# Evaluation of Spot Color Reproduction by Extended Gamut Printing on a Narrow Web Flexography Press

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## Abstract

The FMCG sector (Fast Moving Consumer Goods) is one of the largest industries in the world wherein the brands are reliant on the customer attraction and product sales worldwide. It is important for brands to maintain the quality and color consistency of these products. FMCG labels printed with Spot colors by Flexography process is not cost-effective due to higher job changeover times and wastage. The most effective way of ensuring spot color reproduction is implementing Expanded Color Gamut (ECG) printing by using a fixed set of colors with four process colors namely Cyan, Magenta, Yellow, Black (CMYK) along with three colors Orange, Green and Violet (OGV). These seven colors provide eye-catching graphics and a larger gamut so as to reproduce maximum number of Pantone® colors. The evaluation of spot color reproduction was carried on a Nilpeter FB-430 Narrow Web Flexo press that included runs viz. Initial, Optimization, Fingerprinting, Characterization and Validation on Polypropylene substrate with UV based inks. The runs were carried as per Idealliance® specifications. The aims and tolerance as per ISO 12647-2 with CRPC 6 GRACoL 2013 for CMYK while ISO 20654 Spot Color Tonal Value (SCTV), Chroma and Hue for OGV were achieved. The customized Characterization Test Chart with 2016 patches for CMYKOGV for profile generation and Verification Test Chart with 799 patches of Pantone® Solid Coated from the Digital Library was created in CGS Oris XGamut. These Test Charts were measured using X-Rite EyeOne iO automated device. The magnitude of color match for Spot Colors by expanded gamut printing was verified on a narrow web flexography press. The gamut analysis between CRPC 6 and CMYKOGV showed that from the geometric region of Pantone® Colors Inside CMYKOGV Gamut and Outside CRPC6 Gamut, 85% of the Pantone colors were reproduced below Delta E 2.5.

**Keywords:** FMCG, Label, Flexography, Expanded Color Gamut (ECG), Pantone Colors

## 1 Introduction

The Fast-Moving Consumer Goods (FMCG) industry is the largest group of consumer products along with its production, distribution and marketing. Print labeling is a vital part of marketing, which affects and deeply influences consumer-buying behavior. The global print label market is expected to grow at CAGR of 4.2% by 2025 which is further expected to reach USD 67.02 billion by 2026; growing at a CAGR of 6.5% [1-3]. Furthermore, the global self-adhesive labels market size is projected to grow from USD 46.5 billion in 2020 to USD 59.2 billion by 2025, at a CAGR of 4.9% [4]. With the expanding pool of brand choices in the FMCG Industry, brand managers and designers are searching for ways to attract customers to their respective brands. Flexography printing is a widely used process for label printing as it provides high quality prints and consistent color reproduction at a high press speed. Color is the most crucial aspect of any label or package as it grabs the attention of the customer and plays a very important role in building the brand identity. Brand owners need harmonization of colors on variety of substrates for their applications to convey brand equity accurately to the consumers worldwide. Colors used in packaging of the product contribute the highest percentage to the buying decision of consumers. The usage of spot colors along with process colors contribute in brand building but leads to increased inventory, wastage and cost. Expanded Color Gamut (ECG) or Expanded Gamut printing (EGP) is a cost-effective way of ensuring color consistency with reduced inventory and wastage of ink and substrate. The graphic reproduction with ECG is eye-catching than traditional package and guarantees an increased inclination of the consumers towards the purchase of the product. The printing method employs a fixed color palette with four process colors namely CMYK along with three colors OGV to reproduce maximum number of Pantone shades with wider color gamut and hue stability. However, the expanded gamut softwares evaluation shows no direct relationship between increased number of patches and accuracy of the software's transform [5-7]. Extended Gamut Printing with mono pigmented inks having smaller pigment size results in higher gamut as compared to bi-pigmented inks. The selection of correct ink sequence is also critical for ink trapping, dot reproduction and expansion of color gamut [8-9]. The shift from CMYK to CMYKOGV gamut printing increases the chromaticity to a larger extent that plays a huge role in buying decision of the customer indicating a positive impact on brand management [10]. Stochastic screening provides a higher gamut volume and reproduces images having high contrast without moire pattern [11]. There has been several approaches for calculating gamut volume, gamut prediction and gamut comparison between two devices. The replacement of spot colors with 7-color Expanded Gamut Printing effectively saves time, cost and material [12-13]. ECG involves digital pre-mixing of inks in pre-press rather than ink mixing in the ink kitchen so as to accurately match most of the Brand and Pantone® colors. The ink sets (CMYKOGV), process control and profiles are different than the conventional CMYK; hence ISO 20654 standard was developed for Spot Color Tone Value (SCTV) reproduction. It also comes with some challenges that include moiré effect and registration [14-19]. EGP offers various benefits like gang-up runs, fast changeovers, spot color reproduction accuracy, press optimization, increased productivity with fixed press stations and minimizes the job changeover time, initial wastage of inks, substrate and printed stock. This leads to overall less waste generation and reduced carbon footprint. Thus, the implementation of Expanded Color Gamut in Flexography is ideal for brands in terms of improving their customer base, product sales and ultimately brand recognition [20-25].

