Some Questions (And Answers, Too) About Densitometry

Over the last few decades I have been asked a number of questions on densitometry varying in complexity from the very technical to elementary. I thought it might be useful to include some of the most common questions that might be of interest. In general, I have tried to keep things pretty simple.

What is a densitometer?

A densitometer is a device that shines a light on a sample and measures the amount reflected under rather specific conditions. The light reflected can be broken up into red, green and blue portions of the visible spectrum. The results are given in terms of a logarithmic conversion. For example, a density of 0.00 indicates that 100% of the light falling on the sample is being reflected. A density of 1.00 indicates that 10% of the incident light is being reflected, 2.00 is equivalent to 1%, etc. For the mathematically inclined, the density is the logarithm of 100 over the reflectance in percent.

Is there a set of standard density values for the process inks?

There is no standard set of values. The ink strength, the absorption of the paper and the press combine to determine the most desirable set of values. Too high a set of densities tends to dirty the appearance, clog the shadows, warm the magentas and yellows, whereas too low values give a washed-out look. The densities set should be balanced to give neutral grays over the entire range of gray values. Trap and dot gain should be within acceptable limits. Adopt what works best for you as your standard.

Ha! If that's the case, why not use the eyeball technique?

An old scientist once said. "If you can measure, you can control." If you establish a set of standards initially, e.g., yellow = 1.00, magenta = 1.35, cyan = 1.35, black = 1.50, and the grays are too warm, then reduce the magenta to 1.25 and evaluate the results. Once you set a standard using a densitometer, you have a good means for measuring and, thereby, controlling.

How close should a density be to the standard?

That depends upon the nature of your work. If you are printing a merchandise catalog where the customer wants to show the color of his product accurately and consistently throughout the run, then try to stay within plus or minus 0.05 of the density standard. If the job is pleasant color, perhaps 0.10 is close enough. The tighter the tolerance, the more the job will cost you. This is a fact of life.

I'm confused. Does a standard set of densities always work?

Nope. In an ideal world, the separations would be proved on a press similar to the one it will run on, using the same set of standard densities that you have set up for your operation. Because this doesn't happen most of the time, what should you do? Start with your standard set of densities. Compare the makeready sheet with the proof. Modify as needed, but don't "play the organ." Change overall, if possible, individual keys when necessary. Show results to the customer, if that is your policy, who may want additional changes. You should now have an OK sheet. Check running sheets against the OK sheet. Generally, there will be some areas that are more sensitive to ink variation than others. Read those more frequently. The more control you have over your separations, the more likely you will be able to adhere to your standard house value of densities. If you are using the SCR Scanning Densitometer, it will be possible to read all swatches and produce a printout within 10 seconds, with a reference against either house standards or an OK sheet.

What is meant by transparent or opaque inks?

These terms are only relative. Few inks are completely transparent or opaque. A transparent ink film is one that allows the light to pass through itself like, say, a colored gelatin filter. An opaque ink has pigment particles that them selves opaque or have an index of refraction substantially different from the vehicle. The result is that the opaque ink can absorb or scatter the incident light and thus exhibit "hiding" power. Several layers of transparent process inks on a diffuse reflective surface will produce a combined subtractive effect on the light under which it is being viewed. The light passes through all layers of the process inks and is then reflected for the most part back through the layers of ink. In this way we get the full color range available using the process inks. The analogy to superimposition of gelatin filters falls down a bit with the halftone process. Here for dot areas less than 100 percent, one sees the combined effect of the magenta, yellow and cyan by themselves and in various two-color and three-color combinations.

So all process inks must be transparent for optimum results?

Yes, for the most part. The first down color, for example a chrome yellow, can be relatively opaque and still produce acceptable process results. But don't use a chrome yellow as a second, third or fourth down color if you don't want a yellowish cast over the entire picture

Just what do you mean by a diffuse reflective surface?

Let me answer that one by giving examples of the two extremes. Paper is a diffuse reflective surface. It scatters the light shining on it in all directions. On the other hand, a mirror is a specular reflective surface where the light is reflected in a single direction. (Speculum is the Greek work for mirror.) Few surfaces are completely diffuse or specular. A gloss paper is to a small extent specular, whereas an abraded metal surface is somewhat diffusing. Incidentally, while one can measure the density of an opaque ink on a mirror-like surface, such as aluminum foil, reading the density of a transparent ink without a white background will not give meaningful results. You see, the foil itself can have a density of 2.00 or more. Generally, the better the densitometer, the higher the reading will be with an unblemished mirror surface. Ink on such a surface may actually produce a lower density reading than the uninked surface.

What about water?

Even with a densitometer, the pressman must still use his skills. The densitometer will help control part of the ink/water balance that is needed on a press. That part is the ink film thickness. There remains the paper, the coverage, and the water control system.

What is the advantage of a sophisticated densitometer?

The density values can be used in a microprocessor controlled densitometer to compute automatically and display the results of complicated mathematical expressions to yield such derivatives as: effective dot area or gain, hue error, trap and grayness.

Would you care to explain the use of each of the derivatives?

First, let's look at dot area or dot gain. The printing process prints pictures with dots as well as with solids. If one starts with a 50 percent dot on a negative, the dot as printed may be equivalent to a 70 percent dot. That is a dot gain of 20 percent. It seems that as our technology now stands, it is just about impossible to print without some dot gain. If you know the dot gain then you have a check on the inks, paper, press and platemaking. Densitometers can measure the dot area of a color bar swatch on the negative, determine the dot gain on the plate itself and on the printed sheet. A value around 50 percent dot on the negative will show the greatest sensitivity to dot gain conditions. If the press shows a substantially greater than normal (for you) dot gain, check for slur, overpacking, too soft an ink, too warm an inking system or too much plate exposure. Most importantly, the dot gain for each of the colors should be approximately equal.

