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Color Proofing

Are LCD Monitors Ready? 7

A couple of years ago, LCDs were more expensive than CRTs and their image quality was inferior. But that's all changed. With good production quality control and careful packaging and handling in the transport process, the best LCDs can outperform even the best CRTs. AGI Sweden set up a test to see how some of the leading models fare for prepress color-critical proofing.

The Latest Word

GOA Has a Latin Flavor 2

Evidence of the Latin American printing market surfaced this month at Graphics of the Americas. The annual convention in Miami Beach is billed as an international printing trade show, and with good reason: More than 35% of the attendees come from the Caribbean and Central and South America. The Latin American flavor also has local roots, with a large number of Latinos residing in the U.S. But attendees also came from Russia, Canada and Europe.

The Latest Word

Tech Meets Reality 4

The tests at this year's PIA/GATF Tech Alert Conference included the impact of various PDF workflows on color management efforts, the adverse impact of coatings on trying to match digital proofs to press, how to prevent blanket piling during stochastic printing, and how to minimize the quality degradation on digitally printed products subjected to the high-speed U.S. Postal Service sorting equipment. Also presented was RFID's future role in the printing industry.

Cross-Media Publishing

Print Meets Multimedia 12

According to media experts, print, Web, television and radio will grow closer together in the near future. Publishers will be able to broadcast news through many different channels, not just one. This will allow "cross-platform media" and "multimedia" to attain new significance. Cross-media will actually be media comprehensive. Some media houses in Europe are already there.

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New LCD Monitors Are Superior for Proofing

By Paul Lindström

Sometimes technical developments take a sudden great leap forward. This is exactly what has happened to liquid crystal display monitors in the past two to three years. Compared to cathode ray tubes, they were expensive and their image quality was inferior, but that's all changed now. In a comparative test of monitors originally published by *AGI* Sweden in January 2005, LCDs performed admirably as proofing devices.

LCD monitors have a lot going for them: They take up little space on the desktop, don't radiate much of a magnetic field, are crystal sharp, and have high luminance (brightness) with a larger color gamut than even the best CRTs. In fact, the latest generation LCDs are so successful that most monitor vendors, including Barco, have stopped manufacturing CRTs.

Monitor Monitoring

There are many ways to evaluate a monitor, but the requirements for graphic arts production are particularly demanding. We recently set up a test to see how some of the leading models fare for prepress and to determine whether an LCD monitor could be used for color critical proofing.

For our monitor proofing test, images and other objects on the page had to be rendered smoothly with accurate color, and the page had to look like the type of print being simulated. In our test results, we express color accuracy in ΔE values and measure color differences in CIELab. Generally, a value of ΔE 1 represents a barely perceptible color difference, and for proofing applications an average color deviation of maximum ΔE 4 is considered reasonable.

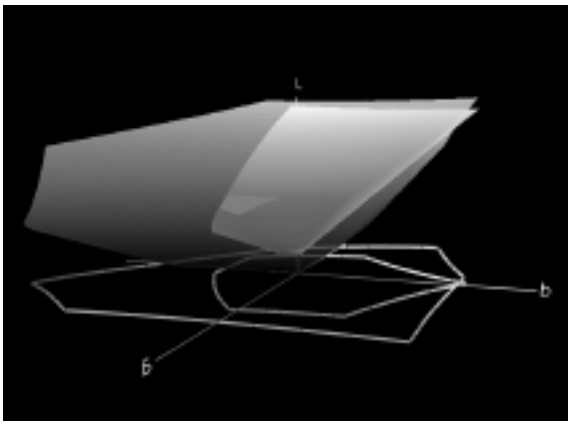
Of course, the color gamut of a monitor used for print simulation has to match that of quality print on high-quality paper, such as sheet-fed print on a glossy or semi-glossy coated stock. The color gamut often referred to in the context of monitors is the Adobe RGB 1998, which is quite a large color gamut. However, it doesn't include the entire color gamut of offset printing, and the full tone colors of the cyan, magenta and yellow primaries are especially difficult to achieve.