## 2 Method and Material

### 1.1 Substrate and Inks

The substrate used for this project was 131μm white polypropylene self-adhesive label stock. The structure of the label included 61μm Bi-axially Oriented Polypropylene face stock, 52μm white glassine liner and 18μm water borne acrylic adhesive to bond between the two layers. A Siegwerk 39-8 I 05 Series UV based CMYKOGV inks were used for surface printing. The ink viscosity was ranging between 0.7 Pas to 1.3 Pas for CMYKOGV.

### 1.2 Plate and Anilox

Kodak Flexcel NX having a thickness of 1.14 mm with standard flat top dot was used for all the runs. A medium hardness backing tape of 0.38 mm thickness was employed for the experiments. The screen angles for CMYKOGV were 82.5˚, 52.5˚, 7.5˚, 22.5˚, 82.5˚, 52.5˚ and 22.5˚ respectively at 133, 150 and 175 LPI plate screen ruling. Traditional anilox rollers having 60˚ hexagonal cell structure ranging from 1000 LPI to 700 LPI anilox screen ruling with volume of 1.94 BCM to 3.4 BCM were used.

## 3 Experimental Process

The print runs were conducted on a narrow web flexography press FB - 430 at 80 m/min and categorized as Initial Run, Optimization Run, Fingerprinting Run, Characterization Run and Verification Run. The layout (Fig. 1) for Initial Run (310 mm x 300 mm size) comprising of bearer marks with registration marks, slur target, step wedge from 0.2% to 100%. pressSIGN control bar was designed for 133 LPI, 150 LPI and 175 LPI.

The purpose of Initial Run was to identify the sweet spot between plate and anilox screening parameters based on aims and tolerances of L*a*b* C, h as per Idealliance® ECG guidelines [26]. The dot structure analysis was carried out for CMYK with AM screening while OGV with both AM and FM screening. The densitometry and colorimetric measurements

