Measurement System Identification: Metric (English)

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WORKMANSHIP STANDARD FOR POLYMERIC APPLICATION ON ELECTRONIC ASSEMBLIES

DOCUMENT HISTORY LOG

Status	Document Revision	Approval Date	Description
Baseline		1999-08-06	Initial Release
Revision	A	2008-03-04	Technical corrections and addition of sections covering bonding and encapsulation.
Change	1	2009-07-23	Editorial errata to paragraphs 2.1.2, 2.1.3, 4.1.4, 4.5.2.a, 5.1.3, 5.2.1, 5.5.1, 6.2.2, 6.3.1.1, 6.5.1.a, 6.6.1.b, 6.6.2.b, 6.8.1.2, Table 6-1, 8.1.3, 8.4.4, Table 8-1 Notes 2/4, 9.1.2.3, 9.1.2.4, 9.1.3.f, 9.1.4.3.c/d/e/f/g, 9.2.1.2, Figures 9-1/2/3/4/5/6/7/10, 10.2.5, 10.2.7.f, Figure 10-3, Table 10-1, 12.3, 12.3.2/3/6/8, Figures 12-1/2, 13.2.2.a, 13.3.g, 13.6.2.d/i thru p, 13.6.3.b/g, 13.7.2.a. 13.7.3.d/e, 13.8.1, 13.9.2.j, 13.10.3, 13.11.3.c/d *(JWL4)*
Change	2	2011-03-29	Editorial errata to Foreword paragraph 2, and paragraphs 1.0, 1.3, 1.4.1, 1.4.2, 4.2.2, and 12.1. Format Page numbers. Add reference to NASA-STD 8709.22 in paragraphs 2.1.2 and 3.2. *(JWL4)*
Revision	B	2016-06-30	· Throughout: changes to accommodate standard format · Throughout: general requirements moved to NASA-STD-8739.6 or updated to synchronize with NASA-STD-8739.6. · Refer to some industry standard definitions in IPC-T-50 and NASA standard definitions in NASA-STD-8709.22. · Apply industry standard test method for evaluating sensitivity to ultrasonic cleaning. · Update or improve definitions for: Accelerator, Bonding, Catalyst, Conformal Coating Test Specimen, Encapsulation, Engineering Documentation, Glass Transition and Glass Transition Temperature High Voltage, Keep Out Areas, Non-common Conductors, Part

			Lead, Pot Life, Solvent, Specimen, Materials Mix Test, Staking, Staking Material, Stress Relief and Test Specimen. · Consolidate duplicate requirements. · Keep out areas must be documented for staking and conformal coating. · Layouts must provide enough room for staking. · The supplier shall define bond line acceptance limits. · High voltage assemblies shall be identified when they will be encapsulated. · Underfill of area array packages is considered non-standard. · Criteria that must be met added for using material with expired shelf life. · Require process controls when baking out boards at 100°C or hotter. · Accommodate pre-mixed and small-volume batches of mixed polymer in mix test and traceability requirements. · Include conformal coating in mix test requirement. · Allow mix test in parallel with use of the material with prior approval. · Use length side staking fillet for both sleeved and sleeveless axial leaded components. Remove requirement for end staking for sleeved axial leaded components. · Clarify that fastener staking is not required. · Fastener staking shall be residue-free and removable. · Correction to figure 9-10 · Coating or staking in keep out areas is a defect. · Metric conversion correction in Fig 10-2 · Caption corrected for Fig 10-5. · Limit scope of bonding requirements to PWA applications. · Ensure bonding material is under fastener flanges to avoid damaging torques on the package body. · Duplicate requirements removed from Chapter 13. *(JFP)*

Change	1	2016-10-07	· Corrected cross references of paragraphs and figures: paragraphs 4.3.6, 8.5.2, 9.1.5.c.(7), 9.2.2.c, 9.2.3.b, 9.3.1.a, and 10.2.3. Corrected formatting of superscript in paragraphs 7.4.1.a and 7.5.1.d. Deleted “(See Fig. 12-2)” in paragraph 12.3.3 and “CONFORMAL COATING” in the title for Figure 9-10. *(JFP)*
Change	2	2021-10-04	Revalidated with changes to: a. Replace references to NPD 8730.5, which has been canceled, with NPR 8735.2. b. Add Section 2.3 Order of Precedence. c. Include other editorial edits to Chapter 1, Chapter 2, and Chapter 3 to align with the OSMA guidance for developing standards

NASA-STD-8739.1B

FOREWORD

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FOREWORD

This Standard is published by the National Aeronautics and Space Administration (NASA) to provide uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA programs and projects, including requirements for selection, application, and design criteria of an item.

This Standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers, and is intended to be applied on NASA contracts.

This Standard prescribes NASA's technical requirements, procedures, and documenting requirements for staking, conformal coating, bonding, and encapsulation of printed wiring boards and electronic assemblies. These requirements establish responsibilities for training personnel, and establish responsibilities for documenting process procedures including supplier innovations, special processes, and changes in technology.

This NASA-STD was developed by NASA Headquarters Office of Safety and Mission Assurance and the NASA Workmanship Standards Program. Requests for information, corrections, or additions to this Standard should be submitted to the National Aeronautics and Space Administration, Director, Safety and Assurance Requirements Division, Office of Safety and Mission Assurance, Washington, DC 20546 or via "Feedback" in the NASA Technical Standards System at http://standards.nasa.gov.

Terrence W. Wilcutt Chief, Safety and Mission Assurance	6/30/2016 Approval Date

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WORKMANSHIP STANDARD FOR POLYMERIC APPLICATION ON ELECTRONIC ASSEMBLIES

1. SCOPE

This standard prescribes NASA's technical and quality assurance requirements for polymeric applications for electrical and electronic assemblies.

1.1 Purpose

This publication sets forth requirements for staking, conformal coating, bonding, and encapsulation of components used in electronic hardware.

1.2 Applicability

1.2.1 This standard is applicable to NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers. This language applies to the Jet Propulsion Laboratory (a Federally-Funded Research and Development Center), other contractors, recipients of grants, cooperative agreements, or other agreements only to the extent specified or referenced in the applicable contracts, grants, or agreements.

1.2.2 This standard applies to production and processing of mission hardware as defined by NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects. Use of the term "supplier" applies to any entity who is manufacturing or processing mission hardware in accordance with the requirements herein including NASA Centers, NASA prime contractors, and subcontractors.

1.2.3 In this standard, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms "may" denotes a discretionary privilege or permission, "can" denotes statements of possibility or capability, "should" denotes a good practice and is recommended, but not required, "will" denotes expected outcome, and "are/is" denotes descriptive material.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

The documents listed in this section contain provisions that constitute requirements of this Standard as cited in the text. Use of more recent issues of cited documents may be authorized by the responsible SMA Technical Authority. The applicable documents are accessible via the NASA Standards and Technical Assistance Resource Tool at http://standards.nasa.gov or may be obtained directly from the Standards Developing Organizations or other document distributors.

2.1.1 Government Documents

NPR 7120.5	NASA Spaceflight Program and Project Management Handbook.

NPR 8705.4	Risk Classification for NASA Payloads.
NPR 8735.2	Hardware Quality Assurance Program Requirements for Programs and Projects
NASA-STD-8739.6	Implementation Requirements for NASA Workmanship Standards.

2.1.2 Non-Government Documents

ASTM D2240	Standard Test Method for Rubber Property – Durometer Hardness.

2.2 Reference Documents

The documents listed in this section do not constitute requirements of this standard, but are cited in the text to provide further clarification and guidance.

2.2.1 Government Documents

NASA-HDBK-8709.22	Safety and Mission Assurance Acronyms, Abbreviations, and Definitions.

2.2.2 Non-Government Documents

IPC T-50	Terms and Definitions for Interconnecting and Packaging Electronic Circuits.
IPC-TM-650	Test Method 2.6.9.1, Test to Determine Sensitivity of Electronic Assemblies to Ultrasonic Energy.
IPC-TM-650	Test Method 2.6.9.2, Test to Determine Sensitivity of Electronic Components to Ultrasonic Energy.

2.3 Order of Precedence

2.3.1 Where conflicts exist between this standard and applicable Federal and State regulations, the applicable regulations take precedence.

2.3.2 Where conflicts exist between this standard and applicable Agency directives, the applicable Agency directives take precedence.

2.3.3 Where conflicts exist between this standard and standards that contain provisions that constitute requirements of this standard as cited in the text, this standard takes precedence, except in the case where those standards are to Federal or State regulations.

2.3.4 Where conflicts exist between a requirement that is meant to be applied generally across all technical disciplines and a requirement that is applicable to a specific technical discipline, the requirement that is applicable to a specific technical discipline takes precedence.

2.3.5 Clarification and further resolution of conflicts is resolved by the responsible SMA Technical Authority.

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms

ASTM	American Society for Testing and Materials
COB	Chip on Board
CTE	Coefficient of Thermal Expansion
CVD	Chemical Vapor Deposition
DIP	Dual-In-Line Package
EEE	Electrical, Electronic, and Electromechanical
ESD	Electrostatic Discharge
FOD	Foreign Object Debris
NASA	National Aeronautics and Space Administration
NASA-STD	NASA Standard
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
OSMA	Office of Safety and Mission Assurance
PCB	Printed Circuit Board
PRT	Platinum Resistance Thermometer
PTH	Plated Through Hole
PWA	Printed Wiring Assembly
QA	Quality Assurance
ROSE	Resistivity of Solvent Extract

SMT	Surface Mount Technology
TM	Test Method
TO	Transistor Outline
UV	Ultraviolet

3.2 Definitions

Note: Definitions for SMA terms are found in NASA-HDBK-8709.22, Safety and Mission Assurance Acronyms, Abbreviations, and Definitions. Terms unique to this NASA-STD are listed below.

Accelerator. A compounding material used in small amounts to increase the cure rate or to change the conditions of the reaction (e.g. cause it to occur at a lower temperature). Accelerators get consumed by the process.

Area array package. A package with an X-Y grid interconnect pattern on the under-surface (i.e., ball grid array, column grid array, land grid array, pin grid array).

Batch. That quantity of material that was subjected to unit chemical processing or physical mixing, or both, designed to produce a product of substantially uniform characteristics.

Blister. Undesirable rounded elevation of the surface of a polymer, whose boundaries may be more or less sharply defined.

Bonding. Method for joining surfaces of parts or materials using a polymer.

Catalyst. A substance that changes the rate of a chemical reaction without undergoing permanent change in its composition or getting consumed by the process.

Coefficient of thermal expansion (CTE). The measure of the fractional change in dimension per unit change in temperature.

Conductor. A lead or wire, solid, stranded, or printed wiring path serving as an electrical connection.

Conformal coating. A thin electrically nonconductive protective coating that conforms to the contours of the printed wiring assembly (PWA) or electronic assemblies.

Conformal coating test specimen. See Specimen, Conformal Coating Test.

Contaminant. An impurity or foreign substance present in a material that affects one or more properties of the material. A contaminant may be either ionic or nonionic. An ionic, or polar, compound forms free ions when dissolved in water, making the water a more conductive path. A nonionic substance does not form free ions, nor increase the water's conductivity. Ionic contaminants are usually processing residue such as flux activators, fingerprints, and etching or plating salts.

