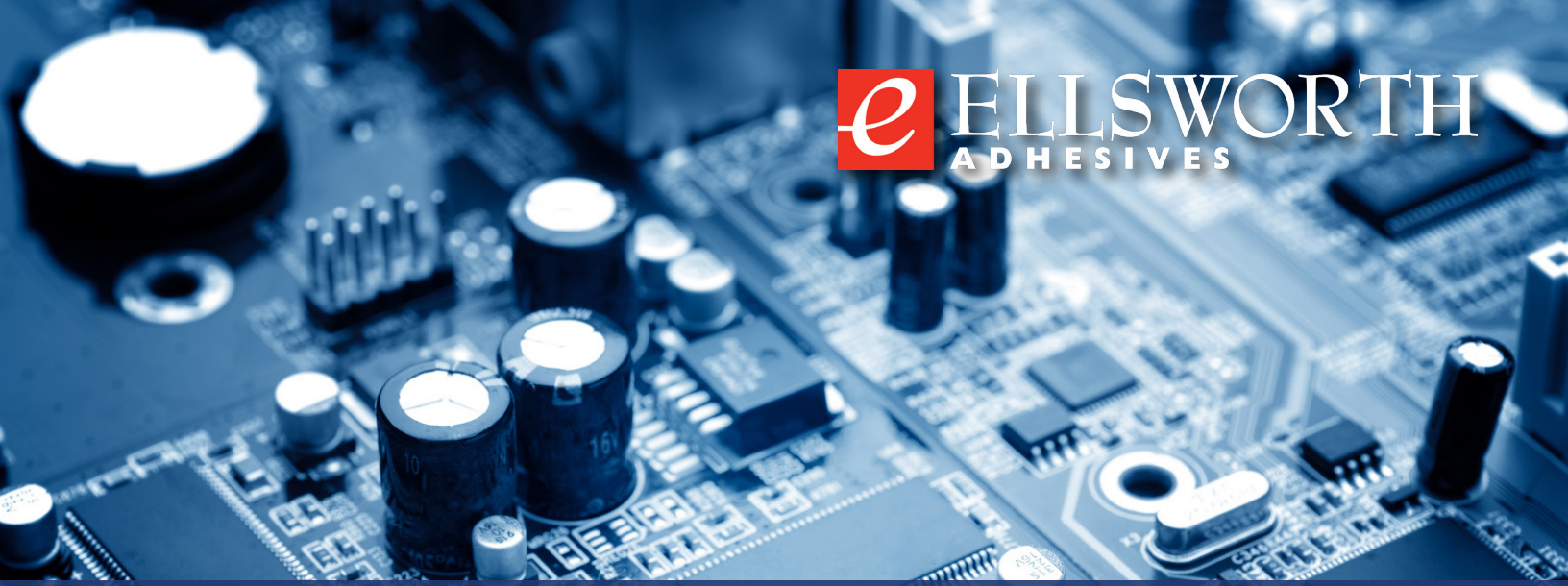

WHITE PAPER

PROTECTING PRINTED CIRCUIT BOARDS

The Benefits of Conformal Coatings on Electronic Devices

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Consumers expect their electronics to take a lot of abuse, yet device durability is ultimately about how well internal electronics have been protected. Destructive factors include:

- Moisture
- Vapor
- Corrosive solutions
- Sand and dust
- Mechanical and thermal stress from vibration, impact and temperature extremes

Engineered solutions for these common hazards routinely use conformal coatings to protect the sensitive printed circuit boards (PCBs) inside devices.

Protection for PCBs has evolved beyond the wax coatings and gasketing methods once used. Potting isn't always practical, as it requires a significant quantity of adhesive and may not be optimal for thermal management. Encapsulants are for individual components, but PCBs often need complete protection. Epoxies are falling out of favor because thermal expansion mismatches can easily damage fragile board components. Overmoldings typically have high viscosities and dispensing requires high pressures that could damage the sensitive PCB.

