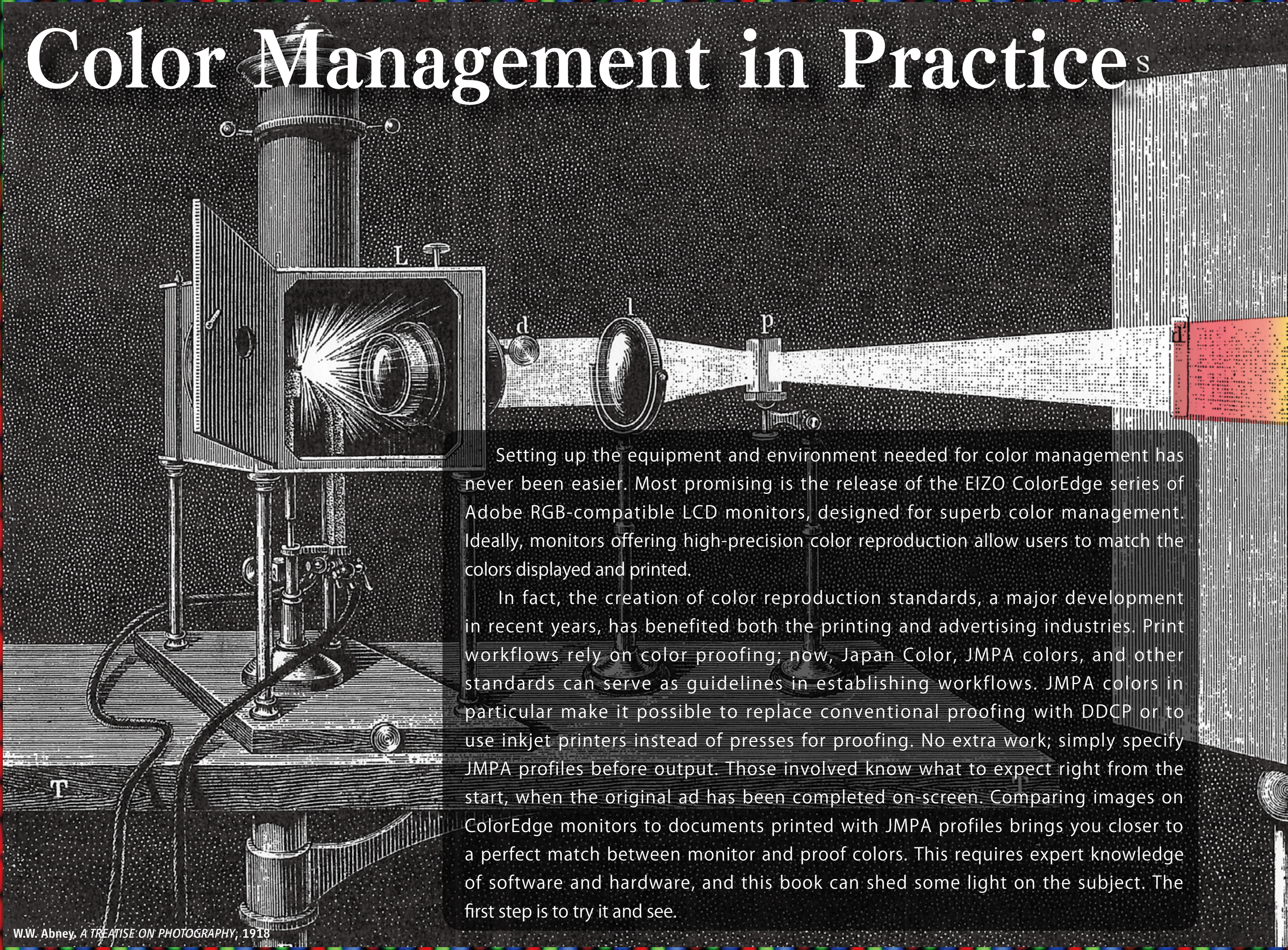
Color Management in Practice



Setting up the equipment and environment needed for color management has never been easier. Most promising is the release of the EIZO ColorEdge series of Adobe RGB-compatible LCD monitors, designed for superb color management. Ideally, monitors offering high-precision color reproduction allow users to match the colors displayed and printed.

In fact, the creation of color reproduction standards, a major development in recent years, has benefited both the printing and advertising industries. Print workflows rely on color proofing; now, Japan Color, JMPA colors, and other standards can serve as guidelines in establishing workflows. JMPA colors in particular make it possible to replace conventional proofing with DDCP or to use inkjet printers instead of presses for proofing. No extra work; simply specify JMPA profiles before output. Those involved know what to expect right from the start, when the original ad has been completed on-screen. Comparing images on ColorEdge monitors to documents printed with JMPA profiles brings you closer to a perfect match between monitor and proof colors. This requires expert knowledge of software and hardware, and this book can shed some light on the subject. The first step is to try it and see.

W.W. Abney, *A TREATISE ON PHOTOGRAPHY*, 1918

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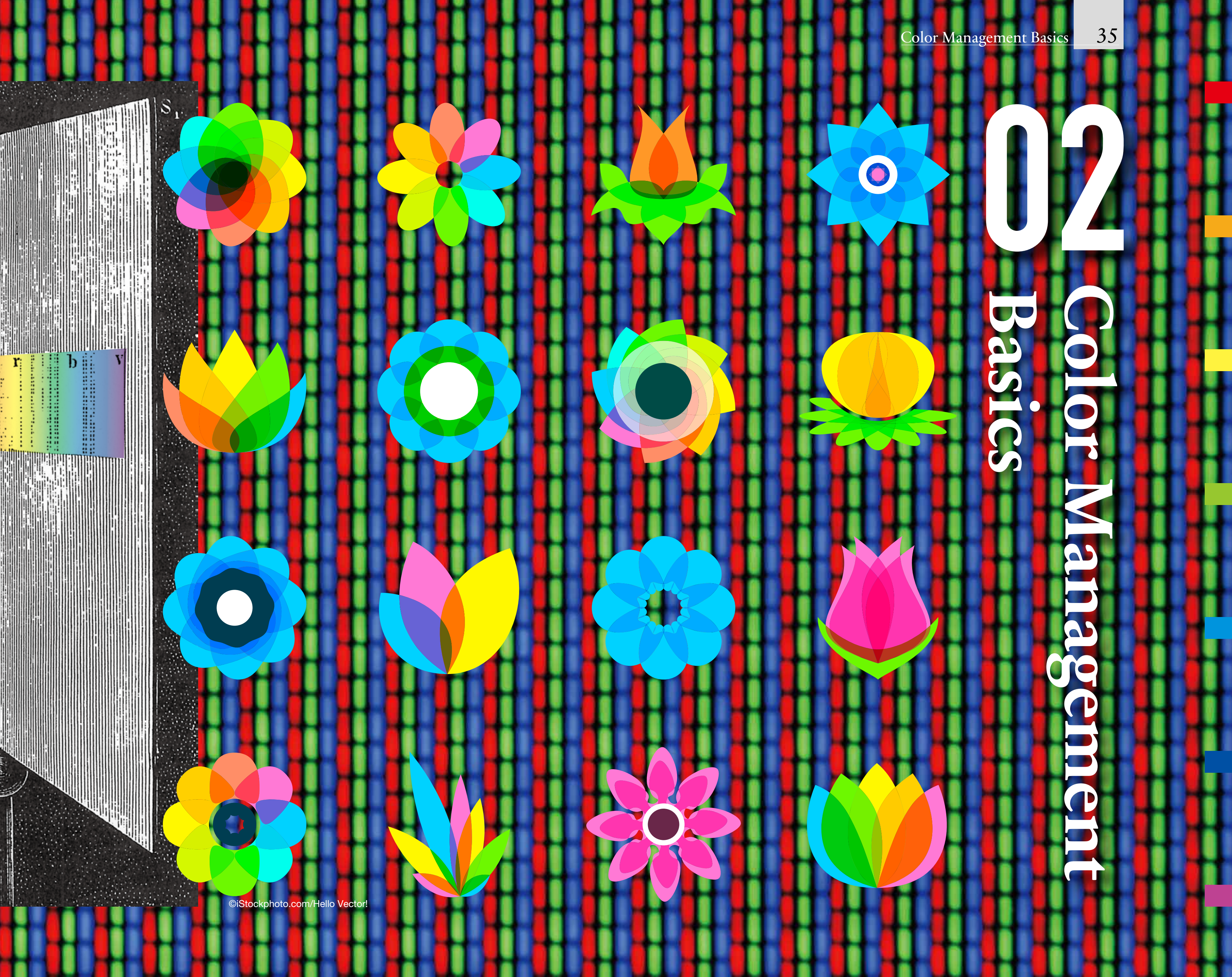
02

Color Management Basics



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Wavelengths and color in light

Combining red, green, and blue light to produce white was a famous feat by James Clerk Maxwell (1831–1879) in lectures at King's College in London in 1861, where he demonstrated the world's first color photo. Maxwell also explored how we perceive visible light in the electromagnetic spectrum.

