Color Tool Guideline
and
Printing Basics

Contents

1. Introduction

The HP Color Tool is an objective method of measuring color to achieve color consistency. Using this tool, color can be numerically communicated, and uniformity in color shades can be achieved with vendors at different locations in different cities, states and countries.

Color of an object is the interaction of that object with the energy from a light source. Printing a color is a combined effect of ink, substrate and printing process. The HP color tool combines the specification of the ink and substrate with numeric color values, color tolerances and viewing conditions to achieve the color consistency.

This guideline explains how to use the color tool and provides an overview of basics of color, color measurement techniques, graphics development, and printing processes to understand the principles of the color tool.

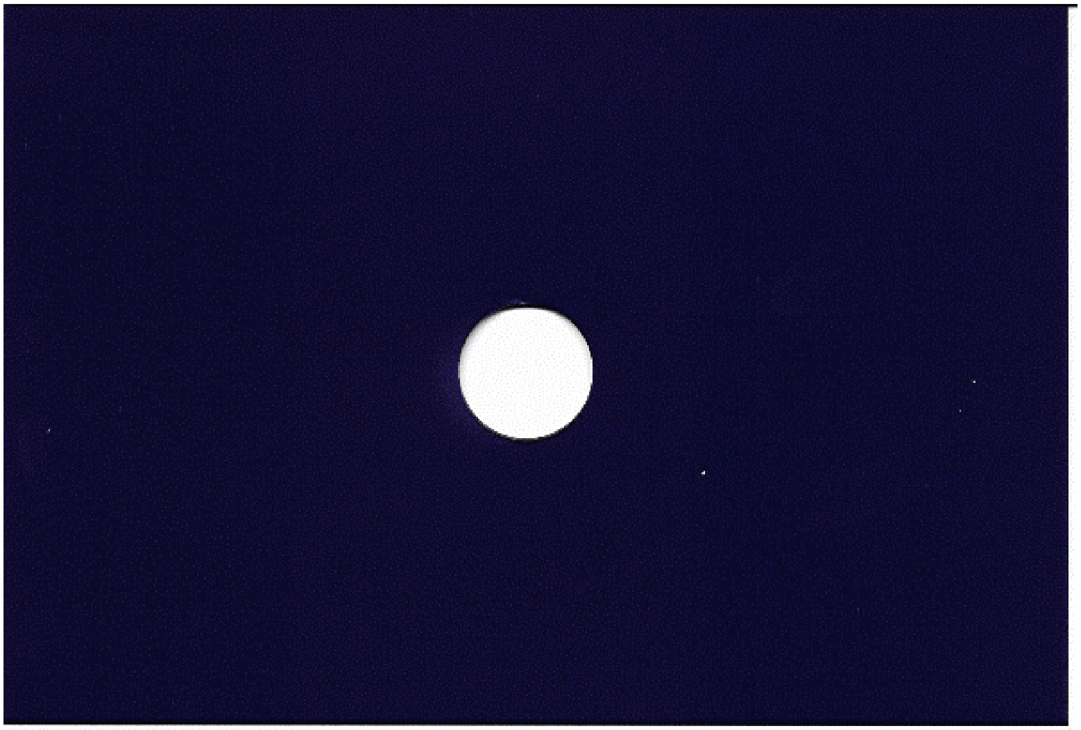
2. Print Specification

2.1 HP Color Tool and How to use it

HP color tool helps to insure consistent color reproduction of all Hewlett-Packard brand identity packaging. For special HP colors a color tool (specfication / swatch) is produced to reduce color variation. Each color tool specifies:

- **Ink.**
  - **Supplier name.**
  - **Pigment code, a universal code to specify required color.**
  - **Formula, internal code of printer to specify other components of ink other than the pigment.**
- **Paper.**
  - **Supplier and Type. The substrate has an effect on the shade and color values. It is advisable to develop both the color tool and actual sample on the same substrate.**
  - **Color values L*a* b* and color tolerence (ΔE) & CMC for the specified color shade on a specified substrate using a specific printing process.**
  - **Overcoat(Varnish) . Coating can change color shade so it is advisable to match the color tool after an overcoat.**
- **Instrument, the color values L*a* b* may vary between instruments, but color tolerance (ΔECMC) should be within the specified limit.**
- **Lighting condition. Metamerism strip is a tool to standarize or identify correct lighting condition.**

Note: Curret color tools have been created for CBI Blue and CBI Gold. Other tools may be created in the future as deemed necessary. The following procedure on using the tool can apply to any agreed on color swatch for other colors, i.e. PMS colors.



*For proper use of this color standard refer to printed instructions on envelope.

Printing Process: Lithograph
Color: Expanding Possibilities Blue

Print Date: May 24, 1999
Part number: 5964-8740

Ink
Supplier: FLINT INK (800.821.4482)
Pigments: Pb 15:3, Pk 7, Pr 269
Formula: gub 069547

Overprint Aqueous Coating
Supplier: FLINT INK
Formula: 0061596

Paper
Supplier: MEAD COATED BOARD
Type: MEAD Custom Kote (800.622.0160)

Instrument
Supplier: X-RITE, INC. (800.248.9748)
938 SPECTRODENSITOMETER
Illuminant/Observer: D50 at 2 degrees

Color Values: L*14.38 a*14.03 b*-35.29
(This is for reference only)
Instructions:
1. Bring into L*a*b* tolerance.
2. Final determination of color is to be based on visual match under the correct light conditions.

Color Tolerance 1.5ΔE cmc 2:1:1.5

GATF/RHEM LIGHT INDICATOR
IF STRIPES ARE SEEN, LIGHT NOT 5000K

Under the correct lighting conditions (5000°K) the label will appear to be a uniform color, no stripes.

Hewlett-Packard Company, Packaging Programs, Palo Alto, CA 94304

(HP Color Tool example)

<u>How to use HP color tool.</u>

<u>Using a Spectrodensito meter</u>

- **Measure L*a*b* value of the approved color on the color tool using a standard spectrophotometer under the specified illuminant D 50 and 2º observer. This L*a*b* value could be same as specified on the color tool, or different depending upon the instrument used.**

- **Measure L*a*b* value of the sample to be approved under the same instrument, set at specified illuminant D 50 and 2 º observer.**

- **The instrument compares color values of the standard and sample to be approved and creates color tolerance (ΔE). ΔE can also be expressed as ΔE cmc**

  1) $\Delta E = \sqrt{[(\Delta L^{*2})+(\Delta a^{*2})+(\Delta b^{*2})]}$ **.**

  2) ΔE CMC value (another method of value, refer 3.2.4.2) is a special calculation of ΔE which weights each parameter (L, a, b) to a compensate for how sensitive the eye is to a particular color region.

- **If ΔE CMC is beyond limits, check if the measuring conditions are as specified. Metamerism strip is a simple tool that ensures measurement is under specified lighting condition. Subsequently, necessary adjustments in the printing process can be made to bring down color tolerance within the limits.**

- **Repeat above steps till printed sample meets the specified color tolerance consistently.**

Note : Conduct visual comparison in a viewing booth with correct lighting 5000º K to derive final color determination. The instrument helps us to get close to our goal; but how it appears to the human eye under correct lighting condition is what counts.

Note that L* a*b* values given on the color tool are instrument, color, printing method and substrate specific. Even if all the conditions are similar, L*a*b* could still be different. So for every approval/check measure L* a*b* values of the color on the color tool and the color on the sample to be approved and compared.

Also, it is vital to compare the specified ΔE and ΔE CMC and the actual for approval.

In the absence of a spectrodensito meter or after the color values are matched the color tool can be used to match color visually.

- **Place approved color standard with a circle cutout over printed area.**

- **Visually compare approved standard to printed sample in a viewing booth with correct lighting condition. Use the metamerism strip to standardize lighting condition.**
- **Repeat above steps till printed sample visually matches with the approved sample.**

Checking and maintaining color consistency

Color tool is used to measure the accuracy of ink color and color consistency. In order to maintain color consistency the following three-step procedure can be followed:

Step 1. Once the color values for a color on a specified substrate are established, the draw down on the approved substrate should be compared with reference color values and tolerance. Necessary adjustments should be made to get color values and tolerance within specified limits.

Step 2. During the press run, printed boxes/sheets should be checked periodically for color values/tolerance to ensure consistency of color as compared against the HP standard.

Step 3. At the HP receiving warehouse or distribution center the color tool should be used to visually check color consistency of the received boxes. Make sure the lighting condition is 5000º K using the metamerism strip. Any variation should be reported to the vendor for necessary follow-ups.

HP consumer brand corrugated boxes can be printed using any one of the following:

- **Flexo Preprint, printing on the liner board before it is combined with a corrugated medium**
- **Flexo Post print, Direct printing on the combined boards cut into sheets**
- **Lithograph , a litho printed label/liner combined with single face corrugated or double face (single face) corrugated.**

On a finished box the Expanding Possibilities blue can be checked on any spot. In case of gold, the color values should be measured using color bar at the edges or other non screened gold area. The gold bubbles use a magenta screen under them to boost the gold appearance and will not match the color tool.

3. Printing Basics

3.1 Understanding color

The color of an object is produced by interaction of that object with energy from a light source. The object will selectively absorb or reflect all of the energy from the light source that strikes it. When all the energy is reflected, our eye sees white. Absorption of all energy yields black, while selective absorption of specific wavelengths results in color. The reflected light is radiated from the object in all directions and is received by the eye. The eye senses this reflected light and signals the brain, which is interpreted as COLOR.

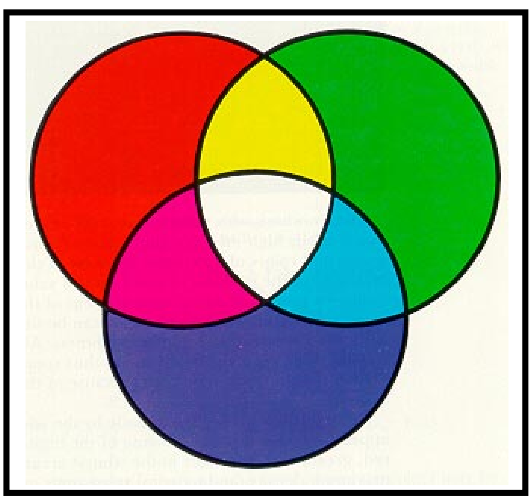
In short, light is radiant energy that is visible to normal human eye. Color of light will vary with its wavelength.

3.1.1 Color Theories

<u>Additive Color Theory</u>

A human eye contains three different color receptors, red, blue, and green. When equal parts of blue, green and red light are cast, the eye perceives this as white light. When light is combined in unequal proportions, we see color. This is the basic of Additive Color Theory.

