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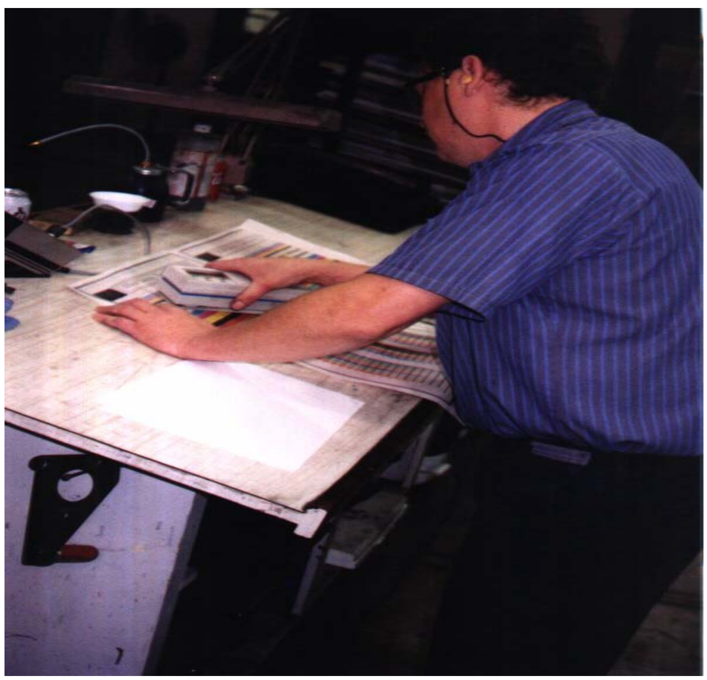
HOW DOES A DENSITOMETER WORK?



Volume IX

In order for correct print color reproduction to remain consistent throughout a run, it is primarily dependent on the following factors; ink film thickness, dot size, registration, and ink trapping. Most of these factors can be measured with a densitometer. With use of a densitometer, a press operator will have greater control of the color throughout a run. In order to gain a greater understanding of the densitometer, it is helpful to have the knowledge of how one works.

The eye is a very sensitive and a good comparison device. It can perceive density and shade variations and compare them to a known calibration standard that identifies these specific color standards. It cannot however, assign precise numerical values to those variations. A densitometer, on the other hand, can assign numbers to the density variations the eye perceives by quantifying the amount of light that is reflected from the surface of a printed sheet. The densitometer cannot be used to measure color differences. It is strictly a device to measure the optical density of the process colors of a printed sample.

Densitometers are used for quality control in printing. Measurement is primarily concerned with the process colors of cyan, magenta, yellow, and black. The light emitted by the densitometer is white light. White light consists of the three primary colors of light, red, green, and blue. When the proportions of these three primary colors of light are approximately equal, the eye will perceive this light as white light.

A densitometer, in order to measure a printed sample, will produce light from a stabilized source (1) (See Figure 1). The light passes through a lens (2), where it is focused on the printed surface. Depending on the film thickness and the pigmentation of the ink involved (4), part of the light is absorbed. The non-absorbed content of the light is reflected by the surface of the printed stock. A lens system (5) now captures the reflected light returning from the ink film at an angle of 45 degrees to the light source, and focuses them into a receiver (Photo Diode) (6).

