# Conforming to a higher standard of reliability

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An electronic product's reliability has the potential to make or break its manufacturer and can be life-threatening in many safety critical applications. Conformal coatings have long been used to protect electronic assemblies from their operating environment but can vary hugely in their protective performance.

It is the objective of this article to explain in detail why it is important to qualify coating products to the relevant standards and how different coating types affect performance.

**What is conformal coating?**

A conformal coating is a 25-75µm thick (50µm typical), protective plastic membrane (polymer film) that adheres to an assembled PCB by literally ‘conforming’ to its varied profile. Its primary function is to protect PCBs used in hostile or harsh operating environments. By being electrically insulating, it maintains long-term surface insulation resistance (SIR) levels and thus ensures the operational integrity of the assembly. It also provides a barrier to air-borne contaminants from the operating environment, such as salt-spray, thus preventing corrosion.

Classic application examples include high reliability defence, automotive and aerospace, where coatings are used to protect against various combinations of moisture, aggressive chemicals and vapours, salt sprays, large temperature variations, mechanical vibration, and even organic attack (e.g. fungus).

The protective nature of conformal coatings, however, means that they not only protect, but also serve to enhance product reliability and thereby reduce the potential cost and damaging effects of early field failures.

As such their use is becoming increasingly common in consumer and domestic applications that can be susceptible to environmentally-induced field failure; including portable devices comprising fine pitch, densely populated assemblies, such as mobile phones, through to washing machines and televisions.

**CONFORMAL COATING STANDARDS AND PRODUCT QUALIFICATION**

The physical characteristics of any conformal coating must meet strict minimal standards. The most commonly used are IPC-CC-830 (intended to supersede the old US military MIL-I-46058 spec – see later), IEC-1086, and UL approval.

For a coating material to be ‘qualified’ to these standards, it has to meet (or ideally exceed) a plethora of detailed electrical and physical technical performance parameters. These include its dielectric constant, dielectric breakdown voltage, dielectric withstand voltage, insulation resistance, moisture insulation resistance, long-term hydrolytic stability, fungus resistance and continuous use temperature range (ºC).

In addition to the mandatory requirements, the coating must have other properties to ensure it can be successfully suitable for use as a conformal coating. These other properties include Thermal Coefficient of Expansion (ppm/ºC), Young’s Modulus (MPa), Chemical Resistance, Ease of application and or rework and Convenient cure times, to name but a few.

**IPC-CC-830 AND IEC-1086**

While the IPC (the US electronics industry standards body) IPC-CC-830 specification is a US-based standard, it is commonly used in Europe. The IEC-1086 specification is an International specification, but is less commonly used than CC-830 standard.

**THE MIL-I-46058C SPEC**

The MIL-I-46058 is the grandfather specification of all conformal coatings standards. It was first introduced in the 1960s and has been revised several times since to keep it updated.

One of its most important requirements is that for a conformal coating material to be qualified, it has to be independently examined and tested by an authorized test laboratory. At the present time, however, there are moves to permit self-certification as commonly referenced national-based standards. Examples include specifications set by the IPC, the British Standards Institute (BSI), AFNOR (France), DIN (Germany), and JIS (Japan).

One potential drawback of this development, however, is that for these national-based standards it is generally a requirement for the conformal coating manufacturer itself to perform the necessary qualifications testing on its own product, instead of submitting it to an accredited laboratory.

As a result of this ‘loosening’ of requirements, it is common to see variously phrased claims that attempt to falsely associate materials with certain standards. Prime examples include phrases such as: “meets the requirements of”, “approved to”, or “meets or exceeds”. These words can be misleading. Either a product is qualified or it is not, and any statement that does not make this clear, should be regarded with caution.

**UL APPROVAL**

A further mandatory approval in the US is that of Underwriters Laboratories (UL). To gain UL-approval, the electronics manufacturer has two choices. The first is to manufacture the end product entirely and submit it for independent testing (with the risk that if the product fails, the manufacturer will have to determine why and correct the problem). The alternative approach (which is the far more common) is to select all components, down to the last nut and bolt that are UL-approved. In this way, the end product will no longer have to be subjected to the rigors of UL-approval testing beyond passing certain minimum safety evaluations.

**TESTING THE RELIABILITY OF CONFORMALLY COATED ASSEMBLIES**

While a conformal coating acts as an effective barrier to external contaminants, it will also seal in contaminants left on a board at the time of coating. It should therefore never be regarded as a robust insurance policy against potential future reliability problems. With the right coating material, the probability of the material itself having failed is extremely unlikely and is far more likely to be due to undesirable 'synergistic' reactions between various other process chemistries and build materials, and the cleanliness of the assembly before the application of the conformal coating.

After the assembly process, a host of residues can be present on a board, especially during a no-clean process. If the contaminant on the board prior to coating is soluble, it can repetitively dissolve and crystallise after coating (between the coating and the substrate) as moist air penetrates and then dries out over time. The contaminant is usually a salt and will combine with humidity to produce an osmotic pressure (pumping action) which can compromise the protective abilities of the coating by promoting coating delamination and subsequent corrosion in the blistered area under the coating.

This degradation can be made worse if moisture penetration reacts in unpredictable ways with assembly materials and residues left on the board after production (including oily organic particulates left by any form of manual handling). Ionic contaminants on insulation surfaces are particularly damaging, and can compromise electrical contact of in-circuit test probes, cause electrical leakage and corrosive degradation of the circuit elements, ultimately leading to assembly failure.

Ionic contamination will also cause 'mealing' of conformal coatings that is cosmetically unattractive, but will also result in rejection of the completed assembly under most supply contracts. Prime sources of ionic contaminants include rosin flux residues, acidic grime

(perspiration and fingerprint residues from manual handling), and previous chemical processing steps such as etching or plating. Whilst rosin itself is non-ionic, it should be removed since it partially encapsulates ionic residues from flux activators.

It is vital to perform accelerated life testing of the end product after coating to ensure field reliability. Ionic contamination can be measured using a range of Ionic Extract testing techniques (ROSE or SEC), to determine the amount of ionic contamination remaining on an assembly after various manufacturing procedures.

The coating must also be electro-chemically compatible with the substrate and its components upon which it is applied. It must not soften plastic cases or remove (or blur) markings. Some materials can affect the bond between the coating and the assembly, inhibiting or extending the cure period. It is strongly recommended that the user run a series of compatibility tests with the pre-production assembly and the planned coating material. Part of these tests should include long-term Surface Insulation Resistance (SIR) analysis on representative coupons of your end product, that have been assembled under factory conditions, conformally coated and de-masked. This helps ensure there are no electrochemical compatibility issues between various assembly chemistries and materials (ie. solder resist, flux, adhesives and cleaning agents) that could cause unexpected long-term reliability problems.

**IN SUMMARY**

Choosing the right conformal coating and application process isn't easy, and there is no such thing as a 'perfect' conformal coating product.

Time and effort invested in getting it right can be amply rewarded by the near elimination of end product failures in the field. These failures and/or recalls can be the most expensive, reputation damaging and dangerous problems a company will ever experience. In short, if you have to conformally coat your boards, you have to get it right. But when you do: you protect your customers and your profits.

-Ends-

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