

Processing instructions for the conformal coatings of the series' ELPEGUARD® SL 1300 to SL 1309 N and SL 1400

AI 1/1

This application information sheet contains detailed and extensive information and advice that are paramount for a safe and reliable processing of our physically drying/oxidatively curing **conformal coatings** of the series' **ELPEGUARD® SL 1300** to **SL 1309 N** as well as our humidity curing conformal coatings of the series **ELPEGUARD® SL 1400**. A processing according to our instructions is mandatory to achieve an optimum protection of assembled pcbs/flat packs.

On account of the different processing/curing separate application information sheets are available for our ELPEGUARD® thick-film lacquers TWIN-CURE® as well as for our ELPEGUARD® silicone thick-film lacquers.

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1. General information

Conformal coatings are used to protect assembled pcbs that have to fulfil high demands on reliable performance, service life and quality even under increased climatic stress (moisture, condensation, temperature).

The complete production and application process of an assembly – not only the protective coating – has to be regarded critically and optimized so that it provides a functional reliability over a long service life under the required conditions. The choice of the base material as well as the solder resist, the pcb layout and the soldering process already have a partly considerable effect on the climatic resistance of an assembly.

Protective coating represents a very decisive process step: the removal of residues that may lead to poorer adhesion and insulating properties, the reliable, faultless processing and complete curing to achieve optimum insulating properties are essential factors in realizing a high-performance protective coating.

This **application information sheet AI 1/1** offers detailed instructions for a reliable processing of the conformal coatings of the series' **ELPEGUARD® SL 1300 to SL 1309 N and SL 1400**:

- **ELPEGUARD® SL 1301 ECO-FLZ** series
- **ELPEGUARD® SL 1301 ECO-BA-FLZ** series
- **ELPEGUARD® SL 1301 N** series
- **ELPEGUARD® SL 1331 N-LF-D** series
- **ELPEGUARD® SL 1305 AQ** series
- **ELPEGUARD® SL 1306 N** series
- **ELPEGUARD® SL 1307** series
- **ELPEGUARD® SL 1308 FLZ**
- **ELPEGUARD® SL 1309 N** series and **SL 1309 N-S** series
- **ELPEGUARD® SL 1400 ECO-FLZ** series.

For details of specific application fields and properties please refer to the technical reports on the conformal coatings that are available upon request. In our report manual these technical reports are filed under group 1. On our report manual CD you will find technical data sheets in the "Products" section.

For the application of thick protective coatings while maintaining short processing times a variety of special solvent-free thick film lacquers are available, as for instance, the **ELPEGUARD®** thick film lacquers of the series **TWIN-CURE® DSL 1600 E-FLZ**, based on a UV and moisture curing copolymerisate of polyacrylate and polyurethane, or the **ELPEGUARD®** silicone thick film lacquers **DSL 1705 FLZ** and of the series **DSL 1706 FLZ** (see also Item 8.1 "Application of too high layer thicknesses/duplicate coating").

On account of the different application/curing of the **ELPEGUARD®** thick film lacquers of the **TWIN-CURE®** series as well as of the **ELPEGUARD®** silicone thick film lacquers separate application information sheets **AI 1/2** "Processing instructions for the **ELPEGUARD®** thick film lacquers of the **TWIN-CURE®** series" and **AI 1/3** "Processing instructions for **ELPEGUARD®** silicone thick film lacquers" are available that we will gladly provide upon request along with the technical reports on these products. In our report manual these technical publications are filed under group 1. On our report manual CD and on our website you will find application information sheets in the "Service" section. Technical data sheets are exclusively available in the "Products" section of our report manual CD.

1.1 Technical service

If the conformal coating has to fulfil special requirements that are not mentioned in this application information sheet or in case of equipment specialities please contact our **application technology department (ATD)**, who will gladly offer you competent support.

1.2 Equipment technology

If you have any queries regarding the optimization or extension of existing equipment and/or the planning of an equipment concept and associated periphery for the processing of conformal coatings **PETERS ENGINEERING für Elektroniklacke GmbH + Co KG** offers suitable processing units in close cooperation with reliable suppliers and takes over the complete responsibility for lacquer and machines. Broad practical experience enables a production accompanying support. The service is guaranteed by the machine suppliers.

Upon request, we will gladly provide information material and a questionnaire for compiling a quotation for conformal coating equipment.