In the 20th century, as we began to understand how insects and many other creatures are physically equipped to perceive phenomena, researchers in animal behavior found that various creatures perceive various wavelengths of light. What we perceive as color, for example, is the specific range of the spectrum that the particular RGB-sensing system of our eyes reveals to us.

Maxwell also established the fundamental principle that light travels in waves, and his research on electricity and magnetism led to the development of the unified model of electromagnetism. Today, both phenomena are identified as manifestations of electromagnetic force. Maxwell showed that light is a form of energy we can describe as an electromagnetic wave and that wavelengths of visible light lie in the range of 380–780 nm (with one million nanometers in a millimeter).

One consequence is that shorter wavelengths of light are refracted more sharply. Research on the spectrum since Newton has made it possible to assign values to the spectral wavelengths that are visible to us. Newton's original classifications of red, orange, yellow, green, blue, indigo, and violet are too general for work in this context.

As for wavelengths we cannot see (shorter than 380 nm or longer than 780 nm), scientists knew that these waves existed even before Maxwell's time. Sir Frederick William Herschel discovered infrared radiation, with wavelengths longer than 780 nm, in 1800. This was followed in 1801 by a discovery at the opposite end of the spectrum by Johann Wilhelm Ritter, who identified ultraviolet radiation with wavelengths shorter than 380 nm.

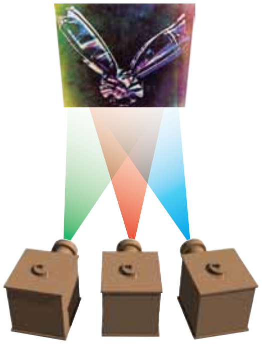
Maxwell correctly concluded that the electromagnetic waves exist at these wavelengths, but that our eyes simply cannot perceive them.

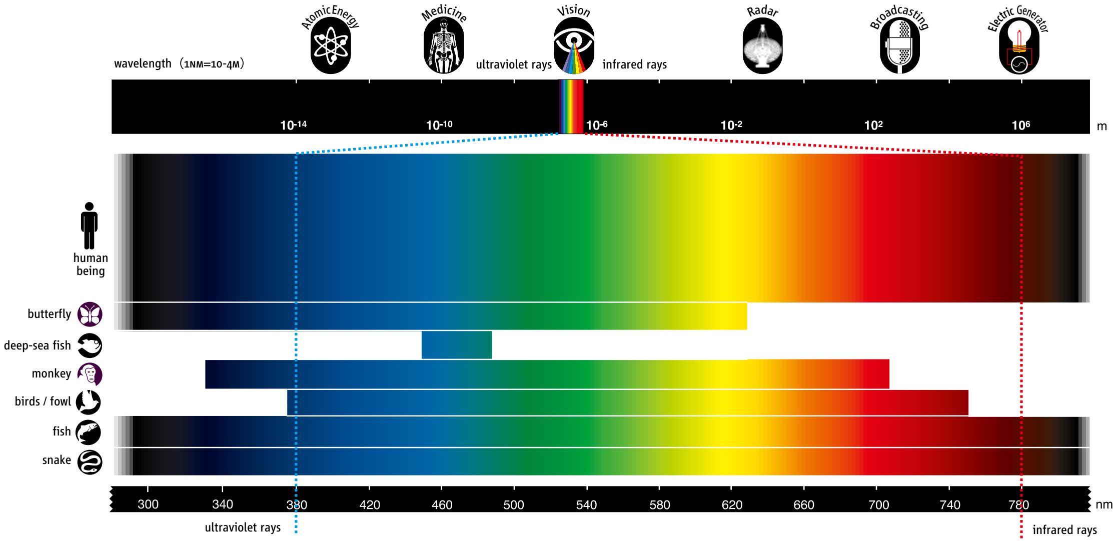
Light radiation, reflection, absorption, and transmission

Light can be described by its wavelength, which determines its color in the spectrum. Two factors affect the wavelength of light: radiation and absorption.

Radiation of light:

When another form of energy is converted to light energy, light radiates from the energy source. This radiation is generated by chemical or physical processes, such as the burning or heating or cooling of atoms or molecules. It is worth noting here that the definition of "white" light varies.





Each animal species perceives color differently. Animals are equipped with what we may regard as unique optical instruments. The particular biological hardware of one species lets it perceive different wavelengths of light than another species. In each case, perception results from long-term evolutionary changes to promote survival in various environments.

Light absorption and reflection:

Absorption is the opposite of radiation, occurring when light energy is converted into another form of energy, when the atoms or molecules of an object or medium struck by light absorb the light. How much light of the various wavelengths is absorbed depends on the chemical structure of the object or medium. Interactions between wavelengths and the structure of the object cause light to be reflected from or absorbed into the surface. Thus, reflections can also be viewed as radiation occurring after light is partly absorbed.

Transmission of light:

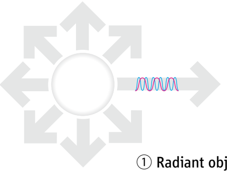
Ancient scholars puzzled over the nature of clear materials and the light passing through such materials. Their confusion arose from a misunderstanding—that color was inherent in the surface of things.

Light passing through clear or semitransparent substances such as water, air, film, or ink is transmitted through the substance. This occurs when more of some wavelengths of light are absorbed than others as they strike molecules and particles in a substance. The thickness of a particular object determines the extent to which various wavelengths are absorbed or passed. Only a vacuum fully transmits light of all wavelengths.

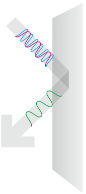
Spectral data and spectral curves

Objects can be broadly classified into three categories based on how they interact with light. In each case, spectral curves show how objects affect light of various wavelengths. The following chart shows examples of several spectral curves.

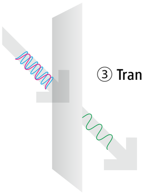
① Radiant objects (such as daylight or monitors)
② Reflective objects or objects that absorb light
③ Transmissive objects



① Radiant objects



② Reflective objects/ light-absorbing objects



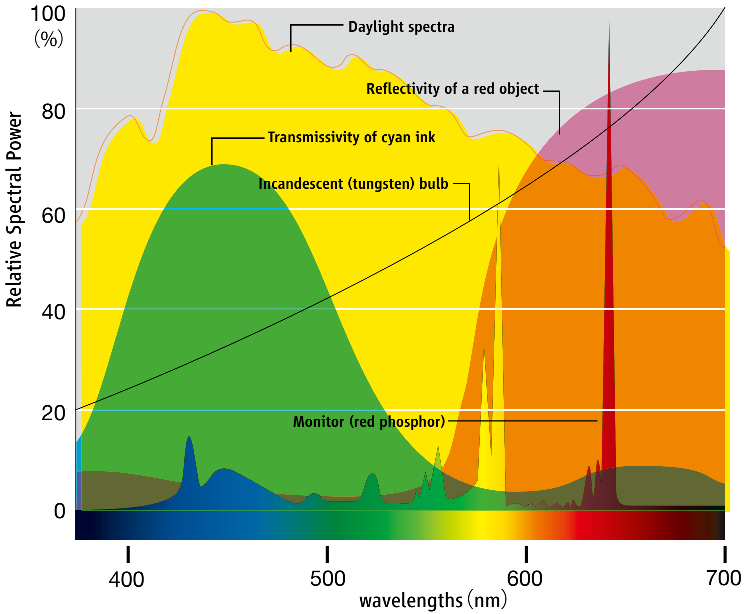
③ Transmissive objects

For objects that radiate light, radiance can be measured and charted. Radiance is the relative intensity of light energy radiated at various wavelengths, based on the total amount of light energy. In the chart, yellow indicates the spectral curve for daylight, with the diagonal line indicating values for an ordinary incandescent (tungsten) bulb.

Similarly, reflectivity can be measured and charted for objects that reflect light. Reflectivity is the ratio of incident light to reflected light at each wavelength. In the chart, magenta indicates the reflectivity of red objects.

For transmissive objects as well, transmissivity can be measured and charted. Transmissivity is the ratio of incident light to transmitted light at each wavelength. In the chart, green indicates the transmissivity of cyan ink.

A colorimeter can be used to measure the spectral data of any object and derive spectral curves. Thus, spectral data provides a detailed record of the amount of light reflected at each wavelength, something that cannot be confirmed by sight alone. Measurements of this kind require an instrument called a spectrophotometer.



Metamerism and color rendering

Color rendering defined

Publications that discuss color often address favorable or unfavorable color rendering properties, but the underlying concept of color rendering is rarely defined. It is worthy of initial consideration, since this is a key issue in the context of metamerism.

Color rendering is the effect of the color of the light source on the appearance of color in objects. This characteristic is known as the light source's color rendering property. The color rendering index is one way to compare relative performance in this regard.

