

# **Part 1: The Complete Guide to Not so Basic Stencil Making**

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Participants of the last SPIA Industry Profile Study in 1990 were asked to list their top three problems in the area of screen printing and in finishing the end product. Leading the resulting list of the industries top then problems is "Getting Good Help", followed by "Basic Screen Making" in second place.

The survey clearly indicates that these areas need special attention. The following series of articles are an attempt to combine both aspects, providing good help in screen making, although not quite so basic.

Let's face it, basic screen making isn't good enough anymore. Our customers as well as ourselves require higher quality of ht end product and consequently a higher level of knowledge and understanding of the process.

What still is not understood by many in our industry is, that the quality of the stencil really determines the print result to a very large extent. That is the reason why so many print shops have nice machinery and good controls in the printing department and the screen making area is crammed into the last corner of the building with no control on the coating results, not to speak of the environment in that area. In many cases nothing has changed here, except- this dark hole grew bigger and bigger over the years.

But remember that printing is the reproduction of an original and the closer our reproduction resemble our original the better is our quality. The stencil is a copy of the original art work and should not deviate from it.

Once you understand the importance of the screen and how it affects your print quality and the economy you might be tempted to change a few things in the screen making "department".

These articles will start with the very basis of the screen making- the chemical make up of the emulsions, explaining the chemical reactions of the different steps. You may think that the chemistry of the product is of no interest for you, but it is the chemistry that makes the product perform and your method of applying the product may cause problems because you disregard the chemical and physical properties.

The next articles will explain how to choose the right emulsion and how to apply it correctly. They will tell you how changes in application will affect the result of your work and how simple controls can be applied to assure consistency in production.

# Chemical Structure of Direct Stencil Systems

## General Structure

Simple stencil systems are based on water solutions of a polymer, which cross-links with bichromate salts under the influence of light. The most common polymers used are gelatin and Poly Vinyl-Alcohol (PVA).

As these simple emulsions did not fulfill the requirement of high durability and excellent print quality, the formulations had to be changed and further developed.

To upgrade the general copying qualities and the stability of the emulsion, synthetic resins and/or dispersions were added to the basic mixture of PVA and sensitizer. The chemist has the choice of a wide variety of material he can use, like polyvinyl-chloride, polystyrene, polyvinyl-acetate, polyacrylates, acrylonitrile-polymer, butadiene-polymer as well as their co- and ter-polymers and much more. Just imagine that the chemist has enough choices in raw materials to change the properties of the emulsion as desired. Using Diazo sensitizer or SBQ- sensitized systems instead of bichromates did further improve the overall quality of the emulsions.

One of the main criteria for choosing the polymer is the film-forming, i.e. the cross-linking of the ingredients with each other.

Initially all polymers are surrounded by a water shell as the emulsion contains at least 50% water. During drying of the coating the water evaporates and the particles get closer to each other. Once the particles are close enough, or the emulsion film has dried completely, the particles stick to neighboring particles and hence form a physical bond between each other. However, this is not a chemical cross-linking yet.

This physical bond is strong enough to produce emulsion films such as the capillary films. In this stage, however, the emulsion can still be dissolved completely by water.

Besides the three basic components- PVA, sensitizer, and dispersion, there are many more ingredients essential for good overall performance of an emulsion. Wetting agents, flow agents, defoamers, plasticizers and dyes are just a few.



The most difficult part in formulating an emulsion, however, is to achieve perfect cooperation of all ingredients, which is a necessity for good performance.

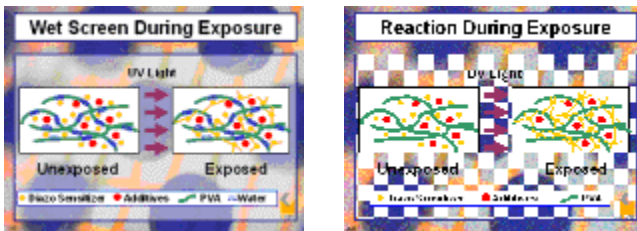
## Reaction During Exposure

If the dried and sensitized emulsion is exposed to UV-light (UV-radiation), the sensitizer reacts with the water soluble polymer and makes the polymers somewhat water-resistant.

During exposure of ht emulsion the photo-reactive group in the emulsion, which is the sensitizer and the photo-reactive resins, are being stimulated by UV-radiation. As a result to the UV-radiation the sensitizer will react with the water-soluble polyvinyl-alcohol and other polymers.

Imagine that the sensitizer is fed with energy from the UV-light and has the desire to change back into a low energy stage. In order to reach a lower energy level the sensitizer chemically reacts with the PVA. By doing so the entire mixture of our emulsion is cross-linked, i.e. one particle holds on to the next one – is chained together.

This process is basically a chain reaction; i.e. once started it would go on forever, if there would be no "traps" which stop the reaction. However, there are multitudes of "traps" which stop the chain reaction after extremely short time. Started at one point the reaction will not even reach as far as a fraction of a micrometer before it is stalled. Such traps can be accidentally introduced by the screen maker. Water molecules for instance will stop the chain reaction and if the coating is not being dried completely the cross-linking can not be completed.



Because of the generally short distance of the chain reaction, a lot of sensitizer is used and the distribution of the sensitizer within the emulsion matrix is very important.

In reality this is much more complicated and the single reactions between the polymers and he sensitizers are not completely known as the reaction really has more than one step. It is extremely difficult for the scientists to record the reaction, as there are many side reactions possible.

For our purposes it is enough to understand, that the reaction during exposure is basically an exchange of energy, which results in a durable chemical link between the ingredients of our emulsion.