Primary colors of the additive color reproduction are blue, green and red. Combining or adding any of these two colors can create secondary colors.



Yellow = Red + Green

Magenta = Blue + Red

Cyan = Blue + Green

White = Red + Blue + Green

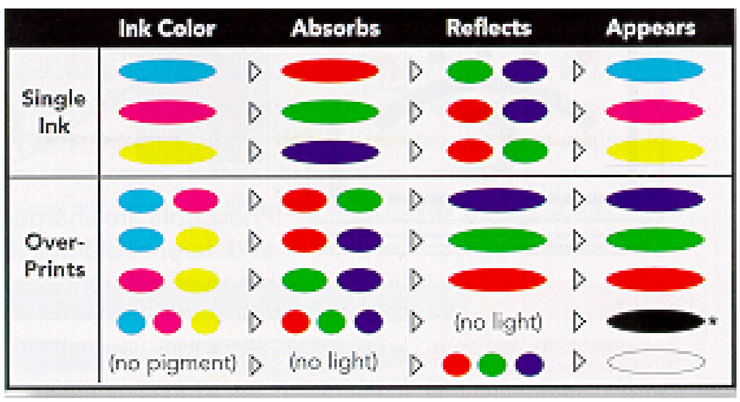
Additive color reproduction system needs high intensity illuminations in order to produce whites and colors of acceptable lightness for example a cathode ray tube in television. On the contrary, color prints produced by color printing process are seen as light reflected off the surface of a print. And additive theory is not used in the color printing.

Subtractive Color Theory

As per this theory, color is the light reflected off the surface of a substrate. The reflected light is filtered by the colorants or pigments in the ink. Thus the printing ink subtract portions of white light illuminating an object and the reflected part of the white light is perceived as color of the object or print.

Printed ink on a white surface absorbs some wavelengths of light and reflects others.

- **Cyan ink reflects green and blue but absorbs red, thus the eye perceives cyan**
- **Yellow ink reflects red and green but absorbs blue, thus the eye perceives yellow.**
- **Magenta ink reflects red and blue but absorbs green, thus the eye perceives magenta.**



- **Cyan + Yellow absorb blue and red, thus the eye perceives green.**
- **Yellow + Magenta absorb blue and green, thus the eye perceives red.**
- **Magenta + Cyan absorb red and green, thus the eye perceives blue.**
- **Cyan + Yellow + Magenta absorb blue, red and green, thus the eye perceives black.**

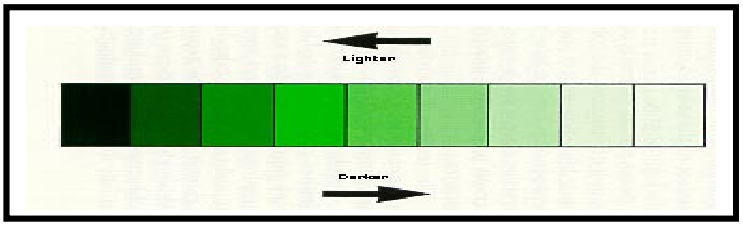
In color printing, colors are overlayed or trapped to produce secondary colors. Color dots are combined to create specific color matches. Though black is a combination of cyan, yellow and magenta, black ink is used to produce black. Sensation of color in printing depends on the ability of a pigment to absorb portions of the visible spectrum. The non-absorbed portions of light are reflected and perceived by the eye and stimulate the brain for a particular color response.

3.1.2 Attributes of Color

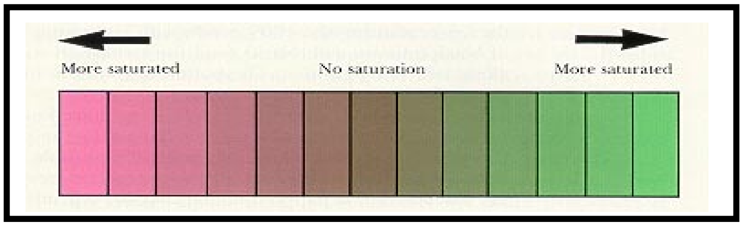
Each color has its own distinct appearance, based on three elements: Hue (colorfulness), Lightness (Value), and Saturation (Chroma). By describing a color using these three attributes, you can accurately identify a particular color and distinguish it from any other.

- **Hue – Colorfulness is how we perceive an object's color such as red, pink or orange.**

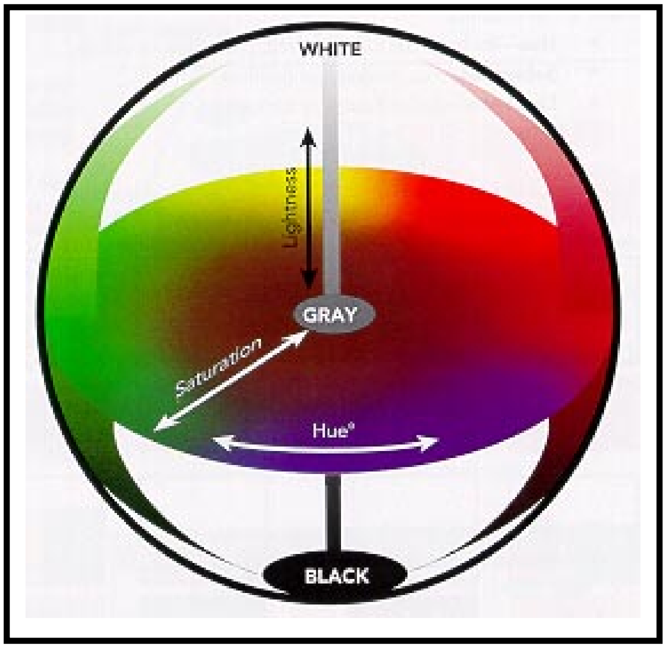
- **Value or Lightness – is its degree of "lightness".**



- **Chroma or Saturation –vividness or dullness of a color.**



Color Space



Hue, Lightness and Chroma demonstrate visible color in three-dimension. A 'Color Space' is used to map colors with lightness in the central vertical axis, saturation in horizontal axis that extends from the lightness axis, and hue is the angle around the sphere away from the chroma axis

Lightness can be quantified from no light to maximum lightness. Saturation theoretically ranges from zero to infinity. And hue is a qualitative attribute represented around the directions of the sphere , with each point around the circle representing a different hue.

3.1.3 Measuring Color

The principal methods of measuring color are based on:

<u>Tristimulus data,</u> where a color space is used to describe the range of visible or reproducible colors of a viewer or device. Three-dimensional color models and three valued systems such as Red-Green-Blue, Cyan-Magenta-Yellow, and Hue-Saturation-Lightness are known as 'Tristimulus data'.

The Tristimulus color descriptions are used in instruments called colorimeters, that measures color by imitating the eye to calculate amounts of red, green, and blue light. These RGB values are converted into more intuitive three-dimensional systems like L*a*b* and L*C*H° where relationships between several colors measurements can be easily compared

<u>Spectral data</u> describes surface properties of the colored object by demonstrating how the surface affects (reflects, transmits, or emits) light. Conditions such as lighting changes, uniqueness of each human viewer, and different rendering methods has no effect on these surface properties.

3.2 Communications of Color

Each observer perceives color differently and sometimes the same observer sees color differently depending on illumination, background and viewing conditions. So a better way of communicating color is specifying the ink, substrate, color values, color tolerance, lighting sources and measuring instruments.

3.2.1 Inks

Printing inks consist:

- **Pigments,**
- **Resin vehicles in which pigment is dispersed,**
- **Solvents or other fluids to control body,**
- **Other additives to induce drying and/or impart necessary working properties to the ink.**

<u>Pigments:</u> Impart color to ink. Hue or the color, good fading and bleeding resistance, good transparency, color strength and brightness are the essential properties for a good pigment. Other useful peroperties include good gloss, durability, refractive index, wettability and dispersability. An environmental friendly pigment is low in toxicity and heavy metal content.

There are thousands of different pigments but most printing ink is made from few important pigments. To formulate ink that best matches a desired color the pigment index numbers for each colorant must be disclosed. Because it is highly unlikely that an ink will be single sourced, the pigment index numbers will allow various ink manufacturers to match the desired color.

<u>Vehicles and Varnishes:</u> The vehicle is the liquid portion of the ink that carries the pigment to the substrate. It could just be resin and solvent (or oil) or could be those two plus additives.

Vehicles and varnishes are many times used interchangeably, but varnish means the ink binder dissolved in a solvent and vehicle refers to the varnish plus additives.

Resin is added as a dispersion aid and also as a binder to affix the pigment to the substrate.It can be natural or synthetic.

Oil or carrier is the medium for transferring pigment and resin to paper

Solvents are part of vehicle. They dissolve oils, resins and additives to produce varnishes that carry the pigment in the ink and adhere the dried ink to the package.

Additives can be plasticizers, wetting agents, anti-skinning agents, stiffening agents and drier.

<u>Properties of Ink:</u>

<u>Physical properties:</u>

<u>Viscosity</u>, the resistance to flow, is measured to check if correct amount of solvent has been added to the ink and to maintain the solvent level during the run. As viscosity increases, amount of colorant delivered by the press increases resulting in change in color. As the pH and temperature of ink changes, viscosity changes too.

<u>Tack</u>, is the cohesion between ink particles or pulling power of ink. A good tack is important to assure proper transfer of ink and maintain good color uniformity. The ink with higher tack pulls the ink with the lower tack from the plate or substrate. As printing ink dries, the force required to split the ink film increases, and a dry printed ink film traps the ink from the next printing plate better than a wet film. This gives an advantage to printing processes wherr the ink is dried after each unit.

Improper tack sequence in multi color printing may lead to pulling of ink film from the substrate by the plate or blanket.

<u>Setting</u>, a measure of ink dryness, means the viscosity of the ink has increased enough to allow the print to go on to the next operation such as cutting, folding or rewinding. Dying or Setting of an ink can be achieved through evaporation, absorption and polymerization or curing.

Optical properties

<u>Color and Color Strength,</u> greater the color strength, the less amount of ink is required to produce the desired color on the substrate.

<u>Opacity and Transparency,</u> the printed ink film acts as a filter with the substrate reflecting the light. So opacity of ink is important to achieve desired color shade.

<u>Color Density</u>, absorption of light by the printed film.

3.2.2 Substrate

Substrate can be paper, films, foils and metals. As the scope of this guideline is limited to paper and paper board the following sections focus on properties of paper that affect printing. Optical and physical properties of a paper substrate change color perception. The picture below illustrates a single ink stain on different substrates.