Metamerism

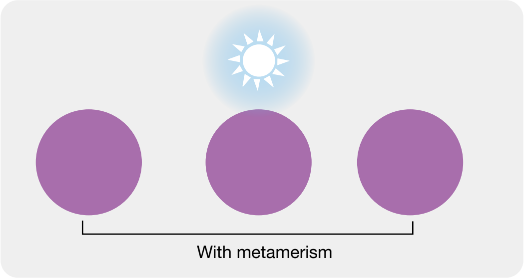
Three requirements are essential in perceiving color: light, objects, and our eyes. Metamerism occurs when these elements are out of sync from their normal relationship. The phenomenon can make two colors that appeared identical under one light source look different under another. Our eyes are susceptible to metamerism, but in fact, the phenomenon also affects other instruments that operate on principles of RGB light mixing, such as scanners and digital cameras.

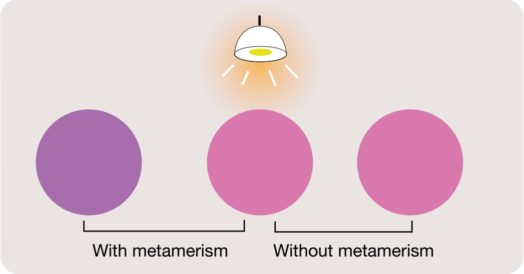
Realistic examples are often cited in explanations of metamerism. Buy fresh fish that looks delicious at the deli, and you may lose your appetite when you see the colors under fluorescent lighting at home. The suitcoat and pants that appeared to match at the store somehow clash at a party. Or the bouquet of flowers that looked beautiful at the florist looks dull and lifeless under your lighting at home. There are countless examples.

We can reverse the underlying principle applying in all these cases to create color with a consistent appearance by combining multiple color components. For example, instead of creating gray from black and white as usual, we can create the same color by mixing complementary hues such as red and blue-green, yellow and bluish purple, or blue and orange.

The following figure shows colors affected by metamerism and colors that maintain a consistent appearance. These three products appear identical under natural sunlight, but incandescent lighting brings out a reddish tinge in two of them. Of course, we can also imagine the opposite effect.

As for ensuring consistent colors through the data used in photographic prints or printing, newer inkjet printers can reduce the effects of metamerism, but a D_{50} or D_{65} light source is recommended for post-printing proofing. Use the isochromatic samples at the end of this book.



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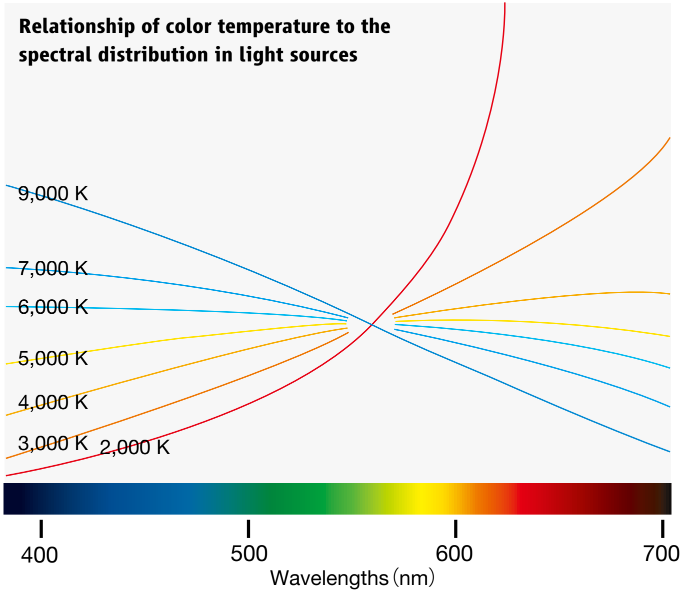
Color temperature

Color temperature is a scale used to distinguish colors of light. Color temperature is measured in Kelvin (a unit of absolute temperature), and values are followed by the symbol K. Color temperature is expressed relative to black-body radiation, as described below. Although the sun and sky appear to change color between sunrise and sunset, we can express a constant color in terms of temperature relative to black-body radiation. As a scale for expressing the color of light, color temperature was first proposed by British physicist William Thomson (Lord Kelvin).

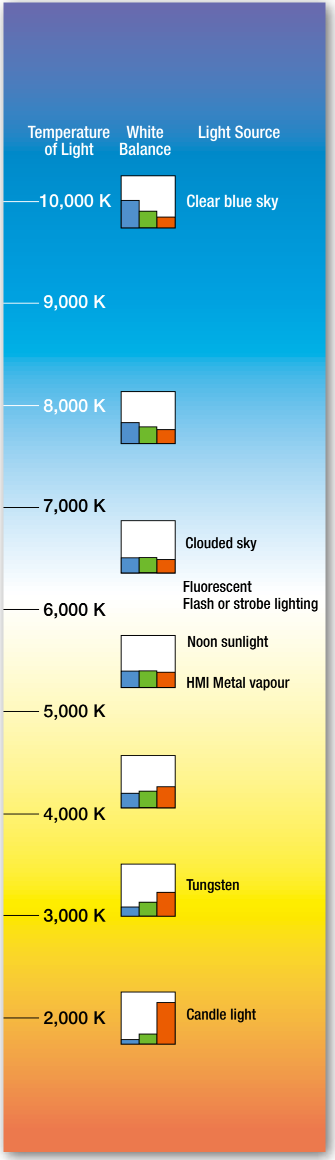
A more detailed explanation will clarify these ideas. Because molecules release energy in the form of light as objects cool, all objects emit light when heated. In this context, the theoretical concept of a black-body, as proposed in 1859 by Gustav Robert Kirchhoff, is useful. This ideal object reflects and transmits no light whatsoever. Because all wavelengths of light are fully absorbed, all light emitted is in the form of thermal radiation.

Since we can calculate wavelengths in black-body radiation, we know that the change in spectral curves is constant (as demonstrated by Max Planck in 1900) and can be predicted. A black body glows red at 2400 K and yellow at 5000 K. At 6500 K, it turns white; at 9300 K, it takes on a blue tinge. The color remains blue even at higher temperatures. This is because the additional wavelengths emitted at these temperatures are too short to be seen.

Next, a system of notation was devised to describe radiant light sources relative to a black body. Measurements were made to determine the spectral distribution of various light sources. These put light bulbs at 2800 K and sunlight at 6500 K, and people characterized colors at various levels. Computer monitors and televisions have specific white points that affect other colors. For example, monitors with a white point at 9300 K have a bluish tinge, while those with a white point at 5000 K have a yellowish tinge. In general, this system of notation is only approximate. Of the many radiant light sources that exist, none perfectly matches the characteristics of a black body. Strictly speaking, descriptions of color temperature are thus the correlated color temperatures. The system of notation also applies only to radiant objects. It cannot be applied to reflective or transmissive objects, since the black body model approximates the molecular process of radiation in objects that emit light.



Relationship of color temperature to the spectral distribution in light sources



CIE

RGB, the dominant color space in digital imaging, is not necessarily ideal for color management.

Everything you rely on in production, from your eyes to devices such as scanners, monitors, and printers, covers a slightly different *RGB* gamut. In other words, there is a different range of colors between red, green, and blue for each device. Fortunately, the values representing colors on one device can be converted relatively easily into those for other devices. No other primary color system shows special promise as a standard color space for typical applications. However, other colors do in fact lie outside the *RGB* triangle. For this reason, the International Commission on Illumination (CIE) has devised a new international tristimulus color system, envisioned as the master system for all other color spaces.

The most reliable color spaces are therefore based on this XYZ color space developed by CIE. Photographers and designers rarely work with CIE XYZ directly, but color experts must know about this system, which is used internally when computer software handles color, and in other applications.

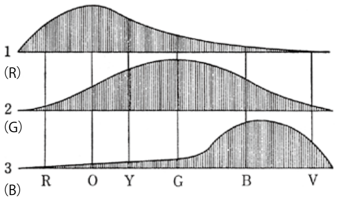
CIE hoped to establish an essential shared point of reference for manufacturers of paint, dye, ink, textiles, and so on, used, for example, when specifying product colors. The historic CIE meeting took place in September 1931 in Cambridge, by coincidence the city where Newton had published *Optics*. This marked the first international attempt to establish a system for observing and measuring color under specific conditions of illumination and observation.

The 1931 CIE system defined ① a standard observer (the field of view for observing colors); ② standard illuminants (light sources); ③ the CIE XYZ set of tristimulus values; and ④ Yxy notation (in reference to a color space and chromaticity diagram), among other matters.

Through many refinements, this system was improved in the ensuing years. In 1964, the definition of the standard observer was refined. 1976 saw the addition of ① perceptually uniform color spaces called CIE LAB and CIE LUV ($L^*a^*b^*$ and $L^*u^*v^*$, respectively), ② a method for quantifying how "close" two colors are (in the form of ΔE^*), and other guidelines. CIE later developed the ΔE_{00} (Δ E2000) color-difference equation and defined the wide sRGB gamut for digital cameras, among many other achievements. The organization remains a leading authority, setting trends in color specifications.

