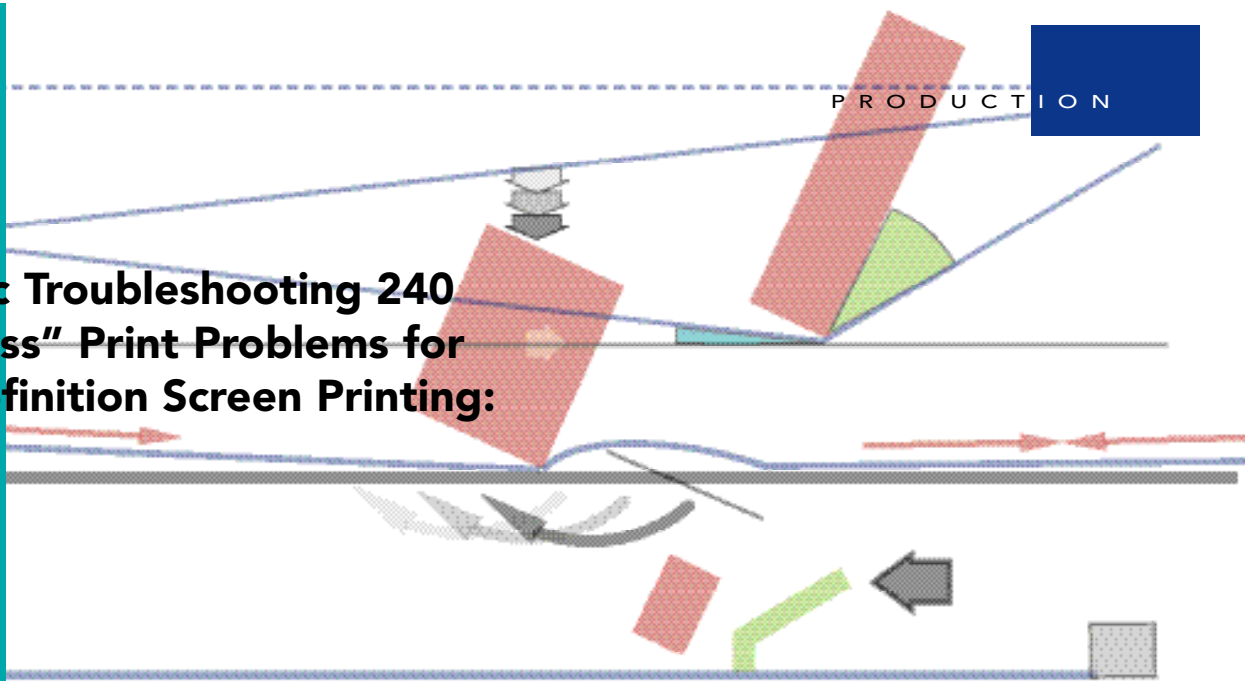




## Dynamic Troubleshooting 240 "On-Press" Print Problems for High-Definition Screen Printing: Part V



**Speed variation** from one **end** of the **image** to the other will correspond **three-dimensionally** to an **uneven deposit**

In Part IV (third quarter 2003), we discussed in detail the negative effects of centering the image with certain (crucial) jobs and issues concerning squeegee/floodcoater length. In this, the final installment in this series, we will review other techniques that make reaching exceptional print performance easier. We'll cover dot banding and the influence of screen tension on print quality, and we'll compare the differences in print finish between a cylinder press and a flatbed and dryer optimization.

### **A Perennial Conflict: Productivity vs. Quality**

They sometimes seem to conflict: Production's ultimate goal to complete jobs and Quality Control and Customer Service's need to maintain in-house quality standard. While production personnel are no less keen on quality, and quality control/customer service personnel are no less anxious to meet customer deadlines, these differing requirements demand the two operations split responsibilities.

Take, for example, how the seemingly harmless action of a squeegee "stroke length" could affect high quality-seeking operations.

