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Screen Printing

Controlling Off-Contact

Of the many press variables in the screen printing process, off-contact is one of the most important to standardize and control. Print quality and registration problems can, in many cases, be traced to off-contact or some other variable poorly set-up on press to compensate for inappropriate off-contact.

Control requires a good understanding of the variable you want to control, and how it affects your print results. Next, a method of measurement must be available; and third, sound practices and standards must be implemented. This article will deal with each of these issues to help you print better, faster, and more consistently.

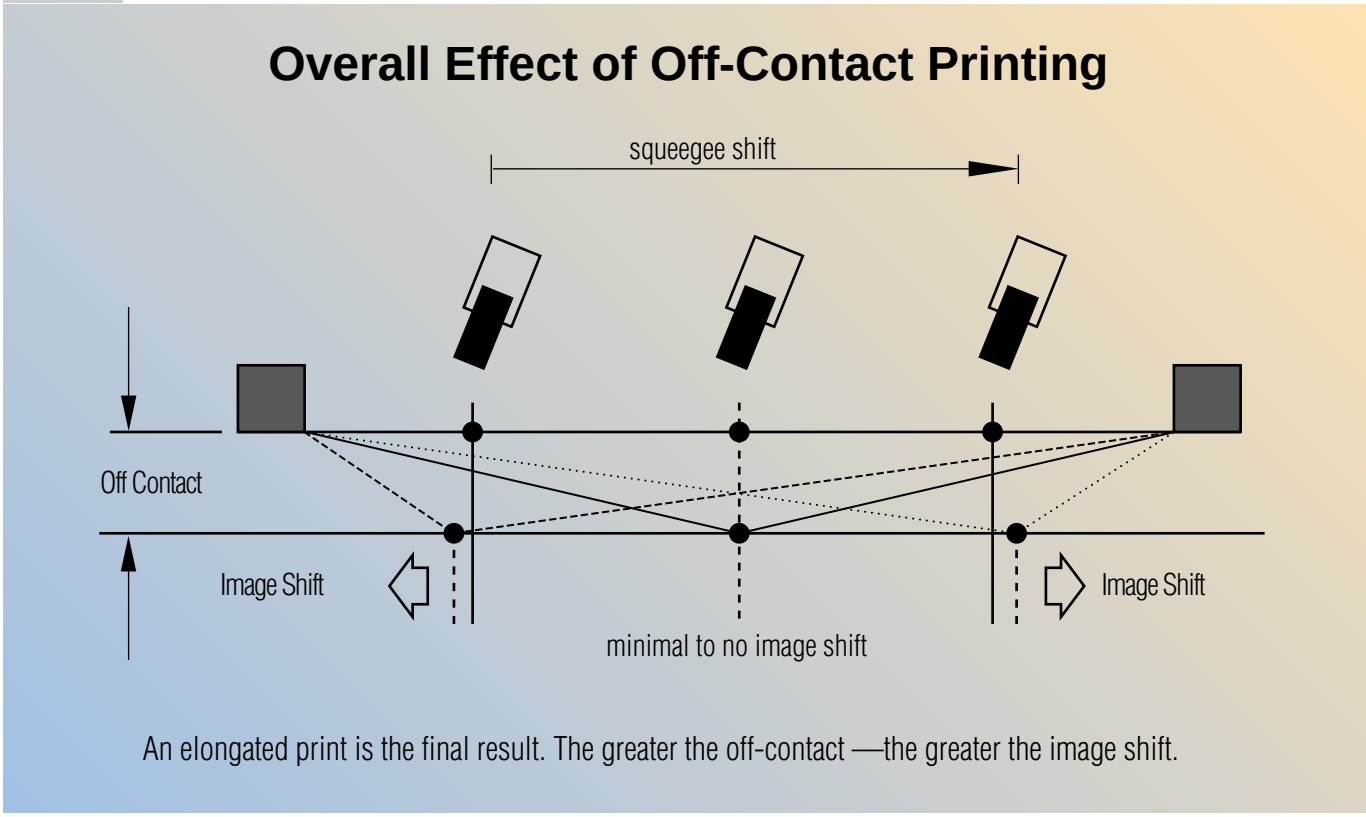
What Is Off-Contact?

