## Principles of LCD monitor colors

Ordinary computer monitors (including notebook screens) are systems incorporating transmissive liquid crystal displays and backlights. The backlight behind the LCD panel goes on, and brightness is controlled by adjusting the light passing through each pixel. Individual pixels are comprised of three components; R, G, and B. Color filters in the three RGB colors are also used to control the wavelength of light that is passed, enabling independent control of red, green, and blue and making it possible to reproduce the colors in the color space (e.g., sRGB, Adobe RGB).
• LCD panels are broadly classified as TN, VA, or IPS.

For Color Monitors

Close up cross section

Displaying colors using color filters
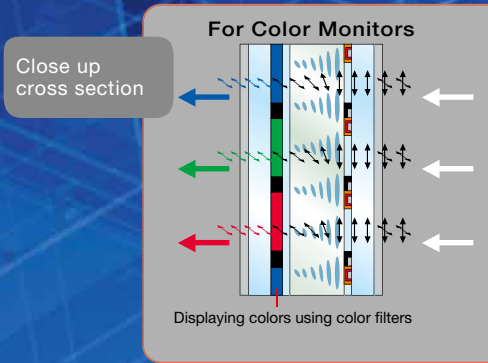
• Enlarged view of LCD panel screen
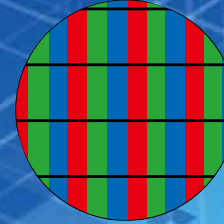
Front bezel:

Protects the periphery of the LCD module. An optional protective panel can be added to protect the LCD screen.

LCD module:

The orientation of the crystals between the two substrate glasses blocks the transmission of light from the backlight.
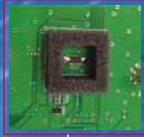
Diffuser:

Evenly diffuses light from the backlight across the entire screen

LCD Driver
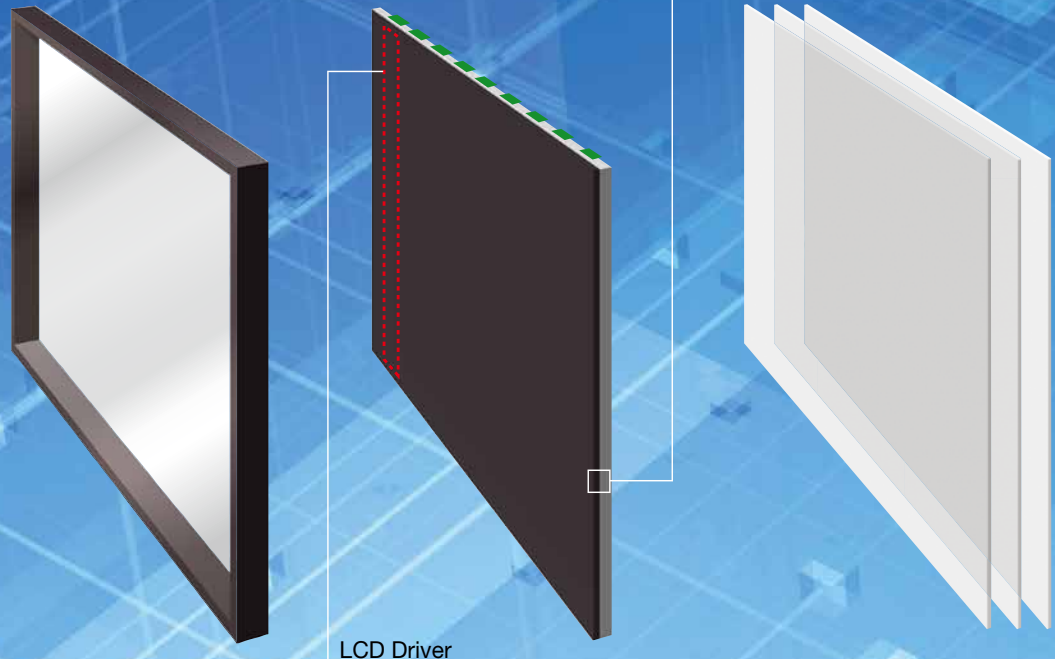
03

LCD Monitors [LCD Monitor Reference]

