Computer-to-Screen & Film Technologies for Screen Printing

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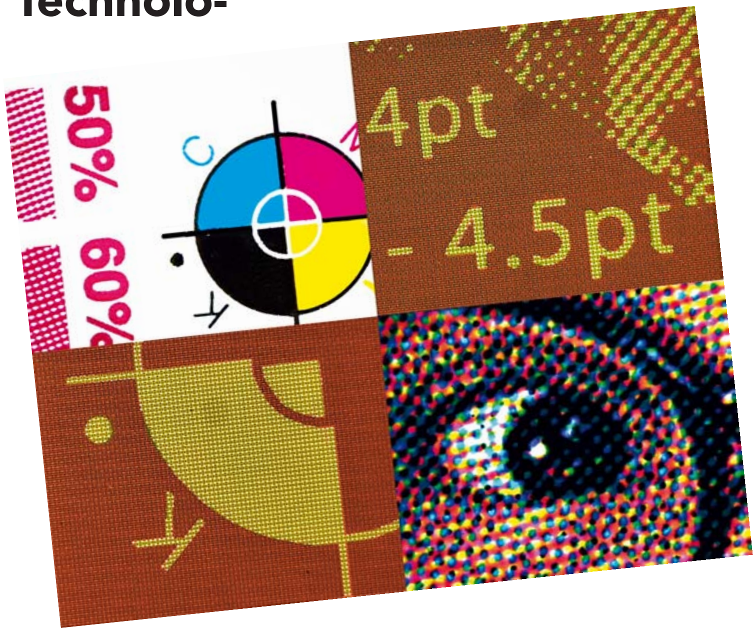

There are several technology choices for generating film positives or imaging stencils for screen printing, but choosing which to use can be an overwhelming task. Presented here are the major technologies currently used, how they operate and additional specifications.

Research and development in new technologies is growing as screen printing continues to compete with alternative imaging technologies. As the technologies continue to advance and payback times become shorter, many screen printers are integrating some type of digital device to generate films and image screens.

Film Positives

Before discussing film positives, there are a few metrics and terms you should be familiar with before shopping for a solution. To allow for optimum exposure, film positives must have enough density to block light in the image area that will be printed. However, they must be clear enough in non-image areas to allow light to pass and fully expose the emulsion. The terms used for these metrics are called D-max and D-min, respectively, and are obtained using a transmission densitometer, which measures the amount of light passing through the film.

Higher D-max measurements indicate greater opacity to light. So, a D-max of 4.50 has a greater ability to block light than a D-max of 4.00. The minimum D-max value recommended for screen printing purposes is 3.5 D. However, lower values may provide suitable results for non-critical work or short production runs. If the D-max value falls below 3.0 D, light will pass through and prematurely expose the emulsion in areas that were not intended. Some technologies used to generate films, such as film imagesetters, can achieve a D-max of 6.0 D. (See Figure 1, page 14)

The D-min value tells us how well the film allows light to pass through the clear areas, and is dependent on the base film material, processing procedures and the technology used. Acceptable D-min values for screen printing are usually below .05 D. Higher values will ultimately block light in clear areas of the film and may cause premature stencil breakdown, pinholes and other related problems associated with underexposed stencils. The difference between the D-min and D-max values is referred to as the dynamic range of the positive. Good film positives have high dynamic range values, with a low number for transparency (D-min) and a high number for opacity (D-max).

Another important metric to consider when choosing a device is its resolution, usually expressed as dots per inch (dpi). This standard of measurement indicates the addressable resolution of an output device or printer. It properly refers to the spots of light or energy used by imagesetters and digital-direct exposure systems; or dots of ink or toner used by an inkjet or laser printer, to output your text and graphics. So, a 600-dpi-by-600-dpi device is capable of imaging 600 dots horizontally and 600 dots vertically in one square inch. The ability to reproduce fine detail diminishes as dpi values become smaller. Additionally for many devices, imaging speeds fall as resolution increases. The importance of a focused inkjet dot or light spot is a considerable factor in producing a stencil image with a crisp edge. This is especially true with newer technologies that use light to image a screen.

