

# AI 1/1: Processing instructions for ELPEGUARD® conformal coatings (thin film coatings)

This application information sheet contains detailed and extensive information that is paramount for a safe and reliable processing of our **ELPEGUARD® conformal coatings** if an optimum coating result shall be reached. For reasons of processing, it may be necessary to follow different recommendations; in this case, the coating results have to be verified by carrying out qualification tests.

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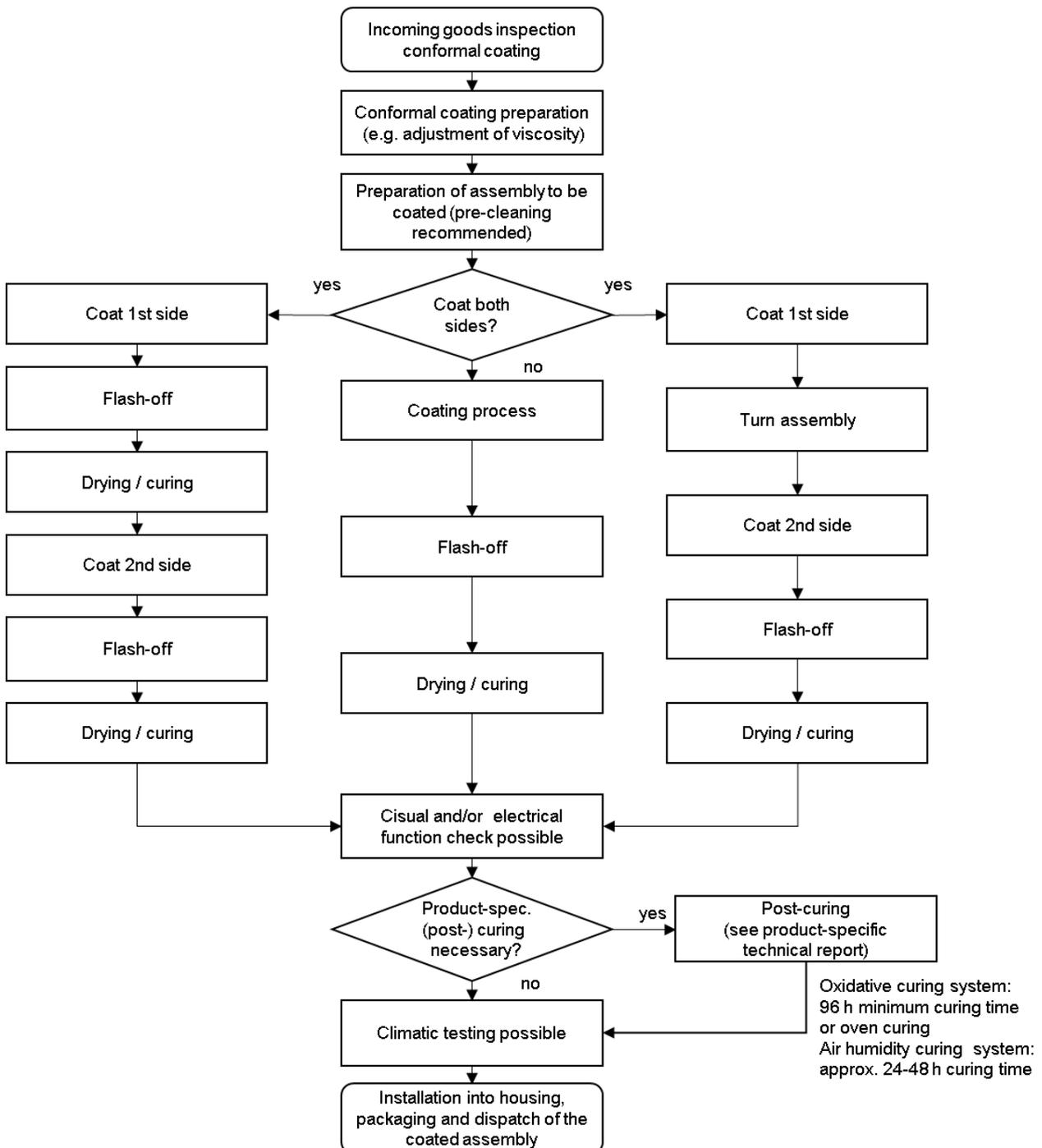
## General information

**ELPEGUARD®** conformal coatings are used to protect and insulate assembled pcbs so that they can fulfil higher requirements regarding reliability and service life. Owing to their very good resistance against moisture and condensation an excellent protection against corrosion (such as electro corrosion and migration) is possible.

The complete production and application process of an assembly – not just the conformal coating – has to be regarded critically and should be optimized to ensure its functional reliability over a long service life under specified conditions. The choice of the base material and the solder resist, the pcb layout and the soldering process contribute to a large extent to the climatic resistance of an assembly.

Conformal coating is a very decisive process step: the removal of residues that may affect adhesion and insulating properties, the reliable and faultless processing plus the complete curing to achieve optimum insulating properties, are essential factors in realizing a high performance conformal coating.

## Schematic of the basic production flow



For the process steps of coating, flash-off and drying / curing one should define process-specific parameters which must be adapted to the individual unit when qualifying the process and the coating results.

If the second side is to be coated directly after the first side, one should apply a layer on the first side that prevents the coating from dripping off, so that the necessary effort for cleaning the equipment is minimized.

When qualifying a coating system the assemblies must be tested under the conditions of later operation, in order to confirm the suitability of the conformal coating for the specific application. Please take note of the advice given under item "Pre-cleaning".

Qualification tests must only be carried out after drying/curing is completed (corresponding advice on the timing of tests is given in the technical data sheets on the individual conformal coatings).

## Coating preparation

Prior to application, the **ELPEGUARD**<sup>®</sup> conformal coatings and the necessary thinner have to adapt the room temperature. The containers with product to be processed the next day should be brought into a room where the temperature is the same as that of the processing room.

### Adjustment of processing viscosity

Each application process requires a special processing viscosity for an optimum coating result. For almost all series of conformal coatings, ready-to-use viscosity adjustments are available which have been adjusted for different coating methods and can be processed in the condition supplied.

As an alternative, the processing viscosity can be adjusted by adding the product-specific thinner and mixing it homogeneously with the coating. The name of the thinner to be used is mentioned both in the corresponding technical report of the conformal coating and on the product labels.

