# SMT adhesive dispensing

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## DISPENSING

The adhesive dispensing process, can be defined as the process of transferring adhesive onto the PCB solder mask in a position suitable for holding the later placed components until the PCB is wave soldered. In some cases, this process is also used to hold heavy components in the second pass of a double-sided reflow process.

## DISPENSING FACTORS

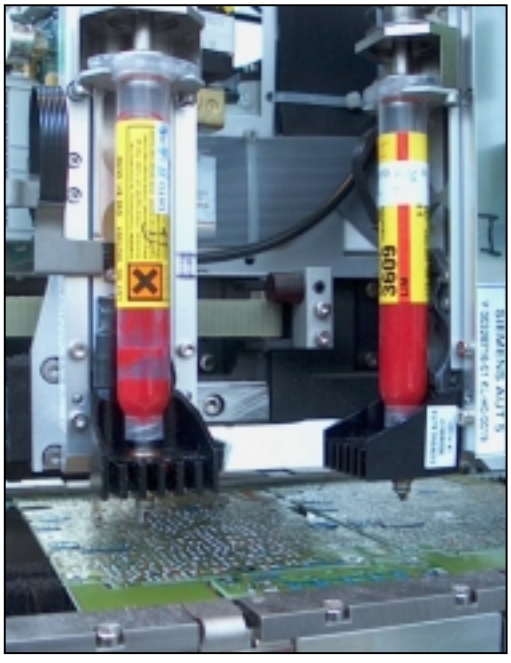
When dispensing adhesive onto a PCB there are a lot of factors to consider. In the listing below the most essential factors are mentioned.

| Equipment | Method | Materials | Environment | Operators |
|---|---|---|---|---|
| -Dispenser unit<br>-X,Y,Z gantries<br>-Head type<br>-Nozzle type<br>-Nozzle temp. control<br>-PCB handling & PCB Support<br>-Vision system<br>-Dispensing Repeatability | -Dispensing parameters<br>-Pressure<br>-Time<br>-Standoff<br>-Auger rotation<br>-Droplet number | -Adhesive<br>-Viscosity<br>-Thixotropic behaviour<br>-PCB<br>-PCB flatness<br>-Solder mask<br>-Flatness / finish<br>-Solder pad<br>-Flatness / finish<br>-Height in relation to solder mask | -Production area<br>-Dust & dirt<br>-Air circulation<br>-Air humidity<br>-Temperature<br>-Static electricity | -Training<br>-Knowledge<br>-Awareness<br>-Authority<br>-Safety |

All the factors in the five groups have different grades of importance, but all play a role in the final result, so it is imperative to take all aspects into consideration if high quality goals are to be achieved.

## DISPENSING EQUIPMENT

The equipment used for adhesive dispensing can be categorized into 2 main groups; In-line and off-line. Choosing an in-line or off-line system depends on the job in hand. If the process is rarely used and only in small production batches an off-line dispenser unit should be adequate, but for high out-put placement lines, where the product cycle-time is short, an in-line system will be necessary.
For both in-line and off-line systems, 3 different dispensing methods are used. The 3 methods are time / pressure, auger pump and piston pump. The similarity found in all 3 methods, is the dispensing head movement on X, Y and Z-axis gantries, allowing it to move over the stationary PCB and transfer the adhesive dots. High speed dispensing, to overcome bottle-necks, can be reached with multi gantry dispensers. These machines allow speeds up to 120.000 dots per hour on a relatively small machine footprint. To increase the possible variation in dot diameter and height, 2 – 4 dispenser heads are usually fitted per gantry.



