Flexographic PROCESS Printing

An Introduction To Color Theory Quality Printing & Process Control

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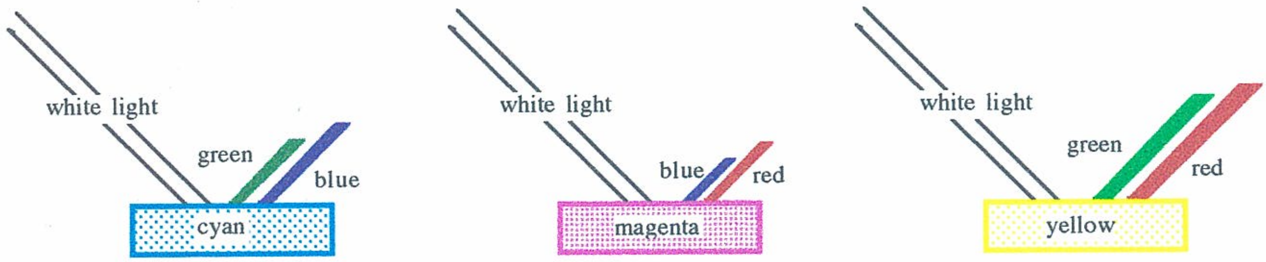
Colors

Subtractive color theory is used in printing with process inks. Process colors (cyan, magenta and yellow) filter, or subtract, from a white back-ground, what it would normally reflect. White light has all the colors in it, process inks selectively filter that light reflecting off the substrate.

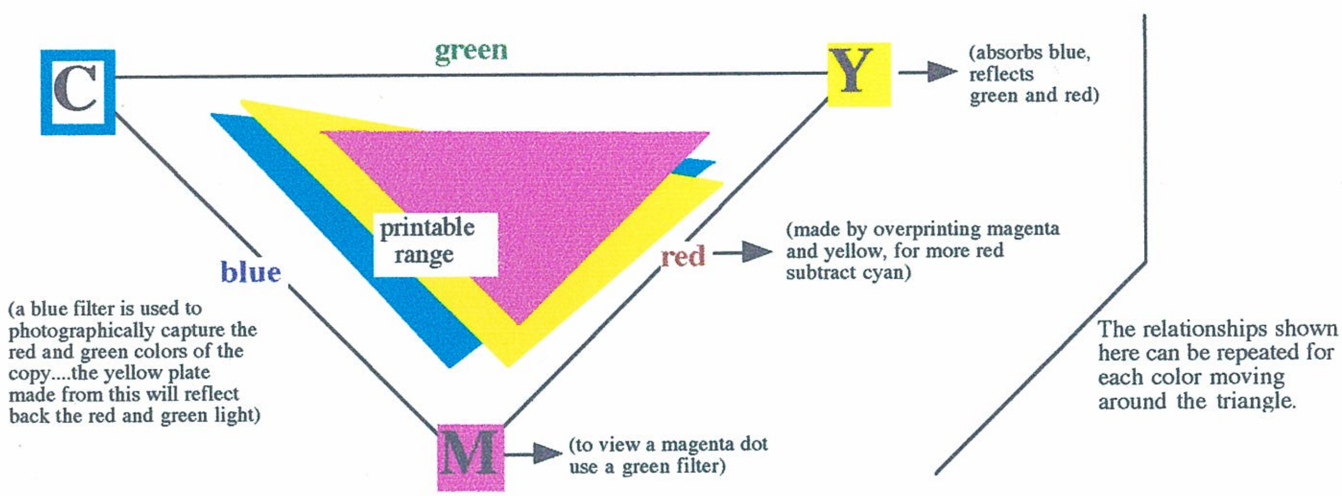
The inks are used to *create* the tonal spectrum in the printed piece. This is the *process* of creating *apparent* colors. By using dot patterns that allow various combinations of reflected light, it appears to the viewer as the complete tonal spectrum. However, process colors are not perfect filters, especially in shadow areas.



Cyan absorbs red light but reflects less green than blue.

Magenta absorbs green light but reflects less blue than red. It is also the poorest reflector.

Yellow absorbs blue light and is the most efficient reflector.



Above: the available tonal range of colors (seen by eye) and the printable range. The printable range available is smaller than the complete tonal range of colors. This compression of the tonal range presents the challenge of printing flexographically. Because the available range has been reduced, the control of screen dot gain is critical.