- Observe the processing parameters indicated in Table 1. Recommendations differing from those indicated in Table 1 can be found in the corresponding technical report of the conformal coating.
- Check the viscosity regularly to ensure reproducible layer thicknesses.

**Table 1: Process parameters for ELPEGUARD<sup>®</sup> conformal coatings  
(unless otherwise stated in the technical report)**

Application process	Processing viscosity		Processing temperature
	DIN 53 211* 4 mm flow cup	ISO 2431 5 mm flow cup	
Brushing	30–40 s	39–54 s	20–30 °C [68–86 °F]
Dipping	20–30 s	24–39 s	20–30 °C [68–86 °F]
Automatic selective coating methods	No general data available; please optimise the parameters for the respective equipment by carrying out pre-trials; contact our Application Technology Department if you need assistance.		

\* The processing temperature should be at least 5 °C below the flash point.

The measurement of the viscosity by the flow time is effected as follows using flow cups according to DIN 53 211 or ISO 2431:

- Place the flow cup on a filling stand/tripod or in a tempering beaker so that the top edge is perfectly level.
- Place finger under orifice to seal.
- Fill the cup completely with coating.
- Push a glass plate over the cup so that excess product is evenly transferred to the outer edges of the cup and the cup is closed. Remove the glass plate horizontally.
- Release finger from orifice while starting a stopwatch.
- Stop the time measurement as soon as the liquid flow breaks for the first time.

The measured time is the flow time in seconds.

- Perform the measurement three times and average the measured values.

If a conformal coating is processed at a temperature lower than the processing temperature indicated, the drying time may be longer and the viscosity will increase considerably, i.e. the coating becomes more viscous so that it is very difficult to process. When thinner is added the solids content decreases so that the layer becomes thinner.

Temperatures in excess of the specified processing temperatures cause the viscosity to decrease so that the coating will dry too fast. As a result, the coating no longer displays an optimum flow and the film formation starts too early. Air trapped under components cannot escape.

Figure 1 shows the relationship between the coating viscosity (flow time) and temperature and quantity of the thinner added (based on the viscosity in the condition supplied) using the conformal coating **ELPEGUARD® SL 1301 ECO-FLZ** as an example. Upon request, we will gladly provide viscosity diagrams of other coating systems. One sample viscosity diagram can be found in each technical report.

When 20 % of weight is added of thinner, the mixing ratio between conformal coating and thinner is 4:1.

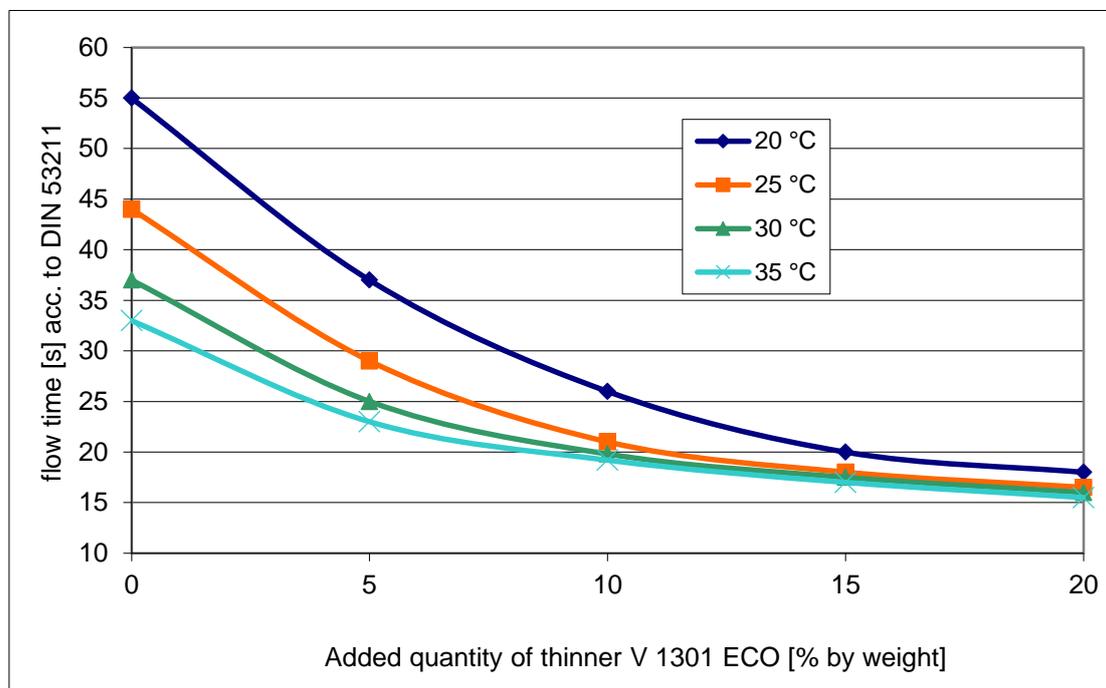


Fig. 1: Dependency of the flow time of conformal coating **ELPEGUARD® SL 1301 ECO-FLZ** on the addition of thinner V 1301 ECO at different temperatures

## Pre-cleaning

Non-cleaned, uncoated printed circuit boards may cause frequent failures when operated under climatic loads later on, since flux agents, solder paste residues or other contaminations may create a system of electric conductivity together with moisture/condensating humidity. By conformal coating such boards, one can achieve a far better climatic resistance provided that the following points are observed:

- Optimise the solder process with regards to the quantity of flux agent and/or solder paste residues remaining on the printed circuit board.
- If possible use a solder paste where the softening point of the residues generated is higher than the maximum operating temperatures

To achieve a particularly performant conformal coating layer and a good climatic resistance of the assemblies we recommend to clean the surface of the boards prior to conformal coating:

Any type of ionic contamination may affect the electrical properties, especially under harsh climatic conditions. Flux agents, solder paste residues or other contaminations can lead to wetting problems, impair adhesion to the substrate and cause the conformal coating to dissolve. Since **ELPEGUARD® conformal coatings**, like all polymers, are permeable for water vapour, it can diffuse through the coating layer. This process is particularly critical in case of hygroscopic contaminations on the pcb surface. In bubbles under components or in areas where the conformal coating exhibits poor adhesion, the water vapour can condensate. In combination with water, residues of flux agents form a system of electrical conductivity. Dependent on the pcb layout (e.g. differences in potentials between adjacent conductors) this may result in electrochemical migration, corrosion or corrosion-induced tracking under the conformal coating. In any case, absorbed moisture due to contamination will decrease the surface resistance and thus the insulation resistance.