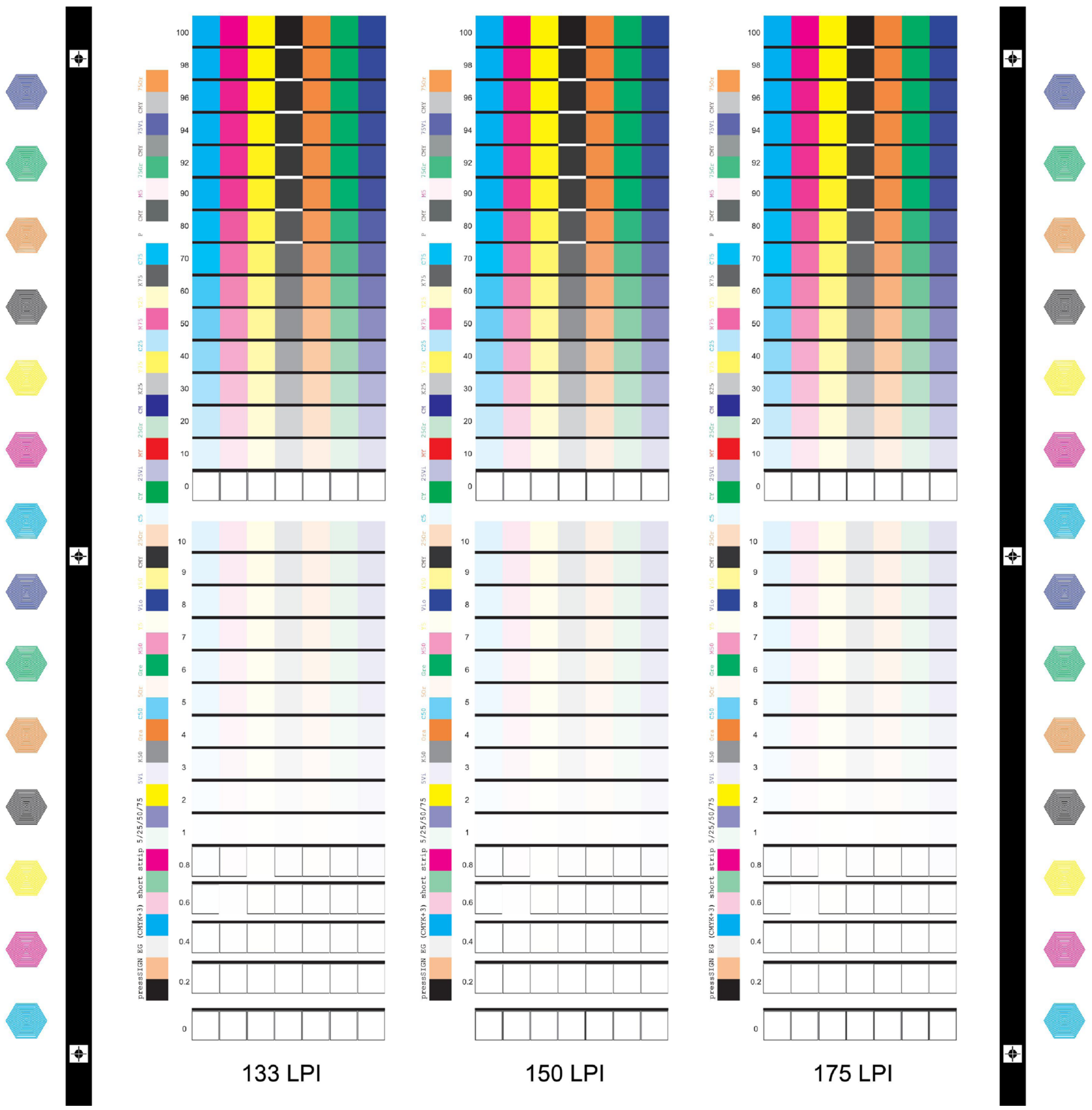


**Fig. 1: Layout Design for the Initial Run**

were done using Techkon SpectroDens with M1 measurement mode under D50 illuminant and 2° observer angle. Optimization Run was conducted with the identified plate and anilox profile from Initial Run. G7 calibration was performed for CMYK while SCTV for OGV as per ISO 20654: 2017 [27]. The samples were evaluated on solids, overprints and checked for tonality and gray balance from the P2P51 X chart. Based on the tonality and grey balance, the wanted values were generated and Neutral Print Density Curves were plotted for CMYK and Spot Color Tone Value curves for OGV. The calibration curves were generated and applied to the new set of plates for the Fingerprinting Run in PACKZ software. The tonality and grey balance were confirmed in this run. Characterization Run was conducted by printing the CMYKOGV test form comprising of varying patches generated in CGS ORIS X-GAMUT 4.0 and measured by the i1 Pro 2 device to generate the profile. The gamut volume of CMYKOGV profile was compared to CRPC6 (CMYK) profile. Finally Verification Run with customized test chart of 799 Pantone® Plus Solid Coated (Fig. 2) was printed and identified for the magnitude of the match for the Pantone® colors.

