Calibration Primer & Tips About ICC Profiles

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Setting Expectations for a Color Management System

The term color management system (CMS) has different meanings to various end-users. For some, it means that the end-user creates device profiles once and then does not have to think about making profiles again for the imaging system. For others, it means the monitor should always have an exact visual match to the output prints and a printing press. No matter what some end-users believe, today, color management systems do work and allow end-users to calibrate and create profiles easily. In practical terms, here is what to expect from a color management system:

• Profiles need to be created for all system components. For a complete color-managed system to achieve the most accurate color matching, an imaging system needs custom ICC profiles for the input, display, and output devices. This includes devices such as scanners, monitors, and printers. The implication is that if an end-user has only one portion of an imaging system profiled (such as just the monitor) and does not have device profiles for the other components (devices) of the imaging system, the partially color-managed system will not always perform to its optimum.

• Quality profiles are necessary to achieve good results. If a color-proofing system requires accurate color matching, then it is necessary to purchase third-party color management hardware and software for creating custom ICC profiles. Another alternative is to purchase services from a vendor who creates profiles.

• ICC profiles are not perfect. Profile creation software does not always produce a perfect visual color match, so skill is necessary to edit profiles.

• Applying profiles in a workflow can be difficult. In some cases, an end-user finds that using profiles in various types of workflows is confusing. The hurdles to overcome are to learn profile terminology, learn the technical details of your specific workflow and then know where to apply profiles in a production workflow.

• New profiles need to be created or updated periodically. When any change takes place within an imaging system, either the old profile needs to be updated or a new profile needs to be created. An example of this would be changing to a different type of media (paper) or replacing the inks of a printer.

• Consistent lighting is required. This entails a light booth with color-corrected lights that ensure accurate color matching between a monitor and printed proofs. If monitor-to-proof lighting is imprecise, then color matches will be inaccurate.

• Color matches are not always exact. Because of device limitations, color matches in a color-managed system will be close but not always exact. However, results of a color-managed system are often visually pleasing.

- A variety of color skills are necessary. Skill is required to (1) color correct images, (2) create ICC profiles, (4) maintain a color-proofing system, (5) calibrate a platesetter, (6) calibrate and profile a printing press. Color management systems do not mean that an imaging system will become a push-button operation that will always produce great results. A color management system is used to match the tones of original source images to different kinds of output devices. If source images are not perfect or if an end-user wants to make subjective color corrections, then the color management system can only replicate the imperfection of the original image.

- ICC profiles make it possible to control and create similar color matches using a variety of output devices. This is a benefit where there is more than one color proofer or printing press in a workflow. When multiple printers are profiled with the same profiling application, each printer will produce visually similar results from the same images. However, two different types of printers may not be capable of producing the same colors and will not produce exact color matches. In that situation, one of the printers profiles needs to be edited, to produce a closer visual match.

- One way to think of an ICC profile is to consider it a snapshot of the devices settings. That is, as long as the printing device does not drift or change the ICC profile is valid. However, if the device does change and the device cannot be returned to that state then it is time to create a new ICC profile. Note in some cases to return a device such as a printer to the state that it was originally profiled requires the end-user to recalibrate the device. And that is one reason why calibration is so important.

Profile Basics

The purpose of a color management system is to use color-matching technology to calibrate an imaging system and then allow the system to accurately transfer the meaning of color from one device to another. Device profiles help make this happen.

What is an ICC profile?

An ICC profile is part of a calibration strategy to make color calibration easier and therefore more practical to create better color reproductions when scanning images , viewing images on a monitor, and printing images. The acronym ICC stands for International Color Consortium. The ICC is a technical committee (made up of many companies, such as Adobe and Microsoft) that sets up specifications to be used by third party vendors for creating ICC profiles.

ICC versus ICM Profiles

ICC designates International Color Consortium profiles used with the Macintosh operating system. ICM designates Integrated Color Management profiles used with the Windows operating system.

ICC and ICM profiles are interchangeable (cross platform) between either operating system. The only difference is that, if an ICC profile is going to be used with the Windows operating system, it must have a file extension of.ICM.

Device Profiles
Technically speaking, to create device profiles, it is necessary to have a profiling application and a measuring tool, such as a spectrophotometer.

Often device profiles are supplied when you purchase such equipment as a scanner, monitor or printer. These are referred to as *canned profiles.* About 50% of the time *canned profiles* are inaccurate, but the other 50% of the time they are quite good.

Some end-users purchase profiling applications and use them with a measuring tool, such as a spectrophotometer, so they can create custom profiles. These custom profiles are the most accurate device profiles. The price of a profiling application and measuring tool can range from $300 to over $15,000. Another less costly method to acquire custom profiles is to purchase them from service providers who are available on the Internet or who can be found in your local area.