Off-contact distance, also called snap-off distance, is the small distance between the bottom of the screen and the substrate being printed. This small space is necessary during printing to keep the screen from adhering to the substrate. Adhesion can cause severe separation problems that damage print quality. Off-contact distance eliminates this problem by allowing the mesh to come in contact with the substrate only at the squeegee edge during the print stroke. Once the squeegee passes the area, there is a zone of peel where the mesh and substrate separate, leaving a crisp print behind.

It is important to clearly define peel-off, as well. Some presses have this option — and it is different from off-contact.

Peel-off refers to a separate upward movement of the frame that happens gradually during the print stroke. It starts at the end where the stroke is started, and only occurs when the squeegee is in motion during the printing cycle.

FIGURE 1



Registration Shift with Off-contact

As the name implies, it helps with the separation (or peel) of the mesh from the substrate. If the press is set to operate this way, the peel distance changes during the print stroke… in addition to the off-contact distance.

Off-contact distances range from "near contact" to as much as 3/8 or 1/2 inch (9.5 to 12.7 mm) in some instances; but ranges from 1/16 to 1/8 inch (1.5 to 3.0 mm) are more common and acceptable. Excessive off-contacts will cause a number of problems in print quality and registration. In most situations, the best off-contact is the *lowest* off-contact distance possible. When printing products with tight tolerances, the allowable amount of screen distortion will dictate the off-contact distance. In electronics printing, stainless steel mesh is often used making it possible to use very low off-contact distances — like 6–8 mils (0.1 to 0.2 mm).

Why Measure Off-Contact?

Whether you are printing graphic or textile products, off-contact is one of the critical press parameters that deserves attention. Incorrect or inconsistent off-contact distances can cause myriad problems that end up costing you money.

We've touched on some of these problems before, but they warrant a closer look.

Registration

In multi color and four-color process printing, registration must be maintained. Off-contact plays a vital role in consistent print registration. By definition, it is understood that off-contact printing cannot produce a true 1:1 reproduction of the original image. This is due to the deflection and elasticity of the fabric during the print stroke. The higher the off-contact the more the squeegee elongates the mesh *(Figure 1)*, resulting in a displacement of the image on the substrate. Peel-off further compounds this problem. To minimize this distortion, the lowest possible off-contact distance should be used. Recommended off-contact is 1/16" (1.5 mm) for tight tolerance printing, but no more than 1/8" (3.0 mm).

As off-contact distance increases, several things happen. First, the squeegee pressure must be progressively increased to create contact between the mesh and substrate for ink transfer. The extra force exerted on the screen is magnified at the edges of the squeegee blade. Longer squeegees, relative to the frame size, will make this effect even more problematic *(Figure 2)*. The result is not only increased image distortion at the edges but poor print quality, as well.

Second, the integrity of the image gets more skewed and elongated. This condition can be attributed partly to the effect just mentioned; but it also will vary with image placement, squeegee length, and stroke direction. The size and locations of these irregularities are not defined and can be difficult to predict and manage.

Substrate shrinkage and expansion can also be a primary part of the problem.

Off-contact uniformity is an issue. If it is not the same front-to-back or side-to-side, registration will be off in a localized area. In such a situation, when the next color is put down, it is highly unlikely to register with the first — no matter what you try. If this registration problem becomes aggravated, the whole job could be lost.

It is worth mentioning that some distortion can be compensated for in the artwork with calculations, often done in electronic printing. In addition, some equipment manufacturers offer an optional compensating feature on certain types of presses to deal with such problems.

