



COMPLETE

**GUIDE**

TO COLOR MANAGEMENT



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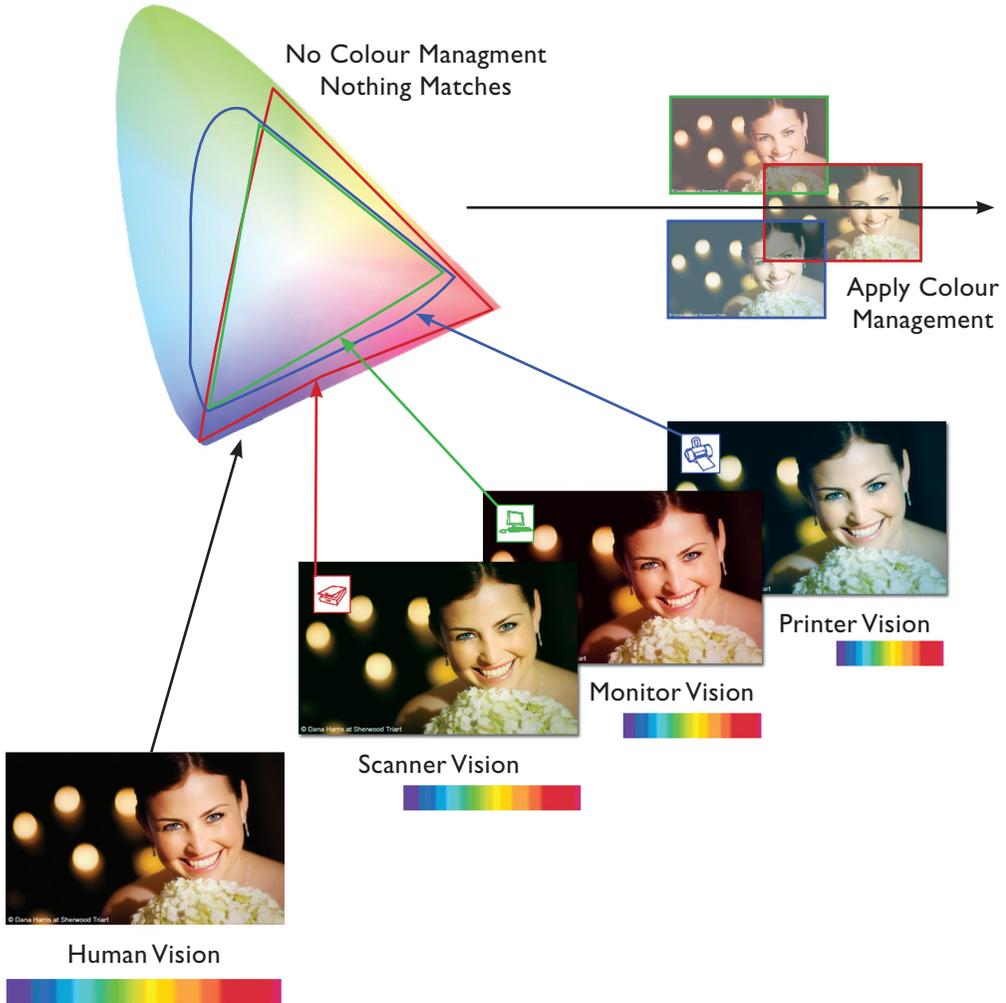
**Tired of Prints that don't match your monitor?**

The fact is all your devices – scanners, digital cameras, monitors, and printers – reproduce colors differently. There are even differences in the way individual printers of the same model manage color. Many variables affect color, including your ink and paper type. Time to take control!

Color Management – is a way to set up your environment (called a workflow) to allow all these devices to speak the same language so you can get accurate and predictable results. The ultimate goal is to match the colors of the image displayed on your monitor with the ones produced by your printer.

We use Color Management software to create profiles for all your devices. A profile provides a description of each device's color gamut – the range of reproducible color. You use these profiles in your workflow, and the result is an accurate translation from one device to the next, giving you consistent, predictable color.

This diagram (FIGURE 1) presents a simple look at Color Management. The fact is the human eye sees a very wide range of colors – wider than scanners and cameras can “see” and much wider than any monitors and printers can “show”. Each of these devices reproduces color differently, both in terms of how many colors and also in terms of which colors, or the shape of their “vision” (gamut). They truly each speak a different language. Color Management acts as the translation system and finds a



common language or vision. Once we turn on Color Management software and apply the unique translation controls (profiles) the work is done – colors match! If you are expecting to get a match between your original image and your final output, without the hassle of trial and error, Color Management is for you. Get the competitive edge to creating accurate prints. Get out of the loop – save time, money, ink and paper using proven

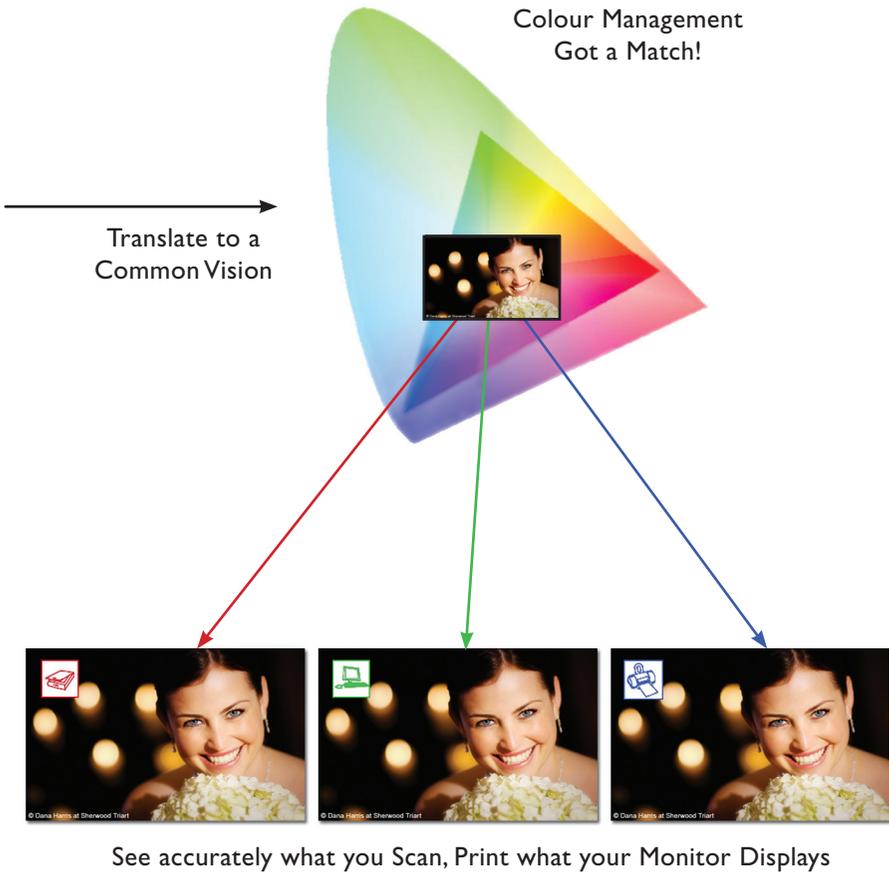


FIGURE 1

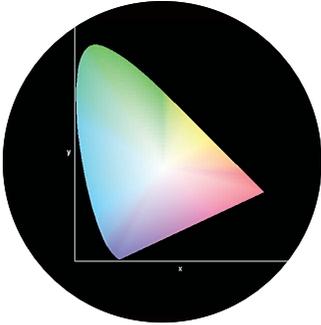


FIGURE 2

If you really want to understand how things work we need to start with some basics. When color reproduction was first becoming a science it was determined that all the colors visible to the average person could fit into a twisted horseshoe-shaped graph affectionately known as the *xyY Chromaticity Diagram*.

