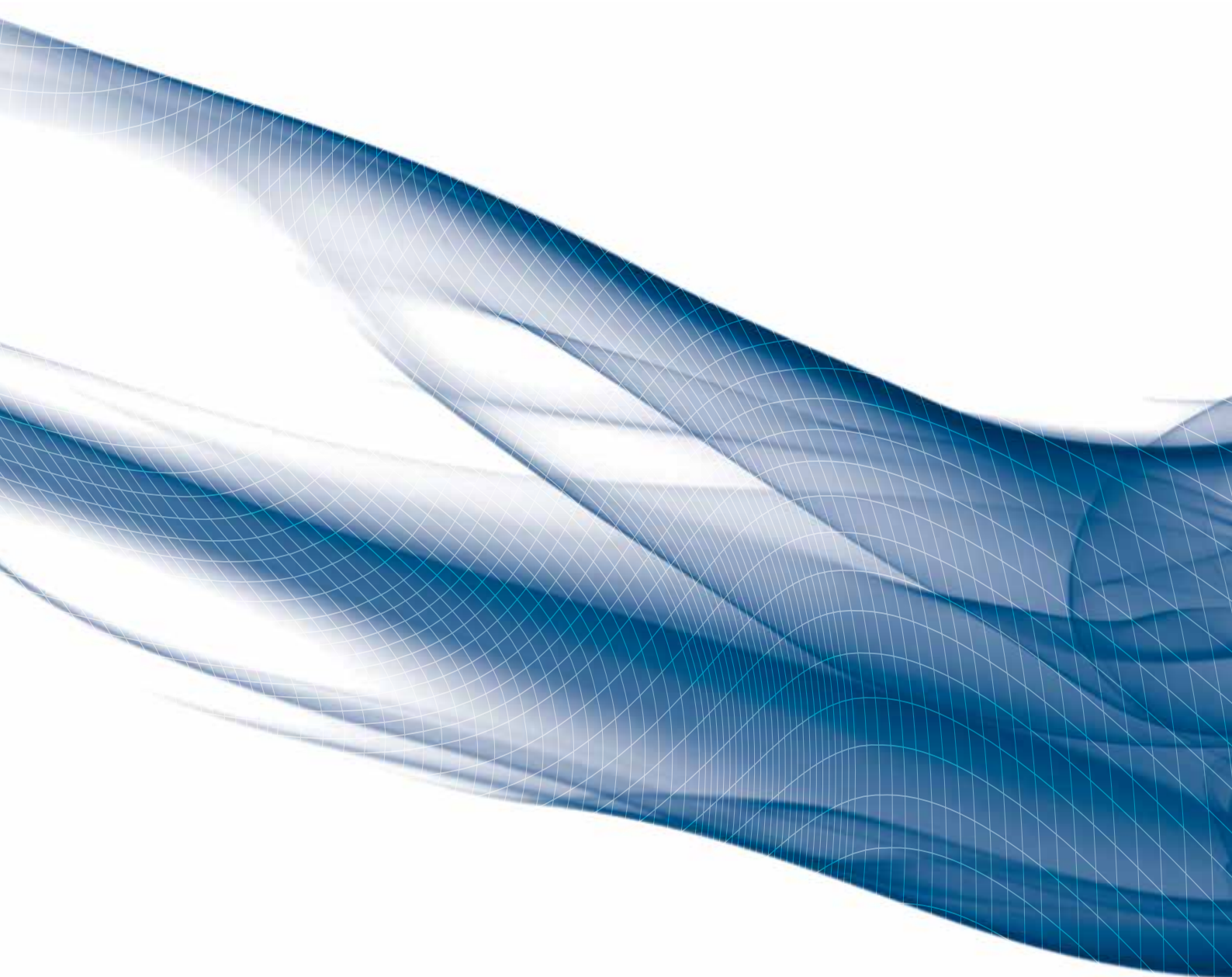


Conformal Coatings

Enhanced protection for enhanced PCB performance



ELECTROLUBE
THE SOLUTIONS PEOPLE

Conformal Coatings



- UL, MIL and IPC-CC-830 approved
- Solvent removable and solvent resistance coatings
- Acrylic, Silicone, Polyurethane and Hybrid Materials
- UV cure and water-based options available
- UV trace to aid inspection
- Thinners and masking products

Conformal coatings are designed to protect printed circuit boards and related equipment from their environment. Typically applied at 25-75µm, these coatings ‘conform’ to the contours of the board allowing for excellent protection and coverage, ultimately extending the working life of the PCB.

