# Evaluation of Expanded Gamut Printing In Flexography

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Keywords: ECG, expanded gamut, flexography, OEE, sustainability

**Abstract**

There is a great need in the packaging industry to produce increasingly smaller lots in a more cost-effective and sustainable way, where the spot color accuracy of the brand elements is critical. Traditional flexography is spot color printing or four-color process printing supported by spot colors that consume a lot of time, effort, and materials. This paper presents results from Ph.D. Thesis by Kai Lankinen of the transition from spot color printing to Expanded Color Gamut printing, ECG, i.e., a multicolor process in solvent-based wide web flexography, which reduces the complexity of the printing process and produces spot color simulations in a simpler, more effective, and more sustainable way.

This study shows an improvement in the OEE of 42% to 85% and a total cost savings of around 0.6 to 1.3 million euros per printing press per year, while the $CO_2$ equivalent is reduced by 34% to 51% compared to spot color printing, the results will be different case by case. The studied tests show the capability to expand the color gamut with additional process colors, up to 91% of the Pantone Color Matching System (PMS) colors for the studied 7-color system of less than 3.0 ΔE2000, as expected. However, against expectations, high-pigmented inks also expands the color gamut by 14% for the studied 4-color inks. The Total Area Coverage (TAC) calculations of the tests show that ECG can save ink.

The original Ph.D. thesis book “Evaluation of Expanded Gamut Printing in Flexography” can be downloaded at: http://urn.fi/URN:ISBN:978-952-03-2027-0

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## Introduction

The trend in the printing industry is that the order length of a printing job is decreasing and there is a strong common need to reduce setup time and costs. Moreover, brand owners are actively looking for greener processes for packaging production, as consumers and retailers seek to use more ecological products.

The preparation and matching of traditional spot colors take time, occupy printing machine capacity, cause makeready waste, and also result in growing ink storage inventory and ink waste. The application of multicolor process printing to flexographic printing could result in a substantial efficiency increase and cost reduction due to a decrease in setup times, makeready waste and ink logistics. Furthermore, the expanded gamut printing system is also more ecological overall in comparison with traditional flexographic printing with spot colors.

## The possibility and importance of industrial implementation

The main factors for the transition from traditional printing to expanded gamut printing are to make the printing process more effective, flexible, and even more sustainable, while the order lengths become shorter with more product variants. Although multicolor process printing is traditionally marketed on its efficiency and cost saving, the sustainability aspect has been missing. Since making this study, the author was able to raise the sustainability of packaging printing in public debate as an added value of expanded gamut printing.

Expanded color gamut printing (ECG) is a challenging system to implement as an industrial process at first. However, once done successfully, well-accepted print quality can be achieved with a remarkably shorter setup time and better sustainability compared to spot color printing. Therefore, the author has carried out pioneering work by collecting the data presented in this study, compiling, proving facts and making novel calculations to expand knowledge, creating examples of color accuracy and production possibilities including gang-run printing. Further, a consumer-level study was performed with a brand owner using ECG. All of this contributes to encouraging and helping printers and brand owners to start implementing multicolor process printing for the packaging printing supply chain, providing a more efficient and sustainable process compared to traditional spot color printing.

While writing the thesis from 2004 to 2019, it was interesting to note how sustainability in packaging has become a very hot topic in recent years, even though it has not yet affected printing itself to any great extent. Sustainability in packaging has been focused on first in downgauging the materials and then replacing substrates with degradable and bio-based materials, but printing itself has seen only a few approaches regarding sustainability.

## OEE – Overall Equipment Effectiveness

OEE describes how effectively a manufacturing process is used. OEE is a calculation formula in which the performance of the manufacturing process is divided into three measurable components (availability, performance and quality), as shown in Equation 1.

$$OEE = Availability \times Performance \times Quality \quad (1)$$

On the basis of the example efficiency calculations made with the ECG calculator developed for the thesis and discussions with numerous printers, the author concluded that the traditional flexo printing process had a typical OEE of between 25% and 45%.