Device profiles are used in desktop publishing programs such as Photoshop, InDesign, PageMaker, Quark Xpress, and Illustrator to transfer and convert image data from one color space of a device to another. The purpose of a profile is to preserve the intended meaning of the original color based on the limitations of the device (scanners, monitors, or printers). Each type of device has its own limitations and handles color differently based on its specifications when it was manufactured.

For example, consider an imaging system with a scanner and a printer. The scanner has a short dynamic range, making it incapable of capturing good shadow image details. But, the printer can create a full range of colors. In this example imaging system, the scanner's limitations make the color prints look dull and desaturated. When device profiles are created, the limitations of each device are taken into account, but in this situation the limitations of the scanner will not allow the entire imaging system to create good results with or without device profiles.

Types of ICC Profiles
There are seven classes of ICC profiles.
They include:
• Display profiles (mntr)
• Input profiles (scnr)
• Output profiles (prtr)
• Device Link (link)
• ColorSpace Conversion (spac)
• Abstract (abst)
• Named Color (nmcl)

The most well known types of profiles are Display profiles, Input profiles and Output profiles.

1. There are two types of display profiles. One is a monitor profile represents the hardware of the monitor and is not an Adobe Working Space. The second type of display profile is an Adobe Working Space. These ma-made Adobe Color Spaces that are used to standardize how you see color on your monitor in an Adobe application. These working spaces are considered to be profiles that are used as a Source or a Destination profile.

People often get these two types of profiles mixed up so be aware that when referring to a monitor working space (which is a type of profile) is being discussed.

2. Input device profiles. These device profiles describe the characteristics of a scanner or digital camera. They are usually in the RGB color space.

3. Printer device profiles. These device profiles describe the characteristics of a printer. The most common color spaces are RGB or CMYK.

Color Matching Method (CMM)
The Color Matching Method or CMM is software that is part of any modern color management system. The CMM allows images to be converted from one device's color space (source) to another device's color space (destination). Photoshop 6.0 supports at least five CMMs.
These options are found in the Color Setting/Conversions/Options/Engine dialog box. The Adobe Color Engine or ACE is the native (built-in) color separation method that Adobe System has created to convert RGB images into CMYK color separations. ACE is also known as the CMM. We believe ACE is the best CMM to use if you are using Adobe applications. If you are not using Adobe applications in your workflow, then we suggest using Apple Colorsync.

Source and Destination Profiles
Profiles used in imaging applications work in pairs: that is, one (profile) is a source profile and the other (profile) is a destination profile.

In this system, the source profile describes colors of a device and then, through the Profile Connection Space (PCS), the meaning of the sources colors are transferred to a destination.

Here's an example of this process when scanning an image and then viewing it on a monitor. The scanned image has a profile applied as the Source and the monitor's working space profile is applied as the Destination. In Photoshop 6.0, 7.0 CS1, CS2 and CS3, you use the Assign Profile settings to select the profile of the source image and you use the Convert to Profile settings to select the profile of the destination image.

Profile Connection Space (PCS)
A profile connection space is part of a color management system that the end-user has no control over, so you don't have to worry about how it actually works. The profile connection space (PCS) is a CIE-based reference color space (LAB) that is used in conjunction with the imaging system's Color Matching Method (CMM) to transfer color information accurately between source and destination devices. The PCS is usually the Lab color space.

Working Spaces
Working spaces are made available beginning in Photoshop version 5.0 and have continued through CS3. Working Spaces are part of the color management system for displaying and editing color. In Photoshop versions 5.0, 6.0, 7.0, CS1, CS2, and CS3 provide Working Spaces for RGB, CMYK, Gray, and Spot colors (though the spot colors are really grayscale profiles). Each Working Space is based on the ICC profile file format.

In earlier versions of Photoshop, such as 4.0, 3.0, 2.5, and 2.0, the monitor's color space was the actual color space in which image editing was done. Because each brand of monitor is different, it affected the way a color image was reproduced. The modern Photoshop RGB Working Space (of 5.0, 6.0, 7.0, CS1, CS2, and CS3) method overcomes this problem.

The Adobe RGB Working Spaces

The original purpose of the RGB Working Space was threefold: to remove the limitation of the monitor's color space for image editing, to make color management more practical with Photoshop, and to create a more standardized method to reproduce and view color images. The Photoshop RGB Working Space does those three things.

In Photoshop, the Color Settings/RGB setup option defines a Working Space for editing RGB images. In an attempt to make color management more friendly and less confusing in Photoshop,

Our advice is to standardize your Photoshop Monitor Working Space.

While there are a number of options, one rule of thumb is to try one of two RGB color spaces.

• Adobe RGB (1998) for print and non-print work.
• Use SRGB for Internet imaging.