Discovery of tristimulus color perception

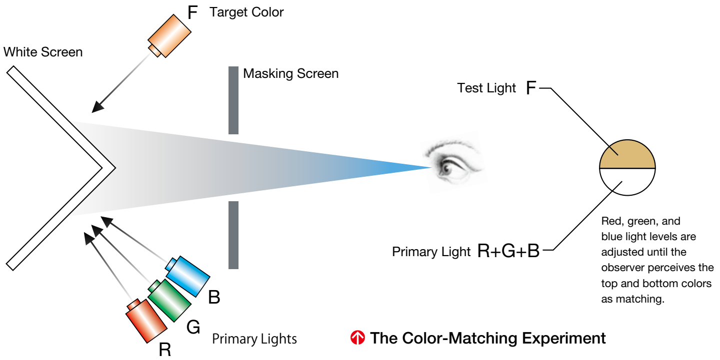
Thomas Young, who postulated retinal RGB receptors, observed that many colors can be created from the three primary colors of red, green, and blue. These theories were later refined by Hermann von Helmholtz, who presented spectral curves for each color. In practice, it is useful to understand that tristimulus principles form the basis for describing individual colors as combinations of three primary colors (such as RGB) and for deriving HSB and similar color models.



Helmholtz's sketh of estimated spctral sennsitivity of three fundamental color vision processes.（1860）

Color-matching experiment

How can we verify this basis for our sense of color experimentally? The environment shown below is used to demonstrate how we perceive color and derive the ratio of constituent colors that match a reference color. Subjects compare the colors of the top and bottom halves of a circle seen through a hole in a screen and respond to questions on the perceived colors. Behind the screen are the two sources of these colors: a trio of red, green, and blue lamps (the three primary colors, to test the tristimulus theory of color perception) across from a reference light source. *RGB* levels are adjusted until the subject feels the top and bottom halves match. This demonstrates tristimulus color perception and makes it possible for us to derive the corresponding ratio of red, green, and blue.



The Color-Matching Experiment

CIE standard observer

CIE color measurements clearly require a controlled environment in several basic respects. First are requirements regarding the observer. To determine the definition of a "normal" observer, data was gathered as several subjects peered into the color-matching equipment.

The 1931 definition of a standard observer specifies a 2° field of view for measurement, since most cone cells (color-sensitive photoreceptors) are concentrated at the center of the retina. This remains a common standard even today.

In 1964, discrepancies were identified after measurement with a field of view wider than 2°, and the data was reexamined. This problem was especially pronounced for the range of colors from blue to green. Again, anatomical considerations arose. The fovea centralis is an area at the center of the retina in which more cones than rods are found. But even within a field of view wider than 4°, which includes an area without many cones, color can be discerned.

Only slight discrepancies were noted between color as perceived from these different fields of view, rarely rising to discernible levels. But advances in measurement technology enabled researchers to gauge this subtle discrepancy, and in 1964, CIE added the supplementary standard observer (based on measurements from a 10° field of view) to account for fields of view wider than 4°. A new notation was introduced to distinguish between these 2° and 10° fields of view: X10Y10X10. However, in the absence of indications to the contrary, a 2° observer is still assumed.

ΔE* and color difference

To calculate how "close" two colors are, we use color spaces with relatively perceptually uniformity, such as CIE LAB and CIE LUV. The value is called the ΔE^* (Delta E) or color difference, and a color difference equation is used to calculate this value. Of these two color spaces, CIE LAB is often used in professional settings.

Determining the distance between two colors involves plotting their coordinates, then measuring the distance—i.e., color difference—between the two points.

In the case of CIE LAB, the color difference between the two colors is expressed as ΔE^*ab, which is calculated as follows:

$\Delta E^*ab = (\Delta L^{*2} + \Delta a^{*2} + b^*2)^{1/2}$.

However, this is easier to understand if we describe the practical significance of some color difference values.

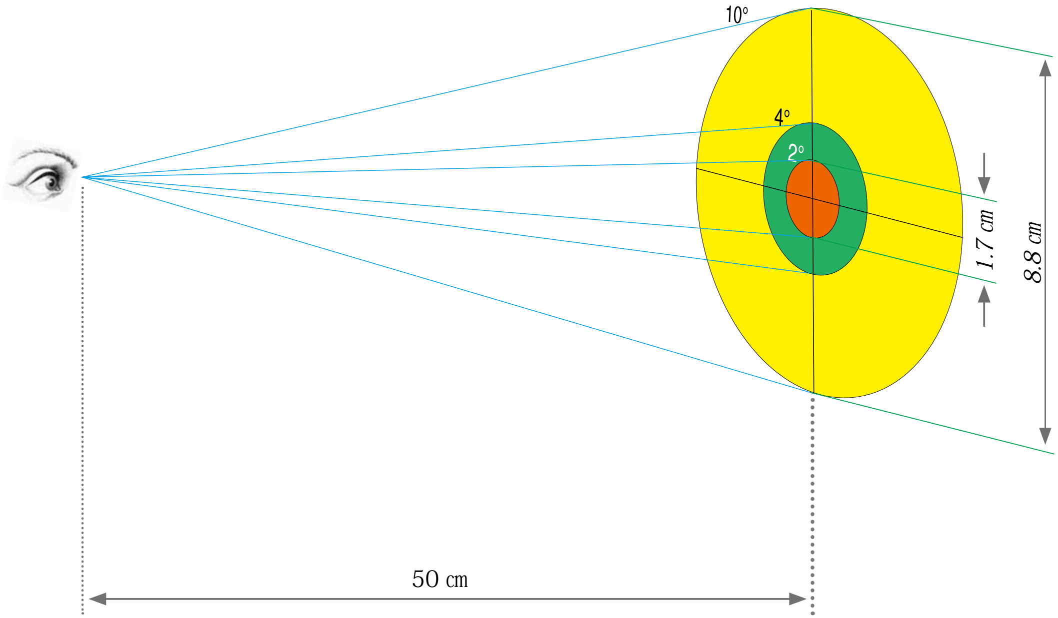
Generalizations are as follows:

$\Delta E^*ab = 0.5$… The difference is nearly imperceptible.

$\Delta E^*ab = 1.0$ …A very slight difference can be seen.

$\Delta E^*ab = 2.0$ …The color difference is clear when one color is placed over the other, but the colors look identical when two small samples are compared.

A tolerance level of around $\Delta E^*ab = 6$ is common in typical printing applications. However, values around $\Delta E^*ab = 6$ are significant given the performance of current equipment, so an approximate value of $\Delta E^*ab = 3$ may be preferred in the printing industry.



Basic Terminology

You may encounter a variety of unfamiliar terms in the context of color management. Some terms are defined as they are introduced in this book. Here we provide a basic reference glossary.

CMY (K) :

A model used to produce colors from subtractive color mixing of the three primaries of cyan, magenta, and yellow. Unlike additive color mixing, in which the three primaries are added to black, color is produced in the CMY model by subtracting particular wavelengths from white. This model is used in printing. To overcome limitations associated with ink composition, black (K) is usually added to the other colors. The less cyan, magenta, and yellow are used, the more red, green, and blue are apparent. Thus, CMY can be interpreted as a special application of the RGB model. (See Fig. 1)

CMM:

An abbreviation of color matching module or method. As one component of a color management system, CMMs use profile information, describing device characteristics, for color conversion from the color space of one device to that of another. Profiles are device- or tool-dependent, and individual profiles utilize the CMM of the same manufacturer or developer.

RAW Data:

An image format in SLR cameras. Although JPEG files offer both convenience and smaller file sizes, typical SLR cameras can save files in a proprietary RAW data format. The term RAW derives from the fact that data is saved nearly unchanged from the raw information captured by the CCD. Since RAW data is not subjected to image processing to refine sharpness, white balance, or other parameters, professional photographers generally save in RAW format, then use image editing software to achieve the desired effects.

RGB:

A model used to produce colors from additive color mixing of the three primaries of light—red, green, and blue. Color is produced in the RGB model for equipment that uses color in a way that resembles tristimulus color perception. Our eyes and all devices such as scanners and monitors use a particular set of RGB colors that differ slightly from others. In other words, there are as many RGB formats as there are devices. Describing colors in the RGB model thus requires identification of the specific device.

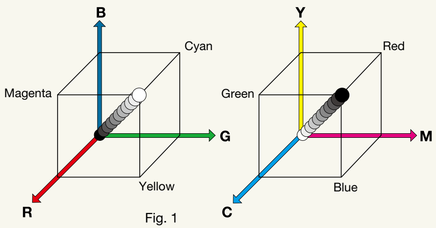


Fig. 1

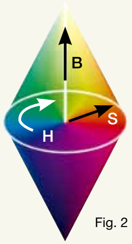


Fig. 2

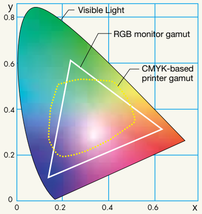


Fig. 3

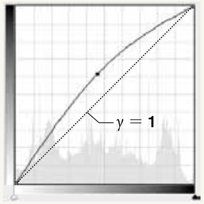


Fig. 4

RGB Workflow:

Although images or graphics files are traditionally converted into CMYK format before submission for printing, RGB workflows have emerged in the past few years. With RGB workflows, after approval from the printing company, images and layout files are submitted in the RGB format used by the photographers and designers involved, and an optimal conversion method is then applied by the printer. People are moving to RGB workflows in part due to the many problems that have emerged at the design stage from CMYK conversion of perfectly captured photographs. RGB workflows are desirable when using wide-gamut ink such as Kaleido, for which more ink in intermediate colors is required. Here, special profiles must be used in color separation to avoid problems.