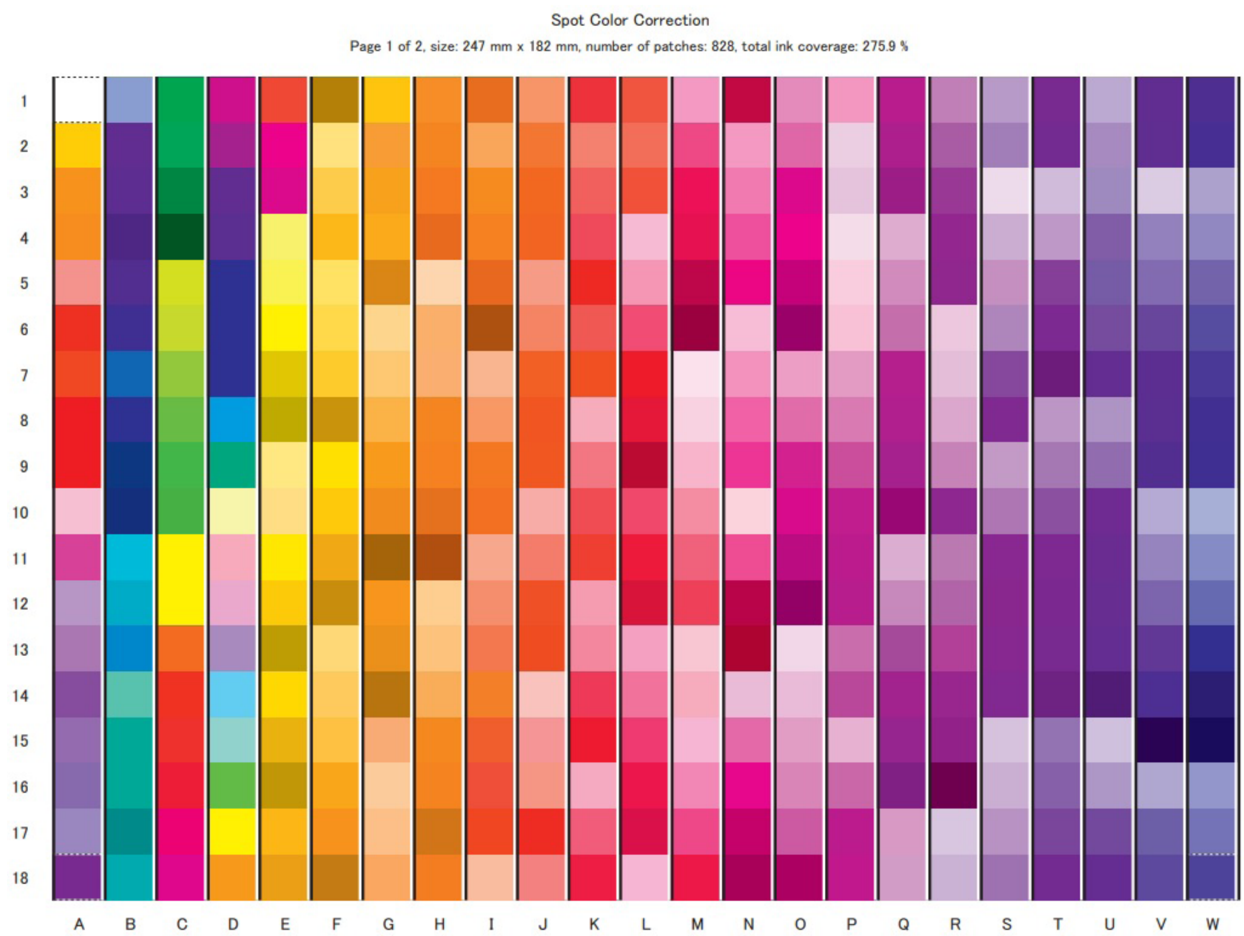


**Fig. 2: Layout Design (Page 1) for the Verification Run**

## 4 Results and Analysis

### 4.1 Dot Structure Analysis

The printed dots for CMYK were captured at 50% with Dinolite Microscope at 200 X magnification. A muddy pattern with uneven spacing between the dots was observed at 133 LPI for CMYK (Fig. 3) due to coarser plate line screen. The dot sharpness improved as the plate line screen increased to 175 LPI. Similar results were observed for OGV (Fig. 4) for both AM screening. A higher dot gain with dot bridging problem was observed for FM screening as compared to AM screening. The dot circularity also referred to as roundness for CMYKOGV was higher at 175 LPI than 133 LPI and 150 LPI. The dot roundness was calculated in ImageJ software that showed the circularity ranging from 0.82 to 0.89 for CMYKOG while 0.64 for Violet.

