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The Guide to...

Colour Management & Proofing

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Digital Dots Technology Guides

The Guide to Colour Management & Proofing

Second Edition

Digital Dots Technology Guides

The Digital Dots Technology Guides

This publication is part of a series of independent technology guides for publishers, graphic arts professionals, printers and print buyers. Technology Guide titles provide straightforward explanations of how technology works, what it's for and considerations for investment.

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About Digital Dots

Digital Dots is an independent graphic arts research and content development company established in 1999. The company is a collection of like-minded graphic arts consultants, pixies and professional journalists specialising in digital print production and publishing technologies. Digital Dots provides exclusive market research and content based on its own testing and evaluation services for prepress and publishing applications. It also publishes Spindrift, the industry's only independent journal for graphic arts news, analysis and comment.

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Introduction

Welcome to the Technology Guide to Colour Management & Proofing

In the following pages you will find everything you need to know about colour and how you can produce it accurately in print. Colour is one of the most effective tools for increasing response rates for virtually any form of print, from newspapers to labels. Even though everyone's eyes are on cost reduction, the use of colour in print is rising steadily, despite the additional expense. Colour is one of the few remaining areas of prepress where improved process management can yield tangible savings. If you know what you're doing and how to take advantage of the technology, you can have the best of both worlds: colour and economic production.

The following pages deal with everything you need to know about colour management and digital proofing. We explain the basic physics of colour without making your head hurt, along with the background for how digital colour and proofing work, why ICC colour management is so important and its importance of standards for workflow automation and production efficiency.

There are some very important issues to think about when you are trying to get the most out of your colour workflow, particularly if you are planning an extensive investment programme. Colour managed workflows depend on up to date information technologies, hardware and software. But the most important part of it is the people involved whose knowledge and skills can make such a difference to quality control. Device calibration and profiling are fundamental to an efficient, colour managed workflow, but their importance can often get overlooked. We explain how device calibration and profiling work, and we include some test results from various projects we have worked on over the last couple of years.

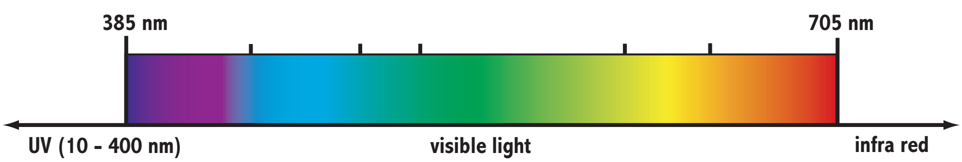
This guide is not exhaustive and it does not include an endless list of colour management tools. Using examples of hardware and software we have worked with, we have instead tried to explain how colour management and digital proofing technologies perform. Colour management helps extract costs and improve efficiency and makes a vital contribution to process automation. It's well worth the investment in time, people and technology.

The Digital Dots Technology Guide to Colour Management & Proofing will help you understand the underlying technology and how to implement it. We hope you find this publication useful and welcome your feedback.

Captain Fantastic or Brown Dirt Cowboy?

Elton John has given much to the world including a somewhat underrated song called "Captain Fantastic and the Brown Dirt Cowboy". It's unlikely that Sir Elton planned it, but this song title rather aptly summarises where the graphics industry is with colour management. There is a small elite of Captain Fantastics for whom digital colour management is a glittering triumph, and there's a mass of brown dirt cowboys doing their best but struggling. They've got limited budgets and knowledge, inadequate system capacity and customers or content providers with no inclination at all to bother with colour management. Most of us are in the brown dirt cowboy category, which is why colour management is still a problem. As more and more people contribute content to print media production workflows, it will continue to be so.

The problems don't lie with the technology, but with understanding the inherent conflict in digital colour. Colour perception is highly subjective, but an electronic system uses binary logic to define objects and processes. Clever software works by reducing all parts of a process to a series of logical choices between true and false, but real world colours aren't at all binary, either conceptually or practically.



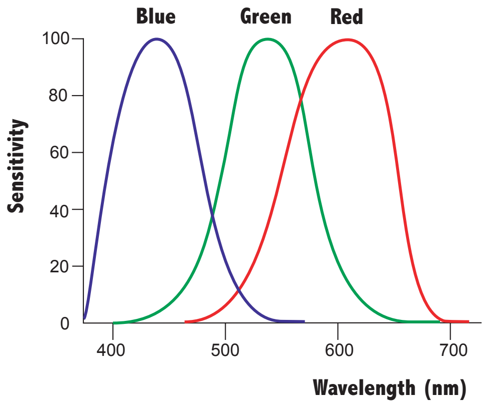
Every colour in nature is a complex muddle of stimulation and response values. It's subjective, not objective, absolute or tangible. Even describing it is confusing!

In the real live analogue world glittering and shimmering all around us, colour is everywhere. It's a property of our environment rather than a real entity, so it can't easily be pinned down and fixed. Colour is an attribute, perceptible when light interacts with the objects and surfaces that make up our world. Everything absorbs and reflects light to some extent. Some things absorb so much light they appear black, some so little they appear white, but most do both. The combination of how the eye captures light and the brain processes the photometric signals, turns bouncing light into colours, even though it's only inside our heads.

Real Colour Capture

Light enters the eye through the iris, which expands and contracts to control how much of it enters, much like the aperture on a camera. Information about the light gets sent to the brain, which differentiates it as colours. They range from no perceivable differentiations, where there is no light reflected, to where all wavelengths are reflected and there can be no differentiation. We perceive the former as black and the latter as white.

In many ways, a digital capture device works rather like the eye, but there is one very important difference. Digital capture with a digital camera or scanner samples a series of points in a scene or image. Software builds a digital equivalent of the image based on the



red, green and blue light information captured in each sample, converted from analogue information to digital data. Although such mathematically constructed colour descriptions can never exactly match perception, they can be controlled to come extremely close. Colour management is entirely about control.

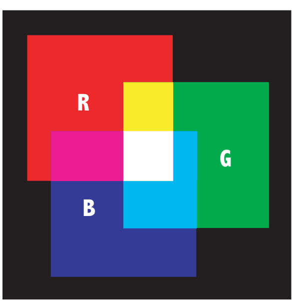
Additive & Subtractive Colour

So light is made up of red, green and blue wavelengths and when it hits a surface some wavelengths get absorbed and some don't. Adding together all of the wavelengths of light makes white, and adding selected wavelengths together creates different colours, hence the term additive colour.

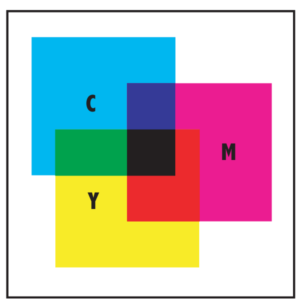
If there is no light source such as the sun or a computer screen to emit the red, green and blue light, there is only black. When emitted light hits a surface such as paper or board, the fixed texture of the surface absorbs or reflects it. Printers rely on how a surface absorbs and reflects light to create the illusion of colour, using subtractive rather than additive colour principals. They use cyan, magenta and yellow inks each of which absorb and reflects different parts of the visible spectrum, working rather like a filter. Light passes through the ink filters both as it reaches the page and when it is reflected from the white paper. Ink that absorbs the red component transmits green and blue to appear cyan; ink that absorbs the green component transmits red and blue to appears magenta; ink that absorbs blue transmits red and green and so appears yellow. With this subtractive colour system cyan, magenta and yellow are the primary colours and together all three colours will absorb all of the light, to appear black.

Basic Black

But impurities in inks mess up the physics here, so if one overprints cyan, magenta and yellow the result is a sort of murky brown, not black. Printers add black as the key



Additive colour mixing



Subtractive colour mixing

colour (K) to pull the rest together, enhance contrast and achieve a really deep, dark black. Together cyan, magenta, yellow and black print (CMYK) can mimic many, but not all, of the red, green and blue combinations visible on televisions, computer screens and the real world. A clever printer can even convince us that the cyan, magenta, yellow and black on the page replicates what we see in the natural world.

Black effectively increases the apparent density and richness of the print. It's cheaper and dries faster than coloured inks, so it can save money. Black can be used to enhance contrast and achieve a really deep dark black. It is also better for printing text and black line art, which look blurred if printed CMYK or only CMY.

The Temperature of Light

Wherever it occurs, be that in the natural world on a monitor or in print, colour is about light. If colour management is about control, it's also about understanding how light affects colour perception. One way of classifying a light source is its colour temperature, which is measured in Kelvin units (Lord Kelvin was a British physicist and inventor, who defined the light temperature scale). Candlelight is the gloomiest at around 2000ºK and the brightest sunlight is at the top, at around 10,000ºK. Within these extremes colour appearance will obviously vary, so graphic arts professionals use D50 with a colour temperature of 5000˚K, as a standard light source. D65 is defined as an average daylight simulation. D50 or 5000˚ Kelvin is a compromise between indoor light (3-4000˚ K) and outdoor light (6500˚ K) and is often used for viewing on press.

Colour Spaces

The only way to turn the RGB data captured with a digital camera or scanner into something that can be printed with CYMK inks, is to convert the source data into data defined for the target colour space: RGB to CMYK. It's a bit like transposing a piece of music from one instrument to another. The music should sound the same on both instruments, without compromising the characteristics and attractions of each.

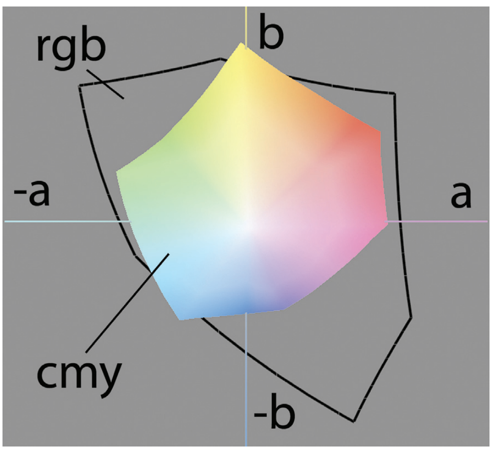
Black effectively increases the apparent density and richness of the print. It's cheaper and dries faster than coloured inks, so it can save money. Black can be used to enhance contrast.

Conversions from RGB to CMYK are notoriously badly behaved, but not only because they are based on different principles of rendition. Colour data conversions have to include some means of mathematically defining the characteristics of the digital devices used to create and render it. And the maths has to kick in every time a colour file is opened or printed on a different device. This is what ICC standards are all about.

International Colour Consortium (ICC) & Device Profiles

ICC standards are developed by colour scientists, technology developers and users from all areas of printing and publishing. ICC standards optimise accuracy in data transfers, taking into account the colour spaces and the devices in the workflow. In a controlled workflow, where all devices are calibrated and accurately profiled, colours appear the same wherever they are rendered, on screen or in print.

Any device used for colour production has to be calibrated and profiled. A device profile is a small data file with information about the device's characteristics and how closely it matches the colour values it is supposed to have. The ICC's standard file format for these profiles is one of the great leaps forward for digital colour management



The inner contour represents the colour gamut of sheetfed offset quality print. The outer contour (black line) represents the colour gamut of a standard CRT monitor.

ICC colour management works on the principle that all colour spaces can be defined within the CIEL*a*b* colour space (CIE stands for Commitée Internationale d'Eclairage). CIEL*a*b* is a perceptual colour space that defines colours according to their luminance, from black to white and degrees of red or green-ness, and of yellow-ness or blue-ness. It can define most colours that exist in nature and its vast gamut means that there are no colours in either RGB or CMYK colour spaces that cannot be defined. It's a sort of universal melting pot for colours, turning data defined in the source colour space to CIEL*a*b* values, then converting them into those required for the destination colour space. It sounds simple but the maths involved also has to include the device profile data, so it's far from straightforward. This may be why for many people it's just easier to dismiss ICC colour management and rely instead on a closed system, even though closed systems belong to another age.