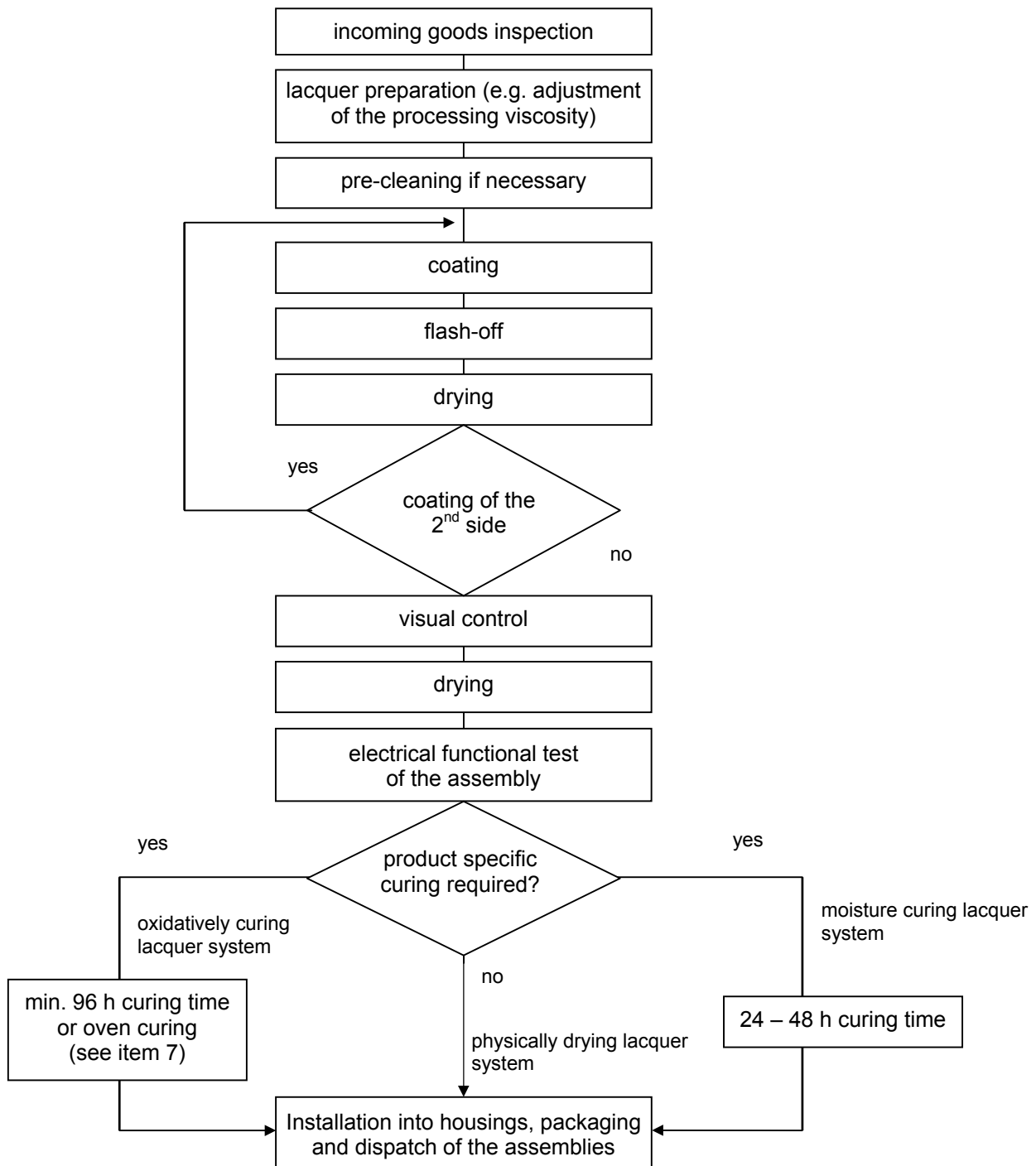
1.3 Reports and further technical information

Particularly detailed information on numerous aspects of lacquer processing, environmental and quality questions in the production of printed circuit boards and assemblies is available in the form of reports and Technical Information Sheets (TIs).

We will gladly place a list of available publications at your disposal (**Technical Information TI 15/100 "Overview of Technical Information Sheets"** and **Technical Information TI 15/101 "Reports"**). In addition, a wide range of literature can be obtained on our website at <http://www.peters.de>.

1.4 Schematic of the basic production flow

Exact parameters for each process step are given in the relevant technical reports.



When qualifying a lacquer system the component assemblies must be tested under the conditions of later use in order to confirm the suitability of the conformal coating for the specific form of application. Please also pay attention to the advice given in item 4 “Pre-cleaning”. Qualification tests must be carried out only after complete drying/curing (corresponding advice on the timing of tests is given in the technical data sheets on the individual conformal coatings).

2. Safety recommendations

- Please read our material safety data sheet according to directive 1991/155/EEC where you will find detailed specifications of safety precautions, environmental protection, waste disposal, storage, handling, transport as well as other characteristics.
- When using chemicals, the common precautions should be carefully noted.
- Please also pay attention to national guidelines or directives concerning the handling of flammable liquids as for example the German TRbF (technical regulations for flammable liquids) or European directives.
- Ensure that the equipment used complies with the requirements of the material safety data sheet.



When handling solvent-based systems, within the scope of the legally prescribed / required hazard assessment measures it is imperative 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 BGR 104). 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.

3. Lacquer preparation

Prior to use the conformal coatings of the series' **ELPEGUARD® SL 1300 to SL 1309 N** and **SL 1400** as well as the necessary thinner have to be brought to room temperature (see Item 3.1, table 1). The containers to be processed the following day are appropriately transferred into a room where the temperature is the same as that of the processing room.

3.1 Adjustment of the processing viscosity

Each application process requires a special processing viscosity to achieve an optimum coating result. The processing viscosity is adjusted by adding the product-specific thinner and mixing it homogeneously with the lacquer. The name of the required thinner is mentioned in the corresponding technical report of the conformal coating as well as on the product labels.



Theoretically, processing in the condition supplied is possible but should be avoided or verified by the qualification of the assembly under the subsequent conditions of use due to the potential problematic curing of thick lacquer layers (see also Item 8.1 "Application of too high layer thicknesses/duplicate coating").

- Adjust the processing viscosity for each application process and observe the recommended processing temperature. Indications on this topic can be found in the corresponding technical report of the conformal coating.
- Check the viscosity regularly to achieve reproducible layer thicknesses.

**Table 1: Process parameters for ELPEGUARD® conformal coatings
(unless otherwise stated in the technical data sheet)**

| Application process | Processing viscosity | | Processing temperature |
|---------------------------------------|---|---------------------------|-------------------------|
| | Flow time at 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] |
| Compressed-air spraying | 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 processes | _*** | _*** | _*** |

- * Although the DIN 53 211 is no longer valid the measurement of the flow time by means of the 4 mm DIN flow cup is still widespread. Thus, for comparison purposes this value as well as the value acc. to ISO 2431 that is determined by means of the geometrically different ISO flow cup is specified in the table.
- ** The lacquer viscosity to be adjusted is also dependent upon the spray nozzle diameter used. When using small spray nozzle diameters (see also Item 5.4) lacquer with a low viscosity can be better processed. Thus, depending on the spray nozzle diameter used the viscosity may have to be adjusted.
- *** For automatic, selective coating a general processing viscosity cannot be indicated as the viscosity has to be optimized for each unit. Therefore, determine the optimum viscosity by means of pre-trials. In case of further queries our application technology department (ATD) will be glad to assist you.

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

- 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 lacquer.
- Push a glass plate over the cup so that excess lacquer 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 below the indicated processing temperatures the drying time may be extended and the viscosity will increase considerably, i.e. the lacquer becomes more viscous so that it is very difficult to process. When thinner is added the solids content decreases so that the lacquer layer becomes thinner.

Temperatures in excess of the specified processing temperatures cause a considerable decrease in viscosity so that the lacquer dries too fast. This means that the lacquer no longer displays an optimum flow and the film formation starts too soon. Air trapped under components cannot escape.