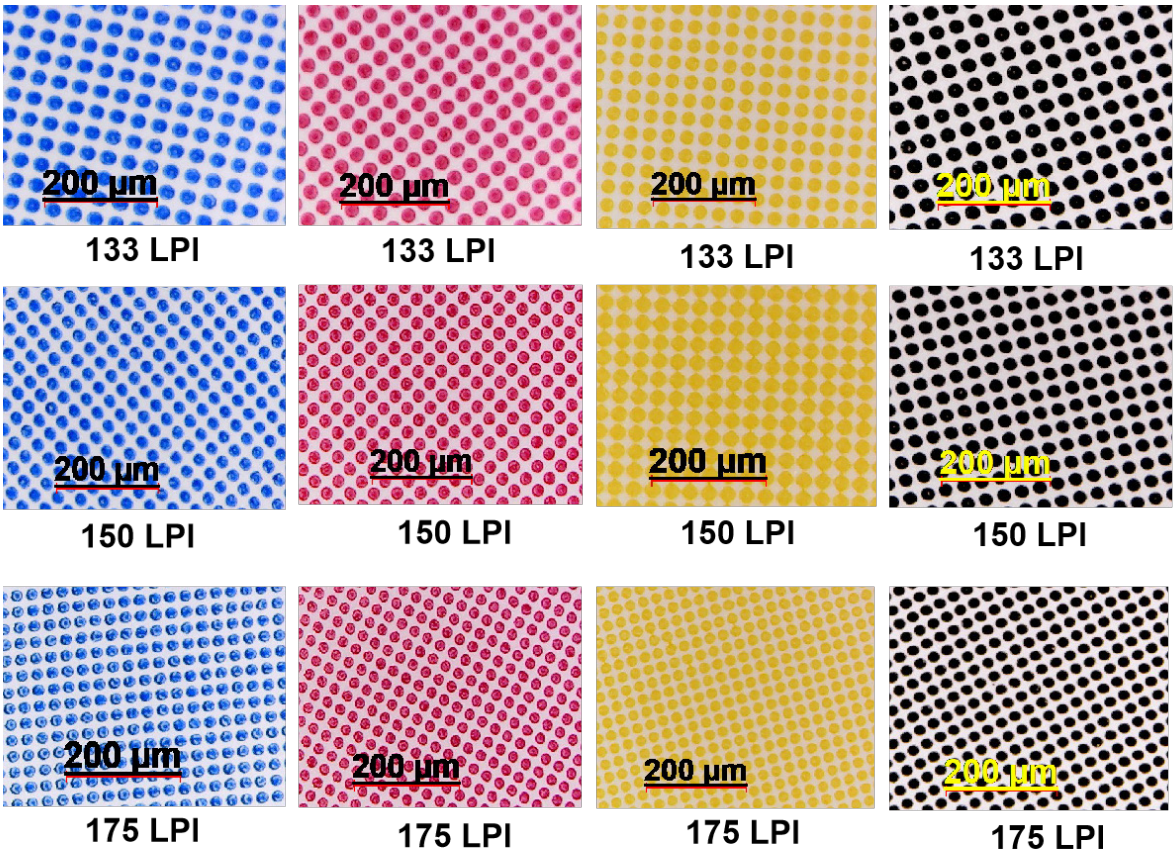


**Fig. 3: Dot structure for CMYK at varying plate resolutions**

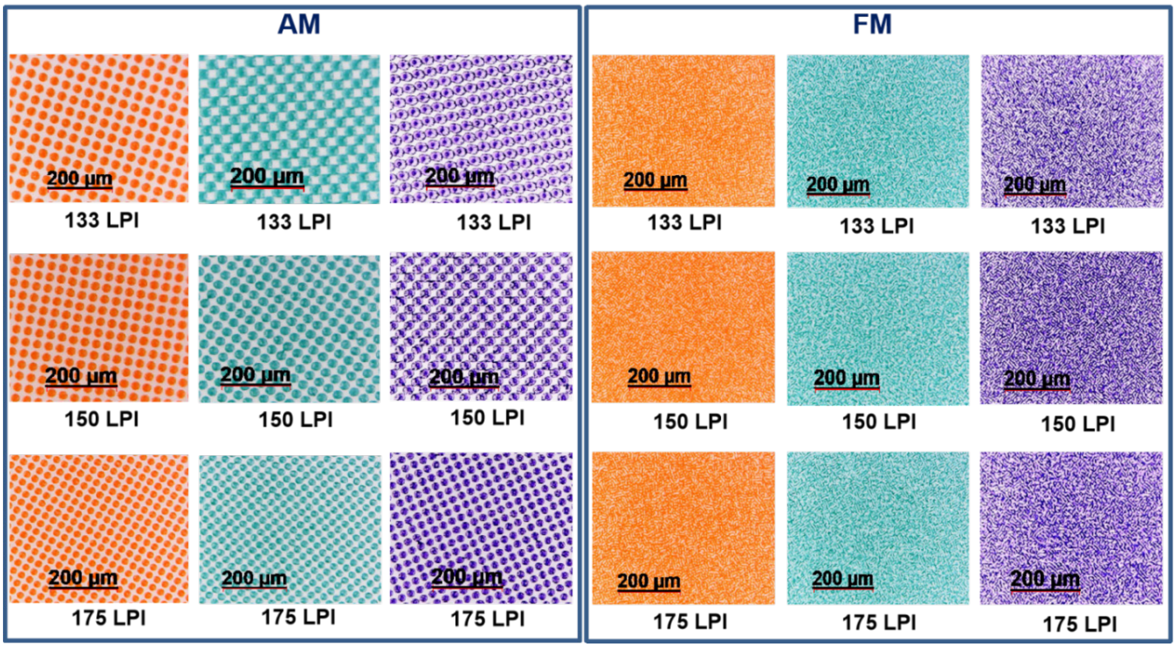


**Fig. 4: Dot structure for OGV at varying plate resolution of AM and FM**

## 4.2 Initial Run

The printed samples were evaluated based on L* a* b*, Chroma and Hue and were in close accordance to Idealliance® specifications for XCMYKOGV with a tolerance of dE00 ≤ 3.5 for CMYOGV and dE00 ≤ 5 for K (Table 1).

The measured chroma and hue values for CMYKOGV were in close agreement with the target (Table 2). Thus, on the basis of aims and tolerances as per Idealliance® specifications and dot reproduction, 175 LPI plate screen ruling fulfilled all the requirements and hence considered for furthers runs.

**Table 1: Targeted and measured L* a* b* and dE00**

| S. No. | Ink | L* (Target) | a* (Target) | b* (Target) | L* (Measured) | a* (Measured) | b* (Measured) | $\Delta E_{00}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | Cyan | 49 | -31 | -59 | 50.3 | -34.3 | -55.7 | **2.2** |
| 2 | Magenta | 45 | 79 | 9 | 42.89 | 85.11 | 12.12 | **2.57** |
| 3 | Yellow | 90 | -5 | 103 | 89.2 | -3.1 | 104.7 | **1.15** |
| 4 | Black | 10 | 0 | 0 | 14.4 | 0.2 | 1.1 | **3.04** |
| 5 | Orange | 70 | 55 | 82 | 70.5 | 52.8 | 81.3 | **0.92** |
| 6 | Green | 66 | -73 | -1 | 64.5 | -71.6 | 0.9 | **1.61** |
| 7 | Violet | 24 | 46 | -57 | 24.3 | 49.8 | -59 | **1.22** |