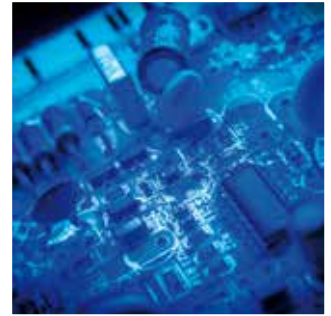
The use of conformal coatings is particularly important in automotive, military, aerospace, marine, lighting, industrial and green energy applications. Due to the rapid expansion of the electronics industry, conformal coatings are also finding their way into the domestic and mobile electronics industries, providing the necessary combination of high performance and reliability within a vast array of electronic devices.

Conformal coatings can be used in a wide range of environments to protect printed circuit boards from moisture, salt spray, chemicals and temperature extremes in order to prevent corrosion, mould growth and electrical failures, for example. The protection provided by conformal coatings allows for higher power and closer track spacing, in turn enabling designers to meet the demands of miniaturisation and reliability.

Electrolube is among the world’s foremost experts in the formulation and application of conformal coatings designed to meet international approvals (including European and American military specifications). The range of products currently available comprises acrylics, silicones, polyurethanes, hybrid chemistries and environmentally friendly options.

Electrolube can offer both transparent and pigmented coatings to improve or camouflage the appearance of printed circuit boards. The range also includes a number of ancillary products to complement the use of our conformal coatings, including thinners and removers, peelable coating masks and thixotropic materials for dam and fill applications.

Selection and Best Practice



In order to achieve the best performance, it is imperative that the most suitable coating and application methods are chosen. The main considerations during this selection period are:

Application Method

Conformal coatings can be applied via spray, dip or brush methods either by manual or automated application. Products are available in bulk, aerosol and small packaging sizes, therefore the correct method and conditions should be assessed for each application. Careful consideration of the advised humidity and temperature conditions for the selected coating should be taken for both application and curing stages.

As well as working with a number of local and international equipment suppliers to apply conformal coatings, Electrolube also offer a range of water and solvent-based cleaning products to ensure all corrosive residues are removed from the printed circuit board prior to conformal coating application. Electrolube therefore offers superior technical support in ensuring the correct application parameters are identified. Please contact us for further information where required.

Operating Environment

The coating must be suitable for use under the required operating conditions. Technical data is provided based on a range of internal and external tests according to international standards. Tests must also take place to ensure that the coating retains all the required properties throughout the duration of use. This is due to the differing conditions exhibited as a result of varying PCB materials and designs.

Electrical Requirements

Conformal coatings form a protective, insulating layer. The most common electrical parameter tested is the Surface Insulation Resistance (SIR). This measurement is often taken before and after coating and exposure to harsh conditions, thus ensuring the coating continuously provides the level of insulation required. The coating should also exhibit high dielectric strength; the minimum required can be determined from the inter-track separation and the potential difference between adjacent tracks.

Board Layout

The design of the board should include consideration of the placement of components that should not be coated. Selective spray equipment or the application of a peelable coating mask can be used to help avoid such areas. Alternatively, gel materials can be used to form a 'dam' to contain the coating and avoid capillary effects transferring material to unwanted areas, such as connectors.

Rework and Repair

If the assembly requires repair then consideration must be given to the ease of removal of the coating. Electrolube offer products for the effective removal of conformal coatings, including those that are solvent resistant.



Coating Options

ACRYLIC	HPA, APL, TFA, AFA
MODIFIED SILICONE	DCA – SCC3 Range, LFCC, FSC, FSCP
POLYURETHANE	PUC, PUCAF
WATER-BASED	WBP, WBPs
UV CURE	UVCL

Electrolube offer a range of conformal coatings including solvent-based, hybrid chemistries and environmentally friendly products. The most widely used materials are historically solvent-based, the benefits of which include:

- Ease of processing and application
- Simple viscosity adjustment
- Suitability for a range of application methods
- Tailored application and cure

VOCs – The Need for Change

- Volatile solvents used in conformal coatings are classed as VOCs (Volatile Organic Compounds).
- VOCs contribute towards the formulation of ground level ozone.
- Such pollution can have many detrimental effects on the environment, damaging forests and vegetation.
- In addition, some materials classed as VOCs can act as irritants and over exposure can lead to a variety of health problems.

VOC Definitions

EPA

'Volatile Organic Compounds (VOC) means any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate, which participates in atmospheric photochemical reactions.'