Cure. A chemical reaction that hardens and changes the physical properties of a material(s).

Deterioration. (as in the context of the condition of stored polymer materials) A change in the material that can be observed prior to its use, or during use, that indicates it no longer meets its performance requirements. Deteriorated in this context includes degraded or separated.

Dielectric. A material with a high resistance to the flow of electrical current, and which is capable of being polarized by an electrical field.

Diluent. Any material that reduces the concentration of the fundamental resin; usually a liquid added to the resin to afford lower viscosity.

Encapsulation. The complete encasement of a component or module in a resin. Other terms used in the electronics industry to indicate encapsulation are "potting," "embedment," and "molding."

Filler. A material added to polymers 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 the printed circuit board (PCB)).

Flatpack. A part with two straight rows of leads (normally on 1.27mm (0.050 inch) centers) that are parallel to the part body.

Flux. A chemically-active compound that, when heated, removes minor surface oxidation, minimizes oxidation of the basis metal, and promotes the formation of an intermetallic layer between solder and basis metal.

Gelling. Formation of a semi-solid system consisting of a network of solid aggregates in which liquid is held; the initial gel-like solid phase that develops during the formation of a resin from a liquid.

Glass transition. A reversible change in an amorphous polymer or in amorphous regions of a partially crystalline polymer from (or to) a viscous or rubbery condition to (or from) a hard and relatively brittle one. Not only do hardness and brittleness undergo rapid changes in this temperature region, but other properties, such as dissipation factor, thermal expansibility, and specific heat, also change rapidly.

Glass transition temperature (Tg). The approximate midpoint of the temperature range over which glass transition takes place. The observed transition temperature can vary significantly depending on the specific property chosen for observation and on details of the experimental technique (for example, rate of heating, frequency). Therefore, the observed Tg should be considered only an estimate.

High voltage. An application voltage that will support coronal discharge or the development of charged plasma due to the environment's atmospheric conditions (i.e. elemental gasses or vacuum, and pressure) unless mitigations such as rounded surfaces at interconnections and insulative layers of staking or conformal coating are applied.

Keep out areas. Surfaces on PWAs that must remain free of polymeric material following bonding, staking, conformal coating or encapsulating processes to enable subsequent system assembly processes and system performance requirements (e.g. fastener or electrical ground interfaces). Masking is used to prevent polymeric material from coming into contact or covering keep out areas during polymeric applications.

Lifting. Any separation of conformal coating from the PWA.

Manufacturing documentation. Instructions, drawings, specifications, work orders, travelers and all other documents provided to manufacturing operators and inspectors defining the intended design, manufacturing methods, and quality controls.

Mission hardware. Items made of a material substance that make up, or are integrated into, spacecraft, launch vehicles, or aircraft used to execute a NASA mission. *Source NPR 8735.2.*

Mix record. A record of the procedure followed for mixing the polymeric compounds.

Module. A separable unit in a packaging scheme.

Non-common conductors. Conductive surfaces that are not attached to the same electric node.

Part lead. The conductor attached to an electrical, electronic or electromechanical (EEE) part.

Peeling. The separation of conformal coating from the PWA, usually due to improper preparation or abrasion. Peeling is distinguished from lifting in that the layer of conformal coating is not continuous.

Polymer. A compound of high molecular weight that is derived from either the joining together of many small similar or dissimilar organic molecules or by the condensation of many small molecules by the elimination of water, alcohol, or a solvent.

Pot life (aka. Working life). The length of time a material, substance, or product is in use while it meets all applicable requirements and remains suitable for its intended use (IPC T-50).

Printed circuit board (PCB). A composite structure incorporating point-to-point interconnections for electronic circuits. It may include embedded components. (This includes single-sided, double-sided, multi-layer, rigid, rigid-flex, and flex constructions (IPC T-50)).

Printed wiring assembly (PWA). The PWA consists of the PCB, components, and associated hardware and materials.

Resin. Generally, any synthetic organic material produced by polymerization.

Solvent. A non-reactive liquid substance that is capable of dissolving another substance (IPC T-50). Other terms used are: chemistry, cleaner (of any type), cleaning solution, cleaning solvent, detergent, saponifier, etc.

Specimen, conformal coating test. A spare PCB or similar substrate that is coated with the same material and process as used for the mission hardware that is used for evaluation of the quality of the conformal coating thickness.

Specimen, materials mix test. A test sample that meets the requirements in ASTM D2240, that is used to evaluate polymer mix quality using a hardness test. The sample of cured material is at least 6mm (0.24 in) thick by 24 mm (0.96 in) in diameter.

Squeeze-out. The resin and/or reinforcement that is visible at the edges of a bond.

Staking. The process of bonding and securing components or parts to PCBs and electronic assemblies by means of an adhesive material, with the intention to provide additional mechanical support.

Staking material. An electrically nonconductive adhesive material used for additional support.

Stress relief. The formed portion of a conductor whose geometry minimizes stress on the mechanically clamped terminations.

Substrate. That surface upon which an adhesive is spread for any purpose, such as coating; a broader term than "adherent."

Test specimen. See Specimen.

Traceability code. The code uniquely identifying the production lot by the manufacturer, equivalent to batch code, lot code, or date code.

Transmissivity. The fractional quantity of incident radiation transmitted by matter.

Viscosity. A measure of the resistance of a material to flow under stress.

4. GENERAL REQUIREMENTS

4.1 General

4.1.1 When there is a conflict between the requirements of NASA-STD-8739.6 and those herein, the requirements in NASA-STD-8739.6 shall take precedence.

4.1.2 A program shall be established to assure continuing process capability.

4.1.3 Controls shall be developed for process parameters and equipment settings that influence product compliance with critical performance and quality requirements.

4.2 Electrostatic Discharge Control Requirements

4.2.1 When Electrostatic Discharge (ESD) control is required during workmanship operations defined herein, the ESD control requirements in NASA-STD-8739.6 shall apply.

4.3 Selection and Approval Requirements for Polymeric Materials

4.3.1 The polymeric material(s) shall be:

a. Workable using the processes described herein such that the intended performance of the polymer is realized in the application. This includes continuous and consistent coverage for conformal coating, material volume control for staking material, and bond line control for bonding materials.

b. Suitable to the complexity of the assembly and the mission lifetime defined by the project.

c. Compatible with, and adheres to, the intended substrates (e.g. the PCB, electrical, electronic, and electromechanical (EEE) parts, jumper wires, cable ties, metal brackets, enclosure surfaces).

d. Stable with respect to moisture exposure, the project's test, operating, storage temperature range, and vacuum conditions (including thermal-vacuum). Other environmental conditions may be applicable such as ionizing radiation and UV radiation.

e. Noncorrosive to the electronic assembly for which it is selected.

f. Curable under processing conditions compatible with the assembly on which it is located.

g. Selected to enable the finished assembly to meet all mechanical, thermal, electrical, and optical requirements associated with test and mission use, with consideration given to the following characteristics: dielectric constant, permittivity, dielectric withstanding voltage, tensile modulus over temperature range, coefficient of thermal expansion (CTE), glass transition temperature (Tg), viscosity and transmissivity, and Project-specific requirements.

4.3.2 Preference shall be given to selecting materials that allow repair and rework without damaging the assembly or other elements.

a. Suppliers of polymeric materials shall only be those that have established a uniform record of supplying lots which have been verified to meet their datasheet characteristics and are homogeneous on a lot-to-lot basis using criteria that is critical to the application.

b. Materials shall be traceable to a production lot identifier and manufacturing date.

c. Procurements shall be made from the original manufacturer or their authorized distributors.

d. A certificate of compliance from the supplier is required for each purchase certifying compliance with 4.3.2.b and 4.3.2.c above.

e. The supplier shall implement controls to assure that only approved and conforming materials are used.

4.3.3 Special Design Elements for Staking Material. Additional minimum design elements when staking are:

a. Keep out areas shall be defined in the manufacturing documentation.

b. The mechanical design/layout of the PWA shall provide enough room for staking.

c. Staking shall not negate stress relief.

d. Through-hole solid tantalum capacitors and jumper wires in excess of 25 mm (1 inch) shall be staked.

4.3.4 Special Design Elements for Conformal Coating. Additional minimum design elements for conformal coating are:

a. Keep out areas shall be defined in the manufacturing documentation.

b. The conformal coating material and process shall be chosen and developed, respectively, to maximize continuous and uniform coverage of the assembly that will be coated.

c. Preference shall be given to conformal coating materials with a fluorescent indicator.

CAUTION: ULTRAVIOLET (UV) SENSITIVE EQUIPMENT MAY BE ADVERSELY AFFECTED BY USING FLUORESCENT INDICATORS.

d. The following shall be identified in the manufacturing documentation:

(1) Masking material and areas to be masked.

(2) Conformal coat material.

4.3.5 Special Design Elements for Bonding. The minimum design elements for bonding are:

a. Fixturing or other methods for controlling component placement during bonding and cure, may be required.

b. The following shall be identified in the manufacturing documentation:

(1) Bonding material.

(2) Locations of the items to be bonded.

(3) Bond line thickness requirements if applicable.

(4) Method for evaluating finished bond line thickness and acceptability of voiding.

4.3.6 Special Design Elements for Encapsulation.

a. Encapsulation materials and processes shall prevent damaging stress during processing.

b. The following shall be identified in the manufacturing documentation:

(1) The encapsulation material.

(2) The items to be encapsulated.

(3) Whether the assembly is considered high voltage.

4.3.7 Underfill of Area Array Interconnect Packages.

a. Underfill of area array interconnect packages is considered nonstandard and shall require approval per NASA-STD-8739.6.

5. TRAINING AND CERTIFICATION PROGRAM

5.1 General

This section has been superseded by NASA-STD-8739.6. Refer to NASA-STD-8739.6, Chapter 5 and Appendix A for applicable training and certification requirements.

6. FACILITIES, TOOLS, AND MATERIALS

6.1 Safety

6.1.1 The occupational safety and health requirements in NASA-STD-8739.6 shall apply for polymeric application processes.

6.2 Environmental Conditions

6.2.1 The environmental control requirements of NASA-STD-8739.6 shall apply.

6.2.2 Field Operations Requirement. In field operations where the required controlled conditions cannot be effectively achieved, special precautions shall be documented and implemented to minimize the effects of the uncontrolled environment on the operation being performed on the hardware.

6.2.3 Lighting Requirements. Light intensity shall be a minimum of 1077 Lumens per square meter (Lm/m^2) (100 foot - candles) on the surface being staked, conformally coated, or inspected. Supplemental lighting may be used to achieve the required levels.

6.3 Silicone Operations

6.3.1 All silicone processing, including the use of curing ovens, tools, equipment, fixtures, the supplies, and garments used in the operations, shall be segregated from other polymeric material operations to preclude contamination of assemblies, tools, workspaces, and equipment not intended for use with silicone materials.

> *WARNING: FLIGHT EQUIPMENT CAN BE CONTAMINATED WHEN TOOLS AND EQUIPMENT USED FOR SILICONE PROCESSING ARE NOT RIGOROUSLY SEGREGATED FROM THOSE NOT USED FOR SILICONE PROCESSING.*

6.4 Tool and Equipment Control

6.4.1 The tool and equipment selection and control requirements of NASA-STD-8739.6 shall apply. See NASA-STD-8739.6 for metrology and calibration requirements.