Dot gain is an increase in size, mechanically achieved or visually perceived. *A 2% gain will create a perceptible change in hue.* Selective control over dot gain in this compressed tonal range is the function of color correcting. Highlights and mid-tones are affected most by dot gain. *Reproduction of the dot throughout the entire range is* **THE** *key to good process printing.*

≈3% ◄ highlights ► ≈30% ◄ mid-tones ► ≈70% ◄ shadows ► ≈98%

The composite of all three colors is supposed to create grays and black, (like the type on this page, made without black ink) but especially in the "shadow" ranges process inks are not perfect filters. Typically, reflected shadows appear as muddy and unnatural browns or purples. Black ink is used instead, the fourth color in the process.

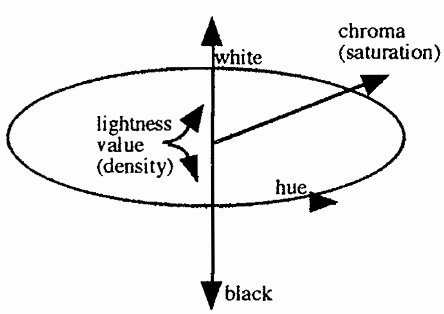
Two different conventions exist in the use of the fourth color, black (K.) In *Under Color Removal (UCR)* cyan is used to control lightness and darkness (*value*) and more image detail. Cyan is a better balanced reflector than magenta and easier to see than yellow. Muddy shadows are removed, and replaced by a black "skeleton" for subtle shifts of value. In *Gray Component Replacement (GCR)* much more of the value and detail functions are controlled by black. GCR is considered an evolved version of UCR, by taking the removal and replacement concept further. It affords more control over printing results and can reduce ink costs.

Arriving from the manufacturer, inks will produce predictable results when they are run with the proper viscosity and density. These two variables are specific, known by the manufacturer. *Density* is a measure of the ink film thickness applied to the substrate. Density changes do *not* change the hue of the ink printed, but rather the *value*, (lightness and darkness). The thinnest possible ink film thickness that yields the proper density range is desired. The thinnest film at density will minimize dot gain which causes hue change. Proper *viscosity* allows the printer to apply the proper thickness of ink film.

In process printing *trapping*, the ability of a wet ink film to grasp and hold a second film printed over it, will contribute to color changes. Measured in percentages, high percentage trapping yields predictable color, low percentage trapping gives uneven color or "wrong" colors. The proper thickness of the ink film is the best start to control of trapping.

At the proper density, process inks will reflect their secondary colors in a balanced way. Though not perfect, each reflects an approximate *2/3* of the tonal spectrum and *blocks* the other 1/3. When in balance, the three inks will produce a neutral gray, although this can vary in value (light to dark). A measured sample of the gray will show roughly equal percentages of the three process inks. This is known as *gray balance*. Using a densitometer to measure gray balance is a good way to check several printing variables (density, dot gain, color strength) at one time.

Color Separating



Left: Illustration expressing color values and relationships
Hue: the "name" of the colors, visible spectrum
Chroma: the intensity or saturation of the color (gloss vs.absorption)
Lightness: amount of white vs.black (reflectance of substance, density)

The first goal of color separation is to render the original artwork in its component process colors in a way that can account for the reduced tonal spectrum available and the substrate the job is being printed on. Compare as an example, a bright white poly film with a white paper board. The paper typically is not pure white, it will in fact have its own color cast. Color separations account for this existing cast and adjustments are made in the separations. Some papers have a bluish cast so less cyan would be needed in the separations to offset this reflected bluish cast.

The second goal of color separation is to account for press dot gain as a factor in color. Fingerprinting a press will yield information predicting dot gain throughout the tonal range. Once it is known what pattern of gain can be expected, color separations are adjusted to reduce the original tone values below normal. Then the printed gain returns these reduced values back to the normal ranges.

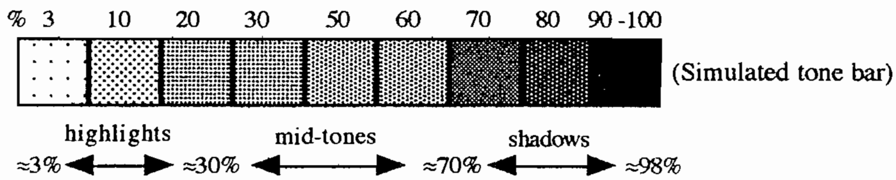
Industry standard dot gain curves exist for offset printing. Because standards exist for papers (whiteness and calibration) and inks, (densities and reflectance) fairly predictable results are attainable for offset printing. Because of the increased number of variables for flexo printing, particularly in substrates, standards are only approximate at this time, and methods of controlling the variables are critical.

