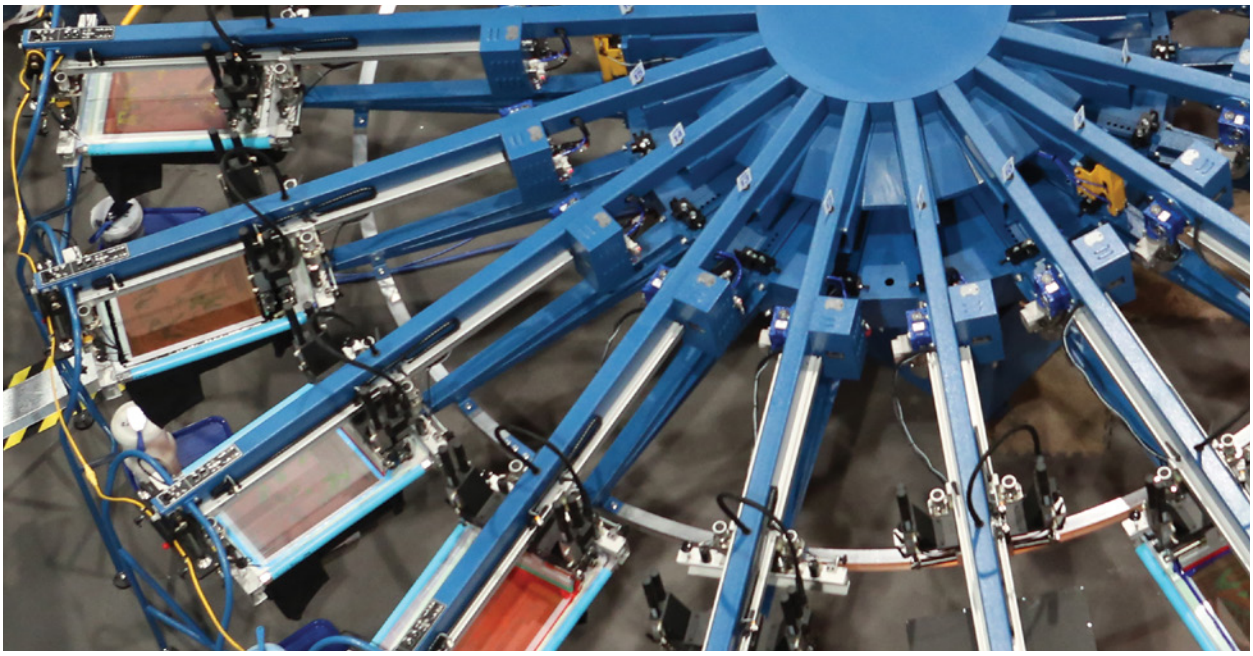

Advances in Stencils for Printing Water-Based Inks

Apparel printing is a highly evolved yet dynamic activity. In its infancy, the only screen printing inks available were water based. These inks were transparent and suitable for printing only light-colored, 100-percent-cotton materials. The introduction of PVC plastisol inks has revolutionized the industry. Plastisols are opaque and suitable for use on dark as well as light-colored garments. They also enable high productivity by utilizing techniques we currently take for granted, such as flashing and high-speed, wet-on-wet printing.

Plastisols can also be printed on nylon, polyester or polyester/cotton blends, and they have allowed screen printing to expand onto a wide range of items in addition to the ubiquitous T-shirt, including bags, umbrellas, outerwear and more.

Although still in common use, plastisols have been subject to scrutiny by regulatory agencies. First to replace phthalates and now PVC, the basic resin system used in plastisol ink is itself a subject of concern for some applications. Many retailers are now requesting PVC-free prints, and brands such as Nike, Inc. have mandated that no PVC ink be used during the manufacture of their goods.

As a solution, PVC-free plastisol technology has been developed based on acrylic polymers, and these inks mimic many of the properties of traditional plastisol.