6.4.2 The supplier’s process documentation for tool and equipment use and control shall be available for review and approval prior to processing mission hardware.

6.5 Material Storage and Records Retention

6.5.1 Shelf Life.

a. Shelf Life Stickers. Material storage shall be controlled. A standard method used is attaching shelf life stickers to each material container.

b. Expired Shelf Life. Staking, conformal coating, bonding, and encapsulating material shall not be used if the shelf life has expired. Shelf life extension may be granted on an individualized basis when adequate data is provided that demonstrates that the material will continue to meet processing and performance specifications for the intended application.

c. Shelf Life. The material shelf life shall be as stated by the manufacturer and in accordance with the manufacturer’s specifications governing the usable life of the product.

6.5.2 Storage.

a. Solvents. All cleaning and diluent solvents shall be stored in accordance with applicable regulations.

b. Polymeric applications Materials. Materials shall be stored in accordance with the manufacturer's recommendations.

6.5.3 Records.

a. Purchase Data Recording. Records of the manufacturing date, lot number, receiving date, and manufacturer's certification of compliance of each material shipment shall be maintained.

b. Container Markings. Material containers shall be marked with the following:

(1) Manufacturer's identification.

(2) Manufacturer's product designation.

(3) Traceability code (if applicable).

(4) Storage temperature range (if applicable).

(5) Expiration date of guaranteed product life or use.

(6) Caution notes (where applicable).

6.6 Inspection and Inspection Optics

6.6.1 The Inspection and Inspection Optics requirements of NASA-STD-8739.6 apply.

6.6.2 Visual Inspections shall be performed using 1X to 10X magnification. Higher referee magnification may be used, as necessary, to inspect suspected anomalies or defects.

6.6.3 With the exception of the pre-cure inspections, the polymeric materials in the products being visually inspected shall be completely cured.

6.7 In-Process Storage and Handling

6.7.1 Containers shall be compatible with items stored therein.

6.7.2 When handling metal surfaces, printed wiring terminating areas, terminals, connectors, wire ends, or part leads is unavoidable, clean, particulate free gloves or finger cots shall be used.

7. CLEANLINESS REQUIREMENTS

7.1 General

7.1.1 Prior to bonding, staking, conformal coating or encapsulating, the assembly shall be cleaned to remove ionic and non-ionic residue and shall be demoisturized. The requirements for cleaning and solvents of NASA-STD-8739.6 apply in addition to those defined herein. The cleanliness test methods and minimum cleanliness limits are defined in 7.2-7.5. The demoisturization method and criteria are defined in 7.6.

7.1.2 The cleaning process shall not deposit residue on electrical contact surfaces such as those in switches, potentiometers, or connectors.

7.1.3 There shall be no manufacturing processes applied to the assembly which can introduce residues between the time the board is cleaned and the time the polymeric materials are applied.

7.1.4 Monitoring. The effectiveness of the cleaning process depends upon the purity of the cleaning solvents and the proper execution of the approved cleaning procedure. To assure the effectiveness of the cleaning process, a system for monitoring the purity of the cleaning solvents shall be established.

CAUTION: SOME SOLVENTS OR METHODS OF CLEANING MAY BE DETRIMENTAL TO POLYMERIC MATERIALS.

7.1.5 Protection of Unsealed Parts. Unsealed parts or hardware containing unsealed parts shall not be immersed in the solvent unless the parts have been sealed or masked prior to cleaning.

7.1.6 Ultrasonic Cleaning. Ultrasonic cleaning is allowed provided that the manufacturer has evidence that it does not damage the types and arrangements of parts on the board. See IPC TM-650, Test Method 2.6.9.1, Test to Determine Sensitivity of Electronic Assemblies to Ultrasonic Energy and Test Method 2.6.9.2, Test to Determine Sensitivity of Electronic Components to Ultrasonic Energy.

7.1.7 Rework Cleaning. The rework area shall be cleaned and dried prior to application of rework staking and conformal coating.

7.1.8 Immersion Cleaning. Conformal coated assemblies shall not be immersion cleaned.

7.1.9 Alternate Cleaning Processes. Use of cleaning processes and systems which are not solvent-based, such as plasma systems, shall be supported by objective evidence that their use does not degrade the hardware and shall meet the nonstandard process approval requirements in NASA-STD-8739.6.

7.2 Cleanliness Testing

7.2.1 All PWAs shall be tested prior to conformal coating.

7.2.2 One of the following shall be used to determine the cleanliness level:

a. Resistivity of solvent extract testing in accordance with the limits in paragraph 7.3.1 and the method of paragraph 7.4.

b. Sodium chloride (NaCl) salt equivalent ionic contamination testing in accordance with the limits in paragraph 7.3.2 and the method of paragraph 7.5.

7.2.3 Failed PWAs shall not be re-cleaned until appropriate corrective actions have been performed on the cleaning system to ensure its correct operation.

7.3 Test Limits

7.3.1 Resistivity of Solvent Extract Test. The resistivity of the solvent extract shall have a final value greater than 2,000,000 ohm-cm.

7.3.2 Sodium Chloride Salt Equivalent Ionic Contamination Test. The final value for this test shall be less than 1.55 micrograms per sq. cm (10 micrograms per square inch) of PCB surface area.

7.4 Resistivity of Solvent Extract Test (ROSE Test)

7.4.1 Solvent extract resistivity shall be measured as follows (also, see Table 7-1):

a. Prepare a test solution of 75 percent by volume isopropyl alcohol and 25 percent by volume deionized water. Pass this solution through a mixed bed deionizer cartridge. After passage through the cartridge, the resistivity of the solution shall be greater than 6×10^6 ohm-cm (conductivity less than 0.166 micromhos/cm).

b. Clean a funnel, a wash bottle, and a container with a portion of this test solution.

c. Measure out 1.55 ml for each square centimeter (10 ml for each square inch) of PWA area on both sides of the PWA.

d. Slowly, direct the test solution in a fine stream onto both sides of the PWA until all the measured solution is used.

e. The resistivity of the solvent extract shall be determined by using a resistivity meter.

7.5 Sodium Chloride Salt Equivalent Ionic Contamination Test

7.5.1 Sodium chloride salt equivalent ionic contamination shall be measured as follows (also, see Table 7-1):

a. The sodium chloride salt equivalent ionic contamination test shall use a solution of 75 percent isopropyl alcohol and 25 percent deionized water.

b. This solution shall be verified for correct composition upon initial use and every 4 hours during a shift. The time limit may be extended when the results of data provide definite indications that such actions will not adversely affect the results of the test.

c. The equipment shall be calibrated using a known amount of sodium chloride standard on the same schedule as the percentage composition verification.

d. The starting or reference purity of the solution shall be greater than 20×10^6 ohm-centimeters (0.05 micromhos/centimeter) before each sample is tested.

Table 7-1. Cleanliness Test Values

Test Method	Starting Resistivity	Ending Values
Resistivity of Solvent Extract	6 X 10^6 ohm-cm	Shall be greater than 2 X 10^6 ohm-cm
Sodium Chloride Salt Equivalent Ionic Contamination	20 X 10^6 ohm-cm	Shall be less than 1.55 micrograms/square centimeter (10.0 micrograms/square inch)

7.6 Demoisturizing

7.6.1 Following cleaning and prior to application of polymeric material(s) the PWAs shall be demoisturized.

7.6.2 Conditions for demoisturizing PWAs shall be defined on the manufacturing documentation.

7.6.3 Demoisturizing may be accomplished by an oven bake at 90°C ± 5.5°C (194F° ± 10°F) for a minimum of 4 hours, or by a vacuum bake at a lower temperature (See Table 7-2). The time in and out of the bake-out and the temperature shall be recorded.

7.6.4 Process controls shall be applied when using a bake-out temperature at or above 100°C to avoid damaging PCBs, parts or assemblies from high temperature vapor entrapment.

Table 7-2. Recommended Demoisturizing Schedules for Polymeric Applications

Drying Process	Minimum Bake-Out Time (hours)		
	+66°C (+151°F)	+90°C (+194°F)	+100°C (+212°F)
Recirculating Oven	6	4	2
Vacuum Oven	2.5	2	1.5

Notes:

1. Times specified are recommendations. Actual drying time may be affected by the amount of humidity already absorbed by the board, board assembly type, component technology (PTH / SMT / COB, etc.), PWA population density, layer count, ground/power plane(s), PCB thickness, via aspect ratio, cleaning method, cleanliness verification method, or other conditions.

2. Vacuum Oven: Chamber pressure: 3 torr / 3 mm mercury (Hg).

3. See 7.6.4 for requirements applicable to drying schedules which use temperatures at or above 100ºC.

4. Oven temperature ramp rate requirements, intended to protect the assembly from thermal shock during the baking process, are established and controlled at the Project level. Ramp rate control limits and monitoring requirements are determined by the process owner and are defined in the manufacturing documentation per 7.6.

5. A dry nitrogen blanket/purge is recommended to limit the formation of oxidation on solderable surfaces and to accelerate drying.

6. Bake-out at temperatures in excess of +90°C (+194°F) should not exceed 48 hours cumulative.

8. PREPARATION FOR POLYMERIC APPLICATIONS

8.1 Masking

8.1.1 Material.

a. Areas to be kept free of polymeric material shall be masked with approved tape, covers, or other suitable masking material or devices.

b. ESD protective tapes containing conductive adhesive shall not be applied over PCB conductor patterns.

c. Precautions shall be taken to assure that no residues are left when the masking material is removed.

CAUTION: TAPES MAY CONTAIN METALLIC OR METALLIZED POLYMERIC MATERIAL THAT CAN CAUSE ELECTRICAL SHORTS OR CORROSION.

8.1.2 Masking for Paraxylene Conformal Coating. Unsealed parts and areas not to be coated shall be properly masked to prevent paraxylene vapors from penetrating minute openings.

8.2 Priming

8.2.1 Materials Requiring Primer.

a. When a primer is used, it shall be of a material recommended by the same manufacturer that produced the conformal coating material and be applied and cured in accordance with the manufacturer's instruction.

b. Any excess buildup of primer shall be removed.

8.2.2 Re-Priming 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, the surface shall be re-primed.

CAUTION: SOME SURFACE PRIMERS WILL DAMAGE CERTAIN TYPES OF MATERIALS. REFER TO MANUFACTURERS' SPECIFICATIONS FOR THE SPECIFIC TYPE OF SURFACE PRIMER RECOMMENDED FOR USE.

8.3 Material Preparation

8.3.1 Preparation.

a. Material shelf life shall be verified prior to use.

b. Polymeric materials shall be mixed and prepared according to the manufacturer's instructions or the appropriate process document.

c. High-solid materials or high-viscosity materials may be deaerated to remove entrapped air. Volatile ingredients may be lost during the deaerating process.

d. Pre-mixed and frozen material shall be prepared for use according to the manufacturer's instructions or the appropriate process document.

8.3.2 Single-Component Materials. Materials that are supplied as a single part may require stirring because of settling of fillers or other ingredients in the system.

8.3.3 Multicomponent Materials. Multicomponent materials shall be thoroughly mixed until the mixture is smooth and homogeneous and shall be used within the pot life limit.

