SGIA
Screenprinting & Graphic Imaging Association International

Screen Making Basics: Stencil Selection and Application

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Introduction

Preparing the screen is the first step in the screen printing process and is probably the most important one. We can't expect to achieve a good print result when using a screen of poor quality. The objective in any printing process is to reproduce the original artwork as exactly as possible. Hence the "printing plate," or "printing screen," has to match the artwork. The screen printer has to choose the right stencil system and processing equipment, which enables the reproduction of the artwork at an acceptable quality for the specific application. As screen printing can be used in a wide variety of applications, with different quality requirements, this choice often seems difficult. Most modern stencil systems are capable of reproducing the artwork; however, only when used correctly. Even the best stencil system will fail in one way or another if applied incorrectly. This article covers most modern stencil materials and explains the correct application methods.

Requirements of the Stencil

No matter what type of printing you do, you need to identify your stencil requirements before choosing a stencil system. These requirements include:

- Resistance to ink and other chemicals used
- Mechanical resistance
- Edge definition
- Mesh bridging
- Resolution

These features are built into the stencil system by the manufacturer. Every single one of these properties, however, can be affected by means of the application technique. The manufacturer determines the maximum qualities achievable by using the right raw materials and manufacturing techniques. Achieving this maximum quality is dependent on the application method and the equipment used for exposure and development.

Chemical Resistance

Chemical resistance of the printing screen is essential for allowing the use of the variety of ink systems and cleaning chemicals in screen printing. Depending upon the stencil system and its own chemistry, each system offers certain chemical resistances. The manufacturer has the choice of producing certain "grades" of resistance, depending on the application that specific product is formulated for.

Stencil systems can be grouped based on the requirements of a particular ink system.

Ink System	Required Water Resistance	Required Solvent Resistance
Plastisol Inks	low	low
Textile water based inks	high	medium
Discharge inks	high	medium
Solvent based inks for paper & cardboard	low	medium
Solvent based inks for vinyl & PVC	low	high
Solvent based inks for metal & 2 component inks	low	high
Water based inks for paper & cardboard	high	medium
Water based inks for plastic substrates	high	high
UV inks	low	high
Water based UV inks	high	high

The higher the required resistance, the more critical the application of the emulsion becomes. Especially critical is the exposing of the stencil. Resistance is achieved by crosslinking certain chemicals during the exposure of the screen. Under-exposure will result in inferior solvent and water resistances.

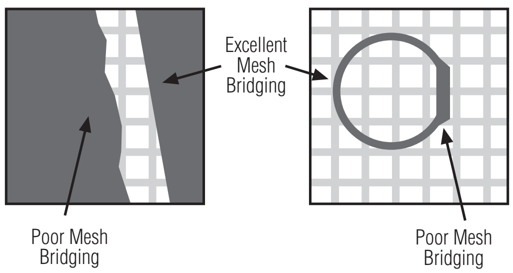
Mechanical Resistance

The mechanical resistance of the stencil is achieved by carefully balancing hardness and elasticity of the material through selection of suitable raw materials. Resistance is further influenced by parameters such as mesh tension, off-contact distance, squeegee pressure and the design of the printing press. If a screen is used with low mesh tension, the mesh stretches during each squeegee stroke putting mechanical stress on the stencil. Mechanical stress is always a combination of the amount of stress and the duration of the stress (length of print run). To achieve maximum available mechanical resistance the screen needs to be processed correctly.

Edge Definition

Edge definition can be described as the quality of the vertical plane of the emulsion edge. High quality emulsions have a very small particle size which results in a smooth vertical edge of the emulsion build up. Lower quality stencils show a fuzzy image edge on the screen rather than a crisp and smooth edge. Edge definition can be altered by improper application, such as over-exposure, under-exposure and too low emulsion build up. Poor edge definition affects not only the ink release out of the stencil but also the resolution; hence, the artwork will be less faithfully reproduced. Edge definition can be observed with a 50x or 60x power microscope.

