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TRIAL KIT DIRECTIONS:
3D Hi-Density Inks

Printing Three Dimensional Designs on T-Shirts: Step By Step

Textile screen-printing has traditionally been a two-dimensional art. You could print anything you could imagine but the only directions your designer could travel were east-west and north-south, so to speak. Puff ink was the only exception. With puff, you could go up, but the amount of puff was difficult to control, even by the best screen printers. Using puff ink also severely limited your ability to render accurate details.

Recently several ink and emulsion manufacturers, working with a small group of textile screen printers, have developed a system that adds a reliable, controllable Up capability to T-shirt design. The cluster of procedures that comprise this system will enable the textile screen printer to print single layers of ink 500-600 microns thick, perhaps even thicker. (500 microns equals 1/2 millimeter or about two-hundredths of an inch.)

To put this in perspective, the thickest single ink layers printed in ordinary production (measuring thickness as the height of the ink film above the surface of the substrate) are usually glitter inks printed on transfer paper. The ink film thickness reported there is usually about 250 microns at the most, and this is on transfer paper, a flat, nonporous substrate with outstanding ink holdout, compared to a jersey knit T-shirt.

The ink film thickness is not the most remarkable attribute of this printing system. What immediately attracts the attention of everyone who sees a sample of good quality three-dimensional printing is the degree of detail that it produces, the outstanding resolution and definition of the print. Three-dimensional printing enables the textile screen printer to provide printed ink layers with vertical edges as sharp and detailed as die cut or even laser cut plastic sheets. Compare this with the ink film printed on high opacity transfers, athletic uniforms, and similar applications notorious for thick layers of plastisol ink. There the edge of the image is thin, often smudged, and at best, resembles the edge of a small puddle of spilt molasses, regardless of how sharp the stencil may be. Puff inks can produce a comparable ink film thickness but the edge definition of a cured puff print has an irregular, almost organic appearance compared with three dimensional printing's clean, sharp, almost machine-cut look.

As an aside, although I must commend the men and women who developed three dimensional printing for devising the most innovative T-shirt decorating process since process color on textile was systematized back in the 1980's, I must say that their language skills leave something to be desired. The common term for this process is "high-density printing." I'm not sure why. The wet ink and printed samples that I've seen do not have a particularly high density. The inks used do have a higher density than an ordinary cured puff, but for the most part they are no denser than a high-opacity white plastisol. However, I'm afraid that the name will stick, joining "self-tensioning frames" and "underbase" as industry standard terms that everyone uses, understanding the true meaning behind the inaccurate or misleading words.

Printing a Three-Dimensional Design, Step by Step
Printing a three dimensional design requires much more than a different ink or emulsion. Successful three-dimensional printing requires that the textile screen printer master several procedures that are different from normal production. They're not necessarily harder than standard production procedures, but they're significantly different and must be linked together into an integrated system to produce this remarkable new effect.

The Screen
The screen should be 86 thread per inch mesh (30threads per centimeter) , tensioned to at least 30 newtons per centimeter. Checking with my handy Comparative Screen Fabric Guide (available from the ST Publications Book Division, insert phone number and price here) I determine that this mesh is available with five thread diameters, ranging from 120 to 145 microns. I would recommend the thinnest thread diameter available and if possible in a dyed thread, although mesh this coarse is not usually available in any color but white.

The reason for preferring the finer thread diameter is that I want the stencil openings to be filled as much as possible with ink, and as little as possible with mesh. Every a micron matters here. I recommend dyed mesh because it will reduce the light scatter inherent in the extremely long exposure times required by the emulsions used in this technique.

The Stencil
It is generally understood that stencil thickness governs ink film thickness. It is certainly true here. There is a direct correlation between the thickness of the stencil and the thickness of the printed and cured three-dimensional ink film. Tests have shown that if you perform every step correctly, you can achieve a cured ink film thickness of about 90% of the thickness of the stencil.

Two hundred-micron stencils are routine in this application, and four hundred and seven hundred micron stencils are not uncommon. Up to a point, the question is not how thick do you want your stencil to be, but how do you produce a thick stencil? Once a method is selected and mastered, additional thickness is usually only a matter of repetition. I will outline three methods of producing extremely thick stencils and comment on the advantages and disadvantages of each.

Although the emulsion type selected for each of the coating methods listed below may vary somewhat, none of them are practical unless the emulsion being used is extremely fast exposing. This is because of the extreme thickness of the emulsion layer. Depending on the coating method used, select some version of a clear pure photopolymer emulsion.