CMYK Working Spaces

The CMYK Working Spaces are primarily used in the RGB to CMYK conversion process. If you create your own or purchase profiles, you can add more profiles to the list by placing them in the ColorSync Folder (Mac OS) or the Color Directory (Windows).

Rendering Intents

Rendering intents are user-defined controls to map or transfer colors from source colors to different output destinations or devices. Rendering intents are built into programs like Photoshop, InDesign, RIPs, and other ICC workflow tools. There are four rendering intents: perceptual, relative colorimetric, absolute colorimetric, and saturation. These rendering intents are chosen by the user based on how he or she thinks the image should be reproduced when printed. The main criteria for choosing a rendering intent is based on each image's tones and colors that are in gamut or out-of-gamut. The purpose of a rendering intent is to standardize the way a profile maps or transfers colors from source colors to different types of output destinations or devices.

Why Adjust Rendering Intents?

The main reason to use various rendering intents is to manage out-of-gamut and in-gamut colors for different types of images when outputting them to various printing devices on different media.

Perceptual

Perceptual rendering is a method that maps or compresses the colors from an image (the source) to the colors of another imaging device (the destination) while maintaining the overall appearance of the image. This is a commonly used rendering intent for converting images from RGB to CMYK and allows an end-user to map the full range of colors from a source image to an output device (the destination). This rendering intent is not as color accurate as relative colorimetric. It maps all colors without clipping out-of-gamut colors. The perceptual rendering intent is typically used on images with a majority of out-of-gamut colors.

Relative Colorimetric

Relative colorimetric is a rendering method that maps the white point and colors of the source image to the white point and colors of the destination device. This is the most accurate method of mapping source colors that are within the printable gamut of the output device.

The Relative Colorimetric Rendering Intent is the best color matching option as long as the tones and colors of your Source image are not outside the gamut of your printing (destination) device. Any tones or colors outside of the printer's gamut will be clipped. If you have been using Photoshop since version 4.0, you sometimes see this behavior when converting from RGB to CMYK in solid colors.

Rendering Intents for Color Separation
Color separation is when an image is converted from one color space to another. For example when going from RGB to CMYK or CMYK to CMYK.

When using a rendering intent for color separation (such as RGB to CMYK) the source image's colors can fall outside the color gamut of the output device and will become clipped to the nearest in-gamut color value. Consider using the Perceptual rendering intent when converting from RGB to CMYK if your image does not have colors that fall outside of the printer's color gamut.

Tip:
A typical situation for using the Perceptual rendering intent is during an RGB to CMYK conversion. In this situation, the source image, often an RGB image, has a larger color gamut (that includes colors that are outside of the CMYK color gamut). The CMYK color space has a smaller color gamut than the RGB image. The Perceptual rendering intent maps and scales all colors perceptually from the source device to the printable colors of the printers color space. The Perceptual rendering intent allows out-of-gamut colors to maintain image details. The trade-off with this rendering intent is that while image details are maintained, some colors become de-saturated.

Rendering Intents for Color proofing
Relative colorimetric is one of the most commonly used rendering intents for pre-press and photographic color-proofing workflows. The Relative colorimetric intent does not include creating the white of the press paper color it only uses the paper white of the substrate.

Absolute Colorimetric
Absolute colorimetric maps the source image's tones, to the output (destination) as accurately as possible. During this mapping of tones, the absolute colorimetric intent also maps the white point values from the source profile (that is the white point of the printer or press you are using as source) to make the printed result (on an inkjet printer) simulate the printer or printing press' paper color.

Color proofing
The Absolute Colorimetric option is typically used in pre-press color-proofing situations. It allows the end-user to simulate the paper color (of the source), such as a press sheet on a inkjet proof sheet.

Saturation
Saturation is a method that maps saturated colors of the source image to the saturated colors of the output device (destination). This is usually good for business graphics where the images need to appear more saturated. This rendering intent is rarely used for pre-press color proofing.

Viewing a Color Profiles Color Space
Testing the quality of a profile is one of the first steps in determining if the profile was created accurately. While there are a number of ways to test the profile's integrity, the first test we always perform after creating a scanner or printer profile is to examine the size and shape of its color space.

To do this we use a software application that graphs the CIE system color coordinates. Many software applications that come with profiling packages for just this purpose
We like ColorThink by Chromix and ColorShop X by Xrite. These are a standalone utilizes for working with profiles. To use an application like this, open up the newly created profile to view the size and shape color space. If you have never done this before then it will not have too much meaning. After some experience of seeing different size and shaped color spaces, then you will understand if you created a good or bad profile. Below are six examples color spaces that represent good and bad profiles plotted on the CIE Yxy system.

Organize your Profiles Tip:

We find that too many profiles are pre-supplied with the computer's operating system or with peripheral devices such as a scanner or printer. And because of that too many profiles cause confusion, especially for end-users who are new to working with profiles.