<u>Whiteness</u> of a substrate can be defined as the absence of a color or the ability to reflect equal amounts of red, green, and blue light. White sheet is supposed to be a neutral sheet, but in practice most white papers have a slight yellow or blue cast. The substrate should be as neutral as possible in order to avoid printed color distortion.

<u>Brightness</u> of a substrate can be defined as the total reflectance of light from that substrate. Generally, the more light reflected from a sheet the better, from a color reproduction viewpoint. A substrate that reflects 90% of the red, green, and blue light that falls on it results in a better reproduction than a substrate that reflects only 75%. Lower-brightness paper produces reproductions with lower contrast and sharpness.

<u>Fluorescence</u> in paper is important to achieve exact color matches of light, pastel colors. The adoption of a standard 5000º K viewing lighting source has helped to minimize this problem. Fluorescence is best detected by illuminating the samples in question with a source rich in ultraviolet and low frequency blue radiation in a darkened room. It is very important that the light source be specified when making such measurements, as fluorescence is highly dependent on the illuminant.

Gloss is a property of reflection that influences the perceived lightness of a sample. Combined effect of high gloss paper and high gloss ink is good for pictorial reproduction.

Smoothness, smoother the paper, higher the resolution of the printing.

Absorbency of paper is one of the causes for shifts in color shades. High gloss and low absorbency give high paper surface efficiency, which in turn minimizes the distortion of printed color by the substrate.

3.2.3 Color values

A color space has three dimensions namely hue, lightness and saturation to uniquely describe a color. Inorder to find a numeric way to describe these three dimensions CIE, the Commission of Internationale d'Eclairage (International Commission of Illumination) has conducted and published several studies about human color vision and perception . These works characterize the interaction of lighting, color of an object and visual perception with the goal of identifying a numeric system that correlates with perceived color.

CIE has established color space standards 'CIE XYZ, L*a*b* and L*u*v* to compare the varying color spaces of different viewers and devices against repeatable standards. These standards are independent of devices and visual skills of a specific observer.

3.2.3.1 CIE XYZ

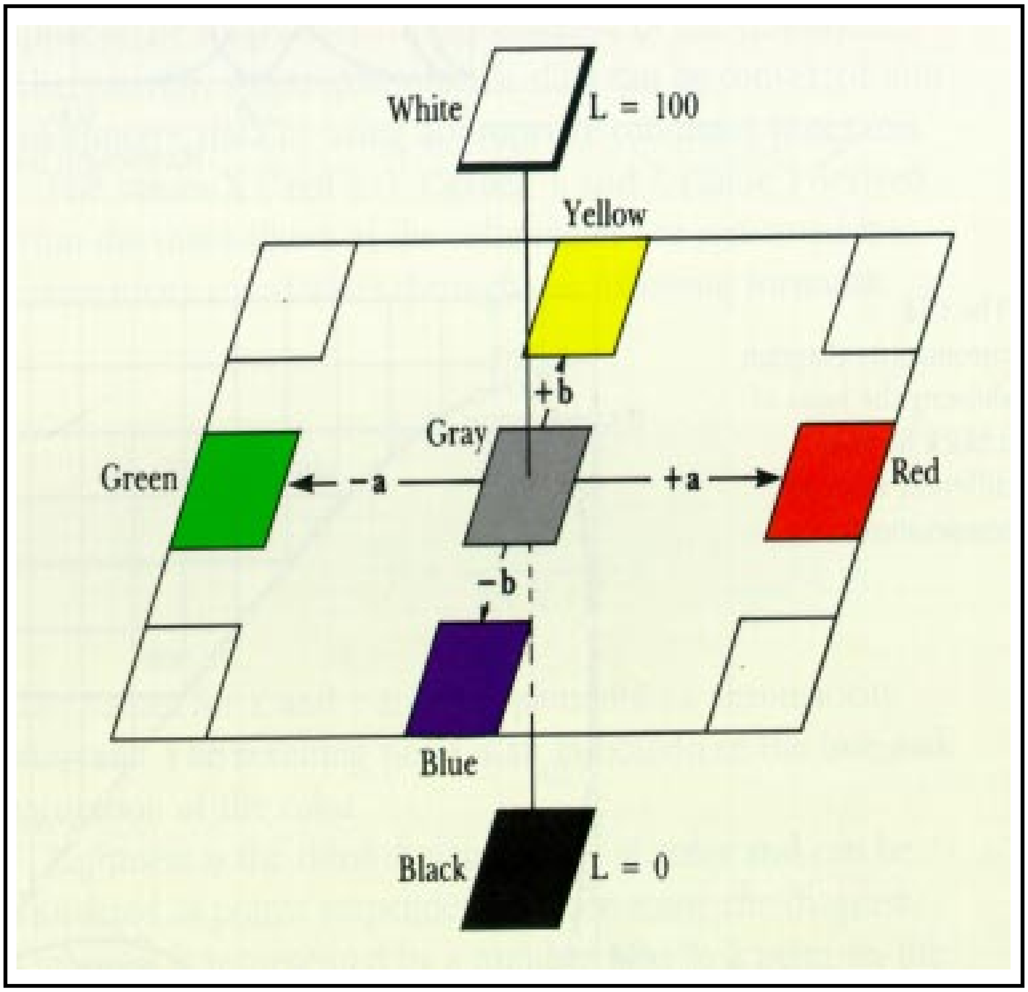
The basic color space is CIE XYZ. It is based on the visual capabilities of a Standard Observer; a hypothetical viewer derived from the CIE's extensive research of human vision. The CIE conducted color-matching experiments on a number of subjects, then used the collective results to create "color- matching functions" and a "universal color space" representing the average human's range of visible colors. The color matching functions are the values of each light, primary-red, green and blue that must be present in order for the average human visual system to perceive the colors of the visible spectrum. Coordinates X, Y and Z were assigned to these three primaries. From these XYZ values, the CIE constructed the xyY Chromaticity diagram to define visible spectrum as a three-dimensional color space. The axes of this color space are similar to the Hue-Saturation-Lightness (HSL) color space.

3.2.3.2 CIE L*a*b*

CIE developed more uniform color scales called CIE L*a *b and CIE L *u *v*. Of these models, CIE L*a*b* is the most widely used. The L*a*b* color space is based on the theory that a color cannot be both green and red or blue and yellow at the same time. As a result, single values can be used to describe the red/green and yellow/blue attributes. When a color is expressed in CIE L*a*b*, L* defines lightness, a* denotes the red/green value and b* the yellow/blue value.

In L*a*b* color model the a* axis runs from left to right. A color measurement in the –a direction depicts a shift towards green and +a direction depicts a shift towards red. Along the b* axis, -b movement indicates a shift towards blue and +b indicates a shift towards yellow. The center L* axis shows L=100 at the top which means a total reflection or white color and L=0 representing total absorption or black color.

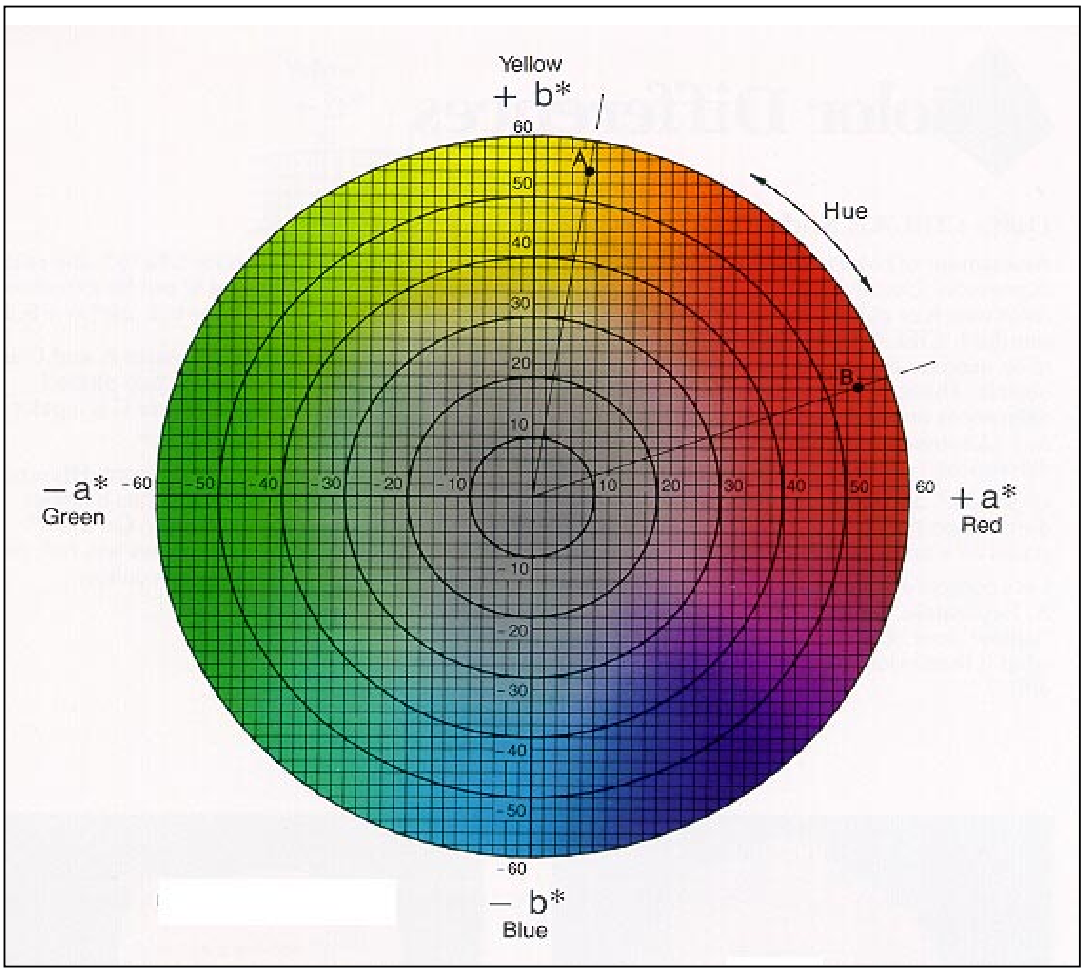
The a* and b* values points hue (color) and chroma (vividness) respectively. L* values describe the degree of lightness.



3.2.3.3 CIE L*C*H*

The CIE L *C*H' color model uses the same XYZ derived color space as L*a*b*, but instead uses cylindrical coordinates of Lightness, Chroma, and Hue angle.

