Choosing the Right Conformal Coating… The Facts & Myths

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Conformal coatings are essential when developing printed circuit boards (PCB) for harsh environments. These coatings cling to the surfaces of PCB's, components, and assemblies to prevent current leakage caused by contamination from the outside environment. There are a massive number of options with conformal coatings, providing engineers with ready-made solutions for any number of design challenges. The negative – it can be difficult to wade through coating specifications to understand the differences that truly are important. This paper summarizes the key coating specifications and debunks a number of myths that can lead to further confusion.

Match Coating With Intended Environment

The choice of coating resin will determine the protective properties it imparts and thus the service life of the assembly. It is important to narrow down what you are protecting against:

- Moisture
- Voltage arcing
- Dust & dirt
- Chemicals
- Vibration

No one coating can protect against everything. There are always trade-offs in protective properties and usability.

Acrylic (AR) — Acrylic coatings offer good moisture protection and some of the best dielectric properties available. They are not chemically resistant, so can be partially or fully dissolved by common solvents. While this can be a negative for some applications, it allows for easier clean-up and rework. The economical price, ease of application, and good general protection makes acrylic coatings a very popular middle-of-the road choice.

Silicone (SR) — Silicone coatings have superior moisture protection, great dielectric strength, flexibility, and resistance to thermal shock. Silicone coatings are generally considered top-of-the-line among the standard spray or dip coatings. Although more chemically resistant than acrylic, silicone can still be easily cleaned and reworked using common solvents. Silicone is often used in outdoor applications for maximum environmental protection. Flexibility makes silicone ideal when there is a great deal of vibration, because it avoids cracking.

Urethane (UR) — Urethane coatings are rigid and hard, providing good moisture resistance and the best chemical resistance. NASA testing has shown that urethane can slow tin whisker growth. Although urethane will not stop tin whiskers, full coverage can prevent whiskers that have broken free from redepositing on contact points. (source: http://nepp.nasa.gov/whisker/)

Epoxies (ER) – Very tough, durable, chemical resistant. Rework can be next to impossible. Micro-blasting with crushed walnut shells is one method of removal.

Paralyne (XY) – Excellent for moisture and dielectric barrier. Very thin layer due to application by vapor deposition. Requires specialized, capital-intensive equipment, so the process is usually outsourced to specialty coating houses. Most paralyne polymers are insoluble at room temp, which makes rework generally impractical.

Application Methods

Conformal coatings come in a variety of viscosities. The required viscosity depends on the application method used to apply the coating. The application method is chosen based on throughput needs and coating requirements (e.g. one sided, two sided, spot coating, final coat thickness).

Dip — Dipping is a high volume method to fully coat boards, front and back, with repeatable results. Thickness of final coating is controlled by viscosity and withdrawal speed from the pot. Pot life, usable life of the liquid coating, is a significant issue, and can be controlled with a nitrogen blanket and reduced pot temperature. As the coating sits in a pot, solvents will evaporate off and thicken the material. To bring back to required viscosity, use a thinner designed to work with the specific coating.

Full coverage atomized spray — An atomized spray system or "spray gun", like what is used in automotive painting, can apply conformal coating with minimal capital investment. This is a high volume method for coating, but spray direction must be controlled to prevent shadows, where components block the spray and leave open areas. Viscosity needs to be monitored to avoid cob-webbing, when coating does not atomize properly. Material can be brought back to required viscosity (generally under 70 cps) using a thinner designed to work with the specific coating.

Selective spray system — Computer controlled selective spray systems, like those made by Asymtek and PVA, can eliminate the need for masking. Higher viscosity than full coverage sprayer is generally needed (70-200 cps) to create precise edge definition and prevent splattering.

Aerosol — Aerosol coatings are generally used for small production runs, rework and repair. If using for rework, the aerosol needs to be compatible with the original coating.

Touch-up brush or pen — Acid brushes are often used for very low volume spot coating, and to fill in shadows, open areas, and around replaced components. Quality and repeatability of a brushing process is user dependent.

Coating Specifications

There are a number of industry standard tests and certifications that can reassure customers a coating is suited for a particular application.

UL746 – This is a battery of tests set by the Underwriters Laboratory (UL) that cycles a coated board through a variety of environments. UL publishes a list of coatings that have passed UL747 and has gone through the certification process. It is important to note that just because a coating is not certified, does not mean it would not pass. UL746 is an elaborate and expensive test that is often skipped by coating manufacturers. Expect compliant coatings to be more expensive.

