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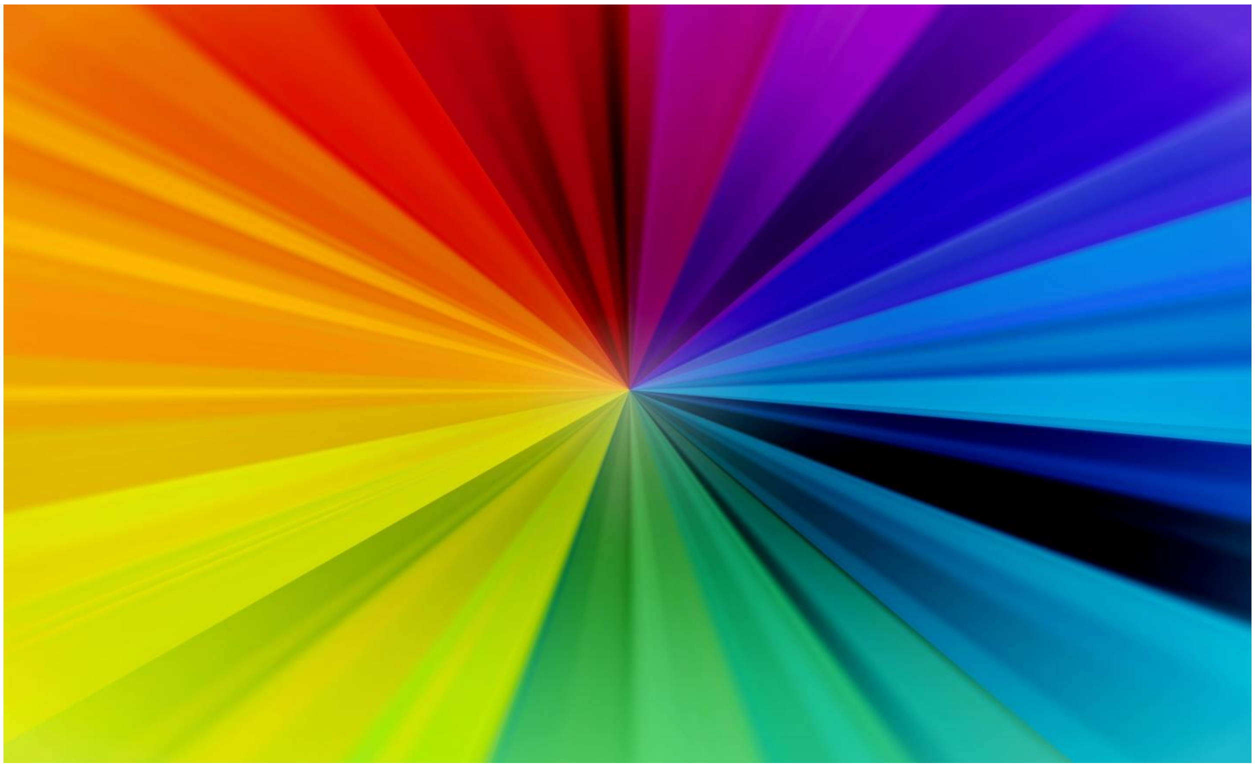
THE PRINTER'S GUIDE TO EXPANDED GAMUT

Understanding the technology landscape and implementation approach



By Ron Ellis

Printer’s Guide to Expanded Gamut Whitepaper

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What is Expanded Gamut

Expanded gamut printing is a popular topic in today's print industry. You have no doubt seen many marketing materials and articles touting the advantages of expanded gamut print. One thing you may have noticed is the many words and definitions used for expanded gamut. Before we get too deep into a discussion of expanded gamut, it is important to define what expanded gamut is.

Currently there are numerous terms used to describe expanded gamut, such as:

- Expanded gamut
- Extended gamut
- ECG
- 6 or 7 color process
- Multicolor
- N-color
- Hi-fi printing
- Fixed palette ink set

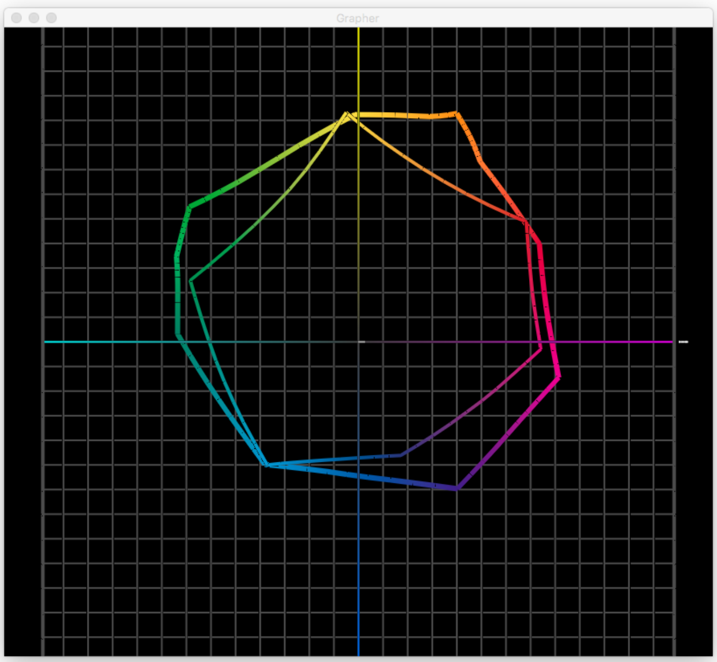
These many different terms cause confusion depending on how they are used, and they do not all have the same meaning, but all are often used in discussions about expanded gamut.

By its very nature, the term expanded gamut indicates a reference point. In order to determine if a gamut is 'expanded' we need to have something to compare it to. It is generally accepted that expanded gamut is *relative* to the standard colorspace gamut used for CMYK printing, such as GRACoL. A print condition is considered expanded gamut when gamut of the colorspace exceeds GRACoL or other ISO 12647-2 colorspaces. Based on this definition, an expanded gamut print condition is not dependent on whether you are using 4, 6, or 7 inks, but instead requires that the colorspace has a gamut that exceeds GRACoL or other ISO 12647-2 colorspaces.

Here are some examples of printing methods that can achieve an expanded gamut:

- CMYK inkjet
- Hexachrome (CMYKOG)
- CMYKOGV
- CMYK Litho with high density inks
- Digital press

A print condition is considered expanded gamut when gamut of the colorspace exceeds GRACoL or other ISO 12647-2 colorspaces.



GRACoL 2006 and Hexachrome, above, showing gamut expansion. Image captured using ColorThink

Why Expanded Gamut

There are compelling reasons to consider expanded gamut. Some of these reasons are related to print quality, and others are related to cost savings. Colorspaces like GRACoL and Fogra are well established and offer cost effective ways to print, but some customers have print requirements that exceed what can be accomplished using standard colorspaces.

One reason to use expanded gamut printing is to produce eye catching graphics that cannot be created using standard print spaces. Many consumer products that are purchased in retail environments fall into this category. Using a design that is more vivid and colorful than traditional packaging increases the likelihood that a consumer will notice and select the product. For many brands, this alone is a reason to consider moving to expanded gamut printing.

A second reason to use expanded gamut involves efficiency and cost savings. Many brands and packaging buyers use spot colors to make their products stand out. By using expanded gamut, it is possible to create these spot colors without having to use traditional spot colors. For example, when using spot colors on press, it requires that the printer keep stopping and washing up the press and changing the different spot colors in between jobs. The process of washing up and changing colors in between jobs is time consuming and greatly reduces the time a press is actually printing. Using single unit spot colors also means that jobs with different spot colors cannot be ganged or combined. By using expanded gamut printing, the spot colors can be created using a standard expanded gamut inkset, and the number of wash-ups in between jobs can be minimized. Use of an expanded gamut inkset also provides the opportunity to gang jobs on the same sheet. The lower costs achieved by the printer when using expanded gamut can potentially be passed on to the print buyer, especially in the case of gang run printing. These efficiencies mean the printer spends more time printing and producing product rather than preparing and performing make ready on each job.

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Multicolor expanded gamut also offers efficiencies by reducing the amount of ink a facility needs to keep on hand. With an expanded gamut workflow, there is less need to keep spot and special colors around. With multicolor expanded gamut, you only need 7 colors. In flexo facilities, multicolor expanded gamut can also reduce the number or anilox rollers needed.