A raster image processor (RIP) is another consideration when shopping for a technology solution. A RIP is a software application that is used to convert the information contained in your image to the format required by the optical or print engine in a device. Not all devices require

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While **advancements** in digital technology seem to make **film positives** an antiquated choice, many **screen printers** still find comfort and **value** in using films.

Figure 1: As litho continues converting to Computer to Plate (CtP), look for imagesetter availability to increase making them an attractive option for many screen printers requiring the finest

Figure 2: The Xante Screen-Writer 4 is a popular choice among laser printers.

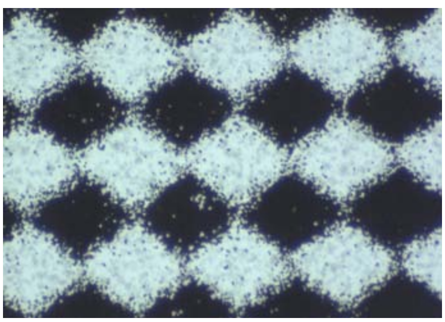

Figure 3: A close-up of a 65 lpi, 50% dot imaged with a PostScript laser printer.

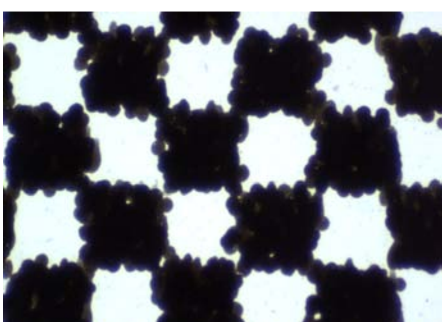

Figure 4: A close-up of a 65 lpi, 50% dot printed with an Epson 4800 inkjet printer.

a RIP, and actually can print halftones to some degree. However, if you regularly print halftone or fine-detailed images, a RIP is almost a must. They provide the necessary features and controls in order to achieve optimum results.

Film Positive Technology Choices

Film positives are a popular, economical and proven choice for the screen printer that offers the largest equipment range — from economical to high-end. While advancements in digital technology seem to make film positives an antiquated choice, many screen printers still find comfort and value in using films. Printer prices have fallen to a level that is both economical and inviting. However, consumable costs for film, ink, toner, necessary chemicals and RIP software are factors when considering film as a choice.

The first masking film introduced to the graphic arts industry was called Rubylith® and invented by Ulano Corp. Masking film is a knife-cut film (usually red or yellow) that is coated onto a clear, polyester backing material. It can be hand-cut but is now more commonly cut by a computer plotter device. While hand-cut stencils were replaced with digital pre-press, computer plotters can still quickly and easily cut text and solid color areas.

Unfortunately, masking films do not allow for the reproduction of fine halftones, and the additional cost to remove the excess material (weeding) can be labor intensive, time consuming and costly. Masking films cost about $2.40 per square meter (24 cents per square foot), making them the most economical choice among the family of films. Cutting can be done with a plotter device, which is commonly used for cutting vinyl letters in the sign industry. These are also economical devices with prices for a 66-cm (26-inch) wide plotter at approximately $2,600.

Laser printers are an entry-level, economical choice for generating film positives. Current models allow for up to 33-cm-by-89-cm (13-inch-by-35-inch) output onto paper vellum or polyester film. (See Figure 2) A laser printer uses static electricity to generate a printed image. It effectively writes the image to a photoconductive drum by neutralizing the static charge in certain areas. Dry toner then sticks to the charged areas of the drum. The dry toner is fused to the paper as it passes through a pair of heated rollers, essentially melting the toner powder and fusing it to the media. Heat can change the physical dimension of the material being printed, which can be a problem for tight registration on multi-color work. Polyester films impart better dimensional stability but also cost slightly more.

In order to print halftones with a laser printer, you'll need a RIP or a PostScript driver supplied by the manufacturer. The PostScript driver will simulate the halftone settings from your graphics application. However, if you have stringent requirements for halftone work this may not be the best approach.

Laser printers have a maximum resolution of 2400 dpi and can produce a standard page size in a very short time. (See Figure 3) Laser system advantages include its relatively inexpensive costs for consumables (vellum and toner) compared with alternative choices, and the fact that no chemicals are required to produce the film. Unfortunately, they produce a D-max value of roughly 3.5 D, which is considered by some as inadequate for proper stencil making.