Colour use in print is rising and modern workflows are open, not closed. Converting red, green and blue data to cyan, magenta, yellow and black data isn't trivial, but it can be done and done reliably. There is no clear consensus on colour management best practices, so a basic understanding of colour principles can only help matters. Awareness of the nature of the problem, plus control in the workflow and good housekeeping for all devices and software used in production is what colour management is all about.

ICC Colour Management Theory & Practice

Progress is about creating order out of chaos, and in many ways this is what digital colour management is all about. However for many people colour management isn't at all interesting, even though it can help cut costs, improve production efficiency and reduce expensive error corrections. Unfortunately colour management is not central to most print buyers' core business. It's someone else's problem and although they recognise that the science underlying colour management is important, it isn't their responsibility. The general view is that colour management should just happen in the background. And that is precisely the ICC's goal.

The International Color Consortium (ICC)

The ICC was founded to develop data standards and a common processing model for managing digital colour within distributed, open workflows. Adobe, Agfa, Apple, Kodak, Microsoft and Sun Microsystems originally set up the ICC to develop software standards that allowed systems based on standard computers and operating systems to produce colour. The ICC standards are designed to provide the kind of colour security typical of high end, closed and highly proprietary colour production systems. Modern technologies have largely replaced these systems, but although any user can take advantage of low cost colour production tools, relatively few users can really manage colour effectively. Instead they rely on software to do it for them, specifically software tools based on ICC standards and specifications.

Anne Mulcahey, chairman and chief executive officer, Xerox:

Colour "is a strategic competitive advantage no enterprise should be without"

Before the advent of desktop computing and low cost colour printing, colour production was the strict preserve of the repro house. It was a mysterious black art and hardly anyone understood it, so it was always toe-curlingly expensive. Computing advances allow anyone today to create and produce colour files. The problem is that not everyone can produce colour files suitable for printing. It's hard enough getting them to appear the way they're supposed to on a computer screen. When it comes to process colour printing, something hard becomes almost impossible. The ICC was set up to make the impossible possible in open colour production workflows.

What is Open Colour?

Open colour production is about marrying the colour worlds of red, green and blue (RGB) and cyan, magenta and yellow (CMY) into some sort of cohesive whole. The RGB world is inhabited by people who mostly don't know a lot about colour printing, and the CMY world by people who mostly do. In the RGB world, light's three primary colours combine to create colour for such things as televisions and computer screens. In the CMY

CIEL*a*b* Colour Space

This standard colour space simulates human perception and is the preferred colour space for print production in digital production environments.

*L*a*b* is the three dimensional reference value for determining a colour's position in a colour space.*

Luminance refers to the lightness of a colour with absolute black at 0 and absolute white at 100.

a is the position of the colour in the red to green axis.

b is the position of the color in the yellow to blue axis.

*In the L*a*b* colour space colours perceived to be identical also have the same metric distance.*

world, light's behaviour is controlled to create the appearance of colour in print. The two colour sets and their user communities are complementary cohabitants of the same digital world. ICC standards embrace both, a sort of universal environment underpinning digital colour description wherever it appears from print to DVDs.

The Black Channel

The natural world exists in RGB and its printed equivalent exists in CMYK. K stands for Key (not black as is sometimes stated) and refers to the black component in a CMYK inkset. It's obviously used to print the black elements of a job, but it's also used to improve the density range of the inkset and to deepen shadow areas. It can also be used to replace some of the cyan, magenta and yellow inks in shadows and some colours. Furthermore, it's a mechanism for reducing the amount of ink used, particularly when printing on low grade substrates. Black ink is also cheaper.

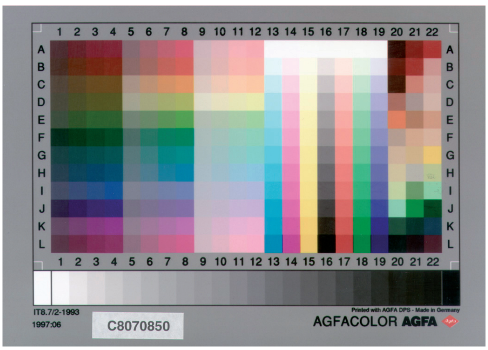
Colour Spaces

RGB colour is rendered with red, green and blue light wavelengths, and CMYK provides an equivalent appearance by cleverly manipulating the behaviour of reflected light. It's all about light, and if colours are light, then digital colours are the numeric equivalent of light for both RGB and CMYK. We can describe colours and their relative differences mathematically using a colour space, but the RGB and CMYK colour spaces are not the same. Not all reds, greens and blues can be printed, and not all cyans, yellows and magentas can be viewed on screen. And it gets worse, because devices don't necessarily display the same sets of red, green and blue, and printing presses don't necessarily print the same sets of cyan, magenta and yellow. There is however one colour space that is larger than both RGB and CMYK, CIEL*a*b*. This is the colour space underlying all ICC colour managed workflows.

ICC colour management works on the principal that all colour spaces can be defined within the CIEL*a*b* colour space CIEL*a*b* is a perceptual colour space that defines colours according to their luminance (brightness), from black to white and degrees of red or green-ness, and of yellow-ness or blue-ness. It can define most colours that exist in nature and its vast gamut means that there are no colours in either RGB or CMYK colour spaces that cannot be mathematically expressed.

ICC Device Profiles

An ICC workflow combines the CIEL*a*b* colour space with the concept of device profiles. Any device used for colour production has to be calibrated and profiled. A device profile is a small data file with information about the device's characteristics and how closely it matches the colour values it is supposed to have. The ICC's standard file format for these profiles is one of the great leaps forward for digital colour management. An ICC device profile defines the spectral and behavioural characteristics of each device used in a digital workflow. This includes everything from monitors, digital cameras or scanners through to proofers and multiunit presses.



The standard IT8 colour chart.

Device profiles contain mathematical representations of each individual device's colour values. Device profiles are based on a simple check of the way a device behaves, referred to as characterisation. Any device can be characterised using measuring tools and comparing the device's colour values to CIEL*a*b* values. Colour values for a device are established by measuring colour charts. Each colour patch in the chart combines specific percentages of cyan, yellow, magenta and black inks and obviously the more patches, the greater the volume of data and the better the device profile. There are standard charts such as IT8 and ECI, and charts built for specific purposes that have many more patches.

> **ICC:**
> *International Colour Consortium*

ICC profiles help to ensure correct colour reproduction throughout the workflow by defining the relationship between the digital values a device captures or transmits, and the CIEL*a*b* colour space. A device profile indicates how its RGB or CMYK colour values ought to be transformed to their CIEL*a*b* equivalent.

These numbers provide the basis for converting one set of values, say for example the RGB of a monitor, to another such as the CMYK values of a digital press. Conversions from RGB to CIEL*a*b* uses the input profile data, and conversions from CIEL*a*b* to the CMYK or RGB output device, such as a monitor, use the output profile. The Profile Connection Space (PCS), based on CIEL*a*b*, is where the colour calculations take place. There are several vendor specific colour management systems that interpret the profile data, before and after it has passed through the PCS. Although developers use the same principals to construct their colour management engines, they do not construct them identically. In other words, they don't all do the maths in the same way.

The device profiles provide the colour management system with additional information for colour calculations. This means that when turning an RGB data file into its CMY equivalent, the characteristics of the devices used to produce the file can be taken into account when the sums are done, to convert one set of data into another. The same principles apply when a digital image is viewed on the monitor, so that the behavioural characteristics of the monitor can also be taken into account when the colours are rendered on screen. Conversions from RGB to CMYK are notoriously badly behaved, but not only because they are based on different principles of rendition. Colour data conversions have to include some means of mathematically defining the characteristics of the digital devices used to create and render it. And the maths has to kick in every time a colour file is opened or printed on a different device. This is what ICC standards are all about so ICC colour management can be applied to any colour workflow and for optimising colour for any output environment.

Conversions from RGB to CMYK are notoriously badly behaved, but not only because they are based on different principles of rendition. Colour data conversions have to include some means of mathematically defining the characteristics of the digital devices used to create and render it.

Deliberate Deception

ICC colour management uses the CIEL*a*b* space as a sort of universal clearing house for colours, so that any colour file will look the same wherever it is viewed. By converting RGB or CMYK colour data into CIEL*a*b* data, it is possible to then reconvert it into a new data set, one that takes into account the colour capabilities of the target output device. Colour data can be converted from RGB into CIEL*a*b* and then again into CYMK values producing as close an equivalent as possible. It also works for converting one set of CMYK values to another for output on more than one CMYK printing system. We can mathematically rearrange data, so that an advertisement or photograph appearing in Vogue should look just as compelling when it's viewed in a newspaper. The colours should appear to look the same on the web, or when printed in a fashion show catalogue or in a brochure. ICC colour workflows strive to achieve complete visual integrity for images and colours across media. It's a deliberate deception that persuades the viewer that the specifics of an image and its colours are the same.

Limitations of ICC Workflows

Although the underlying principles are brilliant, putting them into practice doesn't always produce brilliant results. Keep in mind that colour is highly subjective, and that expectations for how it appears vary with the medium. Most of the problems with colour management are due to the fact that different software developers interpret the specification differently. The ICC has started to address this problem with the version 4 profile specification.

Even so, ICC workflows aren't idiot-proof. Apart from the obvious problems that arise from carelessness and imprecise measurements, there are other more fundamental difficulties. Mostly they come down to the fact that what works well for a standardised process is inherently less likely to work well for deviating processes. In a production environment with a finite number of devices and file interchanges it is relatively straightforward to qualify and quantify the variables. However, in production environments where it is impossible to capture all the variables, colour management can turn into a real mess. All of the processes in the workflow must be properly controlled before you even start to apply colour management.

The ICC workflow has removed a lot of the uncertainty of colour production, but it is still not ideal for all workflows. In environments where there are numerous technologies from different vendors, quality control can be difficult because different colour management systems can produce different matches for the same colour. There is also somewhat limited scope within an ICC workflow for working with non-CMYK workflows such as those exclusively using special inks.

Colour management increasingly has to work with unknown variables and in distributed environments, with output to a range of substrates, the characteristics and behaviour of which may be unknown. We need to know more about how printing stocks behave, but also we need to be able to assign different profiles to different pages in a document if required. This is currently only possible with some RIPs such as Gretag MacBeth's Iqueue which uses single ICC profiles for monochrome images, vector graphics, RGB and CIEL*a*b* images.

Another limitation is that within the ICC framework there is currently no means of controlling individual colour channels. This is why adjustments to the black channel impact the entire page image, rather than just the parts of the image they are intended to affect. Several companies have developed tools to overcome this difficulty, which arises because ICC standards are based on colorimetric rendering. These tools are compatible with an ICC workflow.

Delta E:
A measure of the difference between two colour tones.

Delta E 1:
The smallest colour distance and so difference, the human eye can perceive.

Esko-Graphics for example, has developed a colour management technology called Kaleidoscope based on spectral response. Instead of using colour intensity as the basis for colour calculations, it uses the specific measured wavelengths for a given colour to control individual ink behaviours. According to Esko-Graphics, working with spectral data in this way means proofing with special colours can be more accurate and special inks can be profiled. This workflow is outside the standard ICC processing model, but it is compatible with it.

The biggest challenge for the ICC today is to support a wider range of workflows, so that there are fewer exceptions undermining a colour workflow's integrity. The ideal graphic arts colour managed workflow should ensure the preservation of some specifics of CMYK input channels, accurately convert all colour data for the target output, including contone and screened colours. The conversion of CMYK colours can sometimes result in a kind of double colour management, so digital colour workflows need some means of quality control. The ICC is working on these areas, as well as application development and user education, which are important initiatives for the committee.