- **L represents lightness on a scale of zero to 100 .**
- **C represents chroma or saturation where zero is dull and higher numbers indicate increasing color vividness.**
- **H describes a color's hue as an angle where 0º is red , 90º is yellow , 180ºis green and 270º is blue.**



3.2.4 Color Tolerance

The human eye has some inherent limitations when distinguishing color differences. In addition to color memory loss, eye fatigue, color blindness and viewing conditions, the eye does not detect differences in Hue, Saturation/Chroma or lightness equally. In fact, the average observer will see hue differences first, chroma or saturation second and lightness/darkness last.

Thus, the tolerance for an acceptable color match is bounded by a three dimensional boundary with varying limits for lightness/darkness, hue and chroma.

3.2.4.1 L*a*b* Color Tolerance (ΔE)

On comparing the colors of two objects the difference in their lightness (ΔL), Red- Green (Δa*) and Yellow-Blue (Δb*) can be numerically expressed. Given ΔL*, Δa* and Δb* the total difference can be stated as a single value ΔE using the following equation

$$\Delta E = \sqrt{[(\Delta L^{*2})+(\Delta a^{*2})+(\Delta b^{*2})]}\ .$$

This gives us a spherical set of color limits. While specifying color tolerance care must be taken to arrive at the ΔE which is acceptable to the user and achievable by the printing process. The ΔE can be specific to a printing process.

3.2.4.2 ΔE CMC

The L*a*b* ΔE doesn't take into consideration how our eyes distinguish color deferences. Under the L*a*b* ΔE method the difference in hue, saturation and chroma are equally significant. However our eyes donot detect differences in hue, saturation and chroma equally. CMC is a tolerancing system and a modification of CIELAB, which provides better agreement between visual assessment and instrumentally measured color difference.

The eye generally has greater acceptance for shifts in the lightness (L) dimension than in the chromaticity (C) (hue and chroma) dimension. This tolerance ratio (L: C) is considered to be 2:1. The achievable CMC ratio between lightness and chromaticity (l:c) depends on the type of printing process.

3.2.5 Lighting sources and Viewing condition

We receive light from many sources: fluorescent lights, incandescent lights, and sunlight, either direct or reflected. All of these have different color distributions or spectra. Because the changing viewing conditions changes the apparent color of the package, standard-viewing conditions should be used after the design colors have been chosen. When design, proofs and final package are to be compared, it is vital that all viewers use standard viewing conditions at all stages of production. If the package is designed to be viewed under non-standard conditions, those must be considered and planned from the start.

Standard viewing specifies not only the color of the illumination but also the intensity of the light and the color of the surrounding space. Proofs that match the original under one type of illumination will not match under another as the pigments used in the film are different from those used in printing ink.

Color temperature (5000ºK)

Light is often described in terms of its "color temperature." When a black object, such as a blackened steel rod is heated, it begins to emit light. As the temperature of steel is raised, the amount of light emitted increases and its color changes. At first, the light is a dull red, but it becomes increasingly white as the temperature is raised and the color shifts towards the blue end of the spectrum.

When a cast iron or tungsten wire heats up to 2000 ºK it will glow with a dull red color. If we heat the steel up to 5000 ºK it will be much whiter. At 7500 ºK, it will have a bluish tint. A tungsten filament used in incandescent lamps is around 2800 ºK . This light is very yellow, and packages viewed at 2800 º K do not show good blue colors.

A light temperature of 5000 ºK is closer to outdoor or fluorescent light. This is one of the reasons why it is important to examine proofs and prints under standard viewing conditions, which includes illumination at a color temperature of 5000ºK.

Metamerism

Metamerism (met-am'-er-ism) occurs when two or more color samples match under one light source but appear different under another light source. Just as every color sample has its own reflectance pattern, every light source emits different amount of energy at different points in the visible spectrum. So whenever a light source changes, the color must change as well.

If two or three different wavelengths are present in a color, the eye combines them and sees only one color. For example, presence of red and green wavelengths together produces the sensation of yellow. Mixing different combinations of pigments in ink can produce a given color. However, since inks absorb rather than transmit color, the color that is perceived will depend

on the illumination. Color seen with the eyes will depend on the illumination, and colors that match under one type of light will not match under another light. It is another reason that judgments of color must be made under standard conditions.

3.2.6 Instruments

Human brain interprets the visual impact of light to give the sensation of color. Because psychology is involved, objective measurement of color requires physical instruments. There are three principal instruments for measuring colored objects: densitometers, colorimeters and spectrophotometers.

Color measurement instruments "receive" color the same way our eyes do, by gathering and filtering the manipulated wavelengths of light reflected from an object. When an instrument is the viewer, it "perceives" the reflected wavelengths as a numeric value. The scope and accuracy of these values depend on the measuring instrument. They can be interpreted as a simple density value by a densitometer, a tristimulus value by a colorimeter or as spectral data by a spectrophotometer.

Each type of color measurement instrument does something unique that our eye cannot do. They assign a specific value to the color that can be consistently analyzed in terms of numeric tolerances and control limits. Each instrument makes this conversion differently.

Densitometer

Strictly speaking, a densitometer measurement of color is unrelated to the visual appearance of color. It is a photo-electric device that simply measures the amount of light absorbed by a printed image and computes the physical ink film thickness. The amount of light absorbed is reported as optical density and primarily used to determine the strength of a measured color and control the ink film thickness.

Colorimeter

A colorimeter is designed to perceive the color the same way as a human eye. It breaks down the light into Red-Green-Blue components and a color's numeric value is determined using CIE XYZ color space or CIE L*a*b*. Colorimeter measures samples interms of color temperature of a light source. So the result is an indication of hue, saturation of color and lightness of the sample at a given light source.

Spectrophotometer

This device measures the amount of light energy reflected from an object at several intervals along the visible spectrum. The light reflected at a given wavelength is expressed as a percentage of the incident or reflected light. For example, a perfect white light would reflect 100% of the incident light at every wavelength, regardless of the color of the illuminant.

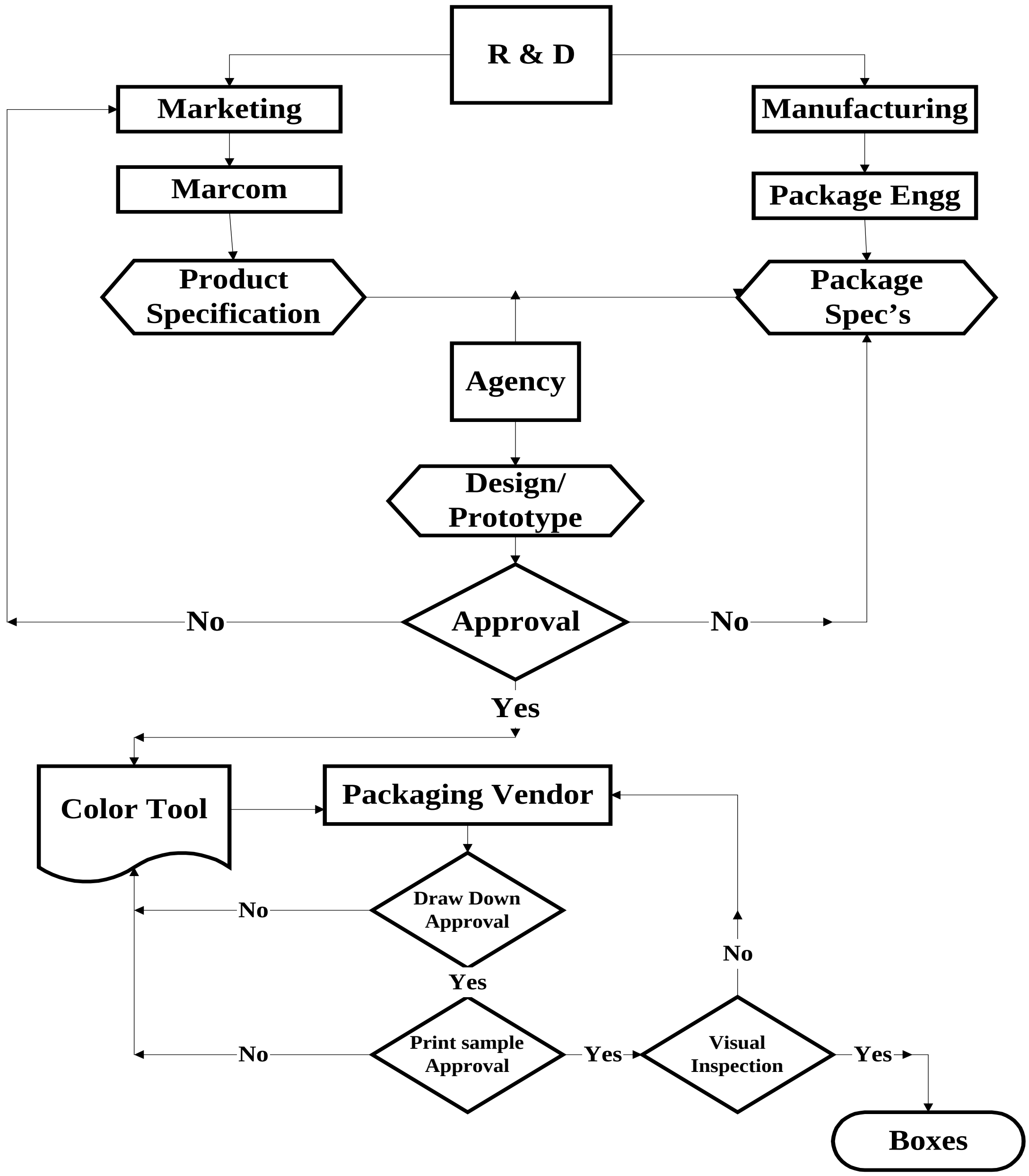
The spectral data measures the composition of light reflected from an object and can be translated into colorimeter data for easy color visualization. Different light sources appear

differently when they are reflected from an object as they contain different amount of spectrum at each wavelength. However the object always absorbs and reflects the same percentage of each wavelength. So a spectral data is a measure of the object's surface property and the change with every viewing condition are bypassed.

Graphics development and printing

4.1 Design Development

The flow chart below is the general schema for the new product package and print Specification development. Package Engineering develops the structural design and Marcom develops the graphic design and communication messages. Divisional Marcom approves the design, artworks, key lines, proofs, film and final packaging. Respective color tools are to be used while approving the proof, film, draw downs and final print sample.



4.2 Proofing

The farther the printing job goes before errors are caught, the more expensive it becomes to correct them. It is the purpose of the proof to eliminate all errors and changes before the job goes to press. Proofing serves many purposes. Firstly it ensure that the required information is correct , that the artwork is properly executed and that words are properly spelled.

Many different kinds of color proofing systems have been developed and are grouped under the headings of press proofs, overlay proofs, transfer or surprint proofs, electronic proofs and digital image proofs.The important characteristics of proofing systems include rendition of solid and tint colors, surface characteristics, image quality (collectively, press simulation), time needed to make a proof, cost of proofing materials and equipment and ability of the system to produce consistent results.