UL94 – If verification of flammability of the final coat is needed, but not the full UL746, UL94 standard can be tested. The test attempts to ignite the fully cured coating with an open flame. The following are the most common classifications found for coatings:

- V0 – Burning stops after 10 seconds, no flaming particles – the best flammability rating
- V1 – Burning stops after 30 seconds, no flaming particles
- V2 – Burning stops after 30 seconds, flaming particles present

IPC-CC-830B & MIL-I-46058C – IPC-CC-830B, titled "Qualification and Performance of Electrical Insulating Compounds for Printed Board Assemblies", is a battery of tests to qualify conformal coatings. This is generally considered the minimum standard to be considered a general purpose conformal coating. IPC-CC-830B replaces MIL-I-46058C, so coatings qualified under the IPC standard can be considered qualified under the military standard. IPC-CC-830B includes a test very similar to UL94, so both standards may not be necessary.

Misconception #1: Higher Solids = Thicker Final Coating

Many engineers, in the search for a coating that meets their requirements, assume there is a correlation of solids, viscosity, and film build (final coating thickness). As counter-intuitive as it seems, these are individual properties that do not necessarily correlate as you cross from one resin to another. A higher viscosity coating may be needed for particular spray or dipping systems, but it won't always lead to a thicker final coat.

The following are several reasons why the correlation between these properties is weak:

- Resin mol weight – A heavier coating resin won't necessarily increase thickness, but it will increase solids percentage if volume is constant.
- Solvent choice – A change in solvent (e.g. from heptane to xylene) can drastically change viscosity, even if all else (e.g. solids %) is the same.
- Ratio between resin & solvent – Intuitive, but only reliable indicator if resin and solvents don't change – e.g. thinning a coating vs. switching resins.

"Solids" is the ratio of non-volatile resins to volatile carrier (solvent or water): e.g. 20 grams resin + 80 grams solvent (fully volatile) = 20% solids. A heavier resin or lighter solvent might raise solids percentage, but not thickness of final coating. The below list of coatings show the incongruity of solids, viscosity and final coating thickness:

	Solids %	Viscosity	1-dip build
Techspray Fine-L-Kote AR (2103)	20.6	44 cp	1 mil
Techspray Turbo-Coat (2108)	17.1	20 cp	1 mil
Techspray Turbo-Coat HV (2109)	25.2	60 cp	1.5 mil
Competing Coating 1	35	220 cp max	2 mil
Competing Coating 2	30	270 cp max	1 mil

Misconception #2a: You Don't Have To Clean "No-Clean" Fluxes

"No-clean" means the flux residues have no ionic characteristics which contribute to:

- Corrosion
- Whisker growth
- Dendrites

"No-clean" does not mean there are no residues to contend with. Like when painting a piece of outdoor furniture, the surface has to be cleaned thoroughly to ensure proper adhesion. Any flux residues can contribute to several coating problems:

- Adhesion
- Dewetting
- Compatibility issues of particular flux residue with coating

Flux residues causing coating uplift
(photo courtesy of NPL)

Misconception #2b: New Bare Boards From The Manufacturer Are Already Clean

There are many release agents used in board and component manufacturing. Some are incompatible with coating, so may cause dewetting or delamination.

Release agents causing delamination/adhesion issue
(photo courtesy of NPL)

Misconception #3a: PCB's Must Be Fully Cured To Handle

When qualifying a new coating, it is common for an engineer to dwell more on final cure time than is necessary. Full cure is achieved when final properties have been attained, i.e. hardness, adhesion, mar resistance, etc. It can be accelerated by heat, moisture, oxygen, and UV depending on the resin. PCB's can often move through subsequent processes when they are only tack-free, when the coating resists finger printing but has not reached its final properties. Like full cure, tack-free cure can be accelerated, sometime in mere minutes. Racking boards and breaking production flow may be avoided with a fuller understanding of the risks of handling tack-free boards.

Misconception #3b: UV Cure Coatings Achieve Full Cure When Exposed To UV

The discussion of full cure versus tack-free cure does not magically disappear when moving to a UV-cure conformal coating. UV light cures UV coatings line-of-sight. If coating is not exposed (e.g. under components), full cure can take up to 72 hrs. UV coatings need a 2-step process for accelerated full cure including both UV exposure and heat.

Lessons Learned:

Specifying the best coating for your application can be vastly simplified by focusing on the most important issues. Coatings must be matched to the expected service and environment of the final product. If qualifying a new coating, use final coating thickness for qualification not solids percentage. Make sure to match coating choice to both the process (e.g. viscosity) and customer requirements (e.g. final coating thickness). For best results, clean the assemblies of all residues before coating – even “no-clean” fluxes. Work off of data sheets and ask your sales representative questions, but when in doubt, ask to speak to the technical representatives of the coating manufacturers. They are your best friends in your qualification process!

Techspray is a formulator and manufacturer of precision cleaners for industrial and electronic applications. More information on Techspray’s heat sink compound and other products can be found at www.techspray.com.