Conformal Coating Testing at Vendor Level

Debora L. Obitz, Senior Engineer
Trace Laboratories-East
Vice Chair of the IPC-CC 830 Conformal Coating Task Group
410-584-9099

Conformal Coatings are subjected to a wide array of both short and long term testing before their arrival at the assembler/user. This paper will familiarize you with these tests and associated usefulness and shortcomings.

As an overview, it is worth mentioning that the current industry accepted document for Qualification and Performance of Electrical Insulating Compounds for Printed Board Assemblies is IPC-CC-830B. It should also be noted that, although the military coatings document (MIL-I-46058) is being phased out, it is still recognized by many users and OEMs. For this reason, IPC-CC-830B recognizes that any coating "presently qualified to the MIL-I-46058 shall also be recognized as meeting the requirements of IPC-CC-830. These products currently qualified or in the process of being requalified to MIL-I-46058 before the publish date of this document will also be recognized as meeting the requirements of the IPC-CC-830".

Conformal Coatings are classified into types based upon their cured chemistry. Coatings can be classified individually or as a blend, in accordance with the following categories:

- Type AR – Acrylic
- Type ER – Epoxy
- Type SR – Silicone
- Type UR – Polyurethane
- Type XY – Paraxylene

Additionally, testing requirements are based on the above classifications.

The coatings are then further classified according to the functional capabilities of the individual coatings. The classes are identified as:

Class A – Non-hydrolytically stable conformal coating. Temperature and humidity aging test is not required for this class of product. Lower moisture insulation resistance is permitted.

Class B - Hydrolytically stable conformal coating. Temperature and humidity aging test is required for this class of product. Higher moisture insulation resistance is required.

Coatings are formally qualified in accordance with Table 3-1 Requirements for Qualification, Qualification Retention and Quality Conformance of Conformal Coating

Products. For clarity purposes, tests are discussed the in the order that they appear in Table 3-1 of the document.

Materials
The materials, which are components of the conformal coating, are to be free of deleterious (harmful/poisonous) substances. The MSDS sheets are to be supplied to insure that this requirement has been met.

Shelf Life
Shelf Life is performed to verify coating performance after long-term storage (typically six months in a controlled environment). Shelf Life parameters (storage and test) are determined by the coating supplier. Typically, Insulation Resistance and Dielectric Withstanding Voltage testing is performed as part of the Shelf Life requirement. The coating is stored as produced and unopened until test.

Cure
The inspection conducted is performed on the conformal coating in the cured state. The cured conformal coating must exhibit all desired properties when the coating has been prepared using the specific instructions outlined by the conformal coating supplier. These instructions will state the mixing ratio (if applicable), application method(s), time(s), and temperature(s) in order to achieve the desired cure of the conformal coating.

Fourier Transform Infrared Spectroscopy (FTIR)
The Fourier Transform Infrared Spectrometer (FTIR) is performed to obtain a “fingerprint” of the submitted conformal coating during initial qualification. The FTIR collects and processes infrared wavelength absorbance/transmission spectra. Infrared spectra indicate the chemical composition and/or bonding of organic, polymeric, and many inorganic substances.

The spectrometer radiates a broad band of infrared light through the conformal coating. Depending on the chemical bonding, individual materials will absorb, transmit, or reflect infrared light of various wavelengths. Information about chemical bonding is obtained from the locations of groups of frequency peaks within the spectra. Most spectra contain additional “fingerprint” peaks that are unique to a particular molecular structure.

Viscosity
Viscosity of uncured conformal coating materials, except type XY, shall be measured per ASTM-D-10804 and the test conditions shall be defined by the coating manufacturer. Viscosity shall be measured as part of data gathering for the conformal coating during qualification inspection. This viscosity data shall be used by the manufacturer to pre-determine an acceptable viscosity range for quality conformance inspection.

A T-F (T-bar) spindle is attached to a viscometer. The viscometer is leveled and its display zeroed. The T-bar spindle is then positioned above the center of the conformal

coating and inserted to a depth of one inch. Rotation is begun at 5 rpm. The viscosity is recorded after two revolutions.