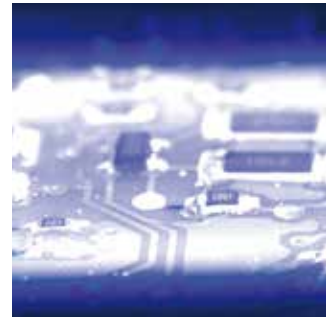
EU Solvents Emissions Directive

'Any organic compound with a boiling point less than or equal to 250°C at a standard pressure of 101.3 kPa.'

Previously the directive referred to the definition as 'Any organic compound, having at 20°C a vapour pressure of 0.01kPa or more, or having corresponding volatility under the particular conditions of use'.

As stated on the European Commission website, either method is suitable:

'The "boiling point approach" was adopted for Directive 2004/42/CE because during negotiations Member States were generally more in favour of this definition of VOCs than the "vapour pressure approach" definition in Directive 1999/13/EC. The main reason is that the boiling point of a substance is easier to identify (and presumably more data are available) than the vapour pressure at room temperature of the same substance. Nevertheless, the results of the two approaches for any one substance are, to the knowledge of the EU Commission, in most cases identical.'



Low VOC Alternatives

Products such as the Electrolube water-based coatings help to keep VOC levels to an absolute minimum without compromising on performance:

- WBP – Utilising hybrid technology, WBP offers the performance characteristics of a polyurethane coating, exhibiting excellent flexibility and solvent resistance. WBP is for dipping application methods.
- WBPs – Is based on the same chemistry as WBP but specifically designed for spraying applications.

In addition, Electrolube manufacture conformal coatings with alternative curing technologies, such as UVCL, a UV cure conformal coating that completely eliminates the use of VOCs.

Electrolube are continually developing ‘greener’ technologies, helping to minimise solvent emissions and their impact on the environment.

Investigation & Methodology

A coating needs to be exposed to a range of environments via appropriate test conditions to establish its performance range and limitations.

The ideal coating should offer a combination of:

- Good electrical properties
- Low moisture permeability
- Good physical characteristics
- Excellent adhesion to all board materials

Basic tests:

- Electrical performance and accelerated humidity testing.

Advanced testing:

- Severe conditions such as salt mist, temperature extremes or rapid environmental changes.

Approvals

The following Electrolube conformal coatings are approved to the standards listed:

- DCA (SCC3) – UL746, Def Stan 59/47
- TFA – IPC-CC-830, UL746
- HPA – MIL 46058-C
- FSC – IEC 61086
- UVCL – IPC-CC-830

Electrolube put all of their conformal coatings through the test conditions outlined in these specifications and therefore, many other coatings from the range also meet the requirements of these standards.

Performance Criteria

Environmental Testing



Environmental testing is essential to ensure the required level of protection is achieved. End-use conditions should be replicated or accelerated, however care must be taken to ensure accelerated tests are suitable for comparison with end-use conditions:

- Humidity Exposure and Salt Mist Testing
- Thermal Cycling, Shock and Aging
- These parameters are either tested individually or combined depending on the requirements

Environmental Cycling

Based on UL746 test methods, the following environmental cycling profile can also be utilised:

- 24 hours immersed in water, followed by
- 24 hours at 105°C, followed by
- 96 hours at 90%RH, 35°C, followed by
- 8 hours at -70°C – end of cycle
- 3 cycles



Humidity Tests

Humidity tests were carried out on comb pattern boards, similar to those in IPC-TM 650 2.6.3.4:

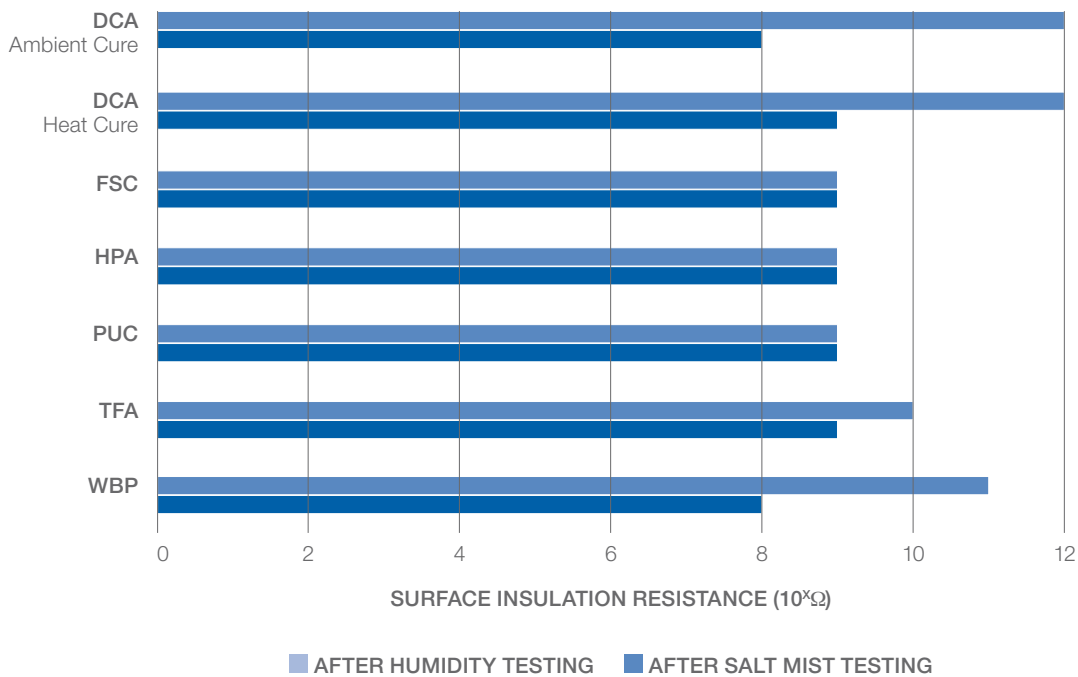
- 85-90% RH, 40°C, 50V DC, 168 hours

Salt Mist Tests

Salt mist tests were carried out in accordance with IEC 60068-2-11:

- 5% salt solution
- 35°C, 168 hours

Environmental Testing

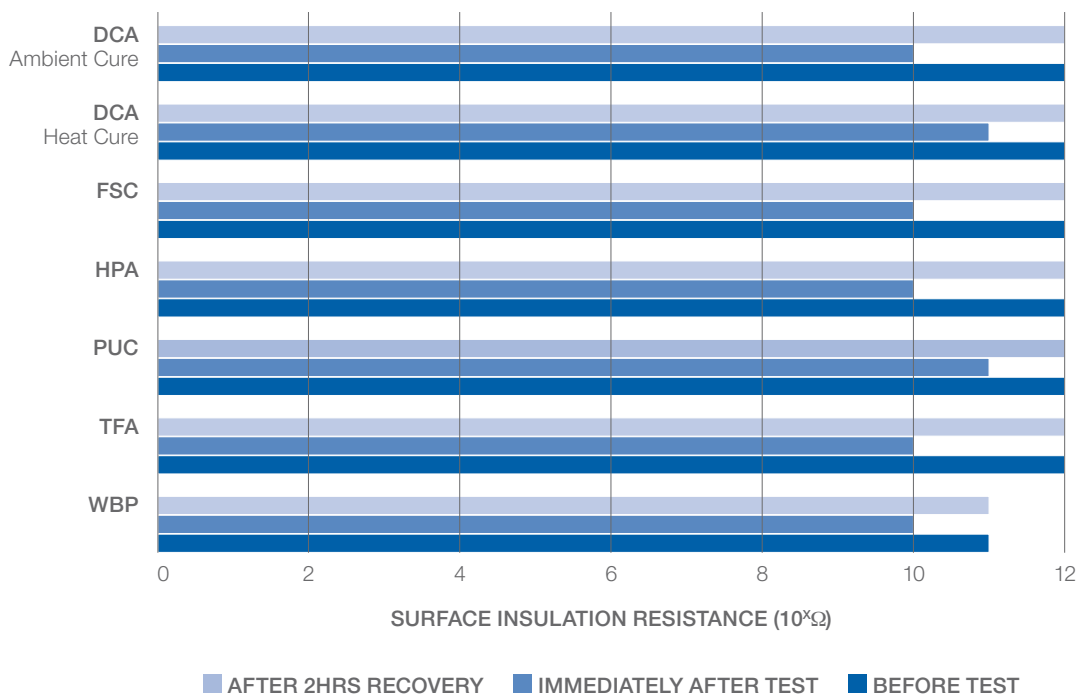




Corrosive Gas Testing

Corrosive gas testing involves exposing PCBs to a mixed gas environment combining hydrogen sulphide and sulphur dioxide – BS EN 60068-2-60, method 1.