Another RGB color gamut, which does include the full tone values of offset printed cyan, magenta and yellow, is often suggested as reference. ECI (European Color Initiative) RGB not only has a fuller gamut, but it has a reference white point of 5000K, rather than the 6500K of Adobe RGB 1998, which is a slightly more bluish kind of white. ECI RGB has the same white point as is used for proof and print evaluation, and as is assumed in ICC (International Color Consortium) profiles for print output. As of today, no monitor on the market can render a color gamut as large as the Adobe RGB, although several vendors have announced that such monitors will be available within months. Given the speed of LCD monitor developments, we expect to reach even the larger ECI RGB's color gamut within a few years.

Is There Really No Standard?

The settings for white point, brightness, luminance and black luminance levels are crucial in monitor-based proofing, so we were a little surprised that not one of the vendors referred to the ISO standard for proofing monitors in their documentation. In general, the manuals are quite poor, and when calibrating a monitor, the user is often left to judge for himself or herself what values should be inserted as the default settings.

The ISO 12646 standard for "displays for color proofing" was written a few years ago and does not include LCD monitors per se. However, it could at least be used as a reference when suggesting settings for



The Adobe RGB 1998 represents a large color gamut and yet it doesn't include all of the color gamut reached in high-quality offset printing. In this 3-D diagram (created using Chromix Color Think software), the outer translucent gray sphere represents the Adobe RGB. The inner and colored sphere represents the gamut of print according to the ISO 12647-2 standard, on glossy coated stock.

Prices

Manufacturer	Model	Size (inch)	Approx. price[1]
Apple	Cinema HD Display 23	23	$1,799
Eizo	Coloredge CG21	21	2,899
La Cie	321	21	1,599
NEC/Mitsubishi	Spectraview 2180	21	N/A[2]
Quato Graphics	Intelliproof 21	21	N/A[3]
Sony	SDM-P234	23	1,999

1) Prices do not include measuring device.

2) Available in the U.S. in the spring, prices not yet determined.

3) Not available in the U.S.

both CRT and LCD monitors used for proofing. Vendors that don't agree that the ambient light should be at maximum 32 lux should explain why and under what circumstances a higher ambient light is acceptable. The same goes for recommended brightness and black luminance level settings.

Most vendors seem to agree on a brightness setting of around 120-140 candela per square meter (cd/m^2), while others use the maximum brightness the monitor can produce as the default setting. On most LCD monitors, this means 250 cd/m^2 or more, which is far too bright in most situations. Ideally, the operator should have a low ambient light and a contrast ratio between black and white of at least 1:100. Using a maximum brightness of 120 means that the black luminance level should be a maximum of 1.2 cd/m^2.

But besides referring to measurement values, the point is that what you see on your monitor should look very similar to what you see in print- or paper-based proofs. And print- or paper-based proofs should be evaluated in a proper viewing booth, at a white point of 5000K and a luminance of around 2000 lux, not under ordinary office light.

To be able to use the monitor for quality color proofing, it should be shielded with a hood so that the incoming light from the viewing booth doesn't pollute the viewing conditions. (See the sidebar on page 11 for a detailed description of how to correctly calibrate a monitor and see page 9 for what to consider when buying a monitor for soft proofing.)

The Monitors Tested

Apple Cinema HD Display 23

This is a very elegant monitor with uniform color rendering over the whole surface, except for the last 5–6 millimeters at the outside edges, where there is a clear reddish color cast. The only adjustment possible on this monitor is for increased or decreased brightness. It's quite "cool" looking, and no problem as long as you want a white point of 6500K.

The Cinema Display is factory set to 7000K and there is no display setting for changing it, so when calibrating the Cinema Display, it can be tweaked in software to 6500K, but beyond this is questionable. We pointed this out to Apple, but its attitude is that so far, "everybody uses 6500K anyhow," so there is no problem. Apple should also consider adding a foot so that the monitor height is adjustable (much cooler to look at than a telephone directory).