Liquid Emulsion
The first possible method is to coat the screen repeatedly with liquid emulsion. Fifteen to twenty coats on the substrate side may be required for the necessary stencil thickness. Be sure to dry each coat thoroughly before applying the next. After the first layer of direct emulsion is applied and dried you can place a frame of tape around the image area on the substrate side of the mesh in order to build up the stencil thickness faster. Keep building up the tape frame as the thickness of the emulsion layer increases. The screen drying room should have a dehumidifier to keep the relative humidity at 40-50% and speed screen drying. The advantages of this method are that you can do it with familiar techniques and materials already on hand. The disadvantages are the length of time it will take to produce one screen (several days at least) and the lack of control of the thickness of the emulsion layer. This is due to irregularities in coating methods and the fact that around the 15th coat, you're likely to miscount the number of coatings you've applied.

Capillary Film Build-Up
A faster method of creating an extremely thick stencil is by laminating layers of capillary film to a screen. The appropriate emulsion for this application is the thickest pure photopolymer capillary emulsion available. Ninety-micron capillary direct films are available and I have been told that a 150-micron film will be on the market by the time this article is published.

Adhere the first layer to the mesh by using the direct/indirect method. This procedure is now rarely used in most screen departments, so unless you have been working in this industry for a couple of decades or work for an emulsion manufacturer, you may not be familiar with it. The procedure goes like this. On a flat table, lay a build-up smaller than the inside dimension of the screen but larger than the outside dimensions of the image area. The build-up should be at least a quarter inch high and the top layer should be absolutely smooth and flat. Plate glass with rounded edges and corners is recommended for this. On top of the build-up lay a sheet of capillary film, emulsion side up. Place the screen, substrate side down, on top of the capillary film. Adhere the capillary film to the dry mesh by pouring a thin bead of liquid emulsion on the inside of the screen along one edge of the sheet of capillary film. Spread the liquid emulsion over the entire area of the mesh in contact with the capillary film.

Use a liquid emulsion compatible with the capillary film. By this I mean a liquid emulsion that uses the same sensitizer as the capillary film and has the same basic chemistry. Since capillary film emulsions are generally only liquid emulsions coated on a plastic backing sheet and dried, most emulsion manufacturers will be able to supply you with a liquid emulsion that is compatible with the capillary film you select.

Let the capillary film/direct emulsion layer dry, strip off the polyester backing sheet, and build up the thickness of the emulsion layer by adhering subsequent layers of capillary emulsion to the layer already adhered to the mesh using the following procedure. Make a coating solution of 1 part liquid emulsion to 15 parts water. Mask out the open areas of the mesh by applying a layer of tape to the substrate side of the mesh. Coat the capillary film already adhering to the mesh with the coating solution by flowing the coating solution over the capillary film while the screen is leaning against the back of a washout sink. Apply a second layer of capillary film, emulsion to emulsion, to the film already in place on the screen. Let the second layer of capillary film dry and continue to build up the emulsion layer by applying additional layers of capillary film until the desired emulsion thickness is achieved. Dry the emulsion thoroughly after each layer of capillary film is applied.

This method results in a stencil of any thickness you desire, with a flat, even surface and excellent control over the thickness of the emulsion layer, but it's slow, although not as slow as the liquid emulsion method.

Thick Film Method

The fastest method of producing a thick emulsion layer is to start with the thickest possible film. Thick photopolymer films are available starting at 100 microns and increasing in thickness to 700 microns. These are not capillary films and require a special application process, a variation on the capillary film build-up method.

Select a piece of film of the desired thickness and cut to size, generally 1½ to 2 ½ inches larger than the artwork on all sides. Peel off the protective plastic sheet from one side of the film and lay it, emulsion side up, on a build-up similar to the one described in the Capillary Film Build Up method. The build-up will insure close overall contact between the mesh and the film. Place the screen, substrate side down, on the film on the build-up board.

With the thick film the manufacture will have supplied a container of liquid emulsion. Reduce some of the liquid emulsion with water (1 part water, 2 parts emulsion). Pour a bead of this liquid across one edge of the film. Squeegee the emulsion evenly across the entire surface of the capillary film. It is important to get a thorough, even coverage. Card the excess emulsion off the open mesh area and set the screen aside to dry.