This diagram (FIGURE 2) represents the way we see and accurately indicates the uneven sensitivity we have to all of the colors. It's also convenient as we can count on this space to stay the same regardless of how it's viewed or imaged with any device. In fact, because of the lack of dependence on any other factors we call it *device-independent*.

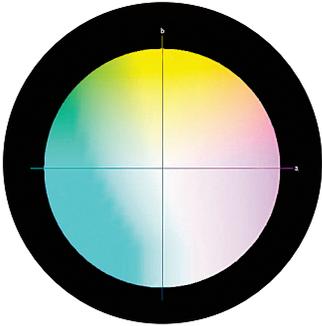


FIGURE 3

As more technologies evolved it became apparent that measurement systems and computers needed a better balance of information, so the spacing between colors was shaped to become more consistent and even. We call this space  $L^*a^*b^*$ , or simply *Lab* (FIGURE 3).

Technically  $a^*$  represents the red/green axis,  $b^*$  represents the yellow/blue axis, and a straight line going right through the center corresponds to  $L$  or the lightness.

*Lab* is a great place for scientists, but it's also the space that's hidden in all of our computers. So we're going to look at a few images the way our computers do.

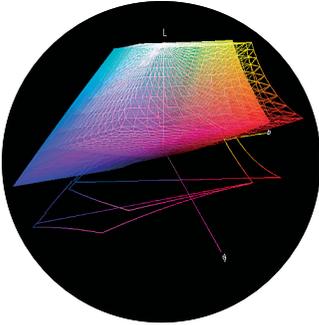


FIGURE 4

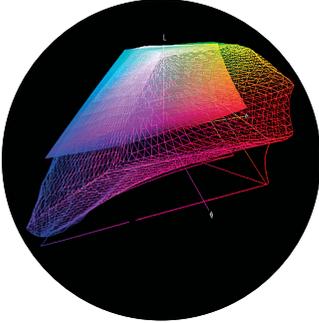


FIGURE 5

Since the computer monitor is our window into the digital world, the question is just what colors can it display. This diagram (FIGURE 4) gives you a three dimensional view of *Lab* and shows the basic boundaries of reproduction, which is called the *gamut*. Not only can we see the reproduction range on the *a/b* axis, but in this view the *L* axis clearly indicates the depth into the dark colors and height into the light colors.

In a perfect world this would be a full sphere, but the world is far from perfect. These are real examples of the gamut of colors a professional CRT (solid shape) and professional LCD (wire shape) can reproduce on their displays. The color we see depends on each of these devices, and therefore, as opposed to color space, hardware is *device-dependent*.

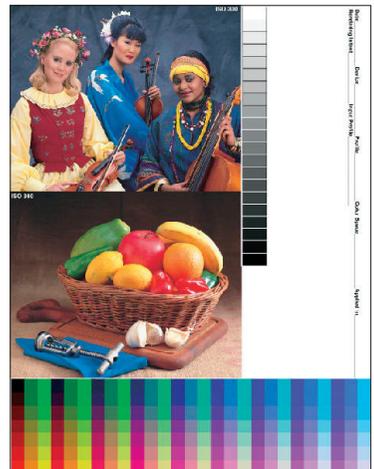
Now that we know what the computer monitor can display, how does that compare to an input device like a camera or scanner? Well let's see. Here's a good example (FIGURE 5) of a professional desktop scanner (wire shape) and a professional CRT (solid shape).

Scanners and cameras can see much more than you could hope to reproduce (just like film). The actual effects of this are shown here (FIGURES 6 & 7) (recognizing limitations to the inks used on this page).



SCANNER GAMUT

FIGURE 5



MONITOR GAMUT

FIGURE 6

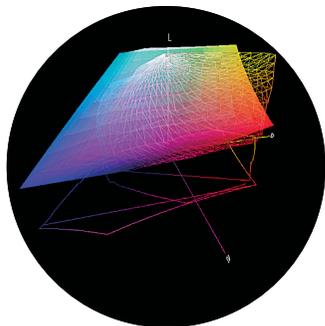
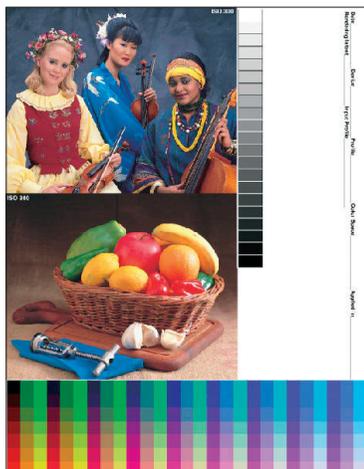


FIGURE 8

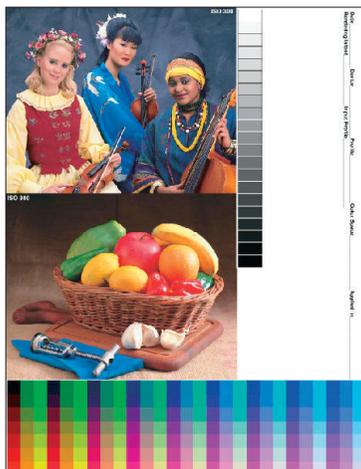
Taking this to the next logical step, let's compare the monitor to a printer. Here's a good example (FIGURE 8) of the output of a professional six color inkjet (wire shape) and a professional CRT (solid shape).

The printing process has always been a limiting factor in how photographs reproduce and that hasn't changed much over the years. However, since there is a closer match between these two gamuts, the actual differences in the effects shown here are not as dramatic (FIGURES 9 & 10).



MONITOR GAMUT

FIGURE 9



PRINTER GAMUT

FIGURE 10

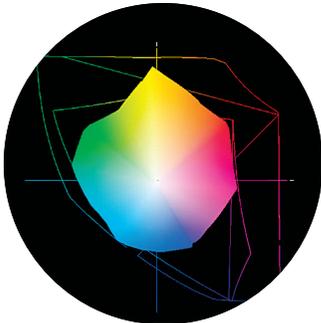


FIGURE 11

Finally, let's put it all together. But this time we're going to compare the three gamuts in a two dimensional space for simplicity (FIGURE 11).

It's quite clear that the printer (solid shape) is the limiting factor. The next outlined shape represents the computer display which pretty well encompasses the gamut of the printer. And of course the outermost line shows the wider range of the scanner (similar to a camera with its extreme gamut).