Even though there are compelling reasons to use expanded gamut printing, there are also some reasons that it is not used for everyday printing. Expanded gamut printing in offset litho typically requires a 6 or 7 color press, and most offset litho printers in the world have 4 and 5 color presses, which cannot be used for many varieties of multicolor expanded gamut printing. In addition to requiring more expensive presses, multicolor expanded gamut printing has a greater degree of complexity than standard CMYK printing. This greater level of complexity can mean higher costs unless you are printing exclusively using multicolor expanded gamut on your press. If you are not running in expanded gamut mode all the time you lose much of the efficiency.

There are four areas in which expanded gamut printing adds complexity to the print workflow:

1. The customer must be willing to pay more for expanded gamut printing than they are for standard four color process printing. For many customers, average or good CMYK printing is good enough, and they are not willing to pay for the extra value and complexity of expanded gamut printing.
2. You need to have your printing process really under control to be able to achieve successful multicolor expanded gamut printing. If you cannot control 4 units and match proofs with process color, then achieving a match using 7 units will be even more difficult. Printing consistent multicolor expanded gamut printing is much more difficult than printing normal process color.
3. There is no standard like GRACoL or Fogra for expanded gamut printing yet, so you must figure out a lot of the expanded gamut process on your own, or with your partners. Unlike G7, there is no easy how-to guide that gives you guaranteed good expanded

gamut printing. In addition, a spot color that can easily be held to 2 delta E 2000 using a single unit often cannot consistently achieve such a low delta E when made of 3, 4 or even 7 colors because the variation between units is naturally greater than a single spot color. This means a spot color that may be held to 2 delta E 2000 will possibly be 3-4 delta E 2000 when printing with multicolor expanded gamut. Expanded gamut is typically best with a newer 7+ color press with coater – a configuration that many printers do not have.

4. While multicolor expanded gamut printing has the potential to minimize wash-ups and downtime in the pressroom, keep in mind that it can add a great deal of time to the front end of the job. Files intended for multicolor expanded gamut typically need to be re-separated in prepress, and cannot just be simply pre-flighted and checked like normal process files with spot colors. The software used to perform multicolor separations is costly and comes with a learning curve. The software and workflows required to proof multicolor expanded gamut is also complex and non-standard, requiring integration and configuration. Staff will also need training on how to perform these operations. A typical move from CMYK and spot to multicolor expanded gamut involves receiving a file, proofing it with conventional and spot methods, separating the file into multicolor channels, proofing and comparing it to the normal spot results, making adjustments as needed, reproofing, and then plating for press. For expanded gamut with the goal of increasing color (instead of strictly simulating pantone colors) the workflow involves taking RGB, spot, and source image data and separating them into multicolor, and then proofing and editing until the desired effects are achieved. Multicolor expanded gamut usually works best on newer and well maintained equipment, and is problematic on older presses that are not in the best of condition. In summary, while expanded gamut can improve the pressroom, it adds complexity to the press operations, and it increases the work required in prepress.

The Current Expanded Gamut Landscape

The current expanded gamut landscape includes many types of expanded gamut printing. The most popular expanded gamut printing is multicolor expanded gamut printing performed using litho and flexo. It is important to remember that there are types of expanded gamut printing in addition to the traditional 7 color multicolor expanded gamut methods. This leads to several categories of expanded gamut printing:

Expanded gamut printing using extra colors (such as CMYK +OGV). This method of expanded gamut printing is very popular with litho, flexo and gravure printing. Right now, a great deal of marketing and product development around expanded gamut print is aimed specifically at this area.

Expanded gamut printing using CMYK. This is common in digital and wide format printing. It can also be achieved by using high density CMYK printing such as Idealliance's XCMYK. This is more popular in digital and wide format printing applications. A new segment of the market, industrial printing, uses many CMYK expanded gamut applications. While many digital print methods can easily achieve expanded gamut print results, the market is not focused on expanded gamut and typically is aimed at traditional CMYK printing. This is because there are few expanded gamut color spaces available to users.

As long as the desired results are achieved, the print buyer normally does not care which method is used to create the expanded gamut print, if the desired result is achieved.

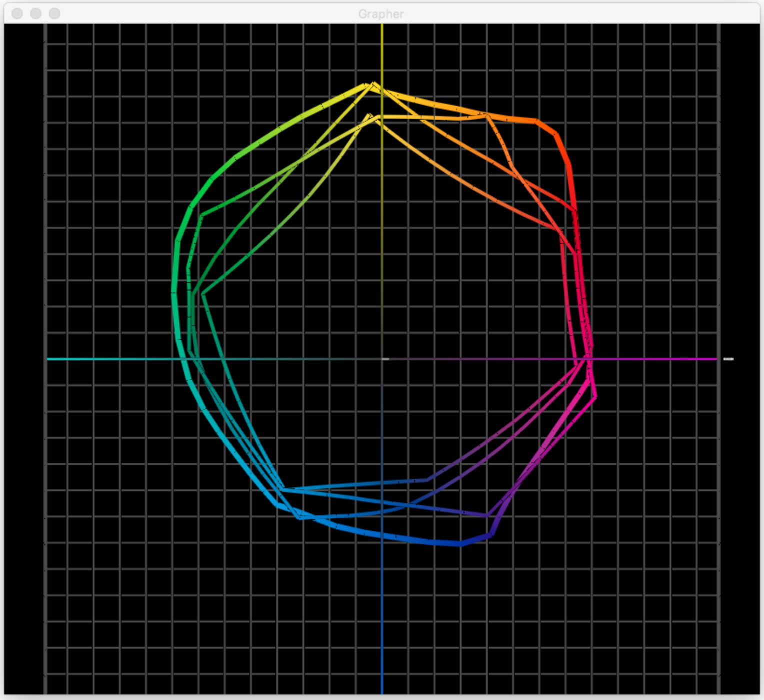


Chart showing a variety of expanded gamuts. GRACoL 2006 is the smallest gamut. Image captured using ColorThink

Standardization and Expanded Gamut

While the process world has benefited from industry standardization such as the ISO 12647-2 series, as well GRACoL and Fogra, there has been very little standardization in the expanded gamut world. Print standards that do exist are mainly for CMYK versions of expanded gamut. For CMYK expanded gamut print conditions there is XCMYK and CRPC-7. XCMYK is a wide gamut profile produced by Idealliance's GRACoL Committee for digital, wide format and litho printing using CMYK inks. XCMYK is available on the Idealliance website. CGATS-21 CRPC-7, is a wide format expanded gamut profile and is part of CGATS-21, as well as ISO PAS 15339. CGATS-21 is available at idealliance.org or color.org.

There are currently no internationally available standards for multicolor expanded gamut colorspaces. The closest thing to standards for multicolor expanded gamut are private colorspaces used by brands, and methods of calibrating used by manufacturers, but these vary greatly. For example, some CPG organizations have specific 7 color colorspaces which they require printers to use for their products, but they usually do not provide a method or even detailed aim points for calibration.

Idealliance currently has a project in progress which is working on development of a 7 color expanded gamut profile (XCMYK was the first part of the project).

For calibrating the individual ink channels, a standard named ISO 20654 is in review. This proposed standard will likely be used in future expanded gamut calibration and standards. The proposed ISO 20654 standard began as an Idealliance Print Properties Committee project called Schmoo. It provides a method for calibration and prediction of spot color tonality. The method uses a G7 like approach called CTV (Colorimetric Tone Value by Birkett) to calibrate the tonality of the spot channel. ISO 20654 can be used to achieve similar results with spot colors on multiple presses. Some software products already include the math from ISO 20654 for use in calibration and evaluation of these additional channels.

Methods of Producing Expanded Gamut

There are a variety of methods for producing expanded gamut, and the methods vary depending on the type of printing. For a wide format printer, achieving expanded gamut printing can be as easy as loading a wide gamut color profile. For multicolor expanded gamut printing there are a variety of software systems and methods of calibration. The software and methods for multicolor expanded gamut vary depending on which manufacturer has created the system and software, as well as the printing process. We will examine these methods further based on the specific printing process.