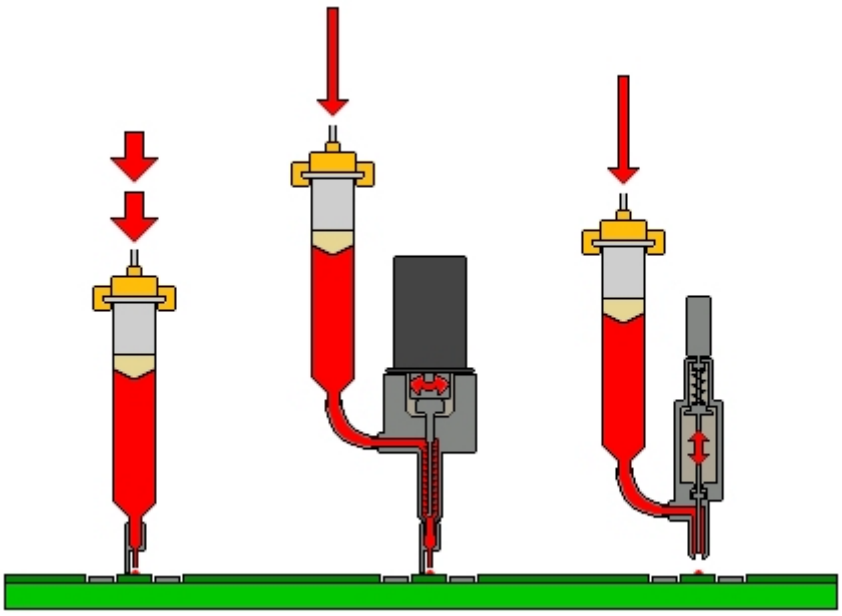
To make perfect adhesive dots, the PCB support must hold the PCB in a locked position and absolutely parallel to the X and Y-axis. The PCB support must be designed for both flexibility and fast change over. To ensure the necessary dispensing accuracy and repeatability an automatic vision alignment system using PCB fiducial marks combined with a closed-loop servo system must be included. These systems correct the program coordinate data to align with the PCB.

The modern dispensing unit can be provided with a lot of options such as computer control, automatic conveyor width adjustment, adhesive temperature control, automatic needle calibration (X, Y, Z), etc.

For really high output lines yet another dispensing method could be used; the pin transfer method (not covered in this paper).

## DISPENSING METHOD

The dispensing system must transfer precise and uniform adhesive dot shape and height at varying volumes onto the PCB solder mask surface. The adhesive must have sufficient attachment capability, also known as "green strength", to hold the components in place until cured. The cured adhesive then must hold the SMD components in the correct position until wave or reflow soldered (second pass in double-sided reflow process).



Time / Pressure  Auger Pump  Piston Pump

The adhesives' deposit and shape are determined by different factors, such as adhesive viscosity, adhesive supply pressure, dispense time (time / pressure system), auger rotation (auger system), number of piston strokes (piston system), dispense rate and nozzle standoff height.

There are some limitations in the SMT adhesive dispensing process. Chip components smaller than 0603 (1608) cannot be placed in SMT adhesive without a very high risk of failure in terms of solder skip. The adhesive will protrude onto the solder land and make soldering difficult. Also, it is not likely that wave soldering of components this size will succeed. Another limitation is to dispense adhesive dots high enough to hold components with a high body standoff. This of course depends on the nozzle diameter and the height of the nozzle standoff foot.

Several parameters are important to reach a good result when dispensing adhesive onto the PCBs. The parameters for each system type are explained below.

### Time / pressure system

The time / pressure is the oldest and most commonly used SMT adhesive dispensing system available. It is however also the most sensitive of the three described systems.

**Time & Pressure**
In a time / pressure system a relatively high air pressure is applied to the top of adhesive cartridge for a controlled period of time (ms) to transfer the adhesive volume needed to the PCB. The air pressure must be accurately adjusted and periodically checked to maintain uniform dot sizes. The chosen dispense time, nozzle inner diameter and standoff height then determine the dot size.
The air pulse response time varies if an adhesive cartridge is full or close to empty. This, combined with air pressure variation can cause the process to fluctuate and result in dot size variation.

