Printing of SMT Adhesives

Technological Considerations
SMT adhesives are applied on PCB's by dispensing (90 % of all manufacturers use this technique at the moment), printing and pin-transfer techniques. The conventional dispensing method of applying adhesive utilizes variations in dispense time, pressure and temperature combined with needle diameter to form deposits with varying volume and geometry. Recently the printing technique has become popular. This technology is very well known from solder paste printing. The major driving force is the higher throughput of this application method. Moreover, a new printing technique with thick stencils allows depositing of glue dots with different diameters and different heights.

Conventional Printing Technology
For many years, numerous manufacturers world-wide have been printing glue with an 80 mesh screen or a stencil using conventional printing technology typical to solder paste printing. Heraeus SMT adhesives PD 860002, PD 922 and PD 945 are successfully used in this process.

Principle Explanation
In the conventional printing process the adhesive is transferred completely from the stencil to the board. The stencil thickness and aperture diameter govern the volume deposited, which can be calculated using the formula for a cylinder:

\[ V = \pi \left( \frac{d}{2} \right)^2 h \]

\[ h = \text{stencil thickness (GDH)} \]

\[ d = \text{aperture diameter (GDD)} \]

Stencil Thickness (determines the GDH)
Stencil thickness must be selected to be slightly greater (e.g. +2 mils) than the component stand-off (distance between the board surface under the component and the bottom of the component after placement). The stand-off after placement can vary for the same component, depending on the:
- Thickness of solder resist and of the copper tracks which may be passing between the pads

![Graph 1](image1.png)
![Graph 2](image2.png)
It is easy to select the optimal stencil thickness when all components on the board have a similar stand-off. However, if on the board we have both active (SOICs, QFPs etc.) and passive components (chips), then the passive components become the limiting value because their stand-off distance is typically no more than 4 mils. After the placement of the component, the excess glue is compressed and it flows in the space between the component and the PCB. The information from the following diagram assumes that all of the glue is transferred from the stencil to the PCB and that the shape of the dot after placement of the component is a cylinder. Stand-off (component to board gap) indicates the distance between the component and the PCB after placement.

If chip components are placed in a glue dot, which is too high, the following problems might occur:
- the glue spreads too much at placement and contaminates the soldering pads or
- the gap between the chip and the PCB after curing might be too large, which will generate “skips” during wave soldering.

A typical stencil thickness is 6 mils for designs with only passive (chip) components and 10 mils for designs with both passive and active (leaded) components. Generally, the glue will be transferred completely from the stencil, if the stencil aperture diameter to stencil thickness is \(\approx 4:1\) or more.

**Aperture Diameter (determines the GDD)**
In order to specify an aperture diameter for a passive component, the distance between the inside edges of the SMT pads must be known or measured. This distance, minus the print alignment tolerance, then becomes the maximum diameter of the post-placement adhesive deposit.

**Thicker Stencils for Printing Glue Dots with Different Heights**
Many companies are testing thicker plastic and metal, machined and laser-cut stencils, which can print glue dots, having not only a different diameter (GDD) but also a different height (GDH).

**Principle Explanation**
When printing solder paste, it is desired that all paste from the stencil opening is being transferred to the PCB. A new printing process takes advantage of the fact that some glue remains in the stencil (which is thicker than for solder paste) after the separation of the PCB and the glue (see Figure 1). The process is based on the surface tension between the glue and the stencil openings, (stencil thickness is constant at 0.3mm or 12 mils):

- If the stencil opening is small, e.g. 0.3 mm (12 mils), the surface tension between the glue and the stencil is so strong that the majority of the glue remains in the stencil. Glue dots on the PCB have the small height (GDH very low).
- With the bigger stencil opening, e.g. 0.8 mm (32 mils), the major part of the glue is transferred from the stencil. During the separation of the stencil and the PCB the stencil drags the glue and the dots will be very high (GDH very big).
- If the stencil opening is very large, e.g. 2 mm (80 mils), all glue is transferred from the stencil opening. The glue dots on the stencil will have a moderate thickness, which is similar as the thickness of the stencil.
Diameter of stencil openings for different components

The diameter (GDD) and the height (GDH) of the glue dots depend on:
- Diameter of the stencil openings
- Stencil thickness
- Viscosity/Rheology of the glue
- Surface roughness of the stencil apertures - surface tension forces between the glue and the stencil.
- Surface topography of the PCB

To find an optimal diameter of the glue dot/stencil apertures for different components, dots with different diameters were printed onto a glass substrate then populated with various components. These combinations of components and glue dots were then inspected for the maximum dot diameter that did not contaminate the component metallizations.

