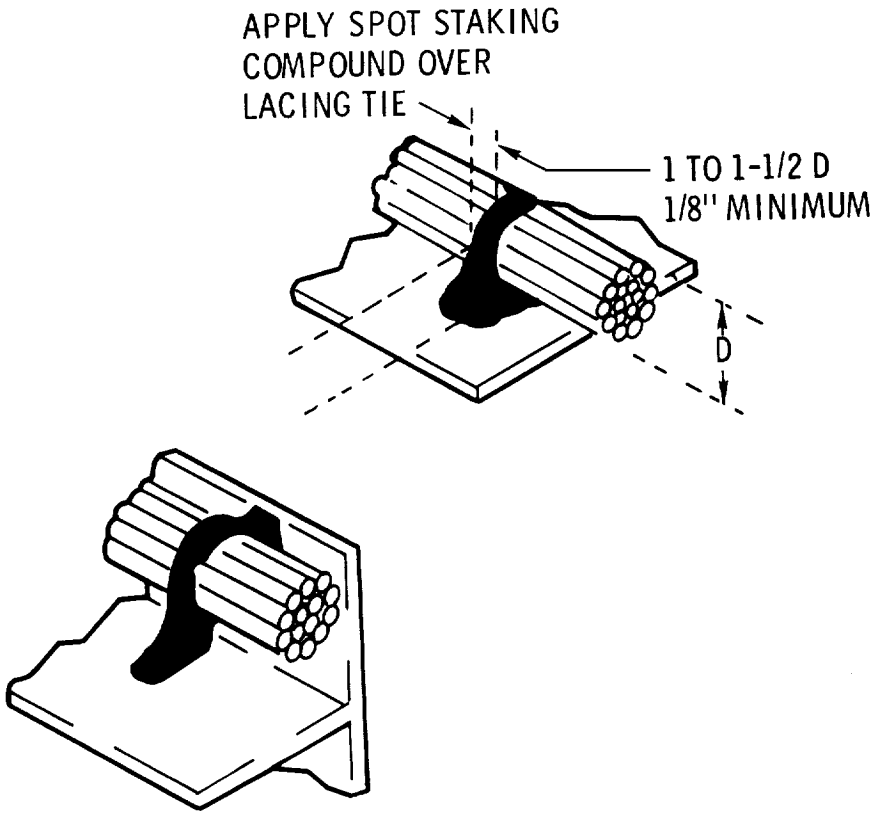


FIGURE 6-4
TYPICAL WIRE BUNDLE STAKING

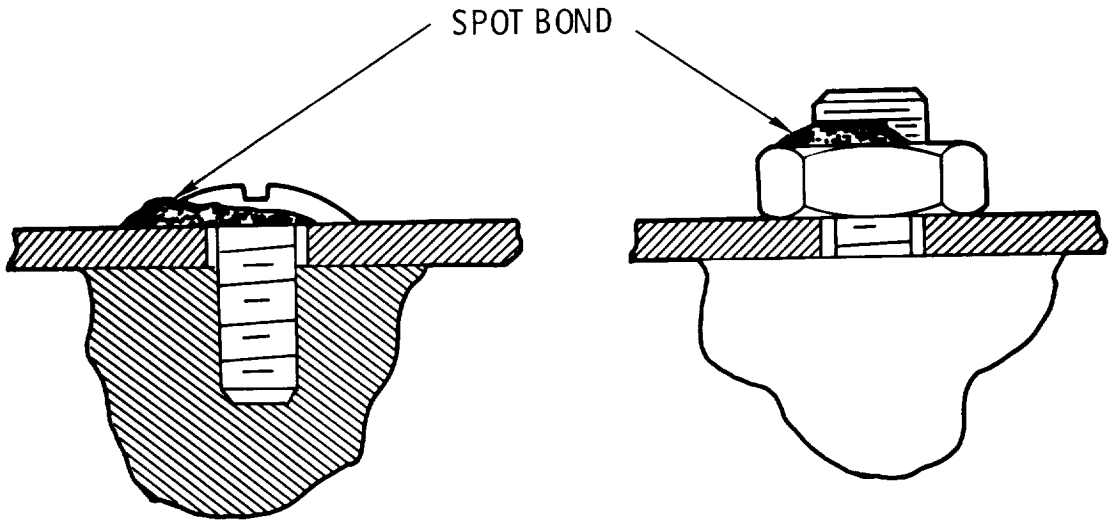


FIGURE 6-5
TYPICAL FASTENER STAKING

CHAPTER 7: QUALITY ASSURANCE

3J700 RESPONSIBILITY FOR INSPECTION

1. **Supplier Responsibility.** The supplier shall be responsible for inspection and quality conformance of staking and conformal coating.

2. **Inspection Records.** The supplier shall keep and maintain inspection records in accordance with contractual requirements.

3J701 ACCEPTANCE/REJECTION CRITERIA FOR COATING

1. **Documentation.** All acceptance and rejection criteria for conformal coating shall be clearly defined in the application processing document(s).

2. **Acceptance Criteria.** Conformally coated PWB's and assemblies shall exhibit as a minimum the following workmanship characteristics in order to be judged acceptable:

   a. Uniformity. Coating shall be uniform in color and texture.

   b. Tack-free. Coating surface shall be tack-free to touch.

   c. Continuity. Coating shall be continuous and present a smooth, ripple-free surface.

   d. Adhesion. Coating shall adhere to all the coated surfaces.

   e. Thickness. Coating shall be uniform in thickness as specified by the approved engineering drawing with no excessive buildup around components.

   f. Coverage. Coating shall cover all areas specified by the applicable engineering document(s). Normal pullback from sharp points and edges shall be permitted unless otherwise specified. See Appendix B for acceptable examples.

3. **Rejection Criteria.** Presence of any of the following workmanship defects in conformally coated PWB's and assemblies shall be cause for rejection.

