Printing ink sequence:
Black - Cyan - Magenta - Yellow - PMS 375 - Metameric A - Metameric B

5mm 4 - color ©1996-1997 X-Rite Incorporated

ColorBasics

Density

Density—the primary control element used on press—is a measurement of light reflected off the press sheet. A densitometer measures ink density on a color bar, telling the press operator how to adjust the ink level. Proper density values are checked in each ink zone using a color bar or other areas of solid single-color ink.

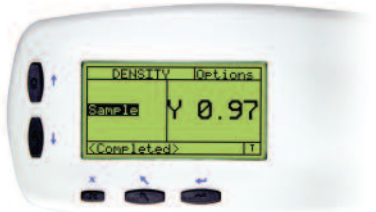
K C M Y

Status T

Status E

Status

Status refers to the kind of filters used in the densitometer. There are several different status filter sets, but Status T and Status E are the most common in the graphic arts. The difference between these two is in the filter used to measure yellow.



Aperture

Depending on the model of your color measurement instrument, a variety of aperture sizes may be available.

The X-Rite 500 Series has user-changeable round apertures in 2.0-, 3.4-, or 6.0mm diameters. A special factory-installed micro-spot aperture of 1.6mm X 3.2mm (rectangle) is also available. The X-Rite 939 and 938 Spectrodensitometers have user-changeable round apertures in 4.0-, 8.0-, and 16.0mm diameters.

2.0 x 3.2mm 4 - color © 2000 X-Rite Incorporated

Used for micro-spot 500's aperture ➡

3.2mm 4 - color © 2000 X-Rite Incorporated

Used for 2.0mm 500's aperture ➡

4.5mm 4 - color © 1996-1997 X-Rite Incorporated

Used for 3.4mm 500's aperture ➡

Tone value (dot area)

50% K, 50% C, 50% M, 50% Y, K, C, M, Y

Most of the detail in printed images is located in the tonal areas. To control the highlight, mid-tone, and shadow areas for each color, a color bar typically has 25%, 50% (40%) and 75% (80%) patches. Monitoring throughout the press run gives a quick indication of halftone reproduction. Equal values for each color are critical for gray balance and proper hue of overprint colors.

50% tone enlarged

75% tone enlarged

75% K, 75% C, 75% M, 75% Y, K, C, M, Y

Backing

Backing what you measure against, can affect measurements. ISO standards specify black backing be used for consistent results. The tear off BLACK cover flap of this brochure can be used for this purpose.

Always include status, backing and aperture size when communicating density data.

Apertures determine the size of the area measured, so always use a common aperture when comparing measurements. ANSI and ISO standards recommend the following minimum aperture sizes be used when measuring tone values with the corresponding screen ruling. If you are measuring tone values (dot area, for instance), refer to this chart to ensure your aperture is large enough for your printed screen ruling.

Nominal Screen Frequency		X-Rite Aperture	ANSI ISO
lines/inch	lines/cm	Minimum	Minimum
65	26	4.0	3.8
85	33	3.4	3.0
100	39	3.4	2.6
120	47	3.4	2.1
133	52	2.0	1.9
150	59	2.0	1.7
175	69	2.0	1.4
200	79	2.0	1.3

Trap

Trap indicates how well a printed ink will accept a second ink printed over it compared to how well paper accepts that same second ink. Poor trapping will result in a color shift and may make it difficult to achieve proper color in different areas of the same image.

Trap is measured from a color bar using patches representing the two-color over-print, the two individual inks, and paper.

C M Y Y/C Y/M M/C

Print contrast

Print Contrast is a comparison of the solid ink density and the shadow tint density (75% or 80%). This makes it a good indicator of print quality because shadow detail often carries important information. Print Contrast values correlate well to the subjective print quality evaluations of “flat” (low contrast) vs. “jumps off the page” (high contrast). Print Contrast is also used as a guide for maintaining proper ink and water balance.

Hue Error / Grayness

Hue Error describes the variation of a printed color from a theoretical pure color. Grayness indicates the presence of gray in a color that makes it appear less saturated.