Figure 1 shows the relationship between lacquer viscosity (flow time) and temperature and quantity of the added thinner (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 you with viscosity diagrams of other lacquer systems. A corresponding sample viscosity diagram can be found in the appropriate technical reports.

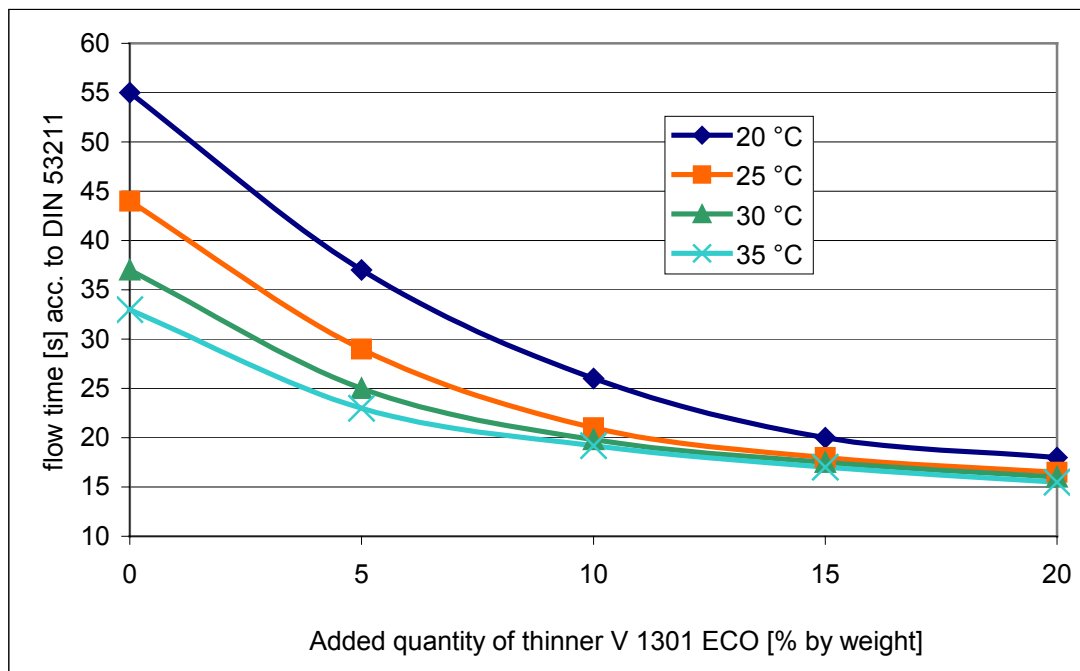


Fig. 1: Dependency of the flow time of the conformal coating ELPEGUARD® SL 1301 ECO-FLZ on the addition of thinner V 1301 ECO at different temperatures

4. Pre-cleaning

Mandatory for a high-performance conformal coating and thus the climatic resistance of the assembly is a clean pcb surface prior to application of the conformal coating.



Any type of ionic contamination affects the electrical properties, especially under harsher climatic conditions. Fluxing agents and other contaminations can lead to wetting problems, impair adhesion to the substrate and in the long run cause a dissolution of the conformal coating.

Like all polymers, conformal coatings are permeable for water vapour and thus water vapour can diffuse through the lacquer layer. This process is made critical by hygroscopic contaminations on the pcb surface. In bubbles, for instance under components or in the lacquer or in areas where the conformal coating exhibits poor adhesion, the water vapour condensates. In combination with water, residues of fluxing agents form a system of low electrical conductivity. Dependent on the pcb layout (e.g. differences in potentials between adjacent conductors) electrochemical migration, corrosion or corrosion-induced tracking under the conformal coating are the possible consequences. In any case absorbed moisture decreases the surface resistance and thus the insulation resistance.

→ Therefore, where applicable remove all fluxing agents if necessary and other contaminations from the assembly to achieve an optimum wetting and adhesion of the conformal coating and the insulating properties or ensure that you achieve the required properties without cleaning by performing corresponding trials.

→ Always check the assembly produced in your series production environment after coating and drying/curing in the application conditions to which it will ultimately be subjected.

Sometimes dewettings on SMD components occur despite precleaning. These dewettings are caused by residues of mould release agents with 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 provide you with the address of a competent contact for precleaning processes and climatic tests.

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

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

→ Due to the large number of fluxing agents on the market perform suitable tests to ensure that you achieve the required properties, 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 whereby the assemblies must be tested under practice-orientated conditions (for instance operating voltage, power dissipation, installation location). After the climatic tests the pcb surfaces are checked for signs of corrosion.

Especially the compatibility with temperature and/or thermal shock stress of more than 100 °C [212 °F] should be checked as many no-clean flux residues may fuse above 100 °C [212 °F].

→ In general, remove no-clean fluxes in case of critical applications.

In case of **dip coating** residues of no-clean fluxes on the pcb surfaces can cause problems for another reason: The fluxing agents are washed off the pcb by the lacquer solvent and remain in the dipping bath. In time the fluxing agent accumulates in the lacquer, pcbs that are coated with this lacquer contaminated with the fluxing agent may exhibit electrochemical corrosion if water diffuses through the lacquer layer and forms an electrically conductive system together with the fluxing agent.

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

4.2 Special notes for the coating of surfaces with resin residues from solder pastes

Solder paste resins may accumulate on or around the solder pad. Depending on the thermal loading particularly in case of thermal shock resin residues may lead to fusing, discolouration and cracks in the resin backbone of the paste. In case of exposure to moisture these cracks represent potential weak points. The protective coating and consequently the protective effect may equally be impaired. It is imperative to conduct corresponding compatibility tests with respect to the expected thermal stress.

4.3 Special notes for the coating of 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 higher frequency. As a rule such “lacquer voids” can be attributed to the presence of silicone-containing additives in the solder resists. What is desired with so-called “hammer effect” paints leads to the above mentioned lacquer voids during coating with conformal coatings. An intensive pre-cleaning programme is often of help (see also Item 4 “Pre-cleaning”).

As a manufacturer of conventional and photoimageable solder resists we know this problem in detail from practical day-to-day experience and guarantee that all our solder resist systems are absolutely free of silicone-containing lacquer additives!

5. Coating



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. 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 us if you have any questions or for a consultation with our application technology department.