**Table 2: Targeted and Measured Chroma and Hue**

| S. No. | Ink | Chroma (Target) | Chroma (Measured) | Hue (Target) | Hue (Measured) |
|---|---|---|---|---|---|
| 1 | Cyan | 66.6 | 65.5 | 242.3 | 240.4 |
| 2 | Magenta | 79.5 | 85.9 | 6.5 | 8.1 |
| 3 | Yellow | 103.1 | 104.7 | 92.8 | 91.7 |
| 4 | Black | - | - | - | - |
| 5 | Orange | 98.7 | 96.9 | 56.1 | 57 |
| 6 | Green | 73 | 71.6 | 180.8 | 179.2 |
| 7 | Violet | 73.2 | 77.2 | 308.9 | 310.2 |

## 4.3 Optimization Run

The P2P chart was measured using Techkon SpectroDens with M1 measurement mode at D50 and $2^0$ observer angle for L* a* b*, Chroma and Hue values for CMYKRGB as per G7 tolerances (dE00 ≤ 3.5 for CMY, dE00 ≤ 5 for K and dE00 ≤ 4.2 for RGB). It was observed that CMYKRGB and OGV were below the Idealliance® specifications tolerance for XCMYKOGV.

**Table 3: Color Deviation between Target and Sample for Optimization Run**

| | Sample | | | | Target | | | dE00 |
|---|---|---|---|---|---|---|---|---|
| | Dens | L* | a* | b* | L* | a* | b* | |
| S | 0.08 | 94.21 | -0.97 | -0.12 | 94.21 | -0.97 | -0.12 | **0.00** |
| C | 1.91 | 48.91 | -36.27 | -56.37 | 48.34 | -32.48 | -56.84 | **1.49** |
| M | 1.56 | 45.83 | 75.04 | 8.20 | 45.43 | 77.95 | 6.60 | **1.06** |
| Y | 1.33 | 89.01 | -0.68 | 109.35 | 88.92 | -4.98 | 105.57 | **2.28** |
| K | 1.87 | 11.96 | 0.29 | 1.54 | 7.42 | 0.11 | -0.27 | **3.35** |
| R | | 45.72 | 72.31 | 59.99 | 45.45 | 71.39 | 55.96 | **1.45** |
| G | | 40.89 | -74.63 | 32.3 | 41.66 | -72 | 25.36 | **2.54** |
| B | | 17.19 | 16.38 | -44.67 | 18.51 | 17.82 | -48.02 | **1.37** |
| O | | 69.66 | 56.07 | 88.94 | 70.00 | 55.00 | 82.00 | **1.89** |
| G | | 65.02 | -73.73 | -0.23 | 66.00 | -73.00 | -1.00 | **0.90** |
| V | | 22.24 | 47.6 | -59.27 | 24.00 | 46.00 | -57.00 | **1.41** |

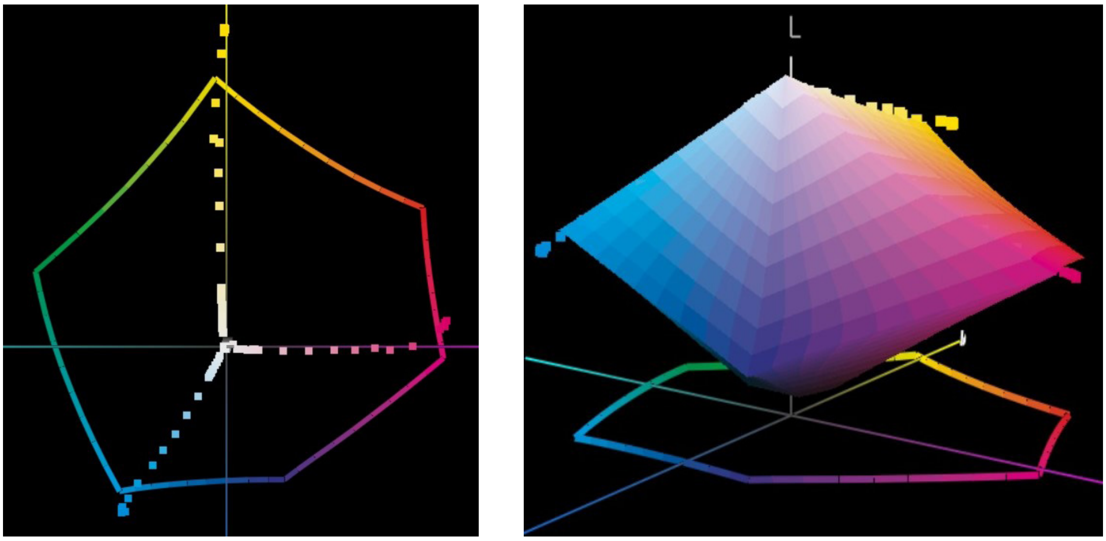


Fig. 5: 2D Plot (l) and 3D Plot (r) of Optimization Run (CMYK) Vs. CRPC 6 GRACoL 2013 Profile

The P2P 51X chart for CMYK was then measured with X -Rite i1 Pro 2 to generate the wanted values. The curves for CMYK was compensated based on Neutral Print Density Curve (NPDC) while OGV on the basis of SCTV. The generated compensated curves were used to prepare the plates for Fingerprinting run. It is seen from 2D and 3D plot (Fig. 5) that the measured L*a*b* values of CMYK from Optimization Run falls outside CRPC 6 GRACoL 2013 profile; hence accomplishment of XCMYK. Thus, XCMYK provided larger gamut without adding any primary inks to CMYK [28].