Hue Error and Grayness are used to check for color consistency throughout a press run. Today, colorimetric measurements are often substituted for Hue Error and Grayness because they correlate better to visual evaluation.

Theoretically Pure | Relative Hue Error | Theoretically Pure | Relative Grayness

Gray balance

Gray balance is a simple concept that can be used to evaluate and control ink levels in order to reproduce pleasing color results. Combining nearly equal* tint values of cyan, magenta, and yellow (CMY) ink results in a neutral gray color. This fact can be used as the basis for a simple method of evaluating color reproduction.

Because a gray balance patch includes all three of the colored inks, maintaining equal CMY densities will ensure that both the neutral and the colored areas of a reproduction have the right proportion of inks. This means that red, green, and blue, referred to as memory colors, will be printed with the right hue, ensuring pleasing color results.

Using the density function you can measure a CMY gray patch and compare the CMY density levels to see if they are equal. If the density of one color is higher or lower than the others, an adjustment is required.

Usually the press ink level is adjusted when gray is not in balance, although if dot gain is suspected to be the issue, ink and water balance may be the cause and the water level may be adjusted. In some cases, ink trapping or registration will affect gray balance, but often only density and water adjustments are used to keep the colors in balance.

The main disadvantage of using only gray balance to control color is the inability to troubleshoot and find the root cause of unbalanced color. Sometimes two or three types of gray balance patches are used to evaluate the highlight, mid-tone, and shadow.

1 2 3

Gray Evaluation

Use the area below to record the density of the samples above.

Are the samples in balance?
What press adjustments would you make?

	C	M	Y
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____

*Actually, the cyan tint value should be 8 – 10% higher than the magenta and yellow values due to impurities in the magenta and yellow inks

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L7-158 (05/05)

What is color?

People commonly describe colors by pairing them with familiar objects: "lime green," "sky blue," or "fire engine red." While this may be sufficient for everyday conversation, professional applications require an absolute value for color that is independent of the viewer.

By arranging color in a three-dimensional graph called a Color Space (shown on the right), we can assign an absolute value to any color using three independent variables: Lightness, Chroma, and Hue (LCh)

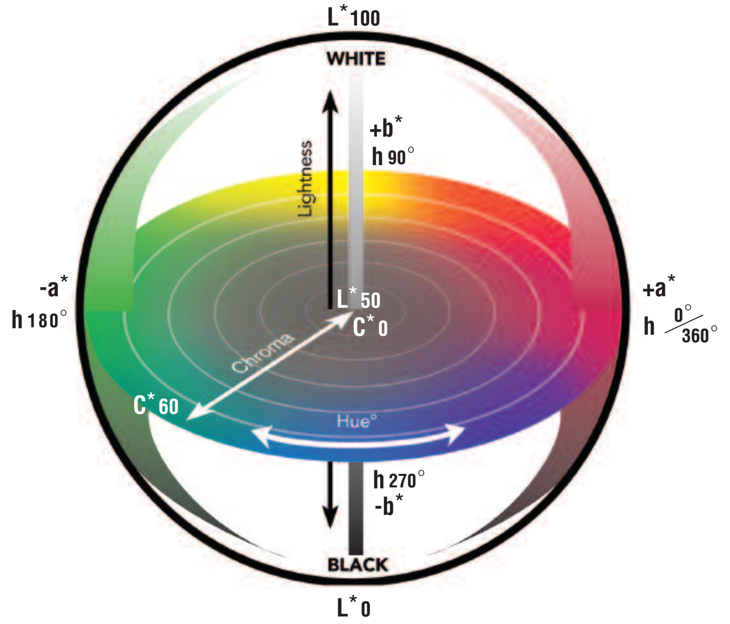
Lightness (also called "Value") – Lightness is plotted vertically in the Color Space graph, with the darkest colors at the bottom, lightest colors at the top.

