How To Optimize Print Quality Through Stencil Testing

By Jay Vande Walle

The screen printing stencil is a critical element that directly affects print quality. This is especially important for screen printers engaged in fine-detail printing. For example, in four-color process printing a poor quality stencil can produce dot gain leading to color shifts and loss of detail. In fine-line printing, poor quality stencils result in poor edge definition. Print quality is directly linked to two stencil variables: stencil thickness and stencil surface roughness (Rz value). With a direct-emulsion stencil system, these variables are mainly controlled by the coating technique used. With a capillary film system, application procedures, film thickness, and mesh count all play a part in determining these characteristics. To achieve optimum print quality it is first necessary to understand the effects both variables have on print quality, and then control them to ensure consistent results.

The influence stencil thickness and Rz value have on print quality can be determined through in-plant testing. The proper stencil can be selected by creating screens that contain multiple stencil combinations, printing them, and evaluating the print quality. The printer will then be able to optimize print quality of fine-detail images, on various substrates, while adding control to the process to create predictability. Increased profits from higher print quality, savings in production time, and less scrap will be the benefit.

The focus of this bulletin is to illustrate how print quality is related to stencil thickness and Rz value, and to present a practical in-shop testing procedure for direct-emulsion and capillary film systems. First, a brief explanation of stencil concepts and relationships is covered. Next, a step-by-step procedure for conducting in-shop testing of stencils to optimize print quality is presented. Finally, practical examples of results obtained from such testing are discussed.

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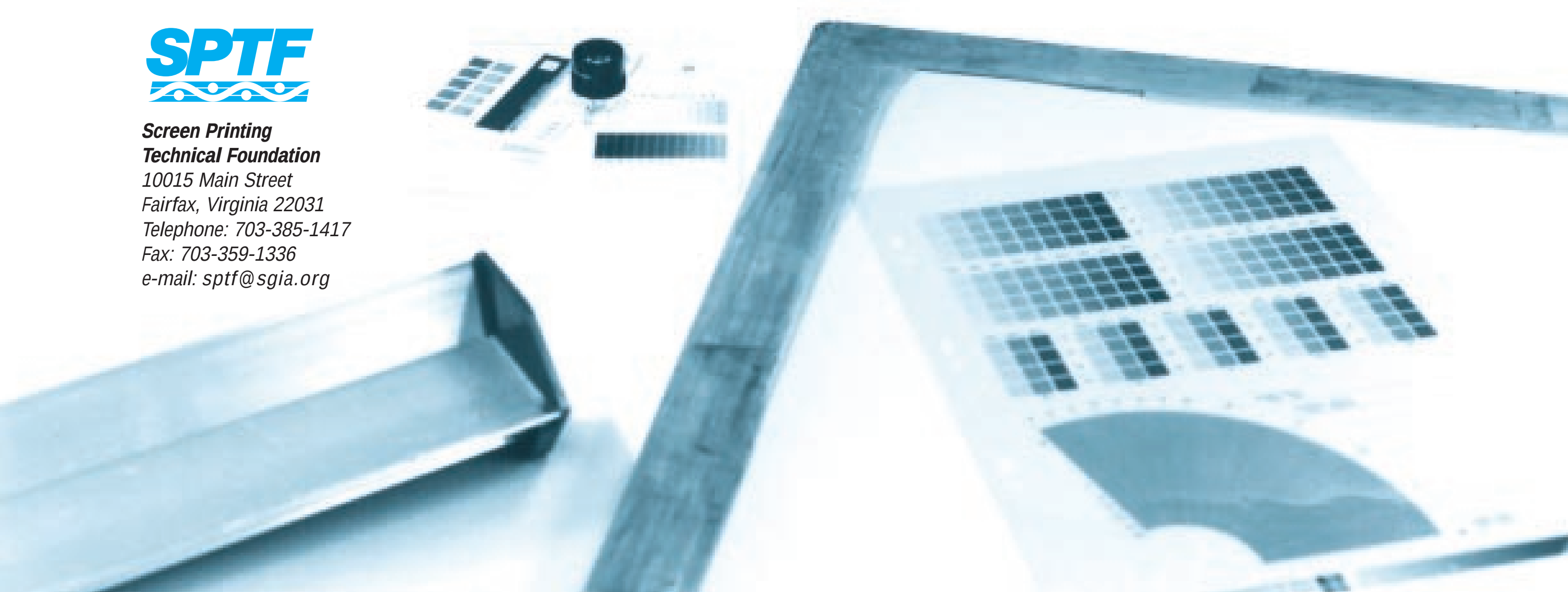


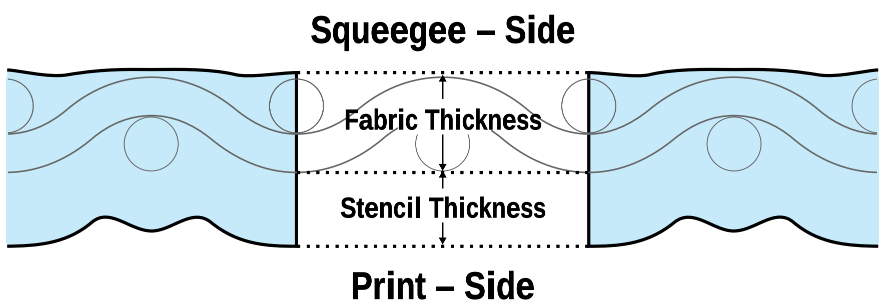
Background

Stencil thickness and Rz value are two critical stencil parameters that screen printers can measure and control. Stencil thickness is defined as the height of the stencil proud of the mesh (**Figure 1**) and is typically measured with an electronic thickness gauge (**Figure 2**). This is accomplished by measuring the mesh thickness in an open screen area, and then measuring the thickness in a stencil area. Taking five to ten measurements in each area and using the average from each set of measurements to calculate the relative difference in thickness between the two areas will provide a good value representing stencil thickness. Specific procedures for measuring stencil thickness can be found in SPTF's Practical Application Bulletin titled "Using Electronic Coating Thickness Gauges Effectively in the Screen Printing Process."

The Rz value is the measure of stencil roughness and is obtained with a surface profilometer (**Figure 3**). Simply put, this instrument obtains the Rz value by drawing a stylus a short distance (about 1 cm) across the stencil surface (print side) and calculating the average height between the peaks and valleys on the surface. In order to obtain a representative Rz value of the stencil surface, three measurements should be made on different areas of the stencil and the average value used. The smoother the surface is, the lower the Rz value (**Figure 4**). In general, as the stencil thickness increases, the stencil surface becomes smoother.

With a direct-emulsion stencil system, the stencil thickness and Rz value are affected by many variables. These include: solids content of the emulsion, number of applied coats of emulsion,

Figure 1

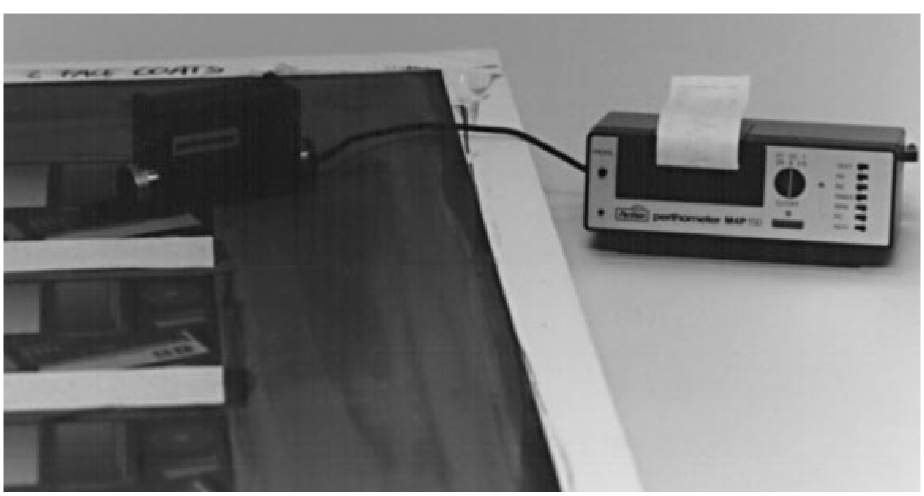


Stencil thickness is the height of the stencil proud of the mesh.

Figure 2

Stencil thickness is measured with an electronic thickness gauge.

Figure 3



A surface profilometer is used to measure the Rz value which indicates the stencil's surface roughness.

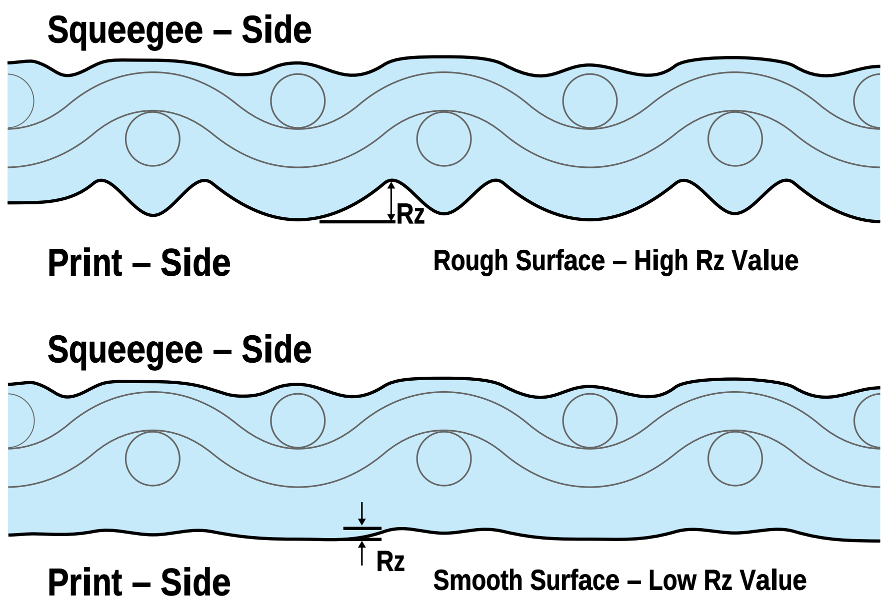
scoop coater edge profile (sharp or round), viscosity of the emulsion, coating speed, mesh count, and thread diameter. Ordinarily, for a given mesh and emulsion, the stencil thickness is controlled by the number of coats of emulsion applied.

Face coating is a procedure used with direct-emulsion to lower the Rz value of the stencil while minimizing additional stencil thickness buildup. After the initial coats on the screen have dried, a sharp edged scoop coater is used to apply a small amount of emulsion to the print-side. This procedure fills in the irregularities on the stencil surface, creating a smoother stencil (**Figure 5**). Multiple face coats can be applied, drying the screen between each one. Testing will indicate if the extra expense yields better print results. It should be noted that some emulsions, especially some of the SBQ-photopolymer emulsions, react poorly to face coating. The coat-dry-coat-dry procedure can actually over-dry these emulsions making it difficult to wash out the image and reclaim the screen. It is wise to check with the manufacturer before face coating with these types of emulsions.

With capillary film, as with the direct-emulsion, the stencil thickness and Rz value are affected by many variables. These include: capillary film thickness, brand of film, film application technique, mesh count, and mesh thread diameter. For a given mesh, the stencil thickness can be changed by using various thicknesses of capillary film. Many screen printers mistakenly believe stencil thickness and capillary film thickness are the same- they are not. The capillary film is partially absorbed into the mesh when it is applied (**Figure 6**).