Backlight sensor: this device increases product life by stabilizing brightness after system startup and automatically correcting for ambient temperature and changes in brightness over time. The light adjustment function is patented by Eizo Nanao Corporation (Japan patent nos. 3171808 and 3193315).
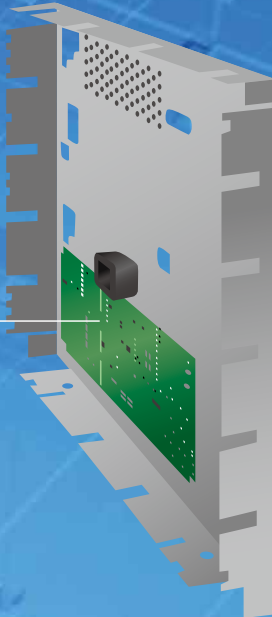
Backlight:

Since the LCD itself does not generate light, its light source is the backlight positioned behind the panel.
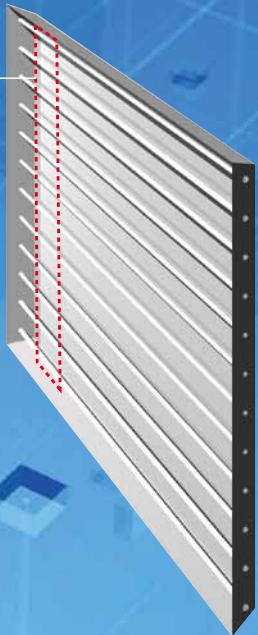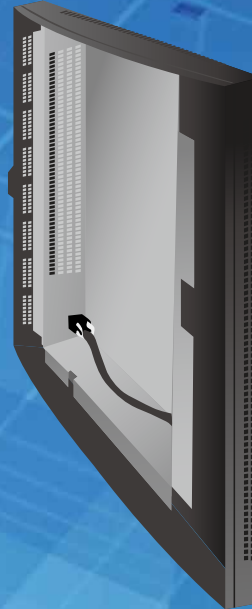
Control board:

The core hardware for image display; allows switching of LCD orientation for image or text editing

Rear bezel:

Featuring heat-vent openings and ergonomic design intended to achieve an easy-to-use interface

Backlight inverter

The monitor screen is like the "paper" in DTP design work. However, the way monitors produce color differs fundamentally from what makes paper look white. In DTP design we must know how to make the white displayed on monitors match the white of paper. Of the basic types of monitors, CRT monitors were most common until relatively recently. However, the introduction of ColorEdge LCD monitors that support superb color management has helped make LCD monitors the leading type in recent years for printing and photography applications. Here, we take a closer look at LCD monitors.

Basic Monitor Knowledge

Popular panel technology

LCD flicker

One characteristic of LCDs is that they do not flicker when viewed. This is clear in comparison to CRTs, in which the fluorescent surface has a high response rate but brightness changes constantly as the electron beam scans the CRT surface. Even when the monitor shows an unchanging image, the image is periodically refreshed at the microscopic level. CRTs with refresh rates lower than 85 Hz therefore give the impression of flickering.

In contrast, it is the LCD's pixels that are periodically refreshed. After a refresh, the same state is maintained and does not change until the values corresponding to the images displayed change. This is because the LCD drive circuit is designed to maintain the same voltage between cycles. For this reason, no flicker is apparent at any response rate. LCD monitors have a vertical scanning frequency of 60 Hz when displaying digital signals supplied via the DVI port. Analog signals are displayed at a low frequency of 60 Hz, but this poses no flickering problems whatsoever.

Monitor color settings and adjustment

The following settings can be adjusted on LCD monitors.