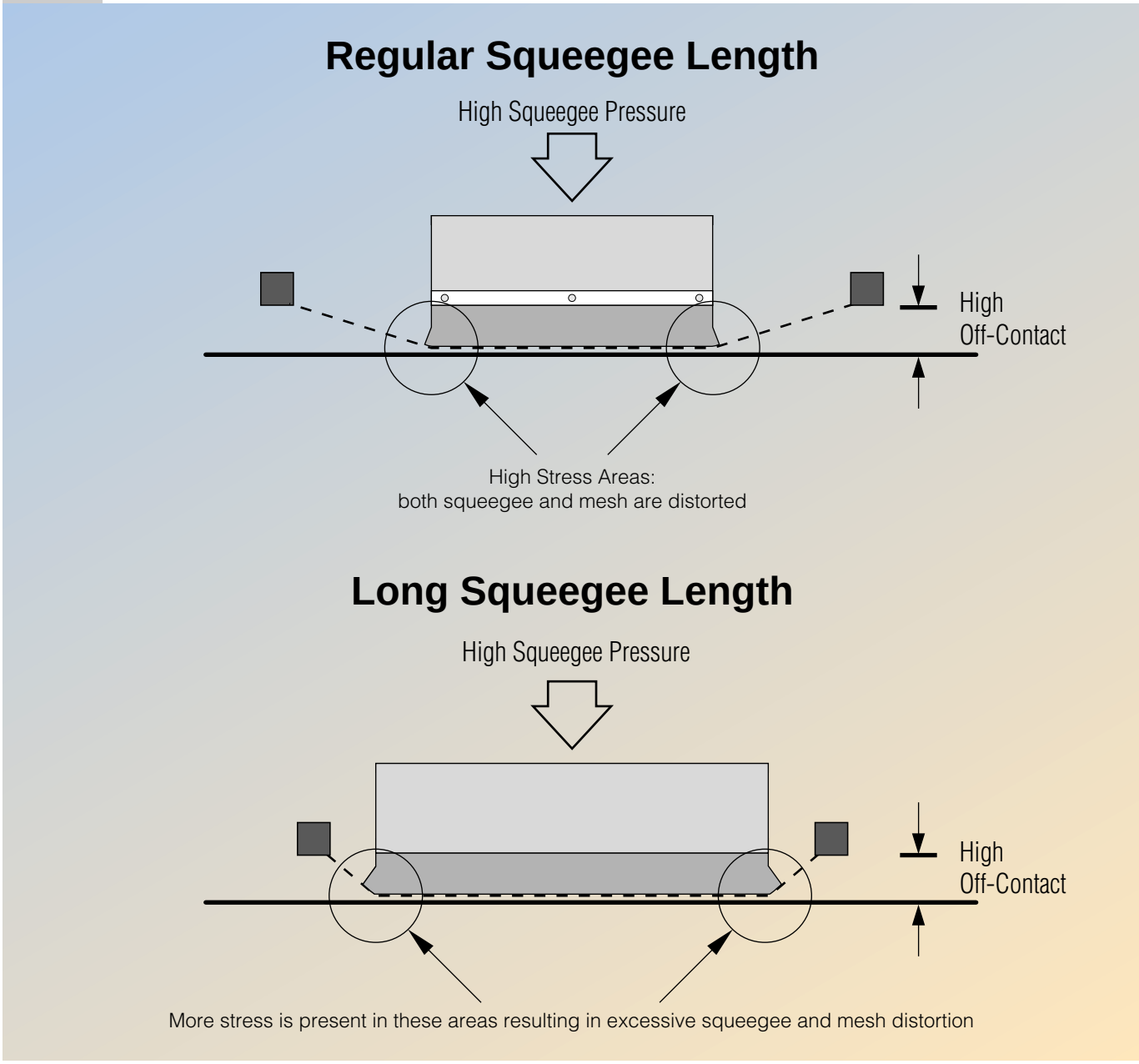
Print Quality

Incorrect off-contact distance can have adverse effects on print quality in that it can require squeegee pressure changes. Examples of problems it can create include: poor reproduction accuracy, smearing, bubbles and voids, double images, ink strings, loss of detail, blocked edges in image, mesh marks and incomplete images.