Surface insulation resistance (SIR) was used to determine the performance of each coating in this environment:

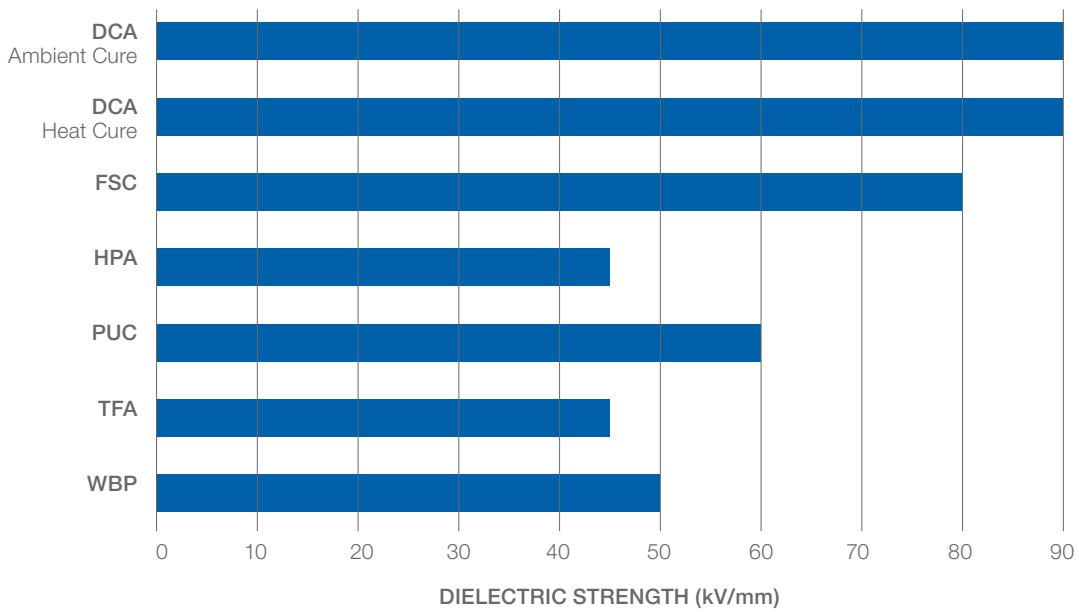
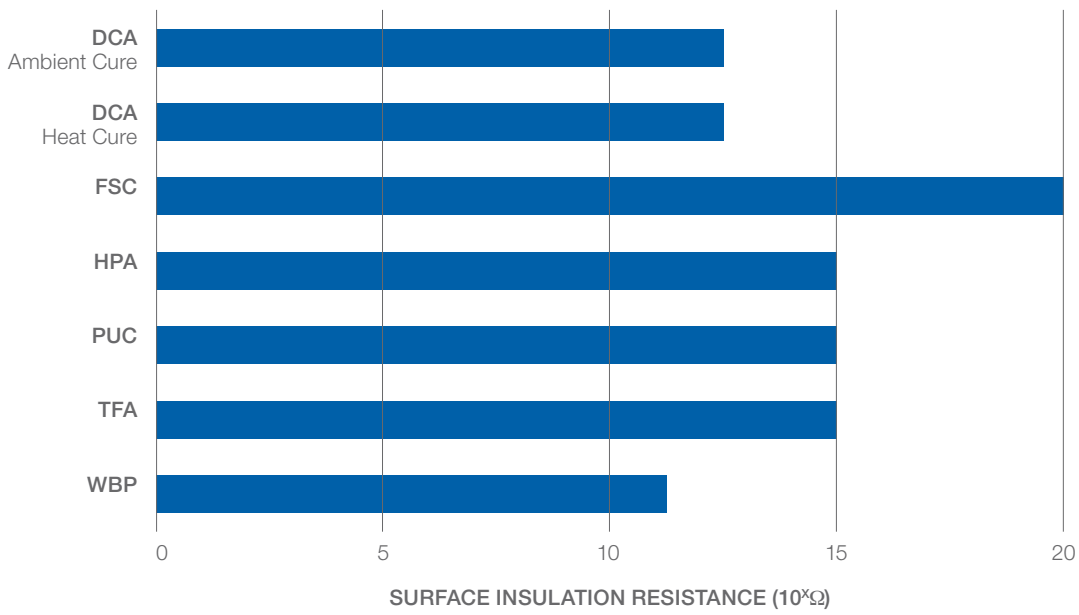


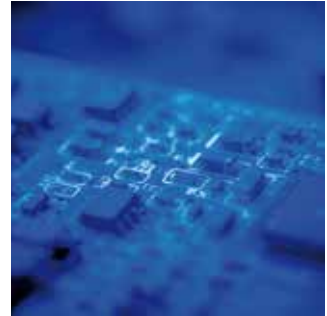
Electrical Testing

Evaluation of electrical properties is essential in all conformal coating applications. Some typical tests include:

- Dielectric Strength
- Dielectric Constant
- Dissipation Factor
- Surface Insulation Resistance
- Comparative Tracking Index (CTI)

Electrical Testing

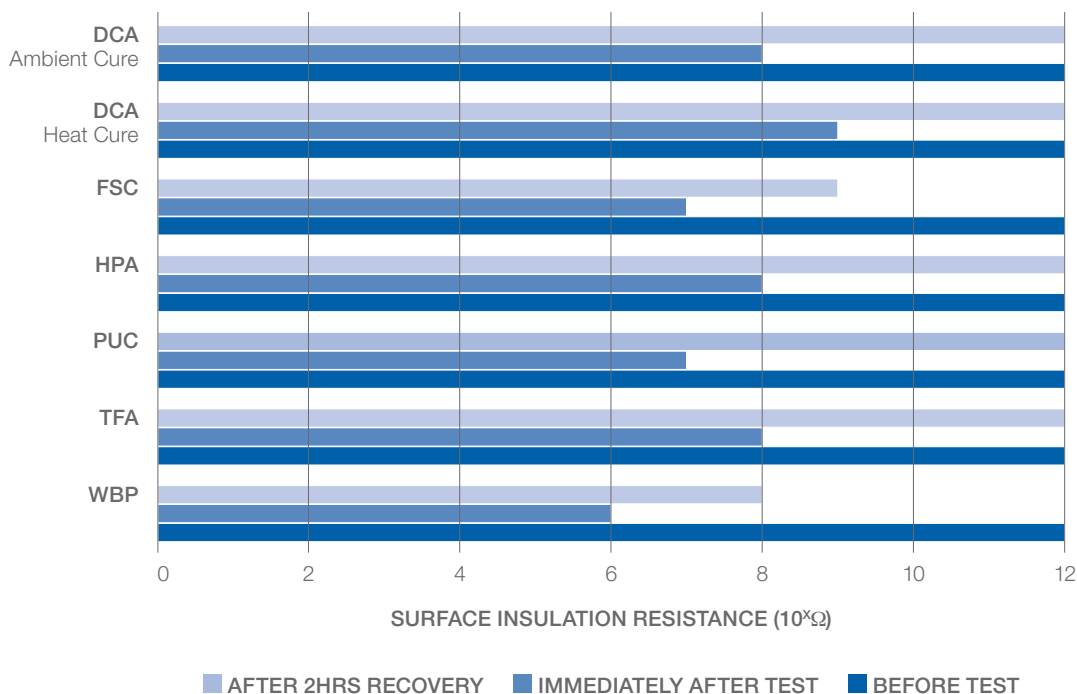




Water Immersion

Immersion in water is an extremely harsh test for a conformal coating to pass. Most coatings will resist immersion for short periods of time however prolonged exposure can highlight issues.

- Coated boards were immersed for 7 days and the SIR results compared.
- For continuous or frequent immersion in water we advise Electrolube Encapsulation Resins



Solvent Resistance

Solvent resistance tests can be carried out in accordance with IEC 61086-2. The performance of the coating will largely depend on the solvents used during the test. Those marked excellent will have a very high level of solvent resistance; Electrolube offer CCRG, a highly efficient coating remover for such products. Those marked 'good' have a reasonable solvent resistance to materials such as IPA but may be easily reworked with specialist products such as Electrolube ULS.

DCA Ambient Cure	GOOD
DCA Heat Cure	EXCELLENT
FSC	GOOD
HPA	GOOD
PUC	EXCELLENT
PUCAF	GOOD
TFA	GOOD
UVCL	BEST
WBP	EXCELLENT

Thermal Cycling



A thermal cycling profile was set up as per IEC 60068-2-14:

- -55°C to +125°C, 25 minutes at each temperature
- 12°C/min rate of temperature change
- 20 cycles

Coated tin, copper, aluminium and FR4 panels were subjected to the cycling and then tested for adhesion (BS EN ISO 2409) and flexibility (3mm mandrel – IPC-TM 650 2.4.5.1)

All Electrolube conformal coatings pass this test when applied to the substrates described above.

UV Resistance

Electrolube have carried out weathering resistance tests on a number of available conformal coatings. Tests were in accordance with ISO 4892, Part 3, Cycle 1: 'Plastics Methods of Exposure to Laboratory Light Sources' and carried out in a QUV SE Accelerated Weathering Tester. After 1000 hours exposure, the results indicated that Electrolube acrylic coatings, AFA, APL, HPA and TFA, have superior resistance to UV light, maintaining their clarity throughout the exposure testing.