Said another way (FIGURE 12)

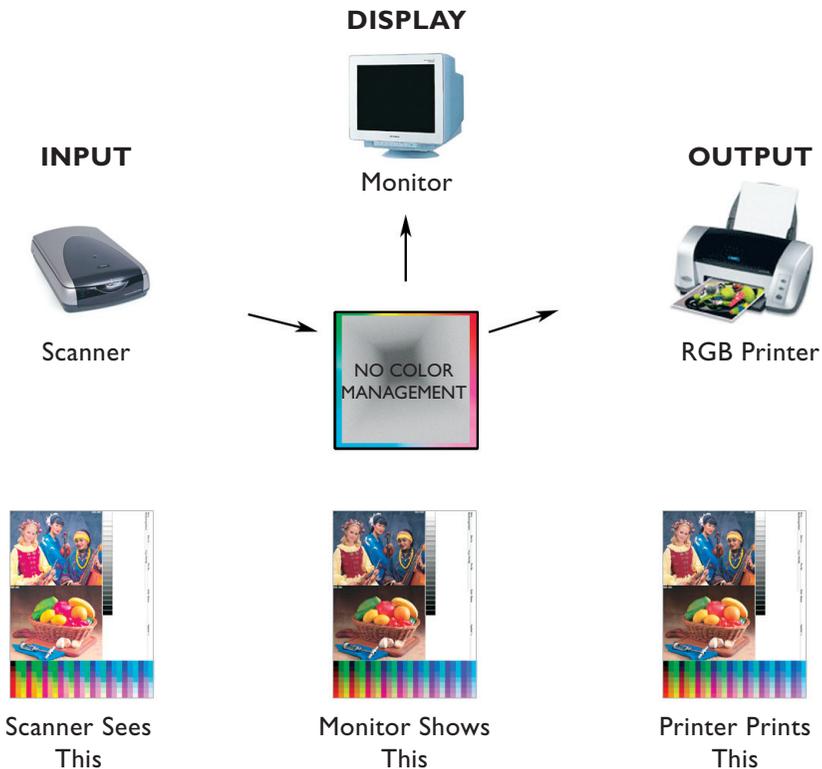


FIGURE 12

It's important to recognize that because every piece of hardware has its own gamut, we need to translate all of their rendering abilities in a common and shared way – that's Color Management.

X-Rite brings powerful color control to you. And considering X-Rite’s only business is making Color Management solutions, you’d better believe we want to make the color look right!

So how does it work? The first step to Color Management is to look at your window into the digital world – your monitor. Making your monitor the reference is actually a two-part process: you need to set the display to some fixed level of performance (*calibration*) and then measure its color-rendering capability in a definable way (*profile*).

Profiles translate the uniqueness of each device into a universal language that can be shared among devices in a “device-independent” Color Management System (FIGURE 13).

*Note: Mac users will see profiles identified as .ICC files. Windows users have .ICM extensions, otherwise both systems essentially work the same way and are cross-platform compatible.*

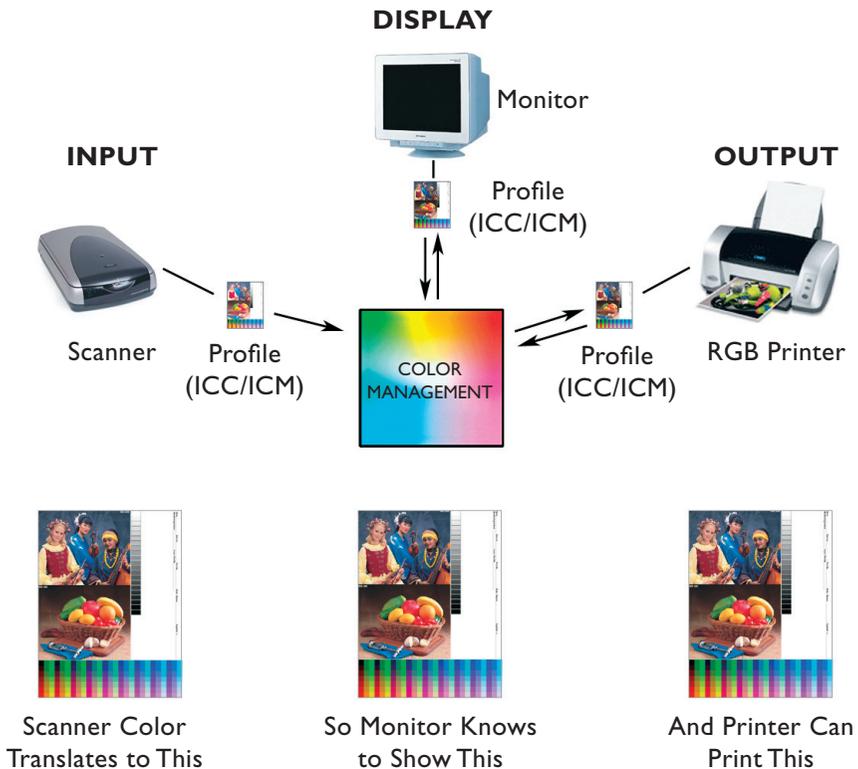


FIGURE 13

Calibration can be done by eye with simple software, but we all see color differently so that doesn't work too well. A special light meter, called a Colorimeter does the job. X-Rite color software automatically guides you step-by-step through the process. In just minutes your brightness and contrast are set to optimum levels, and by comparing actual output from your monitor to reference color data in the software, your computer is told everything it needs to know about how your monitor displays colors – and your *profile* is created.

Whether you make your own prints or send them out, all monitors need to be calibrated and profiled. Otherwise it's like talking on the phone and telling someone how to adjust their television set to display the same color you're seeing on yours. If you've got all the basics on your desktop, then X-Rite color software also makes it just as simple to ensure color accuracy in the workflow between your scanner, monitor and printer. And, special test targets and profiling software can keep the color from your digital camera just as faithful.

There are two types of measuring devices: Spectrophotometers and Colorimeters. *Colorimeters* typically match human vision and measure color targets in four broad areas as we can see in the graph here (FIGURE 14) and offer an excellent price /value relationship. For printer calibration, or more professional monitor calibration you may prefer to use a *Spectrophotometer*. The range of colors that we can see, the visible spectrum (light), consists of wavelengths of radiation ranging from approximately 400 to 700 nanometers (or nm – a unit equaling one billionth of a meter). Spectrophotometers as their name implies look at the whole spectrum and give more accurate results by making up to thirty-one measurements (in 10nm increments).

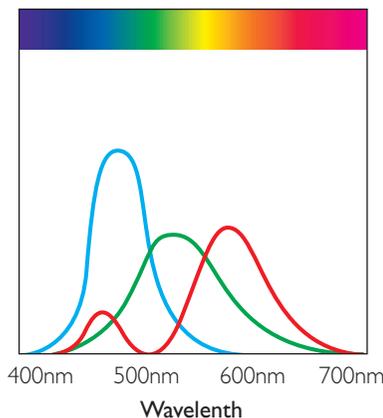


FIGURE 14

### **Profiling the Monitor**

Here are the steps used to profile the monitor, but before you begin, turn off any color management settings that may have come with the monitor as you will apply your own later.

**Adjust the Room Lighting** – Before any measurements are taken or images viewed, the room lighting should be adjusted to the way you normally work. Avoid any harsh direct lighting on the face of the monitor. This will allow more accurate measurements and a better profile.