In terms of productivity alone, it makes obvious sense to run the squeegee at the

fastest possible speed that produces desired results and at the shortest travel length (distance), thus reducing cycle time and increasing overall output rate. That's great if quality does not suffer.

During crucial jobs, on the other hand, changing stroke length and/or speed could result in reduced quality, particularly when three-dimensional requirements are involved — as is often the case with many industrial/electronic type applications. Varying the squeegee speed effectively changes the amount of ink deposited, which could have an adverse effect with fine line image resolution and overall deposit layer.

How much is affected depends on the chemical nature of the ink, mechanics of the screen, substrate surface and the image itself. A squeegee must start from a standing position (zero point), accelerate (ramp-up), reach its maintained speed (pre-determined speed), decelerate (ramp-down) and then stop, thereby effectively creating three continuous but different speed profiles during the same print stroke. (Figure 1a) As such, speed variation from one end of the image to the other will correspond three-dimensionally to an uneven deposit, potentially posing a problem with fine line work and certain types of jobs requiring controlled coating uniformity.

However, if squeegee travel stroke length were lengthened a little, say just 7–10 centimeters (3–4 inches) beyond either end of the image, clearance would then be enough for ramp-up and ramp-down to take place outside the image area without affecting print integrity or deposit uniformity (Figure 1b), because the squeegee would travel at a constant rate throughout the image. Such benefit further adds credence to adopting a healthy image-to-frame ratio to start with as advocated previously in the series.

While it was not my intent to go any further with this issue, because the solution regarding uniformity clearly speaks for itself, it may nevertheless draw some dissenting views, so a few qualifiers may be justified here. First and foremost, I have personally experienced on many occasions immediate improvements with print definition when squeegee travel distance has been extended — without changing anything else. Second, the sum of ramp-up and ramp-down curve (distance in real terms according to preset travel speed) depends entirely on the squeegee drive system used and the speed setting as well as its direct/indirect mechanical smoothness



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**KEY LIST FOR  
ON-PRESS PROBLEMS**

*Listed in no particular order,  
for each illustration with repetitive  
cause amounts shown.*

Letter Effect	Repeat Qty
a) Causes of image distortion (in all directions)	16
b) Reasons for uneven ink deposit	22
c) Reasons that creates image elongation (in print direction)	15
d) Rationales for causing sporadic mis-registration	3
e) Causes of streaks in squeegee travel direction	15
f) Reasons producing smearing (print beyond desired area)	19
g) Typical causes for tone loss (mono or four-color process)	16
h) Causes for tone gain (not opposing causes of "loss" above)	18
i) Reasons creating ghost images (double-edge appearance)	8
j) Factors creating loss of edge definition (sharpness)	18
k) Reasons for detail loss (parts of image, line, character, etc)	22
l) Banding causes with tonal blends/graduations (vignettes)	7
m) Reasons for streaks/lines, perpendicular to sq travel	7
n) Causes for "image" or "screen-stretch" when die-cutting	6
o) Factors for productivity loss with static	3
p) Causes of pinholes and fish-eyes	7
q) Rational creating moiré	1
r) Reasons for orange-peel	5
s) Typical causes for ink spread	12
t) Reasons for saw-tooth	8
u) Reasons that causes voids	12

(non-jerking, non-vibrating, etc). Actual acceleration/de-acceleration curve as illustrated could be considered "normal," but there are some sophisticated drives that pack a very short ramp-up and almost no distance for ramp-down to stop — yet extremely smooth without further inertia. Conversely though, there are drives used that are very sluggish (not readily seen by an untrained eye) while some work on an inverted 'V' principle. The latter basically means travel does not adopt a "maintain speed" line as shown in red in Figure 1b. Here, the squeegee literally ramps up steadily to maximum set speed to the midway point in the screen then, similarly, ramps down to a stop at the other end of the print stroke, thereby forming the inverted 'V' curve. Great for smoothness — absolutely hopeless for coating uniformity!

