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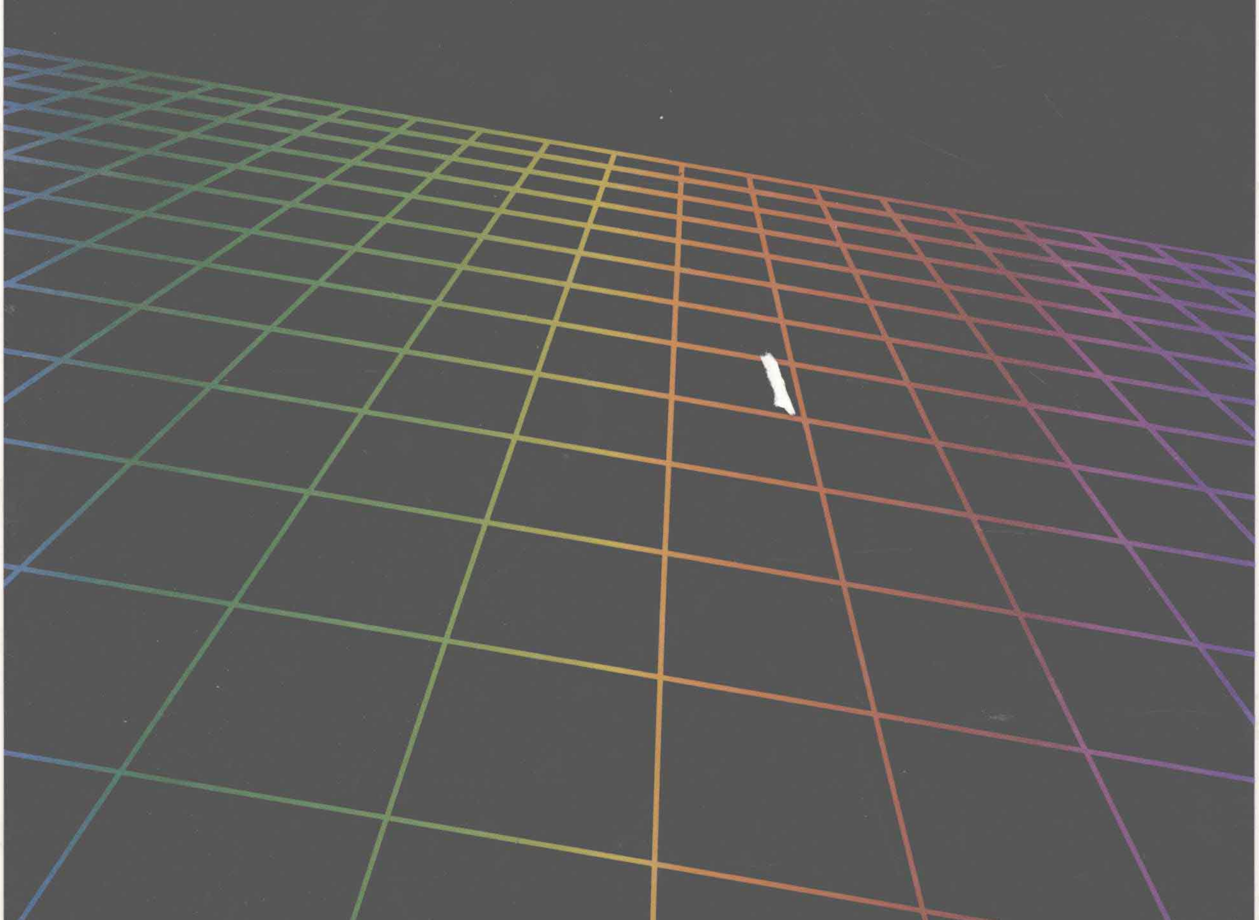
# Tone and Color Correction



Graphic Arts Technical Foundation

GATF

# Tone and Color Correction

by
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# Preface

This text is intended for use as an instructional tool in the field of tone and color correction. The primary audience is those who are involved in the day-to-day task of making tone and color corrections, but it is anticipated that this book will prove to be of value to a secondary audience consisting of sales representatives, quality control specialists, production management, and buyers of printing. Apprenticeship training programs and students in some college courses could also make profitable use of this book.

