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Print Control Strips

In modern offset printing, a colored image is reproduced by the halftone separation process. The areas of light and darkness on the original are represented by dots of different sizes and the tonal range is generally modified to meet the reduced capability of the printing process. To reproduce a color original, the image is separated into its red, green, blue and black components and a halftone screen made for each. These screens are then used to make plates which are used in turn to print the image using the four process inks, cyan, magenta, yellow and black. To ensure color control and to maintain a consistent printed product, the size and color strength of these dots must be monitored, but since the finished printed image consists of the overprint of the four halftone screens it is very difficult to isolate the various components affecting the reproduction of the original image.

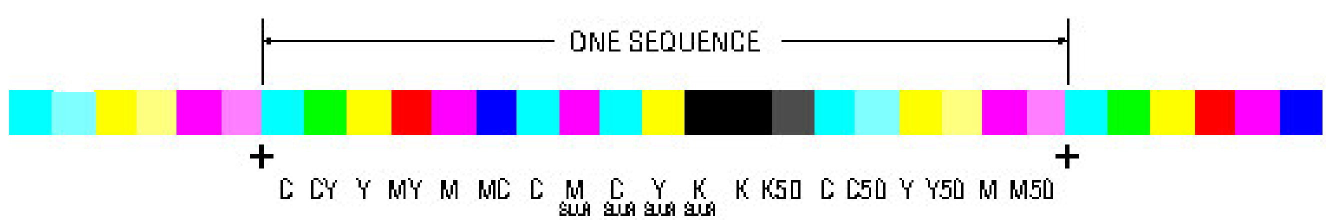
To overcome this problem, a series of test elements can be printed along with the image, and each element can be designed to highlight a particular aspect of the printing process. While some of these test targets can be evaluated by eye, others require the use of measuring equipment. The usual form of these test elements is as a strip across the edge of the press sheet, although in boxboard and label work these elements may be interspersed with the images. These test strips, called control strips or colorbars, are available commercially from various vendors, and consist of strips of film containing the various test elements for each of the four colors. In some cases six color versions are available where special colors might be used.

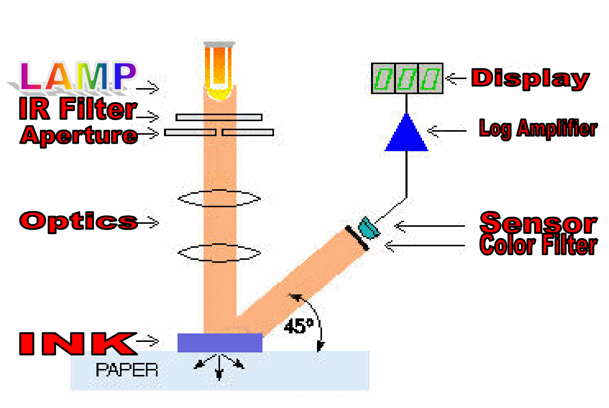
Plate Exposure, Slur, Registration & Balance Targets

The visual test targets may consist of such elements as plate exposure controls, slur targets and registration marks. The plate exposure target usually consists of very small patterns such as microlines and/or microdots, these are graduated in size ranging from six to thirty microns. By examining the plate and finding the limit of reproduction of these micro elements, usually about ten microns, the vacuum frame drawdown time and the plate exposure duration and uniformity can be monitored. Changes in plate types will require test exposures to be made to establish new times. For example the new waterless plates have a much smoother surface and may require a longer vacuum drawdown to ensure proper film to plate contact.

Slur targets may consist of either radial or horizontal and vertical lines that blend together if slurring is occurring on the press. The direction of the blending indicates if the slur is lateral or longitudinal. These targets are sometimes incorporated into other test targets. Registration marks may be simply cross hairs that show mis-register or may be more complex showing direction and amount of mis-register. Other types use micro dots that are scanned by automated equipment.

Balance patches consisting of the three color halftones at about fifty percent dot, often printed adjacent to a fifty percent black, are used to visually check color balance. Some colorbars use visual targets to evaluate dot gain by using graduated micro elements that progressively blend together as dot gain increases. However these two target types, balance and dot gain, can be better evaluated using a densitometer.





Densitometer Optical Layout

Solid Ink Density

In the halftone process, as mentioned above, the tonal scale of the image is represented with dots of differing sizes. This procedure makes the assumption that the ink film thickness of each dot is the same irrespective of its size or diameter. Also as the image coverage varies across the press sheet the amount of ink that is required to print the image changes, requiring different ink fountain key setting across the press sheet. To measure the ink film thickness and to ensure its uniformity across the press sheet, patches of solid ink, i.e. 100% dot, for each color are placed in the color bar.

Basic Theory: Reflection Densitometry

These patches can be judged by eye for color strength and uniformity but this is not very reliable. A much better way is to use a reflection densitometer. This is a device that measures the amount of light reflected by a surface under controlled conditions of illumination. For example, the surface may be illuminated vertically and a measurement taken of the reflected light at an angle of 45º. These conditions avoid gloss reflections and give a diffuse reflection measurement. The other important characteristic of the densitometer is that it reports the logarithm of the reflectivity of the surface and this value is called optical density. Using this type of measurement has two results; first, this approximates the way the human eye perceives changes in lightness and darkness, and secondly, the ink film thickness is approximately proportional to optical density, within limits. This provides a convenient way to monitor the amount of ink that is being applied to the press sheet. To measure the various process color inks, a complementary colored optical filter is place in front of the densitometer's receiving sensor. A red filter is used for cyan ink, green for magenta and blue for yellow.

