I. Introduction

A. Ultimately, the perception of a color printed product depends on:

1. the optical properties of the substrate

2. the optical properties of the printed ink film

3. the attributes of the reproduction process

II. Impact of Paper or other Substrate

A. Paper

1. Reflectance: Use spectrophotometric curve overhead with 440nm peak

   a) percent of light reflected at each 10nm of visible spectrum

   b) optical brighteners cause the peak at 440nm on one example

2. Whiteness

   a) Absence of a color cast

      (1) ability to reflect equal amounts of red, green, and blue

      (2) a white sheet is a neutral sheet

   b) Most papers have a slight yellow cast (see spectrophotometric curve)

      (1) due to the natural color of the wood fibers

      (2) the yellow cast can be neutralized by the addition of blue dye during pulp preparation.

      (3) observers mentally adjust to slight color cast—take it as a reference “white”—and then perceive all other colors in reference to this “white.”

      (4) color casts pose little problem when sheets are viewed in isolation.

         (a) problem: comparing a sheet to a proof

(b) *problem: comparing a sheet to another sheet that has a different cast*

c) *Judge whiteness of sheets by comparing unprinted substrates side by side*

(1) there are also colorimetric tests that can be done—usually by papermaker.

3. Brightness

a) *from a color reproduction perspective, refers to the total reflectance of light from a substrate*

b) *The more light reflected, the better*

(1) if a substrate reflects 90% of the light, the reproduction will be better than a sheet that reflects 75%.

c) *Lower-brightness papers produce reproductions with lower contrast and sharpness.*

d) *Evaluate brightness through visual ranking of unprinted samples.*

(1) colorimetric measurements can also be used — usually by papermaker.

4. Fluorescence

a) *The ability of a sheet to reflect ultraviolet light*

b) *Potentially troublesome when trying to achieve exact reproductions of light, pastel colors.*

c) *Metamerism occurs if proof, original, and printed sheet have differing fluorescence properties.*

d) *Judge fluorescence by viewing sheets under black light source.*

(1) sheets that are fluorescent will glow purple.

(2) visually rank fluorescence under black light illumination.

5. Gloss

a) *High gloss paper improves the reproduction of photographs*

b) *Reproductions of watercolors or other art that was originally done on a matte surface should be done on non-glossy paper.*

c) *Image content Vs paper gloss*

(1) If text and illustrations are to appear side by side, high gloss paper will contribute to eye fatigue.

(2) Printed products that are predominantly illustrations without text are often printed on high gloss paper.

(3) Text-only is best done on matte paper.

d) *Gloss can be examined visually or through the use of a glossmeter.*

6. Internal Light Scattering

a) *After light passes through the ink layer, the light is scattered among the fibers in the substrate.*

(1) Some light follows the hollow fibers and eventually emerges in a non-printed area.

(2) This darkens the appearance of the non-printed area

(a) *makes halftone values appear darker than they actually are.*

(b) *This is called* optical dot gain.

b) *Affect of coating on internal light scattering*

(1) uncoated papers = highest scattering

(2) clay-coated exhibit much less scattering

(3) a printed layer of white ink on metal eliminates light scattering

c) *Impact of light scattering on color reproductions*

(1) Light color tints—such as reproduction of water colors—appear better when there is light-scattering paper (uncoated)

(2) darker colors appear better when there is minimal light scattering (coated papers)

(3) Light scattering reduces the apparent resolution of printed colors—they appear softer.

d) *More opaque papers results in less light scattering*

(1) Opacity can be measured with an opacimeter.

7. Absorbency: **use Flint Ink color example**

a) *Absorbency of paper causes shifts in the color of a printed ink film.*

b) *High gloss plus low absorbency result in minimum distortion of the printed ink film color.*

c) *Low gloss plus high absorbency result in significantly higher distortion of the ink film color.*

d) *Measurement of absorbency*

(1) Use K and N gray testing ink

(a) *Apply ink and wait two minutes*

(b) *Wipe off remaining ink*

(c) *Measure density of resulting stain*

(d) *Higher density = greater density*

e) *For accurate color reproduction, it is better to use substrates with low absorbency to minimize degradation of ink color.*

(1) low absorbency papers problems with ink drying and ink bonding.