Moving to Water-Based Inks

As an alternative to PVC-free plastisol, water-based inks have also made a very strong comeback. New water-based ink systems have been introduced by various manufacturers. These are known as HSA (high solids acrylic) inks, and they have similar performance characteristics as plastisol. Though they are water-based, these inks are opaque and vibrant. They can be printed like plastisol and used on both dark and light materials. They provide soft hand feel and are also suitable for use on polyester and poly/cotton blends, in addition to 100 percent cotton. HSA inks are also flexible enough to be used on stretchable materials that contain blends of Lycra or Spandex and are becoming increasingly popular to use on performance and team apparel. Based on these performance characteristics, HSA inks are now often specified for use by marketers, contract printers of licensed goods and licensees themselves.

The other commonly used water-based ink system is discharge inks. Discharge

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Ross Balfour, Global Business Unit Manager, Saati Chemicals

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Figure 1: M&R i-IMAGE STE II

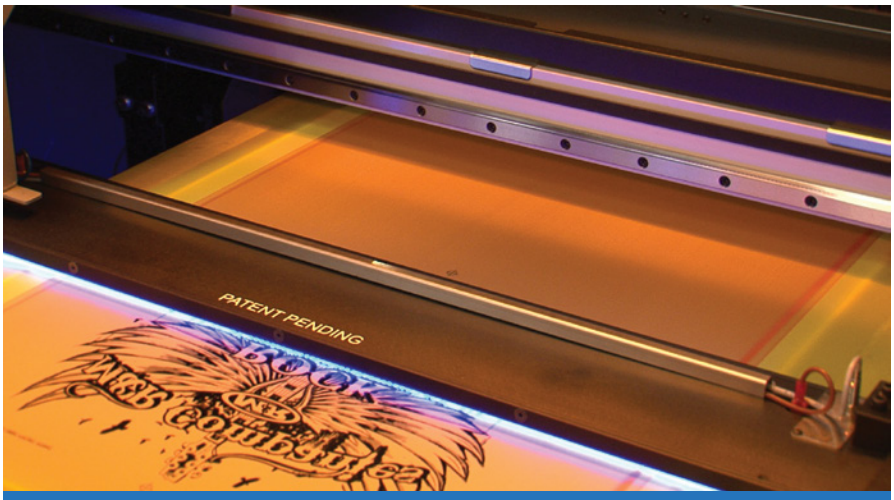

Figure 2: M&R i-Image STE II exposing stencil

inks have been traditionally used in conjunction with plastisol and eliminate the need for underbase when printing on dark garments. Water-based discharge chemically removes the color from the garment and it still retains a soft feel or soft hand, as opposed to masking the underlying color of the material with a heavy, opaque plastisol underbase.

Changing the Screen

This brings us to stencil systems. Plastisol inks in general are not aggressive on screens. Water-based inks, however, are well known for being much more aggressive. Many printers that traditionally consider themselves to be using water-based technology are, in fact, mainly plastisol printers that happen to use water-based discharge ink as the underbase for dark garments. These printers are well aware of premature screen breakdown with water-based ink, and it's common practice to use a different emulsion and/or process to make discharge screens.

The fact is, water-based inks can contain retarder to inhibit premature drying in the screen, reducer and/or extender, and possibly a fixative to improve wash fastness. All of these components combine with the water — and in some cases with a high pH value — to produce an ink that can be extremely aggressive towards the stencil. It is not uncommon that a screen made from an emulsion can print with plastisol all day long, but will be destroyed after only a few prints with a water-based ink. Selection and correct use of stencil material is critical in order to provide durable, problem-free and long-running screens for use with water-based inks.

Traditional two-part, diazo-sensitized, water-resistant emulsions make stencils that do offer a high level of water resistance. The problem is that they have minimal solvent resistance. When used with either HSA water-based inks or discharge inks, these stencils fail due to the additive components in the ink that have solvent activity, which attacks the stencil to cause swelling, softening and loss of abrasion resistance. The use of hardener as a post treatment is not an effective remedy. Even though hardener catalyzes the stencil, it only further improves the water resistance when the breakdown problem is actually caused by lack of solvent resistance.