Techkon and Expanded Gamut

Techkon provides a variety of tools and software that support measuring, calibrating and evaluating expanded gamut. Techkon spectrophotometers can be loaded with primary values used to calibrate the individual ink channels, and can provide recommendations on how to reduce the delta E of the solids colors. The instruments can also be used to check and recommend changes to tonality of process and spot colors. The software contains the ability to analyze and check the gamut of the print condition, as well as recommendations on how to improve ink solids, and tonality. More practical examples will be provided later in this document.

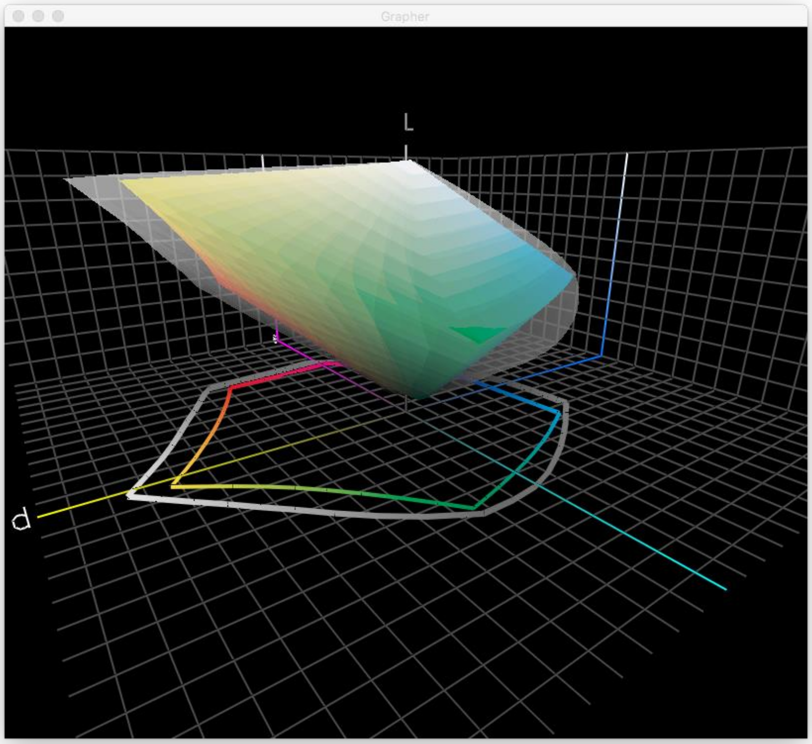
Techkon SpectroDENS, which can be used for assessment and calibration of expanded gamut print.

CMYK expanded gamut

When many people think about expanded gamut they automatically think about 7 color process printing – but expanded gamut does not necessarily require 6 or 7 colors of ink. Examples of expanded gamut printing that use only 4 colors are inkjet and digital printers, as well as some flexo and gravure ink sets. Expanded gamut does not refer to how many inks, or the number of units, but the expansion of gamut. (A print condition is considered expanded gamut when gamut of the colorspace exceed GRACoL or other ISO 12647-2 colorspaces.) Many devices can achieve an expanded gamut without the use of additional inks. In the sign and wide format market many devices are run with no color management (or sometimes custom color management) to take advantage of the full gamut of the device. For these devices, expanded gamut is a natural part of how the machine prints. For other devices like offset lithography CMYK expanded gamut can be obtained by using special inks, or by increasing ink film thickness.

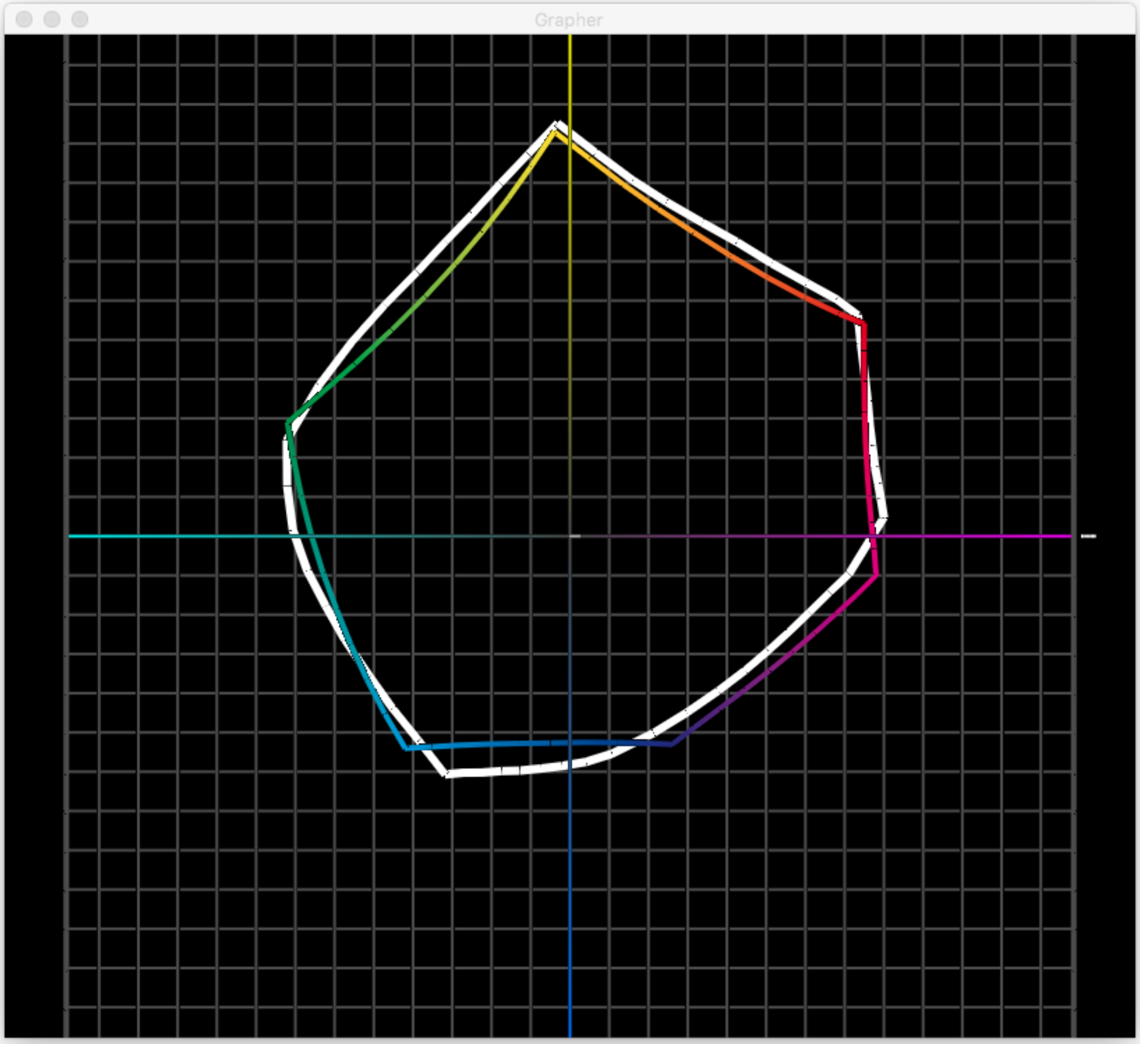
There are two commonly used colorspaces for CMYK expanded gamut:

XCMYK is an expanded gamut color space for use with digital and traditional print. The XCMYK color space based on high-quality sheet-fed offset printing using standard IS0 12647-2 compliant CMYK inks run to higher than normal levels, with nontraditional screening. The XCMYK color space can be reasonably approximated on any suitably-adjusted offset press without a custom ICC profile, and can be simulated on other printing systems with equal or greater native color gamut, by ICC methods. XCMYK is part of Idealliance's Expanded Gamut Project. The XCMYK research was conducted by the GRACoL Committee over a 15-month period in 2015-2016, and involved 26 offset test runs held in the US, Canada, China, Korea, Pakistant, Taiwan and Singapore. The colorspace was also tested with a wide variety of digital printers. One of the benefits of the XCMYK profiles is that while it works easily with digital printers through use of the ICC profile, the same colorspace can also be printed on offset lithography. The relationship XCMYK has between digital and traditional print is designed to give printers and buyers a common space linking wide format digital and traditional print methods. XCMYK can be downloaded from www.gracol.org. A detailed report on XCMYK and gamut analysis is available in the same url/location.