Eizo Coloredge CG21

This is a monitor clearly aimed at the graphic arts market, with a factory setting of 5000K, an enclosing hood and calibration via a special USB connection. Eizo offers its own Color Navigator calibration software. Used with the digital connection (the DCC/CI cable) and the USB cable going from monitor to computer, this makes true "hardware" calibration possible. The signal is 10 bits per channel and the gamma correction is set in hardware. The Coloredge CG21 comes with a certificate of the factory calibration and a printout of the results from the linearization and calibration.

La Cie 321

For a long time La Cie has cooperated with NEC/Mitsubishi, and this monitor closely resembles a Spectraview 2180. Normally, La Cie offers its own hardware and software to calibrate the monitor. How-

Apple Cinema HD Display 23 (left). Eizo Coloredge CG21(right). Photos: Thomas Althin, courtesy of AGI.

Things To Consider When Buying an LCD Monitor for Proofing

Now that LCDs have become the top choice when buying a new monitor, there are many brands and models from which to choose. Although it's possible to calibrate virtually every monitor on the market, the final result can be disappointing if you don't choose carefully. As usual, you generally get what you pay for.

For color-critical proofing applications, choose a monitor from a supplier that either offers its own calibration software or can at least suggest suitable calibration software when asked. A proofing monitor should be equipped with a hood to block ambient light, so vendors that enclose such a hood are likely to understand the needs of a proofing solution.

The monitor should be connected using a digital cable (DCC/CI) in conjunction with a USB connection between the monitor and the computer. This is the only way to set the gamma fully in hardware. It is possible to control brightness and contrast through software and the digital cable, but with the extra USB cable you get an addition level of control.

Check the color uniformity over the whole surface of the screen. It's fine to have accurate colors in the center of the monitor, but the deviation in other places on the screen shouldn't be too great. Set the desktop background to a very light grey, as this often reveals any non-uniformity on screen. If possible, measure patches with a spectrophotometer or colorimeter and calculate the average deviation, expressed as ΔE.

If you think the color uniformity over the whole surface is poor, check your new LCD monitor carefully for damage incurred during delivery. If your new (and perhaps expensive) LCD doesn't have a uniform appearance across the whole screen, it might have been slightly damaged during delivery and you shouldn't accept this particular monitor. A minor non-uniformity is, unfortunately, quite normal on all types of screens. **TSR**

ever, the La Cie software and hardware were under review at the time of our test, so we used our own devices. The characteristics for the La Cie 321 are, not surprisingly, similar to those of NEC/Mitsubishi Spectraview. Currently, La Cie offers generic ICC profiles for the monitor, but these assume maximum brightness, which is not recommended. It's far better to calibrate monitors with the correct settings. La Cie intends to offer proper software and hardware for this shortly.

NEC/Mitsubishi Spectraview 2180

After several years of close cooperation, these two manufacturers recently merged. What makes the Spectraview special is that it is factory calibrated to 5000K, and a certificate is enclosed with the monitor to prove it. NEC/Mitsubishi offers its own calibration software, although it looks very much like the software from the German company Color Solutions, and the manual is written by one of its technicians. Regardless, it's the most comprehensive and thorough manual for any calibration software we've ever tested. One very neat feature is an opening in the monitor hood that allows the operator to drop down the measuring device to calibrate the monitor without having to remove the hood.

Quato Graphics Intelliproof 21

This fairly small German vendor is gaining a reputation on the market for its high-quality proofing monitors. The LCD panels come from Hitachi, the same manufacturer Eizo uses. Quato offers its own calibration software, Icolor Proof, and apart from supporting most measuring devices on the market, Icolor Proof can be also bundled with Quato's OEM version of the X-Rite Monaco Optix colorimeter. As with every monitor that offers real hardware calibration, the Intelliproof monitor is connected to the computer with an extra USB cable, in addition to the digital DCC/CI cable. Quato also has a simple solution for attaching

La Cie 321 (left). NEC/Mitsubishi SpectraView 2180 (right).