HSB:

A color model that describes color not as a combination of primary colors but as a combination of the three attributes of hue, saturation, and brightness. Based on the Munsell system, HSB separates the color-related attributes of hue and saturation from the attribute of brightness (also called lightness or the Munsell value), which is unrelated to color. As a special case of the HSB model, the Munsell system is perceptually uniform. The HSB model is also generally somewhat more intuitive than the RGB model. (See Fig. 2)

sRGB:

Standard color space, established as a specification by the International Electrotechnical Commission (IEC) in October 1998. sRGB covers a slightly narrower gamut than color spaces such as Adobe RGB, and the gamut is restricted in certain areas, including hues of emerald green and cyan and hues of orange, bright red, and yellow. For this reason, sRGB may be considered less than optimal for photography, graphic design, or other professional applications, although it generally presents no problems for general use.

ICC Profile:

The International Color Consortium (ICC) establishes specifications on color management for equipment such as computer peripherals. Data established by the ICC regarding device-specific color reproduction characteristics (written in conformance with color reproduction standards) are called ICC profiles.

Illuminant:

Formal definitions of an illuminant are difficult to understand, and they may refer to a mathematical description of the relative spectral power distribution of light sources. For our purposes, consider an illuminant equivalent to a light source. In practice, there are several “standard illuminants” (A–F). The specific one chosen varies with the application or country of use. The most familiar is probably illuminant D. Illuminant D_{50} and D_{65} are the recommended light sources for color management.

Color Viewer:

Color viewers are dedicated display units used to evaluate colors after printing. Many formats are available, ranging from small units used by designers and photographers to large units sold with printing presses. Although few Japanese models have been produced in recent years, the color viewers mentioned in this book (marketed by German-based JUST or U.S.-based GTI) are popular models. Using JUST color viewers for color proofing on EIZO monitors, viewers can adjust color viewer brightness and intensity in ColorNavigator after connecting the color viewer to a ColorEdge monitor. (See p. 71.)

Gamut:

The range of colors that can be reproduced. The gamuts of common devices such as monitors and printers can be compared—for example—by plotting them on an xy chromaticity diagram. (See Fig. 3) Page 30 provides a detailed illustration of gamuts.

Gamma:

A value that expresses the relationship of image input to output. For example, a gamma of 1.0 would yield a straight line at a 45° angle for equivalent input and output when shown on a graph. All devices have a particular gamma value, and accurate image reproduction requires an overall gamma of 1, accounting for all devices used from initial image input to final output. (See Fig. 4)

Example: Using a scanner with a gamma of 0.45 and a monitor with a gamma of 2.2 yields an overall gamma of 1.

Black Level Adjustment:

Adjusting a monitor so that the darkest image displayed (black) is rendered accurately as black. Monitor calibrators are normally used, but if no calibrator is available, a grayscale image created in Photoshop with about 20 intermediate steps from white to black can be displayed while adjusting brightness so that the darkest part matches the black of the monitor edge, outside the scanning lines. Of course, white level and contrast must be adjusted thereafter.

Color System:

According to JIS Z 8105-1982: a series of definitions (using particular symbols), and the system formed by these definitions, intended for precise color matching. Systems applying to the sequence of colors standardized by the International Colour Association (AIC) are called color order systems. Color order systems were classified by the late color scientist Deane Judd of AIC as (1) systems combining colorants, (2) color mixing systems, (3) color appearance systems, and between (1) and (2), color charts for printing systems.

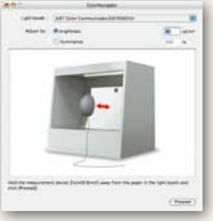


Fig. 5

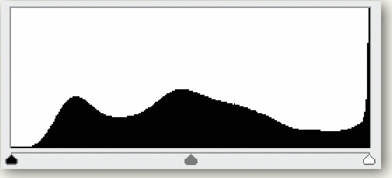


Fig. 6

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Fig. 7

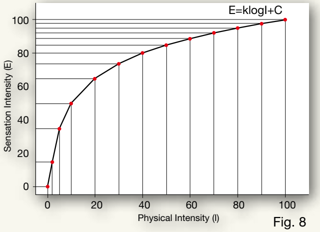

Fig. 8

Color Inconstancy:

Color appearance varies with changes in the color temperature of the light source. The appearance of paintings and photographic works on display depends greatly on the color of the illumination. New inkjet printer ink (manufactured by Epson) reduces such color inconstancies. Attempting to reduce the effect of light sources is, in effect, the opposite of metamerism. (See Fig. 7)

Characterization:

Calculating average values for the same devices made by a particular manufacturer. Characterization enables approximation of equipment color characteristics. Profiles created through characterization are sometimes available from manufacturers.

Calibration:

Calibration involves measuring the display or output of a particular device, determining any variance from a predetermined standard, and adjusting the device to eliminate the discrepancy. Standards used in calibration are either average values derived from several units through characterization or universal standards. Afterward, a profile to compensate for the measured discrepancy with the standard is applied to RGB values created by or transmitted to the device.

Metamerism:

A phenomenon whereby two colors match under a particular light source but not under a different light source. Similarly, under a different light source, colors that originally appeared different may appear identical. Taking this phenomenon into consideration, we recommend a color viewer with a D_{50} or D_{65} standard light source when proofing on monitors, from printed documents, or in printing environments. (For details, see p. 38.)

Fechner's Law:

Law proposed by German scholar Gustav Theodor Fechner (1801–1887), a pioneer in the field of psychophysics, which explores the relationship between sensation and stimulus. Fechner discovered a critical relationship between sensation and stimulus. An example of this relationship is apparent in the fact that even if the actual brightness of a light source is doubled, the increase in brightness is not necessarily perceived to have doubled. Sensation is not proportional to the quantity of physical stimulus. This relationship is illustrated in the chart. We now understand that as stimulus increases, the intensity of sensation traces a curved path that gradually attenuates. This is known as Fechner's law, a key concept in color systems, which quantify color. (See Fig. 8)

First, build an environment for assessing color

➔ Fluorescent lamp for color evaluation (an AAA color rendering index)

➔ A portable viewer from JUST Normlicht of Germany

Your monitors, printers, and similar equipment will fulfill the main role when you introduce a color management system. But don't forget the environment used to assess color. Here, the key elements are indoor illumination and your choice of monitors.

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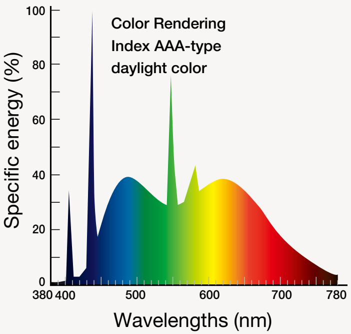
Precautions for indoor lighting

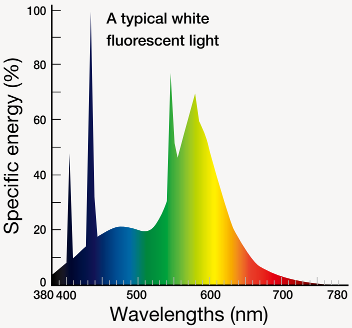
Determining illumination is the first step in introducing a color management system. Lighting is the critical factor for accurate viewing of color in originals and in the results as displayed on monitors or prints. This requires some thought even in closed environments, where the entire workflow up to the final quality check is performed at a single location. By coordinating all conditions in the color-viewing environment, you can ensure that all off-site tasks (at the offices of clients, designers, and platemakers and printers at various times) are performed under identical conditions, allowing you to build an environment that's reliable for substituting color data in DTP or in remote proofing.

The ideal indoor lighting environment serves as the basis for meeting the requirements for a variety of colors. Environments in which color is viewed under sunlight are optimal. But since the nature of sunlight varies depending on the weather, time of day, orientation, season, and location, standard lighting conditions are determined by ISO specifications. D_{50} lighting conditions are considered optimal for printing. Create an environment that will bring you as close to D_{50} as possible. Keep the following points in mind.

Choosing the right light source

As the D_{50} light source, create an environment in which the entire indoor space and the materials to be viewed (original photos and printed results) are illuminated by fluorescent lighting designed for color evaluation. A variety of these specialized lamps are available, and leading manufacturers offer them designed to the same specifications. For example, N-EDL fluorescent lighting for color evaluation with a color rendering index of AAA would be desirable. Additionally, equipment for viewing the materials of interest (original photos and printed documents) in isolation under ideal lighting is available from suppliers of design and platemaking equipment. These are sometimes identified as "color viewers." For design and performance reasons, models from U.S.-based GTI or German-based JUST are recommended.





Precautions related to the brightness of indoor illumination

Once the indoor illumination is ready, seek the optimal viewing arrangement for original photos and printed documents so that only these materials are under the D_{50} light source while conditions in surrounding areas resemble a darkroom. By simulating a darkroom, you can keep light reflected from external sources from affecting color evaluations. However, given the difficulties imposed by working under darkroom conditions, as a practical alternative, consider ways to reduce indoor illumination to the extent feasible. One approach might be to use fewer fluorescent tubes where multiple lamps are installed.