**Affecting Uniform Coating**  
*"Zero-Peel Flood" Allows for Uniform Pre-Fill of the Screen*

Simply put, "zero-peel" flood automatically parallels the screen immediately as the squeegee stroke finishes — well before flooding starts. This operation, a fairly recent technique adopted by equipment manufacturers, is rather interesting because while a number of knowledgeable press operators are fully aware that screen printing tends to deposit more ink at one end than the other — many are at a loss as to the general cause. While discrepancies are naturally more noticeable with larger print sizes (as many frustrated multi-sheet/billboard printers will attest) the results from uneven ink deposits can also present a problem with small format sizes that involve three-dimensional requirements.

You may recall that in Part IV, we discovered that while the flood coater returns ink back in readiness to start the next print cycle, its real purpose in life is essentially to pre-fill the screen with the correct amount of ink.

Most sophisticated flatbed presses are fitted with a peel-off device that lifts the screen incrementally during the print stroke to improve separation between mesh and substrate. The screen peels from the same end where the print stroke begins (Figure 2a). With many presses, particularly older models, however, the screen does not go back to the parallel position until the flood coater returns fully to its own original position, meaning —peel-off gradually deacti-

vates during the flood stroke (Figure 2b).

With the majority of operations, flooding while peel-off is deactivating should not pose a problem (except perhaps for those specializing in large format or critically demanding work). The problem, however, is that peel-off functioning in this way pre-fills the screen with more ink at the beginning of flooding than at the end. Because of the extra upward force the screen exerts on the flood blade at the beginning of the flood stroke in addition to profile angles that may exaggerate the problem, the squeegee will try to deposit more ink, albeit, at the innocent-but-guilty end. "Zero-peel" flood combats this problem by allowing the flood coater to pre-fill the screen uniformly while it is completely level throughout the flood stroke.

*Off-Contact Contributes to Print Success*

Another cause of printing more ink at one end is none other than high off-contact; an issue that has been discussed several times throughout this series. While a discussion of imbalance between the ink and the coating deposit is inherently complex, we'll review it as briefly and simply as possible here (Figure 3a)

The first concern in this respect is the "squeegee-to-fabric" angle at the beginning of the print stroke (not to be confused with the "squeegee-to-table" angle). While the preset mechanical angle stays fixed to the print table, the physical true print angle (flex at squeegee tip) increases, and the actual squeegee-to-fabric angle (shown in green) continuously decreases towards the end of the print stroke. Because a greater push-through force has been created by the fabric aggressively deflecting more tightly to the blade, more ink is transferred towards the end of the stroke

Observe at the start the relatively large "fabric-to-table" separation angle behind the squeegee (shown in blue) to that at the end of the print stroke. At the beginning of the print stroke, ink deposits are difficult because the fabric's upward force lifts off some of the ink that's already been transferred. Then, additional ink gets deposited at the other end of the print stroke because of sluggishness in the screen separation behind the squeegee.

Not illustrated here in Figure 3a is the squeegee's tendency to create more print angle at its tip towards the end of the stroke, when the screen is being lifted (ef-

fectively increasing off-contact continuously – which is precisely what the peel-off function is supposed to do).

Operators are acutely aware this happens. They often find an incomplete impression at the start of print while the screen quickly snaps upwards after it has remained in contact with the substrate well after the squeegee has finished its stroke. Even if poor screen separation does not deposit more ink, image integrity is nevertheless compromised. The wet printed image is pulled along by the fabric, then suddenly, a large area of the screen snaps back up at cycle's end — thereby leaving mesh-like marks on the print surface.

While not perfect by any means, just reducing off-contact helps to equalize both “print” and “separation” angles to more acceptable levels (Figure 3b). Although certain facts and techniques discussed throughout this series have been frequently revisited for good reasons, once again, the need to reduce off-contact (which is directly related to employing good tension levels) is often seen as

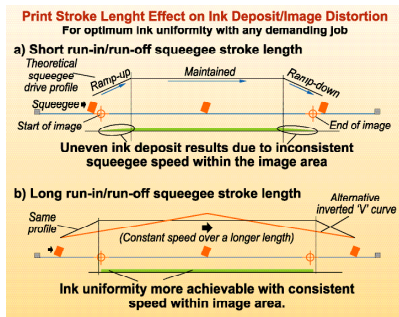


Figure 1: Affects a, b, c, f, g, h, j & k

a major key to success in many aspects of quality screen printing.

