

Stencil Printing Codes of Practice

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Approved on behalf of Managing Director, NPL, by Dr C Lea,
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Stencil Printing Code of Practice

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ABSTRACT

Three related codes of practice are provided, for: solder paste, stencil printing materials, and stencil printing. These are written to be a practical and digestible guide for the production or process engineer on the shop floor. They offer practical advice and best practice to optimise and maintain optimum stencil print yields.

INTRODUCTION

The process of stencil printing solder paste for electronics manufacture is a complex interplay of numerous variables, many of which are out of the direct control of the assembler. These variables represent over two thirds the total variables for the entire surface mount (SM) assembly process. It is therefore difficult to make definitive recommendations for the process but the following codes of practice are based on the results generated from a three year research programme at the National Physical Laboratory and have been found to hold true for a range of solder pastes, stencils and squeegees.

1 SOLDER PASTE CODE OF PRACTICE

Storage :

The conditions under which solder paste is stored to maintain its optimum properties are very paste dependent. Many RMA pastes which are sealed under controlled atmospheres do not require refrigeration if left unopened. However, some aqueous pastes which are not refrigerated may deteriorate to an unprintable condition within a few weeks. Unless the user has evidence to the contrary, the best practice is to follow suppliers' guidelines. Pastes evaluated at NPL were all found to perform acceptably when stored accordingly.

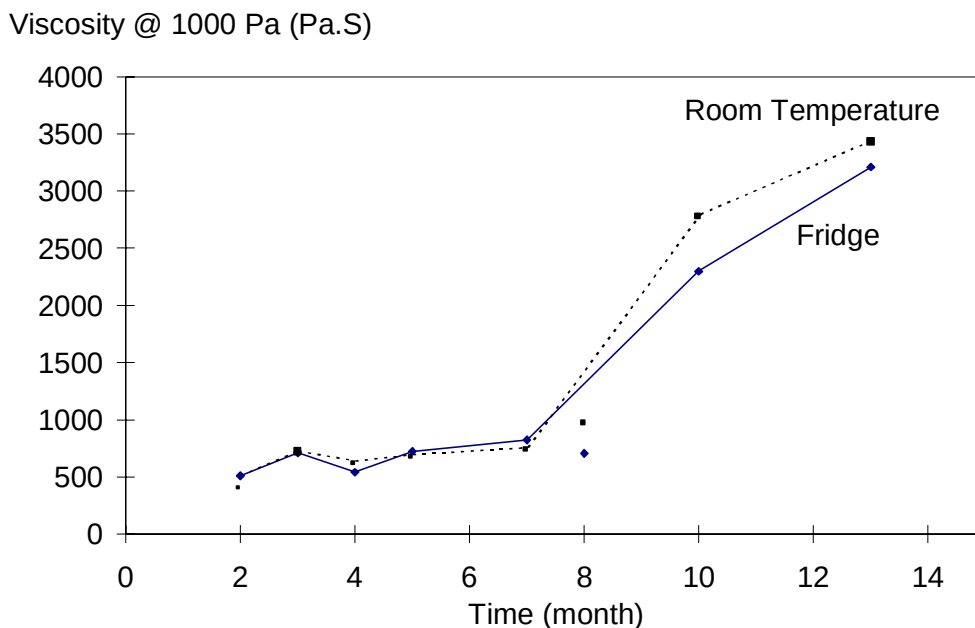


Figure 1 : Change in paste viscosity as a function of time and storage conditions

Pastes which have been refrigerated need to return to room temperature before any attempt is made to print with them. For a 250g tub of paste, at least two hours should be allowed before the paste is introduced into the process. Larger quantities of paste will require longer periods to return to room temperature. Best practice is to remove refrigerated pastes at the beginning of the preceding shift, or the afternoon before if single shift working.

Environmental Control :

Temperature and humidity control play an important part in gaining the best performance from solder pastes. If the ambient and consequently the paste temperature is too low, the paste will be too viscous and will roll poorly across the stencil and fill the apertures poorly. If the temperature is too high then the paste will have a poor stencil life due to more rapid solvent loss. High humidity conditions cause moisture take-up by the paste and subsequent poorer printing performance. The environmental performance for pastes varies enormously, but for most pastes, the closer to 25°C/40%RH the ambient can be maintained, the better the paste will perform and the longer will be the stencil life. Enclosed print heads can be used to negate the requirement for humidity control, but temperature control may still be required.