Although colour management is never going to be easy, software is getting more sophisticated and colour processing more reliable. Implementing a colour managed workflow starts and ends with the ICC, even for systems that rely heavily on proprietary technologies. Standardised processes may not work well for deviating processes, but within the standardised framework there is plenty of scope for application specific solutions. Improved precision in colour transforms and tools for resolving specific problems can all function within the ICC framework. How proprietary they are and how cost effective they are within the framework depends on the nature of the problem and of course the solution. Colour management is something everyone in the media supply chain should care about, because it's about saving time and money. However it's also about increasing colour usage, and improving quality. These give print significant competitive advantages over its electronic rivals.

Calibration, Profiling & Device Management

It's obvious that colour management enhances the publishing production process, but putting it into practice isn't simple because it's all about process control. It may not be very exciting, but device calibration is the foundation of process control for colour managed workflows. Before device profiling or colour conversions can even be considered, device calibration has to take place. Colour management professionals and consultants generally recommend a three step approach to colour management, based on the three Cs: Calibration, Characterisation (often referred to as profiling) and Conversion.

Input Calibration

Workflow calibration starts with monitor calibration. Monitors are fairly simple to calibrate, but there is still some confusion as to how to actually do it. Fortunately there is a standard for monitor calibration, ISO 12646, but unfortunately very few vendors refer to ISO 12646 in their manuals. This may explain why there doesn't seem to be any real consensus for how monitors should be calibrated.

ISO 12646

Approved in 2002, ISO 12646 covers recommendations for monitors used in high-end graphic arts production and colour critical work. It states that monitors should be set up in a room with low ambient light of not more than 32 lux (one lux is a measure of the light intensity produced by one candle roughly one metre away). According to ISO 12646 the monitor's white point should be 5000º Kelvin at a luminous intensity of around 80–120 candelas per square meter. In other words, monitors should work accurately in ambient light conditions, similar to those of a normal office. They should also be positioned well away from incoming daylight from windows and doors. The idea is to control the light around monitors used in a colour managed workflow, ideally conforming to ISO 12646. This year an update to ISO 12646 is planned, and will include specifications covering LCD monitors as well as CRT displays.

Calibrating scanners is even simpler, since in most cases calibration only involves checking the light source intensity and the focus settings. However there may also be a need for adjustment curves for different film materials, especially when scanning negative film.

Output Calibration

Although it's reasonably easy and straightforward to calibrate monitors and scanners, output devices are a little trickier. With a colour laser or inkjet printer, there are paper options to consider as well as such things as resolution, screen type and frequencies. A colour printer should be regularly calibrated, including checking the condition of print heads and so on, and linearised. Linearisation ensures that all input and output values are equivalent, so that when a 40% magenta is printed, you only get 40% magenta and nothing else. Characterisation and linearisation should be done for each paper type and resolution setting, and noted along with other settings that affect printed results.

And that's just the beginning of the story. Calibrating a printing press to create an accurate press profile, must take into account all variables influencing final output. This includes calibration of the obvious components such as imagesetters or platesetters, plus the chemistry and temperature in the developer. It also includes less obvious factors such as the choice of paper, which determines the amount of ink that can be used. Paper and ink characteristics must be embedded in the press profile and there are several standards available such as SWOP (Standard Web Offset Printing), GRACol, (General Requirements and Applications for Commercial Offset Lithography) the Euroscale ink sets and the ISO 12647 series standards for press conditions.

Press profiling is clearly no trivial task so press calibration is best done by an experienced press operator. The press should be regularly maintained and the interaction of press and different paper types documented. Each paper has optimum ink settings for a given press and the dot gain characteristics are often specific for each of the individual CMYK colours. The press should operate to its optimum performance, according to paper type and ink setup. If the platesetter and processor are also functionally correct and stable, characterisation of the devices can be done.

Characterisation (Profiling)

Once the devices in a colour managed workflow are calibrated, accurate ICC device profiles can be made for each input and output device. The monitor is an RGB output device, but other RGB devices such as scanners and digital cameras are input devices. Characterisation starts with scanning or photographing a test form. The resulting red, green and blue colour values are expressed as CIEL*a*b* values and stored in a list or look-up table within the ICC device profile. These values are then used as a reference for subsequent colour value conversions.

For an output device the procedure is similar. A test form is printed, and the result measured with a colorimeter or spectrophotometer. Based on incoming CMYK values the colours the print engine creates are expressed as a series of equivalent CIEL*a*b* values in a list or look-up table. It is sometimes suggested that an ICC device profile can correct errors in the printer or monitor, but this is not true. A device profile only describes the behaviour, good or bad, of the colour output device. Any corrections required are up to the colour conversion engine to handle at a later stage. Some hints for these colour conversions can be embedded in each ICC device profile, such as the amount of ink used and the black generation curves. If the output device software or raster image processor doesn't provide tools for proper linearisation, a linearisation curve can

Press profiling is clearly no trivial task so press calibration is best done by an experienced press operator. The press should be regularly maintained and the interaction of press and different paper types documented.

also be stored with the ICC device profile for later use.

For monitor calibration, the procedure is to generate a series of colour samples on screen for measuring with a colorimeter or spectrophotometer. The results are saved as CIEL*a*b* values inside the device profile. The gamma setting in a monitor is the equivalent of a linearsation curve in a printer, so this is also stated in the profile.

Colour Conversion

Colour management is not possible without device calibration and profiling, but it also needs some means of handling colour data conversions as files pass from device to device within the workflow. Calibrating devices and building ICC profiles is the basis of modern colour management, but the really interesting work starts when we try working with profiles in different colour conversion scenarios. This is where most colour management errors are made, particularly when moving from RGB to CMYK colour spaces.

The most common conversion is from an RGB image to the CMYK values of an output device. If the gamut is about the same for the input device as for the output device, this is pretty simple and straightforward. However in many cases the colour gamut of the RGB image is larger than that of the output device, so it needs compressing without compromising the colours in the image. The colours beyond the scope of the CMYK printing device are considered to be out of gamut, because they really can't be reproduced correctly. To overcome this problem, out of gamut colours are replaced with colours that come closest on the printing device. It is in this delicate work that different colour software will do a good or not so good job.

The ICC standard incorporates four colour conversion methods. Perceptual conversion is often used when coming from a larger colour space to a smaller one. Relative Colorimetric conversion is for converting from similar colour spaces, using the same white point for the substrate. For printers this would typically be ordinary white paper and for scanners or monitors the white point of the RGB colour space. Absolute Colorimetric conversion is used when the white point of the printer is substantially different to that of the original colour space, such as for example when printing proofs for newsprint on a printer loaded with very bright white paper. Saturation colour conversion is often suggested for vector and business graphics, but if the colour spaces are fairly similar it can be used to boost colours in a photograph. The latter should be tried with some caution though, as it's easy to overdo the saturation.

Colour data management is initiated in the computer's operating system or, in many cases, within application software. On a Windows computer the colour framework is called Image Colour Manager (ICM) and on a Macintosh it's Colorsync. Both interface with Colour Management Modules (CMMs) that handle specific colour conversions. Several vendors have developed sophisticated technologies for this, including Adobe, Agfa, Apple and Kodak.

With so many interacting components there is no doubt that colour management is hard. It depends on careful and meticulous device calibration and profiling, and on accurate data conversions. There is however still no real means of evaluating the quality of different profiles. This is the challenge that lies ahead. Also we need to reach a consensus on which standards to follow when calibrating monitors, printers and presses. A colour managed workflow is entirely achievable, but it's a continuous, never ending task.

Colour Management Hardware & Software

Colour management is all about control and hardware and software developments are supposed to enhance process control throughout the workflow. However successful colour management depends entirely on proper calibration and using the correct device profiles based on the International Colour Consortium's (ICC) specification. Calibration requires measurement devices appropriate to the task, and such tools are fundamental to colour management.

Monitor calibration is relatively simple to do, and there are software solutions that don't require a measuring device. Instead, operators make colour decisions based on test patterns projected onto the monitor. Such solutions include Adobe's Adobe Gamma software and the built in calibration tool in the Mac OS, but the results of this sort of calibration aren't generally up to much. Professional colour management demands the use of professional measuring instruments used in conjunction with dedicated software to achieve precise process control.

Measuring Devices

Monitor calibration is fairly straightforward, using either a colorimetric measuring device or a spectrophotometer. Of the two, a colorimeter is the simplest and cheapest, measuring the colour components of the monitor light through red, green and blue filters working much as the human eye does. There are many colorimeters on the market, but the best known and most commonly used within the graphic arts industry are devices from Colorvision, Gretag Macbeth and X-Rite. Most high end monitors designed for colour critical work, are supplied with measuring tools and calibration software from one of these companies.

Calibration of printer or printing presses requires a densitometer to check various parameters. Dot gain and ink density are probably the most important but a densitometer is also required for linearising the imagesetter. When measuring plates, especially digital plates for computer-to-plate output, most conventional densitometers have problems achieving accurate measurements, so a dotmeter should be used instead. A dotmeter, sometimes called a digital microscope, works like a high resolution digital camera to calculate the density values based on the screen pattern imaged on the plate. FAG, Gretag Macbeth, Techkon, Troika Systems and X-Rite all manufacture dotmeters.

Normal densitometers don't work very well measuring dots on a CTP plate. The new Spectro Plate, a spotmeter from Techkon, is more suitable for the job.

Once all output devices in the workflow are calibrated, ICC profiles must be built. It is possible to use a colorimeter for this but a spectrophotometer is preferable. A spectrophotometer measures the whole visible spectrum and can be used in a wide array of applications. With the appropriate software, a spectrophotometer can also serve as a densitometer, so if you invest in a good spectrophotometer you may not need an additional colorimeter or densitometer. There are many spectrophotometers to choose from, ranging from handheld devices to more or less automated versions. Of course the faster and more automated the device, the higher the price, but for creating and editing ICC profiles on a regular basis, the investment is worth it. Avantés, Gretag Macbeth, Techkon and X-Rite are the most well known manufacturers of these tools.

Traditional colorimetric control comes in two flavours: solid colour control using a control strip for process and special colours; grey patch control to measure halftone grey patches, and individual solid colours and halftone patches of chromatic CMY colours.

Colour Management Software

It's all well and good having a measuring instrument, but it's of little use without good software to operate it. Most vendors of computer-to-plate systems offer colour management solutions of their own, so if you already have, or plan to invest in, a platesetting system, you should check out the price and options in the colour management system suggested by the vendor.

Agfa provides a colour management system called Colortune for creating ICC profiles for monitors, digital cameras, scanners and output devices. Colortune can be coupled with Agfa's Quality Management Software (QMS) to facilitate calibration and linearisation of devices throughout the organisation.

Esko-Graphics offers two different colour management solutions. Mosaic has its origins in technology developed by Barco Graphics, which is now part of Esko-Graphics. The company has also developed a colour management system based on Global Graphics' Harlequin technology, with extensions to the Harlequin Postscript interpreter.

Fujifilm Colourkit can create and edit ICC profiles and provides functions to apply electronic sharpening of images at a late stage in the workflow. This type of function is not generally included in standard ICC workflows. Colourkit can be integrated in asset management solutions in order to help automate scanning and image processing.

The new software suite Prinect Profile Toolbox from Heidelberg combines the Printopen 5.1 and Quality Monitor 1.1 tools. Printopen generates ICC output profiles for colour printers, colour copiers, proofers and printing presses. Quality Monitor assures the process and quality control.

Kodak (Creo)'s Profile Wizard is used to edit and create ICC profiles for monitors, digital cameras, scanners and output devices. Profile Wizard supports the use of more colours than just CMYK, and has functions to preserve the black channel information.

Screen has a colour management solution called Labfit, which helps automate image and colour processing. Recently Screen added a JDF compliant colour control system to Labfit, enhancing the software for such things as remote proofing functions.

Software for editing and creating ICC profiles is well established. Distributed production increases the need for reliable colour management, but it all begins with accurate data management on a small scale.

Most of the solutions mentioned above are standalone software that can be bought even by those who don't use the vendor's RIP system. Others cannot be bought unless you buy some other equipment from the vendor.