GRACoL 2006 and XCMYK, above, showing gamut expansion. Image captured using ColorThink

An additional CMYK colorspace is CGATS 21/ISO PAS 15339 CRPC-7. Like XCMYK CRPC was developed by Idealliance and is based on G7. CRPC-7 is an expanded gamut colorspace created for digital print. CRPC-7 is defined as a characterized reference printing condition for Universal Extra large gamut printing processes, as defined in CGATS 21-2-2013. The listed applications for CRPC-7 are digital inkjet and toner, sheetfed offset, flexo, gravure. CRPC-7 was derived synthetically and was not based on extensive testing and live press runs as was XCMYK. CRPC-7 can be downloaded from www.color.org.



XCMYK and CRPC7, above. XCMYK is outlined in white Image captured using ColorThink

Looking at the above images you can see some of the differences between XCMYK and CRPC-7. Note that XCMYK is bigger in many areas, with CRPC-7 larger in a few areas. Which one is right for a user? It depends on the use. XCMYK is based on extensive testing of both digital and litho, so for many users XCMYK is a logical choice.

The CMYK Expanded Gamut Workflow

Unlike multicolor expanded gamut, the CMYK expanded gamut is much simpler, and uses tools that many production environments already have in place. For example, most Epson proofers and RIPs can simulate CMYK expanded gamut, and separations can be made using Adobe Creative Suite and other commonly used tools. Spot color conversion to expanded gamut CMYK can use the industry standard Adobe CMM, and can easily be done using Creative Suite. For those using CMYK expanded gamut to achieve better Pantone colors, the conversion is quite simple, and involves converting the spots to CMYK in the correct expanded gamut working space.

Conversion from source to CMYK Expanded gamut

For those doing images and other artwork and using CMYK expanded gamut colorspaces, the conversion from RGB to CMYK is the key conversion point. If the image is already converted to a smaller CMYK space such as GRACoL or Fogra then the color space of the image will have already been reduced. In the case of using CMYK expanded gamut to improve image quality or color, the user must be aware of the destination space, and must convert to a large gamut space prior to entering the workflow to maintain the benefits of the CMYK Expanded gamut.

Using a CMYK Expanded Gamut Colorspace as a Conversion Space

For those in a CMYK workflow, expanded gamut profiles such as XCMY are a good potential conversion space. They allow a conversion from RGB into a wide gamut CMYK space, allowing for later conversion to smaller CMYK working spaces without color gamut loss or image degradation.

Creating custom G7 based XCMYK using the entire device gamut

In this case, it may desirable to make a custom characterization dataset that conforms to the G7, but uses the entire gamut of the printer. This is also known as 'G7 Extreme'.

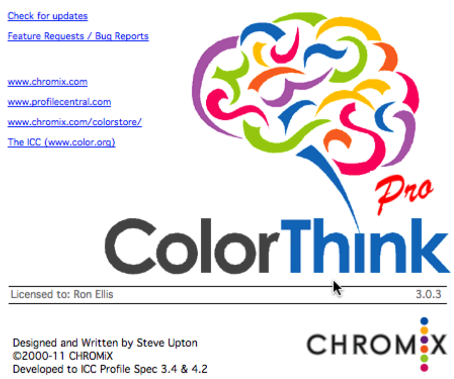
While XCMYK is a larger colorspace than GRACoL or Fogra, some devices (like an Epson, Roland, and others) have an even larger colorspace than XCMYK. In this case, it may be desirable to make a custom characterization dataset that conforms to G7, but uses the entire gamut of the printer. This is also known as 'G7 Extreme'. This can be done with software that can synthetically perform G7 on a non-G7 dataset. The entire gamut of the press is normally not gray balanced, nor does it have any type of standard tonality, and for many digital presses, TVI does not work. In this case, we can take the data characterizing the entire gamut of the press and use software to synthetically 'G7' the dataset that represents the wide open press. Once this is done we have a colorspace that uses the entire gamut of the press, but still conforms to G7. Like XCMYK, this 'G7 Extreme' dataset still has a relationship to GRACoL and other G7 datasets through its tonality and gray balance. This same technique which is applied to digital presses, can be applied to offset and other print processes to produce a custom expanded gamut dataset that conforms to G7.

Assessing Gamut and Quantifying Gamut Expansion

For a print condition to be considered expanded gamut it must have a gamut greater than standard ISO 12647-2 print conditions such as GRACoL or FOGRA, but this still leaves a wide variety of possible expanded gamut print conditions. In order to tell how much the gamut has been expanded, we need to have a way to compare and evaluate the expanded gamut against a standard gamut, as well as to be able to tell if some expanded gamut print conditions are better than others. There are several ways that we can assess gamut.

Visual comparison using Visual Gamut Viewers

One way that we can compare gamuts is to use some of the many utilities that let us view and compare gamuts. The three-dimensional view of the color space is a very easy way to visualize and compare two or even more colorspaces to each other. For example, using a tool like Chromix Colorthink we can load the gamut for GRACoL, and then load the gamut for an expanded gamut colorspace and view the two together. Viewing the gamut is not just a simple as viewing a 2D color plot of the gamut. We also want to compare the highlight and shadow areas of the two colorspaces, and make sure the gamut is expanded throughout the entire colorspace. This is a quick and easy way to see how a colorspace looks when compared to a traditional colorspace, but it is not as objective as using statistics to examine the colorspace. Some tools that can easily show the gamut map are Chromix ColorThink, Techkon Chroma QA, and ColorLogic ColorAnt. Many RIPs and profiling applications also have tools that allow you to evaluate and compare the gamut of multiple color spaces.



Chromix ColorThink is one of many tools that can be used to analyze and display gamut.

Statistical Comparison of Gamut Against the Pantone Library

Another method of comparison is to calculate the colorspace against the Pantone library to determine how many of the Pantone colors can be reproduced. For example, the The GRACoL 2013 colorspace can render 71% of the Pantone + color library within 3 delta E 2000. As a comparison, the XCMYK dataset can render 83% of the Pantone + color library to within 3 delta E 2000. A well calibrated CMYKOGV color space is said to be able to render approximately 90% of the Pantone + color library to within 3 delta E 00.

One benefit of calculating the gamut against the Pantone library is that it gives you a concrete idea of which Pantone colors you will and will not hit. This can be important information – especially if there is a specific set of Pantone colors your client expects you to hit. The comparison of gamut to color library is a more objective way to communicate gamut size than explaining that visually the color space is larger when viewing the gamut. Many pieces of proprietary software (such as software on digital presses) can calculate the gamut against the Pantone library. This can also be done using spreadsheets and color datasets, or by using software such as ColorLogic's ZEPRA's spot color tools.

ZePrA Spot Color Report 2017-01-12

Configuration: My Configuration
Target Profile: ECG 7 Color

Name	Conversion:	Target Lab	7CLR	Lab	dE00	dE76
PANTONE 1685 C	PANTONE+ Solid Coated	34.83 31.95 32.02	0.0 77.7 100.0 51.3 37.0 0.0 0.0	34.82 31.96 32.03	0.0	0.0
PANTONE Black 5 C	PANTONE+ Solid Coated	19.91 10.12 1.42	0.0 65.6 41.3 93.3 0.0 0.0 0.0	19.92 10.11 1.41	0.0	0.0
PANTONE 173 C	PANTONE+ Solid Coated	50.69 55.14 52.82	7.3 74.4 89.7 0.0 62.2 0.0 0.0	50.70 55.14 52.82	0.0	0.0
PANTONE 7603 C	PANTONE+ Solid Coated	32.26 15.89 18.40	0.0 61.1 82.8 69.1 0.0 0.0 0.0	32.27 15.88 18.41	0.0	0.0
PANTONE 3278 C	PANTONE+ Solid Coated	53.47 -62.75 2.82	39.7 0.0 20.0 0.0 0.0 89.7 0.0	53.47 -62.77 2.83	0.0	0.0
PANTONE 5845 C	PANTONE+ Solid Coated	68.88 -3.84 31.29	0.0 5.0 48.9 29.6 0.0 0.0 0.0	68.87 -3.83 31.30	0.0	0.0
PANTONE 7563 C	PANTONE+ Solid Coated	68.74 16.75 62.78	0.0 0.0 77.1 15.6 39.7 0.0 0.0	68.76 16.75 62.74	0.0	0.0
PANTONE 7769 C	PANTONE+ Solid Coated	41.96 1.90 27.87	0.0 23.0 84.5 66.5 0.0 0.0 0.0	41.96 1.90 27.86	0.0	0.0
PANTONE 1245 C	PANTONE+ Solid Coated	64.75 13.92 65.78	0.0 0.0 93.8 23.2 38.4 0.0 0.0	64.74 13.92 65.74	0.0	0[illegible]
PANTONE 7592 C	PANTONE+ Solid Coated	48.22 38.85 37.90	0.0 73.4 93.0 21.7 0.0 0.0 0.0	48.21 38.85 37.91	0.0	0.0
PANTONE 5555 C	PANTONE+ Solid Coated	50.04 -15.71 2.63	0.0 0.0 13.6 52.8 0.0 21.4 0.0	50.03 -15.70 2.62	0.0	0.0
PANTONE 7677 C	PANTONE+ Solid Coated	39.91 24.12 -30.93	15.0 0.0 23.8 0.0 0.0 0.0 78.6	39.90 24.15 -30.95	0.0	0.0
PANTONE 355 C	PANTONE+ Solid Coated	52.03 -67.03 33.95	39.1 0.0 92.8 0.0 0.0 90.1 0.0	52.03 -66.98 33.94	0.0	0.1