Appearance
Appearance is performed on four coated glass plates. These specimens are inspected with 1.75X magnification (referee with 10X) for smoothness, homogeneousness, and transparency of the coating. The coating is also inspected for bubbles, pinholes, blisters, cracking, crazing, peeling, wrinkles, mealing, and/or evidence of reversion or corrosion.

Fluorescence
Fluorescence is performed by coating four copper clad laminates. The specimens are subjected to ultra-violet illumination (black light) and visually inspected for fluorescence. Types SR and XY are exempt due to their chemistry.

Fungus Resistance
Fungus Resistance is performed to determine the resistance of the coating to fungi under conditions favorable for their growth; namely high humidity, warm atmosphere, and the presence of inorganic salts.

The test coating is applied to four glass specimens using the vendor's specified application and curing requirements.

Aspergillus niger, Chaetomium globosum, Gliocladium virans, Aureobasidium pullulans, and Penicillium funiculosum are grown on nutrient salt agar for approximately two weeks before preparing a mixed spore suspension. Once the spores have reached two weeks maturity, they are scraped from the surface of the agar and are cleansed (three times) with sterile water followed by a final rinse in sterile mineral salts solution. The spores are mixed together into suspension and sprayed onto the surface of the test coating. After the coated test specimens (and cotton duck control specimens) are sprayed they are placed in a test chamber maintained at 28 to 30°C, 85% minimum relative humidity, for 28 days. The specimens are removed and visually examined for fungal growth or degradation of the conformal coating.

Flexibility
This flex test is performed to insure that the conformal coating will not crack or craze when the coating is exposed to flexing. The test is performed on four conformally coated tin panels. The coated tin panels are placed on a flat and smooth testing surface (such as a granite surface plate. One side of the panel is fixed so that it will remain in a stationary position during testing. A 0.3 cm (0.12") diameter mandrel is placed in the center of the coated tin panel. One end of the panel is selected and then bent, within one second, 180° around the mandrel. The specimen is then visually examined using 10X magnification for evidence of cracking or crazing of the cured conformal coating.

Flammability

Flammability is performed in accordance with UL94 HB (horizontal burn) on twenty laminate specimens 13mm X 130mm which have been coated with the test coating. The specimens are marked with two lines perpendicular to the longitudinal axis. One line is located at 25 ±1 mm and the other at 100 ± 1 mm from the end that is to be ignited. The specimen held in place at the end farthest from the 25 mm mark. The longitudinal axis is horizontal and the transverse axis is at an angle of 45 ± 2. A 20 ±1 mm high methane flame is applied to the lowest end of the specimen. The burner is positioned so that the flame impinges on the free end (lowest end) of the specimen to a depth of 6 ±1mm for 30 ±1 seconds. After 30 seconds, the flame is removed and the specimen is allowed to burn to the 25 mm mark. As soon as the flame reaches the 25 mm mark, a stopwatch is started. When the flame reaches the 100 mm mark the stopwatch is stopped and the burn rate is recorded.

The calculation for the linear burn rate, V, in mm/minute is as follows:

$$V = 60\ L/t$$

Where:

V is the linear burning rate in mm/minute
L is the damaged length, in mm
t is the time, in seconds

The requirements for HB flammability of coatings are as follows:

- Not have a burning rate exceeding 40 mm per minute over a 75 mm span for specimens having a thickness of 3.0-13 mm or
- Not have a burning rate exceeding 75 mm per minute over a 75 mm span for specimens having a thickness less than 3.0 mm, or
- Cease to burn before the 100 mm reference mark

Dielectric Withstanding Voltage

Dielectric Withstanding Voltage is performed to prove that the coated printed circuit board will operate at its rated voltage, as well as, determining that the coating is adequate during voltage applications. The test is performed on five coated IPC-B-25A boards. Insulated wires are attached to the finger tabs of the “D” pattern. A test voltage of 1500 VAC is applied in increments of 100VAC per second and held for one minute. The leakage current is monitored during testing. The specimens shall not exhibit sparkover, flashover, or breakdown during testing. Their leakage rate shall not exceed 10 microamperes.