The author has kept the overlap between this text and other GATF books on the subject of color to a minimum; consequently, the reader may have to refer to some of these other publications for supplemental information. An appendix is provided that not only lists appropriate GATF sources for further reading but also lists other publications that will prove to be of value.

Several authorities from industry and education have been kind enough to review selected chapters of this book: chapters 1–3 were reviewed by Professor Robert Chung of the Rochester Institute of Technology, chapter 4 by Charles E. Rinehart of Eastman Kodak Co., chapters 5–6 by Don Hutcheson of Crosfield Electronics, chapters 7–9 by Ian Haysom, now retired from the Melbourne College of Printing and Graphic Arts, chapter 10 by Anthony P. Stanton of the Graphic Arts Technical Foundation, and chapter 11 by George W. Leyda of 3M. The entire manuscript was also reviewed by Richard D. Warner and Frank V. Kanonik of the Graphic Arts Technical Foundation and Bruce Tory, graphic arts consultant, formerly of Leigh-Mardon Pty. Ltd. Many of the reviewers' suggestions were adopted for the final version, but any errors or omissions are the responsibility of the author.

At GATF, Thomas M. Destree edited the manuscript, Mary Alice O'Toole produced many of the illustrations, and Martin S. Gonzales was responsible for much of the photography. Several companies and individuals generously provided photographs and other materials to help illustrate the text. Their contributions are noted where they appear.

The author expresses his thanks to these persons and all others involved in the production of this text. He also extends his thanks to Harvey R. Levenson, head of the Graphic Communication Department at the California Polytechnic State University, for his encouragement and support.

Gary G. Field
San Luis Obispo, California
November 1990

# Contents



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# 1 Reasons for Tone and Color Correction

The word "correction" suggests that a conscious change or alteration must be made to the normal course of events so that the desired results may be achieved. When the term is used in connection with the color separation process, it means that the normal process of separating an original by separate exposures through red, green, and blue filters is insufficient to achieve high-quality color reproduction.

In a few rare cases, color separation without correction may be satisfactory. Such cases involve either low-contrast and low-saturation originals, or relatively modest quality expectations on the part of the customer. The assumption made in this text is that the highest possible quality is always the objective, and that the supplied originals and subsequent manufacturing conditions present the maximum degree of difficulty in achieving the quality objectives.

There are four general reasons why tone and color correction are necessary in the color separation process:

- Characteristics of the printing process, which include ink, paper, press, and plate properties
- Tonal and color properties of the original
- Characteristics of the color separation system, including filters, films, light sources, and scanner sensors
- The specifications of the customer

Although these reasons for correction are discussed under separate headings, it must be remembered that the actual process of correction is generally applied without any one specific correction reason in mind. That is, the objective is to produce color separation films containing values that, when printed, will produce the desired colors. To achieve the correct values on the films, *all* of the reasons for tone and color correction must be addressed.

## Ink and Paper Characteristics

In general, the properties of the inks and the papers (or, more broadly, substrates) are the major reasons that tone and color correction procedures must be used when making color separations. In fact, the combined corrections dictated by *all* of the other factors are usually less than those required for the paper and ink factors.

**Ink.** The major process ink requirement regarding color properties is the selective absorption of light. Generally speaking, each of the three process color inks should absorb one-third of the visible spectrum and transmit* the other two-thirds. Yellow inks should absorb blue light and transmit red and green; magenta inks should absorb green light and transmit red and blue; and cyan inks should absorb red light and transmit blue and green. The exact nature of inks having "ideal" absorption characteristics cannot be defined with certainty because there are several ways, at least in theory, of achieving the ideal.