Flux agents/solder paste residues may accumulate on or around the solder pad. Depending on the thermal loading, particularly under thermal cycle stress, such resin residues may lead to fusing, discolouration or cracks in the resin backbone of the paste. These cracks are potential weak points in case of exposure to moisture. The conformal coating and thus the protective effect may equally be impaired. It is imperative to conduct appropriate compatibility tests with respect to the expected thermal stress.

→ Therefore, where applicable remove all flux agents, solder paste residues or other contaminations from the assembly to achieve an optimum wetting effect and the adhesion of the conformal coating and the insulating properties or ensure that you achieve the required properties even without cleaning by performing appropriate trials, in particular with respect to the moisture load expected and the tensions applied in operating conditions.

As far as compatibility tests are concerned, rapid temperature cycle tests and climatic tests at high temperatures and high air humidity are suitable. For this purpose, the assemblies should be tested, if possible, under practical conditions (e.g. operating voltage, power loss, mounting position). For both tests, you should select the maximum temperatures that the assembly will be exposed to in later operation. In addition, one uncoated assembly should be tested in parallel. Upon completion of the climatic tests, the pcb surfaces should be examined for signs of corrosion.

→ Always remove flux agents or other contaminations in critical applications.

→ Always check the assembly of your series production after coating and drying/curing in the operating conditions that it will ultimately be subjected to.

Sometimes dewettings on SMD components occur despite precleaning. Such dewettings are caused by residues of mould release agents having a low surface tension (as for instance silicones) that are used in the production of the components.

→ In this case please contact the manufacturer of the SMD components.

Upon request, we will name competent contacts for precleaning processes and climatic testing.

### **Special notes for the coating of surfaces with no-clean fluxes**

The quantity of flux agent residues should be as low as possible.

→ Given the large number of flux agents available on the market you should perform suitable tests to ensure that the required properties will be reached, especially with regard to the expected moisture stress and the voltages in the ultimate application environment.

The decision about the removal of no-clean fluxes should be made after climatic tests were carried out, whereby the assemblies must be tested in practical conditions (e.g. operating voltage, power loss, mounting position). Upon completion of the climatic tests the pcb surfaces are checked for signs of corrosion.

Especially the compatibility with temperature and/or thermal cycling stress of more than 100 °C [212 °F] should be verified, as many no-clean flux residues tend to fuse beyond 100 °C [212 °F].

→ Always remove no-clean fluxes in critical applications.

In case of **dip coating**, residues of no-clean fluxes on the pcb surfaces can cause problems for another reason: The flux agents are washed off the pcb by the solvent contained in the coating and remain in the dipping bath. By and by, the flux agent will accumulate in the coating; pcbs that are coated with conformal coating contaminated by the flux agent may exhibit electrochemical corrosion when water diffuses through the coating layer, forming an electrically conductive system together with the flux agent.

→ Clean the dipping tank more frequently and fill it with fresh product when coating uncleaned assemblies.

### Special notes for coating solder resist surfaces

Sometimes we receive enquiries from users of our conformal coatings who report about voids in the conformal coating on solder resist surfaces that in these cases are described as “fish-eyes”, “frog-eyes” or even as a “hammered effect” in case of a strong accumulation. As a rule, such “coating voids” can be attributed to the presence of silicone-containing additives in the solder resists. An intensive pre-cleaning programme is often of help (see also item “Pre-cleaning”).

## Coating



Please read this technical report and the publications listed below carefully before using the product. These sheets are enclosed with the first shipment of product or sample.

### MSDS

The corresponding material safety data sheet contains detailed information and characteristics on safety precautions, environmental protection, transport, storage, handling and waste disposal.

### TR

[Technical Reports on ELPEGUARD® conformal coatings:](#)  
This is where the appropriate application method is indicated.

### TI

[Technical information TI 15/3](#) “Protective measures when using chemicals including lacquers, casting compounds, thinners, cleaning agents”

Since the many different permutations make it impossible to evaluate the whole spectrum (parameters, reactions with materials used, chemical processes and machines) of processes and subsequent processes in all their variations, the parameters we recommend are to be viewed as guidelines only that were determined in laboratory conditions. We advise you to determine the exact process limitations within your production environment, in particular as regards compatibility with your specific follow-up processes, in order to ensure a stable fabrication process and products of the highest possible quality.

The product data specified in the technical reports is based upon standard processing/test conditions of the mentioned norms and must be verified observing suitable test conditions on processed printed circuit boards.

Feel free to contact our application technology department (ATD) if you have any questions or for a consultation.

### Safety recommendations

→ When using chemicals, the common precautions should be carefully noted.

→ Ensure that extractor units of workplace ventilation arrangements are positioned at solvent source level.

- Please also pay attention to national guidelines or directives concerning operating safety such as the German TRBS (technical rules for operating safety) and those concerning the handling of flammable liquids as for example the German TRbF (technical rules for flammable liquids) or European directives.
- Ensure that the equipment you use is in conformity with the requirements given in the material safety data sheet.

**When handling solvent-based systems, it is imperative, within the scope of the legally prescribed / required hazard assessment measures, to observe the relevant explosion protection regulations (including appropriate national health and safety regulations, technical guidelines, harmonised EN norms and EU directives plus any other recognised technical rules, e.g. the German DGUV rule 113-001). The key physical characteristics of the individual products can be taken from Section 9 “Physical and Chemical Properties” of the corresponding material safety data sheets.**

**When oxidative curing coating systems cross-link with atmospheric oxygen, reaction heat is generated that may ignite cleaning cloths, filter mats in spraying cabins impregnated with coating and solvent residues, or similar.**

- **Collect and keep soiled cleaning cloths etc. in tightly closing non-flammable containers; remove them from the operating room after the works have been completed.**
- **When processing conformal coatings it is mandatory to observe the safety instructions of the corresponding national guidelines on explosion protection.**
- **When processing coatings by means of spraying it is mandatory to take protection measures in order to avoid the formation of solvent vapour mixtures that might explode.**
- **Use water-irrigated spraying cabins to avoid the risk of the filter mats self-igniting. Moreover, follow the operating and maintenance instructions of the spraying cabin/filter mat manufacturers.**

### **Measures for protection against moisture**

The conformal coatings of the series **ELPEGUARD® SL 1307 FLZ/4** and **SL 1400 ECO-FLZ** must be protected against moisture when processed to avoid the risk of increasing viscosity or drying of the ink.