■ 22°C/RH40% □ 28°C/RH40% ▨ 22°C/RH75% ▩ 28°C/RH75%

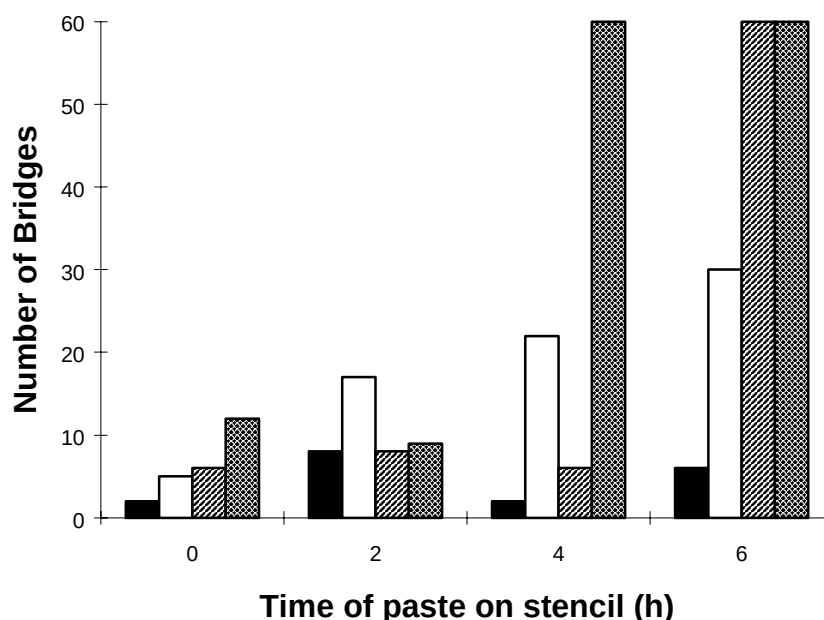


Figure 2 : Variation in bridge formation as a function of paste time on stencil for a variety of ambient conditions

Stencil Life :

Pastes have a finite life on the stencil. Generally, the longer a paste is left on the stencil, the poorer its printing performance will be. This exhibits itself most at finer pitches.