Often, if there is heavy coverage, regions of the page can be "starved" of toner, rendering them lighter than they should be. This can be improved by using aerosol sprays — available from many screen suppliers — that enhance the quality of toner-generated positives by moderately increasing the density. Another drawback to laser is the relatively high D-min values (>1.0 D) caused by the foggy nature of the film material in non-image areas.

A new laser printer can be purchased for $2,000 to $4,000, but used printers can be found for much less. If you print halftone images, be sure the printer is PostScript compatible. Laser printers do offer a solution if your customers are more concerned with price than superb prints. However, if you intend to print photorealistic or fine-halftone images greater than 85 lines per inch (lpi), laser printing often won't provide the necessary detail, registration accuracy or film characteristics.

Inkjet printing's popularity has soared as a choice to generate film positives. It is an attractive technology choice because of its low start-up costs, lack of chemical processing and user-friendly software. Inkjet printing provides acceptable resolution for the garment decorator or shop producing low line-count halftones while producing the necessary densities (D-max 4.6 and D-min .07) with the aid of RIP software. (See Figure 4)

Without a RIP, inkjet printers simply will not produce the required density. Inkjet printing's disadvantages include: Its film and ink costs; slowness in producing a film piece; inability to produce extremely high-resolution images, compared with a film imagesetter; and potential for excessive ink waste and lost production time, which are caused by issues with the print head. Still, if properly maintained and operated on a frequent basis, inkjet devices offer a viable choice.

Several desktop models, costing several hundred dollars, are available from Epson to print film positives. Epson's R1800 and R2400 each produce 5760 dpi by 1440 dpi and have a maximum print size of 33 cm by 111 cm (13 inches by 44 inches). The Epson 4800 can print up to 43-cm (17-inch) wide, with a maximum resolution of 2880 dpi by 1440 dpi.

If you require films wider than 43 cm (17 inches), there are several wide-format inkjet devices available to meet your screen printing needs. MacDermid Autotype offers its Quadra Aspect systems in three sizes: 137 cm, 162 cm and 188 cm (54 inches, 64 inches and 74 inches). Mimaki offers the JV22-160. Epson 7800 and 9800 devices also can be used for generating films, but require the use of Fourth-party RIP software.

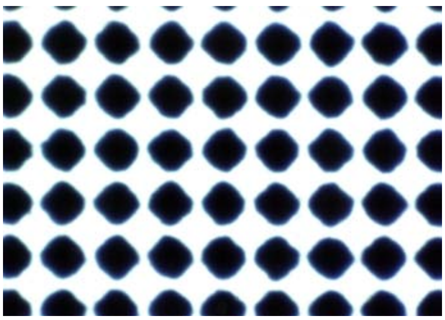

Figure 5: A close-up of 150 lpi, 50% dot imaged with a Linotronic 530 imagesetter.

An imagesetter is a high-resolution device that exposes film to a laser light source. This technology, by far, produces the highest quality films at resolutions ranging from 1200 dpi to 4800 dpi. (See Figure 5) Once imaged, the film must be developed in a separate unit called a processor, which involves chemical use. Films produced with this technology are known for their extreme quality and acutance, which are unmatched compared with other discussed technologies. The offset lithography industry used imagesetters heavily at one time to produce printing plates. A large majority of this industry has now migrated to computer-to-plate (CtP), which eliminates film use and relies on digital technology to image the plate. Therefore, those who prefer using an imagesetter for films can typically find used devices to purchase.

Figure 6: The advantage of a thermal imagesetter is having only one consumable - film. Photo courtesy of OYO Instruments LP.

A thermal imagesetter uses material that has been specially coated with a heat-sensitive substance. (See Figure 6) As the coated film passes over the print head, heating elements activate and cause the film to turn black. The resulting film contains adequate resolution and typically achieves a D-min of .07 and D-max of 4.0. (See Figure 7)

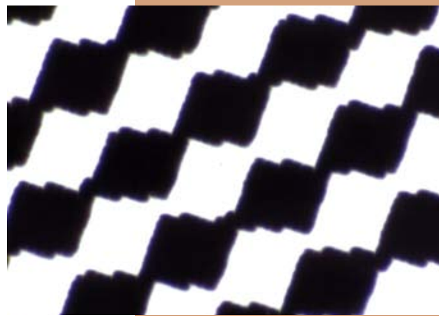

Figure 7: A close-up of a 50 lpi, 50% dot produce with the OYO Thermal Imagesetter.