   a. Bubbles. There shall be no bubbles larger than .03 inch (.76 mm) in any dimension, or bubbles bridging more than 50 percent of the distance between electrically uncommon conductors.

b. Tackiness. Coating shall exhibit no tackiness or soft spots.

c. Contaminants. Coating shall be free from contamination or foreign material. Any contaminant visible under 4- to 10-power magnification shall be cause for rejection.

d. Coating bridging. Coating material shall not bridge stress relief areas thereby negating stress relief. Material shall not be allowed to bridge between the bottom of ceramic bodied dual-in-line packages (DIP's) and the printed wiring board.

e. Charring. Coating shall exhibit no charred spots.

f. Runs and buildup. Coating shall show no excessive runs or buildup.

g. Scratches. Scratches in coating shall not expose conductive surface.

3J702 PREPARATION OF COATING CONTROL SPECIMENS

A control board specimen, preferably a scrapped PWB, shall be coated concurrently with the regular PWB coating operation whenever a new lot of material or a newly mixed batch of material is prepared. The control specimens shall be used for tests and analyses which shall become necessary but cannot be done on the production boards without damage or destruction.

3J703 INSPECTION METHODS FOR COATING

1. **Visual Inspection of Workmanship and Adhesion Requirements.** Workmanship and adhesion requirements shall be verified by visual inspection using 4- to 10-power magnification. Higher magnification may be used, as necessary, to inspect suspected anomalies or defects (e.g., bubbles and bubble sizes) and contaminants.

2. **Black-Light Inspection.** Coating coverage and location shall be determined by visual inspection. A black-light box with adequate intensity shall be used to compare fluorescent areas to uncoated portions.

CAUTION!

