Applied Densitometry

Gretag Color Control

Third Edition

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Table of Contents

INTRODUCTION

When describing a printed piece, the following factors can be expressed numerically; size in inches, number of pages, run quantity, deadline in days or hours.

However, for a long time there was no criterion for assessing the actual print quality.

Besides the criteria like hickeys, scumming, tinting, scratches, register, etc. the print quality is assessed on the faithfulness of the dot and color reproduction, and its stability throughout the run.

The most frequent reasons for complaints are color variations between the proof and the printed piece, and color variations throughout the run.

Correct print color reproduction remaining consistent throughout the run, is primarily dependent on the three factors of; ink film thickness, dot size, and ink trapping. All of these qualities can be accurately measured with a densitometer. With knowledgeable use of the densitometer, the press operator has greater control of the color throughout the run, as well as from run to run. Standards can be established that are meaningful and helpful to both the printer and customer. For the minor expense involved, there are major advantages to using densitometers.

The densitometer is easily the most important instrument for process control in the graphic arts industry. Without it, much of the printing now being done would be severally hampered, and production costs would skyrocket.

COLOR BARS

The solid, halftone, and trap densities required for measuring quality are, as a rule, measured on a print control strip, or color bar, printed on the tail edge of the sheet.

There are many color bars available to the printer. Good color bars should contain both mechanical patches (used in conjunction with the densitometer) and visual elements (used by pressman for visual assessment).

Mechanical

Solid Tone Patches:

For the measurement of density, hue error and greyness.

Halftone Patches:

Used for the measurement of dot gain and contrast. The 80% and 40% screen tints are best for production printing. The 75% and 50% tints may be used as well. 150 lines per inch is recommended.

Trapping Patches:

Used for the measurement of trapping. Should contain solid overprints of (C&M), (C&Y), (M&Y) for use with the densitometer.

Visual

Slur/Doubling Elements:

Used to detect slur and/or doubling occurring in the press. Should react quickly even to minimum slur and doubling, plus show the direction of slur or double.

Grey Balance Element:

Used for monitoring the color balance between yellow, magenta, and cyan. A neutral grey tone is produced if the color balance of the three basic colors is correct when overprinted. (If a spectrophotometer is used this can be measured.)

Plate Exposure Elements:

Used by the pressman to make sure that plates were exposed correctly.

HOW DOES A DENSITOMETER WORK?

The eye is a very good comparison device. It can perceive density variations and compare them to a known calibrated standard that identifies specific density levels. It cannot, however, assign specific 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 press sheet.

The densitometer is used to measure the light that would normally be reflected from the surface and reach the eye. A minimum of reflected light results in a high density, in other words the sample absorbs a good deal of light.

Densitometers are used for quality control in printing. Measurement is primarily concerned with the primary colors of cyan, magenta, yellow and black.

The light emitted by the light source consists of the three light colors of red, green, and blue. Since the proportions of these three colors are approximately equal, we perceive this light as white light.

From a stabilized light source (1), (see Figure 1) the light passes through a lens (2), where it is focussed to fall on the printed surface. Depending on the film thickness and the pigmentation of the ink (5) involved, part of the light is absorbed. The non-absorbed content of the light is reflected by the surface of the printing stock. A lens system (6) now captures those light rays which are returning from the ink film at an angle of 45 degrees to the measuring ray, and passes them to the receiver (photo diode) (8).

The quantity of light received by the photo diode is converted into electricity. The electronics (9) now compare this measured current with a reference value (white). The difference obtained is the basis for calculating the absorption characteristics of the ink film being measured. The result of the ink film measurement is shown on the display.

Color filters (4) in the ray path restrict the light to the wavelengths relevant for the printing ink in question. In addition, top quality densitometers incorporate polarization filters (3) and (7) in the path of the ray, in order to prevent significant differences in the measured values obtained from dry and wet printing ink, plus improve intra-instrument agreement and trapping values.

The printing ink to be measured (cyan for example) affects the light rays like a color filter (color filters possess the property of allowing their own color to pass through and absorbing or blocking the rays of other colors). Since the mixture of the arriving light colors blue and green produces 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

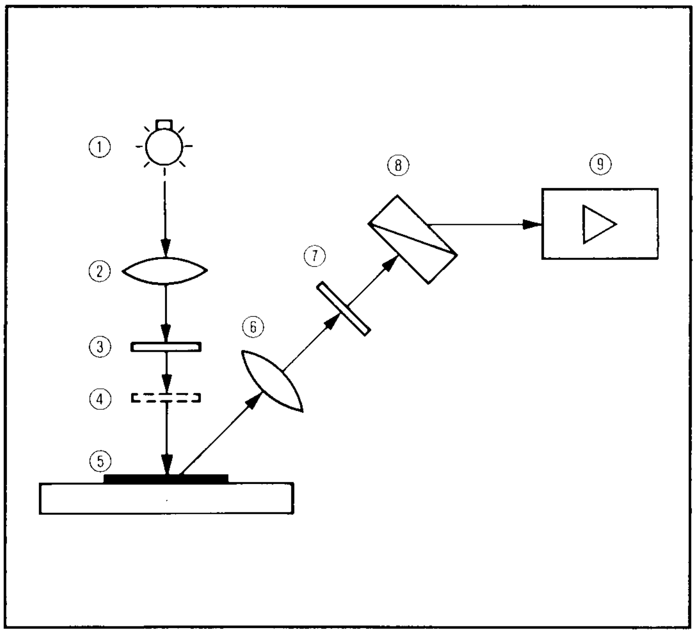


Figure 1

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 consists mainly of blue and green contents.