The conformal coatings of the series **ELPEGUARD® SL 1300** to **SL 1309 N** as well as **SL 1400** can – if not otherwise mentioned in the technical report of the corresponding lacquer – be applied by means of dipping, brushing, spraying or by means of automatic selective coating units. Conformal coatings with the Index S (e.g. **ELPEGUARD® SL 1309 N-S**) are delivered in spray cans.



The conformal coating ELPEGUARD SL 1400 ECO-FLZ cures under the influence of moisture. Take measures, such as using dry inert gas, to protect the lacquer against moisture during processing. Tools of stainless steel and Teflon-coated hoses are recommended.

Clean the threads of opened containers with the cleaning agent R 5804 or thinner V 1400 ECO and then re-seal the containers tightly. Partially filled containers must be filled with dry inert gas.

→ Ensure that the surface to be coated is clean, grease-free and dry (see also Item 4 “Pre-cleaning”).

When processing conformal coatings, an even, not too thick lacquer layer generally should be aimed for (see also Item 8.1 “Application of too high layer thicknesses/duplicate coating”). The layer thickness on bare areas must be between 20 and 50 µm and on component leads (conical foot prints), if possible should be below 100 µm. These values can be achieved with correct processing and drying/curing.

→ Therefore, please observe the subsequent notes under Item 5.1 to 5.7.

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

5.1 Processing advice for highly-viscous conformal coatings (Index HV)



Highly-viscous conformal coatings, such as ELPEGUARD® SL 1331 HV, are only suitable for the spot application of small lacquer quantities. Owing to the danger of an incomplete drying of the lacquer and the resulting risks, under no circumstances should the lacquer be used for blanket application or application in layer thicknesses of >100 µm (see also recommendations under Item 7.3 “Drying/curing of highly-viscous conformal coatings (Index HV)”).

Following large area application or spot application in too large drops or too high layers, solvent inclusions and/or an insufficient curing may result that have a negative effect on the final properties, such as adhesion and electrical insulation. Moreover, in case of thermal shocks, cracks in the lacquer layer may occur that considerably affect the function of flat packs, especially under the influence of moisture. In case of very high lacquer layers wrinkling may result.

5.2 Advantages and disadvantages of the various application processes

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

The following table shows some key advantages and disadvantages of the different coating processes that are important for the choice of the coating system.

Table 2: Advantages and disadvantages of different application processes

| Process | Advantage | Disadvantage |
|---------------------------------|---|---|
| Brushing | almost no investment costs, high availability, suitable for repair purposes, suitable for 2-pack lacquers, possibility of selective application | uneven lacquer layer, bottom side of components remains uncoated, critical from a health and safety aspect, not automatable |
| Compressed-air spraying | low investment costs, high availability, automatable | overspray, uneven lacquer layer, bottom side of components remains uncoated, high cleaning effort for the cabin, tools, etc., effective ventilation and/or deposition system required |
| Spraying with spray cans | nearly no investment costs, high availability, suitable for small series' and repair purposes | similar to compressed-air spraying; not automatable |
| Dip coating | simultaneous coating of component and soldering side, coating even under component assemblies, no overspray, automatable, even lacquer 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, reduced lacquer consumption, even lacquer application, cost-effective production | very high investment costs, only single-sided coating, 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 |

5.3 Application by brush coating

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

5.4 Compressed-air spraying

Compressed-air spraying is a commonly used and fast application process that enables quick lacquer changes with a relatively low cleaning effort for the spray nozzle. The coating result is largely dependent upon the coater's experience.

To prevent voids and achieve as even layers as possible the lacquer should be applied by cross-coating (i.e. coating in vertical and then in horizontal direction).

→ Reduce the lacquer flow volume if you apply too much lacquer with this process. Increasing the compressed-air causes eddies.

Table 3: Recommended process parameters

| Spray pressure | Spray nozzle diameter |
|----------------|-----------------------|
| 1.5 - 4 bar | 0.8 – 1.5 mm* |

* For the conformal coatings of the series **ELPEGUARD® SL 1305 AQ** the spray nozzle diameter should be 0.8 – 1.2 mm.



When applying lacquers by means of compressed-air spraying the safety precautions given in corresponding national regulations on explosion protection must be observed.

When processing lacquers by means of spraying it is mandatory to take protection measures to avoid a formation of solvent vapour mixtures that might explode.

When oxidative curing lacquer systems dry, reaction heat results that may ignite filter mats that are impregnated with lacquer and solvent residues in spraying cabins. Use water-irrigated spraying cabins to avoid the risk of the filter mats self-igniting. Moreover, observe the operating and maintenance instructions of the spraying cabin and filter mat manufacturers.

Exception:

In case of the lacquers of the series **ELPEGUARD® SL 1305 AQ** explosive solvent-vapour mixtures cannot occur, since the solvents have been replaced by water to a large extent.