In the table below are approximate GDD (and openings in the stencil) for different components when printing with a metal, laser-cut stencil of 10 mil thickness using the printing parameters described:

<table>
<thead>
<tr>
<th>Component size</th>
<th>Multiple Dot Approach * (stencil opening diameter in mils)</th>
<th>Typical Multiple Dot Pitch (pitch in mils)</th>
<th>Single Dot Approach (stencil opening diameter in mils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0402</td>
<td>N/A</td>
<td>N/A</td>
<td>12 - 16</td>
</tr>
<tr>
<td>0603</td>
<td>2 X 20</td>
<td>15</td>
<td>16 - 20</td>
</tr>
<tr>
<td>0805</td>
<td>2 X 24</td>
<td>20</td>
<td>20 - 24</td>
</tr>
<tr>
<td>1206</td>
<td>2 X 32</td>
<td>24</td>
<td>40 - 47</td>
</tr>
<tr>
<td>Mini Melf</td>
<td>N/A</td>
<td>N/A</td>
<td>40</td>
</tr>
<tr>
<td>SOT 23</td>
<td>2 X 28</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>1812</td>
<td>2 X 55</td>
<td>40</td>
<td>50 - 60</td>
</tr>
<tr>
<td>SO 8</td>
<td>3 X 55</td>
<td>43</td>
<td>N/A</td>
</tr>
<tr>
<td>SO 14</td>
<td>3 X 55</td>
<td>43</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* For the Multiple Dot Approach for chip (leadless) components, position the dots so that between 0.5 and 0.3 of the dot area is under the body of the component. The Multiple Dot Approach is very effective for preventing skewing of chip components, especially Melf types.
Stencil Cleaning

Metal Stencils

Acetone is the best solvent for cleanup from both a cost and solvency standpoint but if a non flammable solvent with equivalent solvency is desired then EnSolv from Enviro Tech International (708) 343-6641 is recommended. Zestron HC from Zestron Corporation (703) 589-1198 has also been effective for adhesive clean-up. It is recommended to verify the compatibility of the cleanup solvent with the stencil frame adhesive.

Plastic Stencils

Plastic stencils can be cleaned with the same recommended solvents as for metal stencils with a few additional considerations.

- A static charge may build up on the stencil during cleaning that can affect printing results.
- Plastic stencils are more susceptible to scratching during manual cleaning.
- Typically plastic stencils are much thicker than metal stencils and small apertures may require more aggressive cleaning such as high pressure spray and/or ultrasonic methods.

Glue Selection

The shape and the consistency of the glue dot depends on the rheology of the adhesive (yield point and plastic viscosity). The Heraeus PD 955 PY has been specially developed with a rheology designed for stencil printing. It has excellent adhesion with standard and difficult to glue components (Low-Stress Plastic Encapsulated Components). This new adhesive is not hygroscopic.

Printing Parameters
Printing parameters have a crucial influence on glue dot shape and consistency. In laboratory conditions, optimal results have been obtained with the following parameters:

**Stencil Material:** No major difference was observed between metal and plastic stencils. A metal stencil is preferred because it is easier to clean, more robust and more readily available.

**Stencil Thickness:** For chips (leadless), only use a 6 mil thick stencil. For designs that include SOIC’s use a 10 mil thick stencil. It is possible to obtain a dot height of 80 mils with a 1 mm (40 mil) thick plastic stencil.

**Snap-off:** Contact print (0 snap-off). For much higher dots with the same thickness stencil, a snap-off of up to 1 mm (40 mil) is recommended.