In addition to colour management tools that function within a larger system, there is a huge range of vendor independent solutions. One of the most popular software packages amongst colour management consultants is Profilemaker from Gretag Macbeth. One of the features in Profilemaker 5 is an option to save the measuring data either as CIEL*a*b* or spectral data. The latter provides more flexibility for rebuilding ICC device profiles without needing to measure the test form again.

The list of standalone colour management solutions is virtually endless, but some of the most widely used tools are Binuscan's Colorcase, Color Solutions' Color Blind, and Monaco Systems Monaco Profiler.

Software for editing and creating ICC profiles is well established. Distributed production increases the need for reliable colour management, but it all begins with accurate data management on a small scale. As we have seen, the options for this are numerous and the technology stable.

Managing Colour in the Workflow

It's tempting to think digital colour workflow management is something new, but it's existed since the early days of digital prepress. The difference today, is that colour management is out in the open. Instead of happening within a tightly controlled, closed environment accessible only to a chosen few, now everyone can produce colour print files. Off-the-shelf technologies such as Photoshop, standard PCs and Macs and operating systems that cooperate, have democratised colour creation and output. However the problem of accurate colour production is still a long way from being solved, because although some tools, such as Photoshop, create excellent colour files, many of them, such as Powerpoint, do not. Because all files, regardless of their colour data accuracy, find their way into a colour workflow for print output, colour workflows must still be managed. With each new generation of operating systems and software applications, colour management gets more necessary.

Like it or not, graphics professionals have to cope with work produced in all sorts of ways, which is why colour management is still a problem. The broader the colour production base and the range of output types, the more complicated colour management gets. Everyone has their favourite horror stories, but working with colour data doesn't have to be painful or expensive. Efficient colour management cuts production and customer service costs and improves throughput at all stages in the workflow. For example, approving proofs with only a couple of correction cycles saves money and time. Remote softproofing extracts even more costs, which is why more companies are proofing on screen, managing their colour workflows to ensure screen accuracy. Colour managed workflows also save time and money on press, helping to improve press utilisation. This is probably the best reason of all to implement it.

Developing clever colour management strategies is of course not easy, but it is possible. Part of the problem with colour is that there are many people working with it in many different contexts. There is a sort of cultural confusion and somewhere between the graphic arts professional's view of colour management and that of the avalanche of new users working with Photoshop et al, there is a reality gap. Colour management is about bridging the reality gap between specialised print production and ubiquitous digital origination.

Choosing the Building Blocks

The best place to start when building a colour managed workflow is to consider how colour management could enhance the creative and production performance of the business, and of course that of its clients. Prepress production can support almost anything designers want to do, but implementing colour management exclusively within the prepress department isn't necessarily the best approach. Colour management is about accurate, device independent output, at all points in the supply chain. The workflow therefore has to support and manage all links in that supply chain and all tasks associated with it. The workflow should be designed to support new customer and production requirements, as well as new output types. Above all it should use proven technologies and operate with standard tools such as the IT8, ECI 2002 or Ksmart colour targets. Digital image creation is based on RGB, which is becoming the colour space of choice for professional digital image editing and processing. RGB offers output flexibility not possible with CMYK, traditionally the preferred colour model for print production. RGB files are not constrained to specific outputs, whereas CMYK files are generally specific to a given output path.

Colour Management Investment Intentions

Print and prepress firms planning to invest in colour management 12%

Design firms planning to invest in web based colour management 7%

Graphic arts companies increasing their use of online proofing 43%

Design and production firms where colour proofing is a challenge 41%

Printing and prepress firms using film based proofing 25%

Source: Trendwatch Graphic Arts

Accurate and consistent colour output is the goal of every colour managed workflow, so an efficient colour workflow requires careful analysis of the entire production chain. Dataflow analysis encompasses every possible colour data source and every possible output, from digital cameras and scanners through to monitors, hard copy proofers and presses. A thorough workflow audit quantifies all prepress and associated equipment, including input and output devices, computers, software and measuring tools. It determines the production path for all materials produced, establishing where and how production errors occur. Anything that's to do with colour provides the starting point for workflow revision and a list of questions to raise with consultants and colour technology suppliers, and of course with customers and pressroom staff.

ICC Compatibility

All tools relevant for colour production should be ICC compatible. ICC specifications are designed to manage colour in an open environment, supporting digital colour workflows with a common colour data processing model. An ICC profile specification defines the spectral and behavioural characteristics for each device in the workflow. Profiles are relevant for everything from a digital camera to the cardboard used in packaging printing. Together with the ICC's Profile Connection Space which is based on CIEL*a*b*, they can be used to calculate the right colour values for a colour file taking into account those factors influencing its appearance.

Harnessing the Components

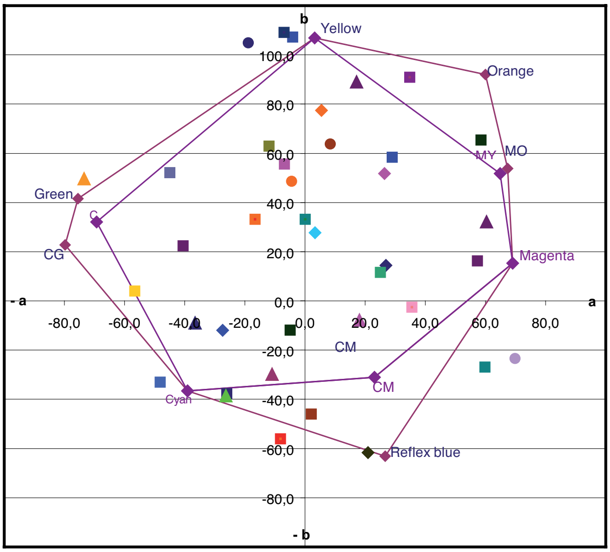
In a complex colour data supply chain there can be many variables to control. Colour is horribly subjective, so it is even more vital to identify and manage variables. Even the origination software used can introduce anonymous factors into the workflow, and so standard defaults should be set up for all operators and all software used. Even Word, if it is to be used in a colour managed workflow, needs to be kept under tight control, particularly since the latest version will be able to create PDF files! Use the same versions of Photoshop, Illustrator, Xpress and Indesign and use the same defaults on all workstations. Everyone involved in a colour managed workflow should understand the processes and what happens to files moving through production. This is basic and makes a serious difference to file processing.

The importance of hardware calibration, particularly monitors, cannot be understated. Manufacturers of high-end monitors for colour critical work such as La Cie, Eizo, NEC and Quato generally recommend specific calibration tools and provide appropriate software. There are also many other tools available such as Colour Blind's Prove It, a simple but effective method for calibrating monitors and building ICC profiles. Gretag Macbeth's Eye-One is also useful for profiling monitors and printers, and further up the scale is Pantone's Colorvision Suite for precision monitor and printer profiling. X-Rite's Monaco Optix XR even has a built in function for evaluating the status of the monitor.

Extending the Colour Gamut

Most every day print production uses standard CMYK ink sets, although the colour gamut achieved with CMY is limited. Over the years several methods have been developed to increase print's colour gamut. While they may differ in details, they all have one thing in common: they assume more ink sets are to be used than just CMYK. In contrast, RGB's colour gamut is much wider than that of CMYK. When printing with only CMYK inks it is impossible to reach the full colour vividness of RGB's primary colours, which are red, green

Colour gamut for Approval XP and selected PMS-colours (in CIELab)



When extending the colour gamut using multicolour printing, it's a challenge to proof correctly. Above is the achieved colour gamut for Kodak Approval, compared to a selection of target Pantone colours. Most Pantone colours can be proofed, but not all.

and blue. To achieve a larger colour gamut we need to add red, green and blue to the ink sets, and to use seven colours when printing. Of course printing with seven colours isn't always possible in all types of presses, so there are various technologies available to extend colour gamuts on press.

Pantone Hexachrome

One of the best known solutions for extending the colour gamut is the Pantone Hexachrome system. As the name implies it assumes six ink sets, CMYK plus an additional green and orange. The formula for the CMY inks is slightly different than that used in normal SWOP or Euroscale printing, so all the printing inks must be Pantone inks. Hexachrome can be used to reproduce about 90% of Pantone colours, with a single ink setup. This is of particular interest for packaging applications, where traditionally up to 10–12 different spot colours might be used in a package design.

FM6 from Printech

FM6 was developed by MY Printech, which has its origins in MY Cartons Printing. FM6 is a colour converter that can improve press efficiency and extend colour gamut, although this is not the software's primary purpose. Benefits include faster printer wash up, as short as 30 minutes, through using a fixed ink sequence for composite printing on press, and the possibility of printing 1000 spot colours in a single pass. The savings in ink, the number of plates required and time are substantial.

The software has four components: an FM screen, standard CMYK colours plus two of three possible specials, and a colour conversion engine. The technology only works on linework leaving alone image areas, and converts data into the special FM6 colours.

With FM6 there is apparently no need for any change to the workflow and no major prepress changes. The technology uses seven inks to print any spot colour to within a Delta E of less than two, and there are two fixed combinations, CMYK plus two of the three FM6 orange, blue or green colours. An FM6 curve, proprietary to a printer's particular output, specifies ink values and is applied at the final output stage. Printech has worked with Dupont to develop various FM6 colour profiles for colour proofing. Good results are still utterly dependent on accurate colour control in prepress, and on the absolute stability of the press. One of FM6's main benefits is the possible ink savings that can be achieved, but MY Cartons has found that instead they use the technology to lay down more ink for really bright, saturated colours.

> In a complex colour data supply chain there can be many variables to control. Colour is horribly subjective, so it is even more vital to identify and manage variables. Even the origination software used can introduce anonymous factors into the workflow.

Spotless and CMYK Plus from Kodak/Creo

Kodak (Creo) has developed Spotless printing with CMYK plus one or two extra colours. Spotless takes advantage of Staccato screening and Squarespot imaging technology's inherent stability to expand colour gamuts. There are two versions, Spotless 4, which is CMYK, and Spotless X for CMYK plus one or two extra colours. This system is based on characterisation of everything in the print process, including paper, and quality requirements for colour improvements such as a wider gamut and brighter images. The technology integrates with ICC proofers, is ink set independent and can convert most of the Pantone library to a printer's conditions. Spotless has been trialled with a number of packaging printers and is gaining acceptance from large consumer companies. Most of these tests have been done with offset presses, but Kodak has also tested Spotless with flexo presses.

Alterna from Agfa

Agfa's Alterna is a multiple colour printing tool for reducing or even completely avoiding the need for spot colours. Alterna also lets the user define their own colour standard working with ICC profiles and PDF based workflows. Alterna includes a colour conversion engine to convert spot colours to the user's defined colour standard. This will allow the user to combine multiple spot colours on a single plate to avoid the need for multiple press runs, saving press time and reducing ink costs. Agfa's objective with Alterna is to expand the colour gamut on press, to improve press efficiency and to significantly reduce printing costs. Although it is positioned initially for packaging, it is likely that Agfa will make this technology available for other applications as well.

Colour Management Developments

While all devices in the workflow have to be calibrated and characterised, the trend at the moment is to define and comply to a reduced number of industry standards and paper options when streamlining the colour managed workflow.

Since the designer seldom knows exactly which press or paper stock will finally be used, it is often practical to assume a standardised printing condition. While it's still possible to work with custom tailored ICC-profiles for a certain press and printing on a specific paper stock, in most cases an accepted industry standard profile for limited types of paper stocks will give an accurate end result. A standardised printing condition is just one part – the final and most important – of a fully colour managed image and page workflow. Fine tuning of ICC profiles normally happens in the prepress department, but the more advanced press control systems are starting to take over this role, making last minute compliance to a given print standard, such as ISO 12647/2-2004, SWOP, GRACol happen on press instead.