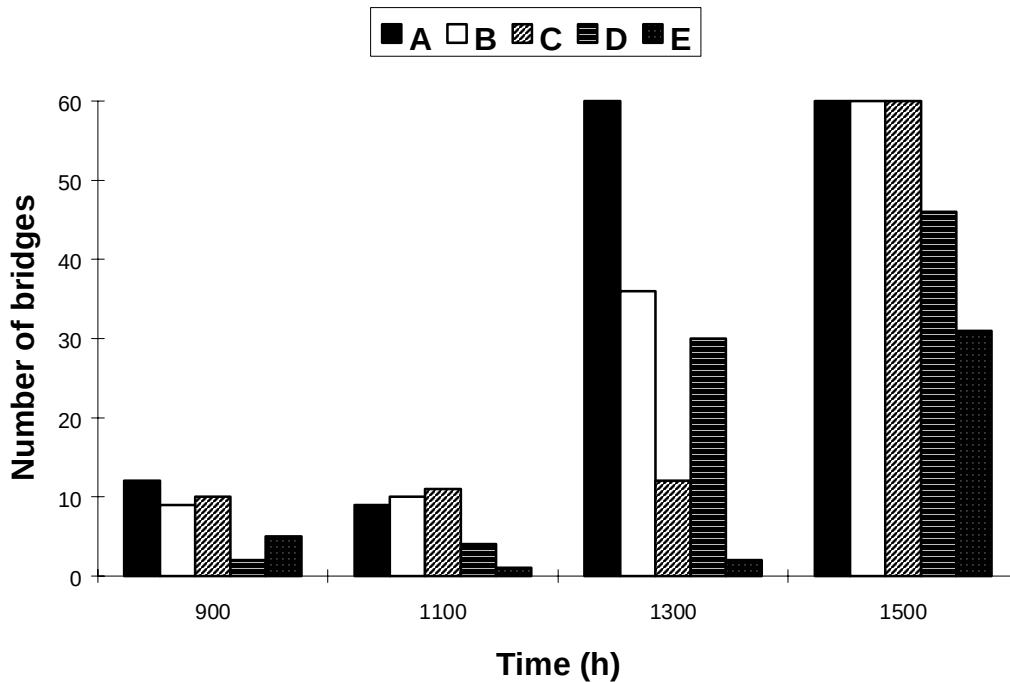


Figure 3 : Variation in bridge formation in 0.5mm pitch apertures parallel to the print direction at 28 °C/75%RH for 5 pastes as a function of print time

Long stencil life pastes formulated with high flash point solvents may show improved performance after being on the stencil for long periods, but they may be more difficult to profile in the reflow oven because of the greater energy required to evaporate these solvents.

2 STENCIL PRINTING MACHINE MATERIALS CODE OF PRACTICE

Squeegee Blades :

Choice of squeegee blade (Figure 4) type depends on the conditions under which the blades are to be used. In general, metal blades out perform polyurethane blades. Metal blades are less prone to deforming into the aperture and scooping solder paste, resulting in low print volumes. However, there is a number of metal squeegee blades types, which do perform differently. Rigid 60° blades, which deflect less due to being of thicker stock material or have a shorter unsupported length outside the blade holder, perform best when the substrate is perfectly flat or can be deflected flat under normal squeegee pressures. However, when the substrate is warped or twisted, flexible blades made from thinner stock material or having a longer unsupported length outside the blade holder, have superior performance. There can be a significant difference (15%) in printed solder paste volume between using flexible squeegee blades and rigid metal blades. The recommended squeegee for flat board printing would be the rigid 60° blade which gives the highest volume of paste. However, an excellent compromise in terms of volume and being resistant to distortion of the substrate, is the flexible polymer coated 60° blade, and which also produces very consistent results.