Dual-cure, two-part emulsions are promoted as being both solvent and water resistant. In general, the solvent resistance is sufficient, but the level of water resistance that can be attained by

dual-cure emulsions is not sufficient to provide really durable stencils for textile printing applications. The use of a post-treatment stencil hardener can increase the water resistance to a satisfactory level, but only at the expense of reclaiming. Normally, stencils that have been hardened are treated as permanent screens and not worth the time and effort it takes to reclaim the stencils. In addition, depending on the type of dual-cure emulsion used, sometimes even hardened and permanent screens break down fairly quickly with discharge due to the very aggressive nature of these inks. It thus becomes necessary to make multiple sets of screens in order to complete a long-run job.

The best option today for making high-durability screens that print water-based textile inks is one-part hybrid photopolymer emulsions. Hybrid denotes that these products have been engineered to be both solvent and water resistant.

Photopolymer emulsions do not require mixing before use or added sensitizer, and these emulsions expose much faster than two-part emulsion systems. They are manufactured using light-sensitive polymer that is capable of much higher crosslinking density than traditional diazo-based products. Also, because there is no diazo, there is no diazo-staining of the mesh that turns used screens to a gray or brown color. Photopolymer emulsions are also very stable, and unlike two-part products they do not require refrigeration to slow down decomposition of the added diazo. Diazo decomposition limits the shelf life of premixed two-part emulsions to only a few weeks, or even only a few days if stored in a room at high temperature.

Photopolymer emulsions for textile printing applications generally have high solids content in the 40–50 percent range, and they are easy to coat with good coverage and thickness on the lower to medium range of mesh counts that typically work best with water-based inks.

The faster exposure speed of photopolymer emulsion also enables the use of new technologies for screen imaging. Computer-to-screen technology is becoming more widely used. An example is the i-Image STE II from M&R (see Figures 1 and 2), which uses LED light to expose an inkjet imaged screen inline, immediately after the inkjet image is applied.

Another example is the DLE-Eco from CST (see Figures 3 and 4), which functions as an image setter and uses modulated light to expose the image directly onto the screen.