Since PCBs are small, delicate instruments, thin layers of acrylic-, polyurethane-, or silicone-based coatings are applied to the PCB's topography to provide dielectric insulation, security against hostile environments and chemicals, defense against mechanical stresses, and a basis to prevent interference from radio frequency or electromagnetic sources.

PCB Problems

Considering the billions of PCBs in use globally, many of them face highly adverse conditions. Some of them operate in conditions where humans can't, such as in the arctic or in outer space, and therefore require exceptional protection from all types of risks. Conformal coatings are the go-to solution as they're versatile, robust, and easy to apply.

Dielectric conformal coatings are useful when electrical shorts are a concern, such as when highvoltage components are in close proximity but need to be insulated, or when conductive contaminants may enter the PCB envelope.

Conformal coatings are used on PCBs in common items like computers and LED lights, protecting the components from moisture, static and vibration, but they are also used to protect PCBs from harsh environments like the salt water, ice and cold a nuclear submarine may encounter, or a volatile chemical factory.

A PCB severely water damaged.

Conformal dielectric materials also mitigate the formation of tin whiskers and prevent whiskers from reaching nearby components, which has become increasingly important with the elimination of lead-tin solders. Components can also be protected from electrostatic discharges.

Dielectric insulating conformal coatings can avert false contacts, such as when PCBs are exposed to humidity or moisture and conductors have an increased risk of oxidation. False contacts can also be created by desoldering or by tiny fractures that result from mechanical stress. PCBs are prone to heat issues due to their dense componentry; which is especially true for LEDs. Conformal coatings cannot be filled with conductive materials, such as metal powders, but thin layers of dielectric conformal coatings allow the board to exhaust heat without creating thermally induced malfunctions.

An adverse operating environment is an incessant risk for many PCBs, especially those that operate outdoors in applications such as vehicles and infrastructure. PCBs in marine electronics need specific protection from corrosive salt water. Those found in aircraft, military hardware, and autos need exceptional dependability. Equipment placed outside, such as broadcast antennas or traffic sensors, aren't sheltered from weather conditions that include

oppressive heat, biting cold, snow and ice, storms, and everything in between. Leading PCB OEMs seek coatings that adapt to any environmental condition.

Other PCBs may be exposed to chemicals or mechanical stress. Sensors in storage tanks need inert coatings to remain effective. The same is true for electronics used in factory environments where chemicals are prevalent. Vibration is a common mechanical stress that is often unavoidable on certain machinery. Other, more violent trauma, such as drops or impacts, place durability demands on PCBs that are solved with a conformal coating.

Conformal coatings remain a solution for isolating radio antennas. Most modern cell phones have at least two antennas that are insulated from each other with copper or laminate shielding. The conformal coating prevents the shielding from contacting the PCB itself and does so without compromising effectiveness.

Conformal Coating Chemistries for PCB Protection

There are four principle conformal coatings materials that are effective for PCB protection: acrylic, urethane, silicone and UV-curing coatings. Each has inherent advantages and disadvantages, but how the conformal coating will be dispensed is also a necessary consideration.

Acrylic Conformal Coatings

Acrylic conformal coatings are the most popular, in large part because they're relatively inexpensive. They are quite resilient and protective, especially against moisture and debris. Acrylics are also easy to apply as they require no mixing and cure relatively quickly. Acrylic is vulnerable to some solvents and chemicals, which makes it easy to remove and repair, but also makes it ineffective against chemical threats. Volatile organic compounds (VOCs) are released as the acrylic cures, which means additional ventilation equipment and personnel protection is required.