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 is inserted in the path of the rays, which holds back the functionally superfluous blue and green light contents and allows only the red light content relevant for measuring the cyan color to reach the photo-diode of the receiver. Depending on the type of instrument involved, the color filters are placed in the path of the rays either before or after the measuring specimen. Special colors are measured using the filter with which the highest measured value is achieved. Use the visual filter for dark colors.

Ink density values are always expressed as logarithmic numbers.

As the logarithmic density values increase, 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 1%, etc.

This conversion is designed to adapt the density measurement to the peculiarities of the human sensory perception. Human beings evaluate optical and acoustic stimuli on a logarithmic scale. This means that 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, then he perceives a light of a 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 level would be perceived to an even lesser degree. The more often the light energy is increased, the less the increase is perceived.

Consequently, for a press operator to print black enough to get a densitometer reading higher than about 2.00 when printing black ink is quite risky. Set-off is more likely, and gains in density are extremely small. Even if the measurement were to be taken in the full ink container, the density would not be much higher.

When reading color bars with an densitometer, the appropriate complementary filter must be used. By using the complementary color filter, the image seen by the densitometer is reduced to black. The ink removes one of the three complimentary colors and the complimentary filter removes the other two.

Filters

Many filters can be used in reflection densitometers, but in the graphic arts industry in the U.S. it has been the custom to use wide band filters.

European printers have been using the narrow band filters which have maximal response to peak absorptions of process inks. They are highly sensitive to yellow ink, so that a smaller change in the ink amount indicates a larger density than would be expected on wide band densitometers. (see Figure 2)

This situation would be similar to making a measurement with a ruler graduated in inches and then making the same measurement using a ruler graduated in millimeters. The object measured remains the same, but the two measurements are different.

Narrow-band readings for yellow ink will produce larger density differences for smaller differences in ink film thickness. This indicates that the narrow-band densitometer has more sensitivity to yellow ink than a wide band densitometer, meaning that a tolerance of +/- .05 variation with a wide-band densitometer might indicate a +/- .08 range of acceptance with a narrow-band densitometer.

The filter set being used must be clearly stated. When communicating any density, hue error and/or greyness values.

Polarization Filters

Most top quality densitometers use polarization filters to eliminate the measured density difference between wet (glossy) and dry (matte) ink. They filter out the stray light of the dry ink reading and make it as dense as that of the wet ink. While the eye can detect the difference between wet and dry ink density, a polarizing filter minimizes the measured difference. Dry ink density readings from polarized and unpolarized densitometers will therefore not agree.

Polarization filters also aid in the linearity between densitometers. In other words, if multiple densitometers are in use in one plant or at sister plants, they will produce consistent readings. Better trapping values are noted because polarization filters eliminate the surface reflection of the first printed ink.

DENSITY

Color is a sensory perception, and can be perceived only in conjunction with light. The light penetrates into the transparent color of the ink film, and when passing through the ink continuously strikes against pigments, which depending on the ink film thickness and the pigment concentration absorb a greater or lesser part of certain wavelengths of the light. The light rays finally reach the white printing stock surface, by which they are reflected back. After travelling back through the printed ink film, that proportion of the light which has not been absorbed by the ink, re-exits. It is this part of the light which is perceived by the eye of the observer, and forms the assessment basis for color saturation.

A thick film absorbs a lot of light, and consequently only a small quantity of light is reflected; the observer sees a dark hue. A thin layer absorbs less light, thus more light is reflected; the hue appears lighter.

There is a close correlation between ink film thickness and ink density. The absorption behavior of an ink film depends on the hue, the ink film thickness, and on the nature as well as the concentration of the printing ink pigmentation. Since, however, the color location (hue) for process colors is standardized, and the pigment concentration for these colors is also specified within a certain framework, only the ink film thickness remains as a variable which can be influenced by the pressman.

Less light is reflected as more ink is put on a sheet, causing the density value to increase. Because of this relationship, density values are used to control the amount of ink put on paper.

Remember that solid ink density does not indicate printing quality, but only indicates how much ink is being applied to a sheet across the width of the fountain.

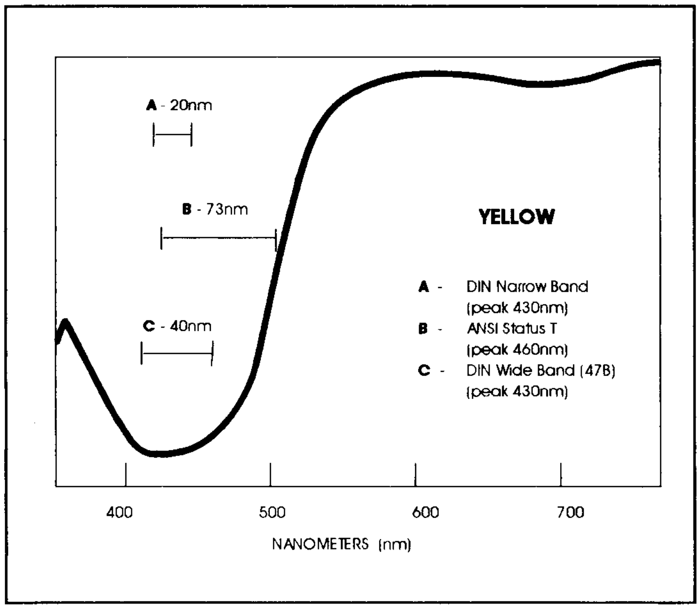


Figure 2

DOT GAIN

Dot gain is the increase in the size of a halftone dot from the time it is created on the halftone negative until it is finally printed on paper.