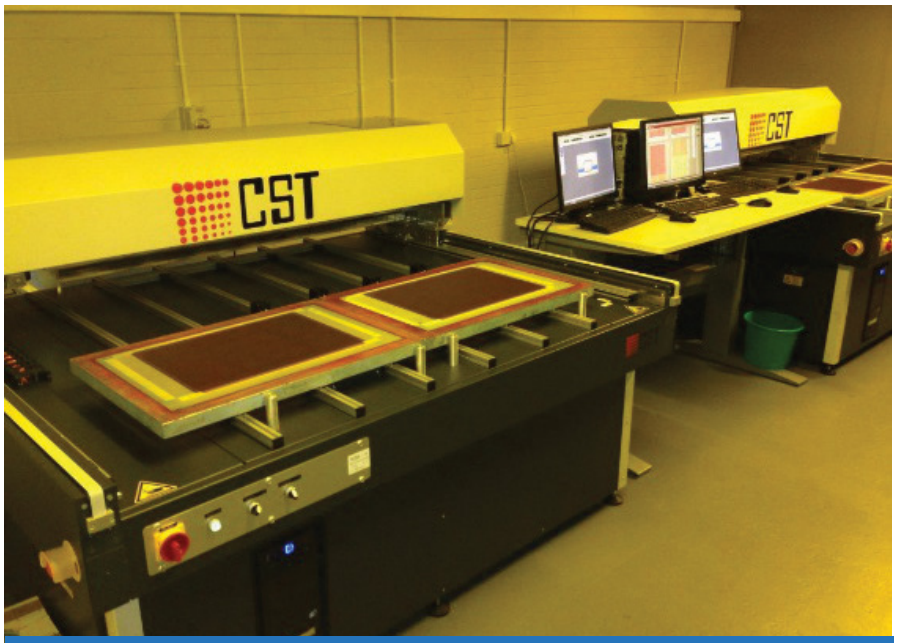

Figure 3: DLE-Eco from CST

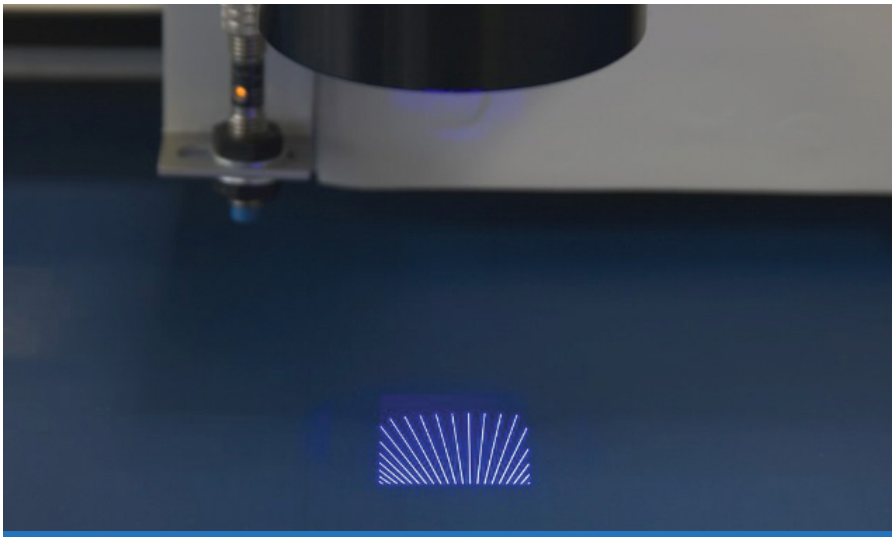

Figure 4: DLE-Eco from CST exposing stencil

A big benefit of these computer-to-screen technologies is very precise image placement so that screen setup time, and thus press down time, is dramatically reduced when used with on-press registration systems.

Figure 5: LED lamp Saati Pro-Lite 450

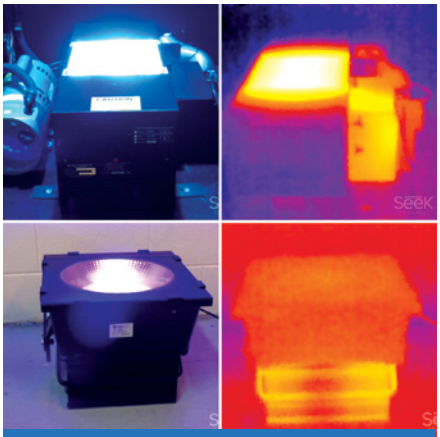

Figure 6. Comparison of light and heat output. 5kW metal halide (top) and LED Saati Pro-Lite 450 (bottom).

Both of these approaches require a very fast-exposing stencil material to maximize productivity, and photopolymer emulsions are the only viable option because two-part emulsions are way too slow. A big benefit of these computer-to-screen technologies is very precise image placement so that screen setup time. Thus press down time is dramatically reduced when used with on-press registration systems.

This combination of no mixing, long shelf life, easy coating and fast exposure makes photopolymer emulsions extremely versatile and easy to use. In terms of exposure, they typically react four to eight times faster than two-part emulsions. This also allows practical use of low wattage LED exposure systems instead of high power metal halide lamps. LED systems consume only a few hundred watts instead of several kilowatts. They also run cool and do not cause heat to build up in enclosed rooms, nor do they warm up the exposure frame so that screens stick to films or glass. Figure 5 shows an example of an LED exposure system that is suitable for use with high-speed photopolymer emulsion. Figure 6 shows a comparison of metal halide lamp with LED in both infrared and visible light. The lack of heat from LED makes it invisible at infrared wavelengths.

Table 1 summarizes the basic properties of all emulsion types available that could theoretically be used with water-based inks and allows a comparison to be made.

Preparation and Exposure

The recipe for highly durable screens to withstand long runs with water-based inks also includes a step for proper mesh preparation, prior to emulsion coating. The use of a mesh prep and degreaser not only cleans the polyester threads, but also primes the mesh surface to accept the emulsion coating. The benefit of correct mesh preparation is better adhesion and wider exposure latitude.