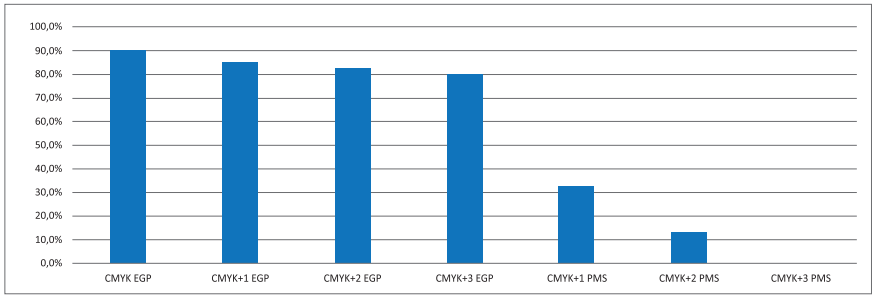


***Figure 1:*** *OEE of different color strategies*

The previous example shows how the production efficiency of a 7-color job increased from 27% to 50% (increase of +85%) and a 5-color job from 36% to 52% (increase of +42%). The OEE of different color strategies is shown in Figure 1. It should be noted that 4-color printing was the most effective way to print a colorful image.

## Reduced setup time and waste

Regarding the makeready time for multicolor process printing, a minimum job changeover time of 5 to 7 minutes and for spot color printing a minimum time of 17 to 30 minutes was reported. Also, a maximum of 30 to 40 minutes was reported for multicolor process printing and 75 to 160 minutes for spot color printing. These answers averaged 19 to 25 minutes of setup time for multicolor process printing and 51 to 94 minutes for spot color printing. The average setup waste and time are shown in Figure 2.

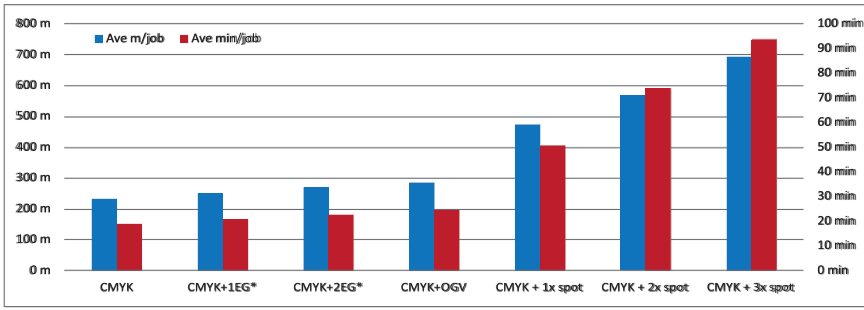


***Figure 2:*** *Average setup waste and time per job*

## Reduced $CO_2$ equivalence

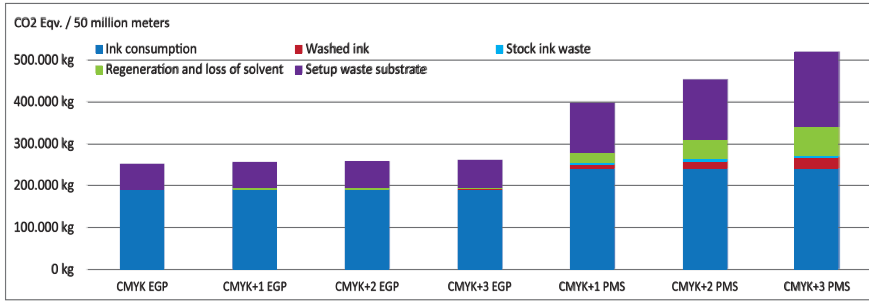


***Figure 3:*** *Comparison of Spot vs. ECG printing: $CO_2$ source*

Comparing the values of the different $CO_2$ sources, as shown in Figure 3, showed that ink consumption represents the largest source of $CO_2$, with setup waste being the second largest. The regeneration of washing solvent and the washed-off inks were also notable as a source of $CO_2$, especially for spot color printing, but the effect of stock ink waste was quite minimal.