Protect against humidity

- When processing the product take appropriate measures, for example using dried air.
- After work, clean the threads of opened containers with the cleaning agent recommended or with the product-specific thinner. Fill up the container with dried air and re-seal the containers tightly.

By turning the container upside down it is ensured that the coating will seal the lid. Especially when containers are opened frequently, it is essential to fill them up with dried air. Repeated opening of the containers will reduce shelf-life.

Tools of stainless steel and Teflon-coated hoses are recommended.

### **Application of ELPEGUARD® conformal coatings**

Unless otherwise indicated in the technical report of the corresponding coating, the **ELPEGUARD®** conformal coatings can be applied by dipping, brushing or by means of automatic selective coating units. Conformal coatings named with the Index S (e.g. **ELPEGUARD® SL 1307 FLZ-S**) are supplied in spray cans.

→ Ensure that the surface to be coated is clean, grease-free and dry (see also item “Pre-cleaning”).

When processing conformal coatings, an even, not too thick layer generally should be aimed for (see also item “Application of too high layer thicknesses/double coating”). The layers on large surfaces must be thick between 20 and 50 µm while they should not exceed 100 µm on component leads (conical foot prints) if possible. These values can be achieved by correct processing and drying/curing.

Suitable layer thickness measurement tools are based on the eddy current method. Upon request we will gladly send you the contact addresses of manufacturers of such tools.

Air-conditioning of the production area is beneficial for homogenous coating results.

### ELPEGUARD® gels for dam-and-fill applications

Applied by dispensing, the highly thixotropic [ELPEGUARD® gels](#) allow to create dam structures around connectors, components and contact pads and thus to avoid the penetration or the spreading of the conformal coating subsequently applied (“dam and fill”).

### Advantages and disadvantages of various application processes

Before selecting the optimum application process for a user, the basic preconditions such as the production capacity required or available, the necessity for partial coating, the request or need for automation, the possibility of contract coating, have to be clarified.

The table below lists some key advantages and disadvantages of different coating methods that are important when choosing the coating system.

**Table 2: Advantages and disadvantages of different application processes**

Process	Advantage	Disadvantage
Brushing	low investment costs, high availability, suitable for repair, suitable for 2-pack coatings, possibility of selective application	uneven layers, bottom side of components remains uncoated, critical from a health and safety aspect, not automatable
Spraying with spray cans	low investment costs, high availability, suitable for small series and repair	overspray, uneven coating layer, bottom side of components remains uncoated, high effort for cleaning the cabin, tools etc., effective ventilation and/or deposition system required; not automatable
Dip coating	simultaneous coating of component and soldering side, coating even under component assemblies, no overspray, automatable, even layer, cost-effective production	high investment costs, assemblies have to be completely dippable, masking very difficult to perform
Selective curtain spray coating	no masking required, specific selective coating, less product consumption, even application, cost-effective production	very high investment costs, single-sided coating only, no coating under components
Selective flood-dip coating	selective coating is possible, combines advantages of dip coating and selective curtain/spray coating	high investment costs, manufacture of special tools required

## Application by brush coating

Application by means of brushing is especially suitable for repair work and small series, since the conformal coating can be applied selectively. However, uneven and hardly reproducible layer thicknesses and often a poor edge coverage can result.

## Dip coating

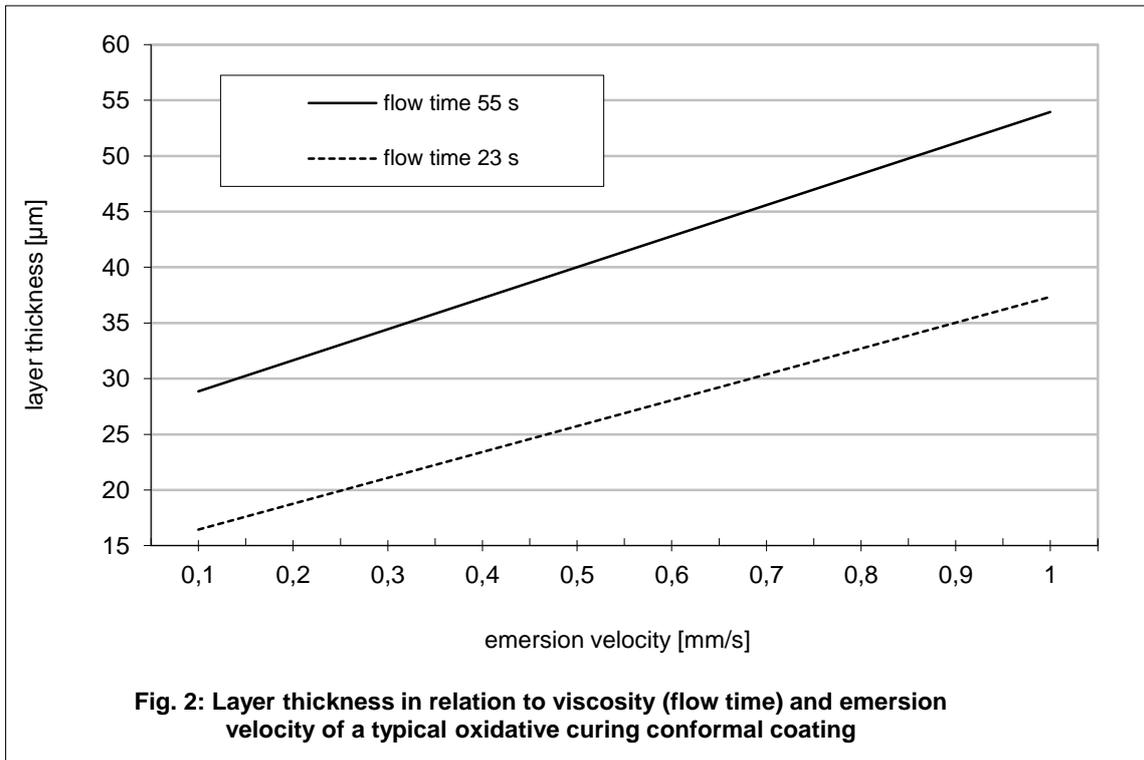
Dip coating is a fast and efficient method to coat both sides of a pcb in one process step. Prerequisite for the dip coating process is that the object to be coated is completely or partially dipable. The achieved layer thickness is both dependent upon the flow characteristics and viscosity of the ink, as well as on the geometry of the components and the emersion velocity.