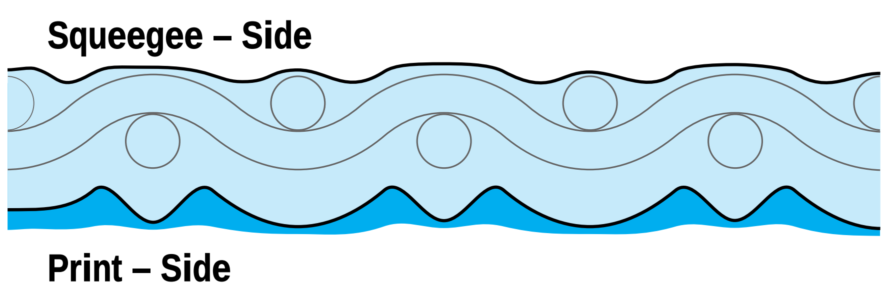
A thin stencil with a low Rz value is usually the goal for fine-detail printing. If the stencil thickness is excessive, efficient ink transfer from the screen to the substrate is sacrificed. Fine details may not print at all if the ink remains attached to the stencil walls, and the images that do print may have significant loss of dimension. A low Rz value provides a smooth stencil surface which will ensure a "gasket-like" seal between the stencil and the

Figure 4



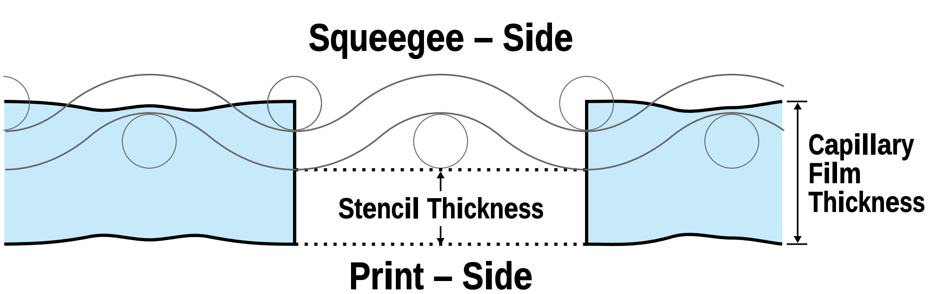
The Rz value is the average height between the peaks and the valleys on the stencil surface.

Figure 5



Applying a face coat of emulsion on the stencil surface fills in the low spots, creating a smoother surface while minimally increasing the stencil thickness.

Figure 6

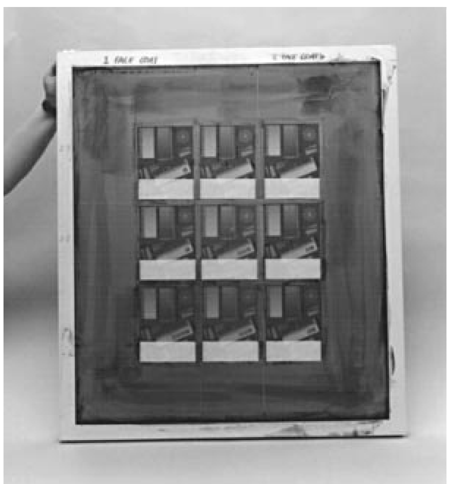


The stencil thickness achieved with capillary film is much thinner than the capillary film thickness since it is partially absorbed into the mesh.

substrate during printing. This "gasket-like" seal prevents the ink from being forced beyond the boundaries of the stencil which causes dot gain and sawtoothing on the printed image. However, it should be noted that the stencil Rz value can be too low. The stencil can actually be too smooth, and can cause printing problems such as static on very smooth substrates.

A test screen with multiple areas, each containing a different emulsion coating technique or a different capillary film, is an excellent means to compare print quality from several stencils simultaneously (**Figure 7**). By incorporating a number of stencil areas on a single screen, many variables are eliminated. Differences seen in the resulting print can then be attributed to the differences in the stencil. The mesh, mesh tension, squeegee pressure, squeegee speed, ink, substrate, and atmospheric conditions are basically identical for each image. In fact, the location of the image on the screen is the only variable among the images.

Figure 7



A test screen containing nine discrete stencil areas is used to compare print quality from all stencils simultaneously.

Excellent results can be obtained from a test screen by making the coating technique or capillary film currently being used the midpoint of stencil thicknesses to be tested. Then, include stencils thinner and thicker than this. For direct-emulsion systems use a different number of initial wet-on-wet coats and face coats. For capillary film systems, try various capillary film thicknesses from several manufacturers.

For example, assume a screen used for four-color process printing is normally coated with two coats of emulsion on the print-side and two coats on the squeegee-side with no face coating. It should be noted that this coating combination is indicated as 2-2-0 *(number of initial coats on print side - number of initial coats on squeegee side - number of face coats).* A test screen could be made that had six different coating areas on it to determine if better print quality could be obtained by altering the coating technique. It could contain stencil areas of 2-1, 2-2, and 2-3 without a face coat and the same three with one face coat. This would give six discrete coating areas on one screen that could be printed to determine if the 2-2 coating, without a face coat, truly produced the best results.

Once the test is evaluated, and the best stencil discovered, the stencil thickness and Rz value can be measured in this stencil area. These values then become the target values for the production screens. Systematically measuring the stencil thickness and Rz value will help maintain stencil quality and ultimately control the process. These measurements should be recorded and used to monitor the stencil quality and identify problems before setting up the screen on press.

It is very helpful to use statistical process control (SPC) methods such as control charts with these measurements. SPC control charts will show the normal variation in the stencil thickness and Rz value that can be expected, while still producing an acceptable print. Measurements that fall outside the control limits, or acceptable range, indicate an aspect of the process has changed or an unusual event occurred. This could signify changes in emulsion or film, a change in the stencil application technique, changes in the mesh, or an error in measuring the stencil.

The frequency that stencil measurements should be taken depends on the individual shop. It is determined by how well controlled the screen making process is, the stencil quality required, the cost of remaking unacceptable screens, and the cost of measuring the stencils. Some shops may be able to justify measuring every screen, while others may only need to measure a couple of screens per day.

Even if stencil measuring instruments are not available, these tests will point to the best coating technique or capillary film for your application. These tests are also useful for determining the resolution limit of a particular stencil under the printer's conditions.

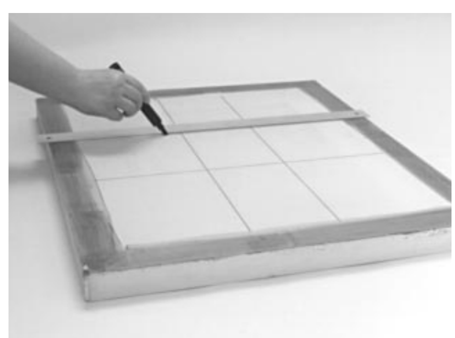
Step-by-Step Procedure for Performing Tests

This section explains procedures screen printers can use to perform in-shop testing of their stencil system. It will discuss: exposure testing, screen preparation, stencil application, image selection, stencil exposure, printing and evaluation, and documentation of results.

Exposure Testing

Each separate stencil area will have its own optimum exposure.

Figure 8



Lines are drawn on the mesh to serve as guides for applying the emulsion.

Exposure testing should be performed for each area before the multi-image screen is made. This is easily accomplished by making a separate screen for each of the coating combinations or capillary films and performing typical exposure testing with an exposure calculator. The exposure time for each coating combination or capillary film that will be on the test screen needs to be individually determined.

1. Select screens with the same mesh and tension as the one to be used for testing.
2. Prepare each screen with a single coating combination or capillary film.
3. Expose each screen with an exposure calculator to determine the proper exposures.
4. Record exposure times.

Screen Preparation

The screen used for testing should be the same as screens used in production. The same size frame, frame type, mesh, and mesh tension typically used for fine-detail printing should be selected. Prepare the screen as normal (abrade, degrease, wetting agent, etc.) using your shop's standard procedure.

Stencil Application - Direct-Emulsion

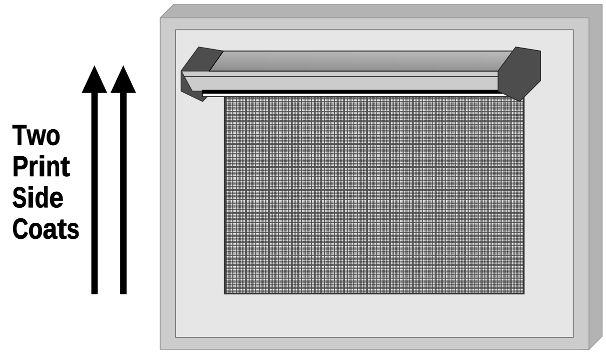
To produce six different coating combinations on a single screen, a seven step procedure is used. It should be noted that the following procedure is for a screen that will contain coating combinations of 2-1-0, 2-1-1, 2-2-0, 2-2-1, 2-3-0, and 2-3-1. The general premise of this procedure can be varied to produce a screen with any kind of coating combination.

Before coating the screen, it is helpful to draw lines on the screen to serve as a guide when applying the emulsion (**Figure 8**). Draw these reference lines on the mesh with a felt tip marker. Make sure that the size of each area is large enough to accommodate the test image, and try to locate the stencil areas as close to the center of the screen as possible. Also, make sure scoop coaters of the proper size, with both a round edge and a sharp edge, are available.

Using round edge of scoop coater and applying coats wet-on-wet:

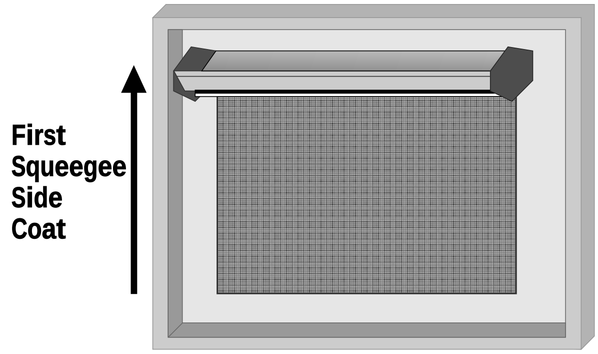
1. Apply two coats to the print-side of the screen (**Figure 9**).
2. Apply one coat to the squeegee-side of the screen (**Figure 10**).
3. Apply a second coat to the squeegee-side, coating only two-thirds of the screen (**Figure 11**).
4. Apply a third coat to the squeegee-side, coating only one-third of the screen (**Figure 12**).
5. Dry the screen, print-side down.

Figure 9



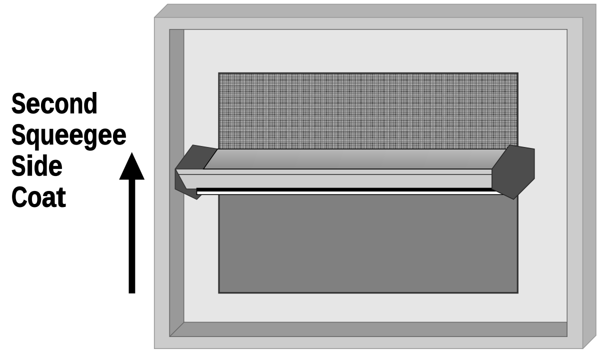
Two coats of emulsion are applied to the print-side of the screen.