Chroma (also called "Saturation") – A color that is very saturated or intense has a high chroma. As colors become more chromatic they move in a horizontal direction away from the center of the Color Space.

Hue – The basic color of an object, such as "red," "yellow," or "green." Hue is located around the perimeter of the Color Space.

How do we measure color and color difference?

Using a device called a spectrophotometer we can measure a color's LCh and assign the color a unique numerical value on the Color Space graph. We can then measure the LCh of another color and plot its location on the graph to determine the direction and degree of color variation between the two colors. The linear distance from one plotted color value to another is called the "total color difference." This value is labeled Delta-E (ΔE) and is the most commonly used measure of color difference in industrial color applications.

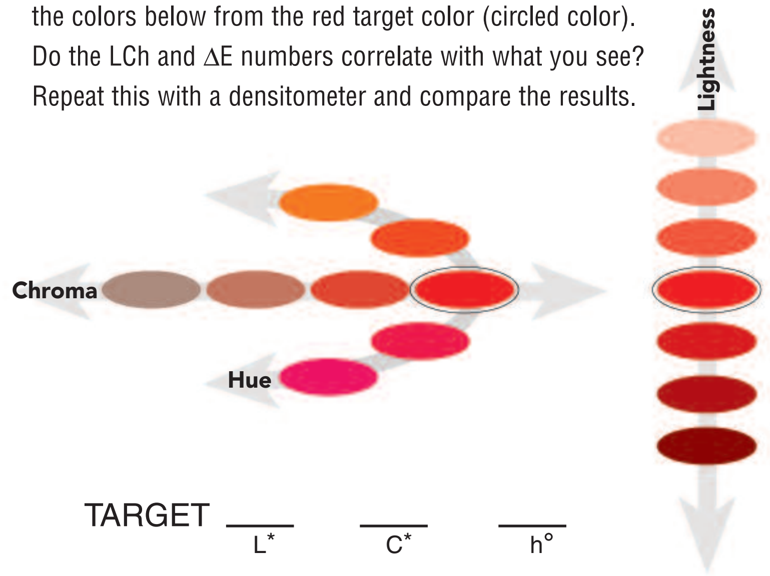


Color Space – color by the numbers

Color can be described verbally or numerically using the same characteristics of Lightness, Chroma and Hue.

Evaluating Color Difference

With a spectrophotometer, measure the color difference of the colors below from the red target color (circled color). Do the LCh and ΔE numbers correlate with what you see? Repeat this with a densitometer and compare the results.



TARGET ____ L* ____ C* ____ h°

MEASURED ____ L* ____ C* ____ h°

ΔE ____

What is the effect of light on color?

Since color can not exist without light, the lighting conditions under which color is evaluated have a considerable influence on color perception. Theoretical, standardized lighting conditions called "illuminants" are used in color measurement to simulate lighting conditions, such as fluorescent for a business or store and incandescent for a home. The graphic arts industry has standardized on an illuminant called D^{50}, which is based on natural daylight.

Colors can appear differently under various lighting conditions because of their chemistry. In fact, two similar colors may be perceived or measured as an exact match in one lighting condition, yet not match in another. This phenomenon is called "metamerism" (see sidebar), and has important implications on the evaluation of color matches in the graphic arts.

How can you best communicate color?

Color measurement data is a universal language. New software solutions are available that create a color data file, which can be shared electronically. These files are an efficient and accurate way to quickly communicate color.

Color measurement data should include the illuminant (typically D^{50} in graphic arts), aperture size, observer angle (typically 2° in graphic arts) and the make and model of your measurement instrument.

Metameric Colors

The colored square above contains a symbol in a matching, metameric color. The symbol will closely match the background when viewed under a 5000°K light source, but will be visible in other light sources.

When measured using the D^{50} illuminant, the color difference will be small, but under another illuminant the color difference will be noticeable.

Physical Color Sample

Record the color measurement data for the physical color sample below.

____ L* ____ C* ____ h°

Observer Angle ________

Illuminant ________

Aperture Size ________

Make / Model ________________