## Reaction During Development of the Exposed Screen

The unexposed emulsion has to remain water soluble, as all direct emulsion systems can be developed with water instead of a chemical like in photographic films.

During development of the screen the water will dissolve the unexposed parts of the emulsion film and wash away all dissolved particles. The exposed areas of the stencil are somewhat water resistant and withstand the process of developing without any damage. However, when using strictly solvent resistant emulsions the developing process should not exceed 5-10 minutes to avoid softening of the exposed parts.

## **Reaction During Post-Curing and –Hardening**

The water resistance of an emulsion depends on the complete cross-linking of the ingredients. If the exposure time is too short, the cross-linking remains incomplete and the full water resistance can not be achieved. However, there are two ways to further increase the water resistance.

Post-exposure is one of these options, but is limited to SBQ-photopolymer and Diazo-photopolymer emulsions. Only these two systems have an integrated light-sensitive group, which will remain in the emulsion after development. In standard Diazo emulsions, where the Diazo is the only light sensitive ingredient, post-exposure does not give usable results as the remaining sensitizer is washed out during development. The other light sensitive groups in SBQ and Diazo-photopolymer emulsions however will further cross-link during post-exposure. To achieve noticeable increase in resistance the post-exposure time has to be a multiple of the original exposure time.

The second possibility is post-hardening with special hardeners and here you have two options: One hardener can be used on all emulsion, as this type of hardener does not require a special counterpart within the emulsion to chemically react with. This hardener changes the OH-groups (alcohol's) present in all modern emulsion systems. The result is increased water resistance, but the stencil can still be reclaimed.

The second option is a chemical curing, which is only possible if the emulsion contains certain counterparts, which react with the hardener. This curing will result in a permanent stencil with outstanding resistances.

## **Reaction During Reclaiming**

All reclaims come in a water solution or as a powder which has to be dissolved in water. The water will swell and soften the emulsion and works like a carrier for the actual reclaiming chemical. The active ingredient in a reclaimer solution is typically sodium meta periodate will attack the cross-linked chain at the alcohol groups in the emulsion. Once it reaches these chemical groups it will break the cross-linking and the emulsion can be washed off.

As the periodate needs the water as a carrier to reach the alcohol groups of the polymer it becomes more difficult reclaiming a water-resistant emulsion than one which is only solvent resistant.

The reclaimer can have an unpleasant side effect, which has to be avoided. If the reclaimer dries on the screen it works almost like a hardener and a repeated application of the reclaimer will not have any effect as the active ingredient can not break the chemical chain. In this case it is almost impossible to clean the screen.

## **How to Avoid Mistakes in Production**

To assure good performance of the emulsion you need to be careful when mixing the sensitizer into the emulsion matrix. All of the sensitizer has to go into the matrix to get the resistances and properties as stated by the manufacturer. If the sensitizer is not added completely or not mixed thoroughly with the matrix the cross-linking can be incomplete and the exposure time changes.

When dissolving the sensitizer powder or syrup make sure everything is dissolved completely and no sensitizer is left in the bottle. Lukewarm water may help to dissolve the sensitizer. You should not leave the sensitizer bottle filled with water for longer than 2 hours.

To check the emulsion for thorough mixing look at it briefly under white light. The contrast of yellow or red safelight is not good enough.

Once the sensitizer is mixed in the emulsion the pot life of the mixture is approximately 4-6 weeks at 68 degrees Fahrenheit. At higher temperatures the pot life is considerably shorter. You can prolong the pot life by storing the mixed emulsion in the refrigerator. The emulsion may change its viscosity due to the temperature.

The coated screen has to be dried completely before exposing it, especially when water resistant emulsion is used. Some emulsions may take a longer time to dry due to their high solids content and high content of resins. Check the room humidity and if possible use a drying cabinet. The room humidity should be below 50% if drying the screen in ambient air. The standard drying method in our laboratory is as follows: Dry the wet coating at 100° Fahrenheit in a drying cabinet. Monitor the humidity in the cabinet and leave the screen in there until the humidity drops to approximately 30%. Once the humidity is down allow another 5 minutes in the cabinet. This is a standard procedure used by the manufacturer and in most cases less time would be enough. However, this gives you an idea about the perfect drying procedure.



Once again, water molecules in the emulsion coating will stop the cross-linking and result in inferior resistance to solvents and water. Only completely dry screens expose correctly and give the correct result.

As the reclaimer needs to reach certain chemical groups, it needs water as a carrier for the active ingredient. The more water resistant the emulsion is, the more difficult to reclaim the screen.

Avoid drying of the reclaimer on the screen, as you will not be able to remove it anymore. Airborne reclaimer particles and drops can settle on adjacent stored screens and form small dots which close some mesh openings and are almost impossible to remove.

Post-exposure is not very efficient and gains only 10-15% in resistance. The correct procedure is to expose the screen long enough in the beginning. Some emulsions have a narrow exposure latitude and don't allow longer exposure times without showing signs of over-exposure. If this is the case, switch to emulsions with longer exposure time and wider latitude. Good quality products will withstand 10,000 to 20,000 (800 – 1600 dozens) prints with water based ink.

Post hardening with the general hardener on any emulsion makes only sense with emulsion of poor resistance. Good products have a water resistance, which is so high, that this type of hardener will not give much improvement. When using standard solvent resistant Diazo emulsions this type of hardener can be used to achieve resistance to room humidity.

**The chemical curing is the most efficient method to improve the water resistance. The emulsion becomes completely resistant and can not be reclaimed anymore, but the screen can in some cases hold up to 1 million! (80,000 dozens) prints.**

**To be continued.....**