Mesh Bridging



Mesh Bridging

Stencil systems with excellent mesh bridging will stretch over mesh openings in exactly the same way as the artwork does. A straight line in the artwork will remain straight on the screen, independent of the angle it crosses the openings and threads of the mesh at. Poor mesh bridging shows deviation in line widths and shape and may show up as stairstepping or sawtoothing. The mesh bridging of a stencil can be evaluated using a 50x or 60x power microscope. The best areas to look at are lines that cross over threads at a very low angle or at circles which are tangential to the edge of a thread. Any changes in shape or deviation from the original artwork are signs of poor mesh bridging. Incorrect application of the stencil material, specifically too thin stencil build up, under-exposure, over-exposure, etc., can result in poor mesh bridging.

Resolution

Good resolution is the ability of the stencil material to accurately reproduce all detail in the original film. The ability of the stencil to resolve all information in the original film is determined by the stencil system, the raw materials used and much more. Once again, however, the application of the stencil material is critical. The resolution of the stencil is influenced by the total stencil thickness (including the mesh), color of the mesh, quality of the exposure lamp, under-exposure and over-exposure. Also, resolution is affected by the particle size of the stencil material (edge definition). Mesh bridging (changes in shape) and mesh geometry also affect resolution.

These five requirements determine to a large extent the performance of the stencil material during printing and the quality of the print result. Stencil materials differ from one another and may have advantages or disadvantages over another product. To choose the right material for your application, it is necessary to establish a catalog of requirements. Most stencil systems will work for most applications and give a more or less acceptable result, but the print result can only be perfect if the features of the stencil match the requirements. Furthermore, a poorly processed stencil cannot provide a perfect print, even when printing with very expensive machinery.

Stencil Systems and Their Properties

There are many ways to create a printing screen. Even today there are printers still using handcut paper stencils or drawing the image directly onto the mesh with some sort of blockout. These types of stencils may still be the best way to achieve certain results and for teaching purposes in art classes. In industrial printing, however, the number of stencil systems is reduced to two or three, which provide excellent results in all types of applications.

Earlier Stencil Systems

Handcut Stencil Films

Direct/Indirect (emulsion + unsensitized film)

Bichromate Sensitized Emulsion

Diazo Sensitized Emulsions

Gelatin Based Indirect Films

Diazo Capillary Films

Synthetic Indirect Films

Modern Stencil Systems

Diazo-Photopolymer Emulsions

SBQ-Photopolymer Emulsions

Diazo-Photopolymer Capillary Films

SBQ-Photopolymer Capillary Films

Derivatives of SBQ Systems

The modern systems have advantages over the earlier stencil systems. They typically have better copying qualities and require less coatings on the screen. The Diazo-Photopolymer systems have higher resistances to both water and solvent than the earlier stencil systems.

Diazo Systems

Diazo emulsions have been available since the late ’50s and still hold a large market share. They are of low to medium quality with regard to chemical and mechanical resistance and copying qualities. Today they are mainly used in applications that are not critical about the screen quality. Many capillary film suppliers still use diazo-emulsions to cast their films and only a few manufacture diazo-photopolymer and SBQ-Photopolymer films.

Properties	Diazo	SBQ-Photopolymer	Diazo-Photopolymer
Water-resistance	low - medium	low - medium	low - high
Solvent-resistance	medium - high	low - high	low - high
Mesh bridging	low - medium	low - medium	medium - high
Resolution	low - medium	low - medium	medium - high
Exposure time	slow - medium	very fast	fast
Exposure latitude	medium	low	high
Average cost	low - medium	high	medium
Recommended applications	low end textile and graphic printing	textile shops with screen demand above100 screens Large format graphic printers	all applications including 4-color process; high quality printing

SBQ-Photopolymer and Derivatives Thereof

SBQ-sensitized systems and their derivatives are extremely fast exposing presensitized emulsions. Compared to diazo emulsions the exposure time is approximately 15 times faster. This is a great advantage for large format printers who need an excessive distance between the exposure lamp and the vacuum frame. They are also suitable for speeding up the exposure process when using weaker light sources. The main field of application is garment printing where many hundreds of screens have to be made every day and the faster exposure times are needed.

The fast exposure times, however, also decrease the exposure tolerance (latitude) for proper exposure of the emulsion: The exposure time has to be determined exactly. Over-exposing or under-exposing a few seconds will change the screen quality dramatically. The copying qualities of SBQ-systems are comparable to high quality diazo-systems, but do not reach the same quality that can be achieved with diazo-photopolymer (a.k.a. dual-cure) systems. The chemical resistance of SBQ's are good, but not outstanding, due to the way this system crosslinks.