If possible, use fluorescent lighting with louvers to reduce glare from monitors.

Precautions regarding the colors of furniture and walls

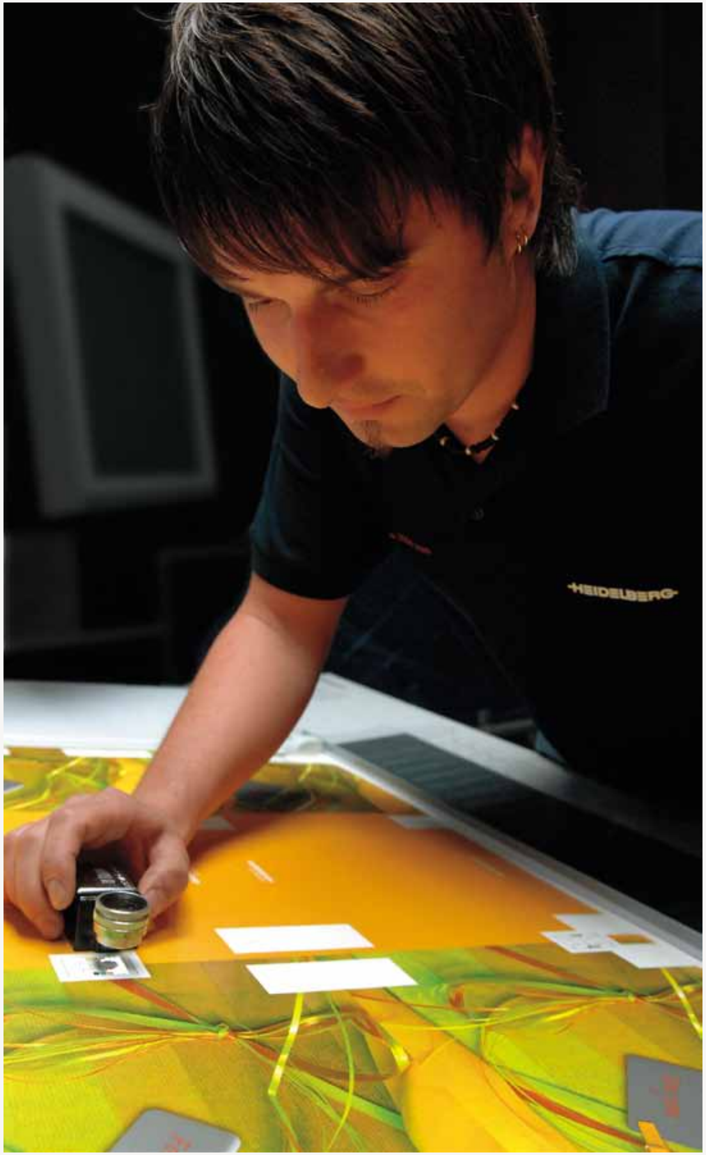
Even if you dim the lights, brightly colored furniture or walls may reflect significant ambient light, or light may enter from windows, mixing with the colors under examination, preventing accurate assessments. Ideally, choose relatively dark furniture and use thick curtains to block external light or take similar measures. These decisions should probably be made on a case-by-case basis, since imposing rigid working conditions may ultimately hinder productivity.

Confirm correct lighting conditions

You may want reassurance that the environment you have carefully arranged is optimal by switching to fluorescent lighting and taking other measures. You can check illumination using the color temperature meters used by photographers and other imaging professionals. Measure the color temperature of monitor surfaces and color proofing environments. D_{50} lighting should register at about 4900 – 5100 K to provide the desired environment. One alternative to expensive color temperature meters is the Simple Metamerism Sample in Appendix B. The card has been printed to account for specific color temperature values, so that the two color patches match most closely under a D_{50} light source. (General guidelines are as follows. For D_{50} lighting, a ΔE of 1.01; for D_{65} lighting, a ΔE of about 1.27; and for three-band fluorescent lamps at a color temperature near D_{50}, a ΔE of about 1.61.) Try using the card to check light sources. Note that the performance of fluorescent tubes will change over time, so they should be replaced at regular intervals.

Monitor selection criteria

The monitor is the most important device in a color management system. Ideally, the colors displayed on the monitor will simply flow from step to step throughout the entire process down through printing. For this reason, a monitor that can reproduce color accurately is essential. Until a few years ago, CRT monitors were the most commonly deployed; LCD monitors were regarded as lacking the color accuracy required for desktop publishing and similar tasks. But the emergence of the ColorEdge series completely transforms this state of affairs. Since the release of the ColorEdge CG220, LCD monitors have become the main-stream for printing and design use.



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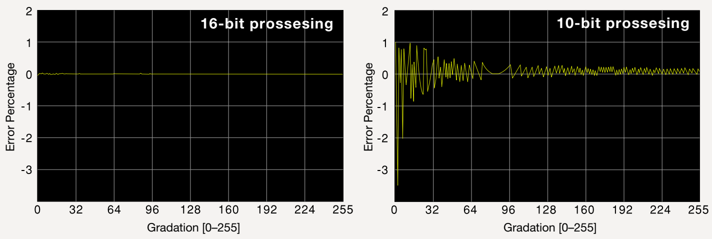
Monitor selection criteria

When selecting the monitor right for you, your key criteria should include the number of display colors and their display stability. ColorEdge monitors support calibration. While more mainstream LCD monitors can also be calibrated, making them more viable choices for applications involving color management, measuring the actual gamma curves of conventional LCD monitors reveals that the curves are not linear, which explains why some image areas appear washed out. In contrast, the ColorEdge series (except for the CG19) has 16-bit internal processing for solid performance rivaling CRT monitors. Support for the Adobe RGB color space with the ColorEdge CG221 makes it an especially good choice from the standpoint of display colors.

To guarantee uniform performance, each ColorEdge monitor is measured and tuned before shipment to compensate for variations between individual LCD panels.

Monitor viewing environment

Once your indoor environment and monitors are ready, prepare the monitor viewing environment itself. Remember that indoor light and other factors can cause glare on glass monitor screens and subtly affect contrast. To prevent glare from indoor lighting when working under conditions not resembling a darkroom, we recommend using a monitor hood or darkroom curtains. The ColorEdge series comes with a monitor hood as a standard accessory (optional with the CG19 and CG232W). DIY monitor hoods may be used, but always apply a non-reflective material such as black velvet to the inner surfaces.



Conversion differences between 16- and 10-bit processing: 10-bit processing generates more conversion errors, particularly in darker areas; 16-bit processing (with ColorEdge monitors except the CG19) results in more precise conversion.

The gamma values of each ColorEdge unit are optimized before shipping.

A ColorEdge series hood

Monitor adjustment

The last requirement to ensure faithful color reproduction is adjustment — specifically, calibration. Broadly speaking, there are two methods of monitor calibration. One approach is to use a combination of hardware (in the form of calibrators or spectrophotometers) and dedicated software, as in i1 solutions. This method offers the most accurate adjustment and management, but requires dedicated equipment. The other approach is to use monitor adjustment software bundled with other applications or operating systems, such as Adobe Photoshop (using Adobe Gamma) and Mac OS X (using ColorSync). (Note: Adobe Gamma is not supported by Mac OS X.) This method lets users make adjustments simply by clicking to indicate the desired values. It also allows easy profile creation.

Calibration intervals

Monitors must be calibrated regularly. Calibration software such as ColorNavigator Agent (p. 71) can automatically notify you when it is time to perform calibration. It is also a good idea to recalibrate monitors after moving them or changing indoor illumination.

JUST colorCommunicator × EIZO ColorNavigator

www.just-normlicht.com

JUST colorCommunicator is the first viewing booth available worldwide that communicates with EIZO ColorNavigator monitor calbriation software tor precisely coordinate the on screen representation and the standardized light to each other.

Standard printing colors and soft-proofing

Soft-proofing is an approach that has become more widely known since last year, and interest is surging, since it lets the user essentially preview on the monitor how documents will appear after offset or inkjet printing. Actual deployment of equipment for soft-proofing is also taking off. The factor driving this trend is the establishment of standard printing practices designed for consistent quality and greater production efficiency. Updated certification programs for proofing systems (including monitor-based proofing) are also earning industry support, as the certification organizations promote higher accuracy.

As international specifications on color reproduction in printing, the ISO 12647 series specifies basic printing characteristics and requirements for digital proofing. This has paved the way for establishing and introducing standard printing colors in line with regional needs: by Fogra in Europe, SWOP and GRACoL in North America, and Japan Color in Japan. Printing characteristics, paper, and target CMYK patch values (L*a*b*) have been tailored to particular printing conditions and standard ICC profiles provided, making it easier to assemble digital proofing systems with inkjet printers and monitors. As a result, soft-proofing is starting to take off in Europe and North America.