8.3.4 Fillers. Fillers shall be free of moisture. A bake of at least 4 hours at 100ºC ± 10ºC (212ºF ± 18ºF) is suitable for demoisturizing fillers.

8.3.5 Stirring and Mixing. Stirring and mixing shall be carefully conducted to minimize entrapped air.

8.3.6 Mix Record.

a. A record for each mix batch shall be maintained. The mix record shall document:

(1) Unique batch identifier (e.g. serial number).

(2) Materials used (including manufacturer, part number, traceability code, and expiration date).

(3) The mix ratio.

(4) Ambient conditions (temperature, humidity).

(5) Time mixed.

(6) Pot life.

(7) Date.

(8) Operator.

(9) Mix procedure name or number and revision.

(a) Test specimen acceptance test results.

(b) Manufacturer datasheet value or range for hardness.

(c) Any special allowances.

b. The mix record for premixed, preloaded syringes as obtained directly from a commercial supplier may not be available. When this is the case, as a minimum the lot date code for each syringe shall be recorded and used for product traceability.

8.3.7 Material Traceability. Traceability to the mix record described in 8.3.6.a, or lot date code for premixed product described in 8.3.6.b, shall be provided for each material mix test sample (see 8.4), for each (see 8.5) and for each use on mission hardware.

8.3.8 Spray Applications.

a. In spray applications, viscosity of conformal coatings shall be closely observed and controlled to preserve the best sprayable viscosity.

b. Solvent addition shall not be used to extend the pot life of the material.

8.3.9 Containers.

a. Nonabsorbent plastic, glass, or metal containers and stirrers shall be used in all mixing operations.

b. Containers with seams and crevices that will trap unmixed materials shall not be used.

c. The stirrer and container combination shall not introduce contamination to the mix (i.e., from metal stirrers scraping the inside of the container, from coatings dissolving from the inside of the container, or from containers supplied with powdered surfaces).

8.3.10 Material Condition. The manufacturer's recommendations shall be followed regarding pot life and acceptable degrees of surface skinning or gelling and of crystallization and residue on the bottom of the container.

8.3.11 Pot Life. The pot life of the material shall begin immediately after mixing or according to the applicable process document for pre-mixed and frozen material.

8.4 Material Mix Test Specimen

8.4.1 A test specimen shall be prepared, hardness-tested, and maintained for each mixed batch of staking, bonding, encapsulating and conformal coating material to ensure the mix was performed correctly prior to being applied to mission hardware.

8.4.2 The Project shall be notified prior to use of mixed material for which mix testing cannot be performed prior to its use on the mission hardware (i.e., cured with the mission hardware).

8.4.3 Each material mix test specimen shall be identified for traceability per 8.3.7 and stored in controlled environmental conditions per NASA-STD-8739.6 for later reference to help resolve any issues that arise related to material reliability.

8.4.4 The material mix test specimen shall be prepared, conditioned and tested in accordance with ASTM-D-2240. Alternative equivalent hardness test methods may be used for product volumes that are not large enough to support the test sample volume defined in ASTM-D-2240.

8.4.5 As a minimum, the processed material mix test specimen shall meet the manufacturer's hardness value or range. The dwell time required to fully cure the test specimen may be different from that used for the mission hardware.

8.4.6 Material mix test specimens shall be maintained for the period specified by the project requirements.

8.5 Conformal Coating Test Specimens

8.5.1 A conformal coating test specimen shall be prepared using a spare PCB, a PCB test coupon, or other similar substrate that can be processed concurrently with and in the same manner as the mission hardware PWA(s) for the purposes of assessing coating thickness and retaining a witness sample for future reference.

8.5.2 The conformal coating test specimen shall be used for evaluating compliance with the thickness requirement in 10.2.3 herein and to avoid damaging the mission hardware.

9. STAKING

9.1 Requirements

9.1.1 Application Sequence. Staking shall be performed prior to conformal coating unless required by design and approved as a nonstandard configuration per NASA-STD-8739.6.

9.1.2 The staking process shall not obscure part markings unless specified in the manufacturer documentation per NASA-STD-8739.6.

9.1.3 Application.

a. Staking material shall be applied to the parts and areas specified by the manufacturing documentation. Spatulas and syringes, with or without pressure-control pneumatic dispensers, may be used to apply the material.

b. Staking material shall adhere to all surfaces to be joined.

9.1.4 Staking Concerns. When staking, the following shall be assured:

a. The staking material does not fill the stand-off space between the part package and the board, does not partially or fully encapsulate the lead bend(s), and does not partially or fully bond the leads to the part body, the PCB, other leads or other parts unless intended by design and defined in the manufacturing documentation (See 4.3.3.a). Slight encroachment into the stand-off space is acceptable (See Figure 9-4, 9-5 and 9-6).

b. Staking material is free from contamination.

c. Glass-bodied parts are covered with resilient material (i.e. sleeved) prior to staking with rigid material, such as epoxy.

d. Fastener thread lubricant, if used, is controlled so that it does not inhibit adhesion of the staking.

e. Staking material does not enter keep out areas, the inside of mounting holes, or connector mating surfaces or cover vent holes.

f. Staking material does not bridge between the bottom of ceramic-bodied DIPs or surface mounted parts, and the PCB.

g. Staking does not contact lead seals.

9.1.5 Mandatory Staking.

a. All required staking shall be detailed in the manufacturing documentation.

b. Jumper wires in excess of 2.54 cm (1 inch) and axial leaded tantalum capacitors of all case sizes shall be staked.

c. If parts are identified to be staked but staking location or staking dimensions are not specified in the manufacturing instructions, the following shall be used as default criteria:

(1) Axial leaded component, sleeved or sleeveless (See Fig. 9-1):

(a) Fillet location: between the board and the length of the body, centered between the part ends.

(b) Fillet length ≥ 50% of the body length.

(c) Fillet height ≥ 25% of the body diameter and the top of the body shall be visible.

(2) Jumper wires (See Fig. 9-2):

(a) Fillet location: at intervals of 2.54 cm (1 inch) maximum and at every change of direction beyond the radius of curvature for a bend that is shorter than 2.54 cm (1 inch).

(b) Be in contact around the full circumference of the wire and in contact with the board.

(3) TO-type packages (See Fig. 9-3):

(a) At least three fillets, spaced approximately evenly around the periphery of the component.

(b) Fillet height: ≥25%, extension over the top of the part is controlled by clearance requirements at the next higher level of assembly.

(c) Slight flow under the part is allowed.

(4) Radial-leaded square or rectangular packages (See Fig. 9-4):

(a) Fillet location: at each corner.

(b) Fillet height: ≥ 25%, extension over the top of the part is controlled by clearance requirements at the next higher level of assembly.

(c) Slight flow under the part is allowed.

(d) Surface mount area array packages require engineering analysis and design instructions to address all necessary polymeric applications and acceptance criteria.

(5) Radial-leaded component whose height is larger than one of its base dimensions (See Fig. 9-5):

(a) Fillet location: on both sides.

(b) Fillet height: ≥ 50% to 100%.

(c) Fillet width: ≥ 50%.

(d) Slight flow under the part is allowed.

(6) Array of two to four components whose height is larger than one of its base dimensions:

(a) Fillet location: connect the tops of the parts in the array for the entire width of each part and connect the end faces of the two parts at each end of the array to the substrate for ≥ 50% to 100% of the height of the parts and ≥ 50% of the width of the parts.

(7) Array of greater than four radial-leaded components whose height is larger than one of its base dimensions, in addition to the requirements of 9.1.5.c.(5) (See Fig 9-6):

(a) Fillet location: both outer side surfaces of every other part (Requirement).

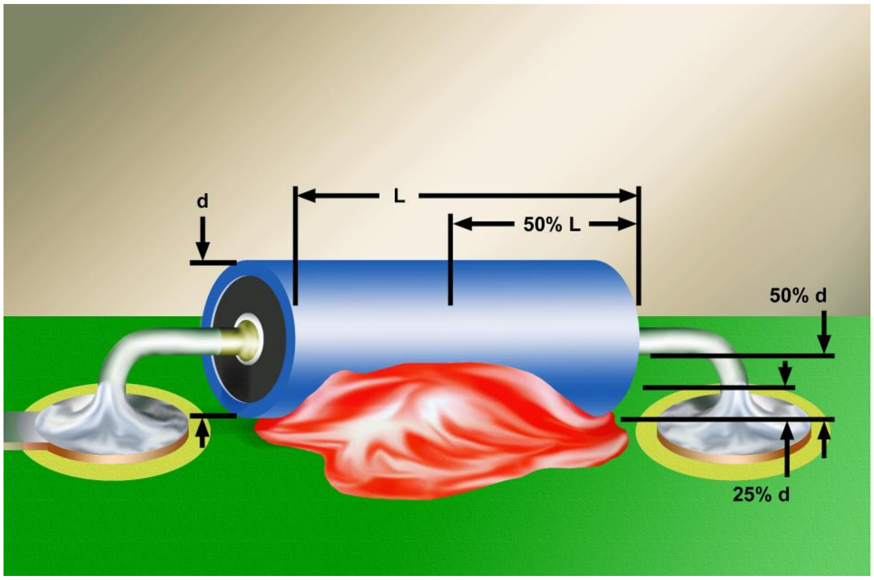
(b) Fillet height: ≥ 25% to 100% of the height of the part.

(8) Wire bundles. Staking stripe width: ≥ 1x the diameter of the bundle (See Fig. 9-7).

9.1.6 Curing.

a. Staking material shall be cured in accordance with the manufacturer's recommended cure schedule or as specified in the manufacturing documentation.

b. Staking material shall be tack-free when cured.

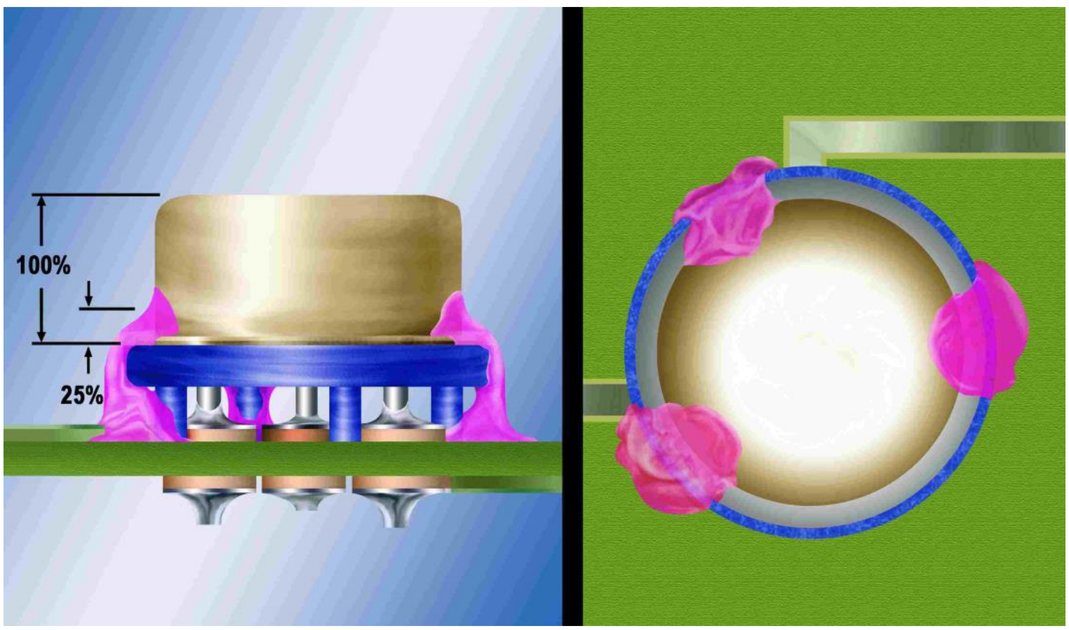


- Fillet Length: ≥50%L to 100%L.
- Fillet Height: ≥25%d to 50%d.