Press proofs

Press proofs are those made with ink and paper using a proof press or production press. Presses that are designed specifically for proofing are generally single-color machines. Production presses in one-, two-, or four-color configurations are often used for making proofs.

The major argument for using press proofs has been that they are more likely to be an accurate simulation of the press result than other proofing methods. Apart from producing a proof with the look and feel of the production job, there are other advantages suggested for the press proof. One valid reason for producing press proofs applies when a large number of proofs are required. Another advantage of preferring press proofs is that progressive proofs can be produced easily by this method. Progressive proofs may have been useful when one-color presses were used to print four-color jobs

The major drawbacks of press proofs are the cost and time it takes to produce one proof. The cost of a four-color sheetfed press can be very high and is in no way offset by the inexpensive paper and ink that are used to produce the proof.

Overlay proofs

Overlay proofs, or multilayer proofs, are made by creating color separation films corresponding to the 4 color process. Each colored film is registered to the other and backed by a sheet of white paper. The resulting proof is viewed by reflected light.

The color of the overlay material is pre-established by the manufacturer. The colors closely match most commercially available process inks.

These proofs have several advantages. No special equipment is required to make them, other than what normally found in a platemaking department. They are also quick to make. Another

major advantage is that one of the four individual layers could be remade without remaking the others.

Major drawback of using overlay films is the difference in feel and appearance of the printed result. The surface finish is high gloss, the overlap colors are often quite different from press results and cannot be used for color matching.

Experienced users of overlay proof materials are adept at "reading" the proof; that is, they are able to make mental transformations on how they expect the job to appear when it is actually printed. Overlay proofs should not normally be submitted to those who are novices at buying or judging color printing.

Transfer proofs

The transfer, or surprint, proof is an extension of the overlay proof technology. Like overlay proofs, transfer proofs often consist of photosensitive transparent colored films. Unlike overlay films, these materials have a release layer between the colored layer and clear base. The color images are sequentially transferred to a white base material during the processing stage. In one process, a sticky, clear image is transferred to the base. The color is obtained by wiping toners across the sticky image. The advantage with this latter process is that it can be customized to the printing ink color by blending toners and by varying the number of wipe strokes until the correct hue and density have been achieved.

Advantage of transfer proof is that the feel and look of this kind of proof is much closer to the printed image than overlay proofs. A key advantage of transfer and overlay proofs is their consistency.

Disadvantages with the transfer proofs include the rather lengthy time it takes to make the proof, cost of laminating and toning machines, and in some cases, unrealistically high gloss of the proof. Using a matte finish final lamination on the proof overcomes the high-gloss problem The cost of materials used for transfer proofing, like those used for overlay proofing, tends to be high. Another disadvantage for some systems is that a white plastic material must be used as the base support. Lastly these materials cannot simulate four-color press trapping.

Electronic proofs

Electronic proofs are sometimes called soft proofs. They exist as images on color video monitors. These images can be generated from completed color separation films or directly from the stored digital image of the original. They are called soft because they do not exist as a tangible object like the other kinds of proofs, which can also be referred as hard proofs. Electronic proofs are also called to as real time proofs because they can be formed almost at the same instant when the original image is scanned.

Electronic proofing devices exist either as a stand-alone unit-the video display of a scanner-or as the display terminal of a color page makeup system . These display a color image that simulates the final printed sheet from the perspective of color. Obviously, the image quality and the surface characteristics cannot be displayed.

Major advantages of this proof are the ability to generate a color display before separations are exposed and ability to modify the proof interactively as an aid to color correction, tone reproduction and retouching .

The key disadvantages of electronic color proofing concern the nature of a soft proof image and the high cost of the equipment. Although the electronic proof is a color separation production aid, it is system dependent, not permanent, and not portable. The image is formed by transmitted light and displayed under ill-defined room light conditions. Electronic proofs are formed by the additive process, whereas the printed image is subtractive. Therefore, it is difficult to adjust the lighting for the satisfactory comparison of both images.

Digital image proofs

Digital image proofs are also called photographic proofs. They are generated from an electronic database onto photographic color print material. These proofs represent an optional hard-copy output that can be obtained from an electronic imaging system.

The advantage of digital proof is its color accuracy. From the digital database, it is possible to form an image which, when exposed onto color print material, simulates the printed sheet. In other words, two images are ultimately generated from the database. One for the films used to make the plates, and the other for making the proof that simulates the printed image produced from the films.

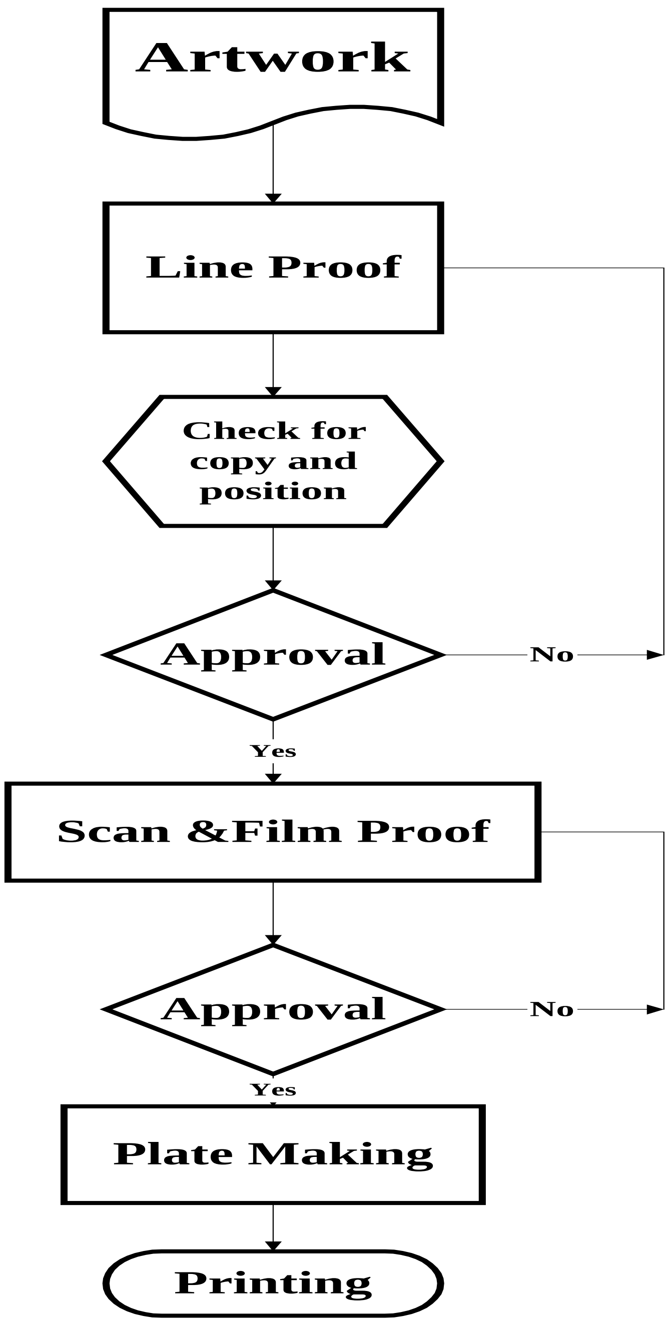
It is feasible to program the proof recording unit to simulate dot gain, trapping and paper and ink color of the final print. This method generates a high-resolution continuous-tone image in place of halftone dot values. It is not necessary to see the actual halftone dots in the proof as long as the tone that is produced accurately simulates what the halftone image will look like. The image quality and the surface effects of this kind of proof will not be the same as actual ink on paper, but the color accuracy probably outweighs these drawbacks.

The photographic imaging material used in these systems can range from instant color print material to conventional color print emulsions to the new electrophotography and toner systems. The image is exposed at high speed through red, green, and blue filters. The time required to make one of these proofs can be as low as 12-15 min. Digital image proofs can be made to simulate any printing process but they are costly.

4.2 Printing

4.2.1 Prepress

Prepress operations include setting the type and preparing the artwork for printing , assembling them into the form to be printed, proofing the form and preparing the plates. The following flow chart is the general prepress schema:



4.2.2 Spot and Process color printing

Spot color

In linework and spot color, each PMS color is produced by one ink. If two colors are called for, the press applies two colors of ink. If the artist selects two colors plus black, they take up three units on the printing press, leaving the fourth unit on a four-color press available to apply varnish or coating. If process color is chosen, four units are required for the color.

It is usually cheaper to reproduce linework and spot color than it is to reproduce process color since it requires color separations and a minimum of four plates and press units. Each spot color can reproduce only one color of choice, whereas process color can achieve a wide gamut of colors. With spot colors, no color separations are necessary, and variability of color and color balance on press are not usually major problems.

When designing and printing linework and spot color, the artist chooses the desired color and selects an ink that matches it from a book of samples. Color matching systems give a wide variety of colors and shades that can be obtained by mixing two or sometimes three inks with basic colors. The most popular of these is the Pantone Matching System(PMS) and Glass Packaging Institute (GCMI) kraft color guides. Each color in the sample book is given a number, and communication between artist, packager and printer can be maintained by using that number.

Spot colors on shipping containers are commonly matched and wide color variation is not acceptable. If ink properties are correctly specified, only the viscosity need be altered by the printer.