Several things occur with high off-contact conditions to create these problems. High squeegee pressure must be used to force the screen into contact with the substrate, and these high squeegee pressures push ink to the print side of the screen before printing. Heavy amounts of ink will ruin image detail. Excessive squeegee force will also crush the image, creating smearing and dot gain.

With high off-contact, the screen may snap back too quickly, not allowing ink to fully transfer to the substrate.

FIGURE 2



Effect of Excess Force on Ends of Squeegee

Resulting print defects can be mesh marks, incomplete images, ink strings, bubbles, voids, and blocked edges in image.

Yet another cause of poor image quality results from low tensioned screens printed with low off-contact distances. In this case, the squeegee produces a ripple in the mesh during printing… throwing off registration as well as causing such print quality issues as double images.

Control and standardization are absolutely essential to achieve the excellence customers are now demanding.

Ink Deposit/Color

Ink deposit inconsistencies can develop from several things: (1) Poor parallelism between the screen and the platen. (2) Unbalanced levels of off-contact, squeegee pressure and tension. (3) Squeegee distortion resulting from high off-contact and squeegee pressure causing the edge area of the print to distort and have more ink deposited. Each of these can cause a non-uniform deposit that will show up as unacceptable color variation.

A low off-contact distance will also produce a uniform deposit, whereas a high distance results in an uneven coating from uneven pressure along the squeegee blade. The high pressure at the squeegee ends caused by the upward force of fabric tension creates negative contact pressure in the center of the blade, producing poor deposit uniformity.

Mesh, Stencil, and Squeegee Durability

Screen printing mesh, stencils and squeegees are resilient by nature — and must be — to work in the process. These properties can be overextended and lost with excessive repetitive force, ultimately leading to short life and even breakdown. High off-contact distances necessitate high squeegee pressures, creating such forces. Durability of the mesh, stencil, and squeegee will be compromised under these conditions.

Production Speeds

High off-contact will slow production speeds. Instead of having the squeegee's transfer force directed to printing the ink, it must be used to overcome the screen tension to make contact with the substrate during transfer. Diverting the force in this manner makes for inefficient printing. In the case of manual printing, the operator must exert more force to print… leading to fatigue and work related injuries.

Off-Contact on Textiles

There are some specific issues in textile printing when discussing off-contact. Due to the absorbent nature of textile substrates, off-contact distances are generally lower on textiles than in graphic applications.

Optimum distances are between 1/32" to 1/16" (0.8 mm to 1.6 mm) for tight tolerance work, but again, will be somewhat dependent on screen tension, screen size, and ink being printed. Lower off-contacts on textiles also minimize the ink build up on the bottom of the screens.

Since textiles are printed with multiple platens and print heads, consistency in off-contact between all components is a key to getting good registration and ink deposit (color) uniformity. Textile jobs sometimes call for several types of garments with the same image. The thicknesses of these garments change, so adjustments to off-contact must be made accordingly.

How to Minimize Off-Contact

Screen tension should be the first area improved in the pursuit of lower off-contact distances. Higher tensions on your screens will allow the off-contact to be reduced and printing speeds to be increased. There are, of course, limits on how high operating tensions

FIGURE 3

Mechanical Off-contact Gauge

FIGURE 4

SPTF Electronic Off-contact Gauge

FIGURE 5a

FIGURE 5b

In the zero mode, the instrument measures the substrate (Figure5a), or in the case of a textile situation, the shirt and the neoprene (Figure 5b).

can get, and there are other issues with high tensions that are out of the scope of this article. But the bottom line is that screen tensions should be the maximum level for your capability and printing application.

Keep in mind that larger screens are more difficult to stretch to higher tensions; so consider both screen size and tension when establishing proper off-contact distances. As a general recommendation, a tension between 18-25 N/cm should be selected. Just increasing screen tension levels can still leave some problems unresolved. Tensions must be consistent screen to screen, as well. In fact, such consistency is more important than tension value. Then, not only is registration maintained color to color, but relative printing force also remains the same.