- Top of component is visible for its entire length.

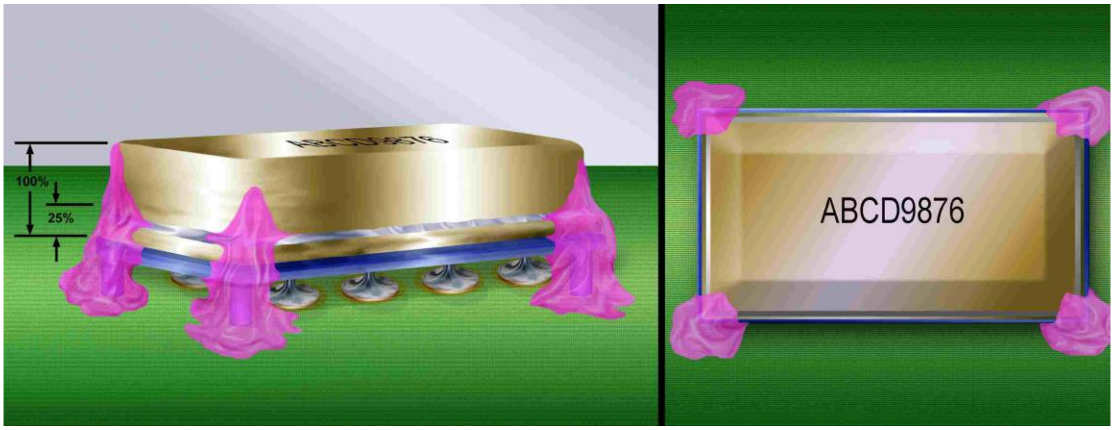
Figure 9-1. Default Staking for Horizontally-Mounted Sleeved or Sleeveless Cylindrical Part

Figure 9-2. Single Wire Staking



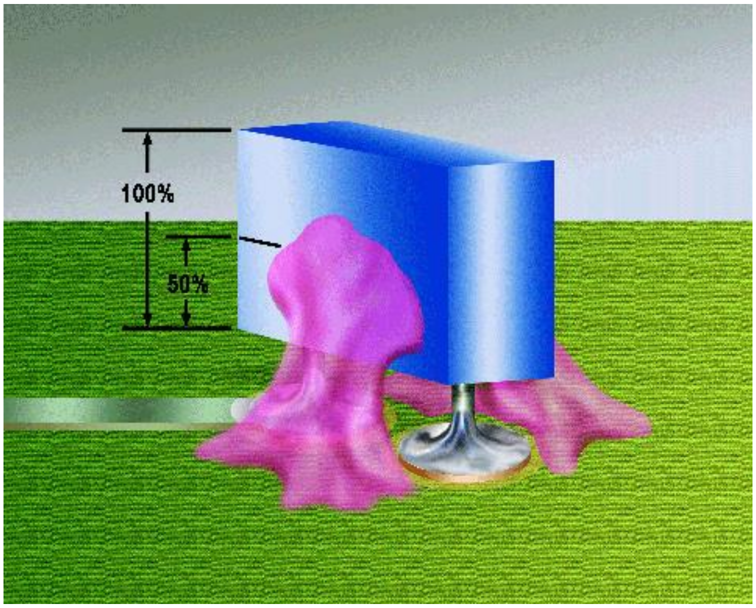
- At least three fillets spaced approximately evenly around periphery of the component.
- Fillet Height: ≥25% to 100% of the component body height.
- Slight flow underneath component.

Figure 9-3. Staking for Radial Lead Components



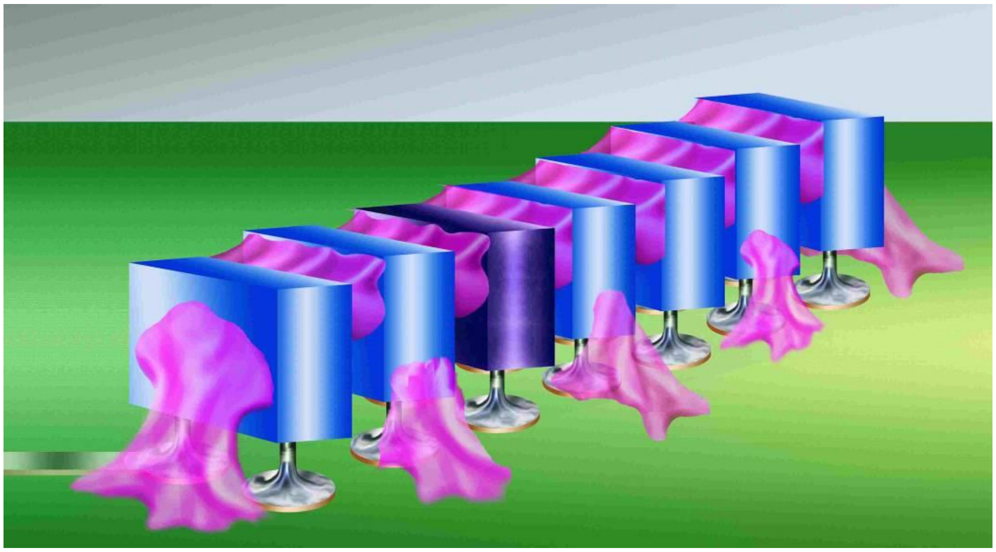
- Fillets on all four corners.
- Fillet Height: ≥25% to 100% of the component body height.
- Slight flow underneath component.

Figure 9-4. Staking for Radial Multi-lead Rectangular Components



- Fillet Height: ≥50% H to 100% H.
- Fillet Width: ≥50% W.
- Slight flow underneath component, but fillets do not contact lead seals or enclose the lead.

Figure 9-5. Default Staking of a Single Vertically-Mounted Rectangular Part



- Two outside ends – Fillet Height: ≥50% H to 100% H.
- End Fillet : ≥50% W.
- Inner surfaces: Fillet is in contact with both surfaces for 100% of component width.

Figure 9-6. Default Staking for an Array of Vertically-Mounted Rectangular Parts

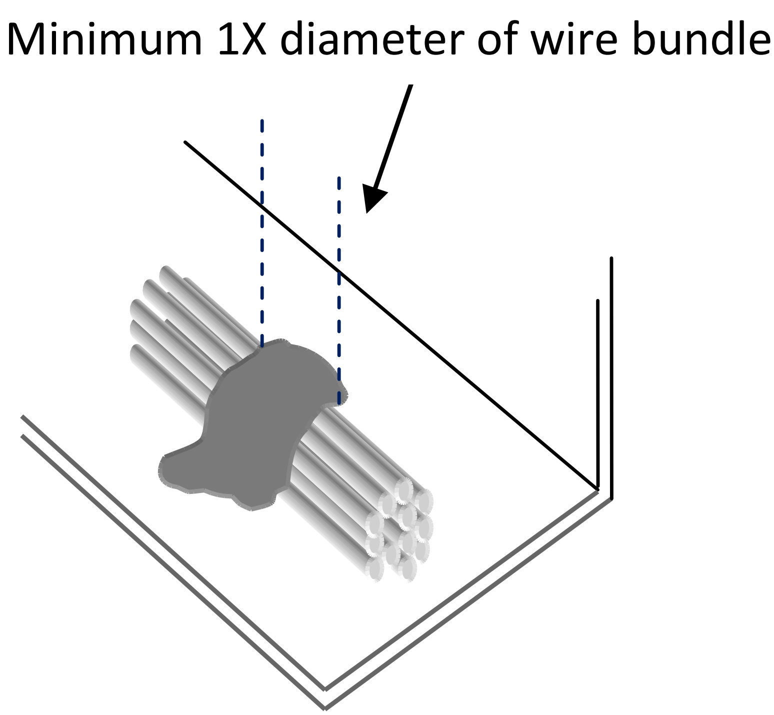


Figure 9-7. Wire Bundle Staking

9.2 Fastener Staking

9.2.1 General Requirements. The requirements in this section apply only to fasteners on PWAs and are not applicable to structural applications.

a. This standard does not require the use of staking for mechanical performance or torque striping as an indicator of torque verification. The requirements to use these techniques are established at the discretion of the NASA project or program. The requirements of this section apply when these techniques are applied by the supplier either to conform to customer requirements or voluntarily.

b. The staking material used for fastener locking or torque striping shall have good adhesion and no evidence of separation or delamination from the bolt, screw, or washer/nut and the adjacent surfaces.

c. The staking material shall be readily removable and residue-free and not prevent a subsequent staking operation.

d. The staking shall not contain voids or air bubbles larger than 0.635 mm (0.025 inch) in diameter or contaminants.

e. There shall be no material spillage or residue on adjacent surfaces.

9.2.2 Fastener Staking Application Requirements. When the manufacturing instructions invoke staking on fasteners, the following shall apply:

a. When the manufacturing documentation specifies that polymeric material be added to the screw threads, a QA witness shall confirm proper application.

b. There shall be no evidence that the staking material has been fractured or disturbed.

c. If a nut is part of the fastener combination, the nut shall be spot staked to the bolt and the assembly in one or two places such that 25 percent to 50 percent of the circumference of the nut is covered. Staking of the bolt head is optional (See Figure 9-8).

d. The staking material shall not enter the internal drive (impede removal of the bolt or screw).

e. If a nut is not used, bolt heads and screw heads shall have 25 percent to 50 percent of the heads’ circumference covered with staking.