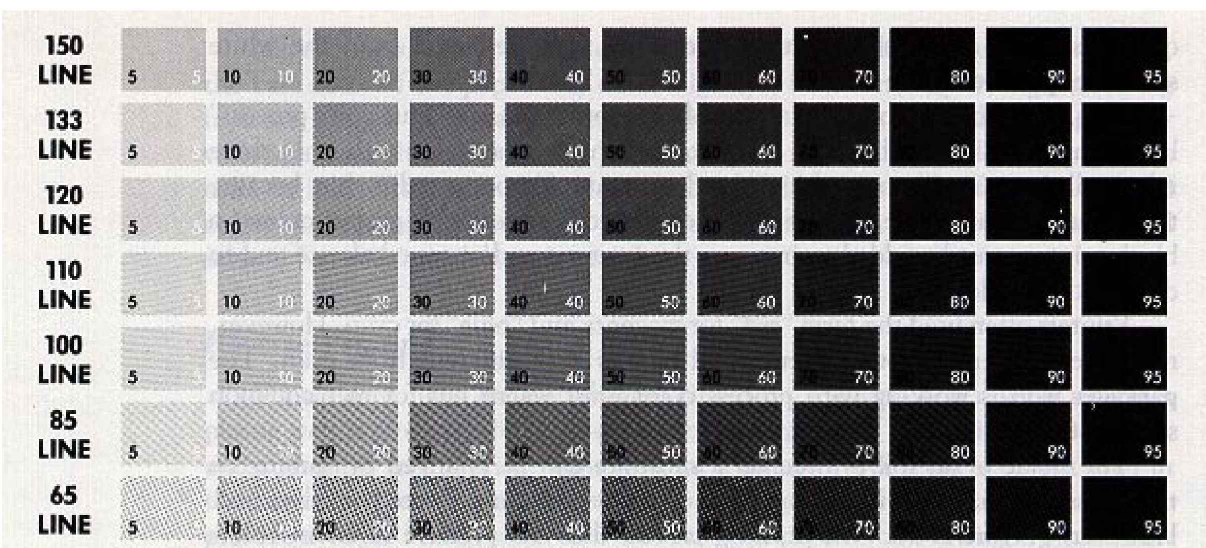
Process color printing

Process color printing produces a wide range of colors from only four inks and is fairly cost effective. Process color printing is the technique of separating a full-color original picture into its basic three or four colors, converting the separated colors into halftone dots and then printing the colors sequentially. This reproduces the original in full color. In process color, three primary colors of cyan, magenta and yellow are blended to produce the illusion of a wide varity of colors. Each ink absorbs part of the white light reflected from the white substrate, producing the desired colors.

This "three-color process" is almost always converted to a "four-color process" by adding black. Actually, it is possible to print process color with only three inks: yellow, cyan ("process blue") and magenta ("process red"), but because the commonly available pigments do not perfectly absorb the proper colors, a black printer must be added to improve contrast and/or tone balance and to deepen the shadows.

<u>Color separation</u> is the process of making four negatives or positive photographic films from a continuous-tone original. The end result is four photographic films, each separated into cyan, magenta, yellow and black. The continuous-tone image of the original can be made into a halftone image either electronically with a color scanner or photographically with a camera and a screen (a piece of film with lines). In photographic separation, the original is photographed through a color filter that cuts out undesired colors and a screen that breaks up the image into halftone dots. The process is repeated three times to give four different images.

A halftone print appears continuous because at a normal viewing distance, the eye cannot detect the tiny dots. It requires a magnifying glass to see them. The colors are recombined by making a plate to print each of the colors and printing each color sequentially in register. The screening process not only breaks the light up into tiny dots (circles, squares, ovals, etc.) but it controls the area covered by the dots. Where the color is heavy, most of the area is covered by the dot. Where the color is light, most of the area is uncovered . The following figure shows the halftone dots from 5% to 95% with screens from 65 to 150 lines per inch.

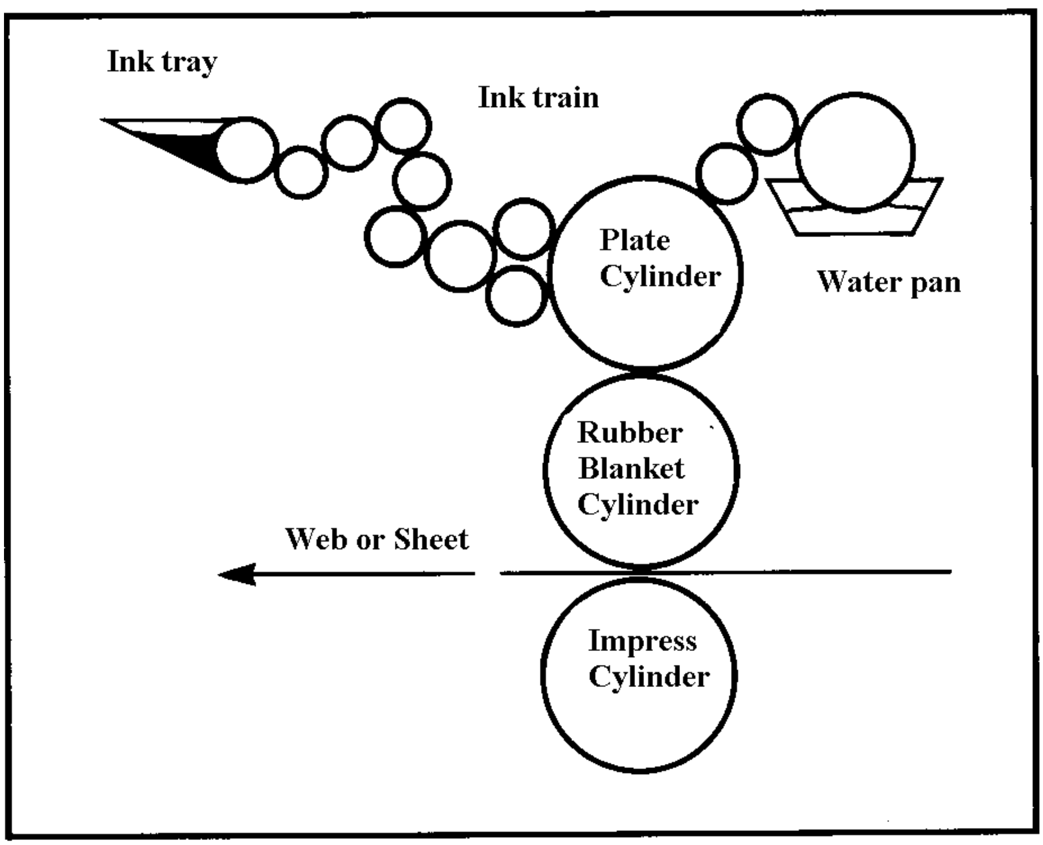


Process color inks must be transparent , because many of the halftone dots fall on top of each other and the top combines with the color of the dot underneath.

4.2.3 Lithography

Offset lithography is a method of indirect rotary printing that generates images from a plate surface that is neither raised nor engraved. The plate chemically separates image areas from non-image areas. The non-image area is moistened with water,the image area with ink. The image is transferred to a rubber blanket that conforms well to a wide variety of surfaces and prints well on uncoated paper. Stiff or paste inks are metered by a series of rolls and a doctor blade or a series of short blades called "ink keys." When applied to a litho plate dampened with water, the inks adhere only to the image area.

The lithographic process includes both sheetfed and web presses, and variations include printing from plates that do not need water for dampening. Although direct lithography (directly from plate to substrate) is possible, it is rarely used in packaging. The name "offset lithography" or "offset" therefore is descriptive of the actual practice of litho in package printing.



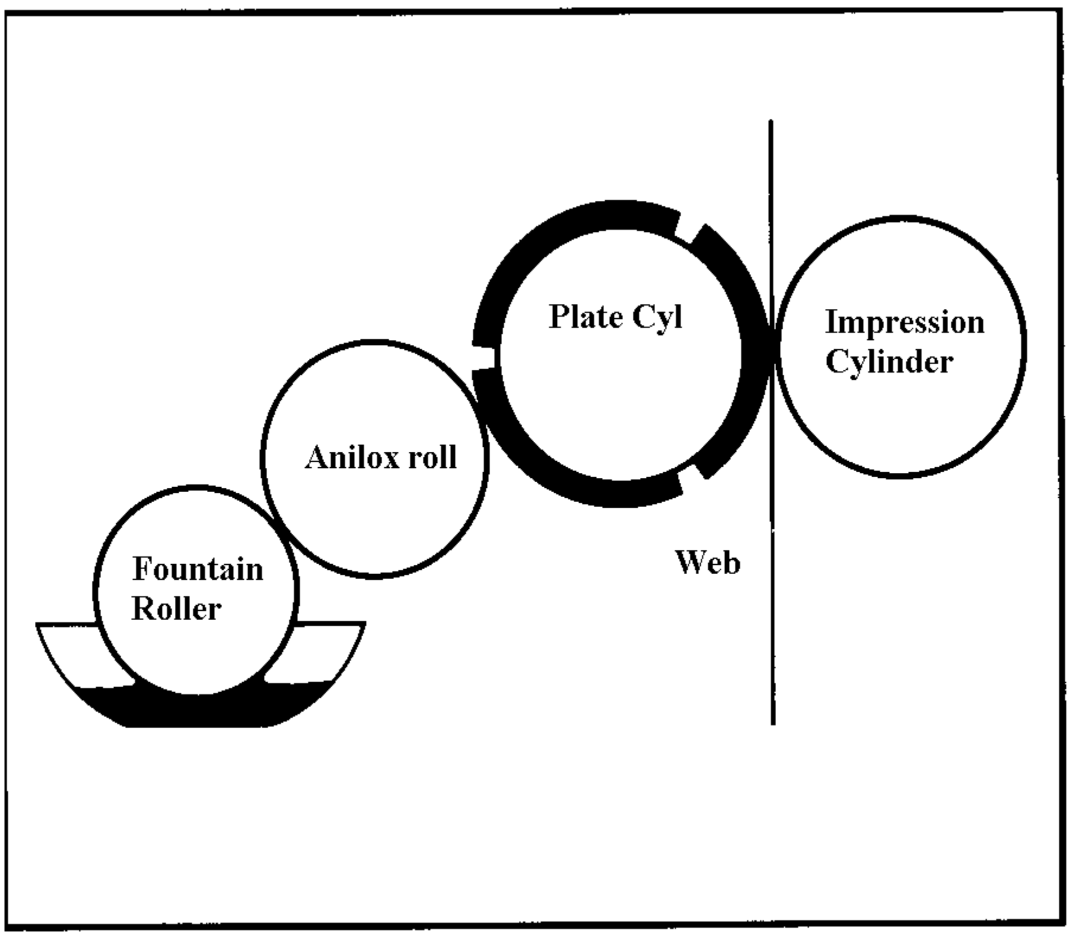
4.2.4 Flexography

Flexography is a method of direct rotary printing that uses resilient relief plates of rubber or photopolymer materials. The fluid inks are metered with an engraved metal roll called anilox roll and excess ink from this roll is removed by a doctor blade or fountain roller.

The advantages of flexography include high speed , variable image cut off length, the ability to print on virtually any surface and relative inexpensiveness.

The disadvantages are lower resolution and image distortion on uneven surfaces.