**Nozzle size**
Some dispensing units feature 2 - 4 dispensing heads on the gantry. Each is fitted with a different nozzle diameter and standoff foot enabling the machines to dispense adhesive dots in a large variety of sizes.
E.g.: A nozzle with a very small inner diameter and short standoff foot will not be able to dispense an adhesive dot proper for large PLCC packages.
The nozzle sizes should be chosen for the job in hand. Generally speaking, the smallest possible dot diameter equals twice the nozzle inner diameter. The upper limit of the dot diameter is dictated by a combination of nozzle inner diameter and the standoff foot height.

**Stand off**
A bend or twisted PCB can result in large adhesive dot size variation and in turn a variation in the strength of the component attachment. The use of a standoff foot will ensure a more uniform dot height but also to a certain degree dictate the dot height. Typically the stand off height is between 0.15 and 0.3 mm depending on the nozzle inner diameter.
A periodic height measurement of the standoff foot is recommended as a part of controlling the dispensing process. The standoff foot is constantly being driven against the PCB surface and will eventually wear down and cause problems such as different dot height, volumes and stringing.
The angle at which the standoff is placed on the nozzle is also an important issue. The standoff foot must never come in contact with previously placed dots. Some systems have a fixed standoff angle, which can give some restrictions to how flexible the system can perform. Other systems give the user a choice of different standoff angles to enhance speed and performance. The system is then optimized with the given angles and must not be altered during production. The operator must be aware of this during nozzle replacement or cleaning.

**Temperature control**
The viscosity of the adhesive is of outmost importance. To reduce adhesive dot volume and shape deviation it is therefore essential to use an adhesive temperature control system. The temperature setting must be optimized for the chosen adhesive but should, as minimum be set above the maximum ambient air temperature by a few degrees Celsius.

## Auger pump system
The auger system is also called rotary pump or Archimedes pump.

**Auger rotation**
A constant low pressure is applied to the top of the adhesive cartridge, pressing the adhesive into the top of the auger chamber. When the auger is turned the adhesive is moved downwards and out through the nozzle. The amount of SMT adhesive dispensed depends on the amount of rotation (degree) of the auger, the adhesive thixotropic behaviour and ambient temperature.

**Nozzle size**
As for the time/ pressure system a variety of nozzle sizes are necessary on the gantry, enabling the machines to dispense adhesive dots in a large variety of sizes. And the rules for choosing the nozzle sizes for the job are also identical.

**Stand off**
As for the time / pressure system, a mechanical nozzle standoff foot is used to overcome problems with bend and twisted PCBs. The standoff height should, for this system also, be between 0.15 and 0.3 mm depending on the nozzle inner diameter. This can be avoided if a mechanical nozzle standoff foot is used. The use of a standoff foot will also ensure a uniform dot height.

**Temperature control**
As for the other two dispensing systems the viscosity and the flow behaviour of the adhesive are of outmost importance. A nozzle temperature control system will therefore be desirable to reduce adhesive dot volume and shape deviation. The temperature setting must be optimized for the chosen adhesive but should, as minimum be set above the maximum ambient air temperature by a few degrees Celsius.

## Piston pump system

The piston pump system or positive displacement pump is the newest of the 3 dispenser types. The advantage of this system is a limited number of critical process factors. A piston pump system included with a nozzle temperature control system is very accurate in terms of the amount of adhesive transferred to the PCB. The variation is usually within + / - 1 percent by volume.
Stringing and tailing is less common with this type of system. But if the viscosity of the adhesive incorrect it still can be seen.

**Droplet number**
The function of one of the available systems is as follows. When the piston is raised by the solenoid valve a constant low pressure applied to the top of the adhesive cartridge fills the piston chamber with adhesive. When the spring-loaded piston is released one droplet is forced out of the nozzle hitting the PCB below.

There are a variety of piston pump designs but all of them apply tiny adhesive droplets one at a time. A larger adhesive volume is applied by stacking multiple droplets on top of one another. This means that the process is easy to control.

**Nozzle size**
With this system only one nozzle diameter is needed. As earlier described a large adhesive dot is simply dispensed by multiple small dots on top one another.

**"Stand off"**
With most piston pump systems the adhesive dispensing is a non-contact process, allowing some components to be in place already. Some units include a PCB height measurement unit to ensure a uniform nozzle height, adjustable around 4 to 6 mm.