Actual inks fall short of ideal, however "ideal" is defined. Yellows are fairly good, but magentas do not transmit enough blue light, and cyans do not transmit enough blue or green light. The lack of blue-light transmission from both magentas and cyans means that saturated blues, violets, and purples tend to reproduce poorly.

Black inks should absorb all light. In practice, most black inks tend to be slightly on the "warm" side, but this condition rarely creates serious problems.

Apart from correct absorption characteristics, the other major requirement for the yellow, magenta, and cyan inks is that they should be transparent. Unfortunately, yellow, magenta, and cyan process inks are not perfectly transparent. An ink lacks perfect transparency if, when it is printed over a solid black, the black takes on the hue of the ink. Imperfect transparency means that the color of the reproduction will depend somewhat on the sequence in which the inks are printed. The last ink down tends to determine the color cast of the reproduction.

**Paper.** The major paper factor that influences color reproduction is probably smoothness. Poor smoothness not only lowers resolution of the reproduction but also adversely influences tone reproduction. Coating type and coating weight contribute to smoothness and other substrate color reproduction quality factors. Rough papers generally require thicker ink films to produce even coverage. This, in turn, leads to higher dot gain than if a thin film was used.

Paper gloss is related to smoothness: the smoother the paper, the higher the gloss. Gloss, as well as paper