Moisture and Insulation Resistance

Moisture and Insulation Resistance is performed to evaluate, in an accelerated manner, the resistance of materials to the deteriorative effects of high temperature/humidity conditions (typical of tropical environments). Test specimens utilized for Insulation Resistance testing (same as above) are subjected to cyclic temperatures of 25°C and

65°C with 85% minimum relative humidity. The specimens are electrically biased with 50 VDC while inside the test chamber. The bias is removed before taking measurements inside the test chamber. A test voltage of 100 volts is applied to each of the individual test points 1-2, 2-3, 3-4, and 4-5 for one minute before obtaining the insulation resistance measurement.

The specimens are placed in an oven maintained at 50 ± 2°C for 24 hours. The specimens are cooled to ambient conditions of 25°, +2, -5°C with 40-50% relative humidity prior to obtaining initial insulation resistance measurements. Electrical measurements are also taken during exposure inside the test chamber and are measured at the first, fourth, seventh, and tenth cycles (during the high phase of each cycle). Upon completion of accelerated cycling (20 cycles), the boards are maintained at 25°, +2, -5°C with 40-50% relative humidity and insulation resistance measurements are obtained within 1-2 hours of removal from the test chamber. The specimens are then held for an additional 24 hours at ambient test conditions of 25°, +2, -5°C with 40-50% relative humidity and the final insulation resistance values are then obtained. The initial requirements established for Appearance and Dielectric Withstanding Voltage criteria must then be met.

Thermal Shock

Thermal Shock is performed to determine the physical endurance of applied coatings to sudden changes of temperature. Testing is performed on five coated IPC-B-25A boards. The boards are placed in a thermal shock test chamber and the parameters are set. Normally the coatings are tested for 100 cycles at -65°C to 125°C with dwell times of 15 minutes at each temperature extreme. The transfer times are typically two minutes maximum. Following the test exposure, the boards are removed and maintained at 25° ±5°C with a relative humidity of 50 +5% for 24 hours. The initial requirements established for Appearance and Dielectric Withstanding Voltage criteria must then be met.

Hydrolytic Stability

Temperature and Humidity Aging (Hydrolytic Stability) is performed to determine the resistance of the applied coating to reversion when exposed to high temperature/humidity, and storage conditions. This test is limited to Class B products.

It should be noted that limitations in the design of the IPC-B-25A test vehicle prohibits proper placement (and soldering) of necessary component resistors for testing. For this reason, use of the IPC-B-25A board is normally bypassed for the military y-pattern currently applicable in the MIL-I-46058. Five y-patterns with standard test resistors (one containing color bands and one containing numbers) are soldered into the appropriate areas are coated and utilized for testing. One specimen is used as a control and is maintained at 25° ±5°C with a relative humidity of 50 ±5%. The remaining four specimens are subjected to 85°C with a relative humidity of 98% maximum for 120 days. Specimens are visually examined after 28, 56, and 84 days of exposure. It is critical to note that specimens must be stabilized for a minimum of two hours at 25°C,

50% relative humidity before each inspection interval. After 120 days, specimens are removed from the humidity environment and maintained at 25° ±5°C with a relative humidity of 50 ±5% for seven days. The specimens are examined for tackiness, softening, chalking, blistering, and loss of adhesion or reversion. The clarity of the coating shall remain suitable for viewing the identification marks and color codes of the resistors.

Other tests not included in Table 3-1:

Coating Thickness

Coating Thickness is measured on four coated glass plates or copper clad laminates. The coating thickness is measured in accordance with ASTM-D-1005 (Standard Test Method for Measurement of Dry Film Thickness of Organic Coatings Using Micrometers) or by standard laboratory micrometer. Thickness requirements are based on type and are as follows:

Type AR (Acrylic) shall be 25-75µm
Type ER (Epoxy) shall be 25-75µm
Type SR (Silicone) shall be 50-200µm
Type UR (Polyurethane) shall be 25-75µm
Type XY (Paraxylene) shall be 12.5-50µm

This concludes the testing for the current IPC-CC-830B. I hope that I have provided some insight into the rigorous testing conformal coatings have endured before their purchase.