The following parameters have a significant effect on the dipping result:

**Table 4: Influence of the dipping parameters on process times and coating result**

Dipping velocity	too fast: foam formation poor underfilling of components, air under components cannot escape, air bubbles gather around component leads	too slow: long process times
Dwell time in dip tank	too short: air under components cannot escape, air bubbles gather around component leads	too long: long process times
Emersion velocity	too fast: air bubbles gather on at the assembly, formation of drops, drain-off edges and wedge-shaped distribution of coating thickness	too slow: long process times
Viscosity	too high poor underfilling of components; air can only escape slowly; risk of air inclusions	too low: too low layer thicknesses, insufficient protection

The emersion velocity and viscosity contribute to the thickness of the coating layer applied: High emersion velocity and high viscosity result in a high layer thickness. This relationship is also illustrated by the diagram below (fig. 2): The layer thickness also varies depending on the pcb layout (the values in fig. 2 were measured on copper-plated base material).



But when dip coating with a high viscosity adjustment there is a strong risk of air inclusions between the pcb and the components, besides the application of excessive coating layers (see item "Application of too high layer thicknesses/double coating).

Optimum dipping parameters include:

- low dipping velocity
- long dwell time in dip tank
- emersion velocity depending on desired layer thickness
- viscosity as required to adjust the three parameters above for optimum processing (from previous experience 20 - 30 s flow time, measured acc. to DIN 53 211/4 mm flow cup, or 24 - 39 s flow time, measured acc. to ISO 2431/5 mm flow cup).

**Table 5: Proven process parameters for dip coating**

Dipping velocity	Emersion velocity
5–15 mm/s	1 mm/s

- The dipping velocity and the dwell time in the dip tank are dependent upon the component geometry: Reduce the dipping velocity or adjust a dwell time in the dip tank if air bubbles form between pcb and components. The risk of air-bubble formation is increased by high viscosity. Therefore, always adjust the conformal coating to the dipping viscosity.
- Let excess coating drip off after emersion by turning and tilting the pcb at an angle of 30°. This way a drain-off tip is created so that residues will only remain there.
- Ensure the dip tank is protected from contamination (see also item "Special notes for the coating of surfaces with no-clean fluxes"):
- Use clean tools only.
- Close or seal the dip tank when not in use and flood it with dried air. If necessary, turn off the heating of the dip tank.

- Clean the complete dip tank regularly and very thoroughly in case of a conformal coating change.
- Replace the coating with fresh product if you have to add increasing quantities of thinner to adjust the processing viscosity (e.g. after longer standing times); in case of oxidative curing systems this can be a sign that the cross-linking reaction has started.

### **Automatic selective coating**

Automatic selective coating units allow to coat previously defined areas of the assembly with a uniform coating film on a reproducible basis. Areas that must not be coated, such as connector strips, do not have to be masked.

There are two different application methods for selective coating:

- **Selective coating by means of curtain/spray coating**

A computer-controlled coating head either coats a desired layout on a pcb, or the pcb is moved under a fixed coating nozzle – also computer-controlled – in such a manner that only previously determined areas are coated. This allows a selective, uniform and exact coating without masking or sealing while the coating consumption is very low.

- **Selective coating by means of dip/flood coating**

With this process contact areas, connectors, mechanical components, etc. are saved out and remain uncoated by means of individual forming tools. This process combines the benefits of both dip coating and selective coating in the curtain coating method. As an individual forming tool has to be produced for each pcb layout this process is only profitable for large-scale manufacturing.

Optimum equipment parameters are dependent upon the component geometry, the final properties required, etc.; thus it makes sense to determine them in cooperation with the equipment manufacturer, Peters and the end user.

### **Spraying by means of spray cans**

The conformal coating by means of spray cans is especially suitable for small series and repair work.

- Observe the processing and safety recommendations on the label of the spray can.
- Ensure that the process temperature indicated is observed, as otherwise irregularities may occur in the coating layer.

In case of low temperatures and/or high air humidity the evaporation cooling may cause moisture to penetrate.

### **Contract coating**

Numerous companies perform contract coating using our conformal coating systems. We will gladly provide a list of these companies upon request.

### **Flash-off**

- Plan a flash-off phase at room temperature so that potential air inclusions, for instance between pcb and components, as well as a large portion of the solvents can escape.

Depending on the ambient temperature the optimum flash-off period is between 5 and 15 min. If a flash-off at room temperature is impossible, e.g. in case of in-line production, a flat oven profile should be chosen (similar to the profile shown under item “Physical drying”).

## Drying/curing

In general, drying/curing already takes place at room temperature, but can be accelerated by means of hot-air ovens or IR curing units, or a combination of both.

- Dry the assembly without its housing to ensure sufficient ventilation.
- When drying in a hot-air oven you should observe the thermal resistance of the assembly and its components. Always start to pack the assemblies after they have fully cooled down to room temperature.

One differentiates between several drying mechanisms:

The conformal coatings of the series **ELPEGUARD® SL 1305 AQ-ECO** and **SL 1307 FLZ** are physically drying systems; once the solvents contained in the coating have evaporated the drying process is completed. The film formation process of the aqueous system (index AQ) is different than the purely physical drying of the conformal coatings of the series **ELPEGUARD® SL 1307FLZ**. For additional information you may consult the reference book “Conformal Coatings for Electronics Applications”, please see item “Further literature” for details on this book.

Drying physically at first, the conformal coatings of the series **ELPEGUARD® SL 1400 ECO-FLZ** subsequently cure completely by reacting with air humidity. Complete curing takes approx. 48 to 96 h and strongly depends upon the coating thickness applied and the prevailing air humidity. Oven curing of this coating system is not recommended owing to the necessity of air humidity for curing; it is imperative to ensure that sufficient humidity from the air is available for the curing process

The conformal coating **ELPEGUARD® SL 9400 FLZ** is a chemically curing coating material that cures at room temperature; however, here we recommend oven curing.

All other conformal coatings of the series **ELPEGUARD® SL 1300** to **SL 1309 N** are solvent-based oxidative curing systems. With this type of curing process often incorrectly referred to as “oxidative drying”, the chemical cross linking of the binder is triggered by absorption of oxygen from the air. The physical drying is finished after a relatively short period of time while the absorption of atmospheric oxygen takes considerably longer (see also item “Oxidative curing”).