After tension is dealt with, the other area to be looked at is the ink. Some inks are simply tackier than others. Ink tack is a characteristic that results from such factors as ink rheology, ink ingredients, pigment size and load, surface tension and age. Modifying the ink, or finding another ink that prints better, are options for reducing ink tack. Lower ink tack will reduce the needed off-contact distance of a well-tensioned screen.

The geometry of mesh is also an issue in ink transfer capacity. A mesh with lower surface area (for example mesh with 27-31 micron threads) will need less force to separate from the ink and substrate than a mesh with more surface area. The less force that is needed, the lower the off-contact distance can be.

The substrate has a lot of influence on ink transfer and peel, too. Absorbent substrates will have a much easier release than non-porous ones. Textile substrates are very absorbent and have no trouble peeling from the mesh. This is why off-contact distances are smaller for textiles than many graphic applications. Substrate surface tensions, as they relate to the ink surface energy, also will have varying effects on peel. This area will soon be investigated using SPTF's Screen Printing Tack Tester.

Other variables that can influence off-contact include frame size, squeegee length in relation to frame size, image area in relation to frame size, and image type (large spot color areas and reverse images may require more off-contact due to increased surface area in contact with one substrate).

While some of these variables are possible to change, others are not. Any given job has its own unique set of conditions under which it must be printed. It is important to realize that off-contact may have to be adjusted somewhat for each job to compensate for different variables. Success in minimizing these adjustments to an acceptable range will occur as each area of the process is adjusted to produce predictable results through standardizing procedures and testing incoming materials.

Measurement

The potential printing problems we have just examined plead their own case. Control and standardization are absolutely essential to achieve the excellence customers are now demanding.

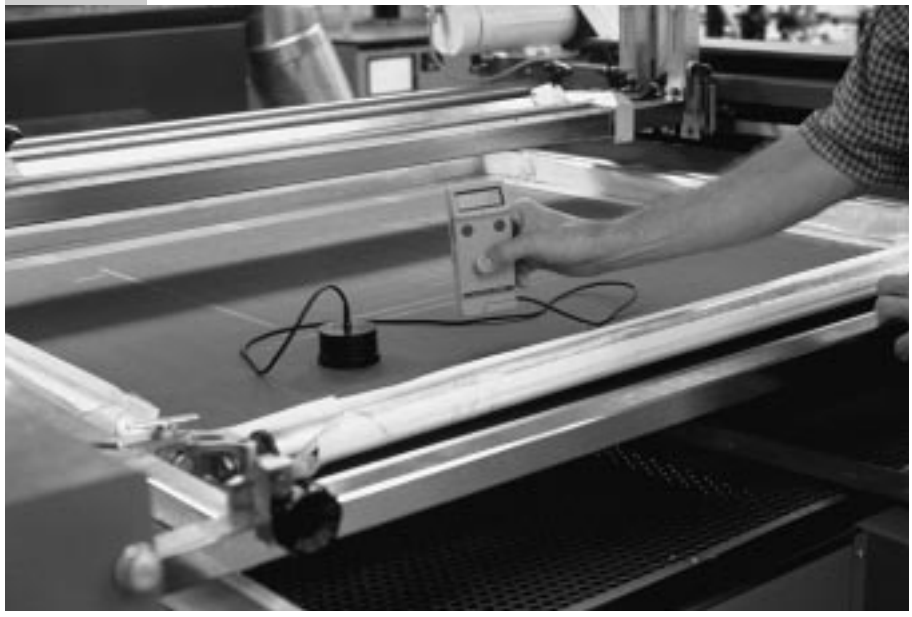
Current Measurement Methods

There are two ways to create and regulate off-contact. Many automatic, and some manual, screen printing presses incorporate some adjustment to vary off-contact distance. The trouble is that many of these adjustments do not have good precision and only the higher end presses actually include a readable gauge. Those presses without a specific feature to set off-contact distance require the operator to shim the screen frame to vary snap-off.