8. Smoothness

a) *The smoother the paper, the higher the resolution that can be achieved.*

b) *Textured papers are often used for reproducing originals that were done on textured material—canvas, for example—but the result is lower resolution than smooth paper.*

c) *Relation between gloss and smoothness:*

(1) high gloss papers always have high smoothness

(2) highly smooth papers are not always glossy.

B. Nonpaper substrates

1. Plastics, foils, metals, glass

2. Commonly used for packaging

   a) chosen for barrier and strength properties rather than printability

3. Attributes: generally

   a) have low absorbency

   b) lack a white, bright surface

   c) are very smooth

   d) have high gloss

4. Usually these substrates are coated with a layer of white ink, on which the other colors are printed

   a) poly bags have the white layer printed last, then bag is turned inside out for use.

   b) effect of white ink is to produce a neutral surface with low light scattering, high gloss and low absorbency

III. Impact of ink

A. Color reproductions are done with CMYK inks

1. Some inks have misnomers—

   a) *cyan ink is sometimes called* blue *or* process blue.

   b) magenta is sometimes called red *or* process red

   c) cause confusion

      (1) regarding *traps* that actually are red or blue.

      (2) regarding red-filter or blue-filter color separations

B. Gamuts

1. In color reproduction objective is to use inks with the widest possible gamuts.

2. Other real-world concerns that get in the way of wide gamuts

   a) *resistance to light, moisture and chemicals*

   b) *cost*

   c) *fineness of pigment particle*

   d) *dispersion ability*

   e) *low toxicity*

   f) *minimize environmental concerns*

3. Process inks have far from perfect gamuts:

   a) *use ink-reflection display*

      (1) cyan ink does not reflect all the blue and green that strikes it

      (2) magenta does not reflect all the blue and red that strikes it

      (3) yellow reflects almost all green and red

      (4) result is way too little blue, and somewhat too little green.

   b) *Cyan ink is probably the worst*

      (1) Causes problems with gray balance

      (2) To produce a neutral gray, one needs to use more cyan ink than magenta or yellow.

         (a) *5C2Y2M for neutral white*

c) *although the inks are not perfect, they are satisfactory for the great bulk of color reproduction work.*

d) *Sometimes fifth and sixth colors are added to help extend the color gamuts of process inks*—high definition color

(1) Usually, additional colors are not used in this way, but to provide solid colors in the background or to match a logo (Pantone, etc.)

C. Transparency/Opacity

1. Ideally, process colored inks should be perfectly transparent—

a) *they should reflect no light themselves*

b) *however, all process inks are slightly opaque*

c) *the top-down color will skew the overall color towards its color*

(1) most noticeable with yellow pigments

2. In some cases, opacity is desired

   a) *to obscure a color that is underneath it*

   b) *screen printing often requires opaque inks*

   c) *metallic colors are usually opaque*

   d) *white base coats for color printing on colored paper requires opaque inks.*

3. Test opacity using a draw-down test.

D. Tinctorial strength

1. The amount of ink per unit area required to produce a given strength of color

   a) *Depends on pigment selection and quality of pigment*

2. High-tinctorial-strength inks are usually preferred because they allow thin ink films

   a) *minimizes dot gain*

   b) *improves resolution*

3. Drawbacks to high-tinctorial-strength inks:

   a) *usually cost more than low-strength inks.*

      (1) balance between cost and thickness of ink film

   b) *lower gloss*

   c) *higher viscosity*

      (1) increased force to split the film

      (2) increases picking problems

4. It may be impossible to match a print made with high-tinctorial-strength inks with low-tinctorial-strength inks.

5. The printing process impacts the need for high- or low-tinctorial strength inks

   a) *Offset needs higher-tinctorial-strength ink due to very thin ink film caused by split-film action*

   b) *Screen printing needs lower-tinctorial-strength inks due to thick layer of ink applied*

      (1) increased dot gain

      (2) decreased resolution

E. Gloss

1. For most pictorial reproduction, high-gloss inks are desirable

    a) *improves contrast*

    b) *improves saturation*

2. Factors influencing gloss:

    a) *amount and type of vehicle in the ink*

    b) *type of drier: gloss or through*

3. Gloss can be measured using a glossmeter or visually by comparing samples

F. Other ink-related factors

1. Color fastness: may fade, bleed or change color depending on

    a) *light (yellows in particular)*

    b) *water*

    c) *heat*

    d) *alkalis*

    e) *acids*

    f) *soap/detergent*

    g) *oils/fats/wax*

2. Fluorescence

    a) *reflectance of "black light."*

    b) *Readily available for uses such as*

        (1) solid type

        (2) background colors

        (3) screen printed items

c) Unwanted fluorescence causes color-matching problems

3. Metallic appearance

a) Undesired (sometimes called bronzing)

(1) migration of toners to the surface of the printed ink film

(2) reflections from surface mix with light reflected from the substrate to distort the intended color.