**Put the Monitor in Its Optimal State** – Before profiling any device, it should be set up to produce its largest, most consistently reproducible color gamut. For monitors, this is accomplished by adjusting the brightness and contrast settings.

**Pick Profile Settings** – Monitor profiles typically have a white point setting (how white will appear on the screen) and a gamma setting. X-Rite profiling software allows you to customize these settings based on your viewing condition and operating system (Mac or Win.).

**Naming and Saving the Profile** – After entering a few easy-to-choose settings, the profile is automatically saved in the correct location so ICC-compliant applications, such as Photoshop, can find it.

### **Profiling the Input and Output Devices**

Printer profiles are built by printing a set of known color patches. A spectrophotometer then reads the color patches so the software can interpret the difference between the original file and the printed patches. This information is stored in the form of an output profile, which is applied to images to ensure they are printed correctly.

Printer profiles are applied when you are ready to print your image. The profiles compensate for any variance that the printer introduces and help the printer to match the image displayed on-screen. If you have a profile for another printer along with a profile of your own printer, the profiles can be used in conjunction to have one printer simulate another.

Depending on the level of color management and application, procedures vary. The final step to profiling and calibrating your scanner and printer essentially involve the following:

Create a profile for your scanner or digital camera using the appropriate target. Scan, crop and name the target.

Select a target patch from an extensive list, and print it using your printer. Color patches vary depending on which level of color management suits your purpose. Targets can range in size from having just a few colors to thousands of colors. And they are read and measured using a spectrophotometer.

Profiles are created by the software which gives further control with features such as ink limiting, black generation, and advanced UCR/GCR.

Step-by-step wizard driven software assures your success! Once you have profiled and calibrated the scanner, monitor and printer, what you see on the monitor is what you'll get from the printer. You'll save at least 75% of your time, 66% of your resources, and at least 33% of your cost. These numbers were verified by an independent study.

### Editing Output Profile

Profiling the output, or printer files is a snap and X-Rite software creates accurate profiles right out of the box. However, sometimes profile editing is necessary. This option allows you to modify any RGB or CMYK printer profile. Printer profiles are edited to create a better monitor-to-print match, original-to-print match, or to shift color balance or tonal values towards a desired result.

With professional software packages there is even greater control over your output file editing. The editing feature is used by those who have a super eye for detail. This option gives you powerful tools for adjusting output curves, editing CIELAB ( $L^*, a^*, b^*$ ) color attributes, customizing gamut compression to affect color selectivity, and fine tuning colors and neutrals in the color space of the profile.

To edit an output profile, simply use the color tools to alter a sample image (or your own image) that has been processed using the profile. Once color edits are made, they are proofed by viewing the image on a calibrated monitor and/or by printing a hard copy of the image.

When editing is complete, your adjustments are saved in the profile and subsequently applied to all images processed using the same profile. You can optionally apply the edits to the sample image if desired.

### Using ICC Profiles

You've successfully created profiles for your scanner and printer. Now what do you do?

To use the profiles, you need an ICC-compliant application, such as Adobe Photoshop, Illustrator, InDesign, and QuarkXpress.

### **Why not use the print drivers color management from the printer manufacturer?**

Color management associated with drivers supplied by the printer manufacturer offers a good starting point to approximate the way color should be reproduced. However, variations in ink and paper manufacturing ensure that a standard print driver will not be able to offer the precise color matching required in professional imaging. Also, the standard print driver does not take into account different inks or paper stocks. These variations can show a significant difference in the printed color.

Finally, the print driver alone provides no support for matching the printer to the monitor. So if it is not possible to see what you are going to print, you cannot judge the image until after it is printed.

### **Color management do's and don'ts**

#### **What it does...**

- Build custom ICC Profiles for color devices such as monitors, printers and scanners
- Improve color matching from device to device
- Provide accurate soft proofing and digital proofing

#### **What it doesn't do...**

- Apply ICC profiles within the graphic application. Applying the profile is done through menu selection within ICC supportive programs such as QuarkXpress and Adobe Photoshop.
- Fix poor quality images or expand the gamut of a device. Proper ICC profiles can only ensure that the reproduction matches the original.
- Work on devices that are out of calibration.

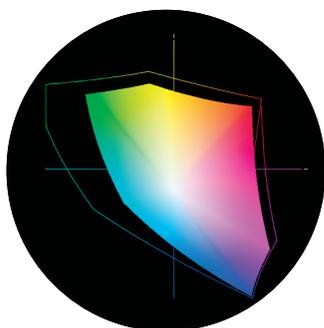


FIGURE 15

There are many options for the actual Color Space in which you choose to work, but the two most common are Adobe RGB (1998) and sRGB. The basic purpose of Adobe RGB is to provide a very wide range of colors that still can be managed in the viewing and final printing space. While this has been great for serious professionals, it requires more advanced techniques than most users want to learn in order to get good results with the majority of photographic imaging systems. To satisfy this application, sRGB was developed. As you can see from this two dimensional view (FIGURE 15), sRGB (the solid shape) provides a smaller gamut when compared to the larger outline shape which represents Adobe RGB.

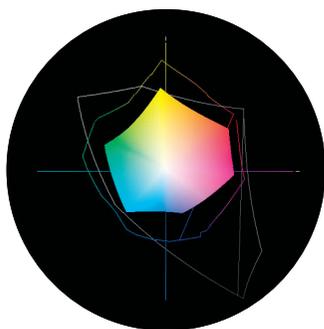


FIGURE 16

Although some users may feel the “safe space” offered by sRGB is too restrictive, if we compare it to the printer’s output we see a different story. In this view (FIGURE 16) the solid shape indicates the gamut of a high-quality printed page (SWOP coated – CMYK). The outermost line shows the gamut of sRGB which totally encompasses the color rendering capabilities of the printed page. The inner line represents a professional six-color inkjet output which is still mostly well within the boundaries of sRGB. The small difference that Adobe RGB can offer requires much work to compress the colors into the output space.

In order to understand how colors are compressed (*Rendering Intent*), let’s plot some actual images directly into three dimensions. First to make it simple we’ll start with an image that only contains 24 discreet colors, a Macbeth ColorChecker (FIGURE 17).



FIGURE 17

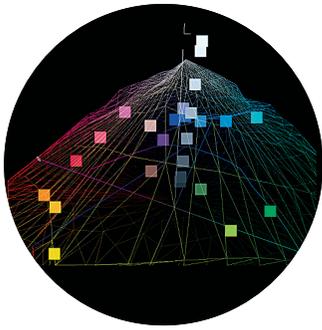


FIGURE 18

If we position these colors relative to our six-color inkjet system we can see where they fall on the gamut (FIGURE 18). The gray scale tracks quite nicely on the vertical L axis, and the colors fall on the higher, more saturated levels (those of you with sharp eyes and more than 24 fingers will notice two extra gray scale steps which are actually the blackest-black of the frame of the ColorChecker, and the white letters on the frame).

Now that we get the idea of how this looks let's move on to something more complex – an IT8.7-2 Target (FIGURE 19) which is used for profiling many photographic systems (as they all work in RGB).