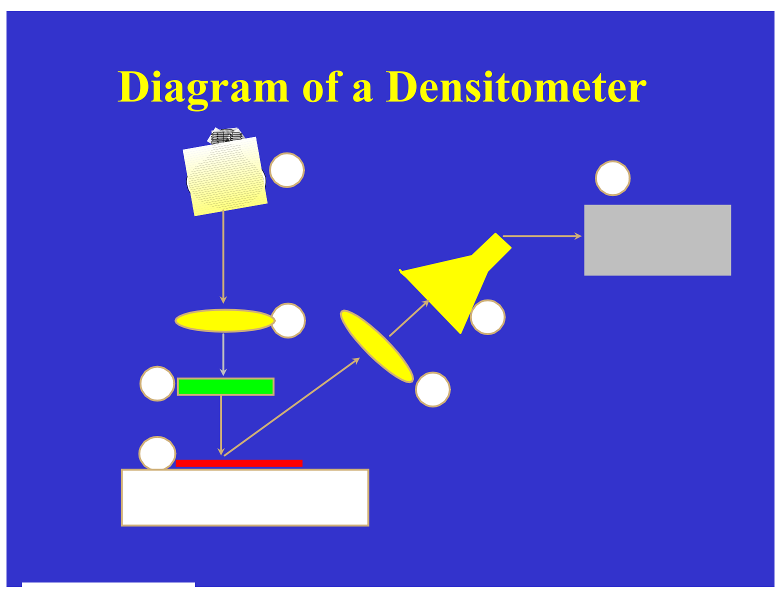


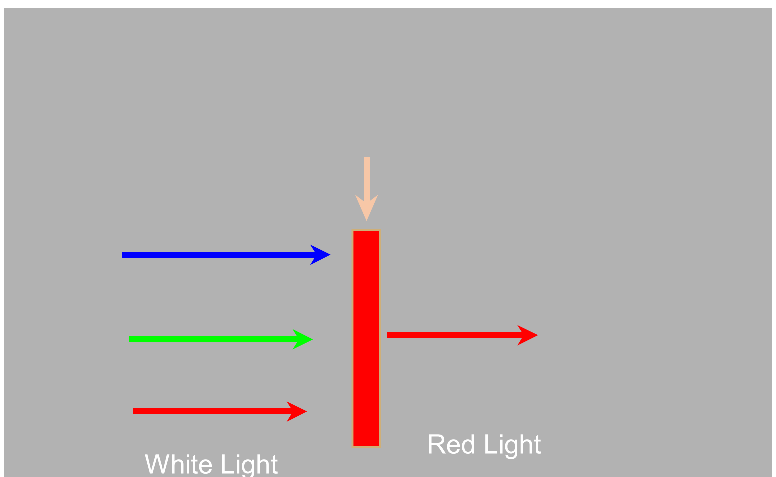
Figure 1

The quantity of light received by the photo diode is converted into electricity. The electronics of the densitometer now compares this current with a reference value (white). The difference obtained is the basis for calculating the absorption characteristics of the ink film being measured. The results of this show the value an operator will see on the densitometer display. Color filters (3) in the light path restrict the light to the range of wavelengths in question.

Different densitometers utilize different filters to measure their responses. In the US, it has been the custom to use the wide band or Status T filters. Several different types of filters are available. The filter set being used must be clearly stated when communicating any densitometer values, or there will be differences in the numerical values.

The printing ink to be measured (cyan for example) affects the light like a color filter. Color filters possess the property of allowing their own color to pass through and absorbing or blocking the light of the other colors. The mixture of arriving light colors of blue and green will produce cyan. These blue and green light contents are able to pass through the ink film unimpeded and reach the white surface of the paper before being almost completely reflected. The red light content, on the other hand, is absorbed by the cyan ink film to a greater or lesser degree. Consequently, depending on the pigmentation and the ink film thickness, only a relatively small proportion of the red light content is reflected. The eye perceives this reflected light as cyan, which consist of mainly blue and green components.

For measuring the ink density, however, only the smaller, red content of the light, which is strongly influenced by the ink film thickness, is significant. For this reason, a filter (see Figure 2) is inserted in the path of the light, which holds back the blue and green light contents. This allows only the red light content relevant for measuring the cyan color to reach the photo diode of the receiver. It is important to understand that the densitometer does not see color only light. Therefore, the other colors of light must be filtered out to achieve an accurate measurement on a sample. Depending on the type of instrument involved, the color filters are placed in the path of the light either before or after the measuring specimen.



Ink Color	Color Absorbed	Color Reflected
Cyan ink	absorbs red	reflects blue & green
Magenta ink	absorbs green	reflects red & blue
Yellow ink	absorbs blue	reflects red & green

Figure 2

The ink density values that are shown on the instrument display are always expressed as logarithmic numbers. As the logarithmic density values increases, the amount of available light decreases. 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 only 10% of the incident light is being reflected. A density of 2.00 indicates only that 1% of the light has been reflected. This is shown in graphical form in Figure 3.

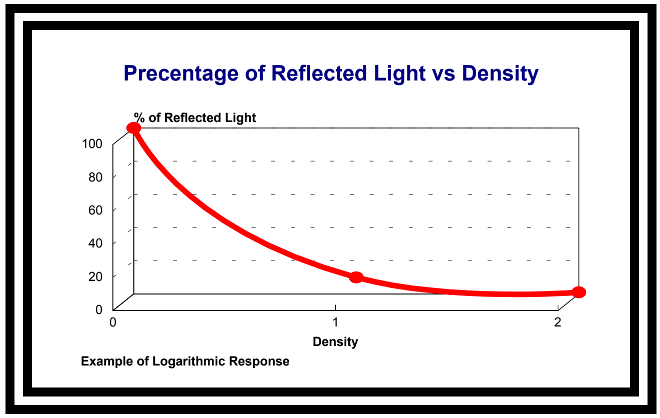


Figure 3

The densitometer is designed to adapt the density measurement to the peculiarities of the human sensory perception. The human eyes and ears evaluate optical and acoustic stimuli on a logarithmic scale. This means that the uniformly rising intensities are not perceived as uniformly rising. For example, if an observer is looking at a light table, where the glass top is being illuminated by a fluorescent bulb, he then perceives a light of certain intensity. If a second fluorescent bulb of equal brightness is now switched on, then although twice the amount of light energy is striking the glass top of the light table, the observer will not perceive the new energy level as double the first. Further doubling of the energy would be perceived to an even lesser degree. The more often the light energy is increased, the less the increase is perceived.