Diazo-Photopolymer Systems

Diazo-photopolymer stencil systems, also known as "dual-cure" are a combination of diazo-sensitizer and UV-hardening resins. The big advantage over all other systems are the outstanding copying qualities and chemical resistance that can be achieved with this chemistry. It is approximately 5-8 times faster exposing than standard diazo stencils and typically has a higher solids content. Emulsions with higher solids content require less numbers of coatings to achieve a certain stencil thickness. Another advantage is very wide exposure latitude. The screens can be exposed correctly and there is no requirement to shorten the exposure time for fine detail work. Diazo-photopolymer systems are at this time the system with the best balance of quality, performance and price.

Screen Preparation

Mesh Selection

Due to the vast selection of mesh counts available and the varying requirements of different applications, it is impossible to make general recommendations regarding mesh selection. There are a few points though that need to be considered:

- Mesh tension should be above 15-20 Newton/cm
- The thinner the mesh the better the resolution
- The thinner the thread the better the resolution
- The mesh determines the ink deposit when printing lines larger than 300-500 micron (14-20 mils)
- The maximum achievable resolution is a line width not smaller than the combined width of one mesh opening + one thread diameter

Most printers still use the same mesh counts that have been established for a specific application many years ago. New developments such as high tension mesh and thinner threads may provide better print results than the usual mesh counts and should be considered.

Mesh Preparation

Before applying the stencil material to the mesh, cleaning is recommended. This reduces pinholes and fisheyes in the coating. New mesh as well as reused screens need to be degreased thoroughly with a commercial degreasing agent. Household detergents may contain other ingredients which may leave residues on the screen. When using indirect film systems a roughening with special abraders is recommended to increase the bond between the stencil film and the mesh. For direct emulsion abrading the mesh is not necessary and not recommended, as the emulsion encapsulates the mesh and thus provides excellent adherence. After degreasing the screen, the mesh can be treated with a wetting agent to improve the wetting characteristics prior to applying capillary films. For direct emulsions this step is not required.

Application Techniques for Capillary Films

There are four basic techniques for applying capillary film. Two are mainly used on small screens, the other two are used for larger formats.

Application Method 1 (small format)

- Cut the film to an appropriate size sheet but avoid kinks in the film that could delaminate the emulsion from the polyester carrier.
- Place the capillary film sheet on a raised horizontal pad with the emulsion side up.
- Take the wet screen and bring the mesh into contact with the capillary film at one corner and slowly lower the frame. The film will be drawn to the mesh by the capillary action of the water. Avoid air pockets.
- Squeegee off excess water and dry the screen.

Application Method 2 (small format)

- Cut an appropriate size sheet of capillary film and place it on a horizontal pad with the emulsion side up.
- Place a DRY screen on top of the film.
- Use a spray bottle with a fine mist to wet the screen evenly. The capillary action will draw the film onto the mesh.
- Squeegee off excess water and dry the screen.

Application Method 3 (large format)

- Roll the capillary film sheet onto a core tube with the emulsion side facing outwards.
- Wet the screen using a soft water spray and immediately dry off the frame to avoid water running down the screen.
- Unroll approximately 2.5 cm (1 inch) of the film on the tube and place this leading edge parallel to the frame at the upper end of the screen.
- Unroll the film from the tube by moving the roll downwards on the mesh.
- Squeegee off excess water on the inside of the screen then dry the screen thoroughly.

Application Method 4 (large format)

In this method the manual application is replaced by an automatic coating machine. The machine wets the screen, rolls out the film and cuts the film off. The film roll rests in a cartridge attached to the machine. This method provides the best repeatability of all techniques.

General Considerations

Capillary films provide excellent screen quality if applied correctly and when using the correct film thickness. When using too thin of a film, the print result will show sawtoothing and ragged edges. To avoid problems, the recommendations of the manufacturer regarding film thickness and mesh count must be followed. This stencil system is an excellent choice for smaller shops which require a small quantity of screens or when a high quality screen is only needed occasionally. For large volume shops and high screen demand the cost of this system should be considered.

