A Digital Test Form for ICC-profiles

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Keyword: Communication, Conversion, Education, ICC, Separation.

Abstract

The majority of Swedish offset printers use color management in order to control color reproduction in their daily production. However, there is a lack of understanding of how well the profiles support agreement among color units. Several parameters in the construction and use of a profile affect the final color result. Print production using ICC-profiles demands a better teamwork in the process. The use of non-dedicated printer profiles may cause a less than optimal end-result. Pedagogic color tools can help the user to understand how well a specific profile defines the color gamut of a digital/analogue printing press.

This paper presents an approach to visualizing how well printer profile parameters are defined in the construction of the ICC-profile. The application Adobe Photoshop ® has been used for profile evaluation because of its widespread use in the graphic arts field. A digital test form has been produced consisting of color test targets and images. This digital test form gives information about: affect of using different color gamuts, total ink coverage, the level of achromatic reproduction, effect on different tones, comparison between different print profiles and the ISO standard, and comparison between different print profiles concerning different variable settings.

This digital test form for ICC-profiles has been evaluated by three independent graphic arts consultants who work with the implementation of ICC-based production. The result of this evaluation is a recommendation for the printers to use this digital test form to increase awareness of the influence of ICC-profiles on the print.

Background

An increasing number of graphic arts companies use ICC-based color reproduction. The companies either create their own printer profiles, or

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hire consultants for the profile creation. A survey done 2003/2004 by Emmi Enoksson ("Image Reproduction Practices", TAGA 2004) showed that 70 percent of the Swedish sheet fed offset printers need the assistance of a consultant in the ICC-profile creation process. The choice of software tool plus the software specific separation settings are also made by consultants. Printers/prepress houses have difficulties to adjust specific parameter settings in the profile creation, due to insufficient color management skills. The survey proves a need for pedagogic tools in order for the user to better understand one's process.

All graphic terms and techniques set high demands on the user at printers and prepress departments. Which separation setting is optimal? Often printers receive their ICC-profiles from color consultants without knowing in what way the separations were set and how the printed result is affected by the chosen settings.

Objective

The purpose of this study was to create a digital test form using the most common color imaging software on the market - Adobe Photoshop. The goal of the test form is to facilitate the practical understanding of profiles and their use, but also to explain the differences between the separation choices, GCR (Gray Component Replacement) and UCR (Under Color Removal).

Method

The project focus was to find a suitable mix of images and test areas in order to point out the differences in color spaces, out of gamut colors, color renderings and separations in a simple and pedagogic way. A number of applications have been tested for the creation of the test form. Adobe Illustrator 10,0 and Adobe Photoshop 7.0 were the final choice for the work. Eight graphic consultants, three printers and their customers have been acting as a testpanel in order to evaluate the created test form.

The test form is aimed to be used in Adobe Photoshop, since this application is most widely used for color imaging in Sweden.

Print profiles are ISO standardized and were downloaded from the Internet, www.eci.org. Measurement data from these profiles constitute the base for new profile creations with alternative settings. These new profiles were tested by using the created digital test. ProfileMaker 5.0 from Gretag

Macbeth and PrintOpen 4.1 from Heidelberg were the applications used for the profile creation. The standardized color space ECI-RGB was chosen as the working space in Adobe Photoshop 7.0.

Limitations

The profile creation only applies to output profiles, i.e. profiles for print reproduction. The offset technique was studied as the only printing method since UCR (Under Color Removal) and GCR (Gray Component replacement) are frequently used in this method, mainly because offset creates the need to control ink film thickness in high coverage color areas.

Today's print adaptation

The development of digital cameras has increased the number of RGB-images handled and thereby significantly decreased the use of image scanners at the printers. Printers' customers send more and more images in the RGB-color mode, but also in the CMYK-color mode for final print. To make a pre-evaluation by soft proofing the final print, the print customers need the print profile (ICC-profile). By using this ICC-profile, an image in the RGB-color mode can be converted to the Cyan, Magenta, Yellow and black (K-key color) printing inks. This color conversion is often implemented in Adobe Photoshop. ICC-profiles contain information about: type of separation, color rendering, black start, black width and total dot area. These terms and settings still concern users since few of them understand the real meaning of these functions and how the settings affect the end result.

The digital test form

To better understand how the profile settings can affect the result, a digital test form has been developed in order to pre-evaluate the result on a monitor. The layout of test form facilitates the practical understanding by visualizing the result from a color conversion RGB to CMYK using a profile. The test form is made by using Adobe Illustrator 10.0 and Adobe Photoshop 7.0.