Uncontrolled dot gain is ultimately to blame for much of the waste in offset lithography. When printing black and white or color halftones, dot gain can change picture contrast and cause loss of definition and detail. In the printing of process color, dot gain can lead to similar loss of contrast and depth, plug up screens, and cause drastic color changes.

Dot gain that varies throughout the pressrun can severely change color. A pressman prints process color to produce certain overprint colors made up of differing dot sizes of cyan, magenta, and yellow. If the dot size of one printer changes in the midtones, ex. magenta increasing 4%, there can be a significant color shift; skin may turn red, neutrals may become pink, greens may get dirty, and blue skies may turn pink. The pressman may need to adjust inking to make the printed result look consistent, even though his solid ink density (SID) is lower. Lowering the SID too much can ruin color saturation.

People will be more critical of hue change than they will of a change in ink amount or SID. Overprint hue changes are caused by unequal changes in SID or dot gain or trapping in one or more of the colors. Monitoring and measuring the midtone dot areas may be far more important than only measuring solid ink density. The solid ink density is effected primarily by ink feed and dampening, where as the dot gain is also effected by these two factors plus pressure, blanket conditions, press capability, and paper.

Effects of Paper on Dot Gain

Pressman often say they can't get as much ink on a poor grade of paper as they can on a coated paper, because it plugs up if the ink is increased.

The gloss of the ink on better quality paper gives a high solid ink density. Most poorer quality papers have a rough, uncoated surface, which absorbs and allows the ink to spread producing dot gain. Absorbed ink will also not allow you to produce a glossy printed surface. In an attempt to achieve more SID, on poor quality paper, the pressman adds more ink which increases dot gain without significantly increasing density in the solids. By monitoring dot gain this can be controlled.

Screen Ruling and Dot Gain

A 65 line screen has almost no dot gain, while a 150 line screen has considerable dot gain. It would be questionable to increase the ruling to more then 150, because in most cases it would cause extreme dot gain. Some printers are capable of printing finer screen rulings, but only with special attention to stock, blankets, ink viscosity, tack, and critical ink and water balance. When printing too fine a ruling, pressman have to keep midtones and shadows open by reducing the SID. Using too fine a screen ruling or a certain paper and ink type will not help print quality.

If controlled, dot gain is not necessarily bad, which is just as well, because dot gain is inherent to every printing process.

Optical Dot Gain

When screens are measured with a densitometer it is not the geometrical (actual) area of coverage, i.e. the area ratio between dots and paper white, which is measured. Due to light absorption, it is the optically effective area of coverage which is measured. The difference is that, both in visual observation and also in densitometric measurements (45 degree measuring angle), a part of the arriving light penetrates into the paper between the dots at the unprinted points. This light is trapped under the dots during reflection and, according to the densitometer, absorbed. (see Figure 3)

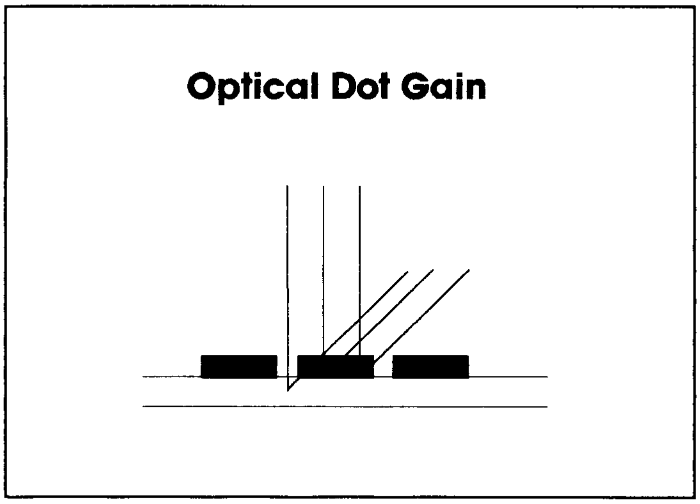


Figure 3

The result is that the dots, and thus the area of coverage, appears optically larger. The optically effective area of coverage then is made up of geometrical (actual) plus optical gain.

Dot gain is one of the most important measured values for quality control and standardization in printing. Printing without dot gain is not possible, both for technical reasons and due to the effect of light entrapment (optical gain).

When reporting dot gain values it is important to include the halftone value of the film (on color bar) where the measurement was made.

Summary

Solid ink density must be optimized to best control dot gain. This will cause an acceptable level of dot gain for a given set of conditions. Decreasing solid ink density may decrease dot gain but it will certainly weaken saturated and overprint colors.

Attention to the possible variation of color during a long run requires a high level of awareness, concentration and strain. Some jobs are relatively loose in their requirements for acceptable variation, while others may have both a highly critical customer as well as color combinations that are highly sensitive to relatively small changes on press. The objective monitoring of density and dot gain throughout the run makes color quality less dependent upon the skill, mood, and health of each press operator.

