Characteristics of Conformal Coatings

A conformal coating is defined as a thin polymeric material which covers the surface of an electronic assembly. These coatings are used to provide an electrically insulative and environmentally protective seal or cover to a completed printed circuit board (PCB).

Conformal coatings protect the PCB from solids, vapors and fluids. They offer physical protection from assembly debris such as wire clippings, loose hardware, and solder splatter and can help protect the PCB from vibration damage. Given a single exposure, they will usually protect the surface against vapors. Different chemistries repel contaminants at different levels; material compatibility studies must be performed to determine the correct one for the application.   Conformal coatings are divided into five classifications, based on their chemistry, as shown in Table 2-1.

Classification	Abbreviation
Acrylic Resin	AR
Epoxy Resin	ER
Silicon Resin	SR
Polyurethane Resin	UR
Parylene	XY

Table 2-1 Conformal Coating Classification

A conformal coating is defined as a thin polymeric material which covers the surface of an electronic assembly. These coatings are used to provide an electrically insulative and environmentally protective seal or cover to a completed printed circuit board (PCB).

Conformal coatings protect the PCB from solids, vapors and fluids. They offer physical protection from assembly debris such as wire clippings, loose hardware, and solder splatter and can help protect the PCB from vibration damage. Given a single exposure, they will usually protect the surface against vapors. Different chemistries repel contaminants at different levels; material compatibility studies must be performed to determine the correct one for the application.   Conformal coatings are divided into five classifications, based on their chemistry, as shown in Table 2-1.

COATING TYPES

Acrylic Rosen (AR) - Acrylic rosin is a relatively hard material with a smooth, glossy finish. It has lower abrasion resistance and yields readily to scraping , chipping and flaking. Most acrylics can be softened by heat resulting in a gummy residue. These coatings are dissolved in solvent in the fully cured state, and as a result, they can be easily reworked. Acrylics can be applied by brush, spray or dip-coating.

Epoxy Resins (ER) - Epoxy resins offer good humidity resistance, high abrasion and chemical resistance as well as having good electrical properties (low dielectric). They are one of the hardest coatings and form a hard, smooth surface that will resist chipping, peeling, or cracking and form one of the strongest surface adhesion bonds. They are difficult to rework and require a soldering iron to penetrate the coating in order to replace a component. Epoxy resins are usually available as a two-part system and can be applied by brush, spray or dip-coating.

Silicone Resin (SR) - Silicon resins have excellent dielectric strength and high arc resistant. Cured, they are rubbery and pliable. Adhesive strengths range from easily detachable to tightly bonded. They have good moisture, humidity and UV resistance and good thermal endurance. They are difficult to rework because they are resistant to most common solvents. Customized thinners and solvents can be purchased from the manufacturer. Silicon resins can be applied by brush, spray or dip-coating.

Polyurethane Resin (UR) - Polyurethane resins offer good humidity and chemical resistance and have high dielectric properties. The coating surface finish is smooth, glossy and non-porous. Coating hardness ranges from extremely hard to relatively soft. They have medium bond strength and tend to peel or flake off in large pieces. Heat at or near the solder melting temperatures will soften polyurethanes and make them pliable. They can be soldered through for rework, but this produces an unsightly brown residue. Polyurethane resins can be applied by brush, spray or dip-coat application.

Parylene (XY) - Parylene coatings have good dielectric strength, low thermal expansion, good abrasion resistance and outstanding chemical resistance. These coatings form a strong surface bond and provide a thin, uniform coverage that conforms fully to the PCB contour. They are used to protect circuits against high humidity, intermittent immersion, salt fog, pollution and aggressive solvents. They are FDA approved for use in medical applications. They are effective in high voltage applications because they can coat sharp edges. Parylene coatings are applied by the vacuum deposition process.

SPECIFICATIONS AND STANDARDS

MIL-I-46058 - Insulating Compound, Electrical for Coating Printed Circuit Assemblies - MIL-I-46058 is an older military specification that lists the technical criteria for conformal coating characteristics. It also lists the quality assurance tests and how they are to be performed. A companion document, QPL-46058, lists coating materials that are in compliance with MIL-I-46058 and is used by the federal government for acquisition purposes.