## 4.4 Fingerprinting Run

The aims and tolerance for CMYKOGV was confirmed. The tonality and gray balance was also verified in Fingerprinting run. The measured tone values for OGV of Fingerprinting Run after calibration exhibited

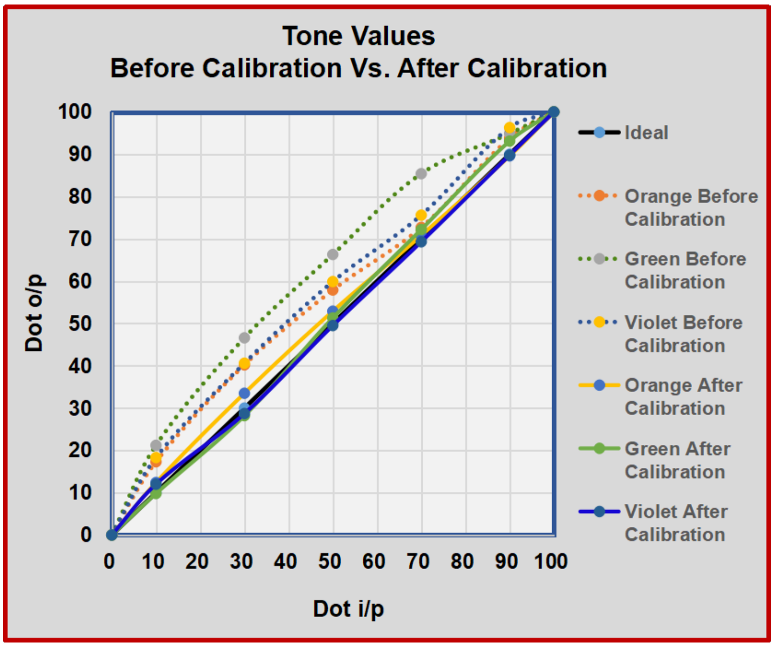


Fig. 6: Tone Values Before Calibration Vs. After Calibration.

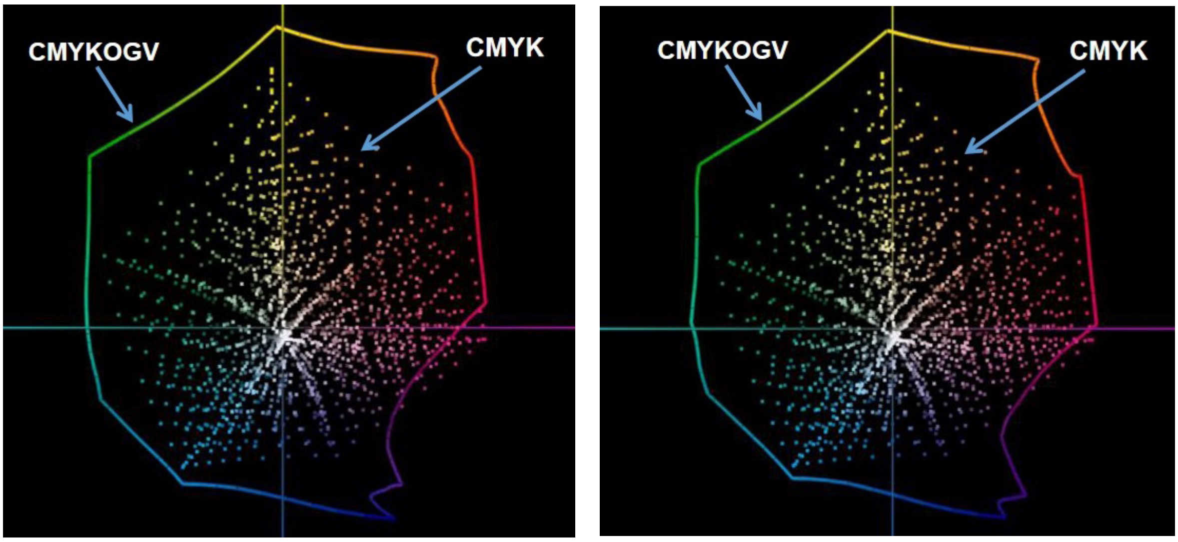


**Fig. 7: Gamut Comparison between CMYK and CMYKOGV with 728 patches (left) and 2016 patches (right)**

linear behavior than Optimization Run before calibration, thus indicating successful calibration of OGV (Fig. 6).