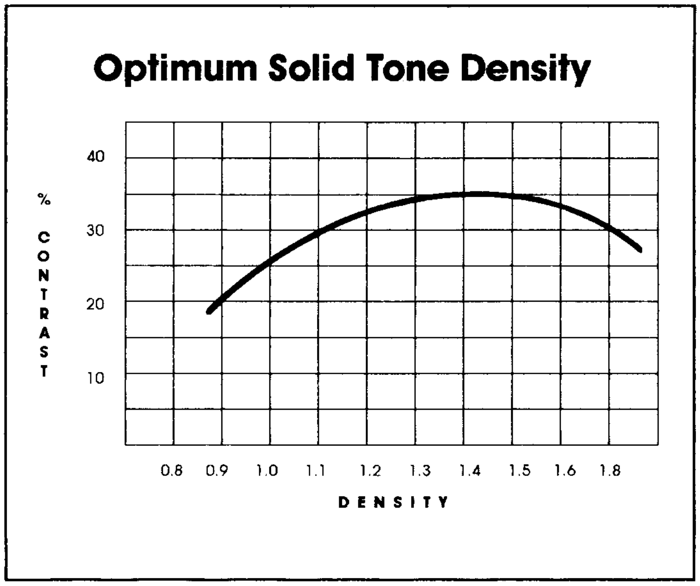


Figure 4

CONTRAST

The relative print contrast is calculated from the measured values of the solid ink density and the screen ink density in the shadow area. The figure thus obtained expresses the amount of contrast between solid and screen.

A print should have as high a contrast as possible, i.e. the solids should have a high ink density, but the screen should remain open. The printed dots form a contrast to the solid. When the inking is increased, with an accompanying rise in the density of the individual dots, the contrast is increased. The increase in ink feed, however, is desirable only up to a certain point. If the ink film thickness is increased still further the dots tend to exhibit gain, and thus, especially in the shadow areas, tend to fill in. This reduces the proportion of paper white, and the contrast decreases.

The relative print contrast is used for checking the dot quality in the shadow areas. For example, if the contrast value deteriorates during a production run in spite of constant ink density, this may be a sign that the blankets need washing. (Reading shadow dot gain will also allow this control.)

In addition, the contrast value can be used to assess (given an identical ink density) various factors which influence the print result. For example; printing pressure, blankets, dampening, printing inks and additives, etc.

Contrast can be used to find the **OPTIMUM SOLID TONE DENSITY (OSTD)** for each process color. (see Figure 4)

As the density is increased, the % contrast also increases. When the % contrast has reached its peak, you have pinpointed the OSTD of that particular color on that particular paper. As the density is increased further, the % contrast decreases, showing the reduction in contrast between the ink and paper white.

PRINT CHARACTERISTIC CURVE

The dot gain in your printing situation can be compensated for when the separations are made, if they are tailored to your needs, not those of other printers with different printing conditions. If the separations have too much printing dot in the midtone and highlight areas for your printing conditions, they need to be sharpened by making film contact negatives or by over exposing positive plates. Changing the inking on the press will not correct highlights that are to dark.

If your printing conditions are consistent you can plot your print characteristic curve and adjust your screening curves of the separations for your dot gain.

To calculate the print characteristic curve, one must print screen step scales (as found on a UGRA plate control wedge). Then use a densitometer to measure the ink densities in the solid and in the screen steps, and calculate the dot area. When the figures thus obtained are plotted on the diagram above the corresponding film values, we obtain the print characteristic. It is only valid for the particular combination of ink, paper, blankets, and press for which it was calculated. If the same job is printed on another press, with different paper and ink, then a different print characteristic will be obtained each time (see Figure 5). For determining the dot gain in print, the middletone range is the most significant.

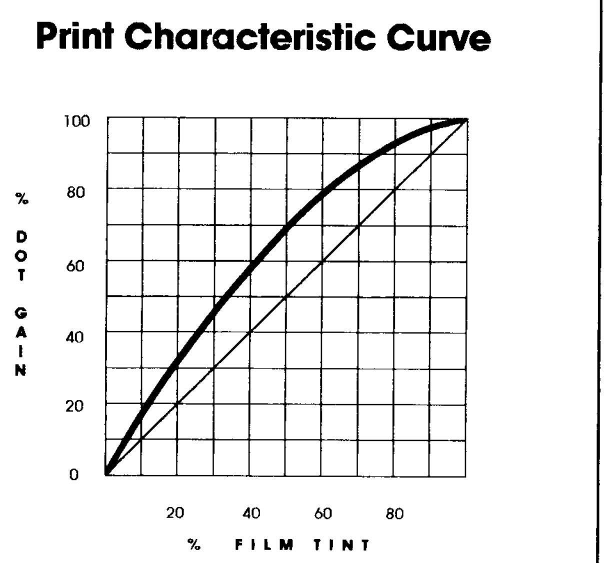


Figure 5

One of the objectives of standardization is to determine standard values for dot gain in all presses, subdivided into paper groups, and to take this standard dot gain into consideration when producing the film. The task of the pressman here is to monitor the dot gain value and to maintain it inside the standard range.

TRAPPING

Trapping is the ability of a wet ink film to grasp and hold a second film that is printed over it. It's like putting the second coat of paint on a wall. If it doesn't stick, the results will be disappointing.

Ideally, you hope to trap one ink with another as efficiently as you trap that ink with paper. Good multicolor printing depends on it. Unless inks are overprinted properly and combine their characteristics in just the right proportions, your colors will be off.