As the first step in process printing, color separations are the first place where the variables in flexographic printing are addressed.

A suggested method for predicting printed results is to render the proof of the color separations with the expected dot gain built into it.

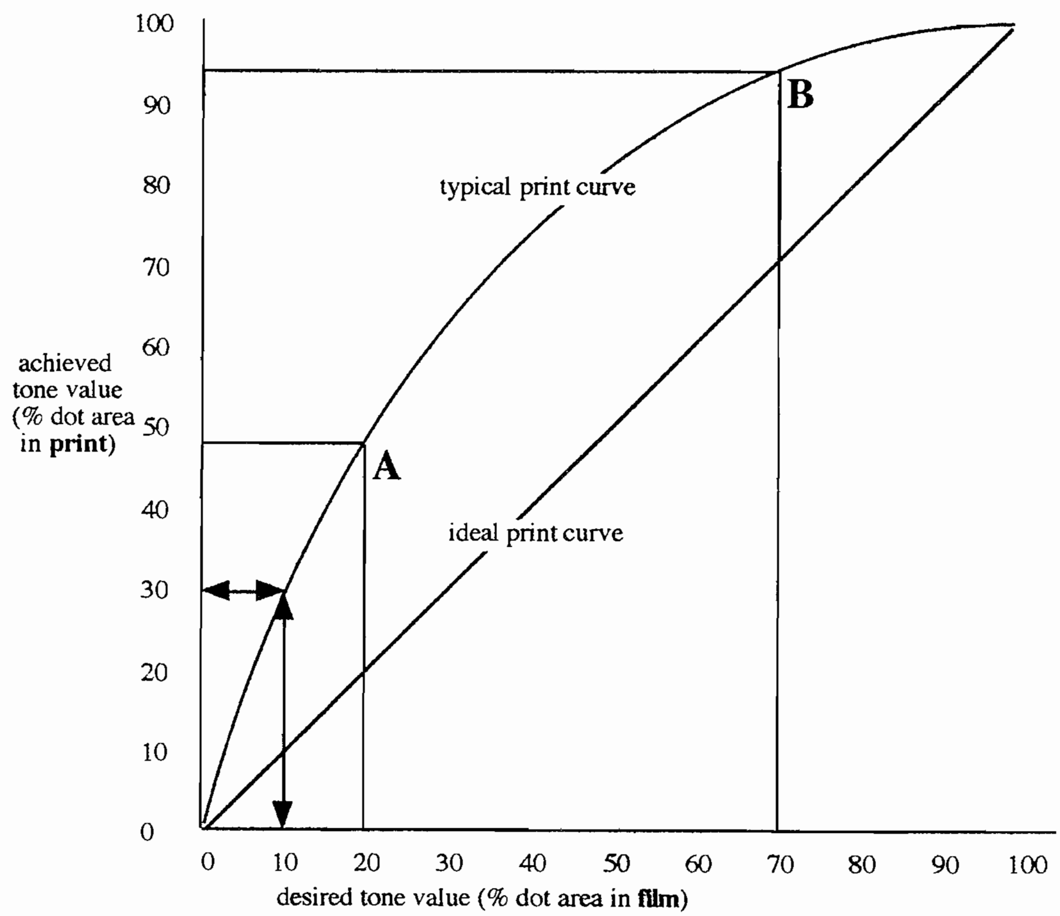
Control

The ability to control the variables of flexographic printing is the first step to successful, predictable results. Controlling hue is a function of controlling dot gain. So many factors affect dot gain that measuring and expressing dot gain graphically is essential.