The basic model is made from a number of color patches forming a uniform matrix pattern (Figure 1). The matrix construction was created in Adobe Illustrator and Adobe Photoshop. The test form is built in the RGB-color mode, using the standardized color working space, ECI-RGB. To achieve an even distribution of lightness and saturation in the matrix, the

HSB (Hue, Saturation and Brightness) color model was chosen. Moving from one patch to the next represents a change in saturation and lightness by ten percent (Appendix). The colors red and cyan, green and magenta, blue and yellow are confronted to each other as a result of their relationship as complement colors. The center point of the model holds a gray scale built from equal amounts of red, green and blue parts in the RGB-mode. The base model contains information about the total ink coverage (%) and control of color cast. Each matrix has been complemented with a color wise corresponding image to enhance the color conversion change. These images have also been divided into a mosaic pattern to enable measurements directly on the images.

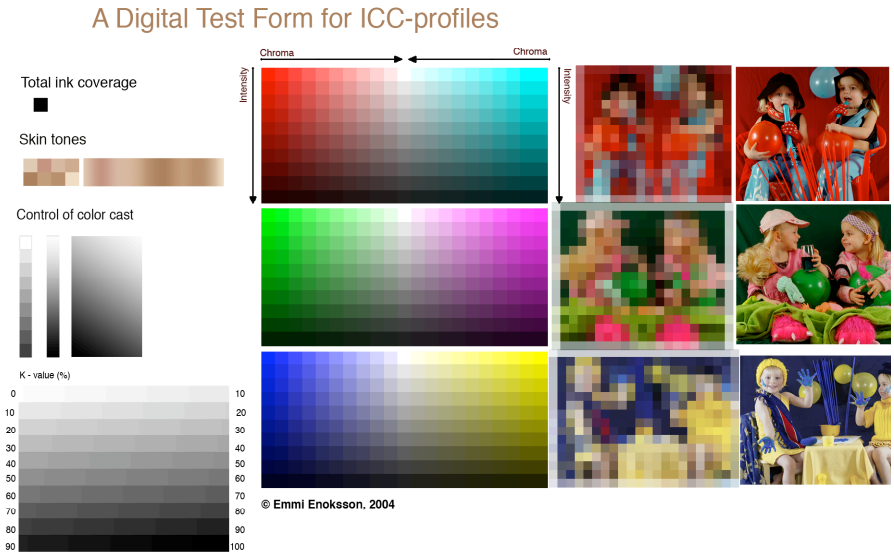


Figure 1: The digital test form layout.

The digital test form was complemented with luminance circles describing the LAB-color space in five lightness levels. The base circle was created in Adobe Illustrator 10.0 and the lightness levels were created in Adobe Photoshop 7.0 (Figure 2). The working space is the standardized color space ECI-RGB.

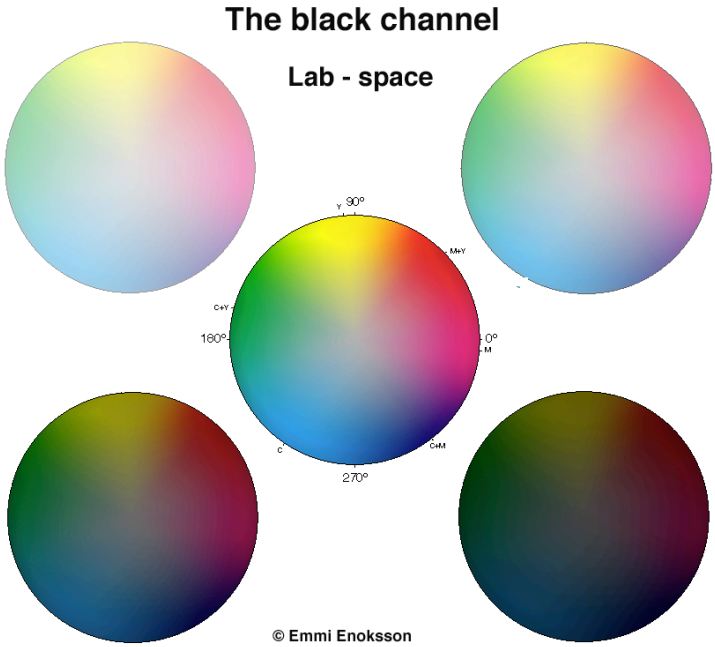


Figure 2: Five lightness levels – Lab-color gamut.

The use of the digital test form:

This digital test form can give information about:

1) differences between color gamuts, e.g. ECI RGB, ColorMatch, AdobeRGB
2) total ink coverage
3) the level of achromatic reproduction, GCR, UCR (Gray Component Replacement, Under Color Removal)
4) effect on different tones, eg. skin tones
5) comparison between different print profiles and the ISO standard - gamut warning
6) gamut mapping
7) different rendering methods
8) chroma shift when converting to CMYK
9) control of gray balance
10) control of color settings in the applications - ProfileMaker and PrintOpen

Differences between color gamuts, e.g. ECI-RGB and ColorMatch

It is not certain that all users are aware of how the working spaces function in Adobe Photoshop. The color conversion from RGB to CMYK is affected by the choice of working space activated in the application. The gamut sizes of these working spaces differ from each other, which affects the color conversion (Figure 3). Adobe Photoshop 7.0 offers two ways of choosing a working space: Assign Profile and Convert to Profile. When using