A functional test of all coating systems is already possible after the assembly has physically dried. In case of a short-term test just after the drying process of the coating it is mandatory to ensure that there are no solvent residues in higher layers and/or under components that are likely to impair the functioning of the assembly. Conformal coatings based on solvents are not affected by this problem. In unfavourable cases, incomplete evaporation of water can cause malfunction when aqueous conformal coatings are used and potentials are connected in such areas.

However, in case of oxidative or air humidity curing coating systems, the steps of fitting in housings, packaging and dispatch of the components as well as tests for qualifying a coating system should only be performed after complete curing.

- When using drying ovens note the relevant regulations on explosion protection!

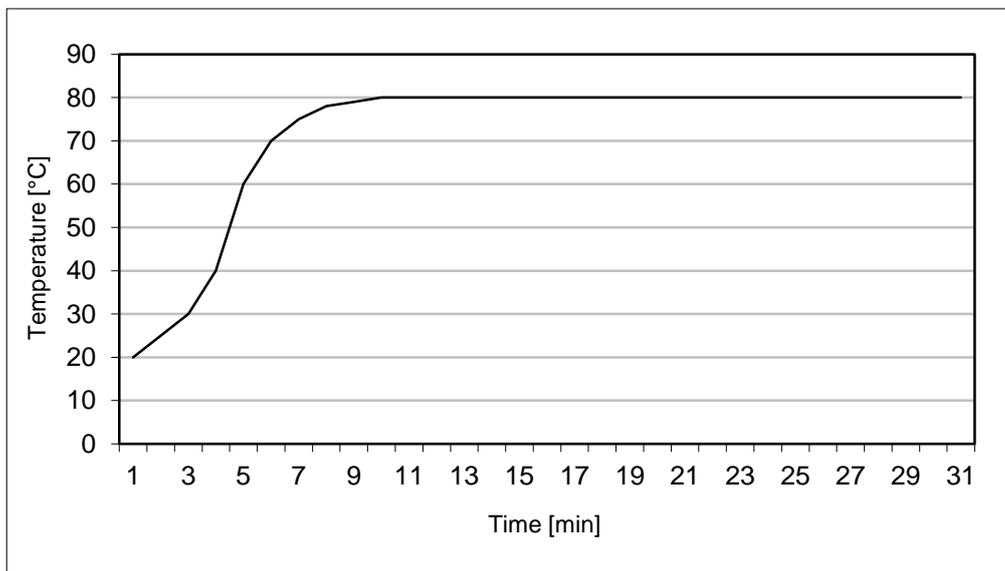
**According to DIN/EN 1539:2010-8 “Dryers and ovens in which flammable materials are released – safety requirements” and in keeping with the German DGUV principle 309-002 – Principles for the calculation of the ventilation requirements for box and conveyerised ovens” (formerly BGG 909) it is not allowed to place more solvent quantities in the drying ovens as can be safely extracted with the exhaust air stream, without reaching explosive solvent concentrations. The manufacturers of drying ovens, too, provide information on the maximum permissible solvent quantities for their dryers on the labels and in their manuals. These details must be checked for the specific application as part of a hazard assessment and be included in customised operating instructions.**

## Physical drying

The guideline values for the drying parameters to be applied before the tack-free stage according to IEC 60464 is reached at room temperature are indicated in the technical report of the specific conformal coating.

Drying can be also effected in a circulating air oven for 10-30 min. at 80-90 °C [176-194 °F] or by means of an IR drying unit, or a combination of both. Different drying parameters can be taken from the technical report of the respective product. The exact parameters must be ascertained by means of pre-trials. Basically, the temperature must not exceed 100 °C [212 °F] since otherwise "boiling" (occurrence of bubbles/craters, temporary or permanent, in the coating) may occur which is caused by the fast evaporation of solvents and low molecular resin components. Depending on the unit and the type of assembly, boiling may even occur at low temperatures; in this case lower temperatures have to be adjusted on the curing unit.

In case of oven drying care must be taken to ensure that the temperature rise is not too steep during the first few minutes, as otherwise the viscosity will decrease considerably and the coating may drop off the assembly. Here, "boiling" may also occur.



**Fig. 3: Example of temperature profile for the circulating air oven curing of ELPEGUARD® conformal coatings**

During the drying process in a circulating air oven solvents may be entrapped if the upper layer has dried before the solvents have evaporated from the deeper layers. In case of IR curing, the IR radiation penetrates the conformal coating and warms it up from bottom to top, in such a way that no solvents are entrapped and curing times are shorter.

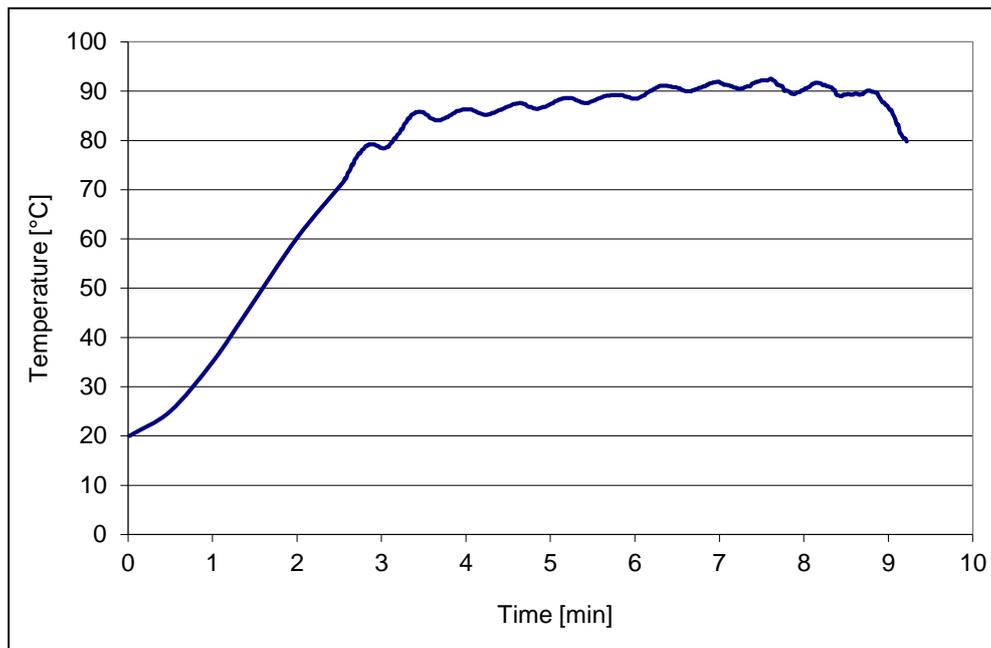


Fig. 4: Example of temperature profile for the IR-curing of ELPEGUARD® conformal coatings

## Oxidative curing

- Oxidative curing at room temperature takes longer owing to the necessity of oxygen absorption. After the tack-free stage has been reached, allow at least 96 hours of curing at room temperature before you check the electrical properties of the coating or pack or encapsulate the assembly, or fit them into housings (see also item "Premature encapsulation of the coated assembly").
- Ensure sufficient ventilation to ensure that enough oxygen is available for complete cross-linking of the conformal coating and that possible solvent residues and low molecular ink components are led away from assemblies.