### Results are What Matters: Cylinders vs. Flatbeds

The subject of printing more ink at one end brings up the old argument about cylinder presses vs. flatbeds. Which does a better job print-wise? Is there a difference in the print finish? Yes there is — but how much of a difference? Everything depends entirely on skill level, techniques and processing abilities employed. However, the fact of the matter is the cylinder press, purely by default, produces a superior result overall on a one-to-one basis.

Nevertheless, on many occasions I have witnessed the same job being printed on flatbeds and cylinders — and found superior results from the flatbed prints.

This discrepancy could relate to varying skills of the operators of both types of press. Plus, when jobs contain crucial demands, flatbeds may offer an “upper hand,” because they allow for larger screens and therefore can usually have the frame ratio-to-image increased. Because frame size is usually fixed for cylinders, that increase is not a normal consideration for them.

Despite all this, it is still easy to see why cylinders have the formidable prowess to produce superior prints with less distortion and with greater coating uniformity than their flatbed cousins. We hear it frequently from production managers, “The cylinders did a fantastic job — could not have done it on my flatbeds.” The basic reason is the flatbeds have a large variation of squeegee-to-fabric and separation angles (Figures 3 and 4a) while corresponding angles with cylinders are more or less consistent throughout the print stroke (Figure 4b). That said, remember what was qualified

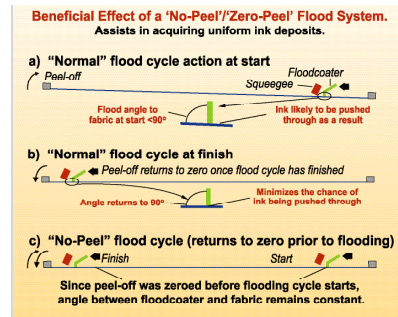


Figure 2: Affects b, g & h

previously: Comparison is based on a “one-to-one” (according to the natural mechanical working aspect of both printing systems) exclusive of screen processing skills and techniques applied. All being equal, cylinders win hands down!

### Take Dot Banding Off the Nightmare List

When dot or tone graduations (also known as blends or vignettes) bunch together instead of decreasing smoothly in size visually, the result is known as “banding” (Figure 5). This seems to be an increasing problem for many operations, grouped by two entirely different types of businesses: those specializing in process work (usually experienced) and those specializing in industrial applications (usually inexperienced).

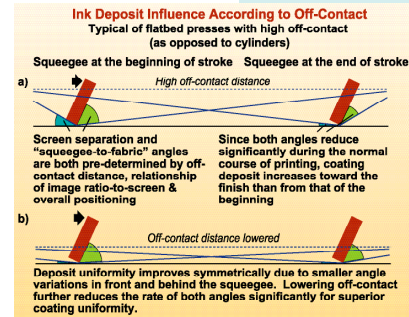
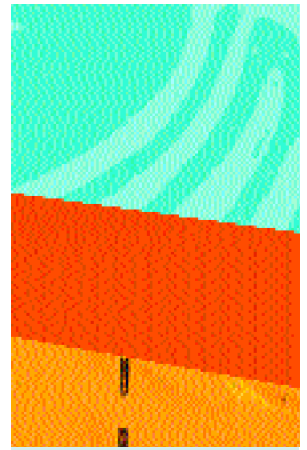