We evaluate or measure trap in terms of percentage. A high percentage is "good" because it gives the desired color. A low percentage, which gives uneven color, is considered "poor". A high percentage of trap requires the right balance of three factors: Tack, Absorption, and Time. Tack is a matter of ink. Absorption depends on paper. Time is related to press speed.

It is important to keep these factors in mind, for when a trapping problem occurs, it can usually be traced to one or more of them.

Tack

The main determinant of tack is ink. With graded tack inks, tack value is built in. But with uniform tack inks, it must be built up and, consequently, is as much of a function of paper absorption and press speed as it is ink itself. Trapping problems often occur when it is assumed that uniform tack inks will trap "automatically" and the paper and press influences are ignored.

It's well to remember also that tack can be affected by temperature, fountain solution, and ink film thickness.

Absorption

Absorption is mainly a function of paper. Its surface and overall structure permit the solvents to drain from the ink, allowing the tack to build up.

But paper has additional jobs to do, such as providing a smooth, tight surface for high ink hold-out. Graded tack inks trap well on a wide range of papers with varied absorption characteristics. Uniform tack inks, however, which depend on rapid drainage in order to develop tack, usually require a paper with a surface that is more open.

Note that blankets play a role here, too: as they vary in the rate that they absorb solvents during a run, each will effect the trapping process differently.

Time

Time is a press factor. With increasing press speeds, particularly on common impression cylinder presses, there is often inadequate time for uniform tack inks to build sufficient tack for good trapping. These inks are run more successfully on a unitized press, which provide a full second or more of dwell time in comparison with the 1/8th second provided by the common impression cylinder press.

The time factor can explain why the production run often fails to match the quality of proof sheets, even when the run has the same inks on the same paper. If the type of press or the speed of the press at which it is run varies, so might your results.

HUE ERROR AND GREYNESS

Hue error and greyness are parameters for the control of the three process colors in printing; cyan, magenta, and yellow.

Both values allow the comparison of two printed inks in regard to their grey level and hue shade.

The hue error and greyness values are relevant for inks, which do not correspond exactly to a defined color standard. They allow a rough comparison of the inks from different manufacturers or between different deliveries of ink from the same supplier. Checking if Hue Error and Greyness changes during the print run due to dirt or other inks is another application.

"Ideal" printing inks for process colors are what is called "two-third inks". This means that each of the process colors absorbs one-third of the spectrum and reflects two-thirds.

In other words:

> ***CYAN*** *absorbs red and reflects green and blue*
> ***MAGENTA*** *absorbs green and reflects red and blue*
> ***YELLOW*** *absorbs blue and reflects red and green*

"Ideal" printing inks meet a second requirement: the two reflected thirds of the spectrum are in a mutually balanced ratio. For an "ideal" magenta, for example, the reflected "red quantity" would have to correspond to the "blue quantity". "Ideal" process color printing inks under this definition are not commercially available, since they cannot be manufactured. All existing inks deviate from the ideal to a greater or lesser degree, whether intentionally or not.

Under the GATF definition, hue error and greyness can be quantified by measuring a process color with the three color filters, red, green, and blue, used in densitometers. If the ink densities measured with the "wrong" color filters are higher than a density of 0.00, this demonstrates the "impurity" of the color.

Hue Error

The hue error is a measure of the deviation of a process color from the "optical equilibrium" of the two-thirds of the spectrum which it reflects. A hue error of "0" signals "optical equilibrium". Deviations from "0" show an indication of one of the thirds.

If the hue error for magenta was 100%, for example, then the color would be red, not magenta. This leads us immediately to the ideal values of the hue error for overprints of red (M & Y), green (C & Y), and blue(C & M). In the "ideal case" they are 100%. To achieve this, however, all primary colors would have to exhibit a hue error of "0", ink trapping would have to be 100%, and the ink film thickness of the individual colors would have to be equal.

Greyness

Here too, the process color printing inks are measured against the "ideal state", in which they should absorb one-third of the spectrum and reflect two-thirds. If they were to do this perfectly, then with the complimentary filter an infinitely large color density would be obtained, and with the two other filters a density of 0.00. As already mentioned, printing inks of this quality do not exist.

If the two ink densities measured with the two "wrong" color filters are equal, then the hue error is 0%, but this does not mean the color is pure. The measured values in our magenta example show density values with all three color filters, including the two "wrong" filters, indicating color contents of blue and red behind filters for cyan (red) and yellow (blue). These equal contents, together with the magenta, add up to a grey, meaning that our magenta is greyer then the "ideal" printing ink . The unit for being "greyer" is defined as greyness (%).

Another parameter which is of influence to the values measured is the type of filter system being used, i.e. Status T, DIN Wide band (47B), and DIN Narrow band (glass interference filters).

That means, that only process colors can be compared in Hue Error and Greyness, if they are measured with densitometers with the same filter set.

In practice, every color will exhibit hue error and greyness. Hue error and greyness values for SWOP (Specifications for Web Offset Printing) colorants are as follows:

FOR STATUS T FILTER SET:

	Cyan	Magenta	Yellow
Density	1.21	1.30	0.99
Hue Error	22%	48%	7%
Greyness	9%	12%	1%

FOR 47B FILTER SET:

	Cyan	Magenta	Yellow
Density	1.25	1.32	1.31
Hue Error	21%	45%	5%
Greyness	10%	3%	0%

FOR NARROW BAND FILTER SET:

	Cyan	Magenta	Yellow
Density	1.25	1.35	1.45
Hue Error	15%	39%	2%
Greyness	13%	5%	0%

USE OF A DENSITOMETER TO CONTROL AN IMAGESETTER

When outputting graphics on a imagesetter, many operators find that the dot percentage they requested is not the actual percentage they measure with a densitometer on film. For example, if a 35 percent halftone tint is requested, the actual percentage may be different, sometimes by as much as 10 percent to 20 percent. Tints may therefore appear darker or lighter than anticipated, and any color separation work will have variations in the resulting printed color.