Figure 10



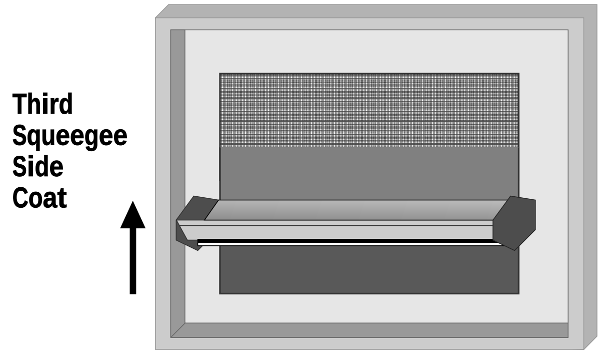
One coat of emulsion is applied to the entire squeegee-side of the screen.

Figure 11



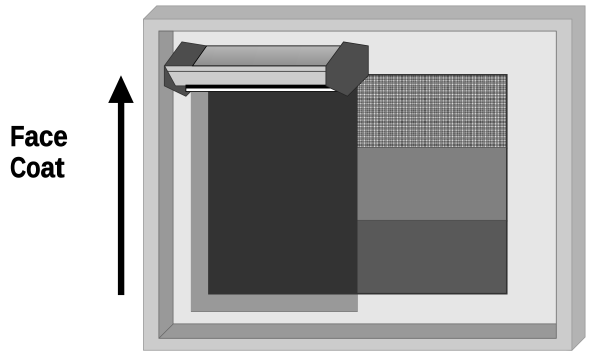
A second coat of emulsion is applied to only 2/3 of the squeegee-side of the screen.

Figure 12



A third coat of emulsion is applied to only 1/3 of the squeegee-side of the screen.

Figure 13

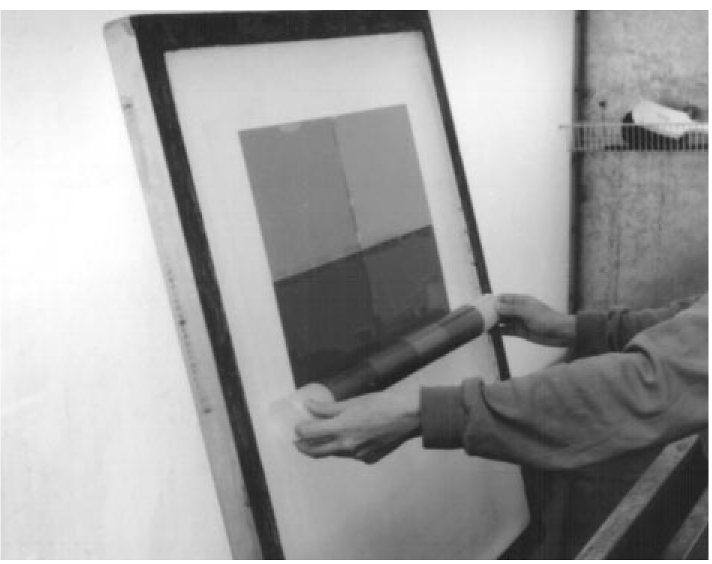


A face coat of emulsion is applied to one half of the print-side of the screen.

Figure 14

Six individual sheets of capillary film are taped together to form one large composite sheet.

Figure 15



All six sheets of capillary film are applied at the same time using the roll-down method.

Using sharp edge of scoop coater:

6. Apply a face coat to one-half of the print-side of the screen (**Figure 13**).
7. Dry the screen.

Stencil Application - Capillary Film

To produce six different stencil thicknesses on a single screen with capillary film, a five step procedure is used. The following procedure is for a screen that will contain six individual pieces of capillary film, all applied at the same time. This general procedure can be followed to produce a screen with any number of different capillary films.

1. Cut a piece of each capillary film to be tested to a suitable size for the test image to be used.
2. Lay the six pieces of capillary film, emulsion-side down, on a clean, dry, flat surface.
3. Position the pieces next to each other and tape together to form what is essentially one large composite film (**Figure 14**).
4. Apply this composite piece of film to the screen as you normally would apply a single sheet of film (**Figure 15**).
5. Dry the screen.

Applying the film in this manner eliminates the effect of application variables. All six pieces were applied at the same time and were subject to the same set of application variables (amount of residual water, temperature of water, squeegee-off pressure, etc.).

Image Selection

The image selected for this testing should contain elements similar to what is encountered in actual production. For example, if small text is the only fine-detail artwork printed, using a halftone as a test image would not be very beneficial. Additionally, the test image should have similar attributes as the production art. Halftones should be of the same line count, lines should be the same width, and the text should be the same size as used in production. Various test targets are available in the industry, but if a single target does not contain all the required elements, the appropriate sections from several can be stripped together.

Stencil Exposure

Since each of the six stencil areas on the screen will have its own optimum exposure time, and since the print results will be easier to analyze if the same image is used in each area, each area needs to be exposed individually. This can be easily accomplished by taping the film positive to one of the areas and blocking off the rest of the screen with masking film. The unmasked area is then properly exposed. An eight step exposing procedure is outlined below.

1. Tape the film positive to the screen **(Figure 16)**.
2. Mask off the rest of the screen with masking film **(Figure 17)**.

Note: The masking film should be in direct contact with the screen inside the vacuum frame, not taped to the outside of the glass.

3. Expose the stencil for the proper number of units.
4. Remove the mask.
5. Reposition the positive to the next area.
6. Re-mask the rest of the screen.
7. Expose the stencil for the proper number of units.
8. Repeat steps 4-7 until all areas are exposed.

After all areas are properly exposed:

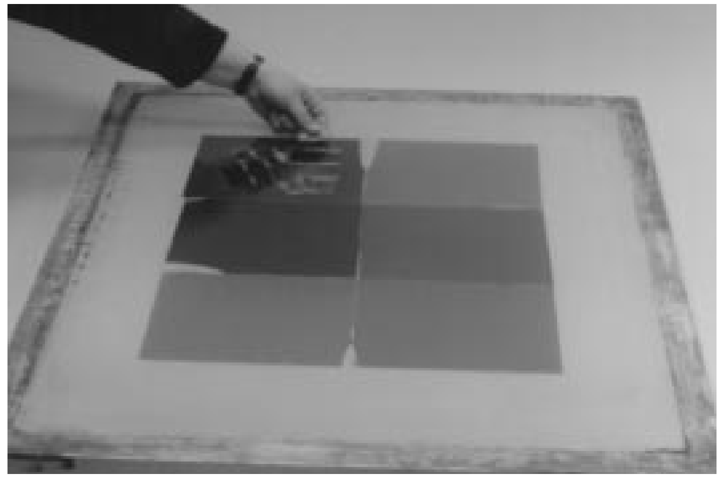
9. Process the screen (wash out image).
10. Dry the screen.

Printing and Evaluation

The test screens should be printed on the same press used for production. This allows a determination of the optimum stencil using real world conditions. Use the ink, squeegee, substrate, and press settings that are normally used during a production run.

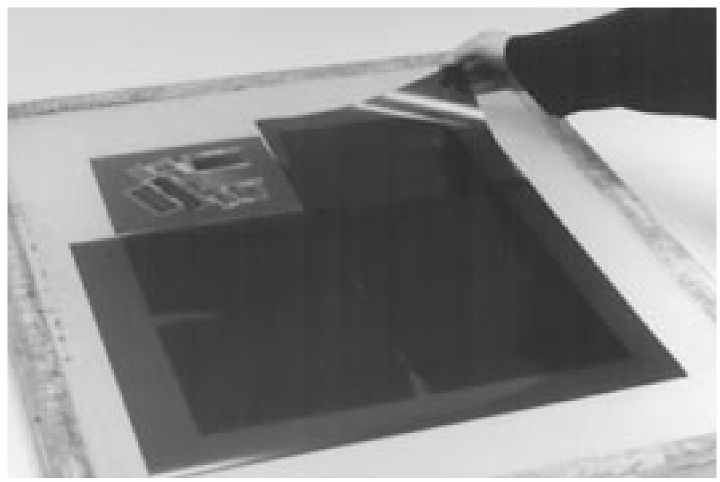
Once printed, the images can be evaluated for print quality. To help in evaluating them, a loupe and a reflection densitometer are useful. Individual attributes such as dot gain, fine-detail resolution, line definition, tonal range, accurate image reproduction, and ink deposit all need to be considered to determine the best stencil. One attribute cannot be pursued without regard to the effect it will have on the others. To achieve optimum print quality a balance of all of them is required.

Figure 16



The test image film positive is taped to one of the stencil areas.

Figure 17



All of the stencil areas not to be exposed are covered with masking film.

Documentation

Documenting all of the test conditions and the results of this test is important. Information regarding all aspects of the screens, press settings, ink, and substrate, as well as a print from the test should be included. These records are especially useful as a reference when future test screens are made.

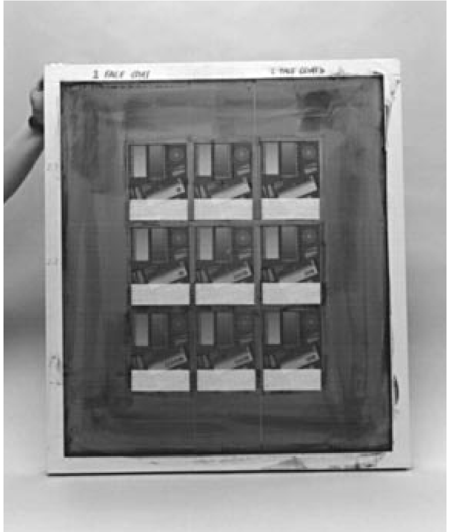
The next section illustrates print results from test screens similar to the screens just described.

Figure 18

MESH	154 threads/cm (390 threads/in.) 34µm thread diameter. Plain weave, low elongation
MESH TENSION	Diazo-photopolymer direct-emulsion screen: 21 N/cm SBQ photopolymer direct-emulsion screen: 21 N/cm Capillary film screen: 23 N/cm
INK	UV process black with 20% base
SQUEEGEE	75-90-75 Durometer
SUBSTRATE	Coated card stock
PRESS	Four Post Flatbed Press
EXPOSURE UNIT	5kW Metal halide at 91 cm
FRAME SIZE	76 cm x 86 cm

Printing specifications for SPTF's tests.