Application Techniques for Direct Emulsion

Direct emulsions can produce excellent screen quality, provided the stencil material is used correctly. The following techniques can be used with most emulsions and will provide a good print result. Due to the different mesh counts and emulsions available, however, it is impossible to give one technique that provides good results with all available materials. Final evaluations must be made by evaluating a print test. An alternative to actually printing a test screen is to measure the thickness of the stencil and the surface roughness of the screen and the substrate. These measurements provide enough information to accurately predict the print result (see SGIA Technical Guidebook article, The Rz Value: A New Concept in Screen Evaluation). The main differences in coating techniques are the number of coats applied on each side of the screen.

The Coating Trough

The coating trough has a tremendous influence on the coating result. It determines the amount of emulsion that is applied onto the screen with each coating stroke. Depending on the design of the coating trough, the emulsion thickness may vary from almost nothing to several microns. There is also the possibility of uneven coating and pinholing due to the coating trough design.

- The coating trough should be designed to hold as much emulsion as possible.
- After coating the screen the emulsion in the coating trough should not be depleted.
- The coating trough should have a round or dull edge with a diameter of 1.5 - 2 millimeters (0.059" - 0.078").
- A sharp edge with a small diameter of below 1 mm (<0.039") is needed for applying face coats or wet-on-dry coats.
- The trough material should be stainless steel or aluminum.
- The coating trough should be at least 5.0 cm (2.0") smaller in width than the inside measurement of the screen frame.

Wet-on-Wet Coating Technique

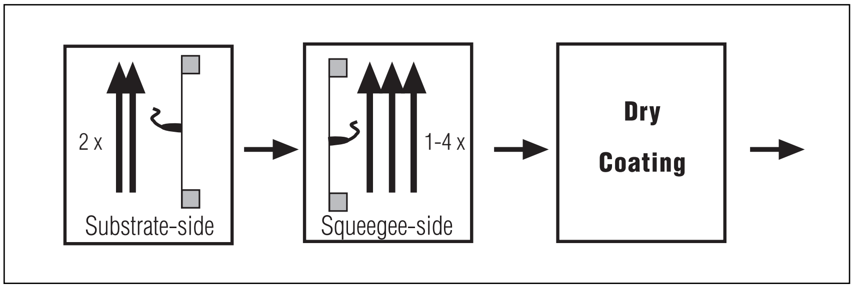
This coating technique is the most common and suitable for 90% of all printing applications. It provides a fast emulsion build up and a durable stencil.

- Step 1: Apply 2 or more coats wet-on-wet onto the substrate side of the screen, using the round edge of the coating trough. Use as many coats as are necessary to see the emulsion come through on the squeegee side of the screen. This step fills the mesh with emulsion and pushes all air out of the mesh openings.
- Step 2: Apply at least 1 coat on the squeegee side of the screen. This coat pushes screen emulsion from the squeegee side to the sub-

strate side of the screen. To achieve higher emulsion build up apply 2 or more consecutive coats wet-on-wet onto the squeegee side.

- Dry the screen

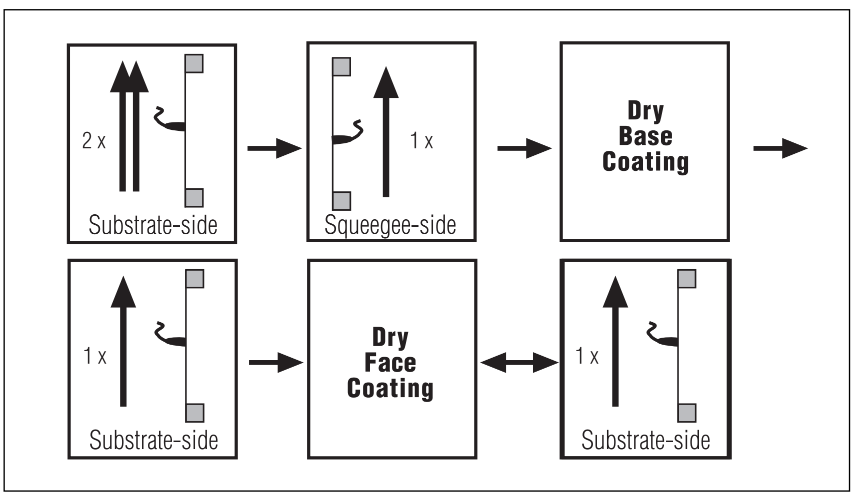
Wet-on-Wet Coating



Wet-on-Dry Coating Technique (Face-Coats)