Finally, there are several points of interest regarding IPC-CC-830B and the committee responsible for its content:

The coating committee (5-33a), during review of the current specification as well as previous specifications, has a number of requests to incorporate the addition of the Adhesion test.

Adhesion is mentioned in IPC-CC-830B, section 6.5 and is to be determined between the vendor/assembler and assembler/user. Adhesion has not been adopted as a qualification test because of its poor reproducibility and reliance on the “human element”. However, it can be an effective test at user level, when parameters can be agreed upon between vendor and user.

The committee has also listed the information constituting a formulation change and therefore requires that the coating under go qualification testing.

These coatings, which fall into this category, will require a new name or product designation. The change must be obvious to the customer and the coating must undergo initial qualification testing. The original formula results cannot be issued for the new formulation. The following constitute a formulation change and require initial qualification testing:

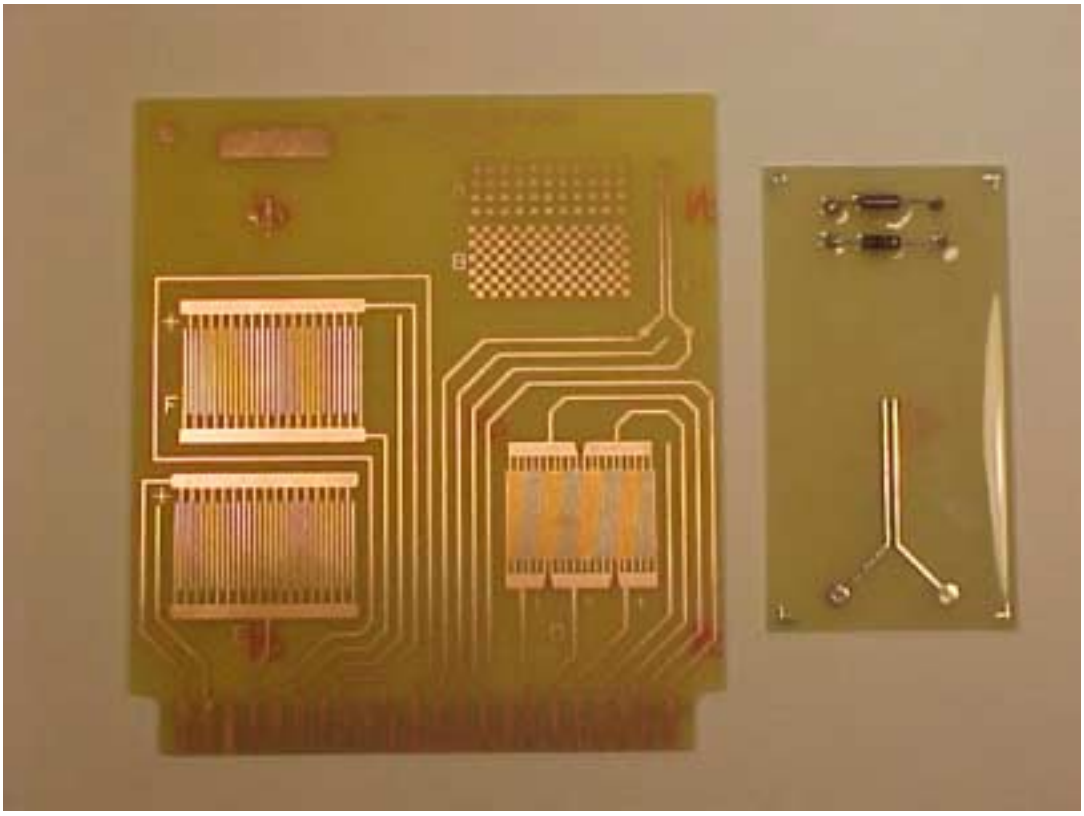
- Changes exceeding ±2% in the formula weight of any nonvolatile ingredient from the ingredient's original formula weight.
- Addition of elimination of any nonvolatile ingredient.
- Changes in type or dye of pigment
- Addition, deletion, or change in composition of "inert" materials in the formulation.