1. Black light intensity from ultraviolet (UV) inspection light sources degrades with time, primarily because of filter solarization, decrease in lamp efficiency and reflector contamination. To assure continuing efficiency of the light source, black light intensity, or light energy per area of coating shall be monitored periodically to assure sufficient visual contrast. Prior to use, new light sources shall be checked at a preestablished distance for output in microwatts per square centimeter. This may be done with a standard light meter using a UV filter of the proper frequency range, or with commercially available meters for direct measurement. Sources shall be checked periodically during their life and discarded when the reading is reduced to a preestablished percentage of the original value, determined by visual testing. The selection of filters for testing is critical, since different fluorescent materials vary in sensitivity depending on the UV frequency range. Most materials used for coating additives are more sensitive to longer wave lengths (~335 to 380 nm) black light.

2. Personnel exposure to black light shall be kept below OSHA standards.

3. **Coating Thickness Inspection.** Coating thickness shall be determined using a micrometer or other tool on flat surfaces of the PWB or electronic assembly.

4. **Tackiness and Soft Spots.** Gentle finger pressure shall be used to inspect for tackiness and soft spots. For this purpose, lint-free gloves or finger cots shall be worn.

3J704 ACCEPTANCE/REJECTION CRITERIA FOR STAKING

1. The cured material shall form a fillet on round-bodied devices or show squeeze-out to the edges of flat, faying surfaces. Evidence of unbonded areas or voids in a fillet or squeeze-out shall be acceptable provided these details do not constitute more than 10 percent of the bonded surface or total fillet length. (The minor dimension of an axial leaded device and the sides of ribbon leaded devices where the leads obscure the fillet shall not be included in the measurement of fillet length.)

2. The material shall be tack-free and manifest the specified hardness when set.

3. Staking material shall be free from contamination or foreign material visible under 4- to 10-power magnification.

4. Staking material shall adhere to the intended surfaces.

5. There shall be no staking material on the stress relief of component leads and wires. Material shall not be allowed to bridge between the bottom of ceramic bodied dual-in line packages (DIP's) and the printed wiring board surface.

6. When a rigid staking material is used, there shall be no material spill over onto any unprotected glass bodied parts.

3J705 INSPECTION METHODS FOR STAKING

1. Workmanship requirements shall be verified by visual inspection using 4- to 10-power magnification. Higher magnification may be used, as necessary, to inspect suspected anomalies or defects.

2. Tackiness and adhesion. Gentle finger pressure shall be used to inspect for tackiness and adhesion. For this purpose, lint-free gloves or finger cots shall be worn.

3. Hardness. When applicable, hardness shall be measured in accordance with ASTM D 2240.

APPENDIX A
DEFINITIONS

The following defintions apply to terms used in conformal coating and staking:

Accelerator. A chemical used to speed up a reaction or cure.

Certification. The act by a delegated authority of verifying and documenting that personnel have completed required training, demonstrated specified proficiency, and met other specified requirements.

Cure. A chemical reaction which hardens and changes the physical properties of a material.

Deviation. A specific authorization to depart from a particular requirement of specifications or related documents.

Filler. A material added to plastics in order to reduce cost or modify physical properties.

Fillet. A smooth, generally concave buildup of material between two surfaces (e.g., a buildup of conformal coating material between a part and a PWB).

Hygroscopic. Capable of absorbing moisture from air.

PWB. Printed wiring board.

Repair. Operations performed on a nonconforming article to place it in usable condition. Repair is distinguished from rework in that alternate processes, rather than reprocessing, are employed.

Rework. The reprocessing of an article or material that will make it conform to drawings, specification, or contract.

Subcontractor. The individual(s) or concern(s) who enter into a purchase agreement under a Government prime contract.

Supplier. A contractor or subcontractor actually performing the services or producing the contract articles.

Viscosity. A measure of the resistance of a fluid to flow.

Waiver. Granted use or acceptance of an article which does not meet specified requirements.

APPENDIX B
CONFORMAL COATING WORKMANSHIP STANDARDS ILLUSTRATIONS

The illustrations in this Appendix depict preferred, acceptable and unacceptable workmanship for conformal coating. They are to be used as visual workmanship standards.