Our recommendation is to organized the profiles in your computer system. The first thing you need to determine is which profiles are necessary. Then you need to move the unwanted ones to another folder or delete them. If you have never worked with profiles before, they are located in the ColorSync folder on the Macintosh and in the Color Directory for Windows. Note the names of the profiles and trash the ones that do not have any meaning to your workflow.

Delta E and CIE Values

CIELAB values can be used to compare one set of color values to another. The result is a mathematical product that is referred to as Δ E (pronounced Delta E). Δ E is defined as the difference between two colors that are measured by the CIELAB system. The Δ E value of 1.0 (which is the lowest value on this counting scale) represents the smallest color difference a human eye can perceive between two measured colors.

In practice, Δ E values are a way to scientifically communicate the change or difference between two colors. Color management systems use Δ E in various ways to determine variation between color prints, input and output profiles, and such devices as scanners, monitors, and printers. Δ E is one measure of quality and can be used to determine how much variation is in your imaging system. For example, some profiling programs use Δ E to give feedback to the end-user when creating profiles. This type of information is useful to determine if your profile meets certain quality standards when creating a profile.

The following list shows how Δ E can be used as a guideline to qualify color differences.

- 1Δ E – represents almost no perceptible differences or variations between two colors.

- 2-5Δ E – represents minute to normal color differences or variations in high-quality imaging systems.

- 6-10 Δ E – represents a relativly large color difference or variation.

- 11-15 Δ E – represents excessive variation so that color matches are not visually close.

Soft-Proofing
Getting a monitor to visually match an original or hard copy proof is referred to as soft-proofing. Setting up calibrated viewing conditions between originals, a monitor and hard copy proofs is one of the keys to successfully creating high-quality grayscale and color reproductions. In relationship to calibrating the monitor to make the monitor and printed hard copy have the same appearance, the most accurate way to create an ICC monitor profile is by using a measuring tool, such as a Colorimeter or a Spectrophotometer with a third party profiling application. The other method is to use a tool such as Adobe Gamma that is supplied with Photoshop.

Lighting Conditions
When viewing occurs under substandard conditions, achieving predictable results or communicating color accurately is impossible. To create a high-quality viewing condition proper lighting is needed. Setting up a monitor and the surrounding environment properly will enable close visual matches between originals and hard-copy proofs. If the external viewing environment is inferior, color management will not work correctly.
Note that when it comes to making the monitor and output visually match, some applications are better at making the monitor appear like the hard-copy output. It is possible to do this in applications like Photoshop, PageMaker, Illustrator and InDesign. It is not possible to do this is Quark Xpress.

Soft-Proofing Tips
There are a few components a good color managed system needs to enable accurate soft proofing.

1. Use custom device profiles. These are 100% more accurate than what vendors supply for free. You can buy them on line or from a service provider.

2. Use a light booth with a dimmer. This allow you to visually match the white of your printed images to the white of your monitor.

3. Use profiles in pairs. When you scan or capture and image with a digital camera you Assign the input profile to the image and then convert the image to your working space. In this process the input image (the scan or digital camera image for example) should use the same settings and lighting conditions. So if you change the lights for your camera or use a curve in your scanner, the input profile is invalid and will not work accurately.

A Color Managed Workflow

To summarize this discussion, a color management system refers to using ICC profiles. This method of calibration is based on using a combination of scientific measuring techniques and practical color methods to create device profiles that help describe color characteristics based on how humans see color from input and output devices.

One of the main goals of modern color management systems is to make color calibration easier. We believe it is easier than the closed-loop approach that does not use profiles, but it still requires skill to adjust tones and colors of images to bring out their best black-and-white and color details.

If you are serious about reproducing grayscale and color images, deciding whether to calibrate your system should not be a difficult one. The problem becomes how to ensure end-users can integrate device profiles into their workflows. This raises a number of questions that we hope this white paper sheds some light on. We also believe that going-by-the-numbers to color-correct images is also practical, and especially if it is used in conjunction with color management

If you plan to use Photoshops color management we suggest establishing the RGB Setup and understanding the monitor Working Space. We also suggest that you standardize on one of three Working Spaces. Use Adobe RGB (1998) for print & non-print work and use SRGB for Internet imaging.

The CMYK Setup offers Adobe created profiles for different printing process and provides the Custom CMYK Color Settings that look like the old Photoshop Color Settings. This option allows you to adjust the controls manually to create your own custom settings. In this case, Photoshop automatically creates an ICC profile based on those adjustments.

The learning curve for adopting profiles into the workflow is not as difficult as learning closed-loop methods. Photoshop 6, 7, CS1, CS2 and CS3 takes full advantage of profiles and can reduce the number of color proofs for projects. If there is a drawback with using profiles, it is that it takes time and resources to establish a color management system. However, when profiles are used correctly, the benefits are tremendous.

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