Keep in mind that it is extremely important that the properties of the coating remain consistent from lot to lot. Small changes in the coating material can have dramatic effects on certain properties (such as flammability, adhesion, etc.) These could create unwarranted changes during application and performance in the end use environment. Therefore, it is of the utmost importance to maintain consistency of each batch/lot, and if a change has been made that the user be informed of any changes.

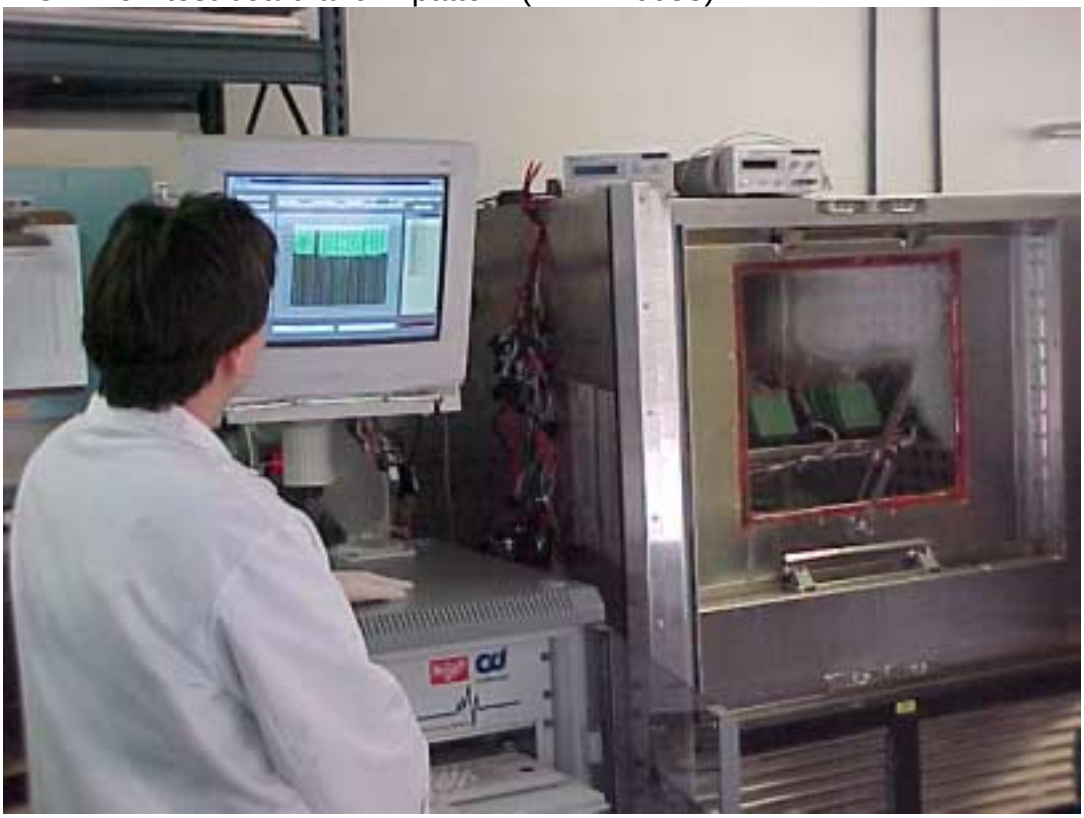
In closing, I should note that although materials-level specifications such as IPC-CC-830B provide a solid baseline for purchasing product, they cannot guarantee performance or compatibility with all applications. That said, it is critical that product be, at a minimum, screened at user level.

References

IPC-TM-650
IPC-CC-830B
MIL-I-46058C, Amendment 7



IPC-B-25A test board and Y-pattern (MIL-I-46058)



Moisture and Insulation Resistance Testing

Thermal Shock Testing