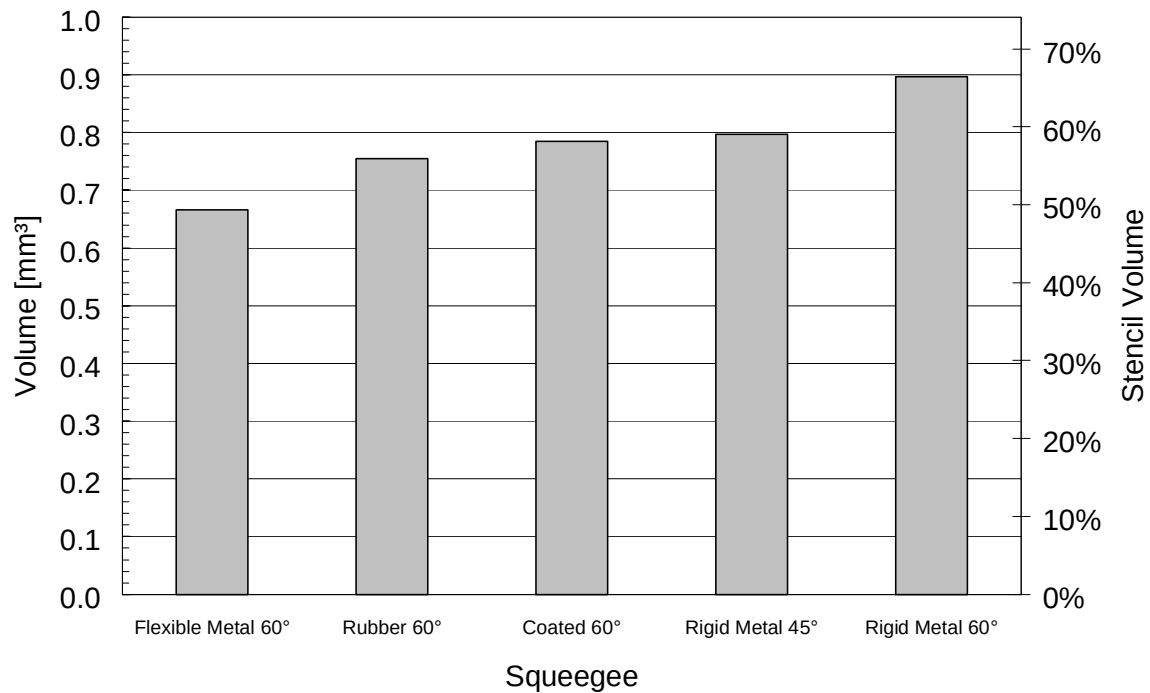


Figure 4 : Variation of aperture filling for different squeegee types (for 0.15mm stencil at 0.5mm pitch, averaged over 2 pastes, 3 pressures, 3 speeds, 3 directions)

Stencils :

Three types of stencil are commonly available (i.e. chemically etched, laser-cut and electro-formed). All perform well down to 0.5mm pitch (0.25mm track and gap). Below this, laser-cut and electro-formed nickel stencils perform better.

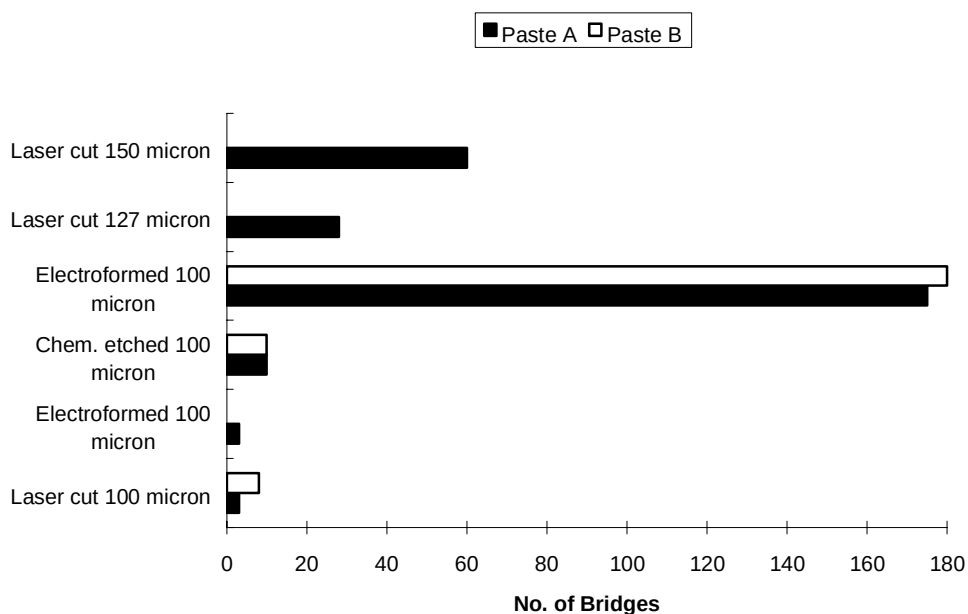


Figure 5 : Variation in the number of bridges for 2 pastes printed through 3 different stencil types at different thicknesses and 0.4mm pitch

The selected thickness of the stencil is dependent on aperture size. Narrow apertures require thinner stencils. The aspect ratio of aperture width to stencil thickness should be maintained as high as possible. **A minimum ratio of 1.75 : 1 is normally recommended.** For fine pitch work, 0.10mm (0.004 inch) thick stencils are recommended. For solder joints requiring large volumes, 0.20mm (0.008 inch) thick stencils are preferred. Where there is a mixture of both fine pitch and large joint volumes, 0.15mm (0.006 inch) stencils are frequently used.

Aperture Orientation :

The long dimension of apertures perpendicular to the direction of squeegee travel result in paste deposits that are of lower volume and more prone to bridging than apertures perpendicular to squeegee travel. More even paste deposits can be obtained by orientating fine pitch components at 45° during assembly design or orientating the substrate likewise during printing.