FIGURE 18

We had to back off a little on the view of the inkjet color space (FIGURE 20) to show everything, but all of the colors in the target are clearly visible and if you look carefully many, especially the brighter areas are actually floating above the surface of the space which means they're beyond the printer's capability to render – they are *out of gamut*.

Fortunately our color managed system has a number of options to make sure these colors still are represented in some way on the final print. This is called the *Rendering Intent*.

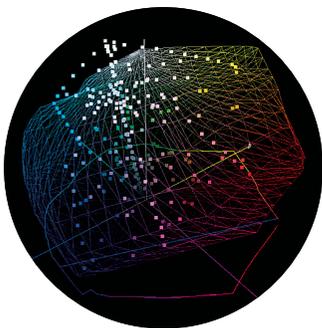


FIGURE 20

Adobe Photoshop provides four different conversions for this purpose in their software and the one you choose will vary according to the kind of work you are doing. There are many technical explanations of exactly how each of these four "Conversion Options" manages this, but a simple way of deciding what to test first is based on your business. If you're dealing with photos select "Perceptual;" for graphics try "Saturated;" on logos choose "Relative Colorimetric;" and if you need the most strict conversion (including simulation of the color of the paper base) use "Absolute Colorimetric."



FIGURE 21

The next image (FIGURE 21) shows the application of *Perceptual* as the *Rendering Intent*. This has moved the out of gamut colors into the range where they can print safely. If you compare the two images you'll see the little streaky comet-like shapes show where the colors were, and also where they have been repositioned to print (the little square dots) as a result of the rendering.

For a more dramatic example let's see how color is shaped to fit the printed page. Our image for this application is the IT8.7-3 Target (FIGURE 22) which is used to profile most 4-color web, sheet fed and offset printers (CMYK). The printing industry has long been very color conscious and needed a different chart with a much greater range of colors to help make images fit into the small gamut of the printed page.

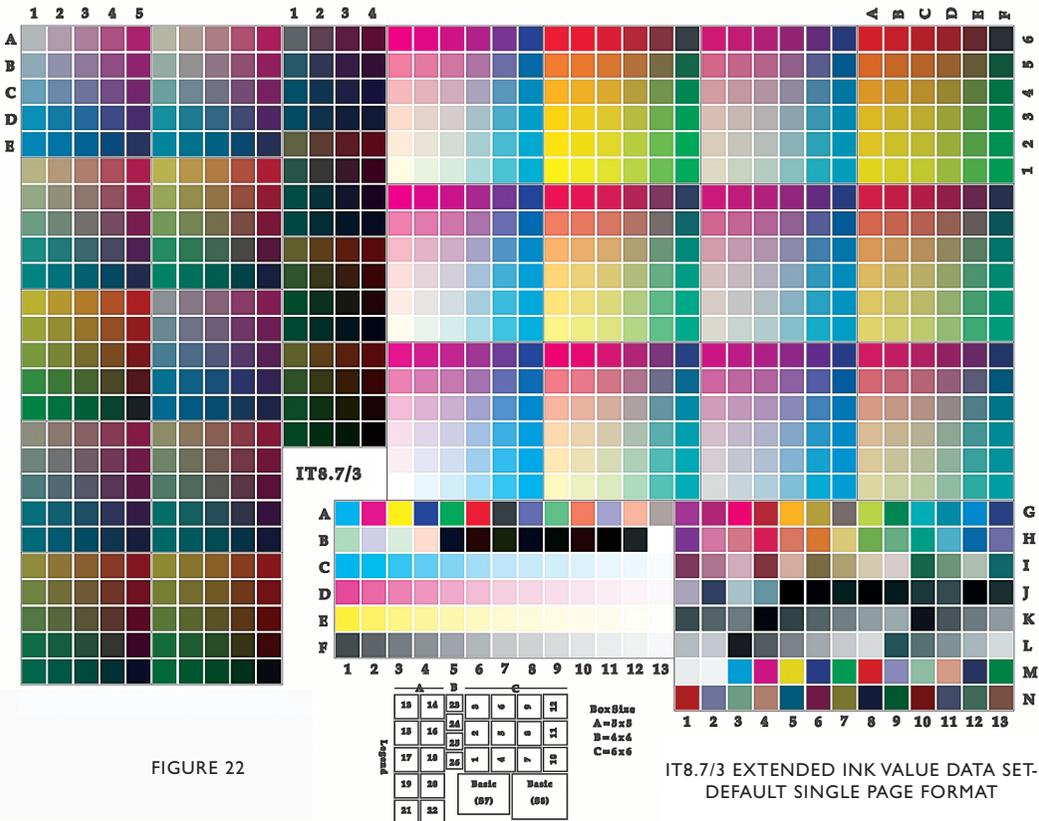


FIGURE 22

IT8.7/3 EXTENDED INK VALUE DATA SET-  
DEFAULT SINGLE PAGE FORMAT

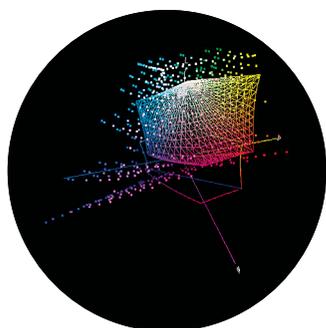


FIGURE 23

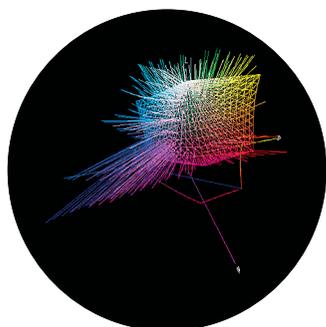


FIGURE 24

In an even more demonstrable way we can see a very large number of out of gamut colors (FIGURE 23). Plus, due to the size of the gamut, the degree of compression must be much greater than our previous example in order to cover the distance.

Tracking the newly rendered, and now in-gamut printable image, it's easy to see that with compression this extreme (FIGURE 24), printers have needed to develop and employ a wide range of techniques to assure the most pleasing (although rarely very accurate) image. Over the years, photographers who shot exclusively for "print" knew to avoid lots of the heavily out of gamut "cooler" bluish colors, and lit scenes in anticipation to compress the tonal range. Obviously this hasn't changed much, but it's much easier to see in this graphic example why good photographers still develop and follow these imaging techniques.

A soft proof is an on-screen simulation of how your image will appear when output on another device – typically a printer. You expect that the image you print will be the same quality as the image on your monitor. When the color does not match, this can be an endless frustration of trial and error color corrections. Using profiles can simplify your workflow, giving you the assurance that the image you see on your monitor will print accurately.



## 1 Profile your monitor

Profiling your monitor is essential as this provides a baseline and assurance that your monitor is displaying colors as accurately as possible. Any edits you apply to an image will be based on your visual judgments.



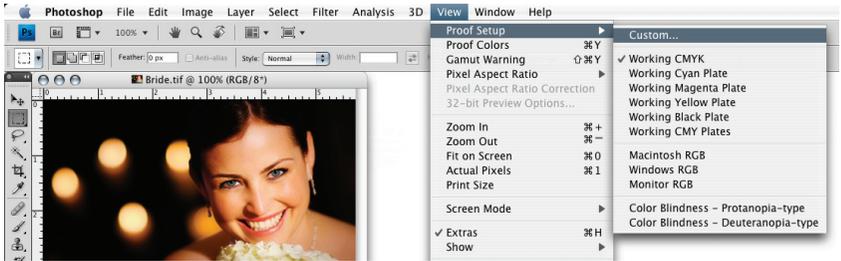
## 2 Profile your hardware

Create custom profiles for your printer. For greatest accuracy, you should create a profile for each combination of ink, paper and printer quality settings.