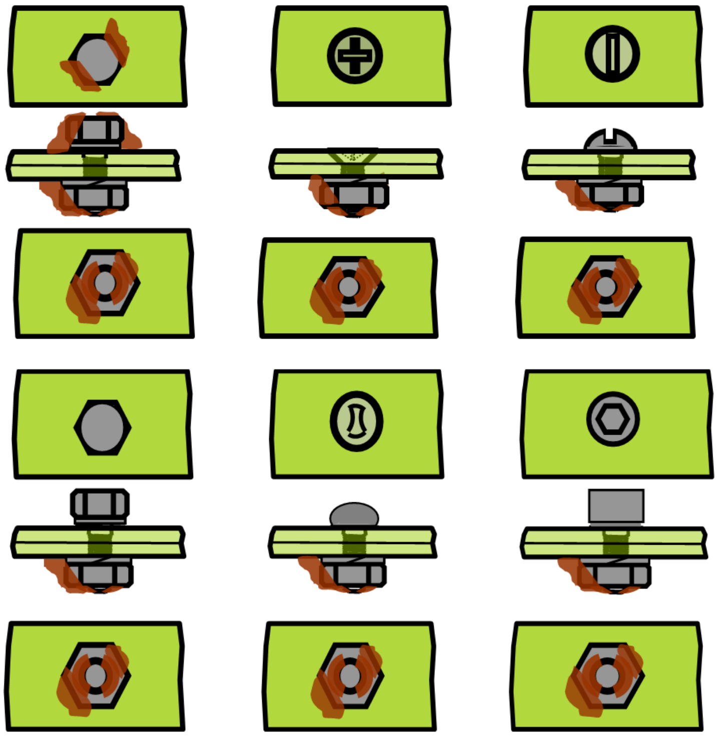


Figure 9-8. Locking of Screws and Bolts with Nuts

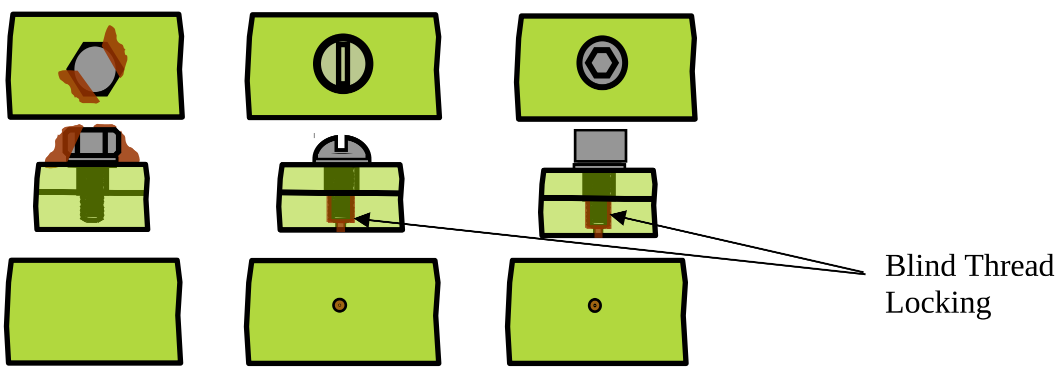


Figure 9-9. Thread Locking of Blind Screw

9.2.3 Fastener Thread Locking.

a. Fastener thread locking shall be inspected during the process.

b. If the application includes a blind hole, a vent hole shall be provided for polymer squeeze-out (See Figure 9-9).

c. If the application includes a blind hole without a vent, polymer thread locking shall not be used.

9.3 Torque Striping

9.3.1 Torque Striping Application Requirements.

a. When used, torque striping shall be applied from the center of the screw or bolt head to at least 3.2 mm (0.126 inch) onto the substrate (See Figure 9-10).

b. There shall be no evidence of process-based defects such as self-initiated cracking in the material, lack of adhesion, or lack of a full cure after the bonding work is completed.

c. Torque striping material shall not be removed without the expressed approval by the Project or the Quality Engineer.

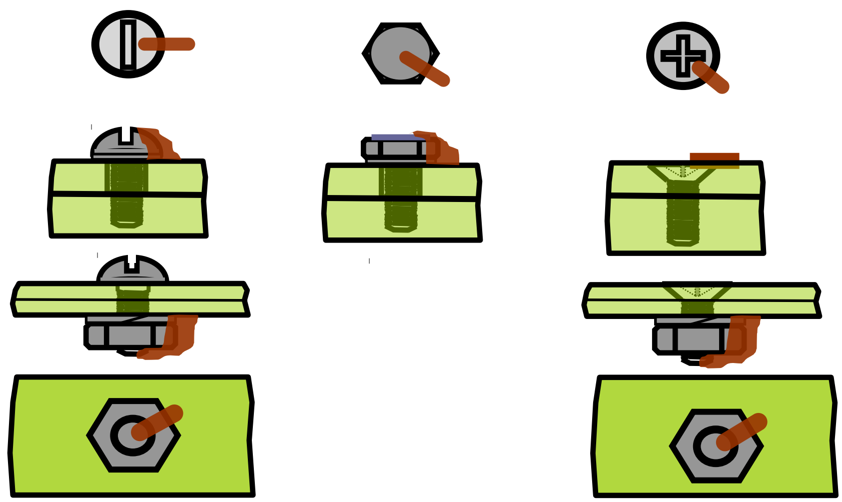


Figure 9-10. Torque Striping Methods

10. CONFORMAL COATING

10.1 Purpose

Conformal coatings are intended to provide electrical insulation and environmental protection thus minimizing the performance degradation to electronic PWAs by humidity, handling, debris, and contamination. Conformal coating materials may include solvents (diluents), fillers, and catalysts and/or accelerators, in addition to the basic resin. Conformal coating is applied by spraying, brushing, dipping, or vacuum deposition methods and then allowed to cure to provide a uniform, continuous coating over the surface of the PWA or electronic assembly. Vacuum deposition methods involve processes, equipment, and materials that are departures from those applicable to the other application methods.

10.2 Requirements

10.2.1 The PWAs shall be cleaned, tested for cleanliness and demoisturized within 8 hours before conformal coating per section 7 herein.

10.2.2 Application.

a. Conformal coating shall be applied in a continuous manner to all areas designated for coverage on the manufacturing instructions without excessive filleting or runs. Common coating application methods include spraying, brushing, dipping, or a combination thereof. Chemical Vapor Deposition (CVD) is the process used for paraxylene.

b. Excessive Coating Removal. Excessive coating shall be removed prior to cure.

c. Spraying.

(1) The conformal coatings shall be sprayed onto the PWA using clean dry gas at a pressure sufficient to provide proper atomization.

(2) One pass shall be sprayed across the entire surface of the PWA holding the spray gun at an angle of approximately 45° to the PWA.

(3) The PWA shall be rotated 90° after each pass, and spraying repeated, so that all four directions are sprayed. See Figure 10-1.

d. Brushing.

(1) The material shall be evenly applied without forming excessive fillets and thick areas.

(2) Particular attention shall be paid to undersides of parts and lead wires.

(3) The brush selected shall provide adequate control for appropriate coverage, be cleaned in a non-reactive solvent, and be thoroughly dried before use.

e. Dipping.

(1) The entire PWA shall be dipped. The extraction rate ensures uniform thickness.

(2) The conformal coated PWA shall be allowed to drain until the conformal coating stops running and minimum part filleting is achieved.

f. Vacuum Deposition.

(1) Paraxylene conformal coating shall be applied using a special vacuum deposition chamber.

(2) The conformal coating shall be thin, uniform, and fillet free.

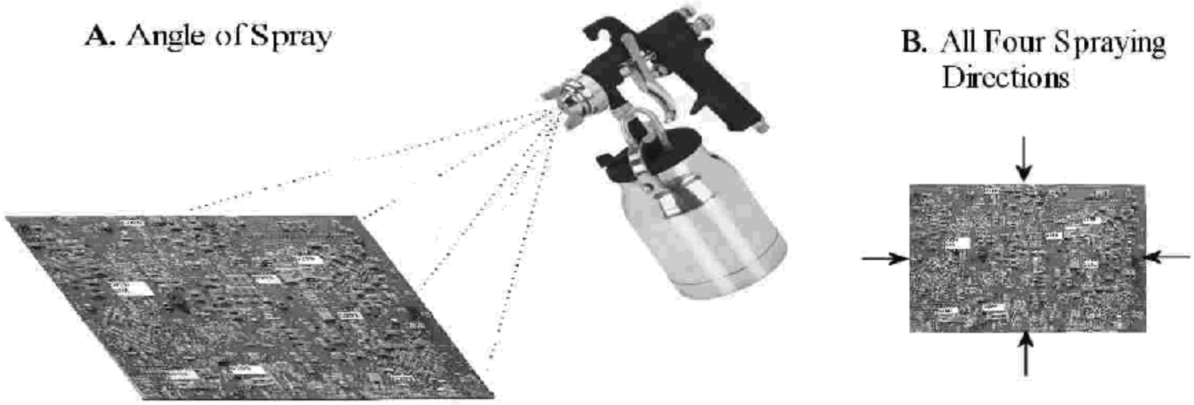


Figure 10-1. Spray Application

10.2.3 Thickness Measurements.

a. Thickness measurements shall be applied to the final cured thickness on conformal coating test specimens (see 8.5 herein) and be in accordance with Table 10-1.

b. An in-process wet film thickness measurement (e.g. gauge, micrometer) may be used provided that it is calibrated to a final cured thickness that meets the values in Table 10-1.

c. Thickness requirement for brush coatings. Variances of brushed coating thicknesses outside of the limits given in Table 10-1 are considered nonstandard and require prior approval per NASA-STD-8739.6.

Table 10-1. Conformal Coating Thickness

Type of Coating	**Cured Coating [mm (inch)]**
ACRYLIC	0.025 – 0.127 (0.001 to 0.005)
URETHANE	0.025 – 0.127 (0.001 to 0.005)
EPOXY	0.025 – 0.127 (0.001 to 0.005)
SILICONE	0.051 – 0.203 (0.002 to 0.008)
PARAXYLENE	0.013 – 0.051 (0.0005 to 0.002)

10.2.4 Pre-Cure Examination. Immediately after material application, the uncured conformal coating shall be examined for:

a. Bubbles and Air Entrapments. Prior to cure, bubbles and air entrapments shall be broken using locally qualified methods such as piercing with a sharp probe or by vacuum methods.

b. Bridging. Locations where conformal coating thickness appears to exceed maximum limits shall be evaluated for impact to stress relief effectiveness (see 9.1.4 for undesirable clamping conditions). Conformal coating webbing around or under leads or between packages and the PCB, of a similar thickness as the conformal coating on flat portions of the board, is acceptable.

10.2.5 Curing.

a. Cure Schedule. The conformal coating material shall be cured in accordance with a specified cure schedule that is compatible with the thermal limitations of the hardware and results in a tack-free finish.

b. Multiple Conformal Coatings. When multiple conformal coatings of the same material are employed, each layer may be partially cured before the next layer is applied.

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

d. Handling and Storage. After application of the polymeric material, particularly when the material is still wet and tacky (during curing cycle), hardware shall be handled and stored in a manner that minimizes exposure to contamination or handling damage.

10.2.6 Post Cure Inspection. After the cure cycle, the conformally coated PWA shall be examined to assure that the following conditions are met. See Figure 10-2 through Figure 10-5 for additional requirements.

a. Cure step achieved the intended time and temperature schedule as defined in the manufacturing documentation.

b. Conformal coating is uniform in color, thickness, and texture, tack-free, and shows proper adhesion to all coated surfaces.

c. Conformal coating covers all areas as specified on the manufacturing documentation, has a smooth continuous surface, and follows the contours of the PWA. Minor pull back from sharp points and edges is permissible.

d. Conformal coating does not exhibit lifting or peeling.

e. Conformal coating is free from contamination.

f. No bubbles or air entrapments bridge between non-common conductors, expose a bare conductor surface, or exceed 0.762 mm (0.03 inch) in any dimension.

g. Scratches on conformal coating do not expose conductive areas.

h. Terminals are conformal coating encapsulated, including the insulation gap of the wire, unless there is a solder ball type connection (as in a high voltage connection). This is normally applied with a brush after the initial conformal coating application.

i. The criteria described in 10.2.4.b also applies for post-cure examination.

j. Conformal coating does not exhibit discoloration (due to such things as excessive curing oven temperature or contamination). Change of color due to temperature aging during normal exposures to test temperatures or standard rework is allowed. This allowance is not intended to apply to color changes resulting from the use of incorrect or defective material.

k. Conformal coating does not extend into keep out areas or cover connector mating surfaces.