Figure 3: Affects b, g & h

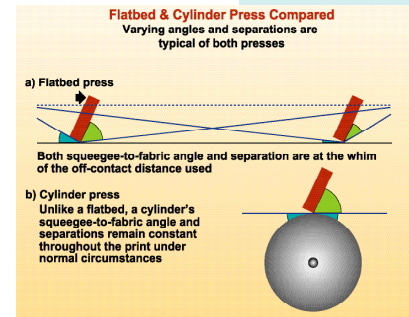


Figure 4: Affects b, g & h

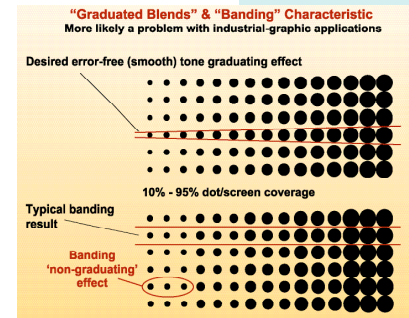


Figure 5

## At least 50 percent of screen printing operations are **not utilizing** their heated air dryers **properly** for production

One of the reasons banding is quickly moving up production managers' lists of problems is because more end users are requesting blends. This is certainly true with many industrial operations, which rarely handle process work, but are thrown into the deep end when designers and customers alike all of a sudden call for this type of effect in their prints.

Understanding the reason behind this trend is to appreciate that customers' and OEMs' designers typically use the same graphics software as screen printing companies. As a result, end customers are creating great futuristic designs for their promotions, and products that look simply terrific on their monitors and when printed on high-resolution printers. Many of these designs are prepared with other printing processes, such as offset or flexo, in mind.

More often than not, the density range required is too wide and to be printed only in a short space, complicating the job further. Unfortunately, screen printers often approve design or improper artwork (photopositives originally produced for other printing processes, for example) without considering what steps will be necessary to reproduce these prints successfully by screening.

Half-tones, angles, line screen and density are much larger topics than this article can possibly cover in-depth. However, there are at least 10 things to consider when printing graduating dots or blends:

- Ensure film positives are clean, free of banding, with dots as perfect as possible. They should be outputted without any evidence of banding — otherwise have them re-outputted at a higher dpi.
- Reduce density range. For example, a 70 percent–40 percent tonal range will produce a much cleaner and more pleasing appearance than will a 90 percent–30 percent range — and it will be considerably easier to print.
- Get customers to agree to have the overall bleed pattern printed at the largest possible size. It is very difficult to screen print a wide range of tonal dots if the pattern image size is relatively small. Dots will have a tendency to condense more size-wise with one another—thus making the smooth graduation indistinguishable from one another. A 90 percent–40

percent range printed over an 20-centimeter (8-inch) length looks a lot cleaner than the same printed over a 10-centimeter (4-inch) length.

- Output dots at a different angle if banding is persistent — a small shift can make a vast improvement. 0°, 45° and 90° angles are particularly troublesome. For example, the 45° angle can create further tone loss, because the dots hit many of the mesh knuckles. (Remember that a screen will not transfer all the information, because it has a relatively small percentage of open areas through which to transfer the ink.) In the case of the 45° angle, a move of 7.5° will be especially pleasing!
- Opt for elliptical dots whenever possible. This is because more dot “information” will be captured (printed), yielding a much better pleasing result to the eye and customer.
- Review your choice of mesh. Those offering larger percentage opening areas are more likely to yield greater and cleaner print “information.”
- Higher tension levels effectively reduce friction and squeegee pressure. Excessive pressure will create the risk of banding in any event.
- Use lowest off-contact distance. Doing so will reduce further squeegee interference and keep the reproduced “image” as clean as possible.
- Thin the ink. Perhaps double the amount normally recommended for solid work, because the customer is clearly looking for a more visual effect than opacity.
- Whenever possible, print perpendicular against the graduation. Such will reduce highlighting and any evidence of banding even if there are faults with the screen or press setup/make-ready.