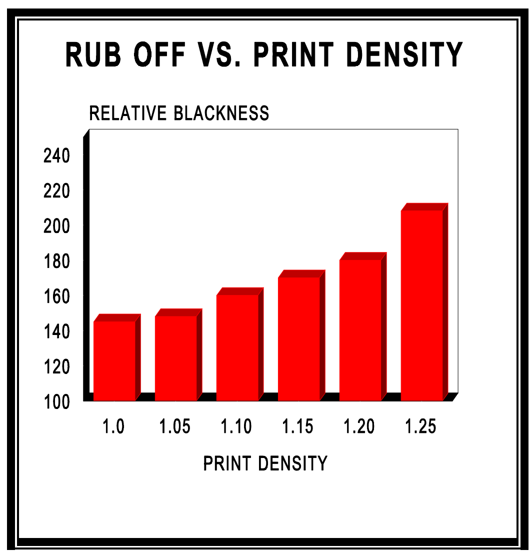


Figure 4

These logarithmic differences are extremely important to understand when setting color on press. The logarithmic increase in visual perception relates to the amount of ink on press to achieve this level of perception. What this means is the level of ink will also have to be increased on a logarithmic scale to achieve higher press densities.

To illustrate this point in the printing world, an excellent example would be to look at how rub-off is affected by the print density. The amount of rub-off of a newspaper print is highly dependent on the print density or the ink film thickness. As can be seen in Figure 4, this varies exponentially with film thickness and becomes particularly bad when the density exceeds 1.10.

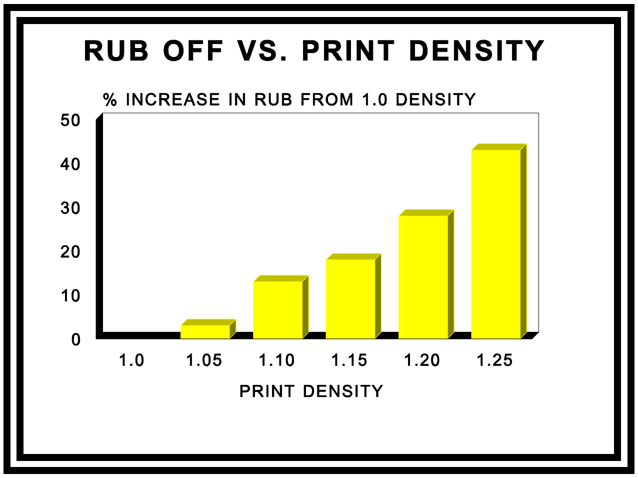


Figure 5

Figure 5 lists these values as a percentage increase in terms of rub-off from a print density of 1.0. As you can see, if you raise the print density from 1.0 to a density of 1.25 (an increase of 25%) the rub-off of the printed sheet increases approximately 45%. The drying or setting process for newsprint is by absorption, and as the volume of ink is increased, the newsprint can only absorb a fixed amount. Therefore more ink will remain on the surface to rub-off.

In addition to the adverse effect on rub-off, higher print density has other consequences leading to poorer ink mileage. This relationship is illustrated in Figure 6, where it can be seen that very little increase in density is achieved when excessive amounts of ink are printed. For example, an increase in print density of 20% (from 1.0 to 1.2) requires an ink film weight increase of 58%. This film weight percentage increase is over double the percentage of the print density change.

INK FILM WEIGHT VS. DENSITY

DENSITY	FILM WT.	% INCREASE
1.00	115	---
1.07	128	11
1.14	151	31
1.22	182	58
1.30	200	74

Figure 6

A densitometer, like any other instrument, will not work properly unless it is calibrated. If the instrument is not using traceable calibration references, each instrument is its own system. One unit will not relate to another. The values obtained with a non-calibrated densitometer will not accurately reflect the variability of the process being monitored. Calibration of a densitometer is simple. In calibrating the instrument, a value for the Azero point”, or low end response, is established first. Then a Ahigh end@ point is set. In setting these two points a slope between them is established, thus allowing for accurate measurements. Besides the calibration plaques offered by the densitometer manufacturers, a AT-Ref J @ is available from the Graphics Communications Association (GCA), which is a printed reference used to verify that a densitometer is truly a Status T response unit.

In today's times of rising costs it is easy to see the functionality of the densitometer in the press room. A densitometer will not have Aeye fatigue@ problems where the human eye becomes "accustomed to@ looking at a subject. When the human eye does this, it becomes less sensitive to changes. The densitometer is easily one of the most important instruments in the pressroom environment. Without it, problems beyond the rub-off mentioned above, such as set-off, pipe roller build up, tracking or marking, and color balance would be difficult to control. Much of the printing done today without this tool would be severely hampered, and production costs would skyrocket.