This technique should be used on mesh counts finer than 140 threads/cm (355/threads/inch) and for applications where a thin emulsion build up is needed, such as printing with UV inks. Mesh counts finer than 140 tpc (355 tpi) have a small mesh opening which allows only a little emulsion to flow through the mesh in wet-on-wet techniques. The finer the mesh count the more difficult it is to achieve a suitable emulsion coating. The wet-on-dry technique or face coats will improve the print result without much increase in stencil thickness.

Wet-on-Dry Coating



- Step 1: Apply 2 or more coats wet-on-wet onto the substrate side of the screen using the round edge of the coating trough. Use as many coats as are necessary to see the emulsion come through on the squeegee side of the screen. This step fills the mesh with emulsion and pushes all air out of the mesh openings. Fine mesh counts may require up to 3 or 4 coats.
- Step 2: Apply 1 coat on the squeegee side of the screen. This coat scrapes excess emulsion off the squeegee side and pushes an even amount of emulsion to the substrate side of the screen.
- Step 3: Dry the screen.
- Step 4: Apply 1 coat onto the substrate side of the screen using a thin edged coating trough.
- Repeat Step 3 and Step 4 at least two times.

More wet-on-dry coats or face coats will result in a smoother stencil. Each coat increases the stencil thickness by only 1-2 microns (1/25th of a mil). If a slightly higher emulsion build up is permissible, additional coats on the squeegee side (during wet-on-wet coating: Step 2) can be applied. In that case the number of face coats may be reduced. This coating technique is for fabrics with a T-type thread (33-35 micron thick). For S-type mesh with thinner threads a simple 2+2 wet-on-wet coating technique may be sufficient. One face coat may be necessary. HD-mesh (thickest thread diameter) requires more face coats.

Coating Guidelines

The following chart provides a guide for coating techniques on various mesh counts. It is based on direct emulsions with medium viscosity (10,000-16,000mPas/1,000-1,600 CPS) and medium solids content (35-40%). Emulsions with lower solids content require more coats, higher solids and less coats. A higher viscosity may result in the need of more coats, thinner viscosity requires less coats. Other features of the emulsion, like flow properties, etc., and differences in the mesh properties as well as the required stencil thickness may also change the coating technique (see SGIA Technical Guidebook article, *The Rz Value: A New Concept in Screen Evaluation*).

Mesh Counts	Wet-on-Wet Coating	Number of Wet-on-Dry Coats
below 34 tpc/86 tpi	1 + 1	0
43-54 tpc/110-137 tpi	2 + 1 or 2 + 2	0
61-78 tpc/156-197 tpi	2 + 2 or 2 + 3	0
91-110 tpc/230-280 tpi	2 + 3 or 2 + 3	0 or 1
120-130 tpc/305-330 tpi	2 + 2 or 2 + 3	1 or 2
140-154 tpc/355-390 tpi	2 + 1 or 2 + 2	2 or 3
165-185 tpc/420-470 tpi	2 + 1 or 2 + 2	2 or 3

General Rules for Good Stencil Quality

- Total stencil thickness (mesh + emulsion) should not be larger than the width of the smallest detail in the artwork.
- Emulsion build-up above the mesh should be 20-25% of the mesh thickness for general printing, 15-20% of the mesh thickness for fine detail printing.
- The thinner the emulsion build-up, the more face coats are needed.
- Maintain a minimum emulsion build-up of 5 microns above mesh.
- The smaller the mesh thread diameter, the better the resolution

Conclusion

Considering the many variables that affect the quality of a stencil and consequently the print result, it becomes difficult to recommend coating techniques and systems. This guideline for coating techniques will provide a good starting point for tests within the production environment. Use them to finalize the best coating techniques for your specific applications in your print shop. When following these general rules a good basis for quality prints is certain.