☼	brightness
◑	contrast
🌡	color temperature

The parameter generally referred to as screen brightness (luminance) is adjusted through Brightness. This changes the intensity of the backlight.

Few LCD monitors enable adjustment of white balance by adjusting the brightness of red, green, and blue separately. Instead, white balance is adjusted on many models by changing the color temperature (measured in units of K — degrees Kelvin), or by choosing settings for warm or cool tones relative to standard values.

☼ Brightness

When grayscale images are displayed from a computer (in increments of 0 – 255, for 256 shades), image brightness is normally adjusted through the Brightness (luminance) setting. Because the overall image is brightened or dimmed while maintaining gradation characteristics, this is the equivalent of Contrast on CRT monitors.

Unlike CRT monitors, LCD monitors have no Black Level setting, since glare does not usually obscure darker image areas. However, to enable monitor-based examination of details in shadow areas, the black level can be set on ColorEdge monitors using ColorNavigator.

🌡 Color Temperature

As with CRT monitors, color temperatures can be set on high-end LCD monitors like the ColorEdge models. However, this setting must be used correctly for the application in question. Setting the color temperature is equivalent to adjusting the white balance. With the ColorEdge series, this was called white point adjustment. The term color temperature was originally used in reference to colors of various light sources. Measured in K (degrees Kelvin), it indicates how hot light sources are.

Hot objects emit bluish white light and cool objects light with a strong red tinge. This helps us quantify the color of light sources.

For graphics applications (viewing and layout of photographic images, for example), 6500 K is considered a suitable color temperature. For printing applications, the guideline value is 5000 K; for video images and TV systems, the ideal color temperature is around 9300 K. 6500 K is also specified for the sRGB color space, standard for images on the Internet.

Although the color temperature should match your particular application, often a range of production tasks is performed in a given environment. Newer monitors simplify color temperature settings with a one-touch configuration. Some models link monitor settings to software programs, so that the setting switches automatically to 9300 K for video applications, to 6500 K for Adobe Photoshop, and so forth. However, many LCD monitors do not offer color temperature settings at all. Instead of adjustment by color temperature values, these monitors offer only general color adjustments. This may be adequate for certain applications, but individuals who regularly handle digital images should choose models that allow manual configuration of color temperature.
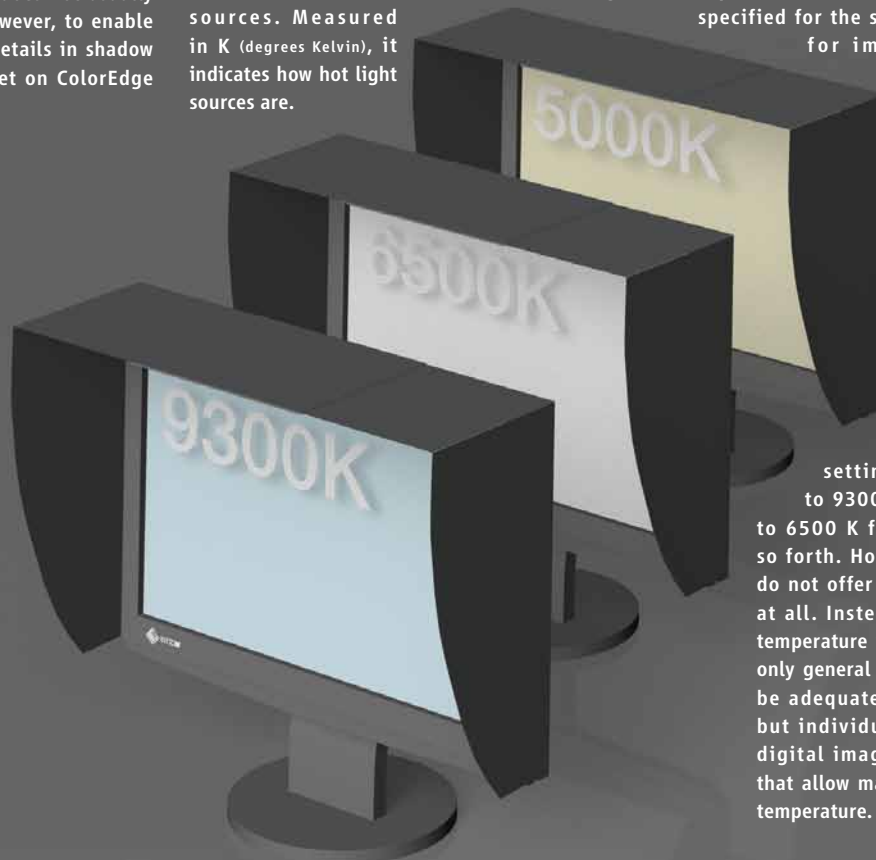
Digital uniformity compensation