When one ink overprints another wet ink, the relative efficiency of the lay-down can be measured by a Trap computation using the Preucil equation. In the SCR Scanning Densitometer, it can be computed either with the Preucil or Brunner equations. There are other equations that have been used. They will all give different results! The Preucil approach has withstood the test of time and is the most popular trap computation method. With uncoated papers that are fairly absorptive, trap is generally not a problem. Coated stocks can produce inadequate trapping if the inks are not adjusted to proper tack values or if the inks get waterlogged. An occasional check on trap can help determine if a condition is developing that ultimately can cause degradation of the quality. An obvious objective in good printing should be to head off a potentially bad condition before sheets are spoiled.

Hue error and grayness can be used as a check on the relative quality of a set of process inks compared to your standard set. A theoretically ideal magenta, yellow or cyan ink would have zero hue error and zero grayness. Available inks depart substantially from ideal. The greater the hue error, the more restricted the color range available becomes. Grayness is a measure of the "dirtiness" of the ink color. These values can be used to compare different sets of ink. They can also be used to determine whether a fountain has been properly washed up, or whether there is contamination carryover among the fountains on a multicolor press during a run. Some have used hue error and grayness to compare prepress proof colorants with the press inks as printed.

Which color bar should I use?

There are many color bars on the market. Each seems to have some desirable features and some undesirable ones. The choice depends upon the aspects that you deem important for your operation. The best ones have solids and halftones. Some have features that are less important if you are using a sophisticated densitometer. The repeat pattern should be about two key widths wide. Again, this may be a matter or preference. Remember that every unneeded swatch uses up precious space. The GATF, FOGRA, BRUNNER, RIT, are just a few of the color bars that are available. Many printers have made up their own. Some of the color bar systems can give you a considerable amount of background survey information. In all cases though, never use homemade contact prints. It is better to spend a few dollars and get factory fresh strip negatives or positives. The variation of a contact halftone, especially if it is several generations away from the original may exceed the allowable tolerance obtainable on press. Almost all commercial bars have had rigid quality control used in their manufacture and some may not even have used silver emulsion originals. Remember too, that in use, gelatin emulsions do wear from abrasion against the plate surface. Check the filmstrip occasionally with a dot area measuring densitometer.

Does the densitometer have any use in non-process colors?

Yes, indeed. Contrary to what many people believe, you don't need to use any special filter. Just look at the color with the densitometer and find which filter gives the highest reading. Read the value that corresponds to an OK. That becomes your standard. Many times a flat color may be more important to control than a process job, if it is a corporate color or is somehow identified with the product. It is useful to keep in mind that with pastel colors a small density difference is more noticeable to the eye than with high density or strong colors. In the Tobias SCR Scanning Densitometer, it is possible to evaluate density fluctuations by considering a deviation as a percentage of the desired density. Five percent of the density of 1.80 is 0.09; five percent of a density of 0.80 is 0.04. The visual effect is approximately the same.

You haven't said anything about dryback.

Good point. When ink dries, some of the vehicle soaks into the paper, the surface of the ink film becomes less glossy, and the paper begins to show through. The result may be a reduction of density as compared to the wet sheets. Different papers and inks show different degrees of dryback. Antique finish papers generally show more dryback than a closed (non-absorbent) coated surface. With a little experience, one can anticipate the amount of density change that will occur on drying.

Why use logarithms?

There are several reasons for this. First, a logarithm will express a very small reflectance in a relatively accurate manner. For example, a density of 2.00 is represented by only 1 percent reflectance. In a circuit that responds logarithmically to a signal, the gain or effective "volume control" is turned up automatically when the "music" being heard is of low intensity.

Secondly, we tend to see equal density differences as equal visual effects – within limits. Equal density differences are equivalent to equal ratios of reflectances. A density difference of 0.30 is equal to a reflectance ratio of 2 to 1 or 1 to 2. The higher density would have the lower reflectance so it is easy to figure out which way the ratio goes.

Thirdly, in the printing industry, we print with layers of ink on paper or plastic or whatever substrate that is involved. The thickness of the film of ink affects the apparent color of the ink on the paper, especially if the ink is transparent. It also affects the mechanical aspects of the printing process: trapping, dot gain, drying, offsetting, etc. It behooves the printer to control this ink film thickness to help control all of the preceding variables, any of which, if out of acceptable limits, can ruin a printing job or at least make life miserable. The logarithmic response of a densitometer gives a result that for a given transparent ink, is very approximately proportional to ink film thickness. Thus with a specific ink, the choice of a running density pretty well pegs the ink film thickness being used.

Can different densitometers be cross calibrated?

Yes, but with care. If a different filter set is used, a pair of different densitometers can be cross calibrated by adjusting the gains of each of the channels so that the readings of the two instruments coincide. In general, this will work for the same set of inks and then for only limited ranges of densities. If a sophisticated densitometer is "forced" to track another, the derivative computations may be in error.

I think I know a little more now. How soon should I expect improvement, if I were to start using a densitometer?

It's not an overnight cure. There is a learning process which will vary with the acceptance and desire of the user. Start using the instrument and in a few weeks, it should become a habit and the benefits of the resulting color control and reduced makeready time will become self-evident.

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Printing Impressions