## Expanded gamut to 91% of PMS colors

The color gamut size of the 7-color profile and different 4-color profiles were compared in spider web and gamut volume, as shown in Figure 4. The spider web illustration presents a projection of all profiled colors along the L axis in the a-b plane. A colored spider web of the profiled CMYK and CMYKOGV L*a*b* gamuts compared to the ISO-coated v2 profile is shown in Figure 4.

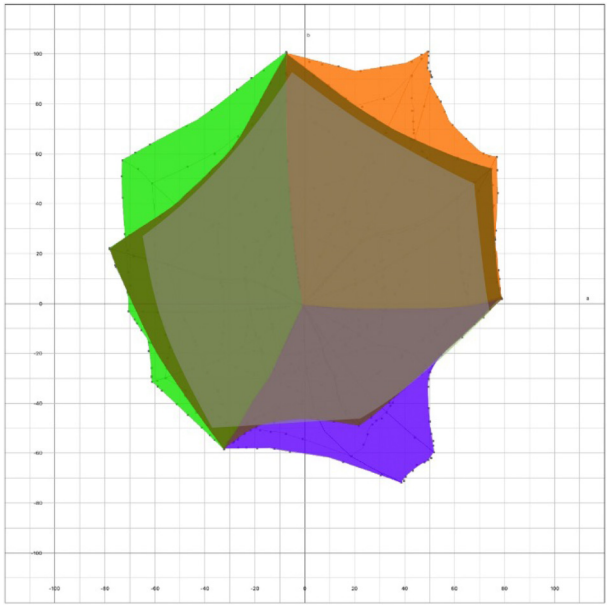

***Figure 4:*** *Comparison of different color gamut profiles*

It can be seen that the printed area of the CIELAB a-axis reached from almost -80 to almost +80 and the b-axis from about -70 to about +100. The illustration shows the ISO-coated v2 (FOGRA39) color space spider web in the middle as a gray area, which is surrounded by the expanded gamut CMYK spider web color space (brown area) of the profiled printing. The additional primary colors expanded the color gamut with orange, green, and violet colors, as illustrated. The profiled CMYK color gamut spider web included almost all of the ISO-coated v2 areas very well, except for a very small area of the violet.

As can be seen in Figure 4, the OMYK, CGYK, and CMVK ECP triads expanded the gamut even further than the ECP-CMYK, although in the green area the CYK triad had a peak exceeding the CGYK triad.

The color gamut volume and in-gamut of the previous profiles are shown in Figure 5 and Figure 6.

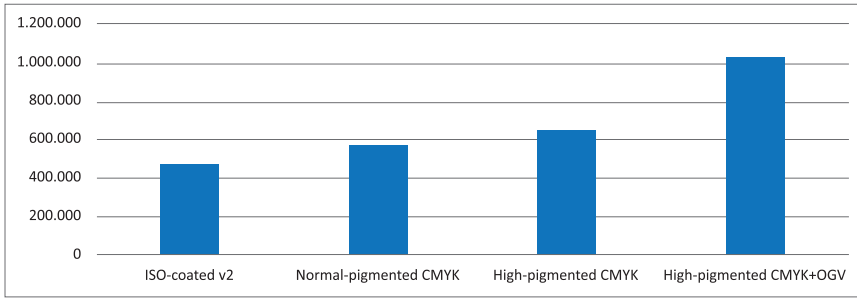


***Figure 5:*** *Cubic color unit comparison of different color gamut profiles*

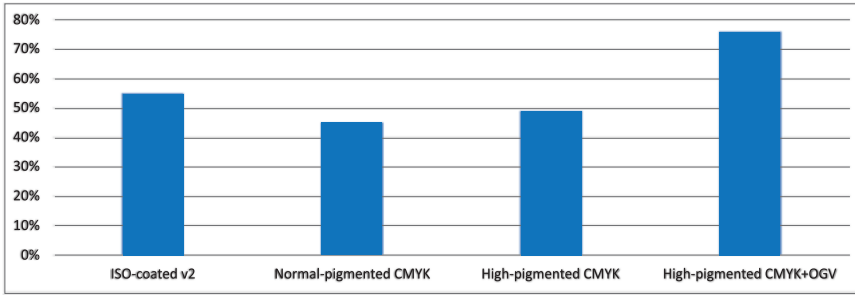


***Figure 6:*** *In-gamut comparison of different color gamut profiles*

The color gamut of the normally pigmented CMYK flexo profile was 22% larger than the ISO-coated v2 profile value, but the in-gamut value of PMS colors was 18% smaller, as shown in Figure 5 and Figure 6. As expected, the in-gamut value of flexographic process printing was lower than that of offset printing. An interesting result, however, was that the color gamut volume of the flexographic profile was larger than that in offset printed.