Figure 19



Coating 1 2 Print-Side 3 Squeegee-Side 1 Face Coat	**Coating 4** 2 Print-Side 3 Squeegee-Side No Face Coat	**Coating 7** 2 Print-Side 3 Squeegee-Side 2 Face Coats
Coating 2 2 Print-Side 2 Squeegee-Side 1 Face Coat	**Coating 5** 2 Print-Side 2 Squeegee-Side No Face Coat	**Coating 8** 2 Print-Side 2 Squeegee-Side 2 Face Coats
Coating 3 2 Print-Side 1 Squeegee-Side 1 Face Coat	**Coating 6** 2 Print-Side 1 Squeegee-Side No Face Coat	**Coating 9** 2 Print-Side 1 Squeegee-Side 2 Face Coats

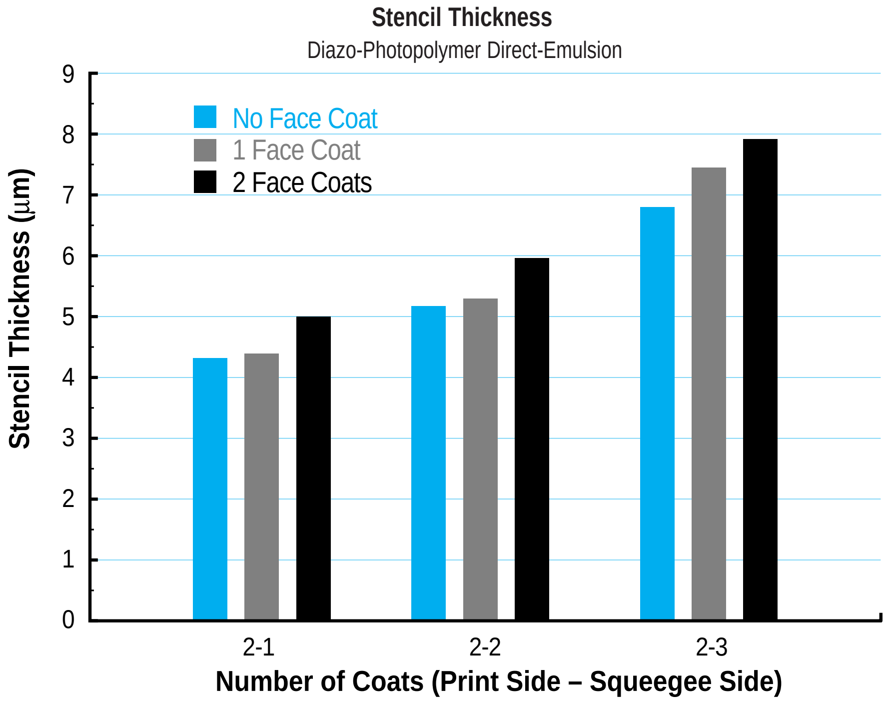
Test screen containing nine direct-emulsion coating combinations and the resulting print.

Results From SPTF Tests

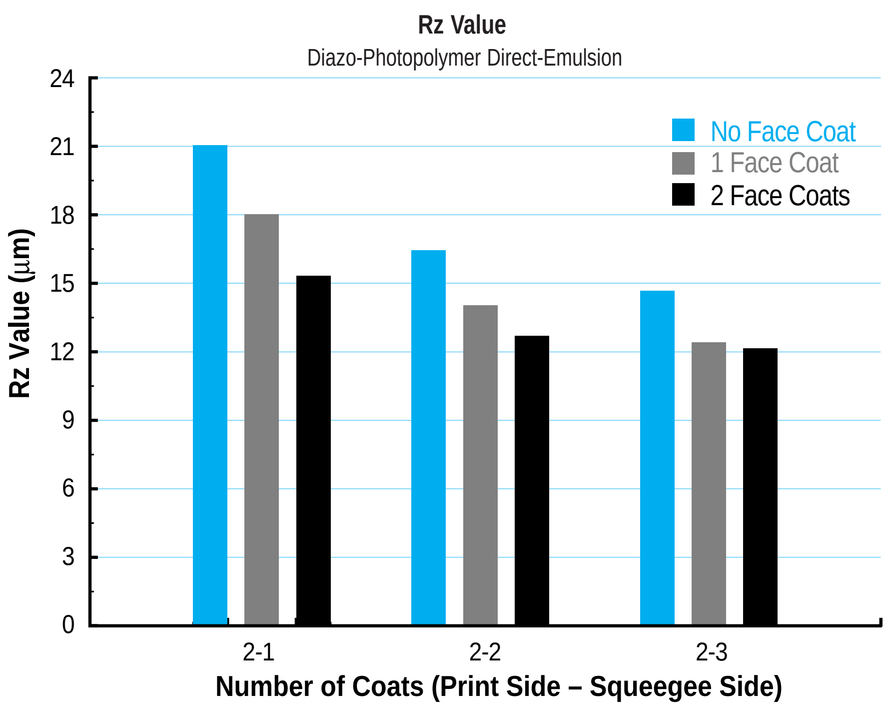
SPTF created and printed test screens, according to the methods outlined in the previous section, to investigate the relationship between stencil thickness, stencil surface roughness, and print quality. Three test screens containing multiple stencil areas were made and printed so a detailed evaluation of print quality could be made. The specifications of these screens are found in **Figure 18**.

Two screens were made using a direct-emulsion stencil. One was made with a diazo-photopolymer emulsion and the second with an SBQ photopolymer emulsion. Both of these screens contain nine discrete coating combination areas **(Figure 19)**.

Figure 20



Stencil Thickness (µm)	No Face Coat	1 Face Coat	2 Face Coats
2 Print – 1 Squeegee	4.32	4.40	5.00
2 Print – 2 Squeegee	5.18	5.30	5.96
2 Print – 3 Squeegee	6.79	7.45	7.92



Rz Value (µm)	No Face Coat	1 Face Coat	2 Face Coats
2 Print – 1 Squeegee	21.05	18.01	15.13
2 Print – 2 Squeegee	16.46	14.04	12.70
2 Print – 3 Squeegee	14.65	12.41	12.14

Stencil thickness and Rz value for each of the nine coating combinations on the diazo-photopolymer direct-emulsion test screen.

The stencil thickness and Rz value for each of the nine areas on the diazo-photopolymer emulsion screen are shown in **Figure 20**. This figure clearly illustrates that as the number of coats of emulsion increases, the stencil thickness increases and the Rz value decreases. For example, the coating combination of 2-1 with no face coat produced a stencil thickness of 4.32 µm and an Rz value of 21.05 µm. Consider the effects of applying two additional coats of emulsion on the squeegee side, thereby increasing the number of coats to 2-3. This increased the stencil thickness by 57% to 6.79 µm and lowered the Rz value 30% to 14.65 µm.

Compare this to the effects of applying two face coats to the 2-1 area, which lowered the Rz value 28% while only increasing stencil thickness 16%. The application of two face coats resulted in an Rz value almost identical to that obtained from the application of two additional coats on the squeegee side, but with 40% less stencil thickness increase. Applying coats of emulsion wet-on-wet usually does not reduce the Rz value until a significant stencil thickness builds up, making it too thick to print with. As mentioned previously, applying face coats lowers the surface Rz value while maintaining a thin stencil.

Figure 21 (a)

Tonal Response
Diazo-Photopolymer Direct-Emulsion

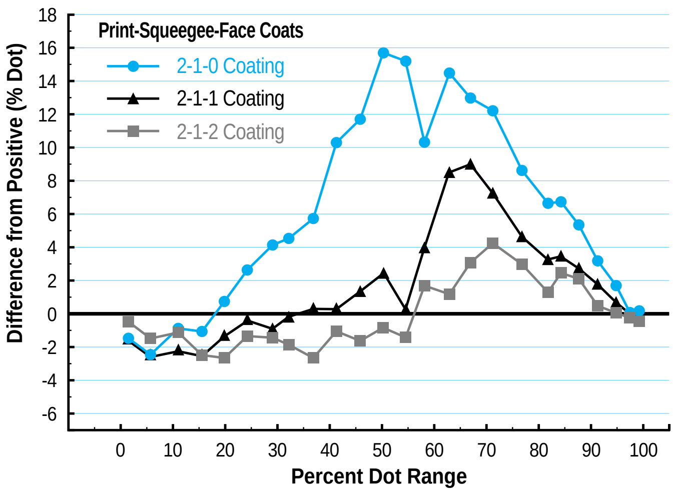


Figure 21 (b)

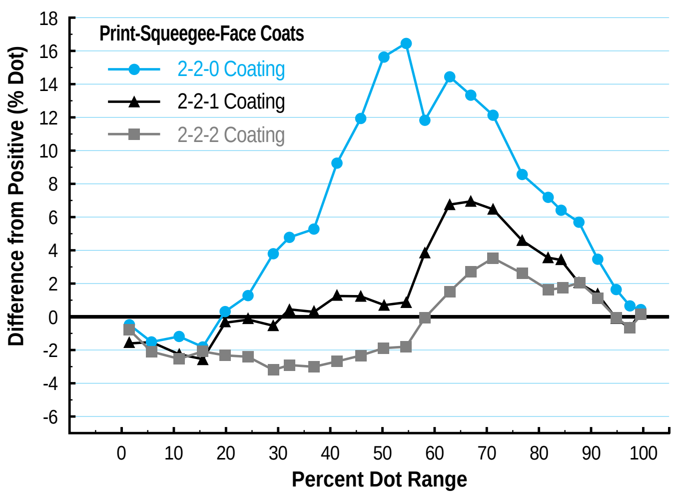
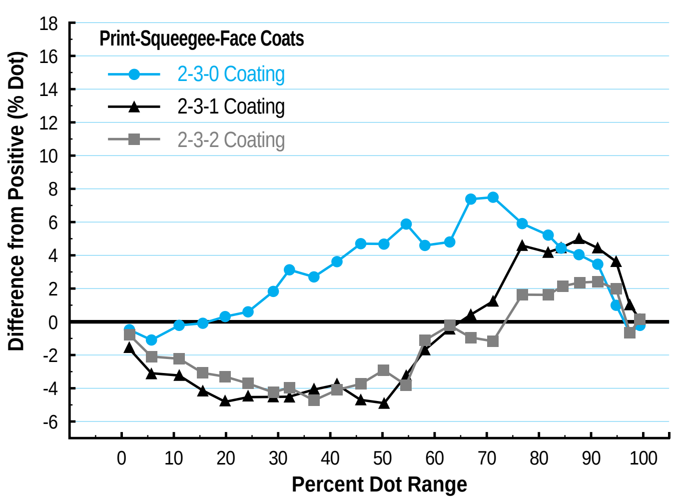


Figure 21 (c)



Dot gain and loss throughout tonal range resulting from a (a) 2-1, (b) 2-2, and (c) 2-3 coating on the diazo-photopolymer test screen.

The importance of this is realized by looking at the graphs in **Figures 21(a),(b)**, and **(c)**, which show the variation in dot gain throughout the tonal range of the 85 lpi (33.5 line per cm) tonal scale portion of the print. There is one graph representing each of the wet-on-wet coating combinations: 2-1, 2-2, and 2-3. Each of these has three curves representing the three face coating options - no face coat, one face coat, and two face coats. These graphs effectively show the dot gain and loss resulting from the nine coating methods under the specified conditions. Note that the coating combination with no face coat in each graph shows excessive dot gain. However, the stencils that have one and two face coats drastically reduced the dot gain throughout the tonal range. Also, notice that the curves in **Figures 21(a)** and **(b)** are surprisingly similar, showing that increasing the squeegee side coats from 2-1 to 2-2 only slightly reduced the dot gain.

Figure 21(c) illustrates the 2-3 coating combination and shows quite different results. Here it can be seen that the stencil with no face coat produced a much lower dot gain curve than in **Figures 21(a)** and **(b)**. Additionally, both of the face coated stencils show increased dot loss, especially in the highlight to midtone range (3% to 56%). This dot loss is probably due to an excessive stencil thickness that is hindering an efficient transfer of ink from the screen to the substrate.