IDEAlliance Monitor Proofing Systems Certification

Focusing on proofing (color sample) systems for web offset printing, the SWOP certification program accepted IDEAlliance calibration techniques and characterization in 2006. With the sheetfed offset printing standards of GRACoL, these standards have been updated as certification for proofing systems applied to offset printing. Objective evaluation methods were also established for monitor-based soft-proofing systems, which determine any color difference from target L*a*b* values when printing colors are reproduced on the monitor and measured. This certification program was launched in April 2008. One requirement for monitors is screen uniformity. Proofing systems are certified as supporting printing conditions corresponding to GRACoL C1 and SWOP C3 and C5. In the certification examination, all 1,617 patches of IT 8.7/4 are displayed and measured for evaluation, enabling objective judgment based on numerical values. Display colors in the center of monitor screens are measured, but to ensure accuracy across the screen, the screen is measured while displaying the three levels of white, gray, and dark gray to check for uneven colors and luminance. A high level of uniformity is required for certification.

An EIZO soft-proofing system (comprising ColorEdge LCD monitors supporting color management as the display device and industry-standard Adobe Acrobat Professional as the viewing software) has been certified as a system enabling simulation of GRACoL C1 printing colors. This is a good example of an affordable, low-maintenance, soft-proofing system.

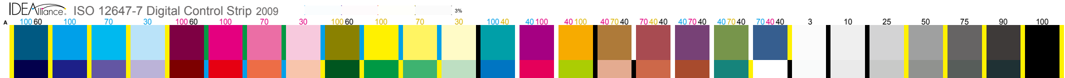
FograCert Softproofing System

Fogra, a German industry association, establishes and conducts certification for monitor-based proofing systems as part of certification for proofing systems capable of reproducing printing colors in compliance with ISO 12647. The criteria for monitors include (1) screen uniformity, (2) monitor profile accuracy, (3) accuracy of gradation characteristics, (4) gamut, and (5) viewing angle characteristics.

What makes the FograCert soft-proofing system noteworthy is that the accuracy of monitor display colors is evaluated by examining color differences relative to a master print, ensuring ample accuracy not just for checking color and color proofing at the prepress stage, but also in scenarios like viewing color samples on the monitor in printing environments.

Japan Color

Standard printing colors and digital proofing, including soft-proofing, have caught on in Japan somewhat later than in other regions. Nevertheless, as with FograCert, the Japan Printing Machinery Association (JPMA) has taken the initiative in establishing a certification program for businesses and for processes that reproduce printing colors conforming to Japan Color guidelines. JPMA is also looking to establish certification for digital proofing systems.



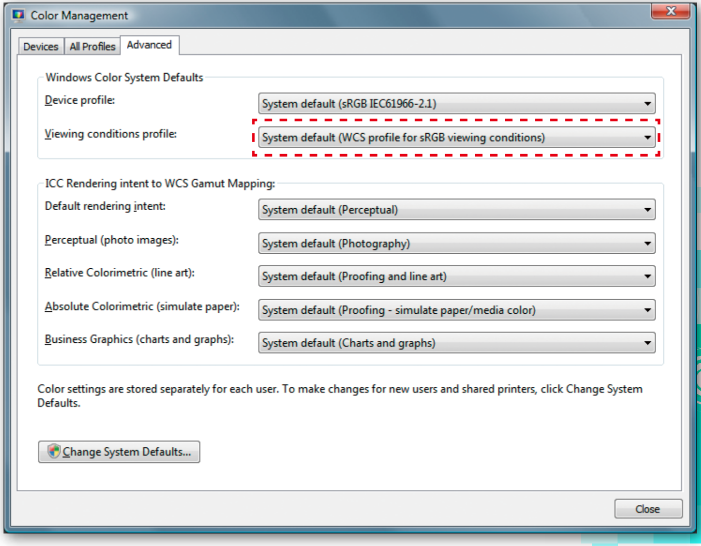
Windows Color System (WCS)

Windows Color System (WCS) is Microsoft's new color management system, introduced in Windows Vista. WCS is positioned as a platform that resolves issues with ICC profile-based color management systems, although few applications using WCS have been developed or launched to date, and the platform is not pervasive.

Among WCS's distinguishing features, color conversion information is kept separate from the device profile as the basis of objective measurement; a gamut-mapping model makes WCS more versatile for color conversion; and CIE CAM02 (a color appearance model ratified by the CIE) is used as the basis for color management.

A prominent example among the few applications that currently support WCS is the Microsoft Office 2007 suite. Once Windows Vista color management settings are correctly configured, images with embedded color space profiles are correctly displayed based on monitor color reproduction information (in the monitor profile) by Office 2007 programs. This is in contrast to earlier versions of Office applications, which process all RGB images as sRGB images. In environments where wide-gamut monitors formerly used only in the graphic arts industry are becoming popular as regular monitors and people use Office applications to create and view business documents with images, demand exists for correct monitor profiles specified in device profiles and correct display colors reflecting sound color management.

Additionally, printer drivers for certain Canon printers can adjust printing colors to suit the ambient light in the specific viewing environment when printing business graphics for presentation display.


Color Management

Windows Color System Defaults

Device profile: System default (sRGB IEC61966-2.1)

Viewing conditions profile: System default (WCS profile for sRGB viewing conditions)

ICC Rendering intent to WCS Gamut Mapping:

Default rendering intent: System default (Perceptual)

Perceptual (photo images): System default (Photography)

Relative Colorimetric (line art): System default (Proofing and line art)

Absolute Colorimetric (simulate paper): System default (Proofing - simulate paper/media color)

Business Graphics (charts and graphs): System default (Charts and graphs)

Color settings are stored separately for each user. To make changes for new users and shared printers, click Change System Defaults.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The ecosystem of color management

Principles in color management

In color document production, a match between monitor colors and printed colors matched without color management would be a remarkable coincidence. Usually, color management is essential for coordinating colors among devices. Colors will not otherwise match since the methods and materials used to reproduce color vary from device to device.

Although our eyes may sometimes fool us into thinking that colors somehow match without color management, measurements with color instruments generally reveal discrepancies. Whether they like it or not, designers and photographers must learn color matching—or, more specifically, color management.

Color management can be summarized by the relationships shown at right. ICC profiles, files that describe the color attributes of each device, are used to maintain the colors of the original across various devices to the extent possible. (This is also called gamut mapping.) The parameters that take priority when matching colors is determined by rendering intent. One of four rendering intents is chosen (perceptual, saturation, relative colorimetric, and absolute colorimetric (p. 96)), depending on the color matching goal. Note that choosing the wrong rendering intent may lead to poor results. For professional color management, start by preparing ColorEdge monitors or others supporting calibration*(p. 43) and a measuring instrument as provided in X-Rite i1 solutions or the Datacolor Spyder series, then calibrate or characterize*(p.43) each device.

Several workflows are conceivable for color management involving printed output, depending on the environment. These can be broadly classified as either application color management or RIP color management. Even in the production of this book, we distinguished between these approaches. Also available are color adjustment functions devised by printer manufacturers and implemented in printer drivers. But since PostScript® files cannot be examined (a prerequisite for most printing), these functions are better suited to photo printing and similar applications.

(Note: Preliminary investigations are advisable before creating workflows that rely on printer drive settings. Manufacturers may change these settings without notice.)

For application color management, simply choose a profile for high accuracy in the profile settings and disable color management in the driver. RIP color management is slightly more sophisticated, but once the principles are understood, this method can be quickly mastered.

Fortunately, while color settings across applications must be considered, Adobe Bridge in Adobe Creative Suite 4 makes it easy to coordinate a color environment comprised of multiple applications. Color management is now less esoteric and much more familiar than it once was.