A number of methods and tricks have been used by screen printers to measure and control actual off-contact distance. One of the simplest methods relies on set-up spacers, like washers or quarters. These spacers are placed on the four corners of the platen and the screen moved to just touch each one. Different spacers are used to create various off-contact distances. Calibrated wedges can also be made for this purpose, and provide a greater degree of accuracy and set-up versatility. Another simple method is to use a straight ruler placed against the bottom of the screen frame to visually gauge the distance from it to the top of the platen or vacuum table.

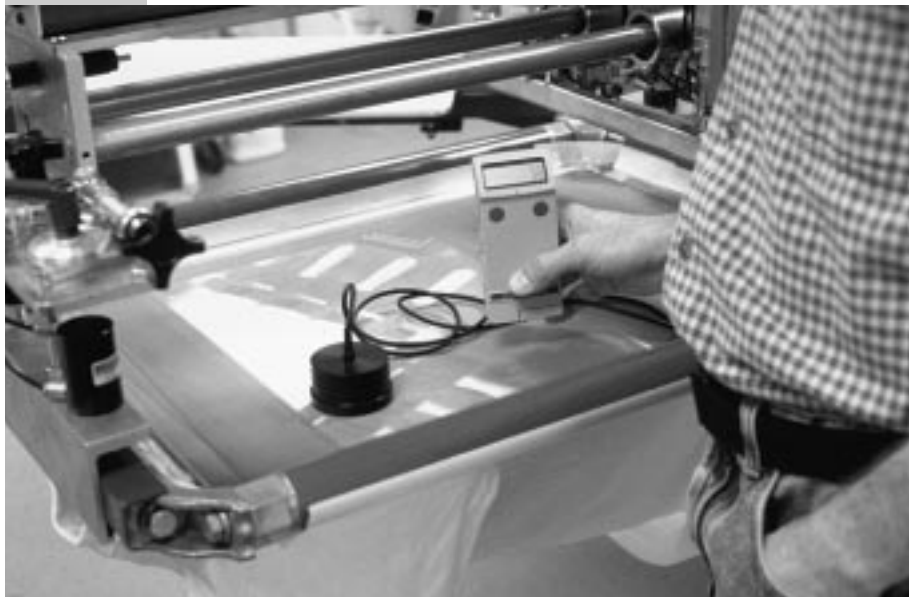
Should you be fortunate enough to have a press with an actual readout to track off-contact distance, this is an obvious method of measurement. However, as stated before, poor precision may be an issue (more on that in the next section). A final option available to the screen printer is a mechanical off-contact gauge suspended over the screen by some means *(Figure 3)*. The gauge is zeroed on the mesh surface, and then depressed until the screen contacts the substrate. The gauge is read at this point, and the mesh/stencil thickness is subtracted to get the actual off-contact distance at that spot. Measurements from this system are fairly accurate and repeatable when used correctly. The downsides to these devices are that the gauge must be reset every reading, and the gauge has limited movement around the screen. It is also somewhat awkward and difficult to use on some presses. Despite these inconveniences, they have been the only stand-alone devices available to the industry up to this point.

FIGURE 6a



Off-contact can then be measured by setting the probe inside the screen (Figures 6a and 6b).

FIGURE 6b



Electronic Off-Contact Gauge

The Screen Printing Technical Foundation (SPTF) has introduced a new concept and device for measuring off-contact more effectively. Instead of measuring mechanically as has been practiced, an electronic gauge *(Figure 4)* has been developed to allow quick and accurate measurements anywhere on the screen. The gauge is easy to use, making it appropriate for the press operator, and readily shows off-contact and level inconsistencies during press set-up.

The new electronic gauge works on a principle of eddy current, and has a customized probe design to accommodate a larger measuring range than many of the currently available electronic thickness gauges. One limitation is that it requires an aluminum platen. In the case of textile presses, an aluminum platen that has a layer of neoprene on top will work as well.