CONFORMAL COATING — BUBBLES

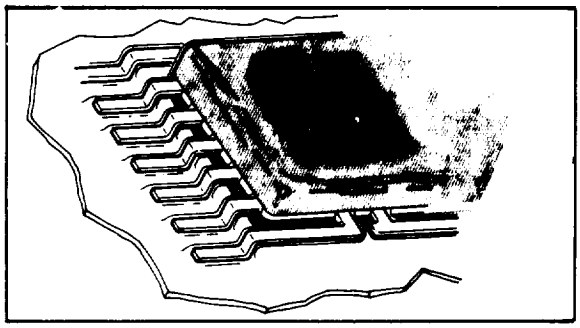


FIGURE B-1

PREFERRED

Complete uniform coverage with no visual bubbles.

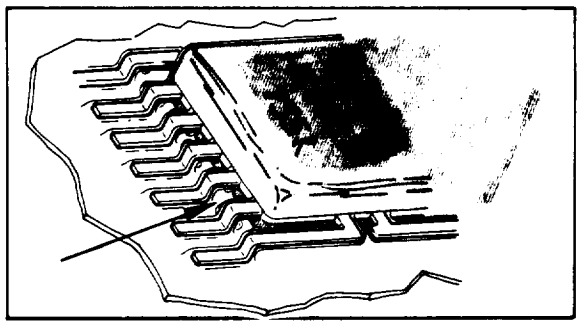


FIGURE B-2

ACCEPTABLE

Small bubbles, but they do not bridge between uncommon conductors or expose bare conductor surface.

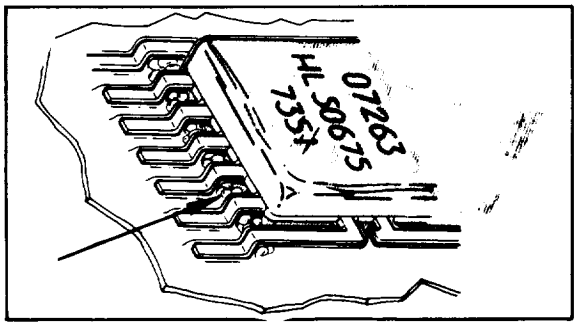


FIGURE B-3

UNACCEPTABLE

Excessive bubbling.

CONFORMAL COATING — SCRATCHES

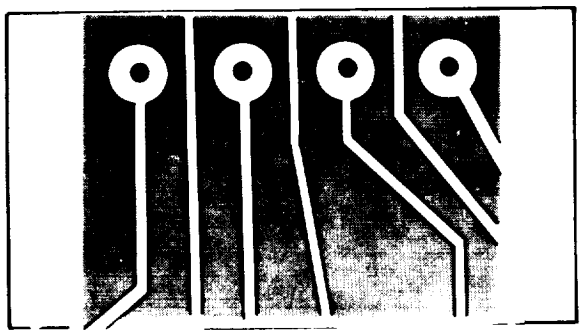


FIGURE B-4

PREFERRED

No defects.

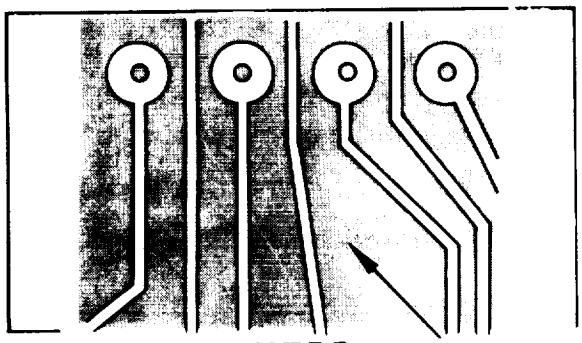


FIGURE B-5

ACCEPTABLE

Scratch does not expose any conductive area.