For CRT and LCD monitors alike, uniformity of screen luminance and chromaticity is an elusive goal. Perfect uniformity across the screen is extremely difficult to achieve, due to various factors inherent in how color is reproduced on monitors. Still, graphic arts work in photography, design, prepress, and printing demands certain uniformity. Significant variations in color and brightness that depend on whether (for example) an image is centered or displayed to the right affect production.

Manufacturers do their utmost to improve the uniformity of LCD panels in monitors, but EIZO has taken this one step further, developing a special ASIC chip that compensates for unevenness at the signal level for superior image uniformity. The chip significantly improves even the uniformity of mainstream panels, as demonstrated to the right.
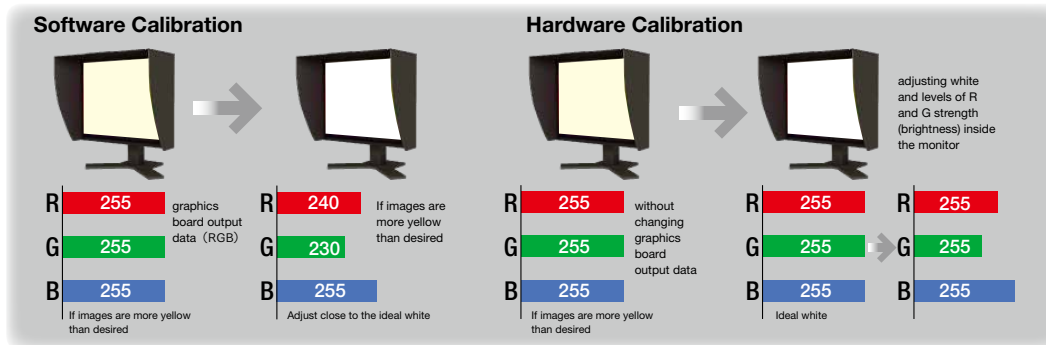
Luminance uniformity is addressed in ISO 12646, which establishes a set of requirements for soft-proofing monitors. To ensure uniformity, the standard specifies that luminance may vary by no more than 10% at nine points around the screen relative to a central point. We consider this the minimal requirement. Monitors with EIZO circuitry for digital uniformity compensation achieve a ΔE value of 3 or better relative to the center across a wider area of the screen.

Powerful processing from a new ASIC chip
ColorEdge monitors are equipped with a newly developed application specific integrated circuit (ASIC) chip that provides internal 16-bit processing for accurate rendering of color image data. This powerful color processing enables smooth tonal transitions and enhances visibility in shadow areas.

Software Calibration

Hardware Calibration

adjusting white and levels of R and G strength (brightness) inside the monitor

R	255	graphics board output data (RGB)
G	255	
B	255	

If images are more yellow than desired

R	240	If images are more yellow than desired
G	230	
B	255	

Adjust close to the ideal white

R	255	without changing graphics board output data
G	255	
B	255	

If images are more yellow than desired

R	255
G	255
B	255

Ideal white

|	
R	255
G	255
B	255

Software-and hardware-based calibration

Calibration adjusts device characteristics to restore them to a specific state. Monitor calibration usually entails adjusting the monitor to restore gradation characteristics and luminance (corresponding to white color temperature and gamma values) to a particular state, but few monitors enable adjustment of these characteristics. Software calibration measures monitor colors, after which any divergence from the target values is corrected at the stage of output from the graphics card to adjust the display.

