Article appeared in *Screen Printing*, August 1990 issue.
The graphics and images have been updated/altered from original article.

# The Influences of Processing Variables on Direct-Emulsion Stencils

**Woflgang Pfirrmann**
**KIWO Inc.**

**An important relationship exists between quality and economy in stencilmaking. The "perfect" stencil doesn't necessarily imply the best one, if quality is tied to economy. Regardless of the desired quality/economy relationship, however, direct-emulsion coating must be standardized sufficiently in order to achieve repeatability – the most important factor in stencilmaking.**

**It has always been difficult to determine what processing variables affect the repeatability of direct-emulsion coating the most. To find out, we tested the influence that some of these variables have on the direct-emulsion coating. This article summarizes our preliminary findings.**

**The test procedures we used were designed to evaluate three specific groups of variables:**

- **Coating parameters: speed, technique, and trough fill level**
- **Mesh parameters: mesh count, thread diameter, and mesh tension**
- **Emulsion parameters: viscosity and solids content**

**Because manual coating techniques vary, we used an automatic coating machine for our tests in order to eliminate the human factor and ensure consistency from test to test. In all tests, we used a diazo-photopolymer emulsion.**

## Coating Parameters

**To evaluate the influence of coating speed on the stencil, we tested seven different speeds on four different mesh counts (FIGURE 1). All of the screen were coated 2-4 (print side – squeegee side), wet on wet, and measured after exposure, development, and drying. The coating trough had an edge diameter of 2.5 mm.**

**FIGURE 2 is a graph of the results from this test shows a decreasing emulsion buildup, regardless of the mesh count, as the coating speed increases. However, the difference is only significant on the coarsest mesh count (195-50). Obviously, meshes with the greatest percentage of open area are more sensitive to coating speed than finer mesh counts with less open area. These results indicate that you can fine tune the emulsion buildup on coarse meshes by varying the coating speed. Unintentional changes in the coating speed (which can occur with manual coating) can have a detrimental effect, depending on the screen's mesh count.**

**According to our test, the coating technique is the most influential variable of final coated-stencil quality. As the coating thickness increases, mesh equalization improves and the Rz value decreases (i.e., the roughness of the stencil surface smoothes out). Obviously, there is a maximum coating thickness where ink release from the stencil becomes difficult or impossible. This maximum thickness is dependent of the detail of the artwork. (Printing fine lines is possible with an emulsion buildup of 15 microns on a 305 mesh, but almost impossible with a buildup of more than 20 microns as the ink will not release properly from the stencil.)**

**FIGURE 3 illustrates the emulsion buildup and Rz value of various coating techniques on a 305-37 mesh. We began the test with two coats on the print side and two on the squeegee side. For each successive test, we added an additional wet-on-wet coat to the squeegee side. While each coat adds 5 microns to the emulsion-over-mesh thickness on the print side, the Rz values do not change proportionately. For example, the Rz value of the 2-3 coating technique is 3 microns better than the 2-2, but the difference between the 2-5 and the 2-6 techniques is only 1 micron, despite the one additional coat in each comparison. This means that the emulsion buildup grows linearly, while the Rz value does not.**

The third coating variable that we evaluated was the trough fill level. Aside from the actual construction of the trough (edge diameter and design), the fill level appears to contribute to the final stencil coating. FIGURE 4 represents the coating result of trough with fill levels of 5 mm and 15 mm of emulsion (standing against the mesh during coating) on three different mesh counts. We used a 2-4 coating technique with a trough-edge diameter of 2.5 mm.

FIGURE 4 shows a clear change in emulsion thickness on meshes with the greatest open area (305-32). The flow-through properties of the mesh with the thinnest thread diameter mesh are better because of the larger mesh opening. The screen with the smallest mesh opening (305-34) seemed less affected by the trough fill level. It is apparent from these results that when coating large screens or mesh with high percentages of open area, the fill level of the trough must be carefully controlled to avoid emulsion depletion during coating, which will cause uneven deposits. Although an automatic trough-filling system, which controls the level after each coating movement, is a good tool for standardizing this process, filling the trough adequately (either manually or automatically) prior to each stroke prevents significant depletion of the emulsion.

## Mesh Parameters

The choice of mesh is most often influenced by the specifications of the print order, ink color, or required ink deposit. Nevertheless, in most cases, the printer can choose among several mesh types that will offer the same printed result. We conducted evaluations to determine what influences the mesh count, thread diameter, and mesh tension wold have on the final direct-emulsion coating.

To investigate the influences of the mesh count, we tested three mesh counts (255-40, 305-37, 355-37 with different coating techniques (2-2, 2-3, and 2-4). FIGURE 5 shows that the emulsion buildup decreases as the mesh count increases. The emulsion buildup gains 7 microns per coating on the 255-40 mesh, 5 microns on the 305-37, and only 3 microns on the 355-37 mesh. In production, this means that good mesh equalization can be achieved quickly on coarse meshes, while fine meshes require additional coats. FIGURE 6 reveals the Rz value for these same meshes and coating techniques. These examples further illustrate that fewer coatings are required on coarse meshes to achieve acceptable Rz values.

Mesh count is not the only variable, however. The actual thread diameter plays a significant role in the required emulsion coating. We used a single mesh count with three different thread diameters (and thus different percentages of open area). FIGURE 7 illustrates that on the 305-32 mesh (S type), the emulsion has less resistance to flow through the fabric than on the 305-40 (HD type), which results in a higher buildup with fewer coatings. The buildup is actually double that of the 305-37 mesh which has 6% less open area. The buildup on the 305-40 mesh is even lower, and it was impossible to achieve acceptable Rz values on this mesh with fewer that 5 squeegee-side coatings. In practice, our results indicate that a better Rz value at a given buildup can always be achieved with the finest thread diameter (S type) in a particular mesh count.