Exposure intensities will vary depending on geographical locations and therefore it is important to establish the correct accelerated exposure time for your region. As an example, this test is roughly equivalent to 4 years weathering resistance in a typical Northern European climate.

The Product Range



DCA – SCC3 Conformal Coating

- High specification flexible modified silicone resin conformal coating
- UL746 approved
- May be ambient cured or heat cured for enhanced performance
- Excellent chemical and solvent resistance when heat cured
- May be soldered through for rework
- Extremely wide operating temperature range



DCA-FD – Fast-Dry DCA

- Touch dry in 20 minutes
- Higher solids content offering greater coverage
- Meets UL746 standard for conformal coating
- Excellent chemical and solvent resistance when heat cured
- May be soldered through for rework
- Extremely wide operating temperature range



DCR/DCRT/DCB

- Modified versions of DCA – SCC3 Range
- DCR is an opaque red version
- DCB is an opaque black version
- DCRT is a thickened opaque red product for covering difficult areas, such as lead ends
- Excellent for camouflaging commercially sensitive circuit board designs
- Meet UL746 standard for conformal coatings



AFA – Aromatic Free Acrylic Coating

- Excellent clarity, ideal for LED applications
- Free of aromatic solvents
- Meets UL746 and IPC-CC-830 industry standards
- Very fast touch-dry time
- May be removed with solvents such as Ultrasolve (ULS)
- UV trace to aid inspection



TFA – Toluene Free Acrylic

- Reduced hazard solvent-based acrylic coating, toluene-free
- Excellent clarity, ideal for LED applications
- IPC-CC-830 and UL746 approved
- Excellent protection in humid environments
- May be removed with solvents such as Ultrasolve (ULS)
- UV trace to aid inspection



HPA – High Performance Acrylic

- High performance flexible acrylic coating
- Approved to US MIL-1-46058C
- UV trace to aid inspection
- Excellent electrical properties
- Excellent clarity, ideal for LED applications
- May be removed with solvents such as Ultrasolve (ULS)



APL – Acrylic Protective Lacquer

- Excellent clarity, ideal for LED applications
- Offers excellent adhesion to all substrates
- Good temperature range and dielectric properties
- May be soldered through for rework
- UV trace to aid inspection
- May be removed with solvents such as Ultrasolve (ULS)



UVCL – UV Cure Conformal Coating

- VOC-free
- Exceptionally fast curing
- Low viscosity, ready to use for selective spray application
- Long shelf life
- Excellent flexibility, even after thermal cycling
- UV trace to aid inspection



FSC – Flexible Silicone Coating

- Solvent removable, modified silicone conformal coating
- May be removed with solvents such as Ultrasolve (ULS)
- High level of protection offered in humid environments
- May be soldered through for rework
- Very high surface insulation resistance
- Wide operating temperature range



WBP/WBPs – Aquacoat Plus

- Water-based coating, very low VOC content
- Excellent solvent resistance
- Resistance to mould growth
- N-Methyl pyrrolidone, isocyanate and phenol free
- Wide operating temperature range
- UV trace to aid inspection



LFCC – Lead Free Conformal Coating

- Compatible with lead free flux residues
- N-Methyl pyrrolidone, isocyanate and phenol free
- Wide operating temperature range
- UV trace to aid inspection
- Excellent electrical properties
- Excellent protection in humid environments



PUCAF – Aromatic Free Polyurethane Coating

- No aromatic content
- Fast touch-dry time
- Excellent adhesion to a wide variety of substrates
- Wide operating temperature range
- Resistant to mould growth
- UV trace to aid inspection



CPL – Clear Protective Lacquer

- General purpose coating for PCBs giving high quality glossy finish
- Ideal for protecting ferrous metals from corrosion
- Good resistance to humidity
- May be soldered through for rework
- No UV trace
- Also used as a top coat for protecting conductive lacquers



PUC – Polyurethane Coating

- Excellent abrasion resistance and mechanical strength
- Excellent adhesion under all climatic conditions
- UV trace to aid inspection
- High level of flexibility, even at low temperatures
- Excellent resistance to a wide range of chemicals and solvents
- Resistant to mould growth



TFCF – Fluorocoat Surface Modifier

- Thin-film coating, excellent coverage
- Reduces surface tension of substrates, protecting from a range of chemicals and solvents
- Superior moisture resistance
- Removed with light mechanical wear, allowing for assemblies to be coated without masking
- Ideal for connectors
- UV trace to aid inspection