10.2.7 When fluorescent conformal coating materials are used, coverage and location shall be verified by Ultraviolet (UV) light illumination.

10.3 Cleanup

After the conformal coating process has been completed, the PWAs shall be cleaned to remove any masking material, loose debris, or material that may damage or degrade its performance.

10.4 Touchup/Rework

10.4.1 Conformally coated assemblies shall be touched up to correct coating coverage deficiencies.

10.4.2 Touched up areas shall meet the minimum thickness requirement of Table 10-1, but may exceed the maximum thickness limit.

10.4.3 The requirements of NASA-STD-8739.6 for rework and repair apply when removing and replacing conformal coating.

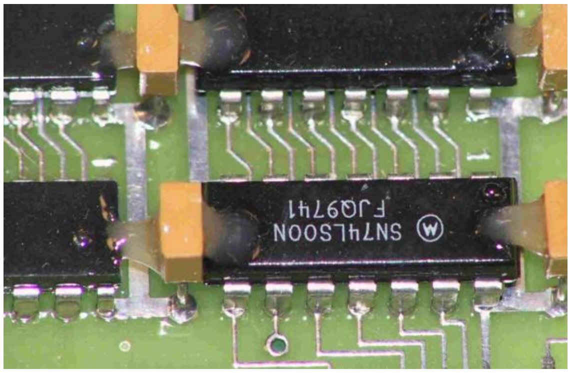
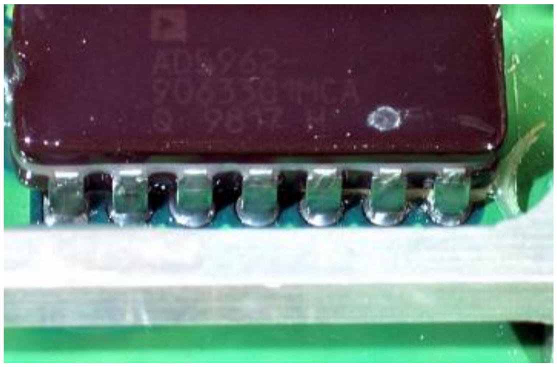
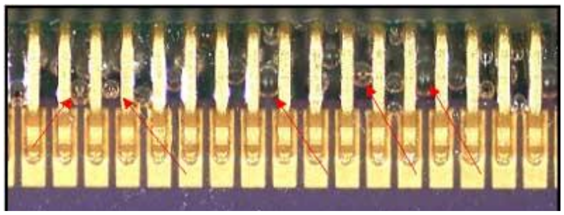
	**PREFERRED** **Completed uniform coverage with no visual bubbles.**
	**ACCEPTABLE** **Small bubbles, but they do not bridge between non-common conductors, expose a bare conductor surface, or exceed 0.762 mm (0.030 inch) in any dimension.**
	**UNACCEPTABLE** **Excessive bubbling.**

Figure 10-2. Conformal Coating – Bubbles

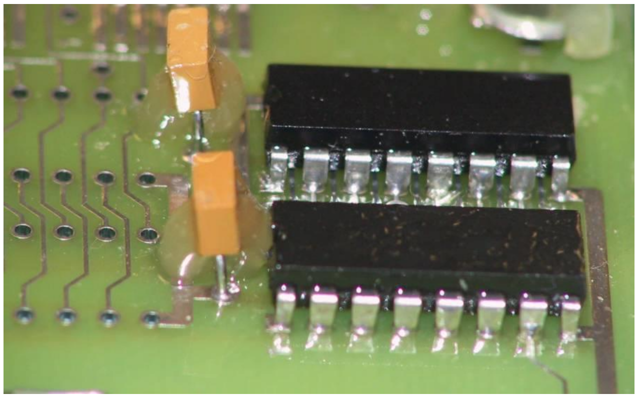
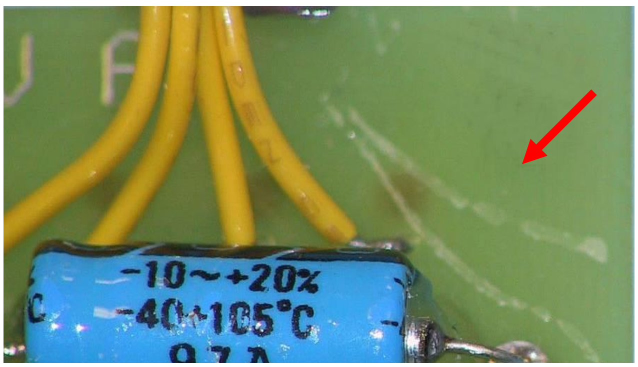
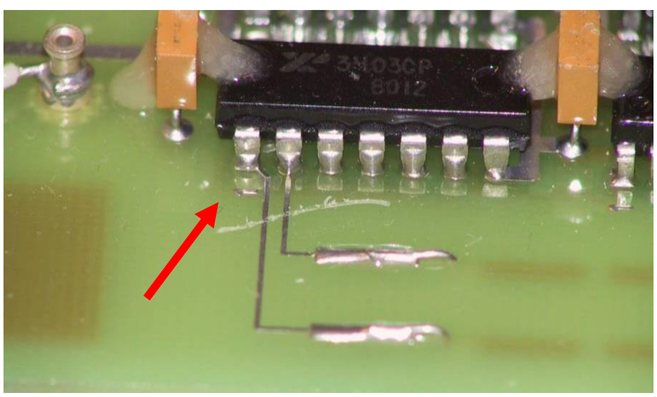
	**PREFERRED** **Smooth, continuous, and without bubbles, scratches or imperfections.**
	**ACCEPTABLE** **Scratch does not expose any conductive area.**
	**UNACCEPTABLE** **Scratch exposes conductive areas.**

Figure 10-3. Conformal Coating – Scratches

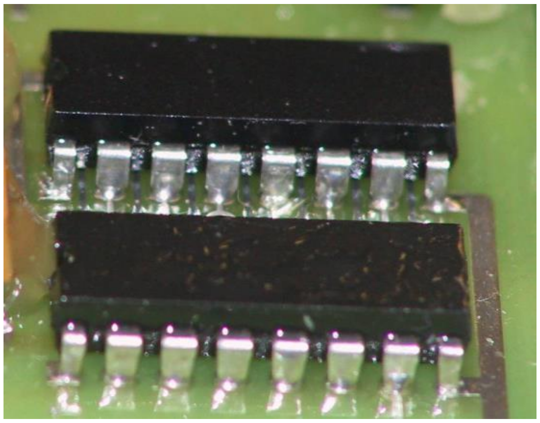
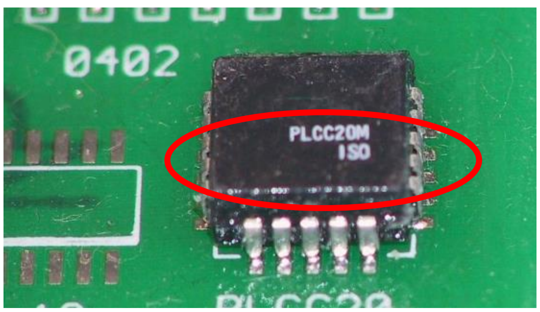
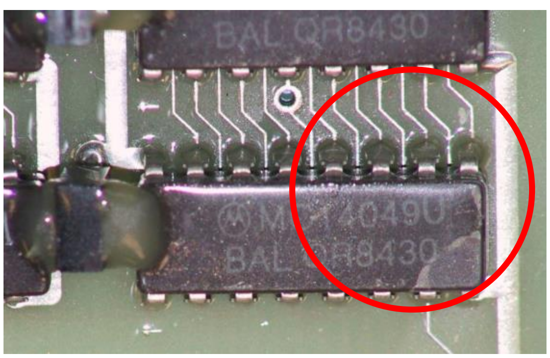
	**PREFERRED** **Uniform color, texture, and thickness with apparent good adhesion on parts and board surface. The coating should show uniform fluorescence under a UV light.**
	**ACCEPTABLE** **Some evidence of variation in coating thickness. Minor lifting on nonconductive areas.**
	**UNACCEPTABLE** **Excessive lifting and peeling indicating improper surface cleaning or excessive thickness. Any lifting on conductive areas is nonconforming.**

Figure 10-4. Conformal Coating - Lifting and Peeling

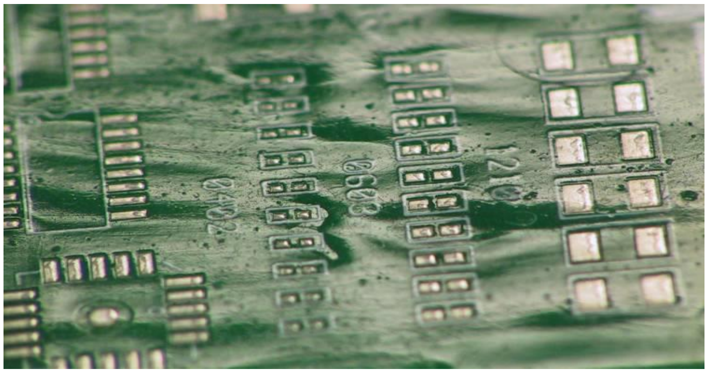
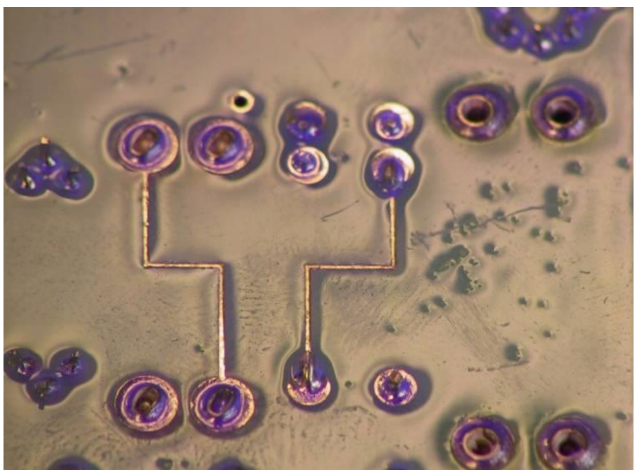
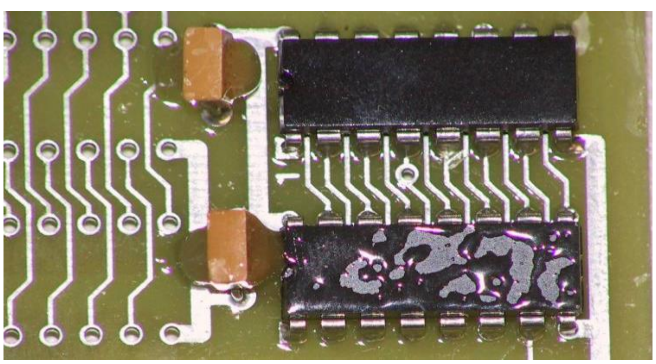
 **Conformal Coating – Runs**	**ACCEPTABLE** **Not to exceed 5 percent of PCB surface area.** **<u>Runs</u>**
 **Conformal Coating**	**ACCEPTABLE** **See 10.2.4 and 10.2.6 for limits applicable to voiding.**
 **Conformal Coating – Dewetting**	**UNACCEPTABLE** **Loss of adhesion.**