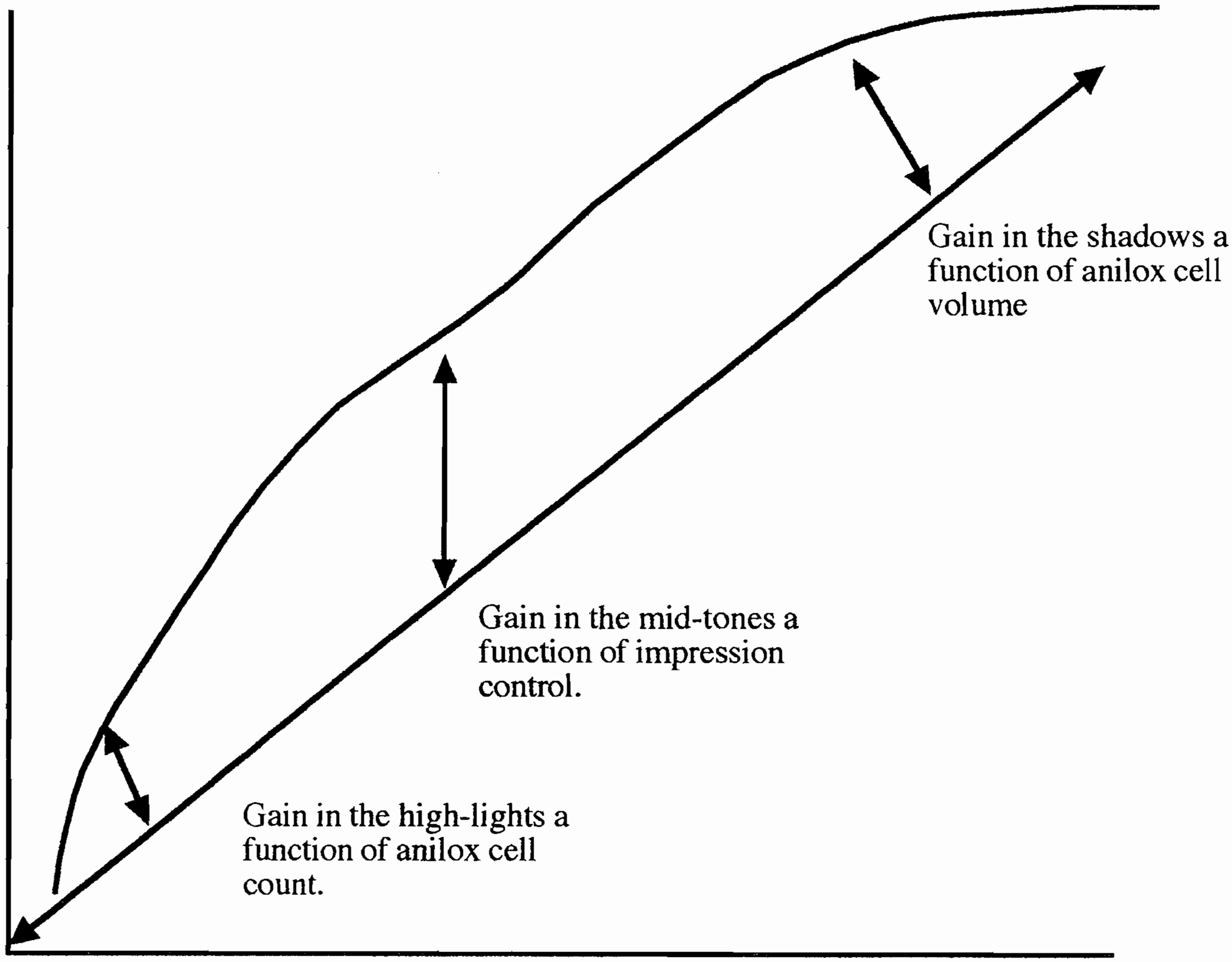


Through the tonal spectrum, dot area coverage is measured and compared to a standard. Known tone values in the film or plates are compared with actual printed values. This illustrates a screen pattern of known dot area which, rendered in printing plates, makes a tool for comparison of dot gain on press.

Dot Gain Illustrated This is a typical gain curve found by fingerprinting a press. As an illustration: @ **A** the desired tone value of 20% prints at ≈48%, and @ **B** the desired value of 70% prints @ ≈95%. A gain adjustment (see ◄—►) would cause a desired 30% dot to be reduced to ≈10%.