This filter selection was once done manually with a switch, but in the densitometers found in today's modern pressroom this has been automated and filter selection is performed by the electronics of the densitometer. The increased power of these densitometers has also simplified the reading of the other test targets that characterize the printing process.

Dot Gain is a Fact of Life

In addition to solid ink patches, print control strips will also have dot test targets for the quarter, half and three quarter tone tints for each of the inks. These targets are used to monitor the way the dot is printed. As the image progresses through the reproduction process from film to plate, plate to blanket and finally blanket to paper, the size of the dot is affected and it may grow or sharpen. This is called dot gain and is expressed as a difference between the original dot on the film and the measured dot on the printed image. For example, if the original had a dot area of 50% and the resulting printed dot area was 68%, the dot gain would be 18%. Because we are comparing the result to an original, it is very important that we do indeed use original colorbar film and not a dupe, since the dupe will itself have some degree of distortion. Dot gain on press is a fact of life and as long as it is consistent and the dot gain of each of the inks is approximately the same, its effect can be accounted for when the halftone separations are made. A typical dot gain for a sheet fed press would be about 20%.

To measure dot gain, the densitometer is used to take a reading of the halftone tint, a solid ink patch adjacent to, or as close as possible to, the tint patch, and a reading of the paper base. Then using, usually, the Murray-Davies equation the dot area and dot gain is calculated automatically by the densitometer.

Trap Calculations

When a job is run, the four process colors are sequentially printed with the order, or rotation, usually being cyan, magenta, yellow with black being either first or last. The inks are formulated to have a certain stickiness or tack according to the rotation on press. This is done so that each ink will adhere to the previous ink that was printed rather than lifting it from the paper. To monitor this, colorbars have targets where solids are overprinted on top of each other, yellow on magenta, yellow on cyan, magenta on cyan. These patches, together with patches of the component single colors, are then measured with a densitometer and a calculation is made to give a percentage trap figure. This is then a measure of how well the inks are "sticking" to each other. The most common equation used for this calculation is that proposed by Preucil.

Contrast, Hue Error & Grayness

These measurements, solid ink density, dot area and trap are the most commonly used to monitor the printing process. Other secondary measurements can be made such as print contrast, hue error and grayness, and also balance. Print contrast is a measure of the ability of the printing process to hold shadow detail. A density measurement is taken of the three-quartertone tint patch and of a solid patch, and the print contrast is expressed as the percentage ratio of the difference in density between the two patches to solid ink. A value above 30% is generally considered acceptable.

To monitor the quality of your inks and to check for contamination, characteristics called hue error and grayness may be read from the solid process ink patches. Hue error is a measure of the deviation of the ink from a theoretically perfect process color. The larger the error, the smaller the gamut of colors that can be reproduced using that ink. The term “error” is really a misnomer since it does not indicate a problem, merely a characteristic of the ink. The grayness reading shows how “dirty” the ink is. For these measurements a three filter reading of the solid ink patches is taken and, again, the densitometer can calculate the results.

Scanning Densitometers

By measuring the color bar, the printer has the tools to control the printing process. The solid ink densities can be kept uniform across the press sheet and color balance can be held by controlling dot gain. The modern densitometer can provide all these measurements conveniently and easily but measuring across the press sheet is still a time-consuming process.

With the introduction of the scanning densitometer, this is no longer a problem. A print control strip can be scanned in a few seconds and the results immediately displayed, showing any problems that may be occurring. Target reference values for the colorbar swatches are easily set and may be a standard value such as a density of 1.30 for a solid magenta swatch or may be the recorded values of an "OK" Sheet scan. There are two main types of scanners, a linear scanner that scans along the length of the colorbar and a two-dimensional or X/Y scanner. The X/Y scanner has the ability to not only scan a colorbar but to also scan test targets anywhere on the press sheet, for example those found on the flaps of cartons in box board printing.

For an automated densitometer, such as the Tobias SXY or SDT, to scan a print control strip, the sequence and position of the elements of the strip must be defined. All commercial control strips consist of a repeating pattern, this may be as short as a few inches or may be up to twenty inches, and this pattern is stored in the memory of the scanner. When a control strip is used, this sequence is repeated across the press sheet as required. The position of first swatch starting the strip, the swatch starting the first repeat, and the last swatch are entered into the scanner. The scanner will then find the bar on a scan and will automatically read the solid ink densities, halftones and traps, and provide almost instant feedback to the pressman on how the job is running.

This type of scanner brings unprecedented sophistication to the pressroom. However, to properly benefit from these densitometers certain rules must be followed. The definition of the colorbar has been stored in the scanner, and the scanner expects to find each test swatch in a certain position. This means that no change in the colorbar can be tolerated without reprogramming the scanner, so it is best to define your colorbar and stick with it. The scanner also expects the repeats of the control strips to be butted together with no spaces between each repeat. One approach to this is to carefully make up a master flat long enough for your largest press sheet. Then mask each end off for smaller sheets, making sure that the first repeat is positioned so that it is always included no matter what the sheet size.

An improvement to this method is to use a colorbar that is mirrored about the centerline of the sheet. This has the advantage in that the center point is easily found for job setup and each swatch, in web printing, is backed up by a swatch of the same color.

The speed with which these scanners can read a control strip provides an opportunity for more detailed analysis of the job. If the results from each scan are recorded, the data can be examined using statistics.

This allows the power of Statistical Process Control (SPC) to be brought into the press-room and provides information on how the job has run, allows relative comparisons of materials and equipment and gives your print customer quality assurance that his specifications have been met.