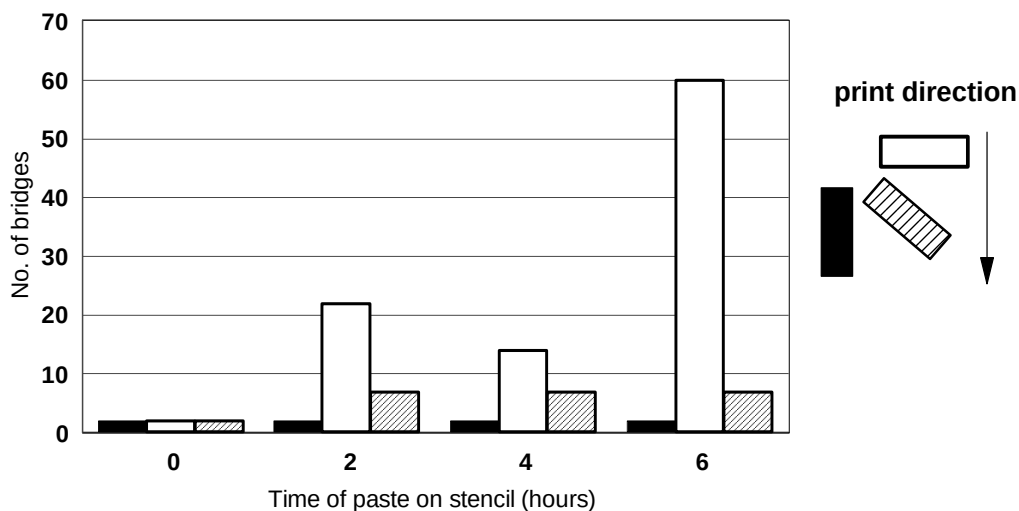


Figure 6 : Effect on the number of bridges formed as a function of time of paste on stencil, and on aperture orientation.

Aperture Shape :

Provided that minimum aperture dimensions in relation to stencil thickness are maintained, the aperture shape has little effect on printing performance. Down to 0.4mm pitch (0.2mm track and gap), there is little difference between square and round ended apertures.

3 STENCIL PRINTING CODE OF PRACTICE

Squeegee Pressures :

Squeegee pressures should be set at the minimum pressure required to produce a clean upper stencil surface after a print stroke. Excessive pressures will reduce the solder print volume and

may cause squeegee or stencil damage. Insufficient pressures will produce irregular print heights and thus irregular print volumes.

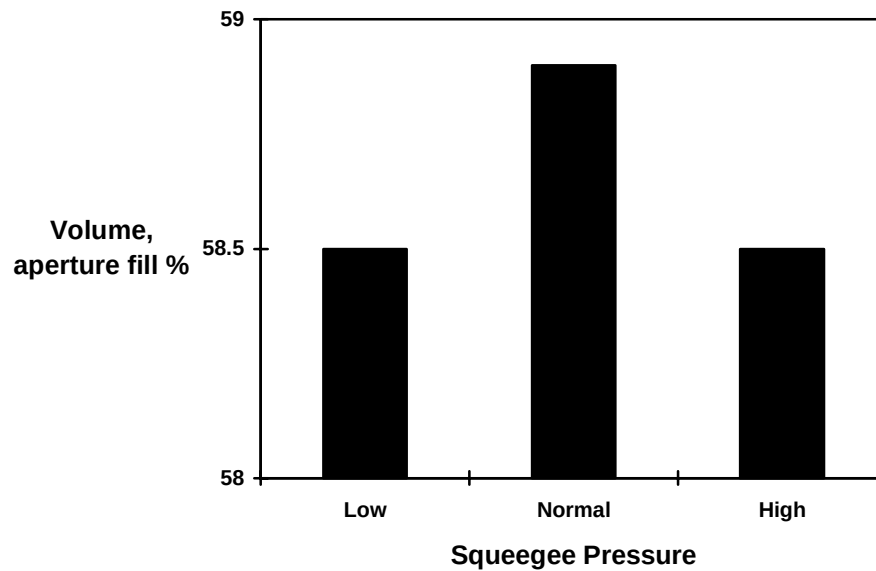


Figure 7 : Variation of aperture filling for different squeegee pressures (for 0.15mm stencil at 0.5mm pitch, averaged over 2 pastes, 3 squeegee speeds and 4 squeegee types)