(3) Black and blue inks are most likely to cause this problem.

b) Desired

(1) Mixing inks with aluminum or bronze particles

(a) very opaque

(b) very expensive

(c) very hard on press rollers

G. Printed ink films

1. Many color properties cannot be measured until there is an interaction between ink and substrate

a) Run a special test form using actual

(1) press

(2) ink

(3) plates

(4) fountain solution

(5) blanket

(6) press settings

b) *Tap-out test*

c) *Draw-down test*

d) *Quickpeek rollout*

H. Standards

1. In many types of printing, there is no need for standards

   a) *ex: bags, corrugated boxes, greeting cards, catalogs, etc.*

   b) *A common standard for all inks would unnecessarily restrict variety and creativity*

2. Magazines and other publications/catalogs must have standards

   a) *ads made and separated by many separators*

   b) *without standards, it would be impossible to match proofs from varying color sources.*

   c) *In the US., the standards are:*

      (1) SWOP for offset

      (2) Gravure Technical Association Standards (for gravure)

      (3) ISO 2846 in Europe

IV. Impact of Printing Process

A. Color Sequence

1. Twenty-four possible CMYK combinations

2. Three combinations are common

   a) *YMCK*

   b) *CMYK*

   c) *KCMY*

3. Color sequence should be kept constant for all but the most rare circumstances.

4. Reasons for choosing a color sequence

   a) *Opacity*

      (1) the color of overprint changes toward top-down color if that ink is at all opaque.

   b) *Production problems*

      (1) Ink, substrate, and plate image may combine to cause a problem that can be improved by altering color sequence—moiré in flesh tones, for example.

   c) *Trapping*

      (1) tack sequence

      (2) you can buy inks in any desired tack for any sequence.

   d) *Doubling*

      (1) Especially when heavy ink films are run

      (2) The most critical color (magenta if skin-tones are being printed) should be run on last unit.

   e) *Mechanical press problems*

      (1) Excessive slur or misregister, for example

(2) run yellow on defective unit (least noticeable)

f) Printback

(1) Contamination of one ink by preceding ink

(2) Minimize problem by printing the lighter colors before the darker colors

g) Ink coverage

(1) Inks with heavy coverage can distort thin papers preventing register of the next color.

(a) Prevent this by running the heaviest image last

(b) This is why many people run yellow last

h) Gray balance

(1) Gray balance should be established for each set of printing/proofing conditions—including color sequence.

(2) If a number of color separators produce films/proofs gray balanced for different color sequences, it will be impossible to match all the proofs on one job.

(3) PhotoShop can adjust its on-screen image to illustrate gray balance

(a) Use the Preferences>Printing Inks Setup dialog box.

(b) Use a printed sheet to adjust the gray balance of the monitor to match the printed sheet

(c) Changing this dialog box does not impact final file—only the way it is viewed on the screen

5. It is strongly recommended that black follow yellow

a) Yellow is most opaque process ink.

b) Printing yellow last:

(1) skews print toward yellow—impacts tone reproduction

(2) decreases maximum print density (D_{MAX})

(3) decreases print contrast

(4) alters gray balance toward yellow—cannot be corrected

c) YMCK is a good choice to prevent the yellow cast

B. Dot gain and related factors

1. Dot gain: a characteristic rather than flaw

a) To transfer ink, pressure is required

(1) this pressure forces ink into the paper and causes it to spread sideways.

(a) the sideways spread is called dot gain

b) Measure using GATF Star Target, and Midtone Dot Gain Scale (Pix on page 116-117 of Color and its Reproduction)

(1) Dot gain is expressed as a percent

(a) If a 50% screen tint measures 70% on the press sheet, 20% dot gain has occurred.