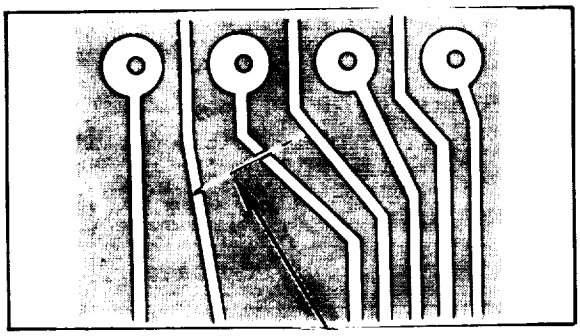


FIGURE B-6

UNACCEPTABLE

Scratch exposes conductive areas.

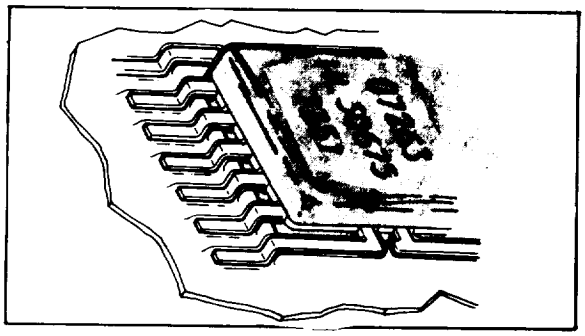


FIGURE B-7

PREFERRED

Uniform appearance and thickness with apparent good adhesion on components and board surface. The coating should show uniform fluorescence under a UV light.

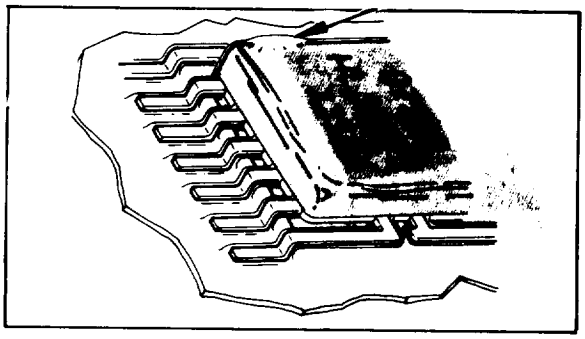


FIGURE B-8

ACCEPTABLE

Some evidence of variation in coating thickness. Minor lifting on nonconductive areas.

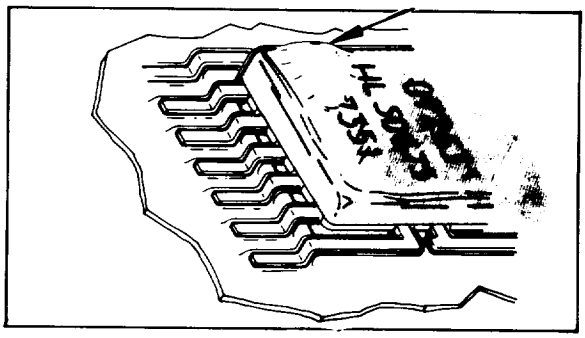


FIGURE B-9

UNACCEPTABLE

Excessive lifting and peeling indicating improper surface cleaning or excessive thickness. Any lifting on conductive areas is nonconforming.

APPENDIX C
CONFORMAL COATING PROBLEMS

The following are the major problems encountered in the conformal coating process:

1. **Conformal Coating Thickness.** Conformal coating thickness can be critical to the proper function of a PWB. If a coating is too thin, proper coverage is impossible; if a coating is too thick, it may create excessive stresses on solder joints and components (particularly glass-bodied components). Controlling coating thickness is of special importance with rigid coating materials (e.g., epoxies and some of the urethanes) because the residual stresses associated with an excessively thick application of these materials are much greater than with flexible coating materials (such as silicones and some urethanes).