Gain Factors



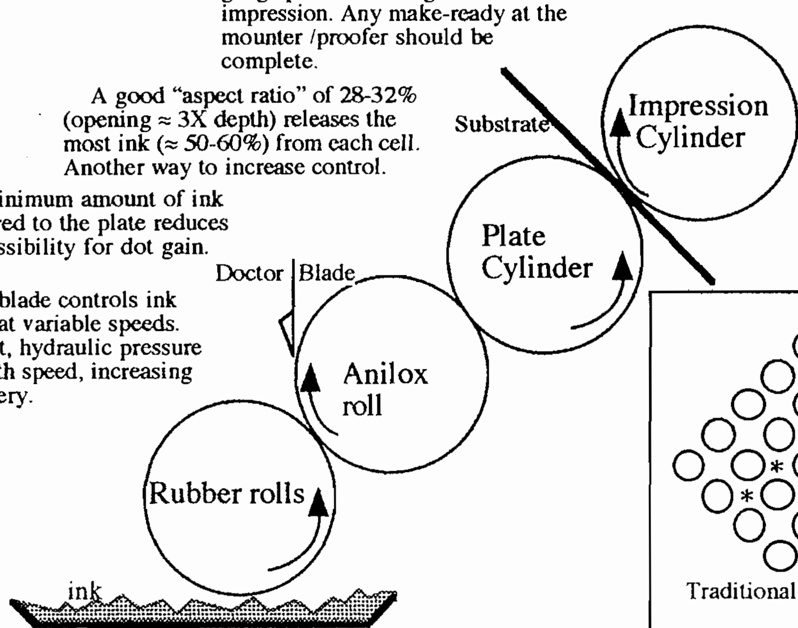
The factors involved in dot gain work in conjunction with ink film thickness variables. This is a look at press factors that control ink film thickness.

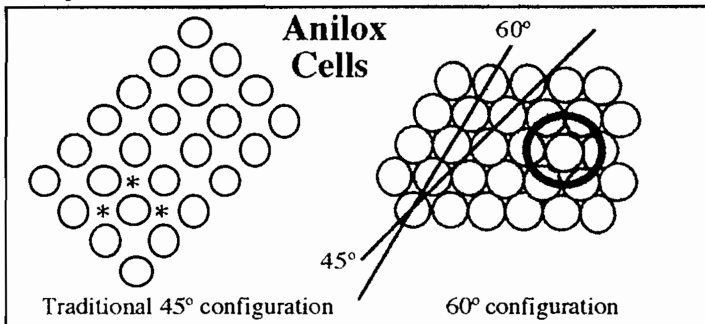
A well made plate of uniform gauge produces less gain from impression. Any make-ready at the mounter /proofer should be complete.

A good "aspect ratio" of 28-32% (opening ≈ 3X depth) releases the most ink (≈ 50-60%) from each cell. Another way to increase control.

The minimum amount of ink delivered to the plate reduces the possibility for dot gain.

A doctor blade controls ink metering at variable speeds. Without it, hydraulic pressure builds with speed, increasing ink delivery.





The symmetry of "six around one" 60° cell configuration (see dark circle) provides more cell area on the surface of the anilox roll. This arrangement provides better ink release and up to 15% more ink delivered. It also reduces moiré patterns from traditional film screen angles and, in corrugated, from fluting. This arrangement has no "mini cell" (see *) between each anilox cell, which increases control over metering of ink.

Ink Systems

The chemistry of the ink is called the ink "system". Ink systems are considered to be made of 4 parts:

Colorant +	**Vehicle** +	**Additives** +	**Solvents**
The hue, made from pigments. Pigments are suspended in ink, not dissolved. As opposed to dyes, they are more light fast.	Resin systems that carry the pigments, keeping them in suspension. They provide *properties* for end-use, such as heat resistance, elasticity, or light fastness. Pigment particles are surrounded, kept apart from each other. Should they touch, they bind together as a precipitate, and fall out of suspension. This causes loss of color or dirty print.	Help maintain resolublity and printing. For example, in a water based system: ph. adjustors (amines) or defoamers, respectively. They can also contribute to *properties*. One example would be wax.	These affect how the vehicle works, thus control *value* (light to dark). Ex: Solvent inks alcohols acetates Water based inks water alcohol (minimum allowable by law) Alcohol, a surfactant in water inks (surface acting agent) changes the surface tension of water, allowing better flow.

Balanced ink, presumably as it comes from the manufacturer, is important to maintain during the press run. The balance is the key factor in maintaining resolubility, which allows as much ink as possible to be released from anilox cells. As they run, anilox cells fill with ink but not all is released. Keeping the ink which remains, from drying in the cells, is the function of solvents and ph. Ph values for a specific ink, (as well as solvent blends/amines) are known specifications from the manufacturer. In water based inks this balance is *much more critical* because some of the resin systems are not resoluble in the solvents they are made with. Once the vehicle breaks down it cannot carry any color.