5.5 Dip coating

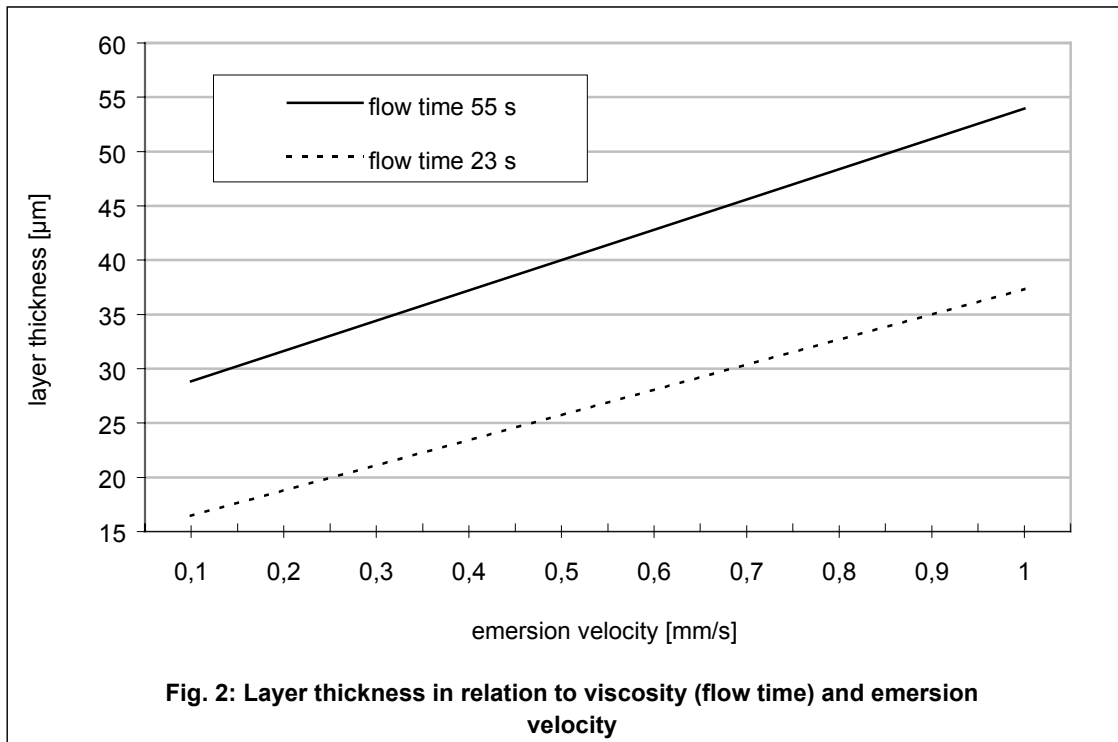
Dip coating is a fast and efficient method to coat both sides of a pcb in one process step. Prerequisite for the dip coating process is that the object to be coated is completely or partially dipposable. The achieved layer thickness is both dependent upon the flow characteristics and viscosity of the lacquer 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 high: 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 high: 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; air inclusions possible | too low: too low layer thicknesses, insufficient protective effect |

The emersion velocity and viscosity influence the thickness of the applied lacquer layer: High emersion velocity and high viscosity effect a high layer thickness. This connection is also illustrated by the following diagram (fig. 2): The lacquer layers achieved with **ELPEGUARD® SL 1301 ECO-FLZ** (viscosity: 55 s flow time, measured acc. to DIN 53 211/4 mm flow cup/20 °C [68 °F] or 75 s flow time, measured acc. to ISO 2431/5 mm flow cup/20 °C [68 °F]) are considerably higher than those achieved with **ELPEGUARD® SL 1301 ECO-FLZ/23** (viscosity: 23 s flow time, measured acc. to DIN 53 211/4 mm flow cup/20 °C [68 °F] or 60 s flow time, measured acc. to ISO 2431/4 mm flow cup/20 °C [68 °F]); in case of both lacquer systems the layer thickness increases as the emersion velocity rises. The layer thickness also varies depending on the pcb design (the values in fig. 2 were measured on copper-plated base material and only serve to illustrate the above mentioned connections).



But in case of dip coating with a high viscosity the risk of air inclusions between pcb and components as well as the application of too thick lacquer layers (see Item 8.1) is great.

Optimum dipping parameters are:

- low dipping velocity
- long dwell time in dip tank
- emersion velocity depending on desired layer thickness
- viscosity as required to adjust the above three parameters 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 danger of air-bubble formation is increased by a high lacquer viscosity. Therefore, always adjust the conformal coating to the dipping viscosity.
- Let excess lacquer drip-off after emersion by turning and tilting the pcb at an angle of 30°. This way a drain-off tip results so that residues only remain there.

Ensure the dip tank is protected from contamination (see also Item 4.1 "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 inert gas. If necessary, turn off the heating of the dip tank.
- Clean the complete dip tank regularly and particularly thoroughly in case of a lacquer change.
- Replace the lacquer with fresh lacquer 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.



Owing to its sensitivity to moisture the conformal coating **ELPEGUARD®** SL 1400 ECO-FLZ must be applied under inert gas.

5.6 Automatic selective coating

The use of automatic selective coating units makes it possible to coat defined areas of the assembly with a uniform lacquer film. When using automatic selective coating units it is possible to coat defined areas of the assembly with an even lacquer film on a reproducible basis. Areas that must not be coated, such as contact fingers, do not have to be masked.

There are two different application processes for selective coating:

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

A computer controlled coating head 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. A selective, even and exact coating with a very low lacquer consumption without masking or sealing is achieved.

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

With this process contact areas, connectors, mechanical components, etc. are excluded and kept lacquer-free by using individually made forming tools. This process combines the advantages of dip coating and selective coating by means of curtain coating. As an individual forming tool has to be made for each pcb layout this process is only feasible upwards of a certain volume.

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

5.7 Spraying by means of spray cans

The protective coating by means of spray cans is especially suitable for low volume series' and repair work.

- Observe the processing and safety recommendations on the label of the spray can.
- Shake the spray can thoroughly prior to use.
- Ensure the process parameters are observed, otherwise irregularities in the lacquer layer may occur.
- Spray from a distance of 30 - 40 cm.
- Clean the spray nozzle after use to avoid blocking. To do so turn can upside down and spray until only gas escapes.
- If use is interrupted frequently and you want to avoid wasting too much propellant we recommend our cleaning agent **R 5817** for cleaning the nozzle.

5.8 Contract coating

Numerous companies perform contract coating with our lacquer systems. Upon request we will gladly name the corresponding companies.

6. 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 period for flash-off is between 5 – 15 min. If a flash-off at room temperature is not possible, e.g. in case of in-line production, a flat oven profile should be chosen (similar to the profile mentioned under Item 7.1 "Physical drying").

7. Drying/curing

Drying/curing already takes place at room temperature, but can be accelerated by means of hot-air ovens. It is differentiated between physical drying (evaporation of solvents from the lacquer) and oxidative curing – often wrongly called “oxidative drying”, during which a chemical reaction of the binding agent takes place on account of the absorption of atmospheric oxygen.

The conformal coatings of the series **ELPEGUARD® SL 1305 AQ** and **SL 1307** are physically drying systems; the film formation of the water-borne system (Index AQ = water-borne, aqua) is described in detail in our report no. 150 E “Protective lacquers and casting compounds as coating materials for electronic assemblies”. It is different to the purely physical drying of the lacquers of the **ELPEGUARD® SL 1307** series.

The conformal coating **SL 1400 ECO-FLZ** represents a further special case that first dries physically and subsequently cures completely by reacting with air moisture. Curing takes approx. 48 to 96 h and strongly depends upon the applied coating thickness and air moisture. Oven curing of this lacquer system is not recommended owing to the required air moisture for curing. However, it is imperative to ensure that sufficient air moisture is available for curing.