(2) Dot gain impacts the midtones and shadows more than the highlights

(3) Higher lpi screens are more susceptible to dot gain than lower lpi screens.

(4) A 20% dot gain means that an 80% dot will appear solid.

c) Dot gain may be different on each unit of a multi-color press.

d) Dot gain is not an error, but a characteristic of the printing process

e) Typical dot gain percentages:

(1) 15% is very good

(2) 20% is normal

(3) 35% is very bad

(4) Newspapers usually have much greater gain than commercial presses.

f) *When preparing the same ad to be run on different presses (and processes), you must take into consideration the dot gain* for that machine.

g) *PhotoShop can adjust its on-screen image to illustrate potential dot gain*

(1) Use the Printing Inks Setup dialog box in the Preferences submenu of the File menu.

(2) Changing this dialog box does not impact final file—only the way it is viewed on the screen

2. Slur: a flaw

a) *a directional form of dot distortion (elliptical dots)*

b) *caused by improper balance of printing pressures*

c) *Measure using a GATF Slur Target*

3. Doubling: a flaw

a) *double-printing of a dot*

(1) dots are out of register

(2) one dot is much lighter than other

(3) darkens overall appearance

(4) causes out-of-focus appearance

b) *typically caused by a loose blanket*

c) *Recognize using the GATF Star Target*

4. Causes of dot distortion problems:

a) *Thick ink films result in more dot gain*

b) *More printing pressure results in greater dot gain*

(1) necessary for rough stocks

c) *Too much water (in Litho) emulsifies the ink causing excessive dot gain.*

d) *Low plate or blanket tightness causes doubling*

e) *Increased press speed increases dot gain*

f) *Rough and uncoated papers result in more dot gain*

g) *High-tack inks exhibit lower dot gain*

5. Dot distortion factors in other (non-Litho) processes

a) *Gravure*

(1) dot distortion occurs due to capillary action of the paper

(2) deeper cells increase dot spread

(3) lower viscosity inks increase dot spread.

b) *Flexography*

(1) plate stretches around the cylinder—must compensate for this before plate is made

(2) the coarser the antilox roll, the more the dot gain

(3) Changing doctor blade angle impacts dot gain

c) *Screen printing*

(1) Increase dot gain by:

(a) *thicker stencil*

(b) thicker mesh

(c) increased squeegee pressure

(d) softer squeegee

(e) lower squeegee angle

(f) lower ink viscosity

(g) rounded-end squeegee

C. Mechanical problems

1. Register

a) Misregister between colors of process-color image

(1) ± 1/2 row of dots usually considered acceptable

(2) Misregister can cause slight color shifts if dots overlap when they shouldn't (or visa-versa)

b) spreads or chokes required when printing colors next to each other.

Screen Ruling	Trapping Value in Points*
65 lpi	.55–2.20
100 lpi	.35–1.44
133 lpi	.27–1.08
150 lpi	.24–.98
200 lpi	.18–.72

* Smaller values require better press registration.

Process/Substrate	inch	mm	points
Sheetfed Offset (all)	.003	.08	.25
Web offset (uncoated)	.005	.13	.40
Web offset (coated)	.004	.10	.30
Web offset (newsprint)	.006	.15	.45
Flexo (coated)	.006	.15	.45
Flexo (newsprint)	.008	.20	.60
Flexo (packaging)	.010	.25	.75
Screen (paper/fabric)	.006	.15	.45
Gravure (coated)	.003	.08	.25

2. Mechanical ghosting or starvation (see pix on page 127 of Color and its Reproduction)

   a) *avoid windowframe designs*

   b) *design form so heavy ink-consumers do not print in line with one another*

   c) *use more opaque inks*

D. Maximum LPI's for process/substrate combinations

Process/Substrate	LPI
Screen-Textiles	50
Letterpress—newsprint	65–85
Screen printing—smooth surfaces	85–110
Flexography	85–110
Letterpress—machine finished	100
Lithography—machine finished	120–133
Letterpress—coated	133–150
Gravure—all substrates	150–200
Lithography—coated	150–250

LPI vs TRAPPING VALUE IN POINTS

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Flexo (coated)	.006	.15	.45
Flexo (newsprint)	.008	.20	.60
Flexo (packaging)	.010	.25	.75
Screen (paper/fabric)	.006	.15	.45
Gravure (coated)	.003	.08	.25