## 4.5 Characterization Run

A customized CMYKOGV test chart was created in CGS ORIS X-GAMUT 4.0 with 728 patches and measured by the i1 Pro 2 device to generate the profile. The comparison of gamut volume between CMYKOGV profile and CRPC6 (CMYK) profile showed an increase of 54% in CMYKOGV (596,830) than CMYK (389,309). However, there exists large no. of CMYK patches falling outside CMYKOGV profile between Red and Blue quadrant. Hence, a new CMYKOGV test chart with 2016 patches was generated and measured. An increase in no. of patches from 728 to 2016 although resulted in increase in gamut volume (639,380) up to 64% but still some of the CMYK patches fall outside CMYKOGV profile. This indicates that there is no direct relationship between increased number of patches and coverage of CMYK profile falling inside the CMYKOGV profile.

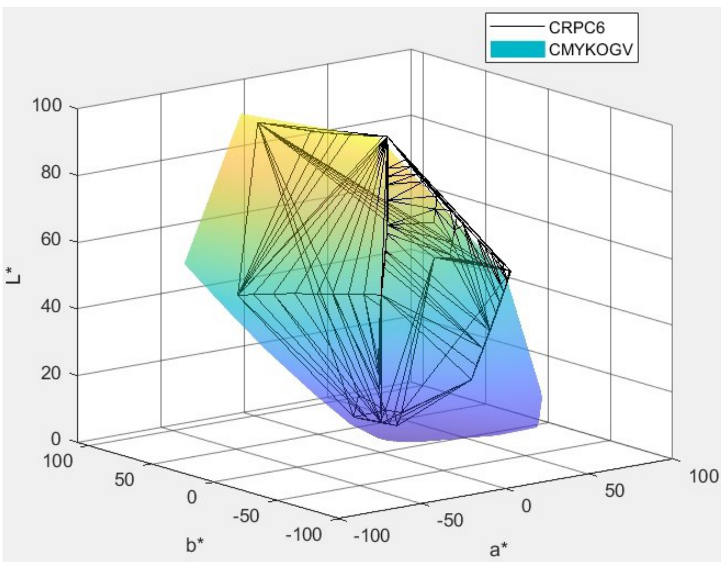


**Fig. 8: Gamut for CMYK and CMYKOGV**

### 3.6 Verification Run

The run included printing 799 Pantone Solid Plus Coated colors from the digital library. A total of 320 Pantone colors fall inside CMYKOGV Gamut and Outside CRPC6 Gamut (Fig. 8). Among 320 Pantone colors, 271 colors reproduced dE00 < 2.5 dE00, hence achievement of 85% of color match.

## 5 Conclusion

This experimental study was focused on evaluating the magnitude of match for spot color reproduction using Extended Gamut Printing on Nilpeter FB-430 narrow web flexography press. The gamut plot shows a significant increase in the volume by 64% for CMYKOGV as compared to CMYK profile. The gamut analysis revealed 85% magnitude of match of Pantone Solid Plus Coated colors with dE00 <2.5 on a Nilpeter FB-430 Narrow web press.

The outcomes of this study shall encourage the converters to shift from traditional four color CMYK printing to fixed seven color CMYKOGV printing. Implementation of Extended Gamut Printing shall benefit the converters in a significant way by reducing the setup time, overall wastage of inks, substrate and production cost. It shall help to optimize the process; thereby increasing the efficiency of the press and overall profit to an organization.

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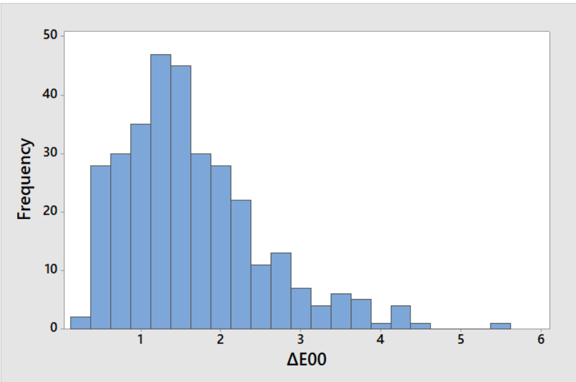


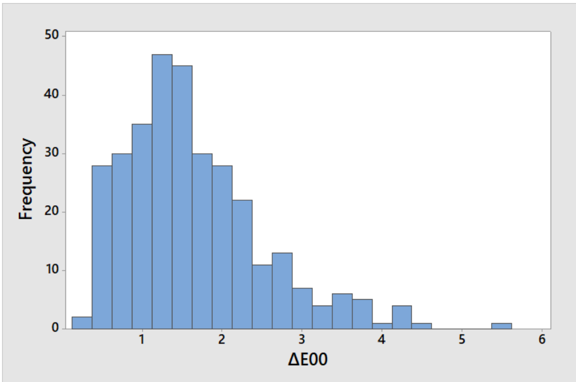

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