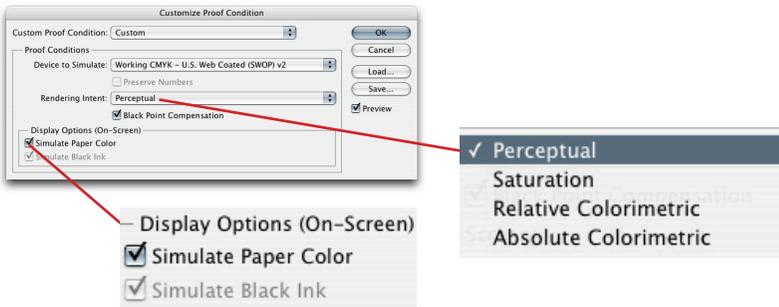
### 3

## View your image in Photoshop® as it will print:

- a) OPEN YOUR IMAGE IN PHOTOSHOP.
- b) CHOOSE **VIEW>PROOF SETUP>CUSTOM**

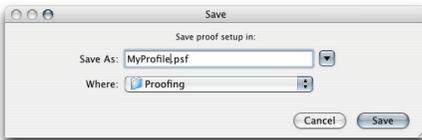


- c) SELECT YOUR PRINTER PROFILE, RENDERING INTENT, AND ANY OTHER OPTIONS YOU LIKE (A good starting point for photographs is the use of “Perceptual” or “Relative Colorimetric” Rendering Intent and “Simulate Paper Color”).



- d) SAVE YOUR CUSTOM PROFILE SO THAT IT IS READILY AVAILABLE FOR FUTURE USE AT THE BOTTOM OF THE PROOF SETUP MENU.

NOW you have a soft proof – the monitor simulates how your printer will print the image. You can edit the image in Photoshop, trusting that what you see on your monitor will print on your printer.



**Tip:** If you want the custom proof setup to be the default proof setup for documents, close all document windows before choosing the **VIEW > PROOF SETUP > CUSTOM**. Whatever you choose as the custom profile will then be selected when you select **VIEW > PROOF COLORS** (or **Cmd+Y [Mac] / Ctrl+Y [Win]**).

## A

**Absorb / Absorption:** Dissipation of the energy of electromagnetic waves into other forms as a result of its interaction with matter; a decrease in directional transmittance of incident radiation, resulting in a modification or conversion of the absorbed energy.  
Additive Primaries: Red, green, and blue light.

When all three additive primaries are combined at 100% intensity, white light is produced. When these three are combined at varying intensities, a gamut of different colors is produced. Combining two primaries at 100% produces a subtractive primary, either cyan, magenta, or yellow: 100% red + 100% green = yellow; 100% red + 100% blue = magenta; 100% green + 100% blue = cyan. See *Subtractive Primaries*.

**Appearance:** Manifestation of the nature of objects and materials through visual attributes such as size, shape, color, texture, glossiness, transparency, opacity, etc.

**Attribute:** Distinguishing characteristic of a sensation, perception or mode of appearance. Colors are often described by their attributes of hue, saturation or chroma, and lightness.

## B

**Black:** The absence of all reflected light; the color that is produced when an object absorbs all wavelengths from the light source. When 100% cyan, magenta, and yellow colorants are combined, the resulting color – theoretically – is black. In real-world applications, this combination produces a muddy gray or brown. In four-color process printing, black is one of the process inks. The letter “K” is used to represent Black in the CMYK acronym to avoid confusion with Blue’s “B” in RGB.

**Brightness:** The attribute of visual perception in accordance with which an area appears to emit or reflect more or less light (this attribute of color is used in the color model HSB – Hue, Saturation, Brightness). See *Lightness*.

## C

**Calibration:** To check, adjust, or systematically standardize the graduations of a device.

**Chroma:** The attribute of visual perception in accordance with which an area appears saturated with a particular color or hue – for example, a red apple is high in chroma; pastel colors are low in chroma; black, white, and gray have no chroma (this attribute of color is used in the color model L\*C\*H – Lightness, Chroma, Hue). Also referred to as Saturation.

**CIE Chromaticity Coordinates:** x and y values that specify the location of a color within the CIE chromaticity diagram.

**CMC (Color Measurement Committee):** Of the Society of Dyes and Colourists in Great Britain. Developed a more logical, ellipse-based equation for computing  $\Delta E$  values as an alternative to the spherical regions of the CIELAB color space.

**CMY:** The subtractive primaries cyan, magenta, and yellow. See *Subtractive Primaries*.

**CMYK:** The subtractive primaries cyan, magenta and yellow, plus black (k) which is required in the printing process for more faithful reproduction. See *Subtractive Primaries*.

**Color Management:** Matching colors between an original image, scanner, monitor, color printer and final press sheet.

**Color Matching Functions:** Relative amounts of three additive primaries required to match each wavelength of light. The term is generally used to refer to the CIE Standard Observer color matching functions designated. See *CIE Standard Observer*.

**Color Model:** A color measurement scale or system that numerically specifies the perceived attributes of color. Used in computer graphics applications and by color measurement instruments.

**Color Separation:** The conversion of the red, green, and blue color information used in a computer into cyan, magenta, yellow, and black channels that are used to make printing plates.

**Color Space:** A three-dimensional geometric representation of the colors that can be seen and/or generated using a certain color model.

**Color Specification:** Tristimulus values, chromaticity coordinates and luminance value, or other color-scale values, used to designate a color numerically in a specified color system.

**Color Temperature:** A measurement of the color of light radiated by an object while it is being heated. This measurement is expressed in terms of absolute scale, or degrees Kelvin. Lower Kelvin temperatures such as 2400°K are red; higher temperatures such as 9300°K are blue. Neutral temperature is gray, at 6504°K.

**Color Wheel:** The visible spectrum's continuum of colors arranged into a circle, where complementary colors such as red and green are located directly across from each other.

**Colorants:** Materials used to create colors – dyes, pigments, toners, phosphors.

**ColorSync:** Built-in color management architecture for Apple Macintosh computers. Third-party vendors utilize the ColorSync framework to provide device calibration, device characterization, and device profile-building methods.

**Chromaticity, Chromaticity Coordinates:** Dimensions of a color stimulus expressed in terms of hue and saturation, or redness-greenness and yellowness-blueness, excluding the luminous intensity. Generally expressed as a point in a plane of constant luminance. See *CIE xy Chromaticity Diagram*.

**CIE (Commission Internationale de l'Éclairage):** A French name that translates to International Commission on Illumination, the main international organization concerned with color and color measurement.

**CIE94:** The CIE94 tolerancing method utilizes three-dimensional ellipsoids as “containers” for color acceptance. CIE94 is conceptually similar to CMC2:1 but lacks some of the hue and lightness adjustments. It is expected that CIE94 will evolve over the next few years as additional studies are performed.