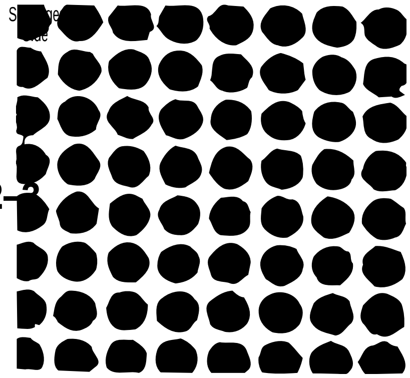
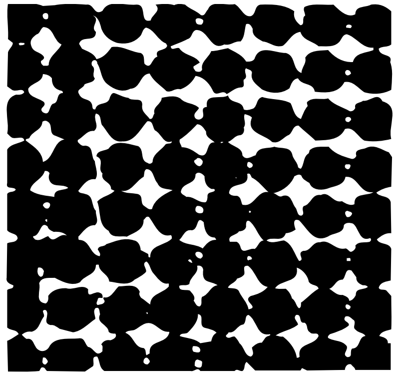
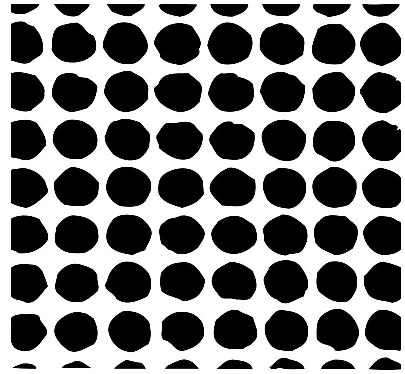
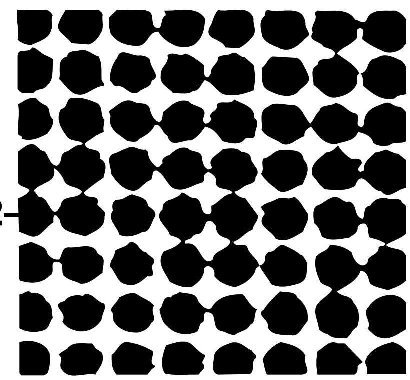
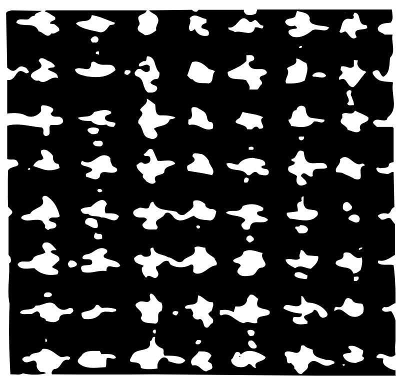
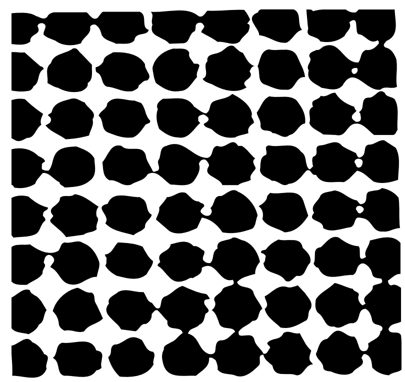
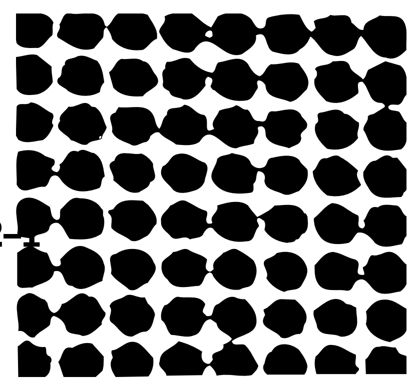
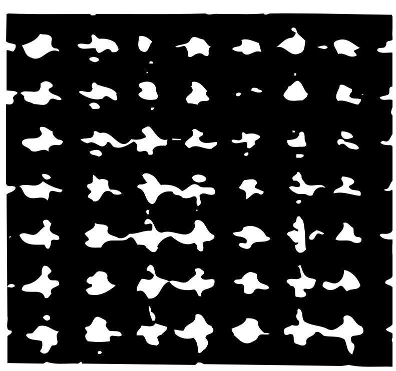
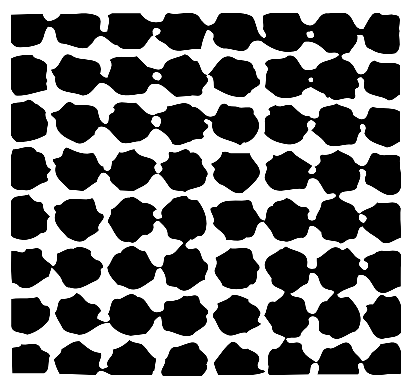
Figure 22 (a)

53% Dot Area Comparison

85 LPI Halftone – Diazo-Photopolymer Direct-Emulsion

Number of Coats

Print Side – Squeegee Side

	2 Face Coats	No Face Coat	1 Face Coat
2–3	 Actual % Dot = 52% Stencil Thickness = 7.92 µm Rz = 12.14 µm	 Actual % Dot = 61% Stencil Thickness = 6.79 µm Rz = 14.65 µm	 Actual % Dot = 52% Stencil Thickness = 7.45 µm Rz = 12.41µm
2–	 Actual % Dot = 54% Stencil Thickness = 5.96 µm Rz = 12.70 µm	 Actual % Dot = 72% Stencil Thickness = 5.18 µm Rz = 16.46 µm	 Actual % Dot = 57% Stencil Thickness = 5.30 µm Rz = 14.04 µm
2–1	 Actual % Dot = 54% Stencil Thickness = 5.00 µm Rz = 15.13 µm	 Actual % Dot = 71% Stencil Thickness = 4.32 µm Rz = 21.05 µm	 Actual % Dot = 57% Stencil Thickness = 4.40 µm Rz = 18.01µm

Magnified images of (a) 53% dot, (b) 2 mil lines and spaces, and (c) small text areas on the print from the diazo-photopolymer test screen. The nine images illustrate the print quality from each of the stencil coating combinations used on the screen.

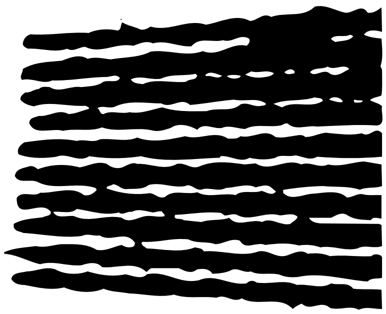
Figure 22 (b)

2 Mil Lines and Spaces Comparison
Diazo-Photopolymer Direct-Emulsion

Number of Coats
Print Side – Squeegee Side

2 Face Coats | **No Face Coat** | **1 Face Coat**

2–3



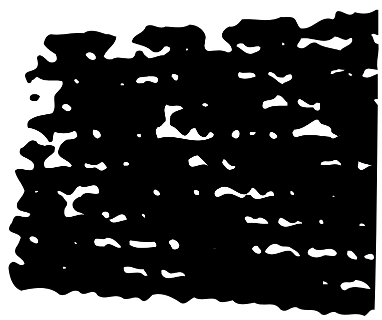
Stencil Thickness = 7.92 µm
Rz = 12.14 µm

Stencil Thickness = 6.79 µm
Rz = 14.65 µm

Stencil Thickness = 7.45 µm
Rz = 12.41µm

2–2

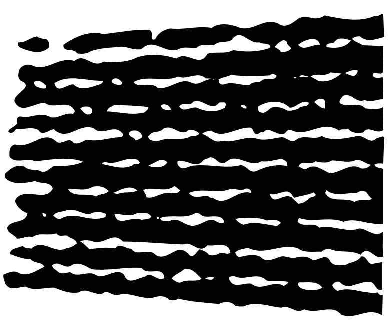
Stencil Thickness = 5.96 µm
Rz = 12.70 µm



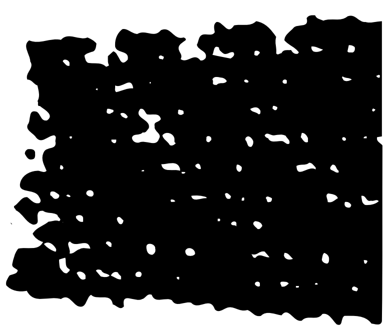
Stencil Thickness = 5.18 µm
Rz = 16.46 µm

Stencil Thickness = 5.30 µm
Rz = 14.04 µm

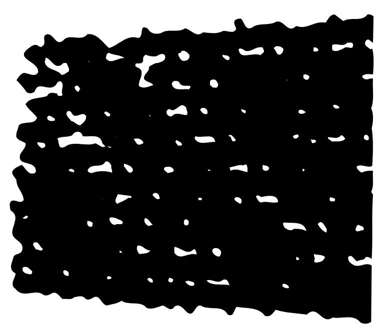
2–1



Stencil Thickness = 5.00 µm
Rz = 15.13 µm



Stencil Thickness = 4.32 µm
Rz = 21.05 µm



Stencil Thickness = 4.40 µm
Rz = 18.01µm

Figure 22 (c)

Text Image Area Comparison

Diazo-Photopolymer Direct-Emulsion

Number of Coats (Print Side – Squeegee Side)	2 Face Coats	No Face Coat	1 Face Coat

2–3

2 Face Coats:

Stencil Thickness = 7.92 µm
Rz = 12.14 µm

No Face Coat:

Stencil Thickness = 6.79 µm
Rz = 14.65 µm

1 Face Coat:

Stencil Thickness = 7.45 µm
Rz = 12.41µm

2–2

2 Face Coats:

Stencil Thickness = 5.96 µm
Rz = 12.70 µm

No Face Coat:

Stencil Thickness = 5.18 µm
Rz = 16.46 µm

1 Face Coat:

Stencil Thickness = 5.30 µm
Rz = 14.04 µm

2–1

2 Face Coats:

Stencil Thickness = 5.00 µm
Rz = 15.13 µm

No Face Coat:

Stencil Thickness = 4.32 µm
Rz = 21.05 µm

1 Face Coat:

Stencil Thickness = 4.40 µm
Rz = 18.01µm

Figure 23

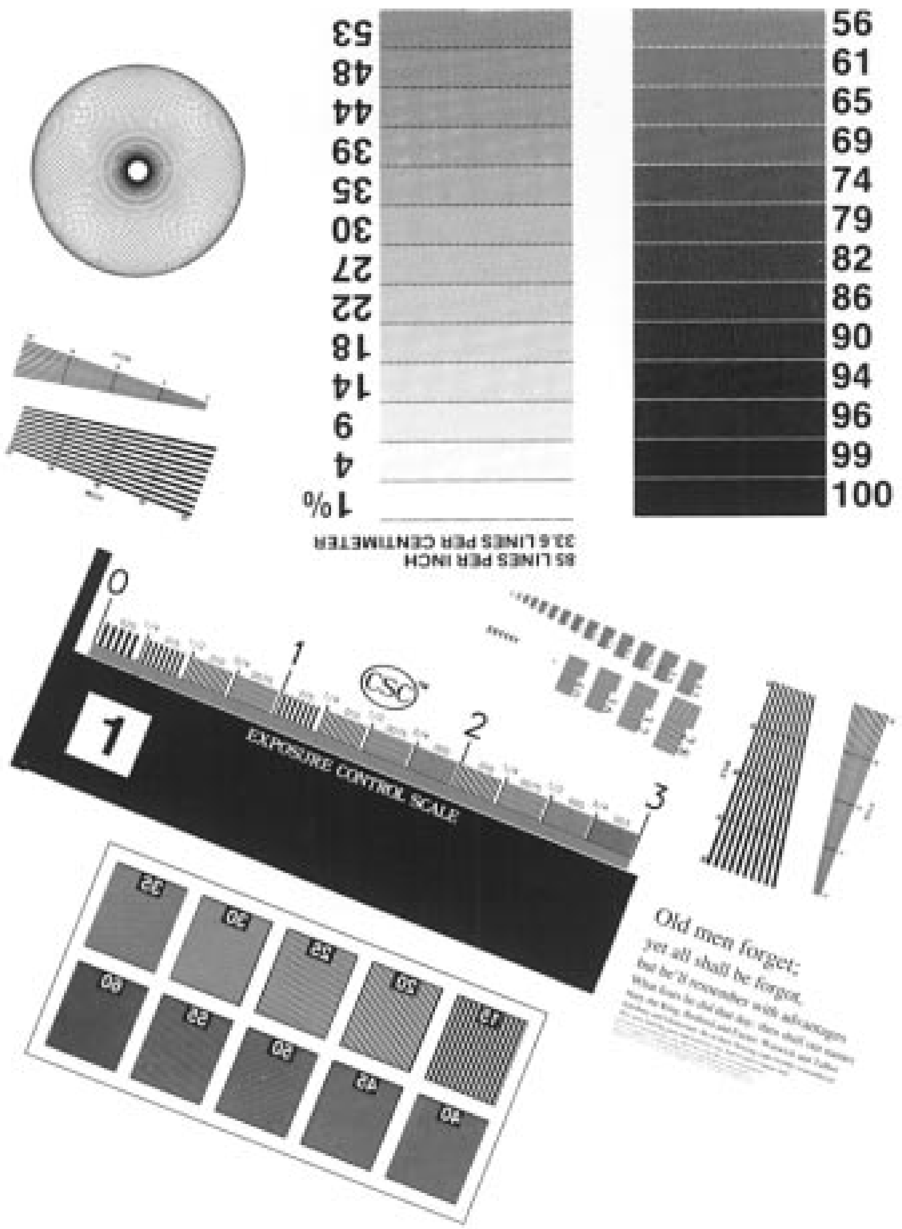


Image used on test screens to evaluate print quality.

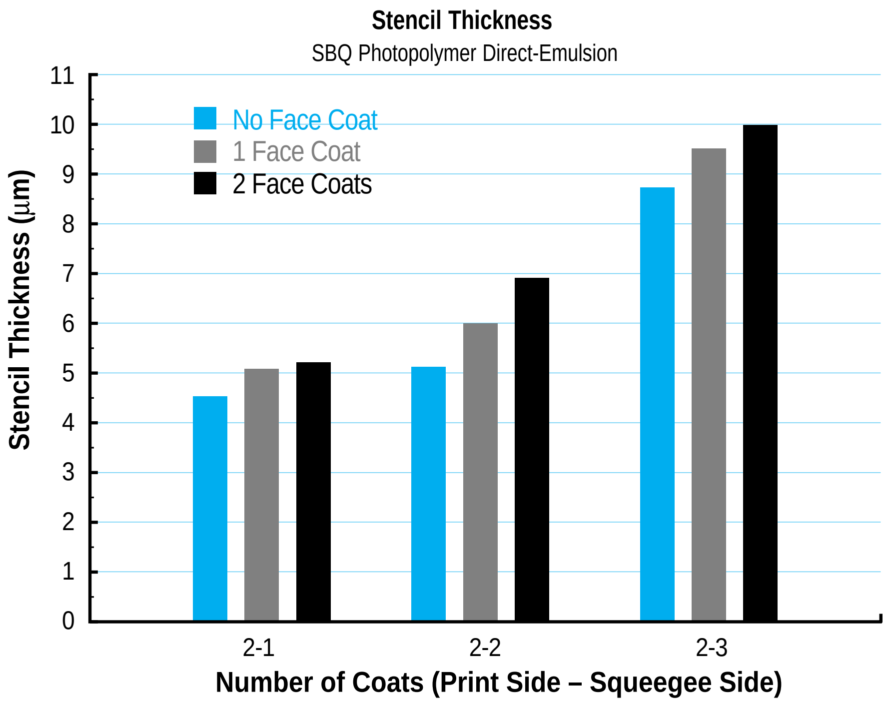
Figures 22(a), **(b)**, and **(c)** show a portion of the print results from each of the nine stencil coating combination areas on the diazo-photopolymer screen. These pictures are magnified areas on the printed image **(Figure 23)** captured with SPTF's image analysis system. Notice the differences in print quality among the nine areas in each figure due to differences in the stencils.

Figure 22(a) shows 53% dots from an 85 line per inch (33.5 line per cm) tonal scale. Observe that the 2-1-0, 2-2-0, and 2-3-0 areas have significant dot gain. Print quality was dramatically improved with the addition of a single face coat, but the addition of a second face coat offered little improvement in quality, providing virtually no benefit for the additional time and work.

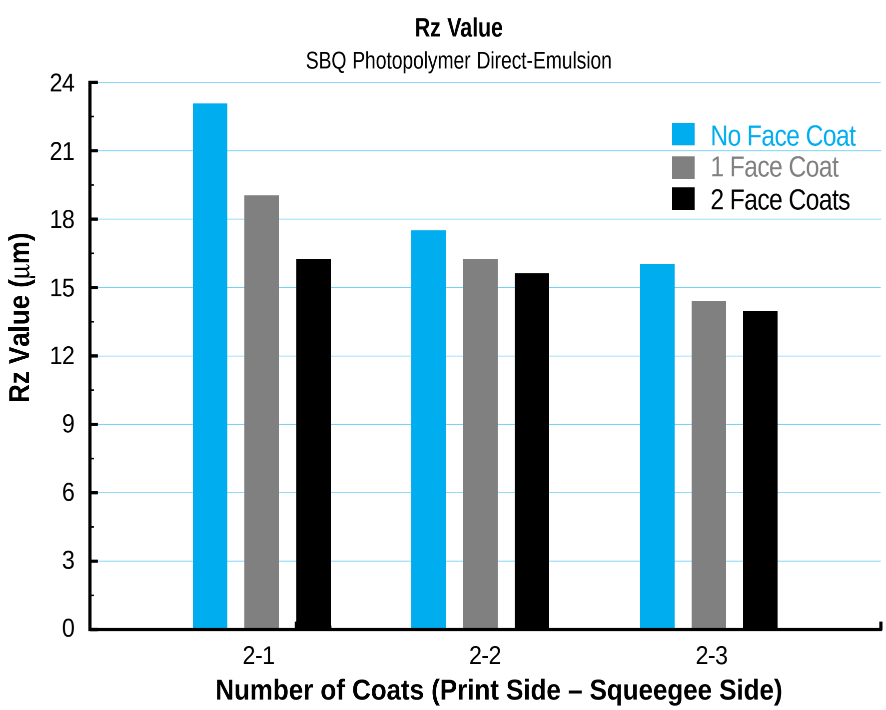
However a second face coat was beneficial to reproducing fine lines as illustrated in **Figure 22(b)** with 2 mil lines and spaces. Observe the improvement in line definition with the addition of one face coat, and a further improvement with the second face coat. In this situation, applying two face coats was beneficial.

Figure 22(c) shows a sampling of 3 point text from each of the nine stencil areas. Notice that with this small text, face coating did not substantially improve the print quality. Applying face coats for this type of image would only add to the expense of screen making.

Figure 24



Stencil Thickness (µm)	No Face Coat	1 Face Coat	2 Face Coats
2 Print – 1 Squeegee	4.52	5.09	5.31
2 Print – 2 Squeegee	5.12	6.00	6.91
2 Print – 3 Squeegee	8.74	9.51	9.99



Rz Value (µm)	No Face Coat	1 Face Coat	2 Face Coats
2 Print – 1 Squeegee	23.07	19.04	16.19
2 Print – 2 Squeegee	17.50	16.25	15.61
2 Print – 3 Squeegee	16.03	14.41	13.98

Stencil thickness and Rz value for each of the nine coating combinations on the SBQ-photopolymer direct-emulsion test screen.

The SBQ photopolymer emulsion test screen gave similar results. **Figure 24** contains the stencil thickness and Rz value for each of the nine areas. As seen with the diazo-photopolymer emulsion, as the number of coats increased, this emulsion produced a thicker and smoother stencil. Again, compare the coating area of 2-1-0 to the coating of 2-3-0. The additional squeegee-side coats increased the stencil thickness over 93% from 4.52 µm to 8.74 µm, and, the Rz value decreased about 30%, from 23.07 µm to 16.03 µm. When two face coats were applied to the 2-1 area, the stencil thickness only increases 18% to 5.31 µm, but the Rz value is again lowered about 30% to 16.19 µm! As pointed out earlier, face coating lowers the stencil surface Rz value substantially with minimal increase to the stencil thickness.

Observe in **Figures 25(a)**, **(b)**, and **(c)** the print quality in each of the nine coating areas on the SBQ photopolymer emulsion screen. As with the diazo-photopolymer emulsion, the stencils produced vast differences in dot gain, and fine-line resolution, while hardly affecting the small text.

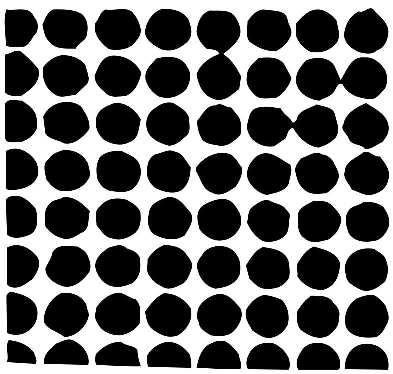
Figure 25 (a)

53% Dot Area Comparison
85 LPI Halftone – SBQ Photopolymer Direct-Emulsion

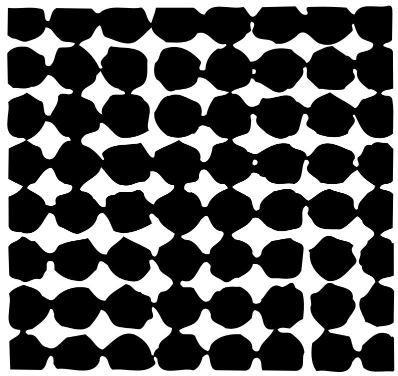
Number of Coats (Print Side – Squeegee Side)