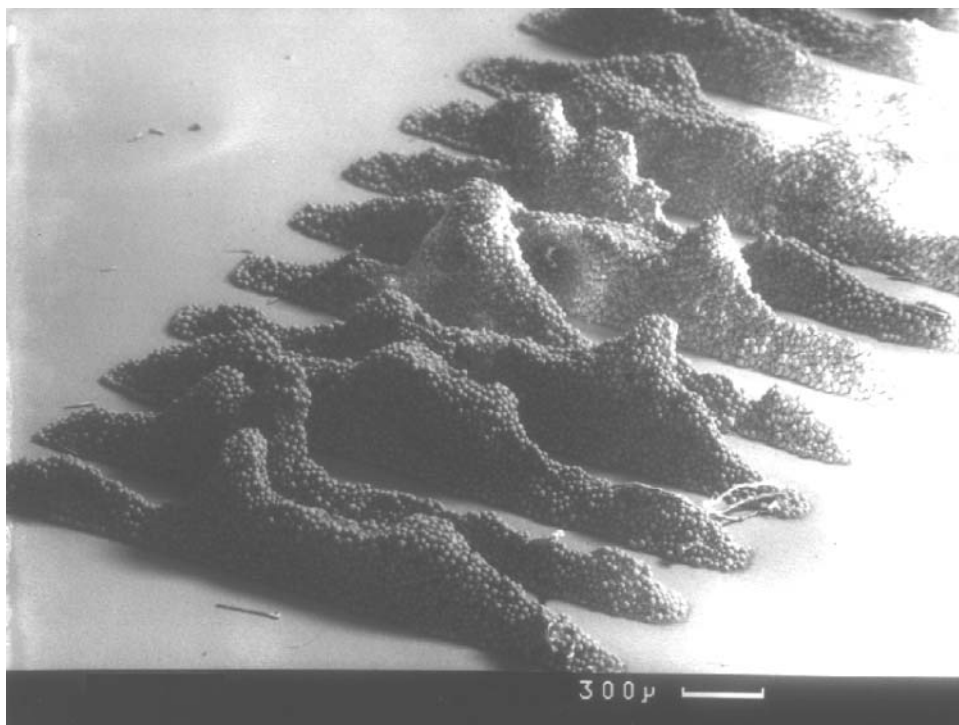


Figure 8 : Typical uneven print caused by insufficient squeegee pressure or distorted substrate

Print Speeds :

Faster print speeds generally result in more inconsistent print deposits. Print speeds must be fast enough to allow the solder paste to roll across the surface of the stencil and roll into the apertures to produce acceptable deposits. Print speeds of around 25mm/sec have been found to work well with many pastes.

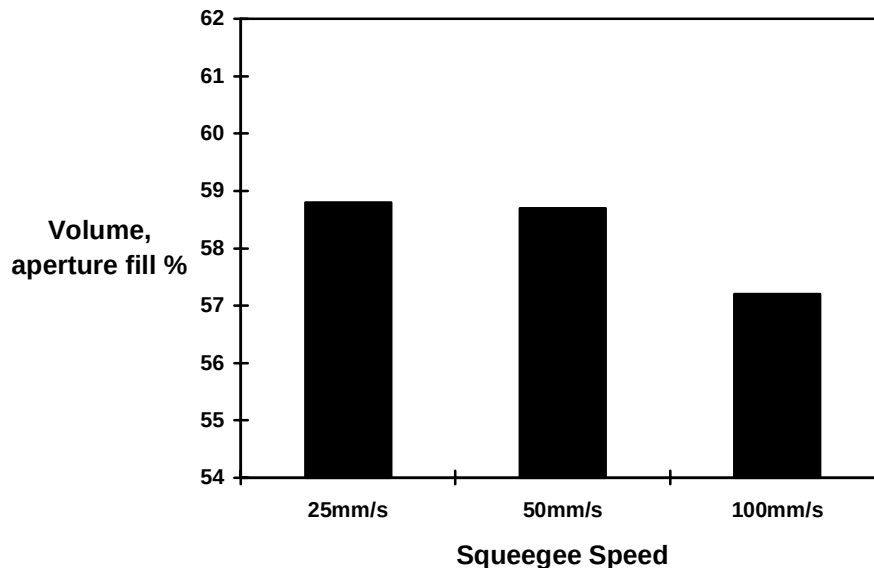


Figure 9 : Variation of aperture filling for different squeegee speeds (for 0.15mm stencil at 0.5mm pitch, averaged over 2 pastes, 3 squeegee pressures and 4 squeegee types)