Color Accuracy and Uniformity

Model	24 patches	Uniformity	Total deviation (ΔE)
Apple Cinema HD Display 23[1]	1.5	1.1	2.6
Eizo Coloredge CG21	3.1	2.5	5.6
La Cie 321	3.4	2.4	5.8
NEC/Mitsubishi Spectraview 2180	2.6	3.1	5.7
Quato Graphics Intelliproof 21	2.8	0.8	3.6
Sony SDM-P234	3.4	2.7	6.1

The total average deviation should ideally be lower than ΔE 4.

1) at 6500K

Color Gamut

Model/Color gamut	% of CIELab	% of ECI RGB	% of Adobe RGB
ECI RGB 1999	19.99	100.0	112.7
Adobe RGB 1998[1]	17.74	88.7	100.0
Apple Cinema HD Display 23[2]	14.23	71.2	80.2
Eizo Coloredge CG21	14.33	71.7	80.8
La Cie 321	15.79	79.0	89.0
NEC/Mitsubishi Spectraview 2180	15.47	77.4	87.2
Quato Graphics Intelliproof 21	13.81	69.1	77.8
Sony SDM-P234	14.12	70.6	79.6
As reference:			
Barco Calibrator CRT[3]	13.69	68.5	77.2
Radius PressView ColorMatch CRT[4]	13.05	65.3	73.6

1) at 6600K

2) at 6500K

3) at 5500K

4) The Radius PressView isn't sold any longer, but is often used as a reference color space, especially within newsprint prepress production.

the measuring device to the screen without taking off the hood (see below).

Sony SDM-P234

This is the prettiest of the monitors tested, but unfortunately the foot isn't adjustable for height, so the telephone directories rather spoil the effect — a shortsightedness Sony shares with Apple. Sony's OSD (On Screen Display) menu presents a wide range of user settings, but Sony doesn't offer any special software for calibration. When asked, technicians recommend the Gretag Macbeth software and hardware, and while we had high hopes for this beautiful screen, it didn't register very high scores. The color change from the upper part of the screen to the lower part was too great, and the color accuracy wasn't as high as we expected. So if your demands for color accuracy are moderate and your demands for beauty and design are very high, then this gorgeous monitor is for you.

How the Test Was Done

We invited the better-known manufacturers and vendors of high-quality monitors to choose one LCD monitor they thought would be suitable for high-quality image evaluation and proofing. We know from previous tests that the very cheap LCDs are normally difficult to calibrate satisfactorily, and their image quality isn't as good as the more expensive ones. As the test results show, even some of the monitors tested had problems achieving the required standard.

Each monitor was calibrated and characterized, and an ICC profile was built using both the measuring device and software recommended by the vendor or distributor and with some other measuring devices and software at our disposal. Among these were the Gretag Macbeth Eye One spectrophotometer and Color Vision's Spyder 2 Pro colorimeter, as well as X-Rite's Monaco Optix Pro. The maximum color gamut, extracted from the resulting ICC profile, was compared to those of Adobe RGB 1998 and ECI RGB 1999.

When testing color accuracy, we used the Monaco Optix Pro software validation process. In this process, 24 different color patches, many of them pastels, are projected onto the screen and then measured with the measuring device. The known colors, expressed in CIELab, are compared with the actual reading, and the

Quato Graphics Intelliproof 21 (left). Sony SDM-P234 (right).

How To Calibrate a Monitor

1. Switch on the power and let the monitor achieve the correct working temperature. This will take at least 20 minutes, but we recommend that you leave the monitor on for a full hour before calibration.

2. Make sure the monitor is connected according to the manual. If there is a special USB cable between the monitor and the computer, this should be connected to achieve full and automatic hardware calibration.