After the screen is thoroughly dried, coat the squeegee side of the mesh again using a scoop coater filled with the undiluted liquid emulsion. Dry the screen again. After you peel off the second protective plastic sheet from the film, the screen is ready to expose.

Screen Exposure and Washout

Needless to say, screen exposure times will be extreme; no matter which coating method you use. Considering the cost of a set of test screens, an exposure calibrator is not just a wise investment, but a necessary one. It's very easy to underexpose these stencils.

After exposing, wet down both sides of the screen and allow the emulsion to soak for a few minutes, then rinse again. The washout process cannot be rushed. Keep soaking and rinsing until the entire image is washed out.

If you are using a sharp, dense film positive, the degree of detail that can be developed will surprise you. These screens take much longer than normal to wash out and you must be extremely patient.

Press Setup

Three-dimensional designs are easier to print on automatic presses because of the greater control of screen off contact that is crucial in this process. Manual presses can be used but it's more difficult to produce a consistent print and ink film thicknesses over 500 microns may be difficult or impossible to achieve. The instructions following are for automatic press operations but they can be adapted to manual press printing.

Place the screen in the press with minimum off-contact distance. Set the flood stroke speed at slightly slower than normal, use a firm flood bar pressure, and if the flood bar angle is adjustable, set the angle at steeper than normal (tipped more in the direction of the flood stroke) to fill the stencil with ink.

Use a medium hard to hard (75-80 durometer) squeegee. Set the squeegee pressure to provide just enough pressure to transfer the ink from the screen to the garment. Set the squeegee speed at slightly slower than normal. Set the squeegee angle so that the squeegee, like the floodbar, is tipped more in the direction of the printing stroke. For the best result, concentrate on producing the best print possible with one clean, smooth print stroke. Double stroking the print may result in a print that is smooshed or smeared.

Although the ink used in three-dimensional printing is generally not unusually thick and flows well, it's a good idea to use slower than usual press speeds.

If you want to increase the thickness of the printed ink film, you can do that by increasing the thickness of the emulsion layer on the screen. You can't achieve greater ink film thickness by printing, flashing the ink, than re-printing the same screen again. The initial ink layer, now cured, will fill the openings in the stencil, preventing the screen from printing a significant layer of ink on the second print stroke. One method that you can use to build up a thicker ink layer is to make two thick stencil screens, with the second screen having a slightly choked version of the image on the first screen. By printing the two screens in succession and flashing between screens the ink from the second screen will be deposited on top of the ink printed by the first screen, resulting in an ink layer that is roughly twice as thick as would be obtainable with one screen.

The three dimensional element in the design should be printed last or flash cured immediately after printing. The three dimensional ink film thickness is such that if the three-dimensional ink is printed, then flash cured and subsequent colors are printed, any image printed close to the three dimensional ink could be distorted.

We have tested some designs with underprinting under the three-dimensional ink. You may question why this is necessary because certainly underprinting is not needed to improve opacity. Some tests seem to indicate that underprinting improves adhesion to the fabric. On the other hand, other test results seem to show that underprinting may cause a loss of sharpness in the print. Further tests of underprinting are necessary.

The Ink

Only inks specifically formulated for three-dimensional printing such as Union Ink's **Hi-Square (3DSQ)** will have the appropriate flow characteristics to create this unusual special effect. A word of caution, these are not puff inks. In fact, any noticeable degree of puff will destroy the three dimensional effect.

Because of the extra thickness of the ink film, three-dimensional designs cure at slightly higher temperatures and require slightly longer curing times than standard plastisols. Hi-Square inks will fully cure when the entire ink deposit reaches 320° F (160° C). Proper curing is extremely important. If the ink is completely cured it will bend, stretch, and wash as well as standard plastisol ink.

Although three-dimensional designs are unusual, to say the least, they are a far cry from the slab-of-plastic look that people associate with heavy layers of plastisol inks. When correctly executed, a three dimensional design has crisp details and sharp edges. The edges of a three dimensional print should rise vertically from the surface of the T-shirt like a tiny but very smooth wall of ink. Even though the inks are heavy and the stencil thickness extreme, this process is capable of producing a surprising amount of detail. I have seen three-dimensional prints incorporating lines only two points thick and halftone dot patterns (12 dots to the inch, it is true, but halftone patterns never-the-less).

For over twenty years our customers have been telling us that they want the design to pop off the shirt. Now we have a printing technique that will allow us to give them what they are asking for.

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