With respect to color control the use of *extenders* (the entire ink system less the colorant) is best because they only change *values* and *density* (not hue) and the resolubility is maintained. Changing colors is done with *toners* (colorants in suspension with just enough solvents to mix into the system).

Documentation: Key to Control

The first principle applied to control the variables is *documentation.* Documentation of *any* problems *or* successes, and the steps taken to arrive at them, is the *only* way to maintain quality. Processing variables for any materials used or generated in the pre-press steps, through platemaking, must be documented. At press any ink system specifications for density, viscosity and ph. should be available along with efflux cups and ph. measuring tools. Anilox and impression controls must be monitored with dial-indicators. Densitometers for dot gain and density must be available.

Control Variables To Document

Pre-press

original art work color separation color correction tone gradation	From the best possible transparency, use separations that account for the reflectance and cast of the substrate and for the expected dot gain from a fingerprinted press. Reasonably divide the tonal range incrementally, and within each division adjust screen dot area values down.
film duplicating proofing platemaking	Always record all processing variables, especially those that deviate from standards. Proof a version of the graphics with expected dot gains built in. Proof plates with minimum impression.

Press

registration	Duplicate the known standard, the plate proof.
dot gain	Achieve ink system specs for viscosity and ph. Know all anilox structural specs and ink delivery limits. Record impression settings and achieve ink density tolerance limits. Known tone values in the film or plates are compared with actual printed values.
ink color trapping gray balance	At proper impression, maintain ink system specs for viscosity, ph., and density. If possible, plates for measuring gain, density, trapping and gray balance should be run with the job.

Density Targets/Flexo Applications

Ink film density targets will be recommended by the ink manufacturer, with variations of $\pm$ .05 units considered acceptable variation. Higher gloss substrates are less absorbent and more efficient reflectors so higher ink film densities will be observed. These are target densities derived from practical application, and they may differ from experiential results at a given facility. The progression of increase shown, moving to higher densities from yellow through black, is the desired result, regardless of the starting density targets.

Process Color	Gloss Paper and film	Coated Paper and matte film	Uncoated Papers
Black	1.75 - 1.85	1.65 - 1.75	1.40 - 1.50
Cyan	1.35 - 1.45	1.25 - 1.35	1.20 - 1.25
Magenta	1.30 - 1.40	1.20 - 1.30	1.15 - 1.20
Yellow	1.00 - 1.10	0.95 - 1.00	0.85 - 0.90