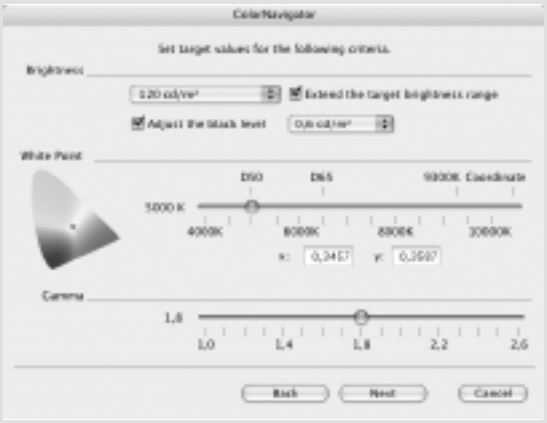
3. Start the calibration software and follow the instructions. For high-end proofing, choose 5000K as reference white. For general image retouching, you might consider 6500K, but then you have to trust the color management function of the operating system and software involved to perform the color transformation to 5000K if you want to simulate the printed result on the monitor. This may or may not work satisfactorily.

4. Try to achieve a low surrounding ambient light condition. The ISO 12646 standard recommends 32 lux as low ambient light, but this might not be practical in a mixed office environment. In low ambient light, you should choose a luminance (brightness) of no more than 120 cd/m2. If you work with a brighter surrounding light you might need to increase the luminance for the monitor to a higher setting, but this is a greater strain on the eyes and the images might not appear the same to other users working with more moderate luminance on their monitors. The whole purpose of ICC-based color management is that images should appear similar, independent of what kind of monitor displays them, whether its a CRT or an LCD.

5. Create ICC profiles using the standard matrix model. It's tempting to choose what should be the better option, using 3D LUTs (Look Up Tables) based ICC profiles instead. Unfortunately, this might not work satisfactorily in a mixed workflow. Apparently, Adobe Photoshop can render images inaccurately if 3-D LUTs monitor ICC profiles are introduced into the workflow.

6. Check your monitor's ICC profile by opening well-known documents and test charts. Compare these on screen against existing print and/or reference proofs. Some software offers validation processes to check the accuracy of the monitor and its calibration, which also might be useful.

7. Recalibrate your monitor every second week, or at least once a month. **TSR**



Calibrating a monitor for proofing requires going through a lot of settings. Here's an example of settings that follow the ISO 12646 standard for "Displays for color proofing."

average deviation is expressed as ΔE value.

Since the calibration and characterization can only be performed using a single spot on the monitor surface, normally in the center of the screen, we also wanted to check the uniformity of each screen. It's not good enough to have the right color in the center of the screen; colors must be accurate all over the surface. Therefore, we introduced a second test, measuring the color in the upper and lower corners of the screen. We set the background color to be a light grey equal to the value CIELab L90. We used the center point, where the monitor had been calibrated, as a reference measurement. In paper-based proofing, an average ΔE of 4 is considered accurate enough, so in our test we stipulated that the total average deviation based on the results from both tests shouldn't exceed ΔE 4.

As can be seen in the chart, only two monitors (the Apple Cinema Display and the Quato Intelliproof 21) achieved this. The Apple Cinema Display has a default white point of 7000K, which we adjusted in the software down to 6500K. Anything less than this done through the software could have compromised the monitor's accuracy, and yet Apple offers no monitor controls other than brightness. It's therefore questionable whether the Cinema Display can be regarded as a high-end proofing monitor. According to all applicable standards in the U.S., Europe and elsewhere, proofing should be done at 5000K, yet Apple doesn't seem to think this matters.

Apple's monitor was not the only one that failed to meet the demands we had set out for this test. Everyone can, of course, set their own demands for a proofing system, but we maintain that the demands on a monitor-based soft proof and a paper-based proof should be very similar. **TSR**

About the Author
Since 1993, Paul Lindström (pl@digitaldots.org) has served as technical editor at AGI, the leading graphics arts trade magazine in Scandinavia. Together with Laurel Brunner, he started Digital Dots, a consulting and publishing company specializing in digital prepress and print production analyses, in 2003.