**Temperature control**
Securing a uniform adhesive viscosity is the main critical factor of the piston pump is system. To reduce adhesive dot volume and shape deviation it is therefore essential to use an nozzle temperature control system. The temperature setting must be optimized for the chosen adhesive but should, as minimum be set above the maximum ambient air temperature by a few degrees Celsius.

# MATERIALS

**Adhesive**
The adhesives function is basically to hold the components on the PCB from placement until the components have been wave or reflow (bottom side) soldered. The main criteria that should be considered when choosing an SMT adhesive are: the dispensing method, the dispensing speed, the working environment, the adhesive pot life, and the curing process.

**PCBs**
The flatness of the PCBs is essential to the dispensing quality. If the PCBs are bend or twisted, the result can be large variation in the adhesive dot size and finally a variation in the strength of the component attachment. However, it will be less critical if using a mechanical nozzle standoff foot, as long as the PCB surface is not lower than the nozzles maximum stroke depth. The PCBs must also be clean and without fingerprints that can cause poor adhesive attachment and finally cause components to fall of the PCB during handling or the wave soldering process.

Also solder pad height in relation to solder mask is an important factor that should be considered when selecting the adhesive dot sizes and standoff foot height for each component type. In fact, the most common problems occur when dispensing on poorly levelled HASL PCB's.

## ENVIRONMENT

Dust and dirt from the air that ends up on the PCBs can result in poor adhesive attachment on the PCBs and finally result in missing components on the PCBs.
Depended on the type of adhesive used, air draught in the production area, high temperatures, high humidity and light can cure or degrade the qualities of the adhesive. The viscosity for most adhesives changes with the temperature and it is important to secure a stable process temperature. Check the adhesive supplier's data for the temperature window.

Static electricity can be a problem in some cases. This occurs if the nozzle becomes charged. The adhesive then tends to stay attached to the nozzle and cause a lot of stringing. To eliminate this problem, an ion blower can be placed in the dispensing unit.

Since the adhesive often is an epoxy, handling must be done with outmost care. Use of gloves will be necessary to avoid skin contact especially in the cleaning process after end dispensing. The easiest system to clean is the time / pressure system due to the few parts involved.

## OPERATOR

Adhesive dispensing is a very sensitive and delicate process. Therefore the operators have to be trained and experienced. The operators should be able to foresee problems and adjust the process to ensure a good dispensing quality. Things like: position of adhesive dots, shape of dots and volume should be controlled frequently.

## LIST OF FAILURES RELATED TO SMT ADHESIVE DISPENSING

**Missing components**

**Missing components** after the wave or reflow (bottom side) soldering process can be caused by insufficient, missing or misaligned adhesive dots. Missing adhesive can be due to clogged or partly clogged nozzle, damaged or a too high standoff foot and entrapped air in the adhesive cartridge.

The solder mask can have a contaminated surface, which can cause bad adhesion to the mask. The mask usually looks oily or very shiny.
A typical sign indicating this problem is that the adhesive is always attached to the removed component and never to the PCB mask.

Be aware that a poor curing process can also result in missing components after the wave soldering process.

**Open joints**

**Open joints** can be the result of misaligned adhesive dots, stringing or tailing. If the adhesive is dispensed onto or partly onto the solder pads and pressed further out by the placed component, wave soldering cannot be performed.

Adhesive dispensed onto the solder pads could be a machine accuracy problem or wrong setting leaving too much adhesive on the PCB surface.

Adhesive stringing or tailing can be caused be several factors; poor adhesive thixotropic behaviour, poor PCB surface condition, wrong machine set-up parameters, static electricity and incorrect dispense nozzle.
For time / pressure and auger systems, a too large amount of adhesive dispensed compared with the nozzle inner diameter and standoff height will result in stringing and a large variation of transferred dot volume. The access adhesive simply sticks to the nozzle tip due to a larger surface tension and then leaving a tail when retracted.