All other conformal coatings of the **ELPEGUARD®** series’ **SL 1300** to **SL 1309 N** are solvent-based, oxidative curing systems. The physical drying is finished after a relatively short period of time while the absorption of atmospheric oxygen needs considerably longer (see also Item 7.2 “Oxidative curing”).

A functional test of all lacquer systems is already possible after physical curing of the assembly. 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 may impair the function of the assembly. Conformal coatings based on solvents are not affected by this problem. In unfavourable cases water that has not yet completely evaporated can cause malfunctions when using waterthinnable conformal coatings if potentials are connected in such areas.

However, in case of oxidative or air moisture curing lacquer systems fitting in housings, packaging and dispatch of the components as well as tests to qualify a lacquer system can only take place after complete drying.

When using lacquer drying ovens give special attention to the relevant regulations on explosion protection!

According to DIN/EN 1539:2000 “Dryers and ovens in which flammable materials are released – safety requirements” and in keeping with the statute of the German employers’ association BGG 909 “Principles for the calculation of the ventilation requirements for box and conveyerised ovens” (formerly ZH1/169) it is allowed to place only those solvent quantities in the drying ovens that can be safely extracted by means of the exhaust air flow without reaching explosive solvent concentrations. The mentioned regulations contain details of the calculation processes and can be obtained at Beuth Verlag (Norm) and/or at Carl Heymanns Verlag, Luxemburger Str. 449, 50939 Cologne, Germany. The manufacturers of lacquer drying ovens also give equipment-specific information on the maximum allowed solvent quantities for their dryers on the model and in their manuals. These details must be checked as part of a risk assessment or the specific application and converted into customised operating instructions.



7.1 Physical drying

The times until the tack-free stage at room temperature is achieved according to IEC 60464 are indicated in the corresponding technical report of the specific conformal coating.

Drying can be 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. In case of IR drying the exact parameters must be ascertained by means of pre-tests. Basically, temperatures must not exceed 100 °C [212 °F] since otherwise “boiling” (occurrence of bubbles/craters, temporary or permanent, in the coating) may occur caused by the fast evaporation of solvents and low molecular resin components.

In case of oven drying care also must be taken that the increase in temperature is not too steep during the first couple of minutes as otherwise an extreme decrease in viscosity will result and the lacquer may drop off the assembly. Here, also “boiling” may occur.

Model temperature profiles for oven drying are illustrated in the following figures 3 and 4:

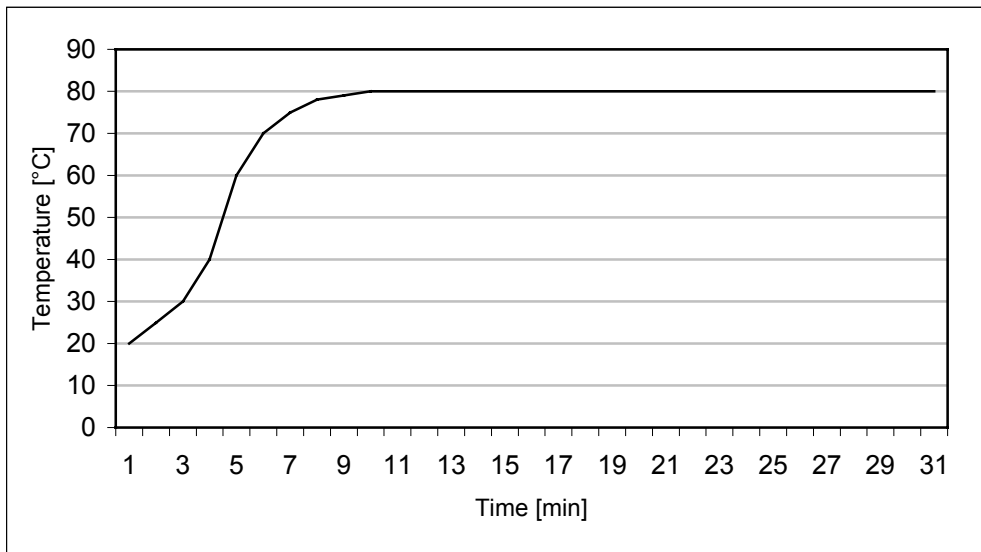


Fig. 3: Model temperature profile for the circulating air oven curing of ELPEGUARD® conformal coatings

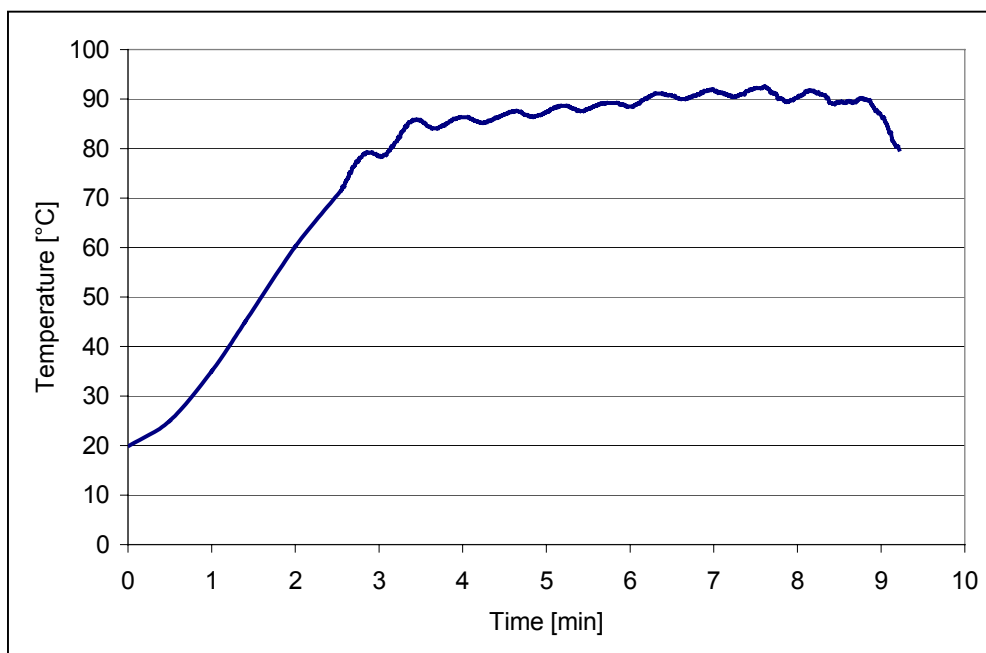


Fig. 4: Model temperature profile for the IR-curing of ELPEGUARD® conformal coatings

7.2 Oxidative curing

The oxidative curing process at room temperature is completed at the earliest 96 hours after the tack-free stage has been reached owing to the necessary absorption of oxygen (see also Item 7.4 “Checking drying/curing for completeness”).