One of the biggest advantages for using thermal technology is having only one consumable for the printer (film), unlike other systems that use ink, toner and chemicals in addition to film. Plus, the image on the film never runs, smears or smudges, and is weather resistant, which means that water and extreme temperatures do not severely affect these variables compared with other technologies.

Figure 8: The Diablo from OYO Instruments LP is the industry's first computer to screen device using thermal transfer technology.

Additionally, thermal imaging cost is not based on a percent of print coverage like other printing methods. Printing a full black page will be the same cost as a page that has only 5 percent coverage. Thermal devices also render accurate registration in multi-color work. Their only inconvenience is the thermal head's sensitivity and individual nibs that are arranged perpendicular to the media travel direction. If one or more nibs become damaged, the resulting film may show unwanted lines where the material did not receive adequate heat. Damaged nibs are not repairable and, depending on the severity that is apparent in the film, may require the entire head to be replaced.

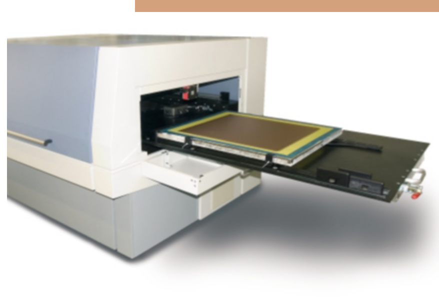

Figure 9: The KIWO ScreenSetter uses Texas Instrument's patented DLP technology.

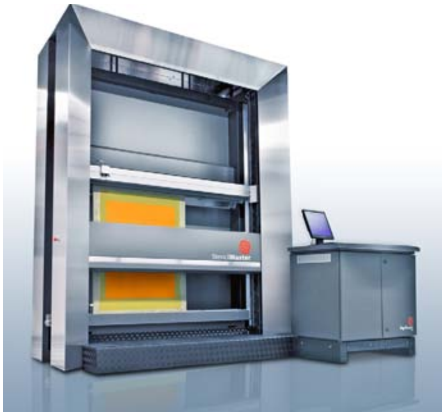

Figure 10: SignTronic Stencil Master. Photo courtesy of Sefar Printing Solutions, Inc.

Figure 11: The K26-S from Werner Kammann Maschinenfabrik GmbH & Co. KG.

Figure 12: Sefar LDS. Photo courtesy of Sefar Printing Solutions, Inc.

Thermal imagesetters are available from OYO Instruments LP in widths from 36 cm to 137 cm (14.25 inches to 54 inches), with prices ranging from $10,000 to $85,000. Film costs for thermal imagesetters average $21 per square meter ($1.95 per square foot).

Direct Projection

Direct projection systems are designed to expose screens by using a camera that projects a small, original film positive onto a coated screen through UV light. These systems can dramatically reduce film costs as they use a smaller film positive, which is projected onto the screen. The film positive is positioned between the condenser lenses, which properly focus the light, and an objective lens that magnifies the image up to 10 times the magnification.

As an example, a 150-cm-by-100-cm (59-inch-by-39-inch) final image size would only require a film size of 30-cm-by-20-cm (11-inch-by-7.87-inch) if using five times (500 percent) the magnification. The film positive used must have sufficient clarity and density with line counts ranging from 233 lpi to 300 lpi. Projection optics are available for 10 times and five times the magnification.

For emulsion choices, manufacturers have developed direct projection emulsions, which have been optimized for direct-projection systems. Exposure times will vary depending on the projector being used. Most manufacturers recommend calculating exposure by using a step-and-repeat exposure test with a test image containing various tonal ranges in order to optimize exposure.

Computer-to-Screen (CtS)

Following in the footsteps of offset lithography, the screen printing industry has seen a dramatic technology shift in its pre-press department with the advancement and acceptability of CtS devices. One of the biggest advantages in using a CtS system is the use, storage and potential for film loss or damage is eliminated, reducing the overall cost of making a screen.