2 Face Coats | **No Face Coat** | **1 Face Coat**

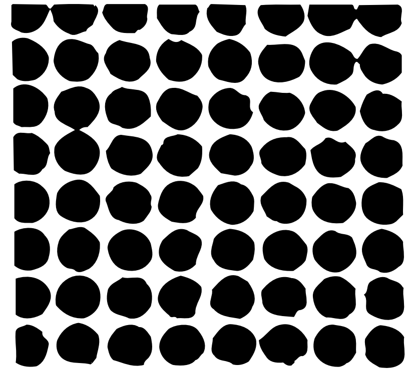
2–3



Actual % Dot = 52%
Stencil Thickness = 9.99 µm
Rz = 13.98 µm

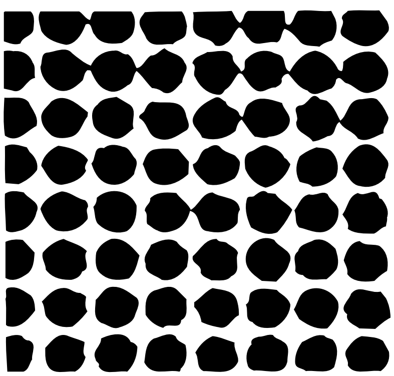


Actual % Dot = 57%
Stencil Thickness = 8.74 µm
Rz = 16.03 µm

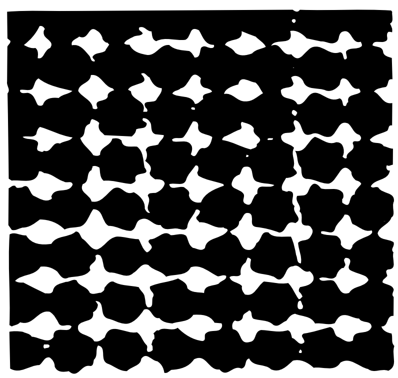


Actual % Dot = 50%
Stencil Thickness = 9.51 µm
Rz = 14.41 µm

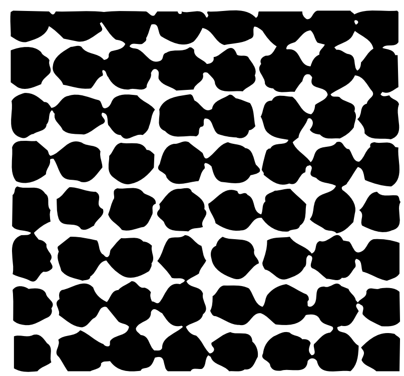
2–2



Actual % Dot = 51%
Stencil Thickness = 6.91 µm
Rz = 15.61 µm

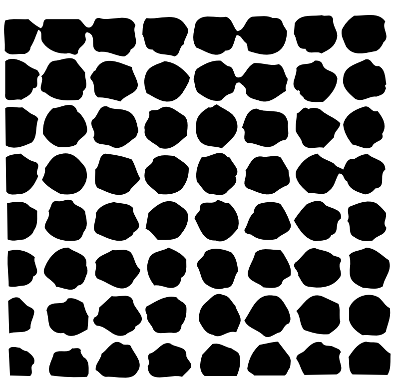


Actual % Dot = 63%
Stencil Thickness = 5.12 µm
Rz = 17.50 µm

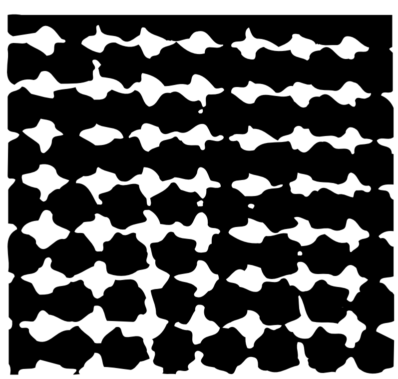


Actual % Dot = 54%
Stencil Thickness = 6.00 µm
Rz = 16.25 µm

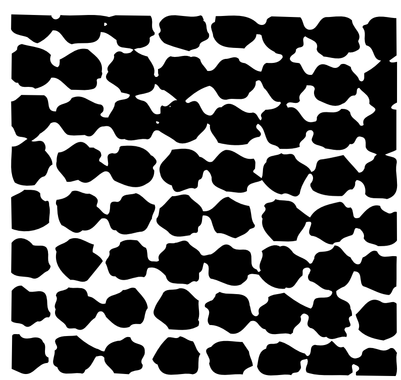
2–1



Actual % Dot = 50%
Stencil Thickness = 4.93 µm
Rz = 16.19 µm



Actual % Dot = 62%
Stencil Thickness = 4.52 µm
Rz = 23.07 µm



Actual % Dot = 53%
Stencil Thickness = 5.09 µm
Rz = 19.04 µm

Magnified images of (a) 53% dot, (b) 2 mil lines and spaces, and (c) small text areas on the print from the SBQ-photopolymer test screen. The nine images illustrate the print quality from each of the stencil coating combinations used on the screen.

Figure 25 (b)

2 Mil Lines and Spaces Comparison

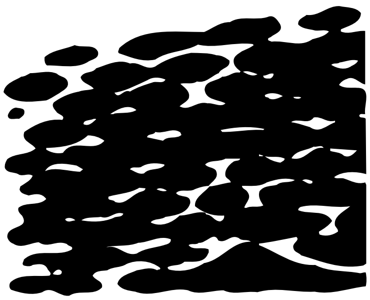
SBQ Photopolymer Direct-Emulsion

Number of Coats
Print Side – Squeegee Side

Columns: **2 Face Coats** | **No Face Coat** | **1 Face Coat**

2–3

2 Face Coats

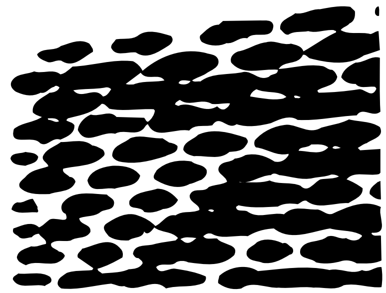


Stencil Thickness = 9.99 µm
Rz = 13.98 µm

No Face Coat

Stencil Thickness = 8.74 µm
Rz = 16.03 µm

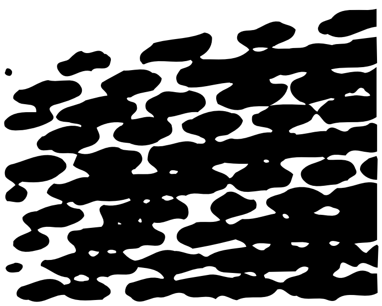
1 Face Coat



Stencil Thickness = 9.51 µm
Rz = 14.41 µm

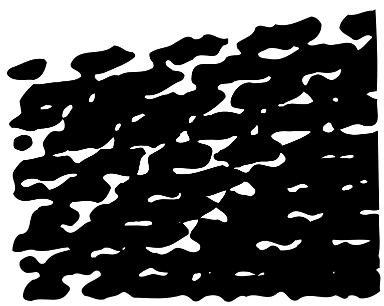
2–2

2 Face Coats



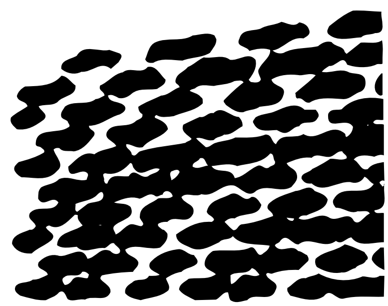
Stencil Thickness = 6.91 µm
Rz = 15.61 µm

No Face Coat



Stencil Thickness = 5.12 µm
Rz = 17.50 µm

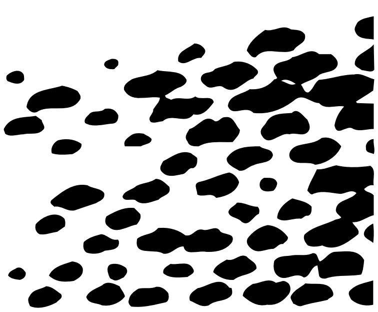
1 Face Coat



Stencil Thickness = 6.00 µm
Rz = 16.25 µm

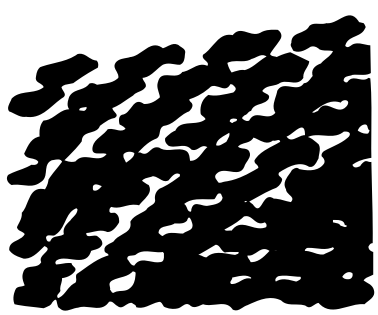
2–1

2 Face Coats



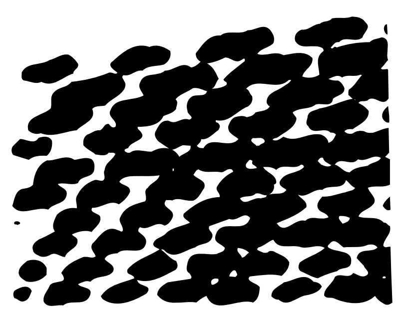
Stencil Thickness = 4.93 µm
Rz = 16.19 µm

No Face Coat



Stencil Thickness = 4.52 µm
Rz = 23.07 µm

1 Face Coat



Stencil Thickness = 5.09 µm
Rz = 19.04 µm

Figure 25 (c)

Text Image Area Comparison

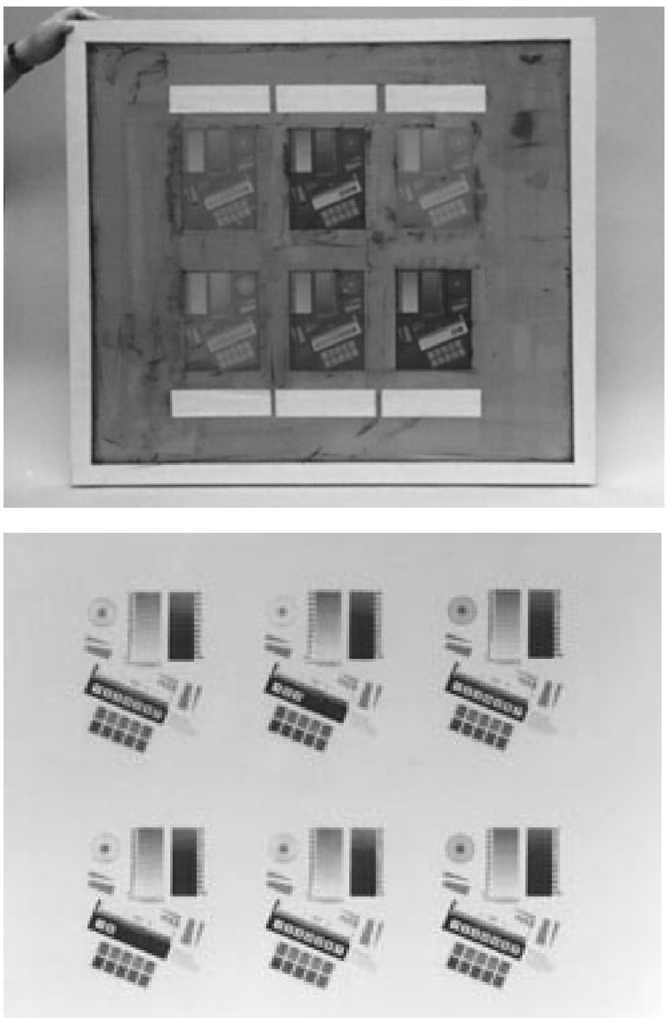
SBQ Photopolymer Direct-Emulsion

Number of Coats (Print Side – Squeegee Side)	2 Face Coats	No Face Coat	1 Face Coat
2–3	 Stencil Thickness = 9.99 µm Rz = 13.98 µm	 Stencil Thickness = 8.74 µm Rz = 16.03 µm	 Stencil Thickness = 9.51 µm Rz = 14.41 µm
2–2	 Stencil Thickness = 6.91 µm Rz = 15.61 µm	 Stencil Thickness = 5.12 µm Rz = 17.50 µm	 Stencil Thickness = 6.00 µm Rz = 16.25 µm
2–1	 Stencil Thickness = 4.93 µm Rz = 16.19 µm	 Stencil Thickness = 4.52 µm Rz = 23.07 µm	 Stencil Thickness = 5.09 µm Rz = 19.04 µm

Capillary film was used to create the third test screen. Six separate stencil areas, each from a different capillary film, were applied to the screen **(Figure 26)**. **Figure 27** shows the stencil thickness and Rz value for each of the six capillary films used on the screen. The graph illustrates that as the stencil thickness increases, the surface Rz value decreases, just as with the direct-emulsion. It is interesting to note that the two 18 µm films both produced stencils thicker than the 20 µm film used.