Associated Products



The Safewash Range

- Water-based cleaning products for use before conformal coating
- Environmentally friendly
- Efficient removal of all flux residues
- Ensures cleanliness to military standards is achieved
- Products available for ultrasonic, spray under immersion and dishwasher application
- Products available for stencil cleaning and uncured adhesive removal



CCRG – Conformal Coating Removal Gel

- Thixotropic gel specifically formulated to remove Electrolube's solvent resistant coatings
- Allows localised removal of components
- Can be used in conjunction with RRS, Resin Removal Solvent for complete coating removal
- Water rinsable
- DCA, DCB, DCR, DCRT, DCE, WBP/S, PUCAF and PUC can be removed
- Does not contain methylene chloride



PCM – Peelable Coating Mask

- Flexible latex for masking components
- Manual removal, leaving no residue
- Solvent resistant and does not contaminate conformal coatings
- Dries at room temperature
- High film strength, does not break easily
- Can be accurately applied using automated dispensing machines



ULS – Ultrasolve Cleaning Solvent

- Allows efficient rework of solvent removable conformal coatings
- Excellent degreasing properties
- Fast evaporation
- Compatible with most plastics, rubbers and elastomers
- APL, FSC, HPA, AFA, TFA can be removed
- Available in bulk, aerosol and aerosol brush version



PCS – Peelable Coating Mask Synthetic

- Thermal cure
- Ammonia free – no odour
- Manual removal, leaves no residues
- Does not dissolve in solvents or contaminate conformal coatings
- Suitable for use with dip, spray or brush applied coatings
- Can be accurately applied using automated dispensing machines



HFFR – Hexane-Free Flux Remover

- N-hexane free
- Efficient removal of all flux residues
- Harmless to most plastics, rubbers and elastomers
- Leaves a perfectly clean, dry surface with no residue
- Fast evaporation
- Available in bulk, aerosol and aerosol brush version



IMC – Industrial Machine Cleaner

- Designed for general cleaning of automated dispensing equipment
- Ideal for cleaning selective spray equipment prior to and following the use of UVCL Conformal Coating
- Non-flammable
- Prevents machine blockages
- Low toxicity
- Very low vapour pressure

*Various sizes are available for most products, including bulk

Conformal Coatings

	DCA	DCB/DCR	FSC	WBP/WBPS	HPA	TFA	PUCAF	UVCL	TFCF
	Silicone Conformal Coating (SCC3)	Silicone Conformal Coating (SCC3)	Flexible Modified Silicone Coating	Aquacoat Plus/Sprayable	High Performance Acrylic	Toluene Free Acrylic	Aromatic-Free Polyurethane Coating	UV Cure Conformal Coating	Fluorocoat
Colours Available	Clear	Black/Red	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Viscosity (mPa s @ 20°C) (Bulk)	200	200/500	550	200/80	300	260	90	200	2
Flashpoint (°C) (Bulk)	27	27	27	None	-7	-7	27	>90	7
Solids (%) (Bulk)	37	47/60	50	35	35	36	37	100	2
Dielectric Strength (kV/mm)	90	90	80	50	45	45	60	27	90
Insulation Resistance (Ω)	1 x 10 ¹⁵	1 x 10 ¹⁵	1 x 10 ²⁰	5 x 10 ¹¹	1 x 10 ¹⁵	1 x 10 ¹⁵	1 x 10 ¹⁵	7 x 10 ¹²	1 x 10 ¹⁵
Temp. Range (°C)	-70 to +200	-70 to +200	-50 to +125	-60 to +125	-55 to +130	-65 to +125	-55 to +130	-65 to +135	-50 to +125
Touch Dry Time (Mins @ 20°C)	50-55	50-55	10-15	25-35	10-15	15-20	10	-	5
Cure Time (Hours @ 20°C)	2 @ 20°C & 2 @ 90°C*	2 @ 20°C & 2 @ 90°C*	24	24	24	24	24	-	24
Solvent Resistance	Excellent	Excellent	Good	Excellent	Good	Good	Good	Best	Good
Humidity Resistance	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Good	Excellent	Excellent
Mould Resistance	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Good
Thinners	DCT	DCT	DCT	DI Water	UAT	DCT	FTH	-	N/A
UV Trace	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Approvals	UL746		IEC61086		MIL-I-46058C	IPC-CC-830, UL 746		IPC-CC-830	

*The SCC3 range may also be cured at ambient temperature however the solvent resistance will be reduced.

**Please refer to the technical data sheet for more information on UV Curing Parameters.

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