As seen in Figure 6, fabric actually “rolls” in front of the squeegee when low tension screens are used, a problem exacerbated by intensifying squeegee pressure in an effort to overcome it. Fabric-roll gradually increases to its maximum point as the squeegee reaches the center and then reduces to zero at the end of stroke. While the

roll effect cannot be seen with a naked eye, its tell-tell sign can typically be spotted by “chatter-like” marks the squeegee leaves behind on the screen. Because the squeegee is pushing the fabric along, it essentially elongates the image (dot/image gain) as screen-roll builds up. Then towards the end of the stroke, fabric slips under the blade, thereby not transferring/leaving behind the proper amount of information. The result: poor looking dots of incorrect size. Proper tension has everything to do with obtaining outstanding quality.

### Dryer Optimization

I've said for many years that at least 50 percent of screen printing operations are not utilizing their heated air dryers properly for production — at least not to the extent of achieving the best energy efficiency or preventing substrate shrinkage. And unlike UV curing reactors, which cure at the fastest possible speed to achieve both cure and adhesion, heated-air dryers can be said to work at the slowest possible speed.

Conventional dryers move large volumes of heated air over the surface to evaporate solvents from the ink layer. Years ago, solvent evaporation was considered a very slow process because of low airflows of that era (which called for an enormous amount of heat to accelerate the job for semi-automatic operations).

However, the good news is that manufacturers of heated-air dryers have kept up closely with ink technology in this respect. Today's conventional solvent-based graphic inks dry by rapid solvent evaporation and, to some extent, moisture removal with (non-textile) water-based coatings. Depending on ink type and substrate, a very small amount of solvent may still be left in the “dried” ink (which is good for inter-ink adhesion) but, nonetheless, considered dry for all intents and purposes from a processing/handling viewpoint.

While configurations and levels of sophistication, features and efficiency vary enormously from dryer to dryer, they are in the main, designed to dry by moving large quantity of air across the print surface aided with a small amount of heat. The right amount of heat helps to bring solvents (or moisture) up to the top of the ink layer while good air management literally scrubs them away and out of the drying chamber altogether. Therefore, it makes more sense to run modern-day air dryers at the lowest possible conveyor belt speed to maximize “resident-time.” In other words, a dryer is set at the lowest speed according to productivity flow — then the lowest temperature can be sought to prevent shrinkage or other forms of damage.

Figure 7a illustrates a typical heated air dryer with the conveyor moving too fast for production — an error you can recognize by the large gaps between each sheet. In this example, because the printed sheets are only in the dryer for a short time, heat has to be increased to compensate for the lack of resident-time. If that conveyor were suitably slowed down, as shown in Figure 7b, not only would it continue to accommodate production output, it would require less damaging heat and cost to dry. Everything considered, it is a win-win scenario:

- Production costs are lower, because the scenario uses less energy.
- Registration is superior, because sheets are less likely to shrink with the lower heat employed.
- Reduced stress and wear and tear on the dryer and conveyor translate to fewer belt replacements and lower maintenance costs.
- Additional expense reductions — and possibly less floor space needed — because of fewer cooling demands, shorter cooling chamber length and the need for expensive refrigeration (air conditioning). Prints will not be subjected to higher temperatures as in the operation example shown in Figure 7a.
- Superior inter-ink adhesion and compatibility is better assured.
- Worry-free deep-pile or auto-stacking: Printed sheets are less likely to “block” when stacked on top of one another, particularly with double-sided work, because they are already at a cooler temperature with lower solvent retention, than the operation shown in example 7a.
- Superior all-round handling characteristics (since lower temperature reduces potential static build-up).
- Reduced static permits easier and more accurate registration because of fewer false positives when sheets become “static-locked” on the print table and not properly in register
- Reduced static build-up means greater productivity. Operators can feed sheets faster manually or automatically without shocks, sheets sticking or interruptions.
- Superior image integrity because reducing static allows better print quality and edge resolution without “print-creep” or “cob webbing.”

Although heated air dryers do not usually get any credit for quality from production personnel, as established, its operational approach can be a very powerful tool if used efficiently to improve overall printing performance.