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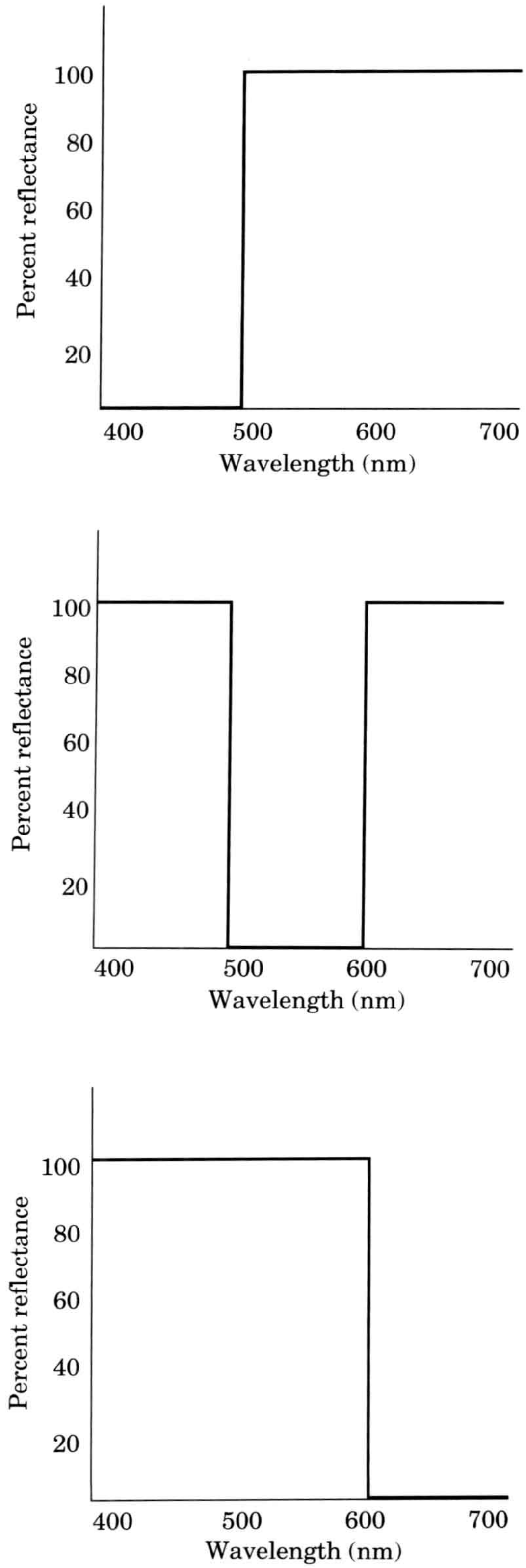
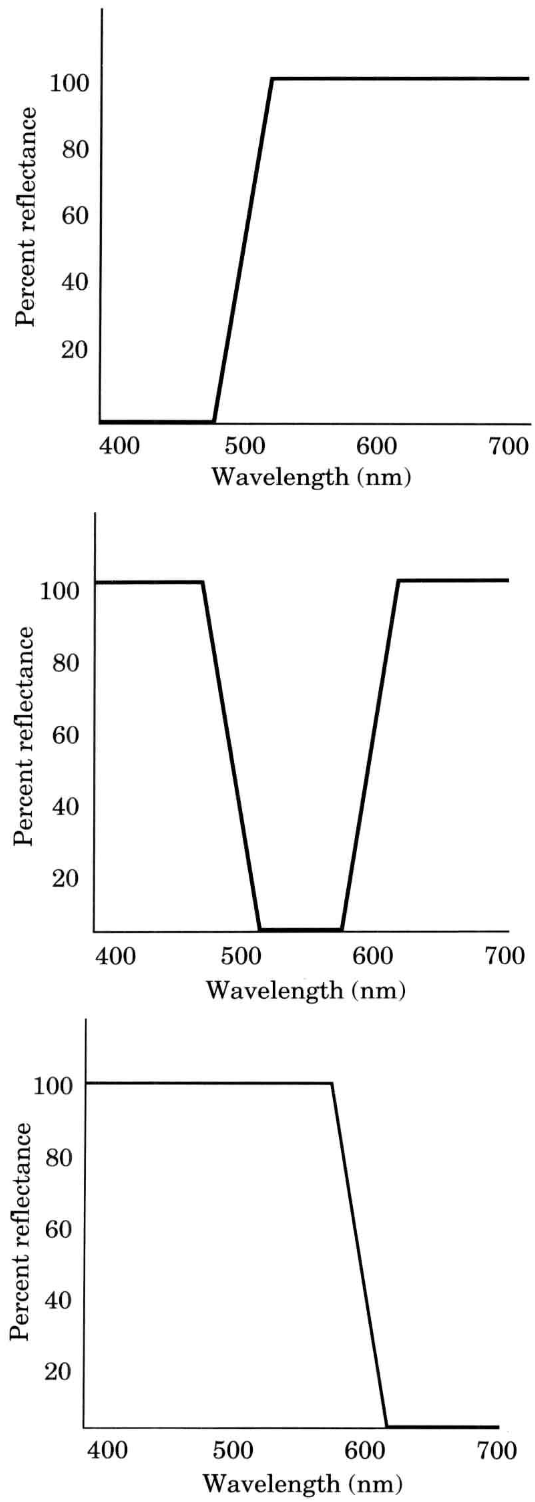
*Technically, process inks should not reflect light. Rather, they should transmit light, which, in turn, is reflected back through the ink film by the substrate.