To test the effects of mesh tension, we stretched 305-37 mesh on screens to four different tension levels. The coating techniques were also varied to determine what influence the quantity of emulsion buildup would have at the various tension levels.

FIGURE 8 illustrates that we were unable to establish any significant differences in emulsion buildup due to mesh levels. The 1-micron variances in both the buildup and Rz values are not statistically significant and may even be attributable to the measuring device. (It should be noted that all screens were tensioned evenly across the mesh and so the test was not designed to evaluate the influence of uneven tension levels on coating buildup.) In the future, testing different mesh counts will be necessary to clearly establish the role mesh tension plays in the emulsion buildup.

## Emulsion Parameters

The specific characteristics of a direct emulsion (solids content and viscosity) are also important variable in establishing the amount of emulsion buildup on a particular mesh. The viscosity is established by the manufacturer and then adjusted depending upon the specific task (e.g., coarse meshes, automatic coating machines, etc.). With the exception of presensitized single-pot systems, most emulsion must be sensitized before use. This sensitizer may vary, causing fluctuations in emulsion viscosity. To investigate the effects of viscosity changes, we thinned an emulsion, measured the viscosity, and calculated the emulsion buildup and Rz values of coated screens.

As can be seen in FIGURE 9, even with thigh thinning percentages (by weight), neither the emulsion buildup nor the Rz value changed significantly, making it probable that the two effects are counteracting each other as follows:

- The thinning of the emulsion causes a decrease in the solids content and thus a lower viscosity.
- The lower viscosity changes the flow properties of the emulsion and a high buildup is achieved. This higher, wet buildup, however, reduces when dried because of the lower solids content.

These tests indicate that you can achieve good production results on most meshes regardless of the amount of thinning. Specific tests should be performed with each emulsion type since results may vary when viscosity is significantly altered.

The solids content of an emulsion is the most important quality characteristic, but this depends on the type of solids used. Filler provide a higher solids content but can cause poor edge definition and mesh bridging, in some cases, if the particle size is not carefully controlled by the manufacturer. High-quality solids are resins that improve edge definition, mesh bridging, and the chemical resistance characteristics of the emulsion. For this evaluation, we used three emulsions containing high-quality solids.

FIGURE 10 lists the solids contents, viscosity, buildup and Rz values of the emulsions that we tested, while FIGURE 11 graphically presents the significant buildup that is achieved as the solids content is increased. It is apparent that mesh bridging, edge definition, and Rz value can be improved with the use of high quality, high-solids-content emulsion.

## Conclusions

A number of conclusions can be reached from this preliminary investigation:

1. The degree of thinning and mesh tension have little effect on the actual buildup of emulsion on the screen.
2. The mesh type, coating technique, and solids content of the emulsion are the major parameters that influence the quality of the stencil. Any changes in these parameters will result in measurable differences in the coating quality.
3. Viscosity, coating speed and trough fill level influence the quality of the coating” however, the actual significance of the effects depends on the specific mesh type.

How can you use this information in production to control the quality of direct-emulsion stencils?

Our investigation revealed that the coating thickness and stencil quality on meshes with large open areas (such as S-type) are more likely to be affected by changes in coating technique, solids content, and coating speed than meshes with small open areas. The S-type meshes (with thin-diameter threads) also give a high emulsion buildup per coating, which provides good mesh equalization with only a few coating strokes. On the other hand, it is almost impossible to adjust the emulsion buildup within fine tolerances unless the coating speed can be adjusted.

We also learned that the solids content of the emulsion is very important when the printer needs to control mesh equalization (and the concave drying effect that occurs with low-solids emulsions). If S-type meshes are coated with high-solids emulsions, good mesh equalization can be achieved with very thin emulsion buildup because of the combination of thin thread diameter and large open areas that enhance emulsion flow. (Note: Thinner threads are not bent as much as T- or HD-type mesh filaments at thread intersections, so the height differences in the mesh are lower and easier to equalize.)

The coating buildup and quality are influenced not only by emulsion viscosity but also by the type of mesh you use. High-viscosity emulsions are generally adjusted to provide stability in the wet coating for thick stencils and coarse meshes. If these same emulsions are used on finer mesh, the flow resistance through the mesh opening is very high. Medium-viscosity emulsions can be used on almost all kinds of meshes, but the number of wet-on-wet coatings is limited on coarse meshes. If the emulsion buildup gets to high, the emulsion tends to flow into and through the openings, resulting in an irregular buildup. Low-viscosity emulsion can be used on fine meshes and ones with lower percentages of open area because the flow resistance in high. They should not, however, be used on coarse meshes.

Although this investigation is not complete, we can already see correlations within the data that could be incorporated into future developments in direct-emulsion technology. Controlling the emulsion buildup is becoming more critical, especially for screen printers used water-based and UV ink as well as those who need to print fine halftones and four-color-process images. Although the most recent developments (SBQ-photopolymers and diazo-photopolymers) have made great strides in allowing screen printers to achieve mesh equalization at lower emulsion-buildup levels, the focal point will continue to be on the formulation of products that offer even better mesh-equalization properties. These and future investigations will help printers understand the emulsion-coating process and establish standards in production that will improve the quality of stencilmaking.