Small is Beautiful

Besides these large companies there has been considerable activity elsewhere in the market. Alwan is a small developer working on colour management tools for ICC workflows. Alwan CMYK Optimizer is essentially a preflighting tool for colour that checks incoming files to help reduce the amount of ink used, without compromising print quality. CMYK Optimizer analyses the CMYK values of incoming images, correcting them for optimum output according to the demands of the destination output process. The software sorts out ICC profile mismatches and also dynamically corrects image dependent Total Area Coverage mismatches. This avoids excess ink on the paper, which can create ink set-off and overprinting problems. Dot gain mismatch between that of the incoming separations and the actual substrate is also corrected and black generation is optimised for ink savings and higher print quality.

One of the greatest difficulties facing colour production professionals is managing colour conversions. The ideal graphic arts colour managed workflow should ensure the preservation of some specifics of input CMYK channels, and accurately convert all colour data for the target output, including contone and screened colours. Black channel control is a particularly thorny problem, but advances here are also underway.

Alwan's CMYK Optimizer and similar tools are all about providing channel control for colour conversions. Prepress and printing companies can therefore produce ICC or standards compliant colour separations using technologies that improve the standardisation and optimisation of CMYK data interchanges. Such software provides controls so that separations are optimised according to a standard or actual production process. They work with either a single standard reference ICC profile, such as SWOP or Euroscale, or with the destination press ICC profile and print specifications.

Work in Progress

Colour data management and harmonisation should ideally be the goal of any workflow management system. Digital origination increases pressure on colour management systems to control RGB data flows and although colorimetric ICC paths are good for proofing, they lose control of the K channel, which causes problems on output. Major RIP developers have taken a revised look at colour management, to improve support for RGB workflows, especially for CMYK applications.

Probably the most important issue facing any company getting into colour management, is training. Educating all contributors to the media supply chain is vital for colour management to become inherent to the production habit. Colour is never going to be easy or interesting for the vast majority of print buyers, however, with a little bit of education, there are plenty of problems that can be resolved before they occur. Who knows, maybe customers would even be prepared to accept the cost of their errors, if they understood why they happened in the first place!

Already many printers have seen substantial financial and competitive returns through managing colour efficiently. However success isn't an immediate result and needs careful planning, testing and re-testing. Like the Japanese Kaizan concept, colour managed workflows are about constant, reiterative, never ending production improvement.

Ten Steps to a Colour Managed Workflow

1. Find out which printing standards are used and whether they are company specific – find out if they comply or differ from industry standards.

2. Calibrate and characterise all equipment involved in colour production. If you don't have the equipment or training necessary for this, go to step 3 and 4. Otherwise jump to step 5!

3. Investigate the types of equipment and software you need, in order to calibrate and characterise the main components of your workflow. For monitors and scanners, a colorimeter might be enough. For prepress equipment and printing plate scanners you will most likely need a densitometer, a spectrophotometer and a dotmeter. The press operator needs at least a densitometer, but in modern colour management environments a spectrophotometer is needed as well. Some spectrophotometers capture densitometric data as well.

4. Learn how to calibrate your equipment, including monitors, scanners (including digital cameras) and colour proofers. In the prepress department you must calibrate and linearise the imagesetter or platesetter, and define and control the working conditions for the processor, unless you use processless plates of course. The press should be regularly serviced and run according to target ink settings described in the agreed standard (in-house or industry standard, see step 1!)

5. Define the tolerance margins for each print workflow. For this you need a spectrophotometer and must calculate a series of target values (expressed in CIELa*b*) and compare them with print samples. The colour difference is described as a value of Delta E, and a common goal in sheetfed offset on quality paper is to try and not exceed a Delta E of 4 as an average during the print run.

6. Audit the whole print process regularly to identify where and why problems might occur. Some equipment may be faulty and need servicing or replacement. Some software may be outdated or of inferior power and need either updating or replacement.

7. Implement changes necessary and update/finetune ICC profiles when needed.

8. Make sure that all the people involved in the printing process, especially those who make decisions on colour, have a good understanding of colour management. If in doubt, set up a plan for how this can be improved. Seminars, courses, books, putting additional information on your web site, anything you can think of to address this issue!

9. Make colour management central to regular work on quality control. This should be an integral part of your company's business, and be more than a single individual's responsibility. Ideally several people in the company should be able to update and finetune ICC profiles used in daily production.

10. Repeat steps 6 and 7 regularly because colour management and quality assurance are never entirely solved. Quality control is a constant, reiterative process.

Colour Proofing Basics

Direct to plate workflows imaging digital plates is reality for well over 30% of the worldwide printing industry and growing rapidly. There has also been a huge rise in the use of digital presses, and although it is hard to quantify workflows, it is certain that direct digital workflows have changed proofing expectations and habits. Traditional analogue proofing, based on reprographic films, is declining and digital proofing based on hard copy and monitor proofing is rising steadily.

The very nature of what constitutes a proof makes it pretty impossible to come up with a definitive list of proofing systems. Proofing's role in the workflow varies with the proof's function and there are lots of systems available more or less suitable to the various functions. Different proofing solutions can be split into several categories, however different front ends and raster image processing systems can drive the same colour printer, producing output at various quality levels. This is one reason why proofing technologies can often seem a little overwhelming. What at first appears to be the same print engine, may provide varying functionality and quality depending on the technology controlling it.

Contract Proofing

The perfect contract proof should ideally be a test print run on the actual printing press using the paper stock to be used for the final print. This type of wet proof is often far too expensive, unless the print run is very long or complex. However, many people still argue that it is the only real way to proof. On a modern press with automatic plate loading and presetting of the ink ducts, for example in a DI-press or on a digital press, sample sheets can be produced in around 15 minutes, so the cost is not as high for wet proofs as it used to be. Compared with the time and associated repro cost for high quality contract proofs of all the signatures, it may balance out. It all

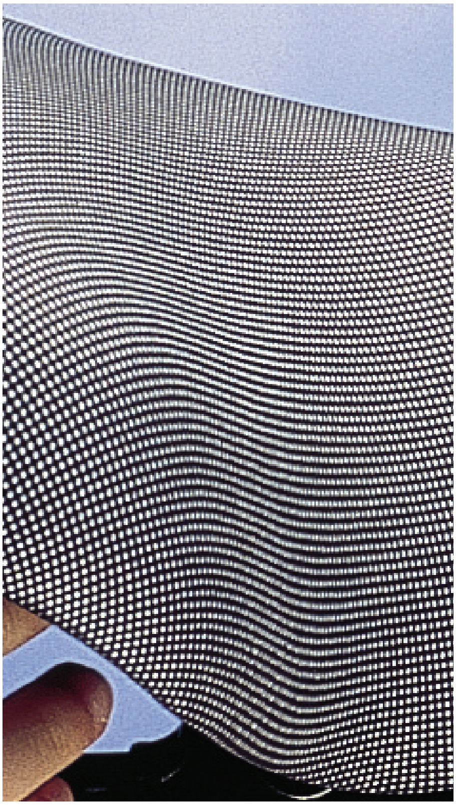


Image related moiré

depends on the job, its content and run length, so for very long runs the economics can easily shift in favour of wet proofing on press. For most output, shorter runs and increased colour usage are undermining the economics of wet proofing and for many applications a digital proof is a better option.

Digital Options

There are digital proofing systems available to suit a range of requirements. They can produce screen accurate dot for dot proofs, colour accurate proofs or both, according to the application demands. There are three categories of digital proofing technologies available on the market: screen accurate dot proofs, colour accurate proofs and soft proofs viewed on the monitor.

The very nature of what constitutes a proof makes it pretty impossible to come up with a definitive list of proofing systems. Proofing's role in the workflow varies with the proof's function and there are lots of systems available more or less suitable to the various functions.

Screen accurate proofs should of course also be colour accurate, but in order to be able to use an identical screen in the proof as the one to be used in the final print, the proofer has to use the same output resolution as is used in the platesetter. The proofer should use the same type of inks, or at least inks with the same characteristics as will be used on press. This may seem obvious, but in reality the characteristics of the inks used, say, in rotogravure are quite different from those of inks used in an inkjet printer. It is still worth the effort to produce screened dots and colour accurate digital proofs, because they can reveal moiré that could show up on press.

Moiré is the bane of printers. This visually disturbing pattern is primarily caused by incorrect screen angle settings. Moiré can also appear if the printed image contains repetitive patterns, for example in woven and checked fabrics such as tweed or taffeta, where the image pattern conflicts with the printing screen. Moiré appears more often in conventional AM screened images, while FM/stochastic and hybrid screens can help mitigate the risk. These technologies use random dot patterns rather than conventional screen angles and so reduce the risk of moiré.

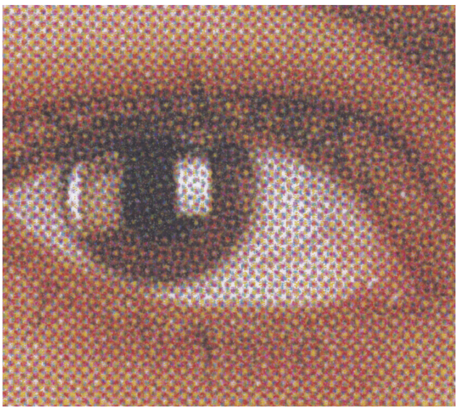
Trying to use the same dot structure on an inkjet printer as that which will be used in print may be desirable, but it is not easy. Normally an inkjet printer places dots in a manner similar to that of FM screening, so forcing it to use a conventional AM screen instead takes clever algorithms and programming. This is the approach taken with solutions developed by companies such as Agfa (Dot4Dot), Compose (Starproof), EFI Best (Screenproof), and GMG (Dotproof).

Another approach is to build a dedicated proofing engine, using special inks to simulate the characteristics of the printing inks. Often those inks are transferred to the paper using special transfer media, so one can proof on the actual paper stock.

This type of proofer is offered by Dupont (Digital Chromalin), Fujifilm (Finalproof) and Kodak (Digital Matchprint, Approval and

Spectrum). These systems offer screen accurate dot proofs as well as colour accurate proofs, but as they are built specifically for proofing they tend to fall into a higher price bracket than systems based on generic colour printers.

If the workflow and proofing don't require screen accurate proofs, there is a wide variety of systems available. This category is by far the largest, as it comprises systems based on general colour inkjet printers and laser printers.

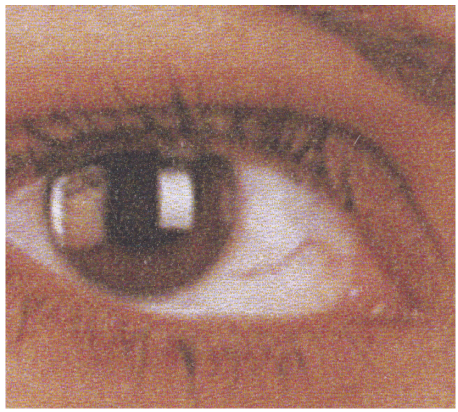


Conventional screening – offset print

In this group almost any quality colour printer can be considered for proofing tasks, but the system must have a suitable RIP system driving the printer. Some of these systems can render dot structures in the proof and most RIP systems from platesetter vendors offer proofing and colour management modules. There are also many standalone solutions on the market.

Vendors of colour printers include Agfa, Canon, Encad, Epson, HP, Kodak, Mutoh, Roland, Mimaki and Xerox, and some of these offer front-end systems suitable for proofing. There are several standalone solutions on the market, including technologies from developers such as CGS (Oris Colortuner), Colorgate (Proofgate), EFI (Colorproof and Splash), Perfectproof (Proofmaster) and Xitron (proofing plugins).

For most users, an inkjet printer generally isn't used to produce screen accurate proofs, since these printers use a screen that is more like an FM screen. Since the ink characteristics are often quite different from those used in printing presses, the colour management system will need to mix the colours that look



Inkjet screening

a little strange, if one looks up close. For example, when viewed under a loupe, a pure yellow area in the final print may appear in the proof to have some elements of cyan or magenta. This is because the proofing engine has to somehow simulate the paper whiteness in the proofs, as well as compensate for differences in ink characteristics.