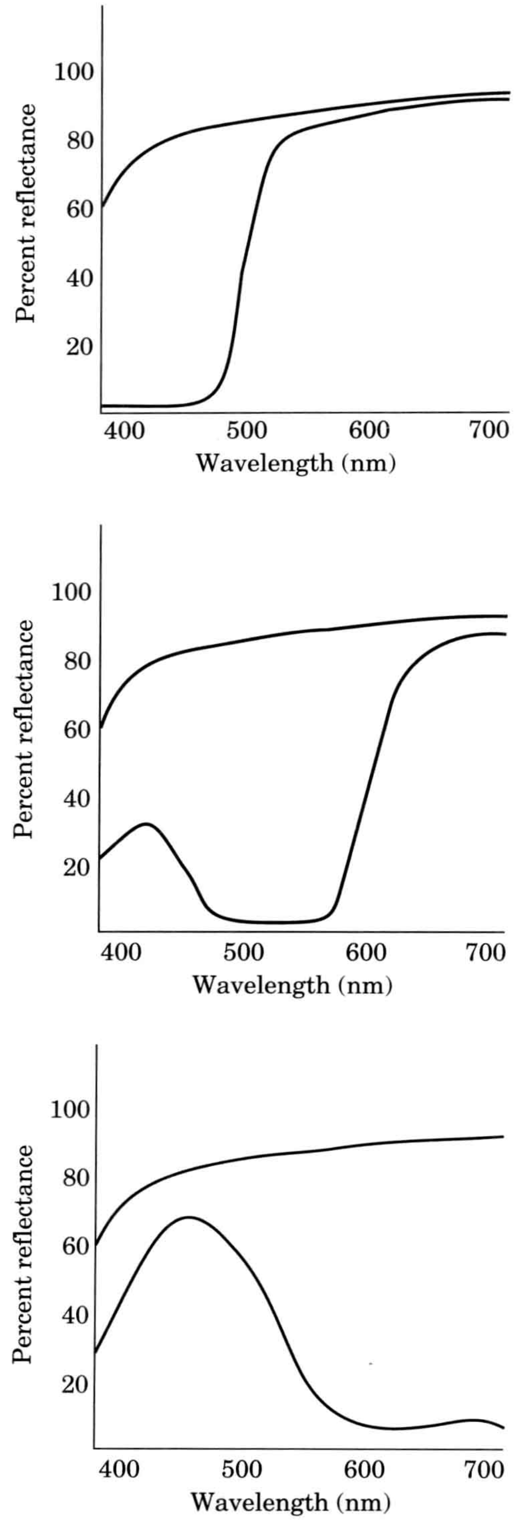

Spectrophotometric curves of a set of hypothetically "ideal" inks (straight-sided version): yellow *(top),* magenta *(middle),* and cyan *(bottom)*

Spectrophotometric curves of a set of hypothetically "ideal" inks (slope-sided version): yellow *(top),* magenta *(middle),* and cyan *(bottom)*



Spectrophotometric curves of a typical set of process inks: yellow *(top)*, magenta *(middle)*, and cyan *(bottom)*

The top curve in each illustration represents the spectrophotometric curve of the substrate.



absorptivity, can seriously influence the color of a printed ink film.

Paper whiteness (neutrality) and brightness (how much light is reflected) are also important. Ideally, paper should reflect 100% of all wavelengths of light. In practice, paper rarely reflects any more than 90% of the light and tends to reflect more red and green light than blue light.

While the ideal whiteness and brightness properties of paper can be specified with some certainty, the same cannot be said for smoothness and gloss. If the original is a watercolor painting, the reproduction should be made on uncoated paper similar to that used for the painting. When reproducing a photograph, however, maximum gloss and smoothness are desired in order to best capture the qualities of the original.

The substrate should have high opacity in order to avoid show-through of the image printed on the reverse side.

## Press-Related Factors

Ink film thickness, ink trapping, and dot gain are the major tone and color factors that may be influenced by press adjustments and settings. Other image quality factors such as register and moiré patterns may also be influenced by the press operator.

**Ink film thickness.** The primary method of controlling color reproduction on press is to vary the ink film thickness of each of the colors. As ink film thickness is increased, density and saturation tend to increase. At a certain point, however, the color of the ink tends to shift. Magenta inks, for example, become redder at higher ink film thicknesses and bluer at lower thicknesses.

**Ink trapping.** Trapping refers to how well one ink transfers to a previously printed ink. If, for example, a yellow ink does not transfer as well to a previously printed cyan ink as it does to unprinted paper, the hue of the yellow and cyan overprint will be bluish green. The trap of one ink over another is influenced by the thickness of the first-down ink, the thickness of the second-down ink, press speed, tack of the inks, and whether the first-down ink is wet or dry.