ColorLogic's ZePrA can be used to calculate gamut against color lists such as the Pantone library.

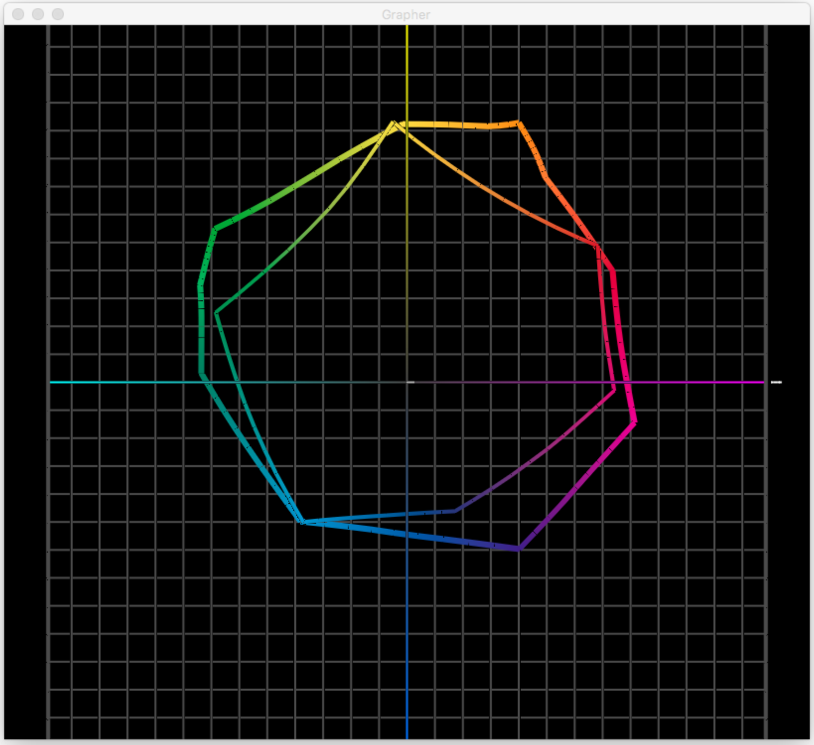
Gamut Volume Calculation

Another method of comparison is to use gamut volume calculation. The gamut volume is based on a calculation involving Lab values and represents an approximation of the number of uniquely perceptible colors contained in a devices gamut. To show an example of two color spaces: XCMYK has a gamut volume of 572150 and GRACoL 2013 has gamut volume of 389023. While the calculations can be done manually in a spreadsheet, Chromix Color Think also offers an approximation of color gamut volume. There are some white papers that cover gamut volume calculation in greater detail, such as *Metrics for Comparing and Analyzing Two Colour Gamuts* by Deshpande, Green and Pointer.

Multicolor expanded gamut CMYKOGV, Hex, Custom

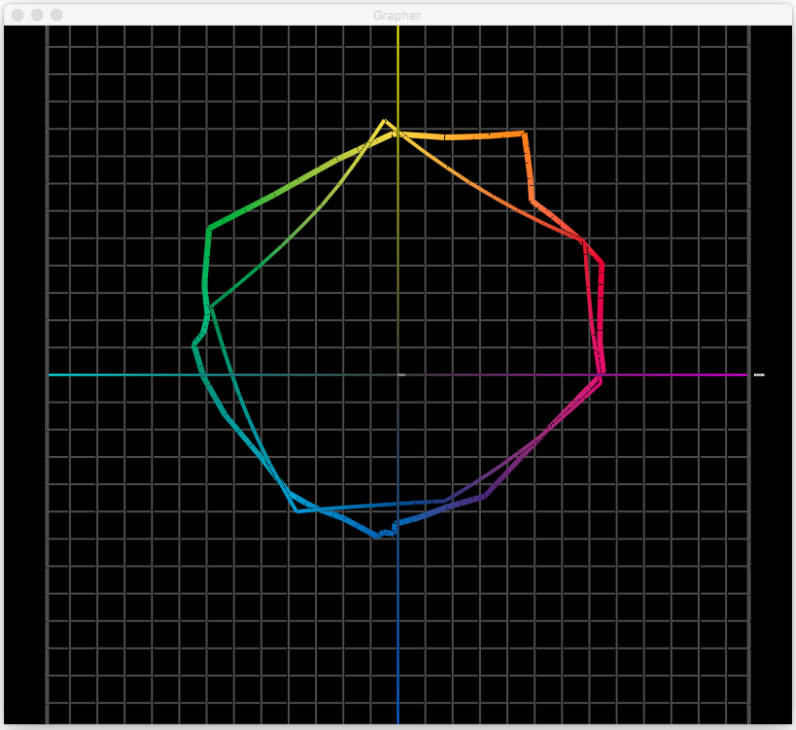
For offset litho, a typical way of producing expanded gamut consists of using process inks together with the addition of multicolor inks. The multicolor inks are monopigment inks. Monopigment inks result in a higher chroma than inks blended from multiple pigments. A typical configuration for a multicolor print condition might be C, M, Y K, O, G, V (Cyan, Magenta, Yelow, Black, Orange, Green, and Violet) if seven colors are available or CMYKOG if only 6 colors are available. While there is no history of expanded gamut print standards, one of the closest available efforts was Pantone's Hexachrome. Hexachrome was developed and announced in 1996, and offered the promise of matching approximately 90% of the Pantone library. While Hexachrome was widely promoted, and many printers tested it with good results, it was not widely used at the time. Additional proprietary expanded gamut methods used by brands and print service providers include C, M, Y, K, O, G, V, which also has been shown to be capable of achieving 90% of the Pantone library. Most current multicolor expanded gamut systems refer to C, M, Y, K, O, G, V. The amount of colors to use for expanded gamut is dependent on the colors selected as targets, as well as substrate and printing machinery.

Most current multicolor expanded gamut systems refer to C, M, Y, K, O, G, V.



GRACoL 2006 as compared to Hexachrome CMYKOG, above, showing gamut expansion. Image captured using ColorThink

One resource for C, M, Y, O, G, V printing is the Pantone Expanded Gamut Coated Guide, which has a series of 1729 color swatches created from C, M, Y, O, G, V printing. The guide includes 7 color process values for each color.



GRACoL 2006 and a typical C, M, Y, K, O, G, V on SBS, above, showing gamut expansion. Image captured using ColorThink

Multicolor expanded gamut calibration methods

While there are no multicolor expanded gamut standards available, there is a common method used by many who perform multicolor expanded gamut calibrations. Most experts aim their CMYK channels to GRACoL aims, and calibrate the CMYK using G7. For the OGV channels they run to ink company recommended aims and rotation, and calibrate using linear DeltaE-to-Paper for spot color tonality. (In the future, this will be changing to CTV based in Schmoo/ISO 20654).