CtS systems are also accurate and repeatable. Because the artwork is imaged directly to the coated screen, a vacuum blanket is not required during exposure, which removes any possibility of film distortion. Since there is no film, exposure time decreases and the amounts of light scatter and stencil undercutting are greatly reduced. Film dust and scratches also aren't a headache for the screen maker.

The four primary imaging technologies used in CtS systems are inkjet, thermal, Digital Light Processing (DLP) and laser. Each has its advantages and disadvantages, but there is not doubt our industry is moving heavily toward CtS in general. What appears to be cutting-edge today will be commonplace tomorrow, as more companies adopt these technological advantages to increase their margins and reduce costs.

Inkjet employs the use of conventional, water-based ink or solid wax, which is jetted directly to a coated screen and exposed. Devices using conventional ink typically utilize Epson print heads, and can reach resolutions of up to 1440 dpi. They are a cost-effective alternative to solid wax systems, which have slightly higher consumable costs. Since the ink is water-based, environmental conditions play a crucial role as day-to-day fluctuations in humidity can make repeatability a bit more challenging. On the upside, print head replacement in water-based systems is relatively inexpensive when compared with wax. Those prices range from a few hundred dollars to $1,000 or more.

Solid wax systems have a maximum resolution of 1300 dpi and employ the use of water-soluble wax tablets, which are heated in the CtS device. The molten wax is jetted onto a coated screen where it solidifies, producing great detail at densities at or above 4.5 D-max. Imaging speed will vary based on the selected resolution and number of nozzles in the print head, but printing speeds of 1-square-meter (10.75-square-feet) in a few minutes are not uncommon.

One of the biggest disadvantages in using a wax system is the cost to replace the print head. Prices can be as high as $5,000 per print head, which, depending on the use and maintenance, could mean an annual replacement. The cost of the wax used in these systems should also be taken into consideration.

Inkjet CtS system prices range from $75,000 to more than $300,000, depending on the frame size, print head configuration and consumables used with the system. If these figures send a shock through your spine, consider how much your company spends on film each year; an inkjet system may pay for itself in a very short time.

Several hundred early adopters of these systems have converted from traditional film — with costs of about $10 per square meter ($1 per square foot) — to inkjet, and are now spending as little as 5 cents per screen in consumables. Inkjet devices are offered by CST GmbH (Colour Scanner Technology), Lüscher AG, KIWO Inc., Richmond Graphic Products Inc. and PlanetB Technologies Inc.

Thermal CtS systems are relatively new to the industry and utilize similar technology that is used in the thermal imagesetter. (See Figure 8, Page 15) The Diablo (MSRP $45,000), offered by OYO Instruments LP, applies the image to a conventionally coated screen, using thermal transfer technology whereby a ribbon coated with a masking material passes over the thermal head. When the heating elements in the print head activate, the water-soluble masking material is transferred from the ribbon to the coated screen.

The ribbon cost is around $7 per square meter (65 cents per square foot). The Diablo utilizes OYO's patented 45.72-cm (18-inch) wide, 1200-dpi thermal print head, which can image at a speed of 38 linear cm (15 linear inches) per minute. It reaches a maximum image size of 45 cm by 76 cm (18 inches by 30 inches) on screen sizes up to 63.5 cm by 91 cm (25 inches by 36 inches). OYO plans to incorporate its larger 91-cm (36-inch) and 137-cm (54-inch) heads in future versions of the Diablo to meet the demands of large-format printing.

Digital Direct Exposure Systems

Since screen printing has been under attack from alternative printing technologies (offset, digital inkjet, etc.), companies are eager to find ways of reducing overhead and consumable costs to stay competitive. Digital direct exposure systems may be the answer. These systems have no consumable usage such as film, ink or processing chemicals. Instead, they work by directly exposing a coated screen using light. Once exposed, the screen can be developed with water, as usual.

Digital Light Processing (DLP) systems are based on an optical semiconductor chip called a Digital Micromirror Device (DMD), which was developed by Texas Instruments in 1987. The DMD chip is covered with nearly 1 million tiny hinged mirrors, which can be quickly repositioned to reflect light to the emulsion. The chip reflects light emitted from a UV-exposure lamp to expose the image on a coated screen.