**Dot gain.** Increase in dot size from the plate to the printed sheet influences the tonal characteristics of the

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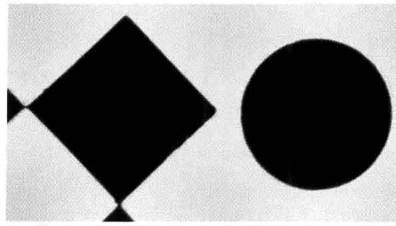
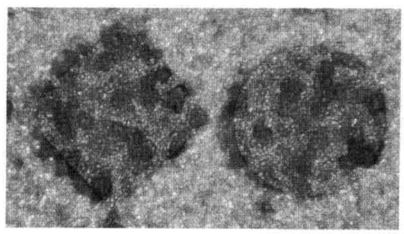
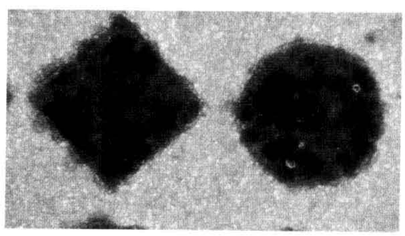
Change in dot size from film to plate to blanket to paper in offset lithography
*Courtesy Heidelberger Druckmaschinen AG*



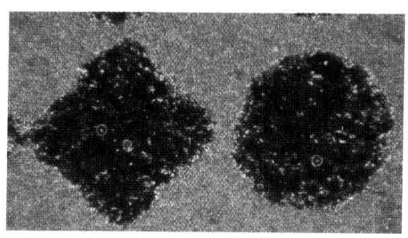
Two halftone dots on film (enlarged approximately 150 times)



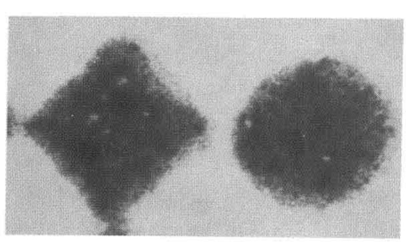
The same noninked halftone dots on the plate (plate has been washed; traces of magenta coating still visible)



Halftone dots on the plate after inking



Halftone dots on the rubber blanket



Printed halftone dots on paper

reproduction. A loss of detail in shadow tones and dark midtones are often the result of excessive dot gain on press. Dot gain is influenced by ink film thickness, impression cylinder pressure, the offset blanket, and other factors including the type of plate.

Some degree of dot gain is inescapable. To transfer ink to paper, pressure must be used. This pressure causes spreading of the image; however, this is not necessarily a problem. The key factor is that dot gain should be constant from day to day, rather than at some arbitrary level. Allowance for dot gain can be built into the color separations if gain is predictable.

**Press control.** Generally, the press operator adjusts the four ink film thicknesses (and the water feed in the case of lithography) to achieve the color saturation, trapping, and dot gain to suit the job at hand. If the prepress work has been done properly, many press settings should be nearly the same every time a given ink/paper/press combination is used.

## Printing Process Characteristics

Each of the individual printing processes has certain characteristics that influence the quality of the reproduction. Most of these factors concern the tone reproduction characteristics of the reproduction.

**Lithography.** This process is capable of the highest resolution—screen rulings up to 300 lines/in. (about 120 lines/cm) may be used under ideal conditions for lithography. Indeed, screenless printing, which has even higher resolution, is possible for this process but, due to control difficulties, is not very common.

Some lithography lacks good color saturation. There are two possible reasons: too much water in the ink; or an ink film that is too thin due, in part, to the fact that the image is offset to a rubber blanket before being transferred to paper. On the other hand, offset lithography is very good for subtle light tones and vignettes, especially on rough papers.

**Gravure.** A major strength of the gravure process is its ability to achieve high color saturation, especially on lower-grade papers. For best results, however, smooth paper is required for gravure printing.

Moiré and trapping problems rarely occur with gravure, but the cell structure of the cylinder can influence image resolution. Economic factors tend to restrict the use of gravure to relatively long-run work.