If a graph was made of requested versus measured dot percent in an imagesetter with densities running too high, it would look like Figure 6. The measured values are higher than the requested values, so the curve moves upward. Figure 7 shows the requested versus measured dot percent after the imagesetter's density setting was corrected. The requested values match the measured values exactly, resulting in a straight line.

Conditions such as the type of film being used, the state of the chemicals in the processor, and the intensity setting of the laser all play a role in the final size of the halftone dot.

If the chemicals in the film processor are particularly weak, then the image may not properly develop, leaving a somewhat shrunken halftone dot. On the other hand, on the day the processor is cleaned and the new chemicals are put in, the images may overdevelop, and, as a result, the halftone dots may be larger than

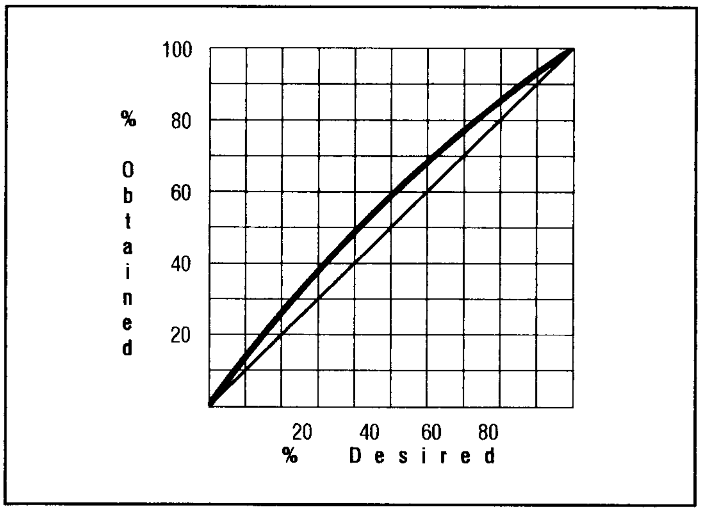


Figure 6

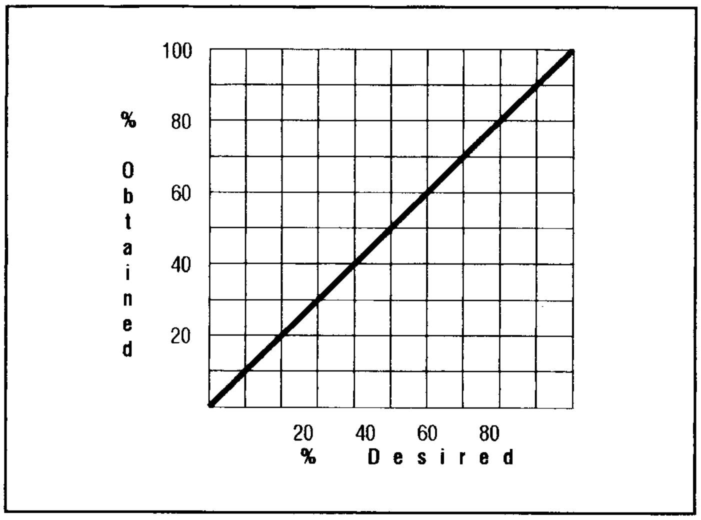


Figure 7

expected. This same effect can be a result of changing the intensity of the laser or even by changing film materials. How is it possible to know how the laser, film and chemicals are reacting on a specific day? The answer is *to measure the density - the darkest black - on the film with a transmission densitometer.*

A densitometer that measures both density and dot percent is required for tint and halftone work. For accurate tint and halftone reproduction most users output to film. Paper is not as accurate a media for tint and halftone work and imagesetter control.

Most imagesetters have density for each resolution, which controls the exposure of the laser on film or paper. Don't confuse these density settings with the actual density number read from the densitometer. The density settings on the imagesetter control the intensity of the laser and therefore, only indirectly affect the final density that will be read on film or paper.

As long as the film processor and film material remain constant, density settings may be used to control the maximum density - the darkest black, (referred to as D-max) on film. Remember that these settings will be different for film and paper. Therefore, if both are being run in a single machine, the density settings will have to be adjusted when changing materials.

Use the existing settings to start and then change them as necessary. It will be useful to keep a chart of the numbers near the machine to see how the numbers change over time. A test has to be run for each material and resolution setting. There may be some variation from lower screen rulings to higher screen rulings, but unless the work demands absolute accuracy, tests do not have to be run for each screen ruling. Select the most common screen ruling for these tests, such as 133 or 155 lines per inch.

CONCLUSION

The preceding pages have provided only a brief insight into quality control in printing, and explained the basic principles of measuring image quality. In production printing, density, dot gain, and trap are the most important values.

Familiarity with these basic principles is essential for performing quality control work with a densitometer.

When using a densitometer, the pressman must always remember that densitometric measurement is only one asset of quality control, and cannot replace a visual inspection by an expert.