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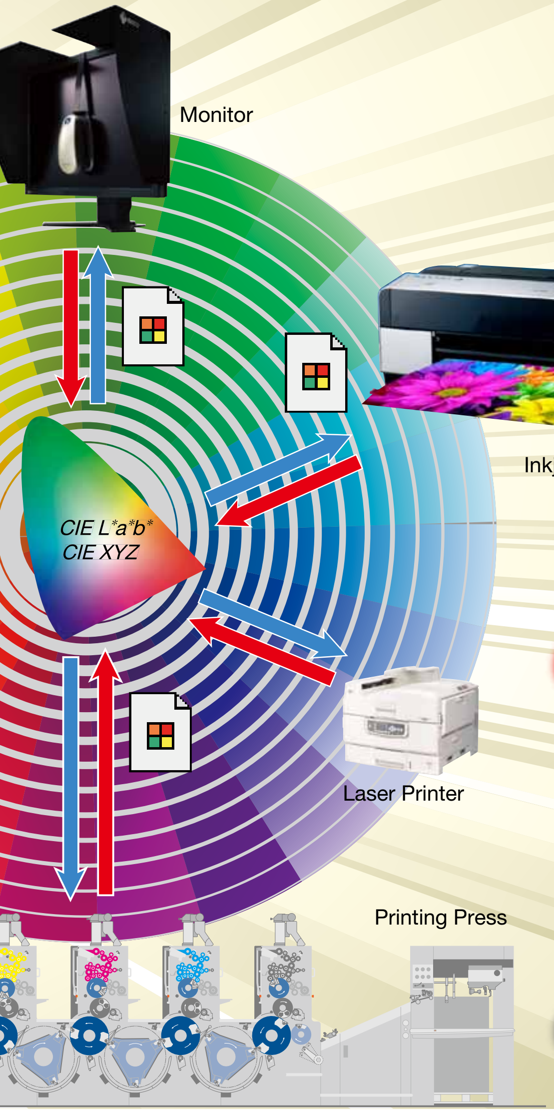
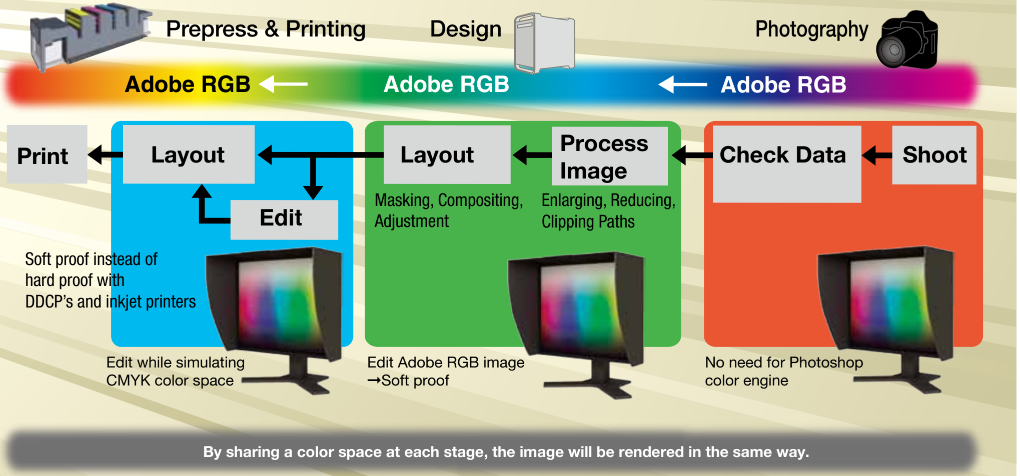


Adobe RGB color space in soft-proofing

This refers to accurate colors throughout the entire workflow—in shooting, layout, and printing. This goal of color management, and the system to achieve it, is fundamental to professional production. Only with a complete color management system environment in place can you appreciate the benefits. An important first step is choosing a common color space, which will serve as the unequivocal standard and prevent needless cycles of color matching. By choosing Adobe RGB as your shared color space throughout the workflow, which may involve shooting with Adobe RGB-compatible digital cameras, editing image data in Adobe Photoshop on Adobe RGB-compatible EIZO ColorEdge monitors, and other steps before conversion to a CMYK format for printing, you can arrange an effective environment for color management, enabling soft-proofing with a higher level of precision.

Color Management in Adobe RGB



By sharing a color space at each stage, the image will be rendered in the same way.

Color management in print workflows

Color management plays a greater role than ever, as print workflows evolve. Here, we explore color management and its benefits.

Color management, the key to efficient DTP

To understand the role of color management in print workflows, consider the stage of printing in the context of DTP. Print workflows are becoming fully digital. Moving to digital print workflows has simplified processes. Clients and designers alike have more opportunities to deal directly with the printing data. The ability to preview the final printing quality during prepress color DTP work paves the way to more efficient workflows and lower printing costs. But some workplaces have yet to reach this stage. When the final color data cannot be previewed as is normally expected during prepress or if it cannot be guaranteed under the current workflow, we often see clients or designers compromising in color proofing of press samples. They accept discrepancies between expected and actual colors. Or we see subtle fine-tuning in prepress or at press, through corrections of the data submitted, ink adjustments, and so forth. Skill in these processes does not draw on expertise with traditional processes, and ultimately, we must rely on the knowledge of advanced techniques of each individual involved. In many cases, frustrated designers and clients are submitting material as they did before, including color samples or actual objects for reference.

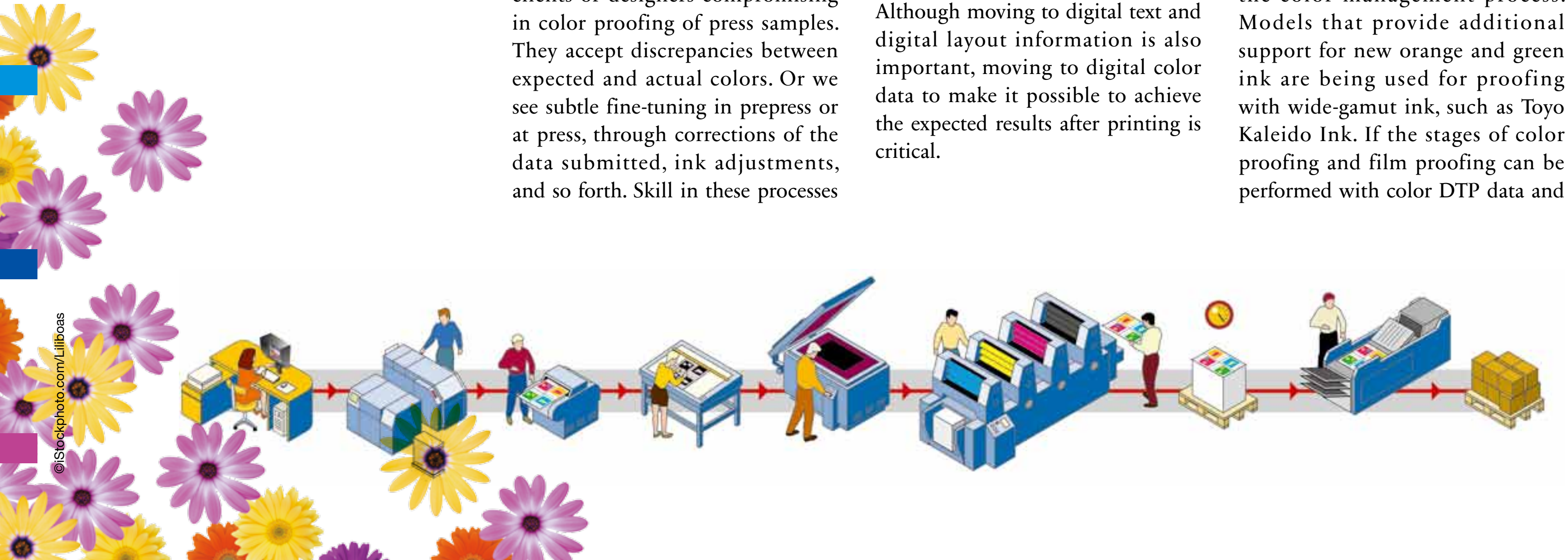
Digital color management is a different way of thinking, a comprehensive approach to color from the initial stage through printing. Color management systems also account for differences among various environments (client, designer, prepress, and printer) and equipment, providing an environment that maintains a consistent appearance for identical color data. Once the color management system is in place with the correct settings, you can enjoy the benefits of simpler, more efficient color DTP print processes. Although moving to digital text and digital layout information is also important, moving to digital color data to make it possible to achieve the expected results after printing is critical.

Color management supports DDCP, CTP, LFP, and POD

Techniques such as direct digital color proofing and computer-to-plate (DDCP and CTP) skip traditional platemaking in several ways. In CTP, color DTP data is burned directly to aluminum plates from a computer. CTP produces screens just as on film, eliminating the step of traditional film-based platemaking. (This book was produced using CTP.)

Direct digital color proofers, a popular type of digital color proofer, take color proofing into the digital age.

Recent large-format inkjet printers (LFP) come with built-in color gauges for more consistent output. More businesses are using these LFPs for proofing as part of the color management process. Models that provide additional support for new orange and green ink are being used for proofing with wide-gamut ink, such as Toyo Kaleido Ink. If the stages of color proofing and film proofing can be performed with color DTP data and



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final print quality can be ensured, these steps can be omitted for simpler, more efficient workflows. For this reason, businesses moving to CTP and other such technologies should commit to a color management system.

Color management in print workflows

Color management in print workflows enables consistent viewing of color data anytime and anywhere for modification, editing, or revisions. Toward this end, an environment for accurate color management must be created throughout the workflow. ColorEdge can be instrumental in this fundamental task of building environments.

As Adobe Creative Suite gains more powerful application color management features, even small-scale photographers and designers can set up color management environments with relative ease.

In Japan, standards are in place for the entire printing industry. Japan Color standards are used in commercial printing, Japan Color JCN2002 for newspapers, and JMPA colors for advertisements.

For remote proofing environments, Epson's ColorBase printer calibration tool can be used to minimize variations between Epson inkjets. Recent models also feature built-in color gauges, enhancing consistency in remote proofing.

The EIZO ColorEdge series is an ideal monitor for color proofing. All RGB levels (0 – 255 for each color) are factory-tuned for each monitor to ensure uniformity and exceptionally smooth gradations. Color management is easy, even in separate environments where several people are involved in remote proofing.

Wide-gamut printing with ink like Toyo Kaleido Ink is gaining in popularity. The basics of color management are illustrated above; see p. 110 for detailed information on Kaleido Ink workflows.