Unfortunately, the problems associated with this method include uneven grayscale reproduction (tone jump) and color casts from the reduction of one or more RGB levels.

The ColorEdge series and other high-performance LCD monitors are calibrated with built-in features that adjust the brightness and gradation characteristics of each RGB color independently, functions originally performed by special software. This is known as hardware calibration. Since there is no need to modify RGB output from computers, this provides a smooth, faithful grayscale display.

■ 9.0-11.0
■ 7.0-9.0
■ 5.0-7.0
■ 4.0-5.0
■ 3.0-4.0
■ 2.0-3.0
■ 1.0-2.0
□ 0.0-1.0
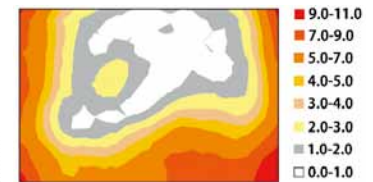
Before adjustment

After adjustment
Color-coded representation of the ΔE*ab distribution across the screen relative to the center, measured at 128 levels of gradation.

Monitor-computer video interface

Deciding on an analog or digital link between the computer video port and monitor is one matter; choosing the interface format is another.

Computer connector and single formats

PC	Video connectors	D-Sub 15pin	DVI-I	DVI-D	DisplayPort
		Connectors on the monitor			
Macintosh	D-Sub 15 pin	○	○	×	×
	DVI-I	○	●	●	×
*¹Mini DisplayPort		○	●	●	×
Windows	D-Sub 15 pin	○	○	×	×
	DVI-I	○	●	●	×
	DVI-D	×	●	●	×
*²DisplayPort		○	●	●	●

○ Analog connection　　● Digital connection　　× Conection not possible

Monitor size and DPI

Screen size and resolution (pixel count) are basic parameters for monitor performance. The resolution you choose in an LCD panel should generally match the display mode you work in. The first step is determining what screen resolution your working environment requires.

Standard numbers of pixels in LCD monitor

Horizontal × vertical	Name	Aspect ratio
1024 × 768	XGA	4:3
1280 × 1024	SXGA	5:4
1680 × 1050	Wide SXGA+	16:10
1600 × 1200	UXGA	4:3
1920 × 1200	Wide UXGA	16:10
2560 × 1600	Wide QXGA	16:10

Monitors in various screen sizes at the same resolution are now available, and users can choose the desired format. A guideline in this regard is DPI, or the number of dots per inch. Monitors with higher DPI values have smaller individual dots, so the same image appears smaller than on low-resolution monitors. Typical examples are given to the right.

Resolution	Screen size	DPI	Typical monitor
1024 × 768	15"	85	Standard monitor
1280 × 1024	17"	96	Standard monitor
	19"	86	EIZO ColorEdge CG19
1600 × 1200			
	21.3"	94	EIZO ColorEdge CG211
1680 × 1050			
	20.1"	98	EIZO FlexScan S2031W
	22.0"	90	EIZO ColorEdge CG222W
1900 × 1200	17"	102	Apple MacBook Pro
1920 × 1200	22.2"	102	EIZO ColorEdge CG221
	23"	98	Apple Cinema HD Display
	24.1"	94	EIZO ColorEdge CG242W
1280 × 1024	21" CRT*	87	EIZO FlexScan T966
	22" CRT*	85	Mitsubishi RDF221S
2560 × 1600	29.8"	101	EIZO ColorEdge CG301W
2560 × 1600	29.7"	101	Apple Cinema HD Display

*For CRT monitors, the figures shown reflect an aspect ratio of 5:4 and vertical measurement matching the effective dimensions of the CRT screen.