Evaluation of the measured results also requires expertise of the operator. When deviations or errors are detected, he should be able to recognize the cause and take the appropriate corrective action.

This manual provides some building blocks for a complete color quality control system. The next step is to incorporate this data into a full statistical process control program.

FORMULAS FOR COMPUTING:

DOT AREA/DOT GAIN (Murray Davies):

$$\frac{1 - 10^{(Dh)}}{1 - 10^{(Ds)}} \times 100 = \textbf{\%DOT AREA}$$

% Dot Area - % Film Tint = % DOT GAIN

Dh = *Density of halftone.*

Ds = *Density of solid.*

PRINT CONTRAST:

$$\frac{(Ds) - (Dh)}{(Ds)} \times 100 = \textbf{\% CONTRAST}$$

Ds = *Density of solid.*

Dh = *Density of halftone (shadow area 75-80%).*

PERCENT TRAP:

$$\frac{(Dop) - (D1)}{(D2)} \times 100 = \textbf{\% TRAP}$$

Dop = *Density of overprint.*
D1 = *Density of 1st down color.*
D2 = *Density of 2nd down color.*

NOTE: *Filter of 2nd down color is used for all density measurements.*

HUE ERROR

$$\frac{(Dm) - (Dl)}{(Dh) - (Dl)} \times 100 = \textbf{\% HUE ERROR}$$

Dh = *Density with the highest value.*
Dm = *Density with the middle value.*
Dl = *Density with the lowest value.*

GREYNESS

$$\frac{(Dl)}{(Dh)} \times 100 = \textbf{\% GREYNESS}$$

NOTE: *The three density measurements are to be taken through all filters for the particular color being read, for example: when reading magenta take a density measurement through all filters, red (cyan), blue (yellow), and green (magenta). Modern densitometers do this automatically with one measurement.*

DENSITY REFERENCE GUIDE

	Color	*Density*	*Tolerance*	*Dot Gain 80&*	*% Tolerance*	*Dot Gain 40%*	*% Tolerance*	*% Min. Contrast*
High glossy paper	CYAN	1.45	+/- 0.10	9	+/- 2	14	+/- 3	35
	MAGENTA	1.40	+/- 0.10	9	+/- 2	14	+/- 3	35
	YELLOW	1.00	+/- 0.05	10	+/- 2	16	+/- 3	25
	BLACK	1.85	+/- 0.15	10	+/- 2	16	+/- 3	40
Coated paper	CYAN	1.35	+/- 0.10	10	+/- 3	15	+/- 4	30
	MAGENTA	1.30	+/- 0.10	10	+/- 3	15	+/- 4	30
	YELLOW	0.95	+/- 0.05	11	+/- 3	17	+/- 4	25
	BLACK	1.75	+/- 0.15	11	+/- 3	17	+/- 4	35
Uncoated paper	CYAN	1.20	+/- 0.10	14	+/- 4	21	+/- 5	25
	MAGENTA	1.15	+/- 0.10	14	+/- 4	21	+/- 5	25
	YELLOW	0.85	+/- 0.05	14	+/- 4	21	+/- 5	20
	BLACK	1.55	+/- 0.15	15	+/- 4	22	+/- 5	30

DIRECTIONS FOR PRINT CHARACTERISTIC CURVE

For use with a **GRETAG D183** or **D186** reflection densitometer and **UGRA Plate Control Wedge (PCW)**:

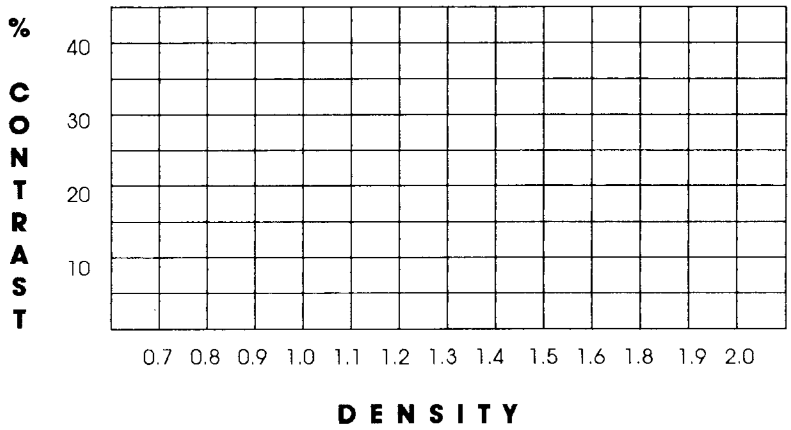
STEP 1: *Place scale on to the plate and expose it with your flat.*

STEP 2: *Check your **PCW** to see if you over- or under-exposed your plate (see "UGRA PLATE CONTROL WEDGE Direction for use" manual).*