**Squeegee Material:** Metal blade for metal stencils, polycarbonate blade for plastic stencils.

**Print speed:** 25 - 50 mm/sec (1 - 2"/sec)

**Squeegee Pressure:** 0.2 to 0.3 kg/cm (enough for a clean wipe of the stencil)

**Separation speed:** slow (0.1 - 0.5 mm/sec) for 3mm distance (separation height)

**Print Sequence:** Print/Print mode is recommended for good aperture fill, especially if large apertures (> 1 mm diameter) are to be printed. Another method of obtaining higher dots than the stencil thickness without increasing snap-off is to leave a film of material over the apertures after the second print stroke by either using less pressure (0.01 to 0.05 kg/cm) or printing much faster (150 mm/sec) with the second squeegee. This simulates a flood stroke.

**Printing Technique versus Dispensing**

**Advantages**

- Higher throughput.
- There is no need to install dispensing machines on the line:
  - shorter lines
  - lower investment.
- Larger glue packages can be used:
  - less package waste
  - lower costs for the glue per quantity unit.
- This process is well suitable for double sided boards populated with SMD-components only.
- Adhesive deposits that are shapes are possible.
Disadvantages

Valid for Conventional and for the Printing Process with Thick Stencils

• Less flexible as each PCB-Layout requires another stencil or screen.
• Thick stencils are more difficult to be cleaned than needles.
• It is not possible to print adhesive on a populated PCB.
• Not applicable for double sided reflowed boards, as it is only possible to dispense the glue after printing of solder paste (process: first side of the PCB - print solder paste, dispense the glue, place the components, reflow the paste and cure the glue ; second side of the PCB - print solder paste, place the components, reflow the paste).
• Adhesive is exposed to the environment over longer period of time - bigger temperature differences and water absorption can cause performance changes in the adhesive - it is recommended to use non-hygroscopic adhesives, which have low sensitivity to temperature.
• There is a danger of dust/lint entrapment in the glue.

Valid for Conventional Printing Process only

• It is difficult to process components with a big difference in stand-off (QFP’s and PLCC’s) as all glue dots have the same height. This assumes that the component stand-off height is > 10 mils.

Concerns

Valid for Conventional and for the Printing Process with Thick Stencils

• There is a danger of air entrapment in the glue during the squeegee process. The danger of air entrapment is bigger with high viscosity adhesive. On the other hand, an increase of the temperature and smaller vertical squeegee movement decreases the risk of air entrapment. The use of metal squeegees, can significantly reduce the entrapment of air.
• If a printing technique is used for processing of PCBs which are populated both with SMD and also with through-hole components, then the process must be organised as follows: print the glue, place the SMD’s, cure the glue, insert the through-hole components then wave solder. During the placement of the through-hole components a strong bending of the PCB is possible which might cause a loss of SMD’s. This danger is less present when the glue is applied by dispensing because through-hole component insertion typically precedes the glue dispense and SMT placement operations.

Valid for Conventional Printing Process only

• If there are components on the board with a very big difference in stand-off, it may be necessary to dispense the glue manually or automatically.

Valid for the Printing Process with Thick Stencils only

• During the cleaning process with plastic stencil a static charge can occur.
• When printing with stencils considerably thicker than 10 mils the dot consistency of small dot (< 20 mils) is compromised.
**Conclusion**

The conventional printing process works fine with the limitation that all glue dots have the same height. High dots with excellent consistency for the component range of 0402 chips to SO 28 leaded components can be obtained with a thick (10 mil) metal stencil. A print-print print mode with a metal squeegee blade and slow board to stencil separation speed are recommended. By adding snap-off or by leaving a controlled film of material over the apertures after the last squeegee stroke, very high large dot heights can be obtained.

The descriptions and engineering data shown here have been compiled by Heraeus using commonly-accepted procedures, in conjunction with modern testing equipment, and have been compiled as according to the latest factual knowledge in our possession. The information was up-to-date on the date this document was printed (latest versions can always be supplied upon request). Although the data is considered accurate, we cannot guarantee accuracy, the results obtained from its use, or any patent infringement resulting from its use (unless this is contractually and explicitly agreed in writing, in advance). The data is supplied on the condition that the user shall conduct tests to determine materials suitability for a particular application.