Those used to working on 21- or 22-inch CRT monitors at a resolution of 1280×1024 would feel comfortable with the display size of LCD monitors with a comparable DPI: 19-inch monitors at a resolution of 1280×1024. Another consideration is the trend in recent years toward widescreen LCD monitors, which offer a broad working area. Users looking to upgrade from a square 17-inch LCD monitor (1280×1024) to an LCD monitor would feel comfortable with the comparable screen height offered by a 20.1-inch widescreen model (1680 × 1050), with the added benefit of a larger working area.

D-Sub 15 pin

DVI-D 24 pin

DVI-I 29 pin

DisplayPort

Mini DisplayPort

*1 Monitors lacking a video connector that can be directly plugged into a Mini DisplayPort interface must be connected via a Mini DP-DVI or Mini DP-D-Sub adaptor.

*2 Monitors lacking a DisplayPort connector are connected via a DP-DVI or a DP-D-Sub adaptor. However, some graphics boards may not support a connection that uses a DisplayPort adaptor.

Monitor calibrators

Tools for monitor calibration and device profile creation

Monitor performance changes slightly over time, and regular calibration is required. A monitor calibrator, which employs a sensor, is also needed to ensure consistency among multiple monitors of the same kind.

Manufacturers now offer sensors at various price points, including the X-Rite i1 solutions and the Datacolor Spyder series.

EIZO ColorEdge monitors are compatible with typical sensors from X-Rite, Datacolor, and other manufacturers intended for a range of design and printing applications. The ColorEdge series was developed to set the standard in LCD monitors for superb color management, and these monitors emphasize both high performance and ease of use. ColorEdge software (ColorNavigator) can be used with i1 solutions as well as Monaco Optix XR and DTP-94. As for calibrators from other manufacturers, support for the Datacolor Spyder series was added in ColorNavigator 4.0.

ColorNavigator 5.1.2 introduces support for the new ColorMunki solution from X-Rite. Download the latest version of ColorNavigator from the EIZO website. http://www.eizo.com

🔺 Datacolor's Spyder3

🔺 X-Rite's new ColorMunki is positioned between i1 Display and i1 Pro and differs slightly from the approach of these solutions. Two formats are available: Design and Photo (for designers and photographers, respectively). Both offer equivalent hardware performance.

🔺 The new design of the i1 Pro ruler, with significantly improved usability.

🔺 X-Rite's i1 Display 2.