**Relief.** The relief processes of letterpress and flexography have some of the same characteristics. Light tones and vignettes tend to be reproduced poorly by both processes. On the other hand, especially for letterpress, color saturation tends to be high in heavy tones.

Unless smooth paper is used, the resolution of relief processes tends to be poor. In letterpress newspaper work, for example, relatively coarse screen rulings (e.g., 65–85 lines/in., or 26–33 lines/cm) are used. Little process-color work is still printed by letterpress, but process-color flexography continues to grow because of steady improvements in plate technology, water-based inks, and printing machine precision.

**Screen printing.** The primary advantage of the screen printing process is its ability to achieve unsurpassed color strength and saturation. On the other hand, the mesh that supports the stencil tends to limit the resolution of the process and can contribute to moiré. Screen rulings of 133 lines/in. (52 lines/cm) can be used by the high-quality screen printers. The screen printing of process-color work tends to be restricted to short-run billboard, poster, and similar jobs. The use of screen printing for process-color work is increasing because of improved materials, equipment, and procedures.

## Tonal Properties of the Original

Many originals cause problems in the reproduction process because they were not intended as originals for reproduction. For example, 35-mm color transparencies are designed for projection on a screen. These transparencies, however, are often submitted as originals for printed reproduction. One problem with 35-mm color transparencies is that their density range (the difference between the lightest and darkest areas of the transparency) usually exceeds the density range that can be achieved with ink on paper.

In cases where the density range of the original is less than the potential density range of the reproduction, it is possible to match the tones of the original in the reproduction. Many artists' drawings and some photographic color prints fall into this category.

In the more common case where the density range of the original exceeds the density range of the reproduction, some tones must be sacrificed in the reproduction. Most color transparencies fall into this category.

### Spectral Properties of the Original

The spectral properties of colors in the original become a matter of concern if they cannot be matched by the ink/paper/press combination. Another problem occurs if artwork prepared using fluorescent colors is printed using conventional rather than fluorescent inks.

Many color reproduction problems can be avoided if artists and designers avoid using nonreproducible colors when preparing artwork. This is a reasonable requirement as commercial artwork is prepared *specifically* for reproduction and it is in everyone's best interest that the final result looks good.

In cases where art is prepared as an end in itself, such as fine art intended for hanging in a gallery, some problems can result from nonreproducible colors. The same is true where actual merchandise samples such as fabrics or paint chips must be used as originals in the reproduction process.

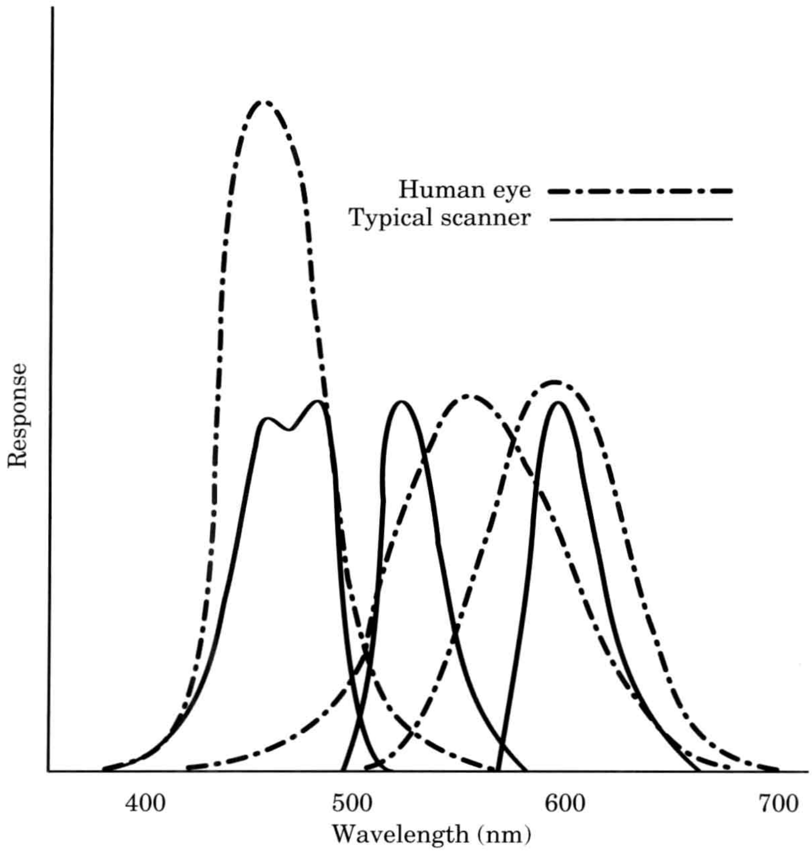
The color gamut or range of most color prints is generally similar to the gamut that can be obtained under good printing conditions. Color transparencies, however, usually contain strongly saturated colors that exceed the range possible with the best four-color process printing.