IPC-CC-830B (with Amendment 1) - Qualification and Performance of Electrical Insulating Compounds for Printed Board Assemblies - This was derived from the MIL-I-46058 and establishes qualification and performance requirements for conformal coatings. This standard allows manufacturers to qualify conformal coating products and define product performance characteristics to the standard.

IPC-HDBK-830 - Guideline for Design, Selection and Application of Conformal Coatings - This document was designed to assist in the selection of a conformal coating. It outlines typical properties of each coating type and how they impact performance considering the intended end use. It also outlines processing steps to assure proper coating application.

COATING ACCEPTANCE CRITERIA

Appearance - coating appearance shall be visually inspected at all stages of evaluation, qualification, and conformance inspection at 1.75X minimum magnification. Test samples shall be prepared in accordance with paragraph 4.7 of IPC-CC-830B. The coating appearance on the PCB shall be smooth, uniform, transparent, free of bubbles (orange peel), pinholes, blisters, or cracks (mealing), and evidence of reversion (tackiness). Cured, coated assemblies shall be free of foreign material, changes in appearance, and separation from the substrate or components.

Shelf life - container(s) of coatings shall be stored at the temperature recommended by the coating vendor. Once a coating has reached the end of its shelf life, it should be discarded, unless the material can be requalified for continued use.

Coating Thickness - coating thickness shall be measured on a coupon in accordance with ASTM-D-1005. Measurements will be made using a micrometer or indicator that is accurate to 0.0005 ± 0.0001 inches.

Moisture and Insulation Resistance - Moisture and Insulation Resistance (M&IR) is a measure of how well the insulation properties are maintained when exposed to elevated temperature and humidity. M&IR is evaluated using test method 2.6.3.1 of IPC-TM-650. A material with a low M&IR would be a poor choice to protect a circuit in a high humidity application.

Dielectric Withstanding Voltage (DWV) - Dielectric Withstanding Voltage (DWV) is a measure of how well a coating resists conducting electricity at a high test voltage for a set period of time. Testing is performed in accordance with IPC-TM-650 2.5.7. Conditions are tested at 500 VDC (default) and 1000 VDC for thirty seconds. This test should be performed after the moisture and insulation resistance tests.

Thermal Shock - Exposure to rapid temperature change can stress a coating that has a slow delta temperature rise and can cause it to crack or delaminate from the substrate.

IPC-TM-650 Method 2.6.7.1 is a thermal shock test that verifies the compatibility of a material with a specific temperature profile. It involves rapid cycling between cold and hot baths. Afterwards, the coating appearance is examined and the dielectric withstanding voltage is tested.

Adhesion - Adhesion of the coating to the circuit board can be tested on a go/no-go basis using a standard paint tape test (peel test) per IPC-TM-650 method 2.4.26.

The Coating Process - A PCB assembly must be cleaned and de-moisturized eight hours before conformal coating. De-moisturizing may be accomplished by an oven bake at 93 ˚C +/- 5.5 ˚C, for a minimum of four hours. The coating material is applied using a method that will yield complete coverage without excessive filleting or runs. Common coating methods include spraying, brushing, dipping or a combination thereof. Chemical vapor deposition is the process used for Parylene.

The EMPF uses a Concoat Systems DC 2002 Dip Coater for application of conformal coating. This model was selected for this process because of the controlled extraction rate of the PCB assembly from the conformal coating bath. The entire PCB Assembly is dipped into the holding tanks with a controlled removal from the conformal coating to obtain uniform thickness.

In conclusion, the following is a list of considerations to keep in mind when choosing a conformal coating:

- Raw material characteristics: viscosity, VOC free, one-part/two-part
- Final cured material characteristics: dielectric, chemical resistance
- Methods of application: capital equipment cost, speed/throughput
- Cure methods available: heat, ultra-violet (UV),vacuum deposition (Parylene)
- Cost of curing equipment: in-line heaters, deposition chambers, etc.
- Environmental impact: volatile organic compounds (VOCs)
- Cleanliness of PWB prior to coating
- Ease of rework
- Compatibility
- End use application

Dave Poulin - *Senior Materials Engineer*