The oxidative curing process can be accelerated by a circulating air oven or an IR dryer, or a combination of both. Experience has shown that good results are achieved in a circulating air oven when curing for 6 h at 80 °C [176 °F] or for 8 h at 60 °C [140 °F].

- Consider the temperature resistance of the flat pack and assembly.
- Ensure adequate ventilation here, too, because if oxygen is insufficient, the conformal coatings will not cross-link completely and thus not reach their final properties.
- Check the electrical properties of the coating (see item "Checking drying/curing for completeness") to ensure curing has been completed. The time needed for curing in a circulating air oven is, among others, dependent upon the component geometry, coating thickness, oven loading, etc.

## Checking drying/curing for completeness

Depending on the layer thickness applied, the coating film may need a longer drying time to reach its maximum property values.

- Check the electrical property values (see the technical report of the respective conformal coating) to ensure that drying is completed.
- Please note that we recommend drying/curing for at least 96 hours at room temperature (after reaching the tack-free stage) to ensure proper drying and curing even of high layer thicknesses on/under components or drain-off edges, for example.

- In case of oven drying wait for at least 24 hours before you start testing while considering that, depending upon the component geometry, layer thickness, etc., more than 24 hours may be necessary until the maximum property values have been reached.
- Check the property values under operating conditions.

## Cleaning of equipment

Whenever different conformal coatings are processed on one unit thorough cleaning is essential, both in terms of the appropriate cleaning agent and the correct sequence of the cleaning steps. The reason for this is the risk of incompatibility between coatings and cleaners or thinners that may cause agglutination, flocculation or a change in the flow behaviour.

We recommend to proceed as follows when cleaning the equipment:

1. Discharge previous coating from the unit
2. Rinse equipment thoroughly using the thinner of the previous coating, discharge thinner
3. (Optional: repeat step 2)
4. Rinse equipment thoroughly with cleaning agent **R 5817** (or **R 5804** when a conformal coating of the series **ELPEGUARD® SL 1400 ECO-FLZ** was processed); discharge cleaning agent (Tip: In case of fluorescent coatings, rinse until no more fluorescence is visible under black light.)
5. Rinse equipment thoroughly with the thinner of the coating to be processed next; discharge thinner
6. (Optional: repeat step 2)
7. Fill in fresh coating

When using the aqueous conformal coatings of the series **ELPEGUARD® SL 1305 AQ-ECO** please note the **additional** advice below:

- After the processing of a conformal coating from the series **ELPEGUARD® SL 1305 AQ-ECO** rinse equipment thoroughly with deionised/distilled water, 1-methoxypropanol-2 (PM) or 5 % ammonia solution before using solvent mixtures such as **R 5817** for cleaning.
- Prior to filling in the new conformal coating from the series **ELPEGUARD® SL 1305 AQ-ECO** rinse thoroughly with deionised/distilled water to remove all components (i.e. cleaning agents) that are not formulated in the new coating system.

Otherwise there is the risk that the conformal coating of the series **ELPEGUARD® SL 1305 AQ-ECO** coagulates in the unit. Such coagulations can be dissolved by 5 % ammonia solution.

- **Follow the explosion protection guidelines!**
- **Test the resistance of the material, particularly of gaskets.**

Work tools can be cleaned with cleaning agent **R 5817**.

## Trouble shooting

### Application of too high layer thicknesses/double coating

Generally, optimum layer thicknesses are achieved when the conformal coatings are processed according to the conditions mentioned above (see also item "Coating"). Thick coating layers should be avoided for the following reasons:

Thick coating layers dry very slowly since on the one hand, the evaporation of the solvents and on the other, the absorption of oxygen is impaired. While the upper layer cross-links the lower one remains sticky and uncured. Solvent inclusions may occur that affect the final properties, such as

adhesion and electrical insulation. Moreover, in case of thermal shocks cracking in the coating layer may occur that considerably impairs the operation of the assembly, especially under the influence of moisture. The risk of excessive layers is particularly high with the brushing and spraying methods, or whenever the viscosity of the coating processed is too high.

→ Always perform suitable tests (climate tests etc.) to ensure that the specified product properties are reached

Whenever thick layers are actually desired, **double coating** is chosen. The second coating process can only be effected at certain times as otherwise wrinkling or swelling of the first layer may occur. Information on the correct time to apply the second layer can be found in the corresponding technical report.

In case of a double coating wet-in-wet, or after a short drying period, a maximum overall layer thickness of between 20 and 50 µm should be coated on large surfaces (see also item "Application of ELPEGUARD® conformal coatings").

If the second coating layer is only applied after the first layer has fully dried, i.e. after 96 h at room temperature or preferably after 6 hours at 80 °C [176 °F], one may aim at higher overall layer thickness; this way, wrinkles can be avoided on the drain-off edges, for example, when coating thicknesses are > 100 µm. The individual layers should be 20-50 µm thick.

The purely physical drying conformal coatings of the series **ELPEGUARD® SL 1307 FLZ** are less suitable for double coating as they are dissolved by the solvent formulated in the coating.

→ Remember that a variety of special thick film coatings was developed for the applying high thicknesses while keeping processing times short.

Alternatively, 2-pack casting compounds can be chosen for applications where 1-pack conformal coatings are not sufficient in terms of resistance, for instance, against aggressive industry atmosphere, wetness, or similar.

Further information on our product range of thick film coatings and casting compounds/resins is available on our website [www.peters.de](http://www.peters.de).

### **Premature encapsulation of the coated assembly**

While the tack-free stage of a coating is often reached after approx. one to two hours standing time at room temperature, oxidative curing systems need at least 96 hours following the tack-free stage for a complete curing/cross-linking at room temperature.