Figure 10-5. Conformal Coating – Coverage Defects

11. BONDING

11.1 Requirements.

a. The requirements of this section shall apply only to attachment of mechanical or electrical parts to printed wiring assemblies or other electrical assemblies using a polymer material, rather than mechanical fasteners and shall not be applied for structural bonding applications.

b. Application Sequence. Bonding shall be performed prior to staking and prior to conformal coating.

c. Surface Preparation. Surfaces being bonded shall be cleaned and prepared in such a manner as to achieve an acceptable bond between the surface and the adhesive. When cleaning and priming surfaces, as required, masking may be needed to prevent contamination of adjacent surfaces.

d. The bonding process shall not obscure part markings unless required by design and specified in the manufacturing documentation.

e. For packages provided with mounting holes on flanges, the bonding material shall extend to the area under the flanges to avoid applying a bending stress to the flange when the mechanical fastener is installed.

f. The bonding material shall adhere to all surfaces to be joined.

g. The leads of thermistors, PRTs, and similar components shall be dressed to provide stress relief and staked in accordance with the wire run rules in section 9.1.4.c herein.

h. For disc-shaped / wafer components whose leads exit axially from the part body and whose body is bonded to the printed circuit board (i.e. thermistors), at least one lead shall not be embedded in the bonding material (See Fig. 11-1).

i. Squeeze-out shall be visible on all sides unless sheet adhesive is used. Squeeze-out should be kept to a minimum while providing enough to confirm via visual inspection.

j. For thermal joints, bond line control and coverage limits shall be defined and inspected for compliance.

k. Figure 11-1 shows some examples of acceptable and unacceptable bonding.

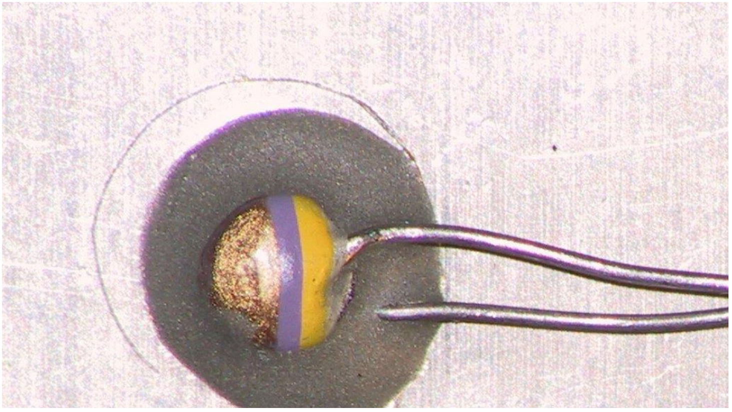
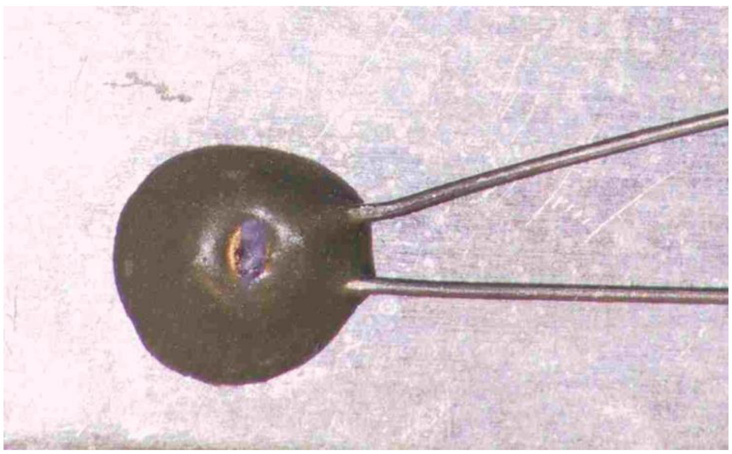
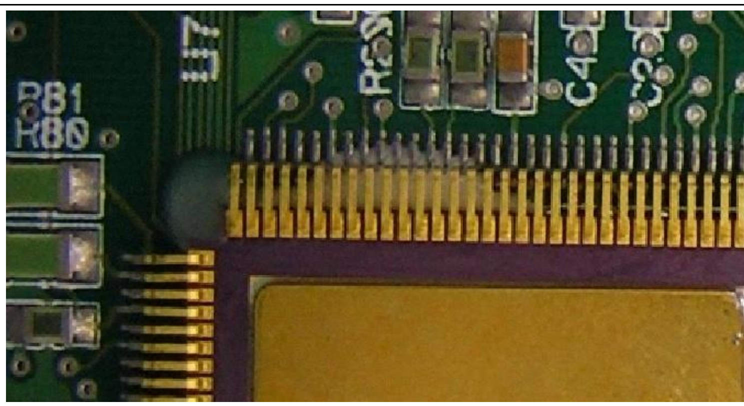
	**ACCEPTABLE** **Markings shall be clearly visible.** **For disc-shaped / wafer components whose leads exit axially from the part body (i.e. thermistors, platinum resistance thermometers, etc.), at least one lead shall not be embedded in the bonding material.**
	**UNACCEPTABLE** **Excess bonding material applied to disk-shaped / wafer component whose leads exit axially from the part body.**
	**UNACCEPTABLE** **Excess bonding material applied, squeeze-out negates stress relief.**

Figure 11-1. Component Bonding - Excess Bonding Material

12. ENCAPSULATION

12.1 General

The purpose of encapsulation is to protect the component or assembly against damage and deterioration from electrical, thermal, mechanical, and space environment stresses under service conditions.

12.1.1 Vacuum Degassing. Encapsulation material shall be vacuum degassed before application.

12.2 Pre-cure Examination

12.2.1 The item to be encapsulated shall be free of contamination or residual solvents.

12.2.2 Masking should be used to minimize material adhesion to the exterior surfaces of the assembly.

12.2.3 For high voltage applications, neither bubbles nor pinholes shall be greater than 0.0254 mm (0.001 in).

12.2.4 The correct implementation of multi-step processes, such as underfill prior to encapsulating, shall be confirmed.

12.3 Post-cure Inspection

12.3.1 The encapsulation material shall be free from contamination.

12.3.2 The encapsulation material shall fill the required areas completely and adhere to all surfaces as intended (See Figs. 12-1 and 12-2).

12.3.3 Bubbles or pinholes shall be less than 0.635 mm (0.025 inch) diameter.

12.3.4 Bubbles or a series of bubbles shall not form a continuous path between two non-common conductors.

12.3.5 For high voltage applications, neither bubbles nor pinholes shall be greater than 0.0254 mm (0.001 in).

12.3.6 Encapsulating material shall not be present on the exterior surfaces of the encapsulation mold (small amount of spillage is allowed if it does not interfere with mounting or markings (See Fig. 12-2)).

12.3.7 The encapsulation material shall be free of fracture lines and cracks.

12.3.8 For connectors, the encapsulation material shall have concave fillets to the encapsulated wires.

12.3.9 Pins and sockets shall be free of encapsulating material.

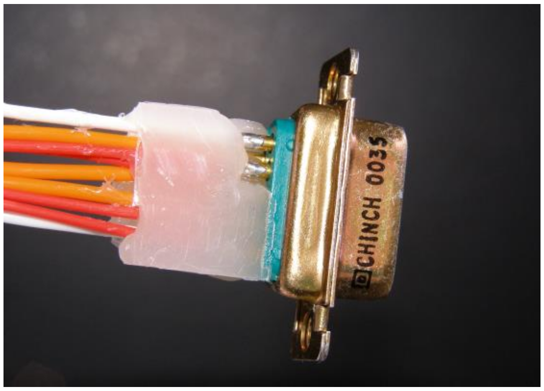
	**ACCEPTABLE** **Wire Encapsulation.**
	**ACCEPTABLE** **Cable Encapsulation.**
	**UNACCEPTABLE** **Large void bridging conductors,** **Improper filling of embedding mold.**

Figure 12-1. Encapsulating Wires at Connector

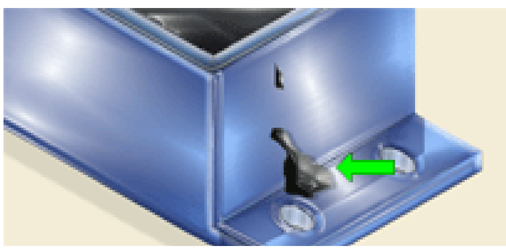
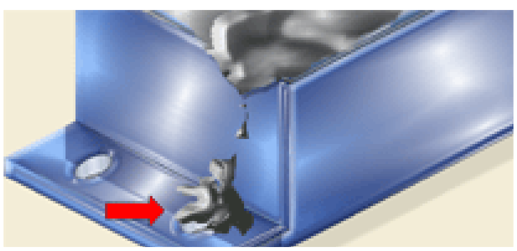
	**ACCEPTABLE** **Bubbles/Cavities** **<0.635mm** **(<0.025 inch diameter).**
	**UNACCEPTABLE** **Lack of adhesion.**
	**ACCEPTABLE** **Spillage** **(A thin film is acceptable provided there is not an interference problem).**
	**UNACCEPTABLE** **Spillage.**

Figure 12-2. Module Encapsulation

12.4 Uses of Encapsulation with Connectors used with Shielded Cable

12.4.1 When conductive epoxy is used in place of a connector back shell, the epoxy shall provide electric conductivity between the connector shell mounting and the cable shield.

12.4.2 All shielding wire end tips shall be captured by the encapsulant to prevent loose wires from causing electrical shorts.

12.5 Cleanup

12.5.1 Encapsulated assemblies shall be cleaned to remove any masking or material that may damage or degrade their performance.

13. QUALITY ASSURANCE

13.1 General

13.1.1 Inspection for acceptability shall be performed on all uses of staking, conformal coating, bonding and encapsulation on PWAs and electronic assemblies to the requirements specified in this Standard.

13.1.2 Inspections shall not physically disturb parts and conductors.

APPENDIX A. CONFORMAL COATING PROBLEMS

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

A.1 Conformal Coating Thickness

Conformal coating thickness can be critical to the proper function of a PWA. 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 of adjacent components, caused by surface tension, may necessitate use of a brush to remove the excess.

Using a wet film gauge after each coating pass in a multiple-coating process helps the operator stay within the required post-cure thickness, that is when the number of passes and wet gauge values have been calibrated and documented in the processing documents with results of cured samples.

A.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 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 better. Vacuum deposition of paraxylene is the best method for covering points and edges.

Using more than one type of coating method (e.g., brush method followed by spray method) can help accomplish acceptable coverage around difficult-to-cover parts such as transformers, components near a stiffener, components mounted to heat sinks, and closely spaced components which limit line-of-sight spray applications.

A.3 Bubbles

Bubbles normally originate from air trapped underneath components and at solder joints. When bubbles bridge non-common conductors, entrapped moisture or other contaminants may reduce insulation resistance or cause shorts and possible arcing.

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 PWA. 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 brush coating. For thicker coating applications, degassing in a vacuum chamber will help remove entrapped air.