**CIELAB (or CIE L\*a\*b\*, CIE Lab):** Color space in which values L\*, a\*, and b\* are plotted at right angles to one another to form a three-dimensional coordinate system. Equal distances in the space approximately represent equal color differences. Value L\* represents Lightness; value a\* represents the Redness/Greenness axis; and value b\* represents the yellowness/blueness axis. CIELAB is a popular color space for use in measuring reflective and transmissive objects.

**CIE Standard Illuminants:** Known spectral data established by the CIE for four different types of light sources. When using tristimulus data to describe a color, the illuminant must also be defined. These standard illuminants are used in place of actual measurements of the light source.

**CIE Standard Observer:** A hypothetical observer having the tristimulus color-mixture data recommended in 1931 by the CIE for a 2° viewing angle. A supplementary observer for a larger angle of 10° was adopted in 1964. If not specified, the 2° Standard Observer should be assumed. If the field of view is larger than 4°, the 10° Standard Observer should be used.

**CIE xy Chromaticity Diagram:** A two-dimensional graph of the chromaticity coordinates, x as the abscissa and y as the ordinate, which shows the spectrum locus (chromaticity coordinates of monochromatic light, 380-770nm). It has many useful properties for comparing colors of both luminous and non-luminous materials.

**CIE Tristimulus Values:** Amounts of the three components necessary in a three-color additive mixture required for matching a color: in the CIE System, they are designated as X, Y, and Z. The illuminant and standard observer color matching functions used must be designated; if they are not, the assumption is made that the values are for the 1931 CIE 2° Standard Observer and Illuminant C.

**Colorimeter:** An optical measurement instrument that responds to color in a manner similar to the human eye – by filtering reflected light into its dominant regions of red, green, and blue.

**Colorimetric:** Of or relating to values giving the amounts of three colored lights or receptors – red, green, and blue.

**Contrast:** The level of variation between light and dark areas in an image.

**Control Limits:** The amount of acceptable variation in press capabilities over the course of a press run.

**Cyan:** One of the process ink colors for printing. Pure cyan is the “redless” color; it absorbs all red wavelengths of light and reflects all blue and green wavelengths.

## D

**D<sub>50</sub>:** The CIE Standard Illuminant that represents a color temperature of 5000°K. This is the color temperature that is most widely used in graphic arts industry viewing booths. See *Illuminants D*.

**D<sub>65</sub>:** The CIE Standard Illuminant that represents a color temperature of 6504°K.

**Delta (Δ):** A symbol used to indicate deviation or difference.

**Delta Error (ΔE):** In color tolerancing, the symbol ΔE is used to express Delta Error, the total color difference computed using a color difference equation. The color difference is generally calculated as the square root of the combined squares of the chromaticity differences, Da\* and Db\*, and the Lightness difference, ΔL. See *CIE94*.

**Densitometer:** A sensitive, photoelectric instrument that measures the density of images or colors.

**Density:** The ability of a material to absorb light – the darker it is, the higher the density.

**Device-Dependent:** Describes a color space that can be defined only by using information on the color-rendering capabilities of a specific device. For example, the RGB color space must be generated by a monitor; a device which has specific capabilities and limitations for achieving its gamut of colors. In addition, all monitors have different capabilities and limitations, as do different scanners, printers, and printing presses.

**Device-Independent:** Describes a color space that can be defined using the full gamut of human vision, as defined by a standard observer, independent of the color-rendering capabilities of any specific device.

**Device Profile:** Device-specific color information that is a characterization of a device's color rendering and reproduction capabilities. Monitor profiles, scanner profiles, and printer profiles are utilized in a color management system such as Apple ColorSync to help the devices communicate color information with each other. Profiles are created by calibration and/or characterization method.

**Dye:** A soluble colorant; as opposed to pigment, which is insoluble.

**Dynamic Range:** An instrument's range of measurable values, from the lowest amount it can detect to the highest amount it can handle.

## E

**Electromagnetic Spectrum:** The massive band of electromagnetic waves that pass through the air in different sizes, as measured by wavelength. Different wavelengths have different properties, but most are invisible – and some completely undetectable – to human beings. Only wavelengths that are between 400 and 700 nanometers in size are visible, producing light. Invisible waves outside the visible spectrum include gamma rays, x-rays, microwaves and radio waves.

**Emissive Object:** An object that emits light. Usually some sort of chemical reaction, such as the burning gasses of the sun or the heated filament of a light bulb.

## F

**Fluorescent Lamp:** A glass tube filled with mercury gas and coated on its inner surface with phosphors. When the gas is charged with an electrical current, radiation is produced which in turn energizes the phosphors, causing the phosphors to glow.

**Four-Color Process:** Depositing combinations of the subtractive primaries cyan, magenta, yellow, and black on paper to achieve. These colorants are deposited as dots of different sizes, shapes, and angles to create the illusion of different colors. See *CMY*, *Subtractive Primaries*.

## G

**Gamut:** The range of different colors that can be interpreted by a color model or generated by a specific device.

**Gamut Compression:** Or tonal range compression. The color space coordinates of a color space with a larger gamut are reduced to accommodate the smaller gamut of a destination color space. For example, the gamut of photographic film is compressed for representation in the smaller CMYK gamut used for four-color process printing. See *Gamut*.

**Gamut Mapping:** Converting the coordinates of two or more color spaces into a common color space. Often results in tonal range compression. See *Gamut Compression*.

## H

**HiFi Printing:** Process printing that expands the conventional four-color process gamut using additional, special ink colors. **Hue:** The basic color of an object, such as “red,” “green,” “purple,” etc. Defined by its angular position in a cylindrical color space, or on a Color Wheel.

## I

**ICC (International Color Consortium):** A group of hardware and software companies dedicated to the development of a specification that is OS independent and provides the digital imaging, printing and related industries with a data format for defining the color and reproduction characteristics of devices and their related media.

**Illuminant:** Incident luminous energy specified by its spectral distribution.

**Illuminant A (CIE):** CIE Standard Illuminant for incandescent illumination, yellow-orange in color, with a correlated color temperature of 2856°K.

**Illuminant C (CIE):** CIE Standard Illuminant for tungsten illumination that simulates average daylight, bluish in color, with a correlated color temperature of 6774°K.

**Illuminants D (CIE):** CIE Standard Illuminants for daylight, based on actual spectral measurements of daylight. D65 with a correlated color temperature of 6504°K is most commonly used. Others include D50, D55, and D75.

**Illuminants F (CIE):** CIE Standard Illuminant for fluorescent illumination. F2 represents a cool white fluorescent lamp (4200 K), F7 represents a broad-band daylight fluorescent lamp (6500 K), and F11 represents a narrow-band white fluorescent lamp (4000 K). **Intensity:** Saturation or reflective energy as related to visible wavelengths of light. Reflectance of wavelengths at high intensity generates high saturation, or chroma.

**IT8:** Series of test targets and tools for color characterization established by ANSI (American National Standards Institute) Committee IT8 for Digital Data Exchange Standards. Different IT8 targets are used to characterize different devices such as scanners and printers.