To read off-contact with the SPTF gauge, a substrate is first placed on the vacuum table/platen. In the zero mode, the instrument measures the substrate *(Figure5a)*, or in the case of textiles, the shirt and the neoprene *(Figure 5b)*. This reading is then stored in the device. Off-contact can then be measured by setting the probe inside the screen *(Figures 6a and 6b)*. The instrument takes this reading and subtracts the stored substrate/neoprene thickness to correctly reflect actual off-contact distance (except for the mesh/stencil thickness). The probe

Procedures to Implement

What practices and procedures can you implement to increase your control of off-contact distance? Here are some to get you started.

1. **Set up tension level standards for your plant.** Using LE mesh, higher tensions can be maintained on all screens. This can only be accomplished if standard tensioning procedures using a tensiometer are used and screens are tracked. At the very least, make sure that your screens used for any job all have the same tension.

2. **Check your frames for warpage.** Any irregularities on the screen plane will be reflected in your print.

3. **Re-level your presses.** It will be difficult, if not impossible, to achieve good parallelism in off-contact if the press itself is out of whack.

4. **When working with textile presses, make sure the print surfaces of all the screens and platens are set to the same plane or height** (not to be confused with level). Also be aware that platens warp and bow from the heat of flashing.

5. **Buy an instrument to measure off-contact** on press, and train your press operators to use it correctly.

6. **Design a procedure for setting up off-contact on each press** (it may vary with press type) that is easy and effective. Remember that the gap you need to measure is between the mesh and the top of the substrate. Change substrates, and this distance will change.

7. **Measure off-contact distance in all four corners of a screen** and ensure that all four readings are close to each other. How close they need to be will depend on the difficulty of the printing application. This will ensure front-to-back and side-to-side uniformity, creating a good parallelism between the screen and the print bed.

8. **Do some simple testing** to determine the lower limits of off-contact you can achieve under your printing conditions. Begin to establish a standard off-contact for printing based on the data you gather from testing and production runs. To minimize registration problems, make it a policy that, during a multi color job, the off-contact distance is the last thing to be changed.

9. **Document what you do.** Keep a running record of the off-contact distances used on each job that is printed. An easy way to do this is to keep a chart by each press. Then, look at and use the data. Measurements mean nothing if you do not use the information to learn about your process. Another important place to reference the off-contact is on the actual job or engineering sheet.

10. **Understand that other press variables changed will have an effect on ink transfer as well** and are inter-related to the off-contact distance. A great example of this is squeegee pressure, which ranks with off-contact as one of the variables most often changed on press. While a change in squeegee pressure will not affect off-contact distance, a change in off-contact is likely to require a change in squeegee pressure. This relationship dictates that off-contact be established before final squeegee pressure is set. These two variables are so linked that optimum setting exists for each, in relation to the other, where the quality of the printed product is at its maximum.

can be moved anywhere on the screen easily, and measurements taken instantly.

Testing at SPTF has proven this new device to be very revealing during press set-up. Several presses were measured using the electronic gauge, and readings showed significant differences in front-to-back and side-to-side off-contact that were not evident from the press's off-contact gauge.

In addition, some had such loose adjustment precision that, even when their off-contact gauge indicated the same point as a previous set-up, the actual distance was quite different. Therefore, it is possible that even if a press has an off-contact gauge it may not reflect reality.

SPTF Research on Off-Contact

In the past year SPTF completed a limited study of the relationships of tension, off-contact, and squeegee pressure on ink deposit. Using the powerful technique of experimental design, the experiment raised some interesting questions. Unfortunately, due to its limited nature, few solid conclusions were gained. A more comprehensive study has been designed and may be conducted in the future. It is hoped that the new study will offer a greater understanding of the interactions of these three variables.

A Final Word

It is important to realize that screen printing variables are often extremely inter-related, and that problems with one translates into problems with all of them. For this reason, press problems are often difficult to accurately diagnose and remedy. All the more reason to eliminate the problems before they happen through standardization and control. While this takes time, the payoff of less time-consuming problems on press will more than compensate for the difference.

For more information on SPTF's new electronic off contact gauge, see the ad on page 4 of this *Journal*.

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