### Final Word on Screen Tension!

Now that we have concluded troubleshooting on-press and dryer problems, I would like to come back to the question of screen tension. Although I’ve advocated good screen tension levels throughout this series, I did not cover the subject separately because tension is not an “on-press” procedure, which is what this troubleshooting article is about. I bring this up here, however, to emphasize that many on-press problems are caused partly or entirely by poor screen tension alone — period!

With that in mind, it is better to start off with proper tension and use on-press adjustments to fine-tune the job rather than to re-engineer faults made upstream in the process. Everything taken into consideration, how many press operators are trained to fix “pre-press” problems “on-press”?

Case in point: The Newman Roller Frame<sup>1</sup> staff carried out a test a few years ago printing process colors onto sheets of clear plastic. They printed two solid areas on each sheet, one poorly printed and the other superbly done (Figure 8a and 8b, respectively).

When experienced printers were asked what one thing was changed to make the difference — most never guessed the answer! The differences between the two are extreme, yet the cause is nothing more than the powerful influence of screen tension. In many respects, perhaps half of all the “on-press” problems typically experienced can be traced back directly to tension alone. While higher tension levels offer far too many advantages to mention here, the only realistic negative point about high tension is that screens will be more fragile to handle. Otherwise, higher tension has everything else going for those seeking superior quality and less on-press hassle in production.

As one becomes increasingly aware that weakly tensioned screens do not transfer sufficient ink, color will have a tendency to shift visually in the eye of the beholder (Figure 9a). This is simply because the previous color will “grin” through the one on top. With weaker screens, it is much harder to transfer the full complement of ink that the fabric and emulsion were mechanically designed to yield; in addition, the mesh lifts off some of the ink that did transfer. This scenario typically leaves behind what looks like mesh marks in the print finish.

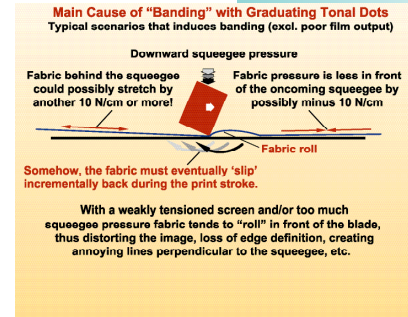


Figure 6: Affects l & m

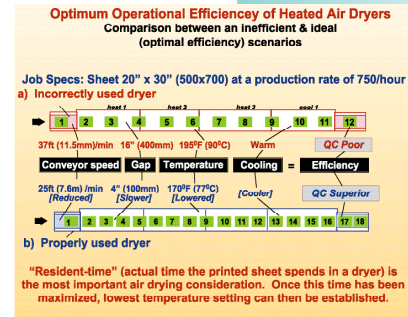


Figure 7: Affects a, d & o

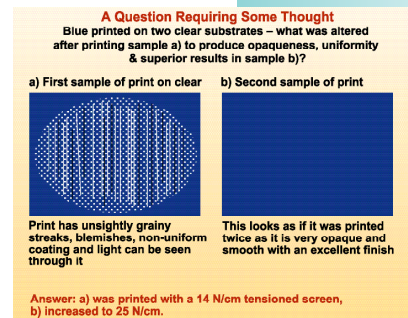


Figure 8: Affects a, b, c, e, f, g, h, i, k, l, m, n, p, r, s & u

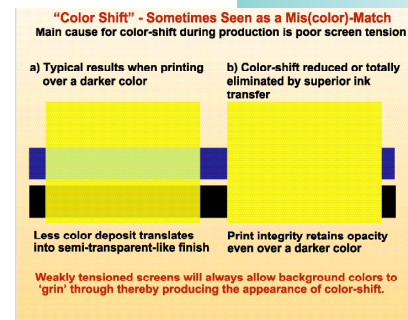


Figure 9a: Affects a, b, c, e, f, g, h, i, k, l, m, n, p, r, s & u



Any **extra care** and involvement undertaken (usually at **no additional** or notable **cost**) will **pay back** handsomely, in terms of **greater productivity**, reduced waste and production costs, achieving **higher quality**, less policing and **quicker turnaround**

Furthermore, not only will the weight of ink that's printed vary according to tension levels used, it makes successful color matching almost impossible. One clear tip that comes out of this is that all screens used for color matching should not only be the same fabric grade but also stretched to those tension levels used in actual production. Otherwise, this will lead to what production managers call color-shift after the ink has been computer-matched perfectly.