→ After the tack-free stage has been reached, allow at least 96 hours’ curing at room temperature until you check the electrical properties of the coating or pack or encapsulate the assembly or fit the assembly into housings (see also Item 8.2 “Premature encapsulation of the coated assembly”).

- Ensure sufficient air circulation in order to make sure that enough oxygen is available for complete cross-linking of the conformal coating and possible solvent residues and low molecular ink components are led away from assemblies.

The oxidative curing process can be accelerated in a circulating air oven. Experience has shown that good results are achieved after 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 here, too, an adequate supply of oxygen because if insufficient oxygen is available the lacquers will not cross-link completely and then will not reach their final properties.
- Check the electrical properties of the coating (see Item 7.4) to ensure curing is completed. The time needed for curing in a circulating air oven is, among others, dependent upon the component geometry, coating thickness, oven loading, etc.

7.3 Drying/curing of highly-viscous conformal coatings (Index HV)

Owing to their high viscosity highly-viscous conformal coatings, such as **ELPEGUARD® SL 1331 HV** are applied in thicker layers than the other lacquer adjustments so that curing takes much longer. They must be cured for at least 96 hours at room temperature to achieve the required properties such as adhesion and electrical insulation.

- Check the required time for drying since even 96 hours may not be enough to cure high layers.

7.4 Checking drying/curing for completeness



**Depending on the layer thickness, the lacquer film will need a longer drying time to reach its maximum property values.
Check the property values acc. to DIN 46 449 “Conformal coatings/test method” at the earliest 96 hours after reaching the tack-free stage.**

On account of its importance we quote paragraph 5.2 “Timeframe of tests” of DIN 46 449 as follows:
“Unless otherwise specified in the individual test methods - the tests acc. to sections 5.5 to 5.12 must be performed on non-aged samples – in case of air drying lacquers 48 to 96 hours after reaching drying grade 3 (determined acc. to DIN 46 456 sheet 1, edition January 1970, section 6.7; VDE 0360 part 1) and in case of oven drying lacquers at the earliest 24 h after drying.”

- Observe that we recommend a drying/curing of at least 96 hours at room temperature (after reaching the tack-free stage) to ensure proper drying and curing even in case of higher layer thicknesses, for instance on/under components or drain-off edges.
- In case of oven drying keep to at least the above mentioned 24 hours while considering that, dependent upon the component geometry, layer thickness, etc., more than 24 hours may be necessary until the maximum property values are achieved.
- Check the required properties under the conditions of use.

8. Troubleshooting

8.1 Application of too high layer thicknesses/duplicate coating

Generally, optimum lacquer layer thicknesses are achieved when the conformal coatings are processed according to the above mentioned conditions (see also item 5 “Coating”). Thick lacquer layers as they result when the lacquer is processed undiluted, for example, should be avoided for the following reasons:

Thick lacquer layer thicknesses dry very slowly since the evaporation of the solvents and absorption of oxygen is handicapped. While the upper layer cross-links the lower layer 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 lacquer layer may occur that considerably impairs the operation of the assembly especially under the influence of moisture. The risk of too thick lacquer layers is particularly high with brushing and spraying or when the lacquer is processed in the viscosity supplied.

→ When processing in the condition supplied always perform suitable tests (climate tests) to ensure you achieve the required product properties.

If high lacquer layers are still required, a **duplicate coating** is possible. The second coating is only possible at certain times as otherwise wrinkling or swelling of the first lacquer layer may occur. Information on the appropriate time to apply the second layer can be found in the corresponding technical report.

The purely physical drying conformal coatings of the **ELPEGUARD® SL 1307** series are not suitable for duplicate coating as they are dissolved by the solvent in the lacquer.

With duplicate coating it has to be considered that wrinkling may occur in case of lacquer layer thicknesses of $> 100 \mu\text{m}$, for instance on drain-off edges. To avoid wrinkle formation in areas with a high lacquer layer thickness a complete curing (96 h at room temperature) is required prior to the second coating.

→ Remember that meanwhile a variety of special thick film lacquers for the application of high conformal coating thicknesses are available that enable the application of thicker layers while keeping short processing times short.

For instance, the **ELPEGUARD®** thick film lacquers of the series **TWIN-CURE® DSL 1600 E-FLZ**, based on a UV and moisture curing copolymerisate of polyacrylate and polyurethane, or the **ELPEGUARD®** silicone thick film lacquers **DSL 1705 FLZ** (thermal curing) and of the series **DSL 1706 FLZ** (room temperature curing) are available. Alternatively, 2-pack casting compounds can be used for such stresses that a 1-pack conformal coating does not sufficiently withstand, as for instance, aggressive industry atmosphere, wetness, or similar.

Further information on our range of thick film lacquers and casting compounds/resins as well as special technical reports and application information sheets for each product or product group are available upon request. In our report manual these technical publications are filed under group 1, 3 and 4. On our report manual CD technical data sheets can be accessed in the "Products" section.

8.2 Premature encapsulation of the coated assembly

While the tack-free stage of a lacquer is often reached after approx. one to two hours' standing time at room temperature, oxidative curing lacquer systems need at least 96 hours after reaching 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 a sufficient air circulation in order to ensure an adequate supply of oxygen (see also Item 7.2 "Oxidative curing").

If capsulation is performed too soon and the lacquer is not completely cured on the one hand, cross-linking cannot be effected completely due to lack of oxygen, and on the other hand low-molecular non-cross-linked lacquer parts may be released that condensate on open metal areas such as relay contacts and lead to sticking and contact problems.