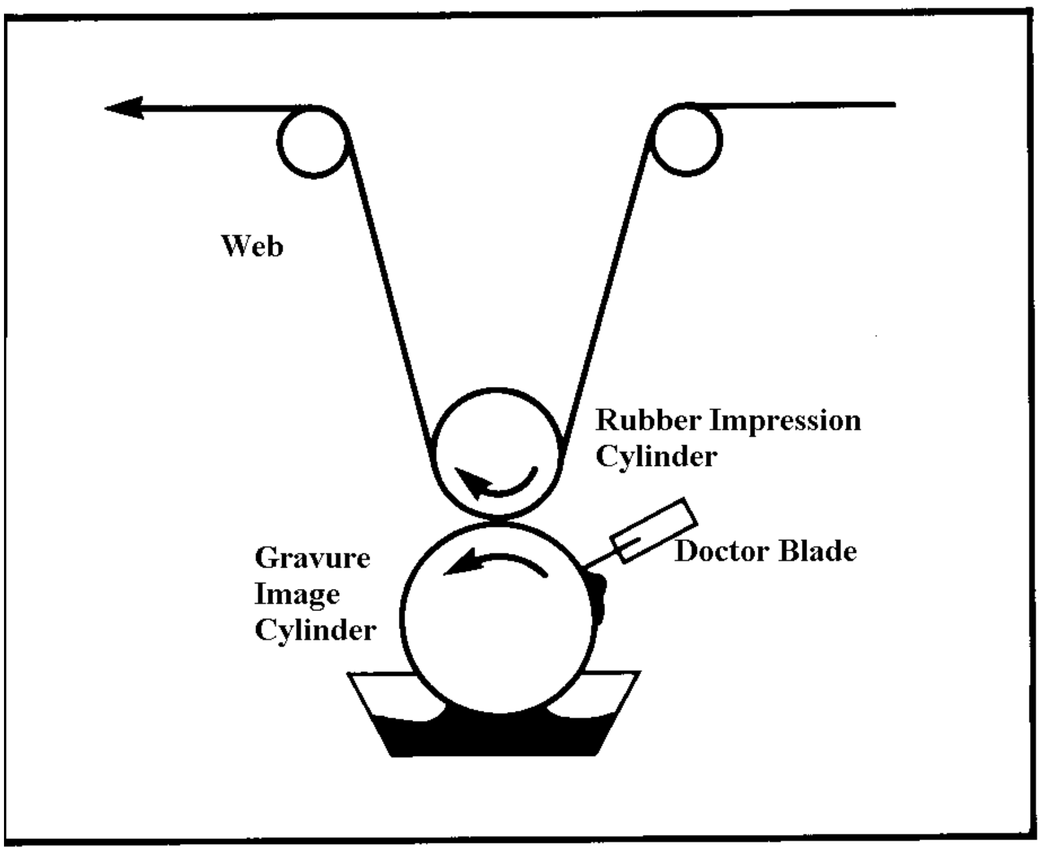
Flexography uses inks of low viscosity, pigments suspended in a soultion of a binder in water or an organic solution like alcohol.There are three types of flexo plates; molded rubber plates , laser engraved rubber plates and photopolymers.



4.2.5 Rotogravure

This method of direct rotary printing uses an engraved metal cylinder to print on smooth substrates such as coated paper and plastic films. The fluid inks are applied directly to the engraved cylinder and metered with a doctor blade.

Key features of gravure are low-viscosity inks made from a pigment and a binder dispersed in a volatile organic solvent or in water. The inks are printed from a metal cylinder that has the image engraved in it. This cylinder is rotated in an ink bath to fill the cells that form the pattern. Excess ink is removed with a stainless steel doctor blade



4.2.6 Letter press

This is a method of direct rotary or flatbed printing that uses rigid relief image plates of metal or photopolymer material. Stiff or paste inks are metered by a doctor blade and a series of resilient rolls.

Although letterpress, like flexo, is a relief printing process, there are major differences in the plates, ink and inking system of the press. Letterpress prints from a rigid plate, it uses a stiff or paste ink and requires a complicated array of ink rollers to work and distribute the ink uniformly.

Letterpress lays down a heavier ink film than offset, about the same as flexo. It is used for top-quality printing where it can hold fine reverses and vignettes. Unlike litho, letterpress requires no dampening.

4.2.7 Screen printing

Screen printing is a method of direct flatbed or rotary printing that uses a stencil supported on a wire or fabric screen to separate image from non-image areas. It is sometimes called "silk screen" because the earliest screens were made of silk. The light paste ink is moved by a squeegee that wipes and forces the ink through the mesh and stencil. The thickness of the fibers used to make the screen determines the film thickness of the print. This process can print on virtually any substrate.

The stencil is prepared from a screen made from synthetic fibers which is fastened to a frame that holds the ink. The screen can be attached to a flat or cylindrical frame used for rotary screen or web printing

Screen printing is an immensely versatile decorating process and is used to apply patterns in all sorts of manufactured products. It produces especially brilliant colors, finest fluorescent and metallic colors fade-resistant pastels and opaque whites and blacks. It applies an extremely uniform coating with no ghosting or streaks.

5. Glossary

absorption The taking up of light energy by matter and its transformation into heat.

achromatic The term used to refer to white, grays, and black-which have no hue.

additive color A means of producing a color reproduction or image process by combinations of blue, green, and red colored lights, such as in color television systems.

additive primaries Blue, green, and red lights of high saturation, which when mixed together in varying combinations and intensities can produce any other color.

black The absence of color; an ink that absorbs all wavelengths of light.

black light source A source rich in ultraviolet and low-frequency blue radiation.

blanket A fabric coated with natural or synthetic rubber that is wrapped around the blanket cylinder of an offset press. It transfers the inked image from the plate to the paper.

brightness
1. The amount of light reflected from a surface.
2. A paper property, defined as the percentage reflection of 457 nm radiation.
3. The intensity of a light source.
4. When used to describe color, this term means highly saturated.

carbon black The pigment commonly used in black inks. Toners are usually combined with this pigment in the ink formulation to make the black ink more neutral.

chroma The degree of saturation of a surface color in the Munsell System.

chromaticity diagram A graphical representation of two of the three dimensions of color. Intended for plotting light sources rather than surface colors. Often called the CIE diagram.

CIE Commission Internationale de ftclairage, a standards-setting organization for color measurement.

CIE diagram See chromaticity diagram.

color balance The combination of yellow, magenta, and cyan needed to produce a neutral gray. Determined through a gray balance analysis.

color bars See color control strip.

color cast The modification of a hue by the addition of a trace of another hue, such as yellowish green, pinkish blue, etc.

color chart A printed chart containing overlapping halftone tint areas in combinations of the process colors. The chart is used as an aid to color communication and the production of color separation films. The charts should be produced by individual printers using their own production conditions.

color control strip Small patches of color solids, overprints, tints, and resolution targets for the purpose of monitoring printing press performance. Sometimes called color bars.

color conversion A color transparency made from a color reflection original. A conversion is made for the purpose of allowing a rigid reflection copy to be color-separated using a drum-type scanner, or for any of the other reasons listed under color duplicating.

chrome A term used to describe a color transparency.

color correction I. A photographic, electronic, or manual process used to compensate for the deficiencies of the process inks and the color separation process.
2. Any color alteration requested by a customer.

color duplicating The process of making a duplicate transparency from an original transparency for purposes of retouching, color cast adjustment, density range normalization, image assembly, or reproduction scale adjustment. Color duplicates are sometimes called dupes.

color gamut The range of colors that can be formed by all possible combinations of the colorants of a color reproduction system.

colorimeter An optical measuring instrument designed to respond to color in a manner similar to the human eye.

color proof A printed or simulated printed image of the color separation films. The colorants used are selected so that the proof will produce a close visual simulation of the final reproduction.

color references A given set of inks printed at specified densities or strengths on a given substrate, used for color control.

color separation The process of making film intermediates from the color original to record the red-, green-, and blue-light reflectances. These films are used to prepare the cyan, magenta, and yellow printing plates. A black separation is also made.

color sequence The color order of printing the yellow, magenta, cyan, and black inks on a printing press. Sometimes called rotation or color rotation.

color temperature The temperature, in degrees Kelvin, to which a black body would have to be heated to produce a certain color radiation. 5,000 K is the graphic arts viewing standard. The degree symbol is not used in the Kelvin scale. The higher the color temperature, the bluer the light.

color transparency A positive color photographic image on a clear film base. It must be viewed by transmitted light.

continuous tone Variation of density within a photographic or printed image, corresponding to the graduated range of lightness or darkness in the original copy or scene. Sometimes referred to as contone.

contrast Differences between light and dark tones, including the visual relationship of the tonal values within the picture in highlight, middletone, and/or shadow tones.

copy Any material furnished for reproduction. For color printing it may be a color photograph (print or transparency), artist's drawing, or merchandise sample.

cyan The subtractive transparent primary color that should reflect blue and green and absorb red light. One of the four process-color inks. Sometimes called process blue.

densitometer An electronic instrument used to measure optical density. Reflection and transmission versions are available.

density The ability of a material to absorb light.

digital The use of discrete pulses or signals to represent data.

doctor blade A metal blade or knife (used in the gravure process) that removes ink from the surface of the gravure cylinder, leaving ink only in the recessed cells. A doctor blade is also used on some flexographic presses to remove ink from the surface of the anilox roll.

dot area The proportion of a given area which is occupied by halftone dots. Usually expressed as a percentage.

dot etching A manual technique for chemically changing the dot size on halftone films, for purposes of color correction or adjustment of individual areas. Similar techniques can be used for adjusting continuous-tone images on film or areas on metal relief or intaglio image carriers.

dot gain The change in size of a printing dot from the film to the press sheet. Usually expressed as an additive percentage. For example, an increase in dot size from 50% to 60% is called a 10% gain. Dot gain has a physical component-the gain in the dot area-and an optical component-the darkening of the white paper around the dot caused by light scatter within the substrate.