COLORMUNKI™ PHOTO

MONITOR TO PRINT MATCH
LIKE NEVER BEFORE

Coloratti

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ColorMunki is an all-in-one color control, creation and communication solution that lets you calibrate your monitor, projector, and printer so they all match. With this new solution, you can also send your images with DigitalPouch™ and create unlimited color palettes! So whether you work on a PC or Mac, ColorMunki is the innovative new way to bring your photos from screen to print accurately, simply and affordably.
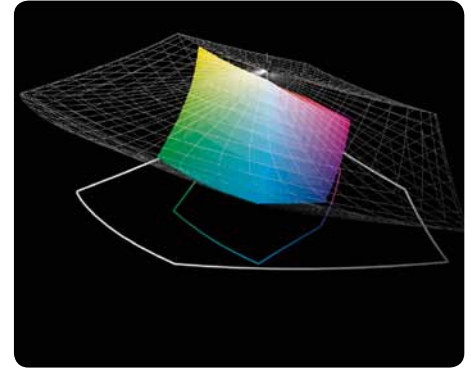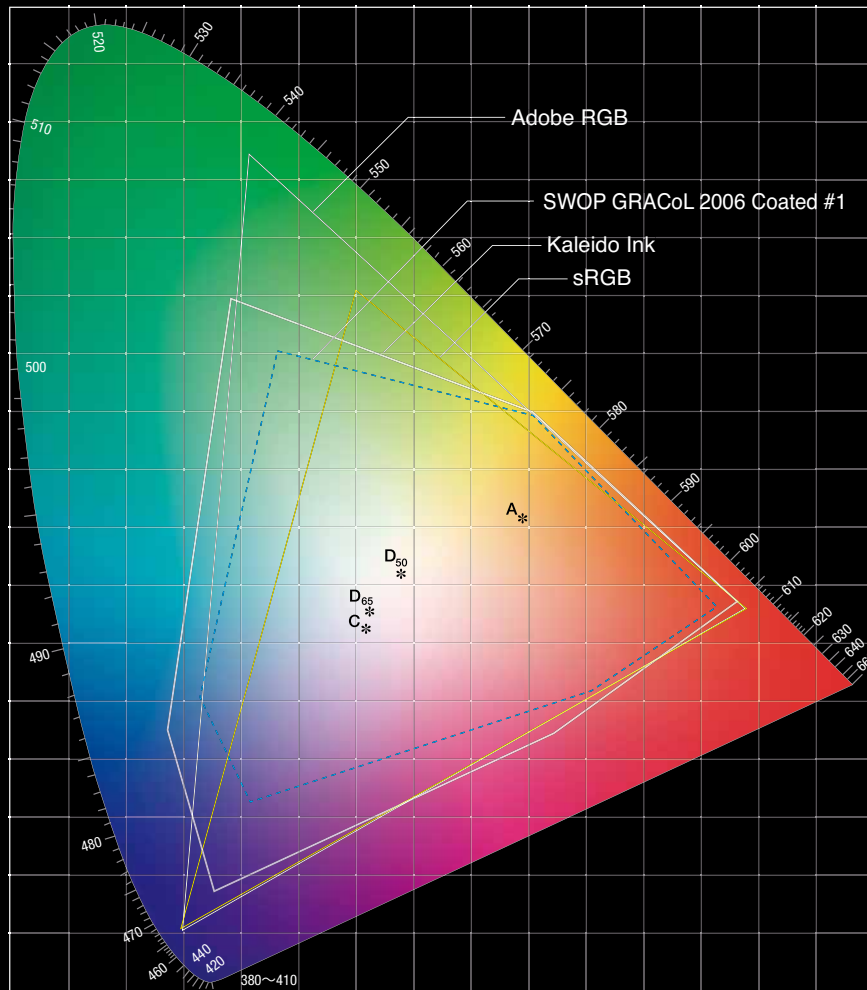
Swing by COLORMUNKI.COM to meet your new best friend!

CIE1931 (x,y) Chromacity diagram
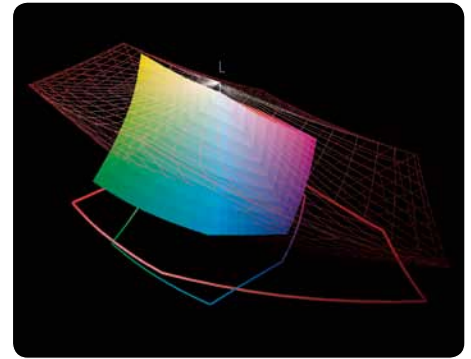
Adobe RGB

SWOP GRACoL 2006 Coated #1

Kaleido Ink

sRGB

$A*$

$D_{50}*$

$D_{65}*$
$C*$

520
530
540
510
550
560
500
570
490
580
480
590
470
600
460
610
440
620
420
630
640
660
380〜410

Comparison of SWOP GRACoL 2006 and Adobe RGB (white frame) color spaces. The Adobe RGB color space fully covers the Japan Color color space.

Comparison of SWOP GRACoL 2006 and sRGB (red frame) color spaces. For areas of the spectrum such as green, cyan, and yellow, the sRGB color space does not include the entire SWOP GRACoL 2006.

The above graph represents the reproduction range of Adobe RGB, sRGB, Japan Color, and Kaleido inks. Since most sRGB and Japan Color spaces are included within the Adobe RGB space, using Adobe RGB for the workspace in color management ensures most colors used for design preparation can be displayed on your monitor.

Created in ColorThink