The colors in originals that tend to be the most difficult to reproduce are the strong saturated colors and the clean, light colors, especially in the blue and red range. In some cases, customers will elect to incur the added expense of five- or six-color printing to achieve a more faithful reproduction, but these cases are rare and tend to be restricted to the fine art poster and similar markets.

### Spectral Sensitivities of Color Separation Systems

The spectral sensitivity of a color separation system is different from that of the human eye. This fact means that two original colors that appear alike visually may record differently because of the way the color separation system "sees" the colors. This characteristic is not due to an error on the part of the scanner or camera operator but is just inherent to the system and is something that must be corrected at some stage of the prepress process.

Spectral response of a typical scanner compared to that of the human eye
*Courtesy Eastman Kodak Co.*




Color reproduction problems that are due to the spectral sensitivities of the color separation system can be minimized if the same type of color film is used for all originals and if a set of compatible pigments are used for hand-drawn artwork. Unfortunately, the color separator usually has little control over the kind of originals supplied for reproduction.

The spectral sensitivity problem is compounded by the fact that nonstandard light sources are used for color separation, whereas a standard 5,000 K light source is used for visual color evaluation. For a variety of reasons, this situation is not likely to change.

**Color scanners.** The factors that influence the spectral sensitivity of scanners are the light source; the absorption characteristics of the color separation filters; the absorption characteristics of the lenses, prisms, and other elements in the optical path; and the spectral sensitivity of the photomultipliers. The spectral sensitivity of the recording film is irrelevant to the spectral sensitivity of the system since scanning the original and recording the image are separate optical operations.

**Camera systems.** Separations made using cameras, enlargers, or contact frames can be grouped in the camera systems category. The factors that influence the spectral sensitivity of these systems are the light source, the absorption characteristics of the color separation filters, the absorption characteristics of the lens and other optical elements, and the spectral sensitivity of the film being used.

**Influence of ultraviolet radiation.** Although ultraviolet (UV) radiation is invisible to the human eye, in some cases it will be "seen" by the color separation system. This radiation from some color separation light sources can also cause colors in the original to fluoresce and thus record differently from the visual appearance under standard illumination.

The UV radiation problem in cameras can be reduced by placing sheets of weatherable Mylar in front of pulsed-xenon lights. The sheets should be far enough away to allow satisfactory air circulation.

For scanners or contact light sources, a Wratten 2B filter placed between the light source and the original will be sufficient to absorb UV radiation. It is important to remember that UV radiation from the *light source* must be filtered in order to avoid fluorescence problems. Merely placing the UV-absorbing filter in the lens of a camera will *not* eliminate fluorescence.

## Customer Specifications

Customer specifications that relate to tone and color correction are those supplied before the color separations are made or those marked on the color proofs. These specifications are used to indicate changes in color from those in either the original or proof.

**Original specifications.** In many cases, the original submitted for reproduction may not represent the ideal appearance desired by the customer. In catalog work, for example, the color of a fabric in the photograph may not match the actual fabric. Sometimes, the overall photograph

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