Optimum exposure of the screen is also very important. Underexposure that can be tolerated when printing plastisol will not work when making stencils for printing water-based inks. It is important to always ensure 100 percent curing of the emulsion in order to make a durable stencil. There are various ways of measuring and determining exposure time, but the quickest and easiest is to use a 21-step exposure guide. This test strip is exposed, then developed to reveal a number of steps cured into the stencil. Target is to retain seven solid steps on the screen. This indicates that the stencil is fully cured and can withstand attack by these aggressive inks. This exposure test is illustrated in Figure 7.

After developing and drying the stencil, it is recommended that unwanted open areas of mesh be blocked out with the same emulsion. The same goes for touch up to repair any pinholes formed during image exposure caused by scratches or debris that's trapped on films or glass. The last step is a post exposure to harden the freshly applied emulsion and seal the screen. An added benefit of this post-exposure process is that further hardening and crosslinking of the photopolymer emulsion stencil is possible.

Post-exposure should also be used to toughen photopolymer emulsion screens for long-run printing as an alternative to using chemical hardeners. The post-exposure process does not affect reclaiming ability. In fact, it makes it easier because the stencil is fully hardened and less likely to be 'locked in' by attack from solvent-based screen openers, press wipe or ink removers that are used during first step of screen reclaiming process.

Table 1: Comparison of emulsion properties for use with water-based inks

EMULSION TYPE	SHELF LIFE (MIXED)	EXPOSURE SPEED	WATER RESISTANT	SOLVENT RESISTANT	WORKS WITH HSA AND DISCHARGE INKS?	STENCIL HARDENER REQUIRED?	RECLAIMING
2-PART DIAZO WR	1-4 WEEKS	SLOW	YES	NO	POOR	YES	POOR
2-PART DUAL-CURE	1-4 WEEKS	SLOW	SOME RESISTANCE	YES	ONLY WITH HARDENER	YES	POOR
PHOTOPOLYMER FOR TEXTILE PRINTING	1 YEAR +	FAST	YES	NO	POOR	NO, POST EXPOSE	FAIR
PHOTOPOLYMER FOR GRAPHIC PRINTING	1 YEAR +	MEDIUM	SOME RESISTANCE	YES	FAIR	NO, POST EXPOSE	EASY
HYBRID PHOTOPOLYMER	1 YEAR +	FAST	YES	YES	YES	NO, POST EXPOSE	EASY

Make Way for Water

Water-based inks today have advanced properties that enable them to be used for just about any application where plastisol is not desired. Emulsion technology has also been advanced, and now hybrid photopolymer emulsions enable the production of high-quality, durable and reclaimable stencils that work well with these new inks. With this, an added benefit is that apparel printers who are looking for maximum productivity can now use new exposure technology.

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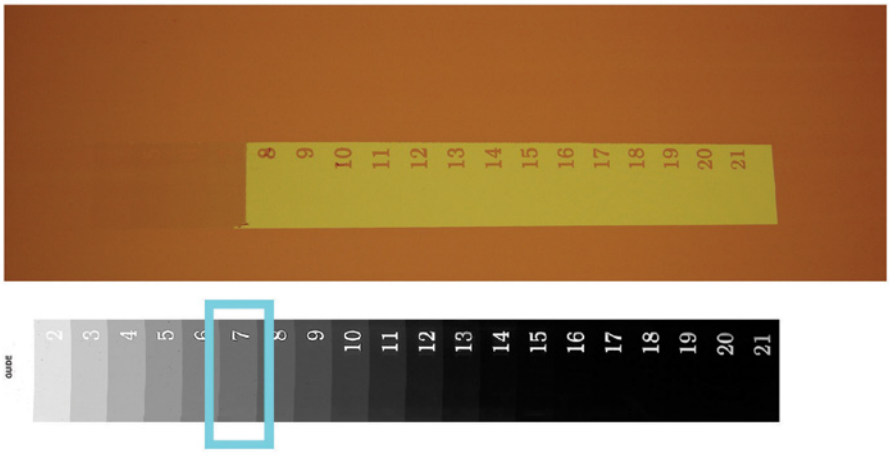

Figure 7: Properly exposed stencil (step 7) shown with 21-step exposure guide.