Screen Angles and Anilox Rolls

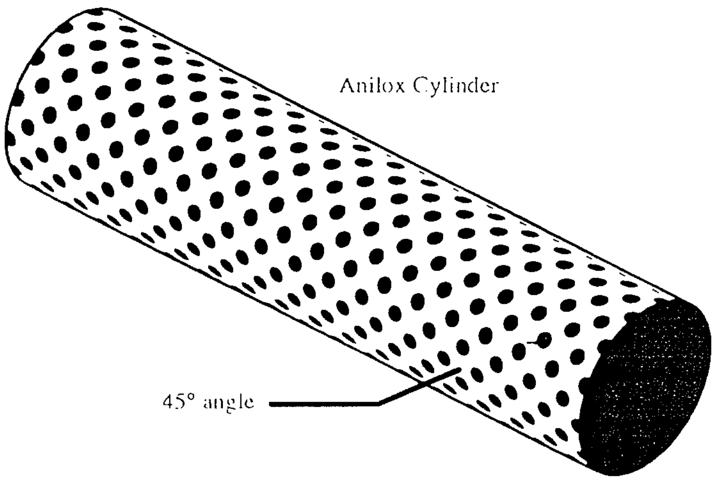


Figure 1

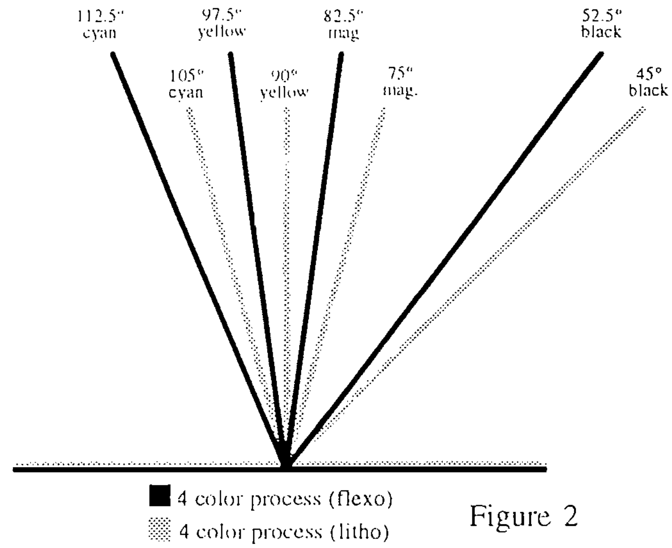
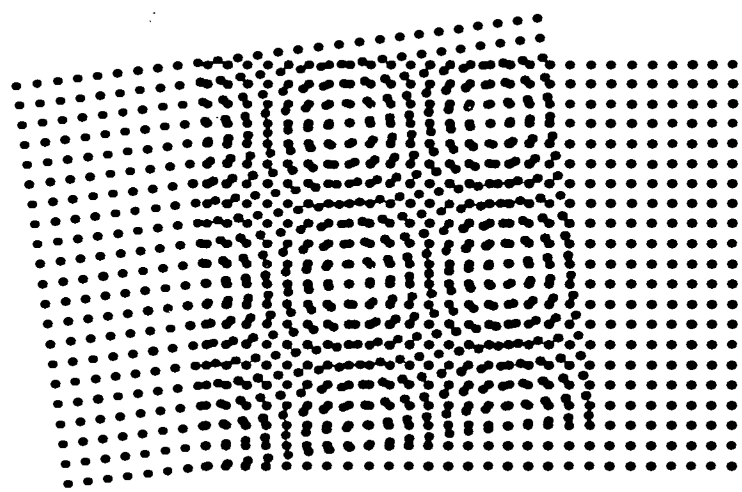
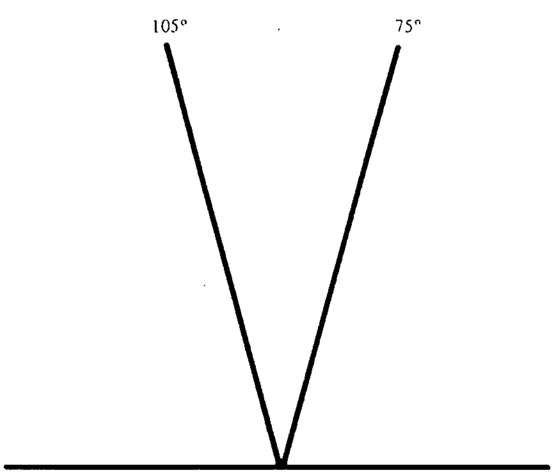


Figure 2

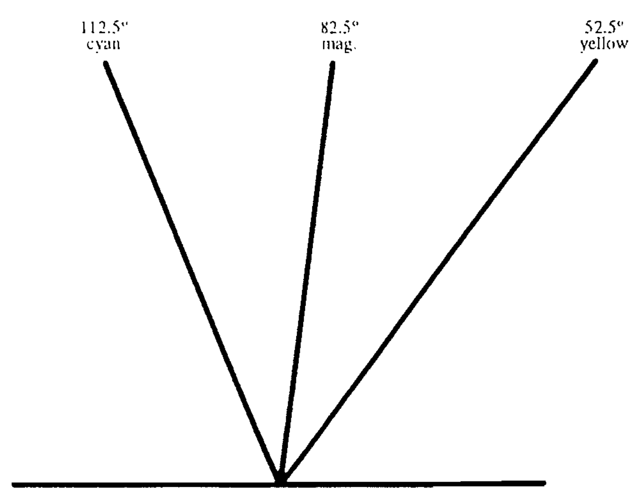
Traditionally, anilox rolls had an engraved pattern of cells at a 45° angle, due to the engraving method, and mechanical limitations. Now that art preparation brings process variables to the equation, this anilox cell configuration must be accounted for. When screen patterns are overlayed, they can create an undesirable effect known as moiré patterns, especially when the angles are very close but not exactly identical. Traditional screen separations from offset printing used the baseline black screen @ 45°. This conflicts with the conventional cell angle of the anilox roll. (see fig. 1) Adjustments are made to accomodate this, and avoid moiré patterns. (see fig. 2) Also, anilox screen angles are being made now @ 60° to address this issue as well as ink delivery.