   The thickness of a conformal coating can best be controlled by controlling the material viscosity during application. Where permitted, diluent solvents can be used to control viscosity. A multiple-coating process can also be used to attain more uniform thickness. Excessive filleting adjacent to components, caused by surface tension, may necessitate use of a brush to remove the excess.

2. **Coverage — Points and Edges.** Liquid coatings, because of gravity and their surface energy, tend to pull away from sharp points and edges which are often formed in conductors needing the most coverage. Inadequately protected conductors exposed to atmospheric humidity or condensing moisture can easily develop circuitry malfunctions.

   This pull-back problem can be alleviated by using a multiple-coat process with some drying between coat applications or by using an initial coat with a filler that will reduce the tendency of the coating to pull away from points and edges. An initial spray coat is also helpful in that spray-coating tends to cover points and edges better. Vacuum deposition of polyxylylene is the best method for covering points and edges.

3. **Bubbles.** Bubbles normally originate from air trapped underneath components and at solder joints. When bubbles bridge uncommon conductors, entrapped moisture or other contaminants may reduce insulation resistance or cause shorts.

   Bubbling may be controlled by various means. The angle at which an assembly is dried, cured, or dipped is important in preventing bubble formation. The best angle for spraying conformal coating is usually 45° to the PWB. The drying and cure schedule can also affect bubble formation. Sometimes air cure is needed to permit solvent evaporation; sometimes immediate thermal cure is more desirable because of lower material viscosity caused by higher temperature. Spray coating, being more thinly applied, is not as susceptible to bubbling caused by solvent and air entrapment as are dip coating and pour coating. For thicker coating applications, degassing in a vacuum chamber will remove entrapped air.

APPENDIX D
GENERAL COMPARISON OF COATING MATERIALS AND PROCESSES

The most commonly used conformal coating materials are listed in the Qualified Product List of MIL-I-46058. The types covered are:

AR - acrylic
ER - epoxy
SR - silicone
UR - urethane
XY - polyxylylene.

Of the five types of conformal coatings listed, acrylics are used infrequently because of their poor solvent resistance. Epoxies are limited in use because they are rigid and not easily reworked. Silicones are not generally desirable because they often become sources of contamination that interfere with the adhesion of bonding, marking, and other coating materials. Hence, silicones are used only when extremely high or low temperatures are involved or reduced flammability is a vital requirement. Urethanes are commonly used because of their combination of desirable properties. Polyxylylene is used when superior environmental protection is needed. Advantages and disadvantages of each type are listed in Table D-1.

TABLE D-1
GENERAL COMPARISON OF CONFORMAL COATINGS

Material	Advantages	Disadvantages
Acrylic	Solvent removable.	Poor solvent resistance.
	Light stability.	Poor temperature resistance.
Epoxy	Good adhesion.	Rigidity.
	Good electrical properties.	Not easily reworked.
Silicone	Good high- and low-temperature properties.	Poor adhesion.
	Flexibility.	Usually requires primer.
	Low flammability.	Source of contamination.
Urethane	Flexibility.	Poor moisture resistance during processing.
	Repairability.	
	Toughness.	
Polyxylylene	Environmental resistance.	Costly material and process.
	Excellent dielectric properties.	Usually requires primer.
	Uniformly thin coating.	Not easily reworked.
	Pinhole-free.	Area of application limited.

The major advantages and disadvantages of the principal methods of applying liquid coatings to materials are listed in Table D-2.

TABLE D-2
GENERAL COMPARISON OF CONFORMAL COATING PROCESSES

Process	Advantages	Disadvantages
Spraying	Fast and cheap.	Difficult to obtain coverage under components and leads.
	Easy to coat uneven surfaces.	
Brushing	For localized application.	Slow and tedious.
		Inconsistent coverage.
Dip or pour	Excellent coverage.	Filleting and excess thickness.
		Material waste.
Combination	Good coverage.	Increased time and cost in processing.

*U.S. GOVERNMENT PRINTING OFFICE: 1985-461-599:30023