Possible contaminations, e. g. fluxing agent residues, can still move in the incompletely cured ink film when a potential is applied and thus cause migration and tracking. Moisture can more easily penetrate and even accelerate the migration formation.

8.3 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. By our experience, corrosion is triggered by the following influential factors meeting each other:

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

8.4 Protective coating of BGAs

Underfill of BGAs before protective coating is mandatory for the following reasons:

- Incomplete drying/curing of the conformal coatings and solvent inclusions under BGAs
Owing to good cross-linking properties of the conformal coatings and high capillary forces under BGAs the lacquer runs under the component as a rule resulting in lacquer layers higher than 100 µm that do not dry/cure completely and leading to solvent inclusions under the BGAs (see also item 8.1 “Application of too high layer thicknesses/duplicate coating”).
- Mismatch of coefficients of expansion
A mismatch between the coefficients of expansion (CTE) of (incompletely cured) conformal coating, printed circuit board and component in case of thermal loads can cause the conformal coating under the BGA to ooze out or even lifting of the components.

Suppliers of underfill products will be gladly provided upon request.

8.5 Specialities when using conformal coatings of the series **ELPEGUARD® SL 1305 AQ**

Since an immeasurable number of components is available on the market in isolated cases incompatibilities between the water-borne conformal coatings of the series **ELPEGUARD® SL 1305 AQ** and the components may occur. This can be make itself noticeable for instance by a poor wetting or non-achievement of the specified properties.

→ Therefore, always perform test coatings with the components to be coated and check the final properties you require.

Under certain conditions failure of components may occur after coating with the conformal coatings of the series **ELPEGUARD® SL 1305 AQ**. Reasons for this can be among others:

- contamination of the components with production residues
- use of a lacquer not suitable to be protective coated during production of the components
- delayed drying of the conformal coatings of the series **ELPEGUARD® SL 1305 AQ** e.g. on account of high lacquer layers or high atmospheric humidity/insufficient air exchange
- applied operating or test voltage during coating (e.g. batteries), apart from malfunctions 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 to e-corrosion and failure of the components.

→ Check the components for their suitability to be coated with the conformal coatings of the series **ELPEGUARD® SL 1305 AQ**.

In case of a short-term functional test of the assembly 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 may impair the function of the assembly. This fact is particularly important with waterthinnable conformal coatings. In unfavourable cases water that has not yet completely evaporated may cause malfunctions if potentials are connected in such areas.

9. Cleaning of equipment

We recommend the following procedure when cleaning equipment used to process **ELPEGUARD®** conformal coatings:

- remove residues of the conformal coating
- rinse equipment thoroughly with cleaning agent **R 5817**. When using our conformal coating **ELPEGUARD® SL 1400 ECO-FLZ** rinse with cleaning agent **R 5804** or when using conformal coating **ELPEGUARD® SL 1305 AQ** rinse with deionised/distilled water, 1-methoxypropanol-2 (PM) or 5 % ammonia solution (**Pay attention to the special advice given in the technical report on conformal coatings of the series ELPEGUARD® SL 1305 AQ**).

Tip when using fluorescent lacquers: Rinse until no more fluorescence is visible under black light.

→ Subsequently rinse the equipment with the thinner of the new lacquer.



Pay attention to explosion protection guidelines!
Test the resistance of the material, particularly of gaskets.
We recommend the use of Teflon® - or Viton® gaskets.

10. Removal of the lacquer layer for repair purposes

Removal of the conformal coatings of the series **ELPEGUARD® SL 1300** to **SL 1309 N** as well as **SL 1400** with cleaning agents/strippers for repair purposes is virtually impossible after curing – with the exception of the physically drying lacquers of the series **ELPEGUARD® SL 1307** that are dissolved by the product-specific thinner. Since aggressive cleaning agents/strippers, such as N-methylpyrrolidone or acetone, can also dissolve the components of the assembly, use of these products should only be effected after checking the resistance of the assembly.

However, the conformal coatings of the series **ELPEGUARD® SL 1300** to **SL 1309 N** and **SL 1400** can be soldered-through without any problems at approx. 280-300 °C [536-572 °F]. The conformal coating can be reapplied after repair and cleaning of the surface (remove loosely sticking parts and wash with a suitable cleaning agent).

11. Visual control

The optimum insulating properties of a protective coating can only be achieved when the lacquer 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 transparent 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. Weak UV sources or “black light” lamps with a UV-A share at 350-375 nm are suitable. Suitable lamps are available for example, from Carl Roth (www.carl-roth.de).

→ Pay attention to the advice given by the manufacturer with regard to possible necessary protective measures.

However, this “black light” inspection procedure is not suitable to discover microscopic pin holes or bubbles or to determine the layer thickness.

12. Further literature

In addition to the recommendations given in this **Application Information sheet AI 1/1**, we can provide technical papers and information sheets written and compiled by members of our staff which give highly detailed information on the application and processing of our products. A list of the technical publications available can be found in **TI 15/101 E** (technical papers) and **TI 15/100 E** (technical information sheets).

On account of the different processing/curing of the **ELPEGUARD®** thick-film lacquers **TWIN-CURE®** as well as of our **ELPEGUARD®** silicone thick film lacquers separate application information sheets **AI 1/2** “Processing instructions for the **ELPEGUARD®** thick-film lacquers of the series **ELPEGUARD® TWIN-CURE®**“ and **AI 1/3** “Processing instructions for **ELPEGUARD®** silicone thick film lacquers“ are available.

In our report manual the above mentioned application information sheets are filed under group 1 and the technical information sheets (TI's) under group 15. Or visit our web-site at <http://www.peters.de>. On our report manual CD AI's and TI's can be accessed in the “Service” section.

Any questions?

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

The above information as well as advice given by our Application Technology Department whether in verbal or written form or during product evaluations is provided to the best of our knowledge, but must be regarded as non-binding recommendations, also with respect to possible third-party proprietary rights.<

The products are exclusively intended for the applications indicated in the corresponding technical data sheets.

The advisory service does not exempt you from performing your own assessments, in particular of our material safety data sheets and technical information sheets, and of our products as regards their suitability for the applications intended. The application, use and processing of our products and of the products manufactured by you based on the advice given by our Application Technology Department are beyond our control and thus entirely your responsibility. The sale of our products is effected in accordance with our current terms of sale and delivery.

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