The above results showed that PMS colors could be simulated below 3,00 ΔE with high-pigmented CMYK inks in 75% of cases and with high-pigmented CMYK+OGV inks in 91% of cases.

## TAC ink reduction 15% - 69%

The OATIS brand co-printing from the company Real Snacks was done at SOMA Flexo Challenges 2019 to demonstrate the eco-efficiency of expanded gamut printing. In the demo the six different jobs were gathered onto a single sheet and co-printed with water-based inks on paper, as presented in Figure 7.


***Figure 7:*** *Co-printing of six OATIS designs in a single run with ECG (Image: Marvaco)*

The conversion from OATIS spot colors to ECG CMYKOGV process colors is shown in Table 1.

| PANTONE to EGP | C | M | Y | K | O | G | V | ΔE00 | TAC | INK |
|---|---|---|---|---|---|---|---|---|---|---|
| PMS 2736 (violet blue) | 65,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 83,61 | 1,95 | 149% | -26% |
| PMS 2925 (light blue) | 58,12 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 4,23 | 0,99 | 62% | -69% |
| PMS 354 (green) | 3,70 | 0,00 | 67,28 | 0,00 | 0,00 | 100,00 | 0,00 | 1,35 | 171% | -15% |
| PMS 485 (red) | 0,00 | 65,89 | 0,00 | 0,00 | 82,71 | 0,00 | 0,00 | 0,07 | 149% | -26% |
| PMS 201 (red brown) | 0,00 | 74,59 | 0,00 | 29,22 | 60,57 | 0,00 | 0,00 | 0,00 | 164% | -18% |
| PMS 7549 (yellow) | 0,00 | 0,00 | 100,00 | 0,00 | 32,56 | 0,00 | 0,00 | 0,14 | 133% | -34% |

***Table 1:*** *Converting OATIS spot colors to ECG process colors*

In all of the cases the amount of consumed ink showed a remarkable reduction when a color was converted from spot color to ECG CMYKOGV colors. In individual cases the calculated ink consumption reduction was from -15% to -69%.

**Cost savings 0.6 - 1.3 M€ p.a.**

Comparing the values of the various additional cost sources, as shown in Figure 8, it can be seen that, in the example, excessive production time costs were the largest costs due to longer makeready times, with setup waste being the second largest source, and the regeneration of the washing solvent the third largest source. Excessive ink consumption and washed-off inks were also notable costs, especially for spot color printing.