Board Flatness :

The degree of substrate bend that can be tolerated during printing is highly dependent of squeegee blade type, and is shown in Figure 10 (similar results are obtained with the top and bottom rows). Some rigid or unyielding blades can only tolerate 0.1% fixed distortion. Other more flexible blades can cope with up to 0.3% distortion. If the substrate is flexible enough to be forced flat by normal squeegee pressures, then greater levels of substrate bend may be acceptable. To improve printing performance on permanently bent boards such as multilayer boards, the use of flexible metal 60° squeegee blades is recommended.

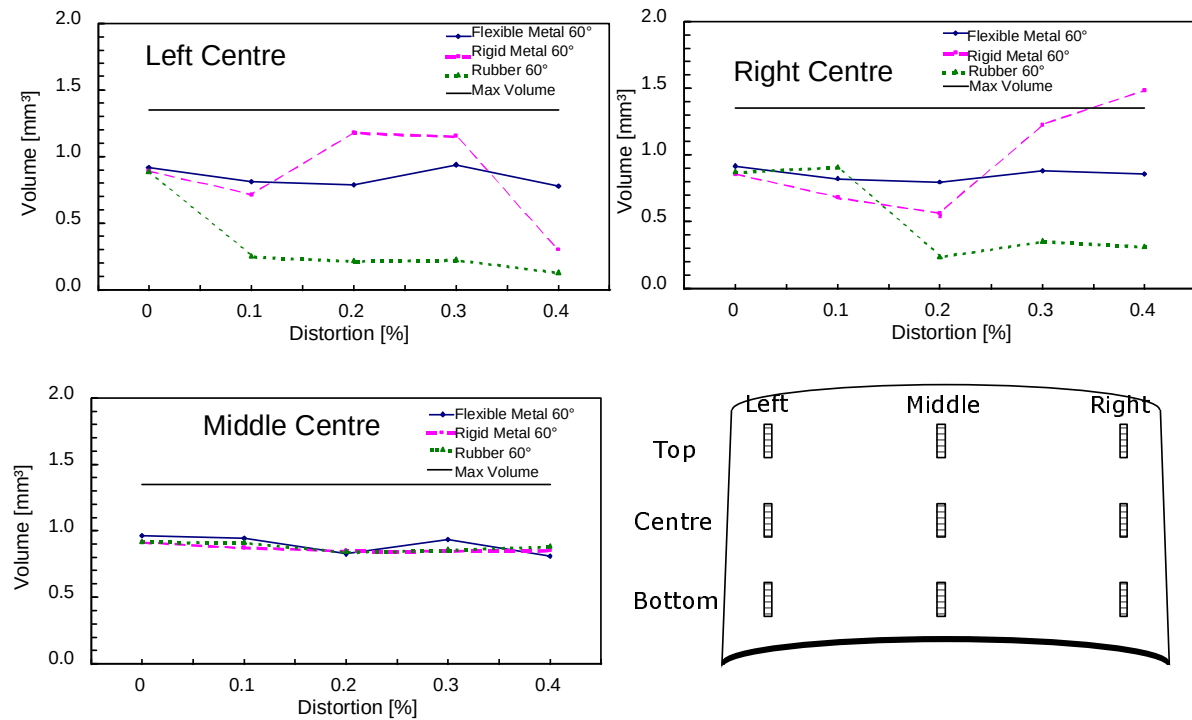


Figure 10 : Effect of substrate distortion on print volume for a variety of squeegee types. The bottom right figure is a schematic of a test substrate with printed paste. The Board is shown in a distorted form with the position of each aperture array identified.

ACKNOWLEDGEMENTS

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