I was once informed that screen tension is like the air pressure in your car tire. If that analogy is justified, as I believe it is, then we are in for a rude awakening! Consider further that we are informed by automobile industry safety experts that when tires are under-inflated by just 4 psi, the result will be a 10 percent loss in fuel energy, efficiency, engine wear, safety, braking, ride, cornering and comfort. This fact is staggering if one considers that many printing operations are not using even half the tension designated by the fabric manufacturer for the level of work undertaken! A reduction of 4 psi from the average car tire is equal to about 12 percent from where it ought to be.

Can you imagine what would happen if you had only 50 percent of the air in your tire? For sure, you would not drive anywhere without it first being fixed — yet that is precisely what is happening in many printing companies today. They drive their operations with massively under-tensioned screens and wonder why they have reoccurring problems!

### Summary

While this troubleshooting series is lengthy, I trust it was educational and beneficial. Going back to what was affirmed in Part I, that “screen printing is indeed a very contradictory process,” it truly is. Because of all the other factors involved, a meaningful adjustment may not always work the way they it's expected to. This is precisely why a particular adjustment works one day but not the next.

Nevertheless, the purpose of this series of articles has been to at least enlighten printers as to causes of on-press problems according to the level of work being printed. What is or isn't influential to a given problem or how much is much depends on the application and desire to meet customers' specifications against those of in-house abilities.

Registration repeatability of 6.35 mm (.25 inch) is fantastic to work with. Other jobs may require  $\pm 0.32$  mm (.125 inches) or a more difficult 0.38 mm (.015 inch) while some applications require an excru-

ciating  $\pm 0.25$  mm (.010 inches) or less — and being off target could put someone's job or business on the line. It depends solely on the job and the desire to succeed where it was previously difficult to do consistently and satisfactorily before.

Companies frequently ask me if they really need to incorporate stringent practices and procedures when they do not think the average job calls for it. “That's not my call” is my usual response. This is then usually followed by explaining that any extra care and involvement undertaken (usually at no additional or notable cost) will pay back handsomely, in terms of greater productivity, reduced waste and production costs, achieving higher quality, less policing and quicker turnaround. It's a win-win situation for everybody. I have even seen press operators happier and less stressful while being significantly more productive (doubling or even trebling their normal output in some cases), because they can get into a swing of things completing jobs without the usual but detestable hassle of stopping frequently blocking out pinholes, wiping the screen every few prints, adjusting this and readjusting that, etc.

Conversely, it can be argued that even simple or less challenging jobs can take advantage as if they were up against tough demanding one. It has been said that to make a cheap product (print) you need expensive tools (process). What this implies is that integrating good techniques and procedures into the system, as well as utilizing suitable equipment, becomes the fast-track approach to produce end results successfully at the lowest unit cost. In most cases, less demanding types of jobs generally have less room or margin for errors profitability-wise — a powerful argument for improving processing techniques regardless of simplicity or complexity.

Having said that, the question still remains: Does it make sense to incorporate much of what has been said if a job clearly doesn't require any form of stringent techniques discussed. As stated, I cannot make that call; the job ultimately decides what techniques to adopt and how much to make life easier in the workplace to improve overall quality together with the impact on bottom-line profitability. While I cannot possibly state all the levels of job difficulties are out there in the marketplace, the depth that this series covered, whatever those levels are, it will make it just that much easier to achieve and maintain. Moreover, all of it will serve virtually any flat-sheet screen printing operation well for many years to come.

<sup>1</sup>Test conducted in the late '80s at Stretch Devices Inc., Philadelphia, Pennsylvania.