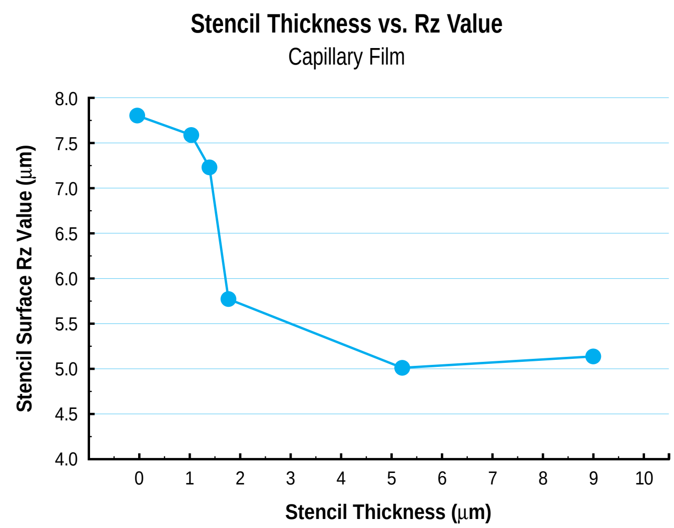
Enlarged portions of the print from this screen are shown in **Figures 28(a), (b),** and **(c)**. In **Figure 28(a)**, the print quality of the halftone dots from each of the six capillary films is comparable. Yet, in the fine-line and small text areas **(Figures 28(b)** and **(c)** you can see considerable differences. It is particularly interesting to look at the print produced from the capillary 25 film from Manufacturer Z. The print quality of the 53% dots from the 85 line per inch (33.5 line per cm) tonal scale look excellent. However, the 2 mil (50.8 µm) lines and spaces and the small text images are both very poor. This clearly demonstrates that testing is necessary to determine which stencil will produce the desired results for a particular application.

Figure 26



Test screen containing six different capillary films and the resulting print.

Figure 27



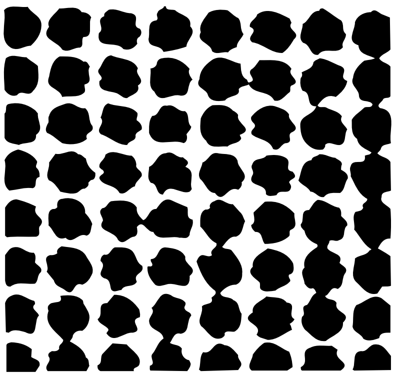
Capillary Film	Rz (µm)	Stencil Thickness (µm)
Manufacturer X – Capillary 15	7.80	.03
Manufacturer Y – Capillary 15	7.58	1.04
Manufacturer X – Capillary 20	7.23	1.38
Manufacturer Y – Capillary 18	5.76	1.73
Manufacturer Z – Capillary 18	5.00	4.98
Manufacturer Z – Capillary 25	5.12	8.94

Stencil thickness and Rz value for each of the six capillary films on the capillary film test screen.

Figure 28 (a)

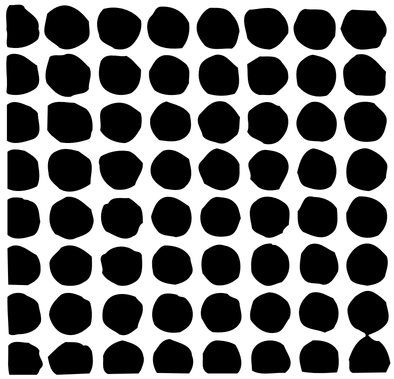
53% Dot Area Comparison
85 LPI Halftone – Capillary Film

Manufacturer Y
Capillary 15



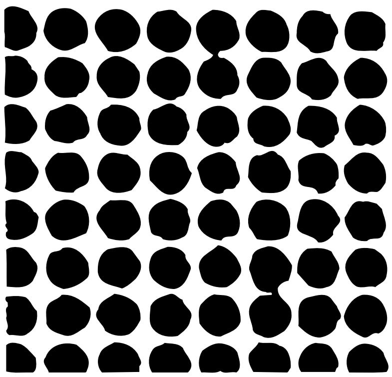
Actual % Dot = 44%
Stencil Thickness = 1.04 µm
Rz = 7.58 µm

Manufacturer Z
Capillary 25



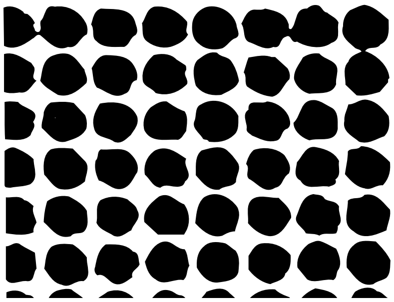
Actual % Dot = 48%
Stencil Thickness = 8.94 µm
Rz = 5.12 µm

Manufacturer Y
Capillary 18



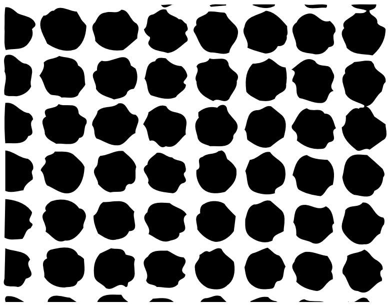
Actual % Dot = 44%
Stencil Thickness = 1.73 µm
Rz = 5.76 µm

Manufacturer Z
Capillary 18



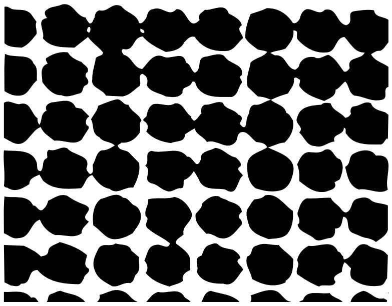
Actual % Dot = 48%
Stencil Thickness = 4.98 µm
Rz = 5.00 µm

Manufacturer X
Capillary 20



Actual % Dot = 44%
Stencil Thickness = 1.38 µm
Rz = 7.23 µm

Manufacturer X
Capillary 15



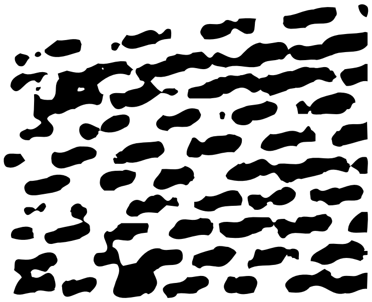
Actual % Dot = 48%
Stencil Thickness = .03 µm
Rz = 7.80 µm

Magnified images of (a) 53% dot, (b) 2 mil lines and spaces, and (c) small text areas on the print from the capillary film test screen. The six images illustrate the print quality from each of the capillary films used on the screen.

Figure 28 (b)

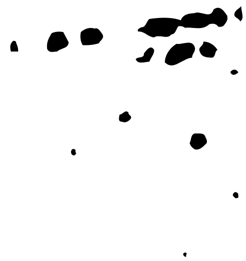
2 Mil Lines and Spaces Comparison
Capillary Film

Manufacturer Y
Capillary 15



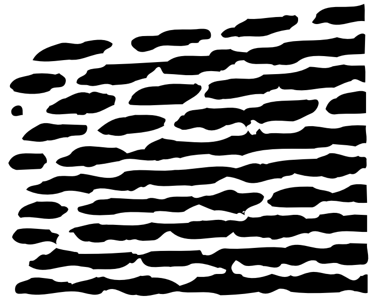
Stencil Thickness = 1.04 µm
Rz = 7.58 µm

Manufacturer Z
Capillary 25



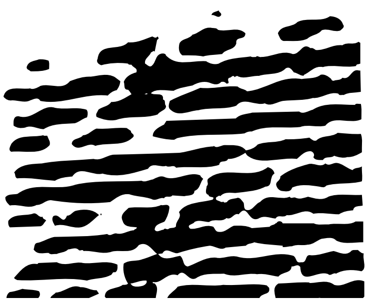
Stencil Thickness = 8.94 µm
Rz = 5.12 µm

Manufacturer Y
Capillary 18



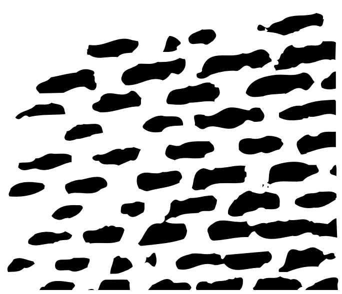
Stencil Thickness = 1.73 µm
Rz = 5.76 µm

Manufacturer Z
Capillary 18



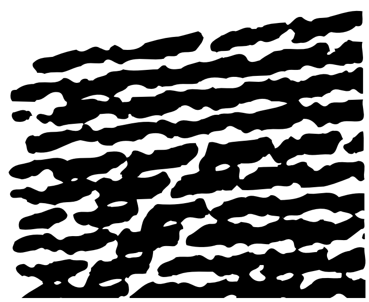
Stencil Thickness = 4.98 µm
Rz = 5.00 µm

Manufacturer X
Capillary 20



Stencil Thickness = 1.38 µm
Rz = 7.23 µm

Manufacturer X
Capillary 15

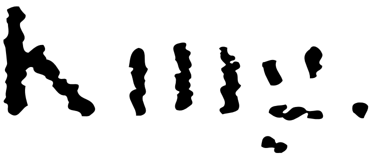


Stencil Thickness = .03 µm
Rz = 7.80 µm

Figure 28 (c)

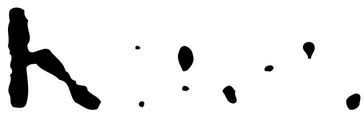
Text Image Area Comparison
Capillary Film

Manufacturer Y
Capillary 15



Stencil Thickness = 1.04 µm
Rz = 7.58 µm

Manufacturer Z
Capillary 25



Stencil Thickness = 8.94 µm
Rz = 5.12 µm

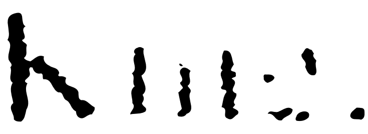
Manufacturer Y
Capillary 18

Stencil Thickness = 1.73 µm
Rz = 5.76 µm

Manufacturer Z
Capillary 18

Stencil Thickness = 4.98 µm
Rz = 5.00 µm

Manufacturer X
Capillary 20



Stencil Thickness = 1.38 µm
Rz = 7.23 µm

Manufacturer X
Capillary 15

Stencil Thickness = .03 µm
Rz = 7.80 µm

Recommendations

The testing described in this bulletin will help the printer determine the optimum stencil for an application. It is obvious from the results shown, that the stencil which produces the best results may be different depending on the image. Similarly, even though one stencil coating technique or capillary film produces excellent prints on a particular substrate, it may produce completely unacceptable results on another.

If screen printers take the time to perform these experiments in their shops with their particular set of parameters (ink, substrate, mesh, squeegee, press, etc.), the results will be invaluable. Better print quality, production time savings, predictable results, and less scrap are achievable, all of these resulting in increased profits for the screen printer.

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