## K

## L

**Kelvin (K):** Unit of measurement for color temperature. The Kelvin scale starts from absolute zero, which is -273° Celsius. **L\*a\*b\*:** A color space which represents human visual perception and has equal spacing between colors. See CIELAB

**L\*C\*H:** A color space that is similar to CIELAB, except uses cylindrical coordinates of lightness, chroma, and hue angle instead of rectangular coordinates.

**Light:** Electromagnetic radiation in the spectral range detectable by the human eye (approx. 400 to 700nm).

**Lightness:** The attribute of visual perception in accordance with which an area appears to emit or reflect more or less light. Also refers to the perception by which white objects are distinguished from gray objects and light- from dark-colored objects.

## M

**Magenta:** One of the process ink colors for printing. Pure magenta is the “greenless” color; it absorbs all wavelengths of green from light and reflects all red and blue wavelengths.

**Metamerism, Metameric Pair:** The phenomenon where two colors appear to match under one light source, yet do not match under a different light source. Two such colors are called a metameric pair.

**Monitor RGB:** Same as RGB; monitor RGB simply refers specifically to the color space that can be achieved by a particular monitor using combinations of red, green, and blue light.

**Munsell Color Charts:** A three-dimensional color system developed by Albert Munsell that is based on the attributes Munsell Hue, Munsell Value, and Munsell Chroma.

## N

## O

## P

**Nanometer (nm):** Unit of length equal to 10<sup>-9</sup> meter, or one millionth of a millimeter. Wavelengths are measured in nanometers.

**Overprint:** On a press sheet color bar, overprints are color patches where two process inks have been printed, one atop the other. Checking the density of these patches allows press operators to determine trap value. The term Overprint also applies to any object printed on top of other colors.

**Phosphors:** Materials that emit light when irradiated by cathode rays, or when placed in an electric field. The quantity of visible light is proportional to the amount of excitation energy present.

**Photoelectric:** Pertaining to the electrical effects of light or other radiation—for example, emission of electrons.

**Photoreceptor:** The cone- and rod-shaped neurons that cover the retina of the eye. Photoreceptors are excited by visible wavelengths, then send signals to the brain where the sensation of color is perceived.

**Pigment:** An insoluble colorant; as opposed to a dye, which is soluble.

**Pixel:** A tiny picture element that contains red, green, and blue information for color rendering on a monitor or a scanner. When generating colors, pixels are similar to dots of ink on paper. A monitor resolution description in terms of pixels-per-inch (ppi) is similar to a printer resolution description in terms of dots-per-inch (dpi).

**Primary Colors:** The dominant regions of the visible spectrum: red, green, and blue; and their opposite colors cyan, magenta, and yellow. See *Additive Primaries*, *Subtractive Primaries*.

**Prism:** Triangular-shaped glass or other transparent material. When light is passed through a prism, its wavelengths refract into a rainbow of colors. This demonstrates that light is composed of color, and indicates the arrangement of colors in the visible spectrum. See *Visible Spectrum*.

**Process Control:** Using densitometric and colorimetric measurement data from press sheet color bars to monitor press performance throughout the press run. Data is analyzed in relation to established control limits. See *Control Limits*.

## R

**Reflective Object:** A solid object that returns some or all of the wavelengths of light that strike its surface. A reflective object that returns 100% of all light is called a perfect diffuser – a perfectly white surface.

**Reflectance:** The percentage of light that is reflected from an object. Spectrophotometers measure an object's reflectance at various intervals along the visible spectrum to determine the object color's spectral curve. See *Spectral Curve*, *Spectral Data*.

**RGB:** The additive primaries red, green, and blue. See *Additive Primaries*.

**RIP:** Raster Image Processor is either a software program or hardware dedicated to the purpose of converting certain file formats (typically vector graphics – such as page layout files) into the rows of pixels (raster) that are the information in the files which printers need to produce output.

## S

**Saturation:** The attribute of color perception that expresses the amount of departure from the neutral gray of the same lightness. Also referred to as chroma.

**Sequence:** The order in which inks are deposited on paper by a printing press.

**Spectral Curve:** A color's "fingerprint" – a visual representation of a color's spectral data. A spectral curve is plotted on a grid comprised of a vertical axis – the level of reflectance intensity; and a horizontal axis – the visible spectrum of wavelengths. The percentage of reflected light is plotted at each interval, resulting in points that form a curve.

**Spectral Data:** The most precise description of the color of an object. An object's color appearance results from light being changed by an object and reflected to a viewer. Spectral data is a description of how the reflected light was changed. The percentage of reflected light is measured at several intervals across its spectrum of wavelengths. This information can be visually represented as a spectral curve.

**Spectrophotometer:** An instrument that measures the characteristics of light reflected from or transmitted through an object, which is interpreted as spectral data.

**Spectrum:** Spatial arrangement of electromagnetic energy in order of wavelength size. See *Electromagnetic Spectrum*, *Visible Spectrum*.

**Standard:** An established, approved reference against which instrument measurements of samples are evaluated.

**Subtractive Primaries:** Cyan, Magenta, and Yellow. Theoretically, when all three subtractive primaries are combined at 100% on white paper, black is produced. When these three are combined at varying intensities, a gamut of different colors is produced. Combining two primaries at 100% produces an additive primary, either red, green, or blue: 100% cyan + 100% magenta = blue; 100% cyan + 100% yellow = green; 100% magenta + 100% yellow = red.

## T

**Tolerance:** The amount of acceptable difference between a known correct standard (usually the customer's specifications) and a set of measured samples. See *Delta Error*.

**Transmissive Object:** An object that allows light to pass through from one side to the other. The color of a transmissive object results from the manipulation of wavelengths of light as they pass through.

**Tristimulus:** A method for communicating or generating a color using three stimuli – either additive or subtractive colorants (such as RGB or CMY), or three attributes (such as lightness, chroma, and hue).

**Tristimulus Data:** The three tristimulus values that combine to define or generate a specific color, such as R 255/G 255/B 0. Tristimulus data does not completely describe a color – the illuminant must also be defined. Also, in device-dependent color models such as RGB, the capabilities of the viewer or color-rendering device must also be defined. See *Device-Dependent*.

## V

## W

**Viewing Booth:** A enclosed area with controlled lighting that is used in graphic arts studios, service bureaus, and printing companies as a stable environment for evaluating proofs and press sheets. Viewing booths are generally illuminated using graphic arts industry-standard D65 lighting, and are surfaced in neutral gray colors. See *D65*.

**Visible Spectrum:** The region of the electromagnetic spectrum between 400 and 700 nanometers. Wavelengths inside this span create the sensation of color when they are viewed by the human eye. The shorter wavelengths create the sensation of violets, purples, and blues; the longer wavelengths create the sensation of oranges and reds.

**Wave:** A physical activity that rises and then falls periodically as it travels through a medium.

**Wavelength:** Light is made up of electromagnetic waves; wavelength is the crest (peak)-to-crest distance between two adjacent waves.

**White Light:** Theoretically, light that emits all wavelengths of the visible spectrum at uniform intensity. In reality, most light sources cannot achieve such perfection.



**Yellow:** One of the process ink colors for printing. Pure yellow is the “blueless” color; it absorbs all wavelengths of blue from light and reflects all red and green wavelengths.



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