Thus, the screen is directly exposed with the reflected light from the chip without the use of masking materials such as wax, ink and film. These systems offer greater flexibility regarding acceptable choices in emulsion as compared with laser systems, which have much tighter requirements of the emulsion used. Using a standard emulsion is much easier than with a laser system.

Current models are available from CST GmbH, KIWO Inc. (See Figure 9, Page 15) and SignTronic AG (See Figure 10) with costs starting at $300,000 and resolutions ranging from 720 dpi to 2540 dpi. There are two methods used for controlling image transfer to the screen. The first technique uses a step method that transmits a small section of the entire image onto the screen. Reports from the manufacturer indicate a repeatability of ±2 microns with this method, which equates to very little undesirable overlap in the image. Conversely, scrolling technology synchronizes the data with head movement, and scrolls the image to the head as it traverses across the screen, much like a scrolling LED sign many retail stores use.

DMD technology does have disadvantages worth consideration. DMD devices negatively expose stencil areas. With other systems, the positive is imaged onto the screen or film. With DMD, we are "imaging" the negative space with reflected light in order to expose the screen. This may require additional screen filler or increased processing times to fully expose the stencil material from edge to edge.

Furthermore, a consistent emulsion thickness is an absolute must to guarantee the emulsion is fully hardened. The light sources distance to the stencil surface also is a factor. Even precision-stretched screens do not have flat surfaces, which can cause fluctuation in the distance to the light source while being exposed. Some devices include a head-distance monitor that adjusts the head distance to the frame's mesh plane.

Laser Imaging

The latest technology in CtS systems utilizes one or more finely tuned lasers to expose the emulsion. These are solid diode, Class-3 lasers that emit light at a wavelength of approximately 405 nm at a power of 120 mW. They can image approximately 30 12.7-cm-by-28-cm (5-inch-by-11-inch) images per hour, at resolutions ranging from 850 dpi to 2400 dpi. The laser is rated to last at least 7,000 hours before needing replacement.

These systems are targeted to companies using small-format screen printing stencils, such as those used in CD/DVD manufacturing, labels, containers, tubes, bottles and other three-dimensional objects. Current offerings include the K26-S (See Figure 11) from Werner Kammann Maschinenfabrik GmbH & Co. KG and the Sefar LDS from Sefar Printing Solutions Inc. (See Figure 12) Current MSRP prices amount to several hundred thousand dollars for these devices, but their quality is certainly a head-turner. (See Figure 13)

As we have covered, advantages in the laser system include the cost elimination

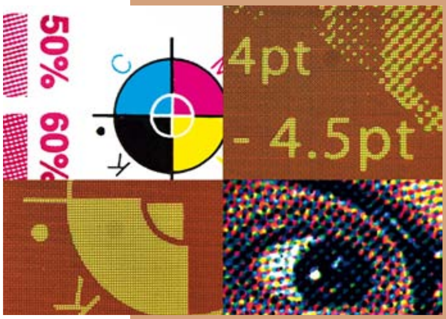

Figure 13: Stencil and print results from the Sefar LDS. Photo courtesy of Sefar Printing Solutions, Inc.

of generating films as well as handling and storage issues. However, one drawback to these systems is the somewhat stringent emulsion requirements for their use. The technology is most attractive to those who usually print the same substrate with the same ink on a daily basis.

CD and DVD manufacturers are prime candidates because of the consistency of the materials used. On the other hand, a commercial screen printer who may print several dozen substrates using several ink systems would find it difficult to incorporate a laser system. However, if this technology is to be a part of our industry's future, this issue will most definitely be addressed by manufacturers.

Conclusion

There are many considerations when choosing a system to generate films or image screens. Obviously, consumables and the initial cost are the most important. However, it's important to factor the time and labor savings each system offers. A higher initial cost may be quickly offset by the accuracy and repeatability the system offers, not to mention the improvements in workflow and savings in consumables. Suffice it to say, the future holds new and exciting developments for the screen printer. Advancements in digital technology will obviously continue, and can only benefit the screen printer's needs.