→ Therefore, allow for at least 96 hours curing at room temperature after reaching the tack-free stage before fitting ("housing"), packing or encapsulating the assemblies, or accelerate the process by means of oven drying for several hours while general attention should be paid to sufficient ventilation in order to ensure an adequate supply of oxygen (see also item "Oxidative curing").

If capsulation is performed too early i.e. when the coating has not fully cured yet, cross-linking, on the one hand, cannot be completed due to lack of oxygen, and on the other, low-molecular and non-cross-linked components may be released at high temperatures which will condensate on open metal areas such as relay contacts, thus leading to sticking and contact problems.

Possible contaminations, e. g. flux agent residues, can still penetrate the insufficiently cured ink film when a potential is applied, and cause migration and tracking. Moisture can penetrate easily and even accelerate the migration process.

## White sediments after premature encapsulation

This specific defect is caused by corrosion on metal surfaces that may occur after premature encapsulation of an oxidative curing conformal coating. According to our experience, corrosion is triggered whenever the following influencing factors come together:

- incomplete curing of oxidative curing conformal coatings (usually triggered by premature encapsulation)
- insufficient ventilation of the assembly that prevents outgassing of by-products from the oxidative curing process. These components may lead to corrosion or salt formation.
- uncovered metal surfaces (zinc is particularly critical forming the so-called "white rust")
- moisture.

## Conformal coating of BGAs

→ Avoid applying conformal coatings under BGAs for the following reasons:

- Incomplete drying/curing of the conformal coatings and solvent inclusions under BGAs  
Owing to the good cross-linking properties of conformal coatings and high capillary forces acting under BGAs, the coating will run under the component where layers thicker than 100 µm will generally be created that will not dry/cure completely and thus lead to solvent inclusions under the BGAs (see also item "Application of too high layer thicknesses/double coating").
- Mismatch of coefficients of expansion  
A mismatch between the coefficients of expansion (CTE) of the conformal coating, printed circuit board and component, can cause the conformal coating under the BGA to ooze out or even lift the components under thermal loads.

We recommend to underfill the BGAs prior to conformal coating or save out the BGAs from the coating process by applying a [dam and fill gel](#).

→ Find out by performing practical pre-trials whether it is possible to use conformal coatings on BGAs without underfill/dam and fill. Besides thermal cycling tests to ascertain the mechanical compatibility, condensation loads and climatic loads should be included in the tests.

## Special features of the series ELPEGUARD® SL 1305 AQ-ECO

Since an immeasurable number of components is available on the market, incompatibilities may appear in isolated cases between the aqueous conformal coatings of the series **ELPEGUARD® SL 1305 AQ-ECO** and the components. This can be recognised, for instance, by a poor wetting or non-achievement of the specified properties.

→ Therefore, always perform test coatings with the assemblies to be coated and test the final properties you have specified.

Under certain conditions components may fail after coating with a conformal coatings of the series **ELPEGUARD® SL 1305 AQ-ECO** for the following reasons:

- contamination of the component with residues from production
- use of an unsuitable conformal coating for components' production
- delayed drying of the conformal coating of the series **ELPEGUARD® SL 1305 AQ-ECO** e.g. on account of thick coating layers or high atmospheric humidity/insufficient ventilation
- application of operating or test voltage during coating (e.g. batteries), apart from malfunctioning water electrolysis and dendrite formation may occur.

These factors lead to a penetration of water (from the conformal coating) into the components and thus, in combination with the applied voltage, cause e-corrosion and failure of the components.

→ Check the components for their suitability of being coated with a conformal coating of the series **ELPEGUARD® SL 1305 AQ-ECO**.

In case of a short-term functional test of the assembly just after the coating has dried it is mandatory to ensure that there are no solvent residues in high layers and/or under components that may impair the functioning of the assembly. This fact is particularly important with aqueous conformal coatings. In unfavourable cases, water that has not yet completely evaporated may cause malfunction when potentials are connected in such areas.

## Removal of the coating layer for repair purposes

Once fully cured, most of the **ELPEGUARD®** conformal coatings can hardly be removed owing to the high degree of cross-linking. Nevertheless, some methods are available for this:

- **Removal with product-specific thinner**

The physically drying coatings of the series **ELPEGUARD® SL 1307 FLZ** can be removed with their product-specific thinners.

- **Mechanical removal (blasting method)**

The conformal coating can be removed by using abrasive materials that are conducted by pressure onto the surface of the conformal coating.

- **Thermal method (through-soldering)**

At solder iron temperature, the conformal coating softens and thermally decomposes in such a way that it can be removed from the base material. Avoid damaging of heat-sensitive components.

→ **Ensure an efficient exhaust of the materials decomposing from the conformal coating and the heavy metal vapours when soldering through, in view of keeping the hazards for the operator of the solder work as low as possible.**

We advise not to remove the coating by means of cleaning agents/strippers (such as N-methylpyrrolidone or acetone) since these, in order to be efficient for the well-resisting conformal coatings, would have to be so aggressive that they would also attack or destroy other materials of the assembly such as the solder resist and components.

The **ELPEGUARD®** conformal coating can be reapplied after repair and cleaning of the surface (remove loosely sticking parts and wash with a suitable cleaning agent).

## Visual control

The optimum insulating properties of a conformal coating can only be achieved when the coating layer is homogeneous and sealed. Dewettings and voids offer surfaces of attack for corrosion. To control the conformal coating simply and reliably for completeness, red or green adjustments with a clear contrast to the substrate, or fluorescent adjustments (index FLZ) are available.

The fluorescent adjustments are visible under UV light so that coated and non-coated areas can be distinguished. For this purpose, we recommend weak UV sources or "black light" lamps with a UV-A share at 350-375 nm. Suitable lamps are available, for example, from Carl Roth [www.carl-roth.de](http://www.carl-roth.de).

→ Please follow the advice given by the manufacturer with regard to the protective measures to be taken.

It is possible to detect voids, pin holes or bubbles by means of appropriate AOI systems.

## Further literature

**Dr. Manfred Suppa, Publisher Werner Peters: “Conformal Coatings for Electronics Applications”**, 1st edition 2012, Lackwerke Peters GmbH & Co. KG, ISBN 978-3-00-039856-8.

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Any questions?

We would be pleased to offer you advice and assistance in solving your problems. Samples and technical literature are available upon request.

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