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drum scanner A color scanner on which the original is wrapped around a rotary scanning drum.

dry etching A technique for creating selective or overall change in dot areas by manipulating c contact printing exposures onto photographic material.

ductor roller On an offset press, the transfer roller that carries the ink from the fountain to the roller train.

duplicate transparency A transparency created by color duplicatnig.

dye A soluble coloring material, normally used as the colorant in color photographs.

dye transfer A method of producing color prints, first involving the making of red-, green-, and blue-filter separation negatives, and then the subsequent transfer of yellow, magenta, and cyan images from dyed matrices.

electronic color correction The process of correcting color on a color scanner or similar electronic imaging system.

filter A transparent material characterized by its selective absorption of light of certain wavelengths. Used to separate the red, green, and blue components of an original when making color separation films.

five- and six-color printing A photomechanical variant of the subtractive color reproduction process that uses additional chromatic colors such as pink, light blue, or red in addition to colors similar to the process primaries. It expands the color gamut but is rarely used.

flatbed scanner A color scanner on which the original is mounted on a flat scanning table. See scanner.

flat color A solid or tint area devoid of tonal variation. The color may be achieved by the use of overlapping halftone tints, a special ink mixture, or a single halftone tint. See screen tint.

fluorescence The emission of light following the absorption of light of a shorter wavelength. Added to the light reflected by the color in the normal way, fluorescence gives an extra brightness. Often occurs through the conversion of ultraviolet radiation into visible radiation. Can occur in printing inks, papers, or original photographs, artwork, or retouching dyes and pigments.

four-color printing A subtractive color reproduction process that uses yellow, magenta, cyan, and black colorants.

gloss Physical characteristic of a surface. A high gloss is suggestive of a polished surface that has the effect of reducing first-surface reflections and increasing the density range of the image.

grain Silver salts clumped together in differing amounts in different types of emulsions. Generally speaking, faster emulsions have larger grain sizes.

graininess Visual impression of the irregularly distributed silver grain clumps in a photographic image, or the ink film in a printed image.

gray balance The values for the yellow, magenta, and cyan that are needed to produce a neutral gray when printed at a normal density. When gray balance is achieved, the separations are said to have correct color balance. Gray balance is determined through the use of a gray balance chart. See color balance.

gray balance chart A printed image consisting of near neutral grid patterns of yellow, magenta, and cyan dot values. A halftone black gray scale is used as a reference to find the three-color neutral areas. The dot values making up these areas represent the gray balance requirements of the color separations. The gray balance chart should be produced under normal plant printing conditions. See gray balance.

gray scale — An image containing a series of tones stepped from white to black that is used for monitoring tone reproduction. A gray scale is a photographic image in either transparent or reflective form. Sometimes called a step wedge or step tablet.

grayness — In the Preucil Ink Evaluation System, the lowest of the three (red, green, and blue) densities expressed as a percentage of the highest.

L

Percentage grayness X 100.

halftone — Image in which the range of tones consists of dots of varying area but of uniform density. Creates the illusion of continuous tone when seen at a distance. The normal imaging technique for reproducing tones by lithography, letterpress, flexography, and screen printing.

halftone tint — An area covered with a uniform halftone dot size to produce an even tone or color. Also called tint or screen ti . nt.

hard copy — A tangible image such as an original, a proof, or a printed sheet.

hue — Quality or sensation according to which differences of wavelength of radiant energy, such as blue, green, yellow, and red, are visually perceived.

halftone — Image in which the range of tones consists of dots of varying area but of uniform density. Creates the illusion of continuous tone when seen at a distance. The normal imaging technique for reproducing tones by lithography, letterpress, flexography, and screen printing.

halftone tint — An area covered with a uniform halftone dot size to produce an even tone or color. Also called tint or screen ti . nt.

Kelvin (K) — Unit of temperature measurement starting from absolute zero, which is equivalent to - 273’ Celsius. Used to indicate the color balance of a light source.

lightness — Property that distinguishes white from gray or black, and light from dark color tones.

lux Metric unit of illumination.

magenta The subtractive transparent primary color that should reflect blue and red and absorb green light. One of the four process-color inks. Sometimes called process red.

masking The process of making light photographic images, called masks, from the original or a photographic image, for the purpose of color correction, contrast reduction, tonal adjustment, or detail enhancement. See two-stage masking, single-stage masking, unsharp masking, highlight masking, electronic masking.

matte A dull surface that scatters the specular component of light, thus causing the underlying tone to appear lighter. Lacking gloss or luster.

metameric color A color that changes hue under different illumination. If two colors match under one illuminant but differ under another, their spectrophotometric curves are different.

metamerism The process where a change in illuminant will cause visual shift in a metameric color.

metamers Colors that are spectrally different but visually identical for a specified viewing condition.

Mottle Uneven color or tone.

Munsell System A method of classifying surface color in a solid. The vertical dimension is called value, the circumferential dimension is called hue, and the radial dimension is called chroma. The colors in the collection are spaced at subjectively equal visual distances.

nanometer Unit of wavelength of electromagnetic radiation. Equivalent to 10-9 meters. Visible light wavelengths range from 400-700 nanometers.

neutral Any color that has no hue, such as white, gray, or black.

nonreproducible colors Colors in an original scene or photograph that are impossible to reproduce using a given set of colorants, because they are outside the gamut of the system. See color gamut.

off-press proofing See Prepress Proofing.

opacity Describes a material's lack of transparency. In photography, it is defined as the reciprocal of the fraction of light transmitted through, or reflected from, a given tone. For printing ink, it is defined as the ink's ability to hide or cover up the image or tone over which it is applied.

optical density The light-stopping ability of a photographic or printed image expressed as the logarithm of its opacity, which in turn is the reciprocal of the reflection or transmission.

optimum color reproduction A reproduction that represents the best compromise within the capabilities of a given printing system.

original A photograph, artist's drawing, or merchandise sample submitted for reproduction by the photomechanical process. Sometimes called *original copy.*

Ostwald System A system of arranging colors in a color solid. The colors are described in terms of color content, white content, and black content. The solid appears as two cones, base to base, with the hues around the base, and with white at one apex and black at the other.

overprint color A color made by overprinting any two of the primary yellow, magenta, and cyan process inks to form red, green, and blue secondary colors.

Pantone Matching System A system of solid ink color mixing, based on eight colors plus white and black. Not to be used for the specification of process dot percentage combinations. Mixed colors were referred to as PMS colors. The term PMS is no longer used by Pantone.

pastel colors Soft or light colors usually in the highlight to midtone range.

pigment An insoluble coloring material in finely divided form. Usually the colorant in printing inks.

pixel Picture element. The smallest tonal element in a digital imaging or display system.

prepress proof A color proof made directly from electronic data or film images.

press proof A color proof produced on either a regular printing press or a special proof press.

primary colors Colors that can be used to generate secondary colors. For the additive system, these colors are red, green, and blue. For the subtractive system, these colors are yellow, magenta, and cyan.

process blue See *cyan.*

process-color reproduction A printed color reproduction using the three process inks or the three process inks and black.

process-ink gamut chart A color chart for comparing the gamut or color limits that can be produced from any given ink set and substrate combination.

process inks A set of transparent yellow, magenta, and cyan inks used for full-color printing. A black ink is also included in a four-color process ink set.

process red See magenta.

progressive proof A set of press proofs that includes the individual colors, interspersed with overprints of the two-, three-, and four-color combinations in their order of printing. The proofs are used by printers on single-color presses as an aid when printing process-color work.

proof prototype of the printed job that is made from plates (press proof), film, or electronic data (prepress proofs). It is generally used for customer inspection and approval before mass production begins. See Press Proof, Prepress proof, color proof.

purity synonym for saturation.

random proof See scatter proof.

resolution The ability to separate adjacent small details either visually, photographically, or photomechanically.

saturation The dimension of color that refers to a scale of perceptions representing a color's degree of departure from an achromatic color of the same brightness. The less gray a color contains, the more saturated it is.

scanner color separation device that electronically processes images point by point through

circuits that color correct, manipulate tones, and enhance detail.

scatter proof Generally a press proof, containing many images placed randomly on the substrate. Also called a random proof.

secondary colors Colors that are produced by overprinting pairs of the primary subtractive colors. The subtractive secondary colors are red, green, and blue.

separation films Three photographic negative or positive images recording the red, green, and blue components of the colors of the original. A fourth image is usually produced through all three filters for the black printer.

separation filters Red, green, and blue filters each transmitting about one-third of the spectrum and used when making color separations.

setoff The undesirable transfer of wet ink to the following sheet in the delivery pile.

shadow mask Generally a light positive image that is registered with a normal density continuous-tone positive for the purpose of enhancing shadow tone contrast.

shadows The darkest areas in a reproduction.

sharpness The subjective impression of the density difference between two tones at their boundary.

soft copy An image on a video display terminal.

spectral response The manner in which the eye responds to visible radiation. Often used to describe how the light-sensitive component (photomultiplier or film) in a color separation system responds to visible and invisible radiation.

spectro- An instrument for measuring the relative intensity of radiation throughout the
photometer spectrum that is reflected or transmitted by a sample. spectro- A graph showing
curve the reflectance or transmittance of a sample photometric as a function of wavelength.

spot color Localized nonprocess ink color. May be printed as a supplemental color.

standard inks A set of process inks made to the color specifications of a standards-setting organization. Common in the publications industry for proofing advertising reproductions, but otherwise uncommon.

standard viewing conditions A prescribed set of conditions under which the viewing of originals and reproductions are to take place, defining both the geometry of the illumination and the spectral power distribution of the illuminant. For the graphic arts, the standard specifies 5,000 K color temperature, 90 color-rendering index, transparent gray surround with transparencies, and viewing at an angle to reduce glare.

substrate The paper or any other generally flat material upon which an image is printed.

subtractive color process means of producing a color reproduction or image by combinations of yellow, magenta, and cyan colorants on a white substrate.

subtractive primaries Yellow, magenta, and cyan dyes or pigments, at least two of which must be transparent. When combined in various intensities or areas (dots), they can produce any other color.

tack The resistance to splitting of an ink film between two separating surfaces, i.e., stickiness. To improve trapping in wet-on-wet printing, the ink being printed should have a lower tack than the ink that was printed before it.

texture **1.** A property of the surface of the substrate.
2. Variation in tonal values to form image detail. See *modeling.*

tinctorial strength The concentration of colorant in a printing ink.

tint **1.** A halftone area that contains dots of uniform size, that is, no modeling or texture.
2. The mixture of a color with white.

tone Any variation in lightness or saturation while hue remains constant.

tone reproduction A term that relates the density of every reproduced tone to the corresponding original density. This may be facilitated by the use of graphical techniques.

toner Pigments that are added to printing inks as supplemental colors, used to get greater tinctorial strength.

transmission copy An original that must be viewed by transmitted light.

transparency See transmission copy,

transparent ink An ink that contains a vehicle and a pigment with the same refractive index.

tristimulus colors Three color stimuli that, when used in appropriate proportions, will closely match any given color. In practice, red, green, and blue lights are used. Their composition may range from monochromatic spectral lines to bands of wavelengths, each of which comprises about one-third of the visible spectrum.

ultraviolet Invisible, electromagnetic radiation of a shorter wavelength (10-400 nm) than blue. Can create fluorescence effects with the appropriate materials.

viewing conditions See *standard viewing conditions.*

wavelength Quantitative specification of kinds of radiant energy.

white **1.** The presence of all colors.
2. The visual perception produced by light of relatively high overall intensity and having the same relative intensity of each wavelength in the visible range that sunlight has.

xenon lamp A powerful light source used for camera illumination, color scanning, and in some optical radiation measuring instruments.

yellow The subtractive transparent primary color that should reflect red and green, and absorb blue light. One of the four process-color inks.having peak sensitivities in the red, green, and blue parts of' thespectrum, respectively.

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