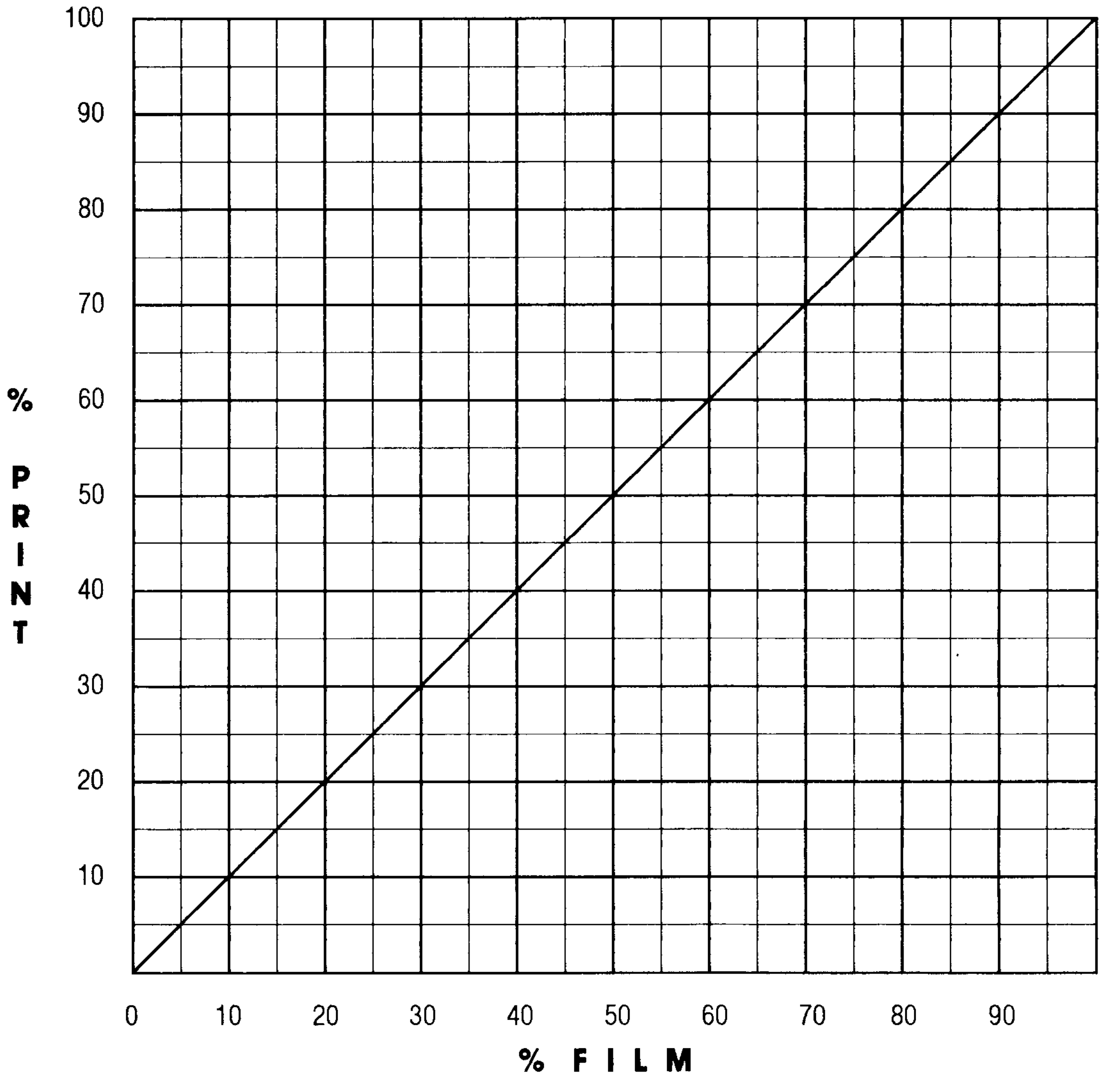
STEP 3: *Enter solid tone reference on **GRETAG D183** or **D186**.*
- *__zero__ the densitometer on to the paper.*
- *set function display __F__ to __Ref.__ (reference).*
- *measure solid tone (100%) of __PCW__.*
- *measured color and the density reference value should now be showing on the densitometer display.*

STEP 4: *Dot area measurement.*
- *set function display __F__ to __Meas.__ (measurement).*
- *set __Mode__ display to __Dot Area__*
- *densitometer display should now read 100%.*
- *measure the halftone patches 10%, 20%, 30%, etc. __(Tone Value Film)__*
- *mark on the graph __(Tone Value Print)__ the dot increase, and draw your curve according to your reference points.*

Optimum Solid Tone Density



Print Characteristic Curve



Gretag Color Control

PROCESS CONTROL FLOW CHART

PROCESS	PRODUCT	APPLICATIONS
Original Artwork	**D182R**	*Density range.*
Halftones and Separations	**D200-II**	*Film control (density and dot%).*
	UGRA PCW	*Exposure, contact, and processing control.*
Proofing	**D186**	*Proof control (density and dot gain).*
	SPM50	*Colorant control.*
	UGRA PCW	*Exposure, contact, and processing control*
	CMS-III	*Color bars for visual and densitometric control.*
	Measureprint and Colibri	*Data collection for display and reporting of averages, trends, deviations, future references, and SPC applications.*
Corrections/ Contacts	**D200-II**	*Film control (density, dot %).*
	UGRA PCW	*Exposure, contact, and processing control.*
Platemaking	**D186**	*Plate control (dot %).*
	UGRA PCW	*Exposure, contact, and processing control.*
	CMS-III	*Color bars for visual and densitometric control.*
Ink and Stock	**SPM50**	*Absolute color values.*
	COLIBRI	*Data collection for display and reporting of deviations, future references, and SPC applications.*
Pressrun	**D186/D181**	*Production control (density, dot gain, trapping).*
	SPM50	*Relative color values.*
	CMS-III	*Color bars for visual and densitometric control.*
	Measureprint and Colibri	*Data collection for display and reporting of averages, trends, deviations, future references, and SPC applications.*

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