Urethane Conformal Coatings

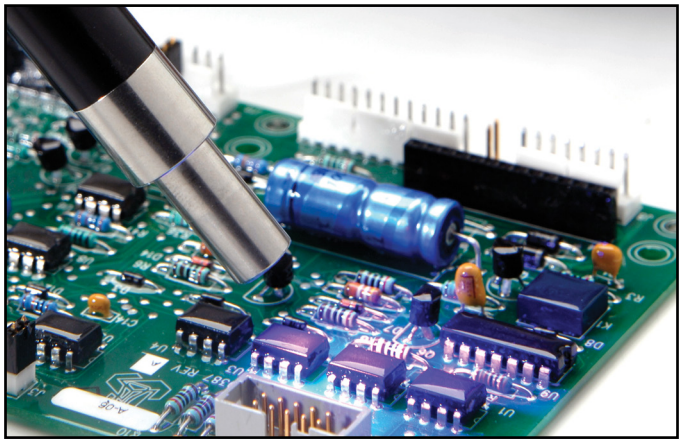
Polyurethane is also a common conformal coating material as it offers exceptional chemical and abrasion resistance, and because of this, conformal coatings are often the choice for automotive, marine, and industrial control uses. Polyurethane conformal coatings cure from exposure to heat or moisture, and have long curing times that can be helpful for reworks when necessary, but can also create production bottlenecks. Since they are chemically resistant, it is almost impossible to repair polyurethane conformal coatings once they are cured. They may be offered as a one- or two-part solution, the latter requiring thorough mixing before application.

Silicone Conformal Coatings

Silicone-based conformal coatings are often the preferred choice when the PCB will be exposed to extreme temperatures, from -40 °C to 160 °C. Silicones also have good solvent resistance that makes them difficult to repair and remove. They are cured by heat, moisture, or ultraviolet (UV) lamps. Although silicone coatings are impermeable to liquid water, vapors can still penetrate. Thus PCBs must be thoroughly cleaned to prevent vapor from being drawn through the conformal coating.

UV Curing Conformal Coatings

UV -curing compounds are preferable when rapid processing is a concern. After exposure to a UV lamp, the conformal coating cures in 15 to 20 seconds. UV lamps are also more energy efficient and adaptable than other curing technologies. Large components may require a secondary curing mechanism if the light is unable to reach all of the conformal coating. These coatings offer quality abrasion and temperature resistance, while solvent resistance is determined by the choice of conformal coating material. Despite their higher initial cost, UV-curing conformal coatings improve productivity due to higher efficiency and quicker throughput.



UV-curing conformal coating with a Dymax BlueWave

Conformal Coating Comparison Chart

Type	Moisture Protection	Debris Protection	Chemical Protection	Ease of Application	Ease of Removal/ Repair	Cure Time
Acrylic	+	+	-	+	+	+
Urethane	+	+	+	+	+	-
Silicone	-	+	+	+	-	+/-
UV Curing	+	+	+	-	-	+

Dispensing and Application

Processing volume, factory floor space, manual versus automated application, and capital investment are all important factors when it comes to selecting the method in which to apply conformal coatings.

Brushing Application

A low-cost, manual method ideal for small production volumes. Brushing requires a skillful operator to manage quality control.

Dipping Application

A simple method that coats all board surfaces simultaneously and is ideal for heat or UV-curing materials. Dipping requires significant masking and can have issues with uniformity, runoff, and contaminants.

Application Comparison Chart

Brush

+ Inexpensive
+ Little to no masking
- Labor intensive (bad for high volumes)
- Accuracy & uniformity issues

Manual Spraying

+ Inexpensive
+ Good for high volumes
- Needs a skilled operator
- Multiple applications are often necessary

Dipping

+ Fast application & easy to operate
+ Coat multiple PCBs at one time
- Requires significant masking
- Accuracy & uniformity issues