Moiré Pattern



Duo-tone or Halftone



3 color process (Flexo)

Notes..........

Anilox:

Volumes..... Even with a doctor blade, volumes from 8BCM and up are in range of simple roller systems for ink delivery, thus harder to control with speed.
Cleaning...... use a higher ph. solution than ink system used.....in water based systems use an amine with water and detergent; higher ph. is more detrimental to chrome, lower ph. is more detrimental to ceramic
Running...... losing color strength with increased speeds? check for cavitation (air in cells)
Specifying...... a ≈ 4/1 ratio(anilox screen line count to graphics screen line count) is the rule of thumb. Mechanically, this prevents screen dots from dropping inside anilox cells, thus preventing dot shoulders from inking and printing.
Testing...... a banded anilox test (several levels of screen line count/volumes on one roll) is a method of determining which set up best delivers ink at the target density.

Inks:

Ideally the highest viscosity possible is best, to achieve density with the thinnest ink film.
Ink system specs (density, ph., viscosity) predict results for PMS inks just as for process inks.
To fix a starved ink station try to reduce out-flow first before increasing delivery.
Measuring...... Some types of efflux cups are better at shearing ink stream and so are more accurate when measuring time.

Color:

The largest color gamut available in the substrate (the best white) is the most desirable to let the inks do their job.
Viewing..... Consistent viewing conditions of print samples is essential. This prevents metamerism. (The apparent change in colors due to lighting conditions).

Press:

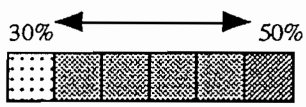
Pre-press graphic adjustments are set up to accommodate the press being used. Obviously maintenance conditions and operator skill affect print quality. Some variables are more critical for quality results. It is *very easy* to see smearing from differing speeds of plate and anilox cylinders. Exacting control of pitch/undercut variables (i.e. plate mounting) is essential to control excess wear of plates, dirty plates, speed variances and gear wear / sloppy mesh.

Fingerprinting:

This is recommended anytime there is a change to any press conditions: inks, anilox, tapes, plates etc. Regularly as maintenance conditions change.

Suggested Elements......Fingerprint Plate Sets For Corrugated

Yes	No
at least two line values 4 solids; traps and singly (solid ink densities and overprints)	duotones....useful for developing the pallette of demand colors, Photoshop™ has color predictors and there are reference books for same
make large slur targets large ladders (see slur write-up)	not small ones which don't cover enough press area



a vignette
from ≈ 30% to 50% to find n-factor
(determine 50% optically)

tone bars with minimum first-printing-tones

Options

option 1. gray balance targets

option 2. process image with heavy GCA in an image that is reduced at least 25%, and no black added in until at least 50% CMY already in those areas

Corrugated Slur Tests

3/95 SW/QP

Run the ladder targets as if they were pull straps, as long of a plate as possible through the press. A typical set-up runs .005" rules with .010" spaces.

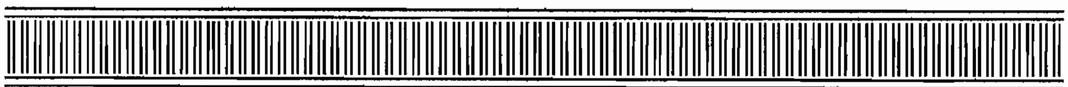
Speed differentials of 1-2% will show density differentials in the ladder that would affect color *value* (not hue). If any more than this occurs there will be visible fill-in within the space areas of the ladder targets.

Run measuring rules as well, they're convenient, and easy to measure.

Afterword place sheet alongside the press to use it as a measuring tool to locate the place on the press the slur is occurring. It should typically happen from the press mechanics.
If it occurs in a regular place, then look to the press for location and cause of speed differentials between components, as an example: the feed rolls' drag impeding the sheet from normal traveling speeds. Mark off the frame of the press on the sheet to find where it is occurring. On the ladder targets this can appear in a very small area.

If it occurs in irregular places then look to the plate set-up for incorrect packing height...(undercut specs correct?) This is rare.

If the sheet is dragged/impeded the rules will measure longer than nominal length.
If the sheet is pushed through too fast the rules will measure shorter than nominal length.



Slur Ladder