It's not always possible to use actual printing stock when using inkjet printers or colour laser printers, although some devices sold for newsprint proofing have this capability. This means that in most cases the proofing system has to be able to simulate both the whiteness of the paper as well as its texture, including gloss, semi gloss and so on. It's about accurate colour appearance: the proof's colour rendering has to look like the final print, even if the dot shape of the screen and the screen pattern may be different.

Remote Proofing

Many proofing systems can be extended to support remote proofing. For this they need dedicated tools to ensure the locally produced proofs match proofs produced remotely and of course those tools vary with the system's complexity. Some users consider the editorial site to be the hub while other contributors produce remote proofs for the production supply chain. This could be the printer, other content providers and advertisers, all of whom could be located across the world.

Proofs are typically measured with a spectrophotometer, with results compared for each location. It's important that the data exchanged contains enough information to set up and control both the proofer and the measuring device accurately. Several of the vendors mentioned above offer this kind of solution, and some use the JDF data format to encode colour information.

How to Verify a Proof?

The most obvious and probably the most common way to evaluate a proof print is to compare it visually with the final print. However to verify a proof before the irretrievable stage when plates are already on press and the print run is almost completed, you need a defined reference and to have accurate colour values measured with a spectrophotometer.

One such widely recommended reference for graphics production is the FOGRA Media Wedge, used in several proofing systems. A useful test form for evaluating a proofing system is the Altona Test Suite, and the FOGRA Media Wedge is a key part of this test form.

The Altona Test Suite

ECI (European Color Initiative) has worked closely with FOGRA and the German Print Federation (bvdm) to design a series of test forms. Among other things these forms help to check a proofing system's colour accuracy. The Altona test suite comprises three PDF/X-3 documents. The first page, Visual, has a lot of different images to help evaluate different aspects of imaging quality. The second page, Measure, contains lots of colour patches for extensive colour measurements, and the third page, Technical, is dedicated to checking how a RIP handles a range of tricky Postscript and PDF interpretation situations. These are quite sophisticated, with checks for correct handling of transparency and overprinting.

Measured values on the proof are compared to values for colour patches on the FOGRA Media Wedge, so there must be some decision about the acceptable degree of deviation. FOGRA suggests maximum average deviation of Delta E 4 for all 46 patches. To achieve this, the proofer must be properly calibrated, and the RIP set up correctly.

Softproofing

Finally, the ideal proofing method, remote or local, may be a soft proof. As with any proofing device this requires accurate calibration and characterisation, if it is to work properly. If some printers and publishers hesitate to opt for screen accurate dot proofing, they are generally even more anxious about using a monitor for high end proofing. With the wide range of softproofing solutions now available, this anxiety is misplaced. A correctly calibrated monitor, be it conventional or a flat screen LCD, can actually proof most colours satisfactorily. All digital retouching is done on screen, even the colour matching, so accurate evaluation and page proofing on screen are entirely possible. They depend of course on a proper setup and no ambient light pollution, but the advantages of soft proofing are self-evident: fast turnaround independent of location, easy collaboration, convenient output management and no costly materials involved.

Softproofing systems are often capable of preflight checking incoming files, colour management and include collaborative proofing tools. Some, but not all, support JDF for job tracking and automation support using electronic job tickets. Following is a brief description of the systems on the market.

Agfa Delano

Agfa originally developed its Delano project management software working with international printers, Quebecor. Delano is designed for connection to a RIP system, either Agfa's Apogee X or another PDF based RIP. Delano uses a standard web browser, so colour accuracy for the pages isn't automatically assured, however it has an option for viewing high resolution PDF files with embedded ICC profiles. When viewed in Acrobat the user can thus check files for colour accuracy.

Colorbus Cyclone Visual Proofer

The Cyclone Visual Proofer is based on the Cyclone RIP with added pixel streaming technologies from Cyan Soft. Visual Proofer supports preflight and colour management, plus collaborative Internet based proofing. All annotations on proofs are viewed via the database and web browser. Java based client users access proofs via log-on onto a publisher's or printer's Internet server. One of Visual Proofer's strongest features is the possibility to merge 1 bit screened and separated TIFF output files into a composite colour managed softproof.

Cyan Soft Eproof

Cyan Soft has a Postscript interpreter called Advanced Sampler, which is used in the Opium OPI software, which works in the background of eProof. Eproof can open several types of native documents, such as MS Word and Indesign documents, so that teams of people can work to proof collaboratively on pages, images or the actual copy. Another strong feature is Eproof's font support for previewing and proofing Cyrillic, Arabic and all Asian language sets. It can display colours accurately as long as the user makes sure the monitor profile is updated in the system and proofing parameters are correctly set up. This has to be done manually so there is some room for improvement.

> Softproofing systems are often capable of preflight checking incoming files, colour management, and include collaborative proofing tools.

Dalim Dialogue

This proofing system works either standalone or with a RIP system, either Dalim's RIPs or any other modern RIP. Dialogue uses the same Postscript interpreter as Dalim's Twist workflow management system, so it can preflight and RIP incoming documents.

If the ICC profiles involved are specified, Dialogue renders colour accurate documents and recently was SWOP certified. Dalim is a strong supporter of JDF, particularly for imposition, so Dialogue can also provide dynamic imposition proofs. Once approved, flats are immediately ready for platemaking.

Heidelberg Remote Access

Heidelberg workflow systems are all part of the Prinect family. In Heidelberg's Printready RIP system, when it is linked to Heidelberg's Prinance MIS users are automatically notified via email when preflighted proofs are ready. Heidelberg recently launched Remote Access, an add-on module to Printready, for remote proofing support.

The user interface is via a standard browser and Adobe Acrobat. With Remote Access, instead of sending PDF proof documents as email attachments, files reside on a server. Through a license agreement with Kodak, high resolution files are displayed fast on screen via streaming technology. Pages are rendered first into pixel data through the Metadimension RIP, using the PDF files created by Printready. Heidelberg calls this post-RIP approval and the user interface allows for further annotations, correction instructions and finally approval.

ICS Remote Director

Although still best known in the US, ICS is planning to distribute its system in Europe as well. Remote Director accepts any ICC profiles as the basis for colour accurate rendering on screen. It has a built in monitor profiling tool that works with any CRT or LCD monitor. If any member of the proofing team tries to work with an uncalibrated monitor, they get a red dot beside their name in the team list, as a warning everyone can see.

ICS Remote Director is SWOP certified when used with selected monitors and includes a Jaws Postscript interpreter for basic preflight checking. The user interface has various annotation tools, including a freehand writing tool for those using a pen tablet instead of an ordinary mouse. All colour settings are shared, based on what the administrator sets up for individual jobs, so this application is easy to use, even for people without in-depth knowledge of colour management.

Kodak Synapse Insite

Kodak's (formerly Creo's) collaborative proofing solution can be integrated into any RIP system. However Insite is generally paired with a Prinergy workflow system or, less commonly, Brisque.

All incoming jobs are preflight checked, so if the customer has already done an early preflight through Synapse Prepare, this second check quickly verifies that the correct preflight profile was used. Synapse Insite uses a standard web browser interface, so here too, perfect colour accuracy on screen isn't guaranteed. Displayed pages are processed in the same RIP as is used for platemaking, but for more accurate softproofing the high resolution PDF files are opened in Acrobat. This function, called Insite Color, is now SWOP certified. With streaming technology users can zoom into pages and add annotations and comments. A built-in densitometer shows CMYK values.

Kodak Matchprint Virtual Proofing

Using Realtime Proof technology from former Realtime Image, plus some special plug-ins, Kodak has added a calibration module to its Matchprint Virtual Proofing system. Monitor calibration is done with Kodak software, which only works with the latest Apple Cinema Displays and the Eizo CG monitor series. In this configuration the Matchprint Virtual Proofing is SWOP certified and if the monitor calibration is wrong or out of date, this is indicated in the lower corner of the user interface. Users can annotate pages or images, and zoom in to have a closer look at the high resolution images, even at low bandwidth. There is no preflight check for incoming files and they are uploaded as is.

Rampage Remote

Rampage Remote is a Java based addition to the Rampage RIP for remote and collaborative proofing via the Internet. Rampage Remote has annotation and approval tools and logs all user activity on the server. The Rampage Remote system has built in streaming technology similar to that of Kodak. Incoming files are prelighted and prepared for impositioning, and clients are notified by email that there are proofs ready for approval. Rampage Remote doesn't check whether the monitor is calibrated or not, but shows colour accurate pages wherever possible. In many parts of Europe, including the UK, Fujifilm distributes the Rampage technology as an alternative to Fujifilm's Celebrant RIP.

Screen Riteapprove

Screen's RIP system is called Trueflow and Riteapprove is an add-on module for it. The user interface is based on a standard web browser coupled with Java plugins. Incoming files are preflighted, colour managed and saved in Trueflow's internal format, which is similar to a Postscript Display List. Clients are notified via email that there are proofs to approve and all proofing team members can view annotations and print out low resolution versions of pages, including annotations. Although pages are colour managed, the browser plug-in doesn't support colour accurate display at the moment. Screen has its own pixel streaming technology for fast zooming on pages.

Web Proof

This Danish software vendor has pioneered online proofing and Web Proof is now in version 4.5. The user interface is well established and thought through and Web Proof focuses on collaborative PDF proofing. Functions for colour managed softproofing have to be accessed via Adobe Acrobat and there is no preflight as such in Web Proof. Incoming documents can be preflighted through third party solutions and the company offers off-the-shelf preflight packages within its workflow solutions products. The administrator sets up different levels of user rights, depending on peoples' roles. Some can only read annotations, while others can write and edit annotations. It's possible to set up rights for a sub contractor, for example the binder, so that they can see the status of the job and are notified when proofs or prints are approved.

Hard Copy Proofers

It is impossible to provide a definitive list of hard copy proofing systems on the market, however the list below should provide a reasonable start. The scope of proofing applications and the technologies sold for proofing is too large for a complete list to be useful. Instead we put together a selection of technologies we believe to be at the forefront for hard copy proofing, and invited leading developers to get involved in our testing work.

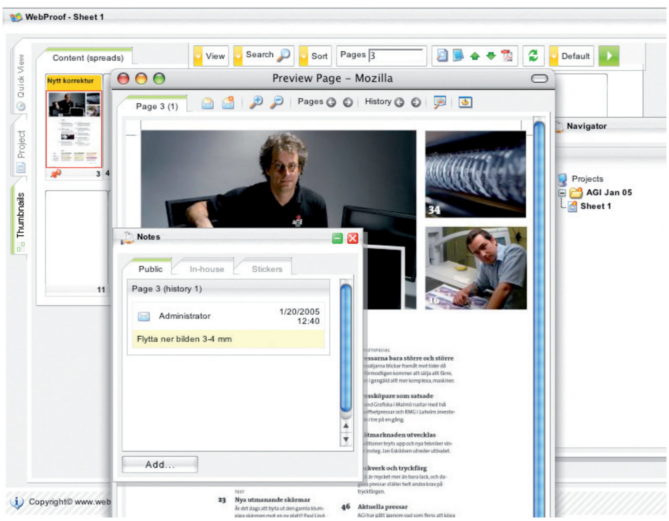
Digital Dots has tested several proofing systems using the Altona Test Suite, in particular the two first test documents, called “Visual” and “Measure”. ECI/FOGRA also provide reference prints to make it possible to compare the proofs according to the ISO 12647-2 standard.