Automated Spray

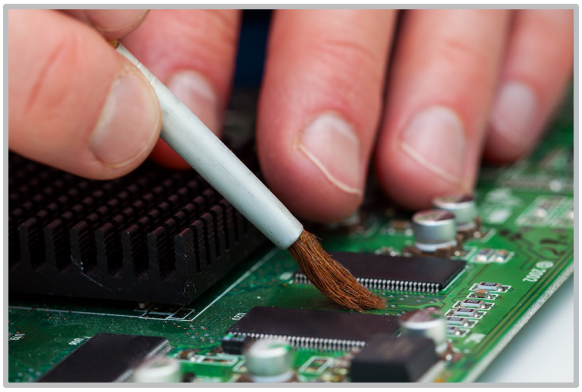
+ Excellent for high volumes
+ Very accurate
- Significant initial costs
- Robot maintenance

Manual Spraying Application

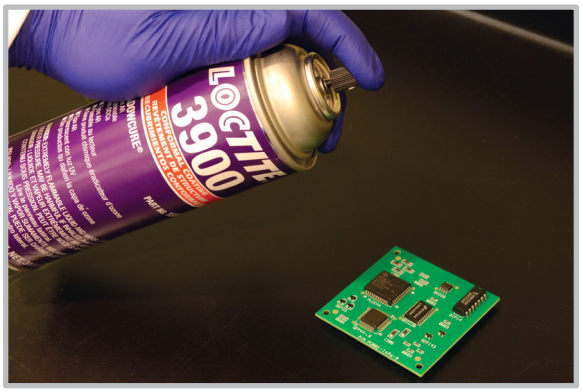
While a skilled operator is needed, manual spraying requires less masking than the dipping process and supports a variety of application resolutions and patterns. However, components often require multiple applications to achieve uniformity.

Automated Spraying

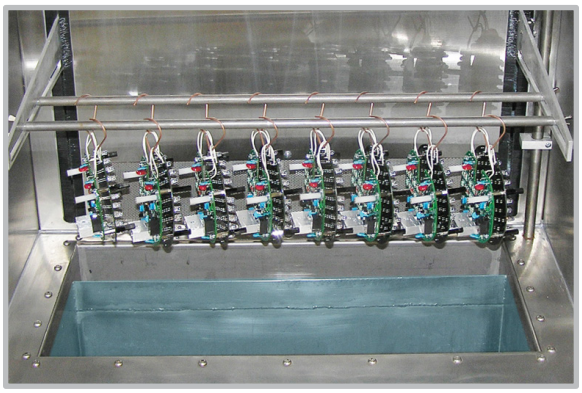
Considered the apex of conformation coating technology, automated spray works best for high volume, high-precision applications with little masking and controllable, repeatable processing.



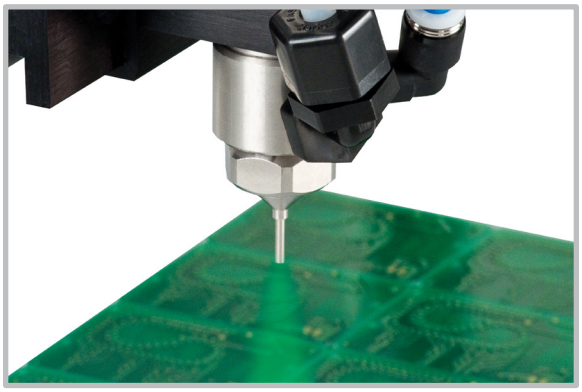
Manually applying a conformal coating with a brush.



Spraying an aerosol conformal coating on a PCB.



Dipping PCBs in a conformal coating (photo provided by Humiseal).



An automated Fisnar robot applying conformal coating.

When selecting a conformal coating, there are four simple questions begin with:

1. What will the PCB need to protect against?
2. What is the volume being produced?
3. Is rework required?
4. Are industry qualifications required (UL, MIL, IPC, IEC, etc.)?

If these or other questions are difficult to answer, Ellsworth Adhesives is available to assist with any and all conformal coating and PCB applications. Finding the best chemistry and application combination produces reliable devices, lowers costs, creates efficiencies, and develops a loyal customer base.

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