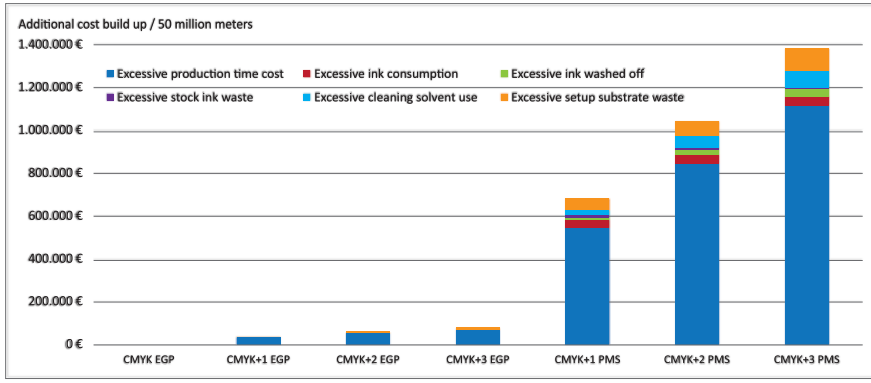


***Figure 8:*** *Comparison of additional printing costs for Spot vs. ECG colors*

In addition to the previous costs, it should be noted that the other perspectives such as increased quality, higher production flexibility, lower print stock, and plate cost reduction can also be achieved when switching from spot color printing to process printing. Furthermore, fewer anilox rolls, and fewer doctor blade and end seal changes are needed, which means not only eliminating the cost of the product, but also the time and effort required to change and organize the tools. In fact, the cost of downtime and machine downtime usually increases, as any break can easily lead to longer break times. Moreover, as the machines get faster and orders shorter, there will be even more job changes per week and higher cost savings potential in the future.

## Problem areas of the ECG

Like all processes, there are advantages and disadvantages also with ECG process:

- The most important is that the whole process is be kept stable and under control: All the equipment must be kept in good condition, process stability maintained, and parameters controlled throughout all the supply chain.
- It is essential that the prepress has the knowledge and experience to perform multicolor separation correctly. The ECG color separation also requires a special software.
- Potential difficulties must be solved on beforehand and necessary changes agreed with the brand owner, for example, the small multicolored texts and barcodes. Until the designers are fit with the ECG design creation.
- The replacement of legacy jobs by ECG may create color matching issues, if not agreed in collaboration with brand owners.

## ECG process summary = WYSIWYG

What You See Is What You Get in ECG printing. The benefit of ECG process is that the proofing, digital printing and flexographic printing can all use similar color strategy (e.g. CMYKOGV). This means, that the color gamut's are close to

each other and what is seen on proofing, can be repeated in digital or flexographic printing. Of course, the expectation is that the process is kept stable and controlled through the supply chain. The principle is shown in Figure 9.

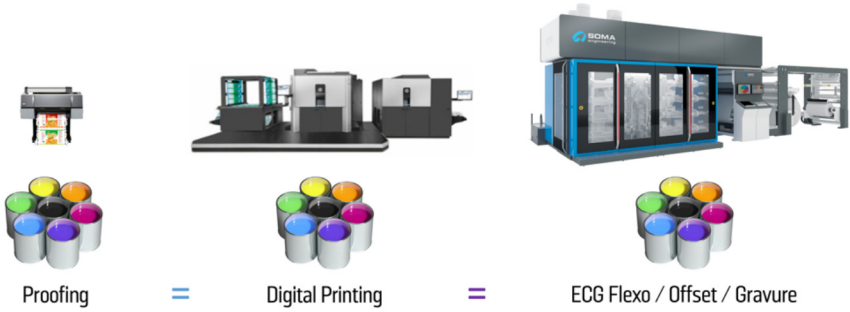


***Figure 9:*** *What You See Is What You Get in ECG printing*

## Conclusions

The Dr. Lankinen's thesis evaluated different ways of flexographic printing with solvent-based inks in packaging. The study confirmed many previous expectations and provided new views on the subject. The conclusions proved that expanded color gamut printing, ECG, has a great potential to make the flexographic printing industry more cost-effective, as well as even more sustainable.

The investigated method offers the possibility to produce even short runs effectively with good color accuracy. The use of ECG simplifies spot color simulations, shortens press setup time, reduces makeready waste, decreases ink consumption, diminishes the multiplicity of anilox rollers and preparation of spot color inks, and reduces the size of ink storage. In addition, eco-efficiency can be further increased through gang-run printing.

The results of the study showed that the volume of the color gamut can be expanded beyond the CMYK color gamut with both high-pigmented process inks and additional primary inks, although the size of the gamut does not always correlate directly with the number of PMS colors in the gamut of different color systems.

Although multicolor process printing is not currently widely used, based on this study, it can be proposed that ECG could replace spot color printing on a larger scale. While ECG technology is not a solution that can replace 100% of spot colors, it can be used effectively to replace the vast majority of PMS colors to make current packaging printing more eco-efficient.

## References

1. Lankinen, K., “Evaluation of Expanded Gamut Printing in Flexography”, Ph.D. Thesis, Tampere University Dissertations 440, http://urn.fi/URN:ISBN:978-952-03-2027-0, 2021.

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