We have tested the CGS Oris Color Tuner driving a Canon BJ W2200 colour printer, as well as the Dupont Digital Chromalin B3 proofer, connected to the Cromanet RIP server. Fujifilm used an Epson Stylus Pro 7600 with the Colormanager controller, based on technology from GMG, and can combine the same configuration within a Celebrant RIP. GMG participated independently with the Colorproof driving an Epson Stylus Pro 7600. Kodak (Creo) participated with the Veris proofer, coupled with a Prinergy RIP and Efi with the Colorproof XF, driving an Epson Stylus Pro 4000. Finally we tested the Perfectproof Proofmaster RIP driving an Epson Stylus Pro 4000 colour printer. As can be seen in the table below, the same type of colour printer may yield different results depending on the control system.

CGS Oris Color Tuner 5.1

CGS (Computer Graphic Systems) has a range of products related to colour management and colour editing, including several products in the Oris Digital Proofing Suite. Oris Color Tuner is a RIP server for various output devices.

The latest version, version 5.1, lets users create a reference master profile for all proof printers in the workflow. This makes it easier and faster to maintain the same output result on several proof printers. The printing devices need to be re-linearised now and then, but this is much faster than generating new ICC profiles.



The Web Proof user interface

The new version of Color Tuner features enhanced performance and speed, in part because it can build and save colour tables for commonly used colour transformations. This makes conversion from, say, the colour space of web offset to rotogravure, fast and accurate.

The Oris Color Tuner RIP server runs under Windows, and supports both Mac and PC clients. CGS also has a simplified version of its software called Color Tuner Personal Edition running under Mac OS X. We haven’t tested it yet, but it uses the same colour engine as the

Windows version of Color Tuner, so it should be possible to achieve the same results.

One often overlooked factor in proof output accuracy is the paper. Many paper types contain optical brighteners, which may not be present in the paper stock used on press. To overcome this problem CGS has a range of proofing papers manufactured for its customers, and has launched a proofing paper without brighteners. CGS hopes this will help customers achieve even more accurate proofs, without the need to simulate paper whiteness.

Dupont Digital Chromalin B3 proofer

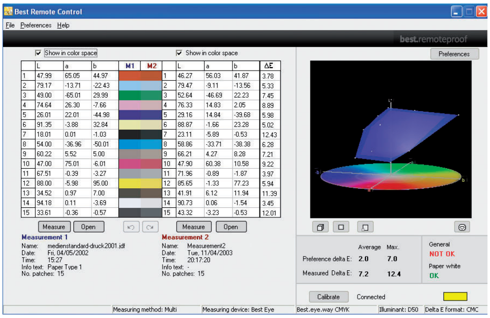
Dupont markets the Digital Chromalin B series proofers as "the first and only drop on demand inkjet proofer that can automatically keep itself calibrated". The colour printer is equipped with a built in spectrophotometer from Gretag Macbeth and the ink in the nozzles is kept at a constant temperature of 17ºC. This ensures ink viscosity remains constant, despite the fact that nozzles get hotter during use. Constant viscosity is, according to Dupont, a driver for consistency in accurate colour matching.

As a proof is printed, the calibration module verifies the printer is operating at a specific level of performance. Thus ink and media profiles used to create the proof remain accurate.

The Digital Chromalin B3 proofer package includes a Windows based proof server, the proof engine, the Chromanet RIP, and Dupont proofing inks and media. The Chromalin B3 proofing system uses eight dye-based inks for a wide colour gamut and correct grey balance ensuring accurate reproduction of CMYK as well as Pantone colours. The inks use an alcohol-based solvent to improve flow through the nozzles and to help penetrate the polymer coating of the paper.

Efi Colorproof XF

When Efi bought Best, one of the first things it did was to improve the Best Color user interface to be more user friendly and intuitive. Efi also replaced Artifex's Postscript interpreter with Adobe's CPSI RIP.



In Efi Colorproof XF it's possible to verify the proof by measuring a control strip with a spectrophotometer. This is a quick way to check it is within tolerances.

Efi's Colorproof XF RIP server only runs on a Windows machine, but the Job Monitor client software runs on both Mac and PC. Pre-configured hot folders make it easy to automate accurate colour output. If users prefer not to the drag and drop files, pre-configured output queues on a Mac or a PC also work.

Colorproof XF is modular so customers can buy a basic version and upgrade when more functionality is required. All modules are on a CD and accessed once the user has purchased the digital keys to unlock them. Among the options is support for more output queues and printer types, extended spot colour handling, dot based proofing and calculation of CIP4/PPF data.

Colorproof XF includes the FOGRA media wedge on output, for verifying it. In our test, printed on an Epson Stylus Pro 4000, we used the Efi Gravure Proof proofing paper. It has a paper whiteness close to that of the offset paper we wanted to simulate.

Fujifilm Colormanager

Fujifilm Colormanager is typically coupled with the Celebrant RIP, and supports a range of colour printers. Beside files from Celebrant, it accepts a wide variety of RIPped, contone and screened raster file formats. With Colormanager Profile Editor, custom profiles can be created and edited to simulate various analogue proofing systems, and printed results.

Colormanager includes technology from GMG (see below), with a separate database for calibrating of special colours. New colours can be added by the user and fine-tuned if necessary, using spectrophotometric data. Dot gain and overprint characteristics can also be specified.

A Profile checksum number can be printed onto the proof and any alterations to the profile will change the checksum number. Users can use this number to check that the proof was made with the correct profile.

Fujifilm Colormanager includes GMG's 4D colour engine, which Fuji and GMG claim provides very accurate profiling because it works with CMYK values. The application is compatible with ICC profiles, and before outputting a proof, the preview function is used to check results visually on screen.

Fujifilm Colormanager has a Dotproof option, for proofing halftone images using 1 bit TIFF files. The proofs both reproduce the actual dot characteristics and allow accurate colour simulation of the final printed copy.

GMG Colorproof

The Colorproof RIP drives many output devices. It includes several elements: the RIP itself, the Profile Editor and the Spotcolor Editor. GMG's colour software is based on its 4-D colour transformation engine which, according to GMG, guarantees the best possible quality and colour accuracy when producing contract proofs on a variety of output devices. Using a spectrophotometer, the system can be calibrated against all standard colour charts. Device independent colour profiles are stored for specific printer

The perfect contract proof should ideally be a test print run on the actual printing press using the paper stock to be used for the final print. This type of wet proof is often far too expensive, unless the print run is very long or complex. However, many people still argue that it is the only real way to proof.

families and, together with the linearisation tool, this system is suitable for remote proofing applications.

GMG Colorproof is compatible with standard ICC profiles. The Profile Editor supports selective correction functions and, in concert with Spotcolor Editor and the official Pantone library, most spot colours can be reproduced.

GMG Colorproof includes a licence for the Fogra media wedge for verifying proofs, but a range of test charts can be used as well. The Dotproof option allows users to create halftone proofs by printing colour-accurate 1-bit TIFF data from the imagesetter or CTP RIP while retaining the original screened information. This allows for early detection of artefacts that are only visible with halftone proofs, such as moiré or trapping errors. The File Out module allows for CMYK colour space conversions, CMYK to CMYK, preserving black channel data. Data optimised for offset output can be converted automatically for gravure.

Kodak (Creo) Veris

The Veris proofer is typically connected to a Prinergy or Brisque RIP. This 4-up contone proofing system based on Kodak's Multi-drop Array inkjet imaging, produces a controlled stream of drops at 1500 x 1500 dpi, for high quality proofs. Each Multi-Drop Array nozzle produces one million, 3-picoliter ink droplets per second. An electromagnetic deflection field guides each charged droplet from the nozzle to the pixel location on the media.

Kodak has a certification process for proofs to ensure that colours, fine text, line work, vignettes, shadows and highlight details are reproduced true to the final output on press. Each time a proof is printed, the proofer checks that calibration is correct and confirms that the correct ICC colour profiles, inks and media were used. If these conditions are met, the Kodak Certified Process stamp is printed on the proof to indicate a quality assured proof.

The Veris proofer is SWOP certified, PANTONE qualified, SICOGIF (France) certified, FOGRA (Germany) certified, and PPA (UK) accredited.

Kodak Matchprint

Matchprint inkjet proofers are available for 2-up, 4-up and 8-up formats, so they are suitable for a range of proofing applications. Like Veris proofing systems, Matchprint features the Kodak Certified Process module. The Matchprint Proofpro RIP is based on Kodak's own colour technology with powerful colour management and production tools, for colour accuracy and spot colour control. This technology is ICC compliant and works with most file formats. Matchprint with output to the Epson Stylus Pro 4800, 7800 and 9800 printers was recently SWOP certified, but we have not yet had an opportunity to test it.

Perfectproof Proofmaster

Perfectproof's Proofmaster system has several versions. The most comprehensive, the bizarrely named Proofmaster Dalmatian, supports proofing of bitmap/screened data plus conventional digital proofing and softproofing. The Proofmaster RIP is available for both the Mac OS and Windows. Perfectproof has its own range of proofing papers.

The user interface is simple and straightforward and the linearisation and calibration techniques give, in our view, good renditions of smooth graduated tints especially. To ensure proofs output remotely are accurate, Perfectproof has a Certified Proof utility whereby the user measures the FOGRA media wedge on the proof with a spectrophotometer, and checks the result against predefined tolerances. This is increasingly common for developers of hard copy proofing systems.

We haven't tested all systems on the market and our tests were conducted over a period of time. The results summarised serve as an indication of what results a validation procedure might produce. Vendors of proofing systems continue to finetune their systems and expect to obtain better results in the next test round.

it visually in a viewing booth. By measuring and comparing data against a known reference, some of the proof approval uncertainty and subjectivity is reduced.

The more one looks into proofing technologies, the more complicated the task becomes. Production demands drive proofing performance expectations and so technologies. With so many options available it is easy to find the right proofing system.

Average Colour Deviation (Delta E)

Vendor/Model (RIP)	Colour Printer	Average colour deviation (Delta E)
CGS Oris Color Tuner	Canon BJ W2200	1.9
Dupont Cromanet Proof Server	Digital Chromalin B3	4.6
Efi Colorproof XF	Epson Stylus Pro 4000	2.5
Fujifilm Colormanager	Epson StylusPro 7600	5.9
GMG Colorproof	Epson StylusPro 7600	2.9
Kodak (Creo) Prinergy	Veris Proofer	5.0
Perfectproof Proofmaster	Epson Stylus Pro 4000	1.7

Visual Evaluation

When evaluating proofs, visual evaluation using a viewing booth should complement measured spectral values captured with a spectrophotometer. We have found that different makes of viewing booths may indicate a slightly different appearance of the proof (or print for that matter). Differences in age or make of the light bulbs, or different materials in the reflectors, may explain this phenomenon. As of today some tolerances need to be allowed both when measuring a proof using a spectrophotometer or evaluating

New Horizons for Colour Management

For the most part, the ICC's work and that of technology developers is pretty much done: the technological infrastructure is in place and process requirements understood. The graphics industry is however still a long way from solving colour. Quality expectations and graphics supply chains are far from static so perhaps we may never actually achieve total process control for all print applications. Experience and application of colour management principles throughout the workflow are the means through which we can ensure progress. Colour management in the press is the final piece in the puzzle and where most colour management innovations are happening. A number of press manufacturers include ICC compliant colour management tools in their press control systems.

Presses don't change at quite the same rate as the more flighty prepress technologies, such as databases and workflow management tools, but change they do. So much so, that press manufacturers are developing sophisticated colour management controls to function on press. Manufacturers such as KBA, Komori and Heidelberg are extending the usual model and taking colour management beyond prepress to the press.

Pressing Ahead with Software Controls

The latest generation of press control systems manage colour data well enough to match traditional prepress expectations. Several can, for example, generate ICC profiles based on the actual print run so there is no need to print special test forms, holding up production just to calculate correct ICC profiles. Printers can work with selected ICC profiles for commonly used paper stocks, and with clients so that they use the right profile during document preparation. Tailor made ICC profiles also gives printers the chance to do CMYK to CMYK conversions, adjusting for possible differences between presses.

ISO 12647-2:
International standard for offset printing process control

Increasingly printers use spectrophotometers for quality control, instead of relying solely on densitometers. A quality spectrophotometer can function as a densitometer, besides reading spectral values, vital, for example, for accurate spot colour measurements. Along with all the other press settings, colour values are also stored to help achieve optimal makereadies. The objective is to have best practice settings for a given type of paper and job, improve efficiency on subsequent repeats or similar jobs.

Talking 'Bout Our Generation

Ten years after printers started using CIP3 PPF (Print Production Format) data, current generation press control systems include colour management tools and allow two way data traffic throughout the workflow using JDF (Job Definition Format). Data interactions, including press, production and management subsystems, are constantly colour managed, which helps keep conventional press technology responsive and competitive.

Following are overviews of the leading press control systems, describing the state of the art for colour managing commercial sheet fed presses. They are based on interviews with the market's leading players and their customers.

Heidelberg Prinect CP2000 Centre

Prinect is the prefix for all systems linked within the Heidelberg software portfolio. Of the press manufacturers listed here, Heidelberg is unique in that it manufactures both prepress equipment and printing systems. Heidelberg integrate prepress and press technologies and its colour management tools calibrate and characterise monitors, digital cameras, scanners, proofers and of course printing presses. ICC profiles optimised for the actual printing conditions deliver the most reliable basis for perfect colour separations, either when created or passing through the workflow.

Prinect Colour Solutions is not unique, but it is a good example of how integrated colour management is implemented in the workflow between prepress and press.

Prinect Colour Solutions is a bidirectional closed loop system based on ICC standards, CIP3/4's Print Production Format (PPF) and JDF. It includes the Prinect Metadimension RIP (for raster processing, setting print parameters and output curves), Prinect Printready (for workflow management), Prinect Image Control (a spectrophotometer which can be connected to up to four presses), and software modules, working with the CP2000 press control system, via the Prinect Prepress Interface. Prinect Colour Solutions provides closed loop colour management from plates to proof to press, minimising press makeready times by defining production conditions during press presetting.

Heidelberg's Prinect Image Control uses a Gretag Macbeth spectrophotometer uniquely designed for Heidelberg, to capture colorimetric values from a printed sheet for comparison with stored reference target values. Differences are the basis for colour data processing and subsequent recommendations to the press control system for correcting ink duct settings. The control software takes into account specific ink properties as well as the characteristics of paper, ink and the target print standard. An internal database with Pantone and HKS colours provides reference data for spot colours, so they can be colour managed in the same way as process colours.

The Prinect Image Control technology measures colour bars plus the whole sheet's content. According to Heidelberg it is the only system to work with spectrophotometric measurement values of the entire print image in process. Image Control compares captured data to a target standard, evaluating ink quality, grey balance control, and so on.

Spot the Difference

Mini Spot technology checks colour values for random selectioned spots, small areas or colour bars, on sheet or proof. It works with other Prinect modules, checking target spots for dot gain and inking.

Prinect Profile Toolbox, for calculating ICC profiles, provides rigorous press control using Mini Spots measurement. With it, Heidelberg combines the idea of device specific profiles with adaptive process control that responds to how the press performs. This can yield considerable savings in time and effort, because all print profiles are being constantly updated.

A Quality Monitor module measures the behaviour of inks on press, to ensure the press functions to specified tolerances. Corrections can be made during the run and data fed back to production, so subsequent plate output is correctly calibrated and colour profiles adjusted for any deviation from the target Delta E on press. There are tools for resolving quality issues caused by the interaction of different inks, screen rulings and substrates, plus tools for checking linearisations and adjusting CTP output. A data repository is the basis for creating common printing characteristics for all output devices, for faster quality management and process control.

According to Trendwatch's 2005 report Graphic Arts Market Demographic Profiles for the US printing industry there are:

Less than 30,000 commercial printing service companies in the US.

Less than 5% of presses installed are digital engines.

Less than half the industry is made up of small commercial printers, contributing only 10% of all print shipments.

The heart of this technology, and of its competitors, is the ink control system sitting in the press control system. A database of values based on colours and print substrates, provides the raw material for calculating optimum inking for each job, according to how print variables interact. Operators can rely on the database or create new ink key presetting characterisations themselves for different materials and printing conditions. Within Prinect CP2000 these values can be adaptive, according to how the press behaves during the run. The software compares reference values with ink duct setting and works out new references, according to the percentage coverage on the sheet for a given ink duct, ink series and target print standard. Ink presetting optimisation curves can be saved and curves developed, based on adjustments for a given job. Assuming there are no changes to ink, paper and so on, this can simplify later reprints considerably. It's all about removing subjectivity on press to provide tight, automated process control.

CMC:
Colour Me Confused

KBA (Koenig & Bauer) Logotronic

Logotronic is the heart of KBA's press control system and is available in basic and professional versions. Basic includes all the functions needed to actually run the press and Logotronic Professional has extended functionality, with MIS connectivity via JDF. Print measurements are done with KBA's Densitronic system: the base version uses conventional densitometric readings, whereas Densitronic S uses a spectrophotometer. Like the Heidelberg technology, it provides spectral readings for accurate data capture and spot colour analysis.

KBA CIP Link manages the connections to the press control system, either through JDF or using PPF/CIP3 data. This data can be used to preset such things as the ink duct and ink/water balance. The Logotronic Professional module can preset virtually all electronically controlled parameters on the press. This includes such things as blower air parameters, powder spray amount and required print pressure.

Unique to this technology is the system's adaptive function, monitoring how the press operator works with the various control parameters. If the operator consistently makes the same sorts of changes, the system automatically adjusts the general settings to match. This adaptive behaviour can be controlled so that it only takes place after a certain number of similar adjustments. It has huge scope for process automation and colour management improvements.

Logotronic S measures critical colours such as, for example, a spot colour used in a logo. The colour balance is then adjusted to make as close a match as possible to the spot colour on press when only using CMYK inks. Logotronic S automatically monitors print quality warning the operator if the given tolerances are about to be exceeded. It suggests a change of settings to bring the print within tolerance, which the press operator can accept or decline with a single mouse click.

KBA has a special module for quality assurance called Qualitronic II. Using a high resolution video camera mounted in press (two cameras in a perfecting press) print quality, register and paper handling are monitored inline. This can be very useful when printing super high quality print, like bank notes and cheques. It is also useful for gathering colour data.

Komori KHS (High Performance System)

The Komori press control system is based on KHS, Komori High Performance System, designed to achieve fast makeready with high and even print quality. Komori KHS is modular but even in its most basic form the print operator can control the press in a standalone environment. Through system extensions, the printer can connect to both prepress and MIS, optionally via JDF. Komori has not said much about its colour management intentions, however it is developing a technology called Digital Open Architecture Network to provide the necessary infrastructure for colour management throughout the workflow.

The latest generation of press control systems, like the Komori K-Station (above), can generate or modify ICC profiles based on the actual print run.

A dedicated workstation linked to the press, K-Station, manages all jobs for the press, preparing them and calculating presettings according to the job requirements. A full duplex connection to both the prepress and MIS is possible by extending the system with the Komori Management System. Komori's High Performance System plans new jobs in view of the job already printing, to minimise settings changes. When starting a new job, the press is not reset to base settings, but instead transforms existing ones as smoothly and quickly as possible to fit the new job. The goal is to achieve targeted print quality within 30 sheets and according to Komori this is normally achieved.

Increasingly printers use spectrophotometers for quality control, instead of relying solely on densitometers. A quality spectrophotometer can function as a densitometer, besides reading spectral values, vital, for example, for accurate spot colour measurements.

Komori KHS stores all data in a database, with information on printability of different paper stocks as well as the paper characteristics. When building this database Komori measures print density values and uses spectrophotometric readings. Using this database, tailored ICC profiles are built using production data instead of working with special test charts. It can also be used to fine tune proofing processes.

Samples are measured and checked throughout the print run, so that target tolerances aren't exceeded. Information is expressed as Delta E values, and the goal is to have the lowest value possible for minimal deviation from target values.

MAN Roland's Printnet

MAN Roland's press control and management system is based on separate modules for colour and job management for individual presses. There are also systems for managing larger fleets of presses. For both, MAN has solutions to link prepress and/or MIS systems to its presses.

Printnet Color Pilot for colour control is integrated into the press control system and can include a scanning spectrophotometer. Color Pilot Plus captures control strips anywhere on the sheet. Color Pilot Smart is available for smaller presses with a limited number of printing units.

MAN has a software suite called Printnet Press Manager within which are various components for managing data flows, with direct access to the database of job and colour information. The database is fundamental to this system. It helps to manage all critical processes including job data, ink setting, machine settings and colour management, with a

Pantone spot colour library, data on different paper stocks, and ink data.

Printnet Press Manager has tools for job management, press presetting and monitoring. The objective is to automate the workflow as much as possible, and to provide the press control system with all necessary presetting data to enable the fastest possible and most accurate makeready. Users can work with either JDF or CIP3 data, depending on their preference, and it is possible to upgrade to JDF when they want. The system transfers job data and ink key settings but also press presettings for all digitally controlled components on the press, including settings for feeder, pressure, dampening, air and delivery, to fully automate the press. This is done by an intelligent and automatic management of data stored from previous print jobs.

Optical Density:

The range of tones a device can capture measured on a scale of 0 for white to 4, which is black, and higher.

For speeding up makeready, MAN has introduced several Quick Change options. These functions reduce makeready times, by allowing for presetting of virtually any component on the press that can be electronically controlled. This includes the order of blanket washing, automatic plate change and other steps, as well as storing extensive information about such things as blower air parameters.

As with its competitors, these technologies can integrate with MIS systems, either external or to the host production management system. Such connections can be made via JDF, although MAN has found that CIP3 is still the preferred route. Printers who prefer to work with a CIP3 based automatic workflow can upgrade to JDF and JMF to manage dataflows between the press control system and MIS.

Mitsubishi IPC (Intelligent Press Control) Server

At the centre of the Mitsubishi's press control system, which includes colour management, is the modular IPC, Intelligent Press Control. This can be connected to prepress and MIS through Mitsubishi MAX Net (Mitsubishi Accomplished Extensible Network).

The IPC Server uses a scanning spectrophotometer with a dedicated subsystem to measure control strips on a sheet. Mitsubishi prefers to use its own control strips which include readings of the paper white, but the system supports many commonly used ones. The MCCS can also generate ICC profiles based on the measured colour data, plus information such as ink data, taken from the system's central database. There are six separate IPC modules which together help the press operator achieve fast makeready. Most of Mitsubishi's colour management takes place in these modules, however colour does not seem to figure high on the company's priorities.

QSI (Quick Start Inking) sets and optimises start up ink duct settings and ink/water balance. When printing speed increases or decreases, the Ink Flood module makes sure print quality is maintained working with the Ink Key setting module which has two settings modes for either uniform changes to ink supply, or proportional settings for multiple keys. The Ink Fountain roller speed module automatically adjusts the ink fountain roller to match printing speed, for optimum ink density throughout the run. This works with the Variable Ink Duct roller module, which adjusts the interval of the contact frequency of the ink ductor roller to the fountain roller.

The PPC server (PrePress Connection) links to any prepress system that can deliver JDF and/or CIP3 data. This data is then used for presettings which are transferred to the Mitsubishi IPC press control system. Here maintenance and support also can be supervised and scheduled.

There are still many colour management issues to resolve, however the fact that press manufacturers are taking such pains to improve it bodes well for the future. Printers demand faster production throughput and improved quality control, with less waste and full cost accountability job to job. Colour management on press assists with all of this, however it should not be taken as a means of avoiding colour management in document creation and production. Standards such as the ICC have developed help, but there is unfortunately no such thing as a standard print job or even a standard printing condition. As long as people come up with creative ways of using print, and as long as printers keep printing those jobs colour management will be problematic.