Once calibrated, the results are measured and recorded for use in proofing and separation. The exact charts and measurement methods vary, depending on the software and tools used, but the measurements record the characterization data for the entire multicolor profile.

Because there is no industry standard for multicolor expanded gamut, the method of calibration is important. If done correctly the calibration can be repeated across multiple presses, or the same press at a future date when conditions have changed. Until there is an industry standard calibration for multicolor expanded gamut, each new instance of calibration involves creating a custom standard. There are a variety of software and tools available for calibration, and a list of the most common of these is included later in this document.

Multicolor calibration can be done with as little as curve creation software, ICC profiling software, and a proofing engine that supports multicolor profiles or can also be done using an advanced suite of tools that simplify creation and conversion of files into the multicolor space.

Expanded Gamut and Screening

In addition to using standard process and OGV mono pigmented inks, most expanded gamut print benefits from the use of stochastic screening. Because of the way stochastic screening carries ink it can give the appearance of fullness, and will increase the gamut in the highlight and midtone areas beyond what would be achieved using traditional am screening. The look achieved on litho when using FM screening is similar to the look of gravure or flexo when compared to typical litho output. Stochastic screening is more complex to print and control than AM screening, and this adds one more layer of complexity to printing expanded gamut. (For printers who do not have good press control, FM screening is more challenging). While it is possible to print expanded gamut with AM screening, the results are much better and gamut is increased more when using FM screening. Some print methods also use Concentric screening for the same effect.

Summary of Multcolor Calibration Method

A summary method for calibrating multicolor expanded gamut is as follows:

1. Print the C, M, Y and K, O,G, and V inks

2. Use a P2P51 for process colors, a scale for O, G, V, and use a multicolor test chart for C, M, Y, K, O, G, V. The multicolor testchart will be dependent on software and tools used to characterize the multicolor print condition
3. C, M, Y, K inks are aimed at ISO 12647-2 lab values
4. O, G, V inks are aimed at Pantone Expanded Gamut Guide lab values
5. Ink sequence for CMYK should be KCMY
6. Ink sequence for O, G, V should be provided by ink manufacturer
7. C, M, Y, K channels are calibrated using G7 method
8. O, G, V channels are calculated using a preferred method such as CTV (Schmo/ISO 20654)
9. Re-run the calibrated plates to targeted LAB numbers for C, M, Y, O, G, V
10. C, M, Y, O, G, V print results to be measured and recorded for use in proofing, color separation, and process control.

The above method is dependent on specific tools and software used for calibration and characterization. There are a number or tools available that can be used to perform expanded calibration. Because there is no standardized target to aim at, results will vary based on the software, method, goals, and printing machinery.

Recommended Aims

As a start the following aims are recommended:

- ISO 12647-2 for C, M, Y, K ink solids.
- G7 for calibration of C, M, Y, and K channels
- Pantone Expanded Gamut Guide for O, G, V ink solids
- CTV (Schmoo/ISO 20654) for calibration of O, G, V channels

The above aims should allow for repeatable calibration results across similar print machinery. For example, using the above aims should provide similar results across offset print equipment on a similar substrate, or flexo print equipment with a similar ink set and substrate.

The Multicolor Expanded Gamut Workflow

In addition to requiring a different way of calibration, the expanded gamut workflow itself is also different. To take advantage of the benefits offered by expanded gamut, files need to be processed differently. Because the files require special treatment, most prepress operations invest in advanced tools in order to efficiently perform conversions and adjustments to the files.

There are several reasons to use multicolor expanded gamut when printing, and the reason for using expanded gamut has implications for how files are processed through the workflow.

If using expanded gamut to create a more vivid and appealing color space, then source files need to be converted from original RGB and spot color spaces into the multicolor expanded gamut colorspace. This type of workflow begins in the creative and design part of the workflow, during image and artwork creation. The artwork is designed to maximize the expanded gamut colorspace.

If using expanded gamut to minimize spot colors and eliminate wash-ups, then files need to be processed so that Pantone colors are converted into the expanded gamut workflow. In this case the normal design is used, and software is used to convert Pantone or spot colors into the closest match that can be created using the expanded gamut color space.

In a typical prepress workflow, files are checked for fonts, TAC, spot color names and other basic prepress functions. In the multicolor workflow, rather than just being checked, files are converted from spot and other non-CMYK colorspaces into the multicolor expanded gamut color space. Once converted, files need to be checked to verify that the desired color conversions are acceptable. These additional tasks put a great load onto the prepress department.

The toolset required for the prepress workflow can range from simple and inexpensive to quite complex and expensive. On the inexpensive side of workflow is the use of multicolor ICC profiles, Adobe Photoshop, and a proofing engine that can accurately render the multicolor output. On the more expensive side of workflow are custom software tools that predict color conversion, allow the constraint of the conversion to limited number of channels, and provide calibration tools to assist in calibration of both press and proofer.

An example of a basic system would be using Curve 3 to create the plate calibration for Cyan, Magenta, Yellow and Black. Characterization could be done with i1 Profiler or ColorLogic CoPrA. For proofing software, CGS or GMG could be used with multicolor ICC profiles.

An example of a more comprehensive system might use Esko Equinox, or Hybrid/GMG Opencolor. These systems cost much more, but have specific tools that can be used to optimize and streamline expanded gamut characterization and printing.

Conversions and Calculations

There are many special conversions and calculations that are made as part of the expanded gamut workflow. One of the most basic of these is the conversion from source colorspaces such as RGB or LAB to the destination multicolor colorspace. While Adobe Photoshop can perform a conversion to a multicolor destination through use of a multicolor ICC profile, it does not offer any special capabilities or functions that are helpful when in a multicolor workflow. For example, when converting from RGB to 7 color using a multicolor profile Adobe Photoshop may put color on all 7 channels. It is desirable when printing expanded gamut to use as few colors as possible to reduce variation and improve stability. Some of the third-party multicolor plugins will allow you to force the conversion to a minimum number of channels to reduce variability across the units. Additionally, these plugins allow you to perform conversions with a specific set of rules based on the destination profile.

There are several types of conversions to keep in mind in this workflow. The first is from a source colorspace to multicolor expanded gamut. An example of this would be separating an RGB image into multicolor expanded gamut to maximize appearance and come out with a more vivid result than traditional CMYK can do. For this type of conversion, it is important to make sure that the file has not been converted to standard CMYK already – otherwise the ability to achieve an expanded gamut result will have already been compromised through the prior gamut reduction.

The second type of conversion is from a special color such as a Pantone color to multicolor expanded gamut. The goal of this conversion is to move from the Pantone or other special color LAB values to the closest possible color made of the multicolor expanded gamut color set. This type of conversion may be done to a standard CMYK file with special or spot colors. In this case, only the special or spot colors would be converted.

Another calculation that must be performed involves the tone curve to be applied to the process and spot colors for plating. For CMYK colors G7 calibration is most often applied. For spot colors, many systems right now use a calculation called Linear DeltaE-to-Paper (Samworth). Based on the results of the Idealliance Print Properties Committee (and their Schmoo working group), many applications will begin to calibrate using a new method. This same method is being proposed as an ISO standard - ISO 20654. It was tested extensively over the past 3 years and has been shown to yield good results. Schmoo stands for Spot Color Halftone Metric Optimization Organization. The Schmoo project was started because spot color behavior does not normally correlate with expected visual behavior. With this project, the objective was to produce a consistent tonal behavior with spot colors, and to provide a standard tone target across inks, processes, and presses. The project involved testing a mixture of processes, inks and colors, and involved testing 9 different metrics, both spectral and colorimetric. When all the data and results were analyzed, colorimetry based methods provided better results than density based methods. CTV (Colorimetric Tone Value) produced the best results and had a good visual match to Adobe Creative Suite. The formula is now being written as a prospective ISO standard, and the match has been integrated into industry calibration tools for easy use. CTV should be replacing DeltaE-to-Paper in most software applications and quality assurance programs soon. The implication of this technology for expanded gamut is much like G7 was for process color channels. This will give a consistent way to calibrate a spot color to an expected visual result. This means that printing to the same spot channel in multiple locations should become easier to do – and offers the promise of multiple presses across processes and location matching the same spot color behavior.

Proofing Expanded Gamut

Proofing expanded gamut is important for many reasons. An obvious reason is to simulate how the press will print expanded gamut and there are some less obvious reasons as well. One reason is to specifically see the resulting spot color renditions. When doing spot color conversions, many operators will print out the job with normal spot colors, and also with spot colors separated to expanded gamut. The purpose of this is to tell if the separation is close enough to the original spot color.

Not every proofing RIP can handle expanded gamut files, and proof them correctly. Some rips are much better at spot colors, and do a better job of predicting how colors will render, including the tints and overprints of the spot colors. The minimum requirement for the proofing RIP is that it can handle multicolor ICC profiles. With the multicolor ICC capability, some RIPs can produce a good match to the multicolor expanded gamut print condition. A multicolor ICC profile allows non-CMYK channels in the file to map to the same color in the multicolor ICC profile. (This is different than mapping to any spot color in the file. A channel in a multicolor profile has completely characterized how that specific color behaves, including mixing and overprinting with the other colors in the profile.) For this to work, the input files must have the exact same separation names as the multicolor profile. This traditionally has been the multicolor expanded gamut workflow.

In addition to multicolor profiling capabilities, a few RIPs have specific proprietary multicolor profiling capabilities. This means that in addition to being able to characterize the multicolor print condition, these rips may have ties into a larger workflow and plating rip, or may have specific tools available for separation and integration. For example GMG's Open Color has a plugin that lets the user tie into the color profile used by the GMG Open Color Characterization system. Esko's Equinox has a plugin that lets the user separate to the specific Equinox color strategy. So very often it is not just the multicolor capability of the RIP itself, but the tools and workflow that tie into a specific multicolor ecosystem and make if more efficient.

At the lowest end, you need a proofing system that supports multicolor ICC profiles. Even better systems have toolsets for working with and characterizing multicolor, as well as proprietary techniques, and direct connections to a larger multicolor workflow.

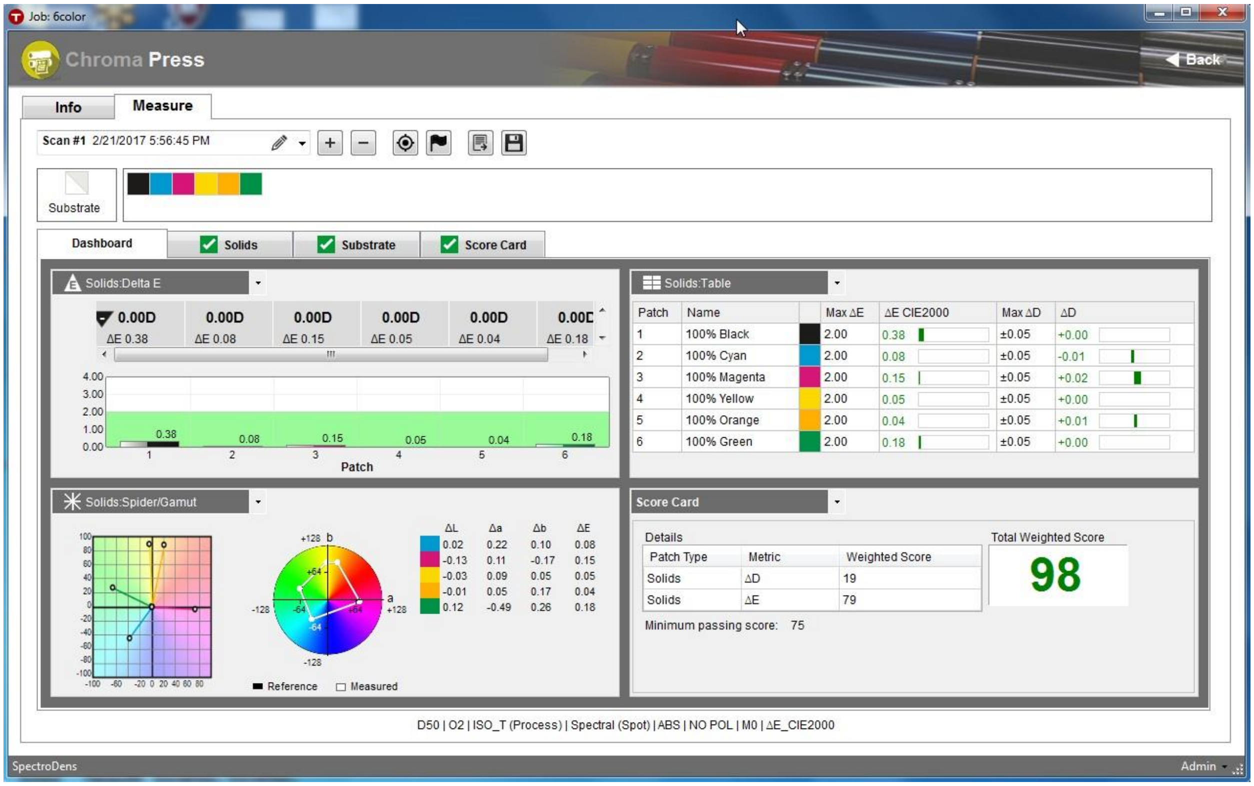
Characterizing Expanded Gamut

Characterizing expanded gamut depends on the type of expanded gamut. For CMYK expanded gamut, characterization is simple, and treated just like normal CMYK characterization. For characterizing multicolor expanded gamut the method quickly becomes proprietary to the system you will be using.

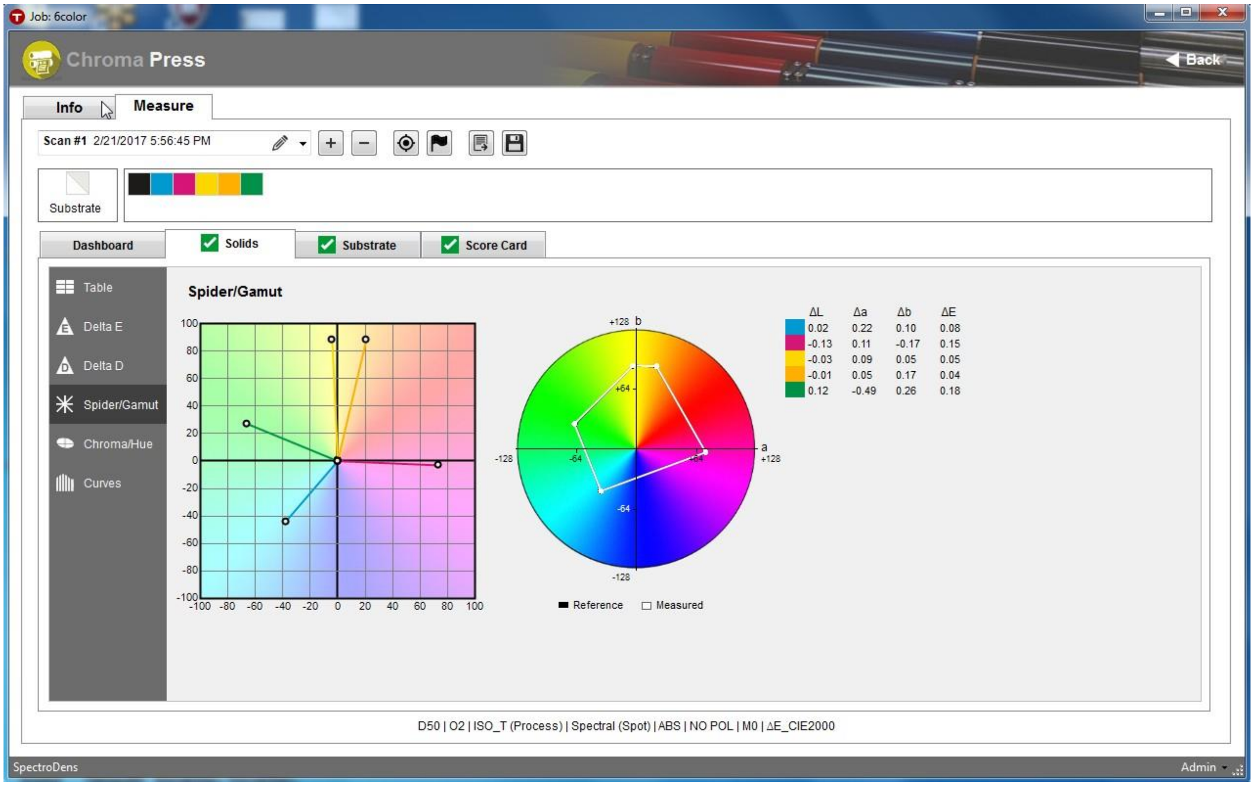
Unlike CMYK, multicolor does not have industry standard charts like the it8 and ECI that can be easily read and imported into all systems.* The specific charts and chart layout for multicolor are specific to the characterization engine and measurement device. A chart that works with a common application like i1 Profiler often will not work with specific rips or multicolor systems, and while the CMYK part of a CMYKOGV system is calibrated just like GRACoL, the multicolor charts often cannot be used in the same way as normal CMYK charts for calibration. A multicolor calibration often requires running very specific charts so that the software being used can import the data. In addition, with multicolor characterization it is not easy to share data between systems. While some systems accept data from other systems, most do not allow easy transfer of data from one system to another. The result is that in many cases multicolor characterization is often proprietary and data is often hard to capture and share between systems. Because of this, characterization often may involve running multiple charts and test elements for use in the various systems. There are a number of specialized tools that can be used to perform gamut analysis, and analyze multicolor data both within and without proprietary systems.

Process control and expanded gamut – controlling more than 4 units

One of the challenges with expanded gamut printing is process control. Process control is important for process printing, and even more important when using 6 or 7 colors. Minimizing variation is critical. For this reason, having good printing equipment, as well as scanners and other tools for measuring and analysis of color is important. If you cannot print well with 4 colors, printing well with 7 colors will be even more difficult. So when working with expanded gamut, process control is more important than ever.



For process control you must have a clearly defined printing specification to print to and compare against. You must also have printing data for the specific machine you are on, in addition to the printing specification. You must be able to determine that the machine is printing correctly and that ink, gain, color and tonality are within your specification before you begin printing.



To do this you will need a scanner or measurement device. On traditional litho presses this would mean a full sheet scanner. (On digital or flexo presses, a handheld would be adequate unless recalibrating or characterizing, in which case a scanning spectro would be recommended.) The scanner must be connected to software to help the press operator make sense of the data. In many cases the actual press console software may not provide adequate data, but at minimum the operator needs to be able to see the delta E of the solid inks and overprints, as well as the dot gain. For shops that do high quality printing they often will have additional software that helps them to monitor and evaluate the printed results. These systems can easily show the operator how they are doing by showing a score on solid colors, overprints, gray balance, dot gain, and provide guidance on how to correct the print condition.

In addition to having tools and software to monitor process control, the press needs to be in maintained and in good condition in order to run expanded gamut. Because process builds are made of more than one color and unit, those units need to be in good condition. Variation due to roller, pressure, and other press maintenance issues will result in unacceptable results.

Connections – tying together traditional and digital expanded gamut

It is important to keep in mind connectivity between traditional and digital expanded gamut. More and more printing is done using digital methods so characterizations should be created with an eye to being able to be produced by both methods. For example, devices such as an HP Indigo and Litho are often paired together in the same plant. The HP Indigo is often used for short runs, while Litho is used for the longer runs. In the best scenario, both would use the same multicolor expanded gamut print condition, and jobs should be able to be moved interchangeably between both methods. This requires an understanding of the gamut of both devices and using aims that allow both devices to be capable of printing to the same data set.

Practical use of Techkon devices for expanded gamut

There are a number or practical ways to use Techkon devices in expanded gamut workflows.

- ChromaQA and Techkon devices can be used to target and adjust ink solids for process and non-process ink channels. The software and devices can tell you deviation from the target values, and recommend values to improve the delta E.
- ChromaQA and Techkon devices can be used to evaluate and correct G7 gray balance and G7 tonality. The software and devices can tell you specific ink moves to adjust and evaluate gray balance via moves to solid ink density.
- ChromaQA and Techkon devices support scanning of control strips for evaluation and direction. The SpectroDENS itself supports scanning of strips and scoring of the result, with troubleshooting information based on dot gain, gray balance, and solid ink. With third-party software the SpectroDENS also can scan control strips in strip mode, and can work with these products for additional support in expanded gamut calibration and direction.
- ChromaQA displays gamut information and can visually show and compare actual vs. target gamut.

- Techkon scanners like SpectroDRIVE provide fast and automatic feedback of the above metrics when needed.

Definitions

- **Expanded Gamut** - Expanded gamut is a colorspace where the gamut exceeds GRACoL or other ISO 12647-2 based colorspaces.
- **Extended Gamut** – same definition as expanded gamut
- **ECG** – ECG stands for Expanded Color Gamut, and is often used as a term describing 7 color printing.
- **Fixed Pallete Printing** - same definition as expanded gamut
- **6/7 Color Process** - often used as a term describing 7 color printing.
- **Multicolor**- Multicolor is a term to describe a printing using more than any non-process colors. Multicolor is defined as CMYK + additional colors. Many systems do not support more than 7 colors
- **N-color** – N-color is short for aNy color, and refers to any spot colors. The term was first used in ProfileMaker Packaging software.
- **Gamut** – The range of colors available on specific device
- **TVI** – Tonal Value Increase – dot gain
- **Schmoo** - Schmoo stands for Spot Color Halftone Metric Optimization Organization. Originally an Idealliance initiative, it is being worked on as ISO 20465
- **GRACoL** – Idealliance's most popular printing specification based on ISO 12647-2, and like Fogra.
- **CRPC** – Characterized Reference Printing Condition
- **CGATS 21/ISO PAS 15339** – Print specifications based on G7 and containing 7 CRPCs across a range of substrate and print methods.
- **CPG** – Consumer Packaged Goods
- **Adobe CMM** – Adobe's color management module, used in Creative Suite

- **XCMYK** – Idealliance's new CMYK Expanded Gamut profile
- **Monopigment Ink** – ink created from a single pigment
- **ICC Profile** - an ICC profile is a set of data that characterizes a color input or output device, or a color space, according to standards promulgated by the International Color Consortium (ICC)
- **Multicolor ICC profile** – Same as above, but containing colors other than or in addition to C, M, Y, K

Expanded Gamut Software and Tools

GMG OpenColor

Esko Equinox

Xrite I1 Profiler

Xrite ProfileMaker 5 Packaging (discontinued but still widely used)

ColorLogic CoPrA

ColorLogic ColorAnt

Alwan Print Standardizer Multicolor

Oris ColorTuner Web (Multicolor ICC)

Kodak

Pantone Hexachrome

Kodak Spotless

Kodak Colorflow

Heidelberg Prinect

Heidelberg Multicolor Toolbox

Alwan Colorhub

Bodoni pressSIGN

Curve 3

ColorLogic Touch 7

Remote Director

About Techkon

Techkon is the innovation leader in densitometers, spectrophotometers and software solutions for the global print community. With a track record of 28+ years of continued technological excellence, Techkon products are chosen for their high degree of measurement speed, accuracy, repeatability, reliability and ease of operation in all sectors of the printing industry.

Techkon's unique color measurement solutions serve a wide range of customers in commercial, corporate and package printing facilities, and ink manufacture. Our handheld devices provide the perfect entry point into easy-to-use, precise color control. Our high-end scanning devices have led to highly successful implementations by leading OEM press manufacturers and large commercial printers, yielding dramatic gains in quality, productivity and cost savings.

With an innate understanding of critical issues in color print reproduction, Techkon's entire product line is recognized by leading industry organizations, and its products are positioned as the color measurement tools of choice for the printers around the world.

About Ron Ellis, Ron Ellis Consulting LLC

Ron Ellis is a consultant specializing in brand quality, color management, automation and workflow integration. Ron is Chair of the GRACoL Committee, and an Idealliance G7 Expert, and G7 Expert Trainer. He has performed hundreds of G7 training and calibrations and has conducted training and consulting for a wide range of customers in Europe, Asia, and North America, Well versed in ISO standards, he is certified as a PSA consultant as well as an FTA Flexo Level 2 Implementation Specialist, and was the primary developer of IDEAlliance's G7 Process Control program. Ron specializes in creating and implementing working spaces for brands and agencies that allow them to work more efficiently with vendors, saving both time and money. Ron is published frequently in industry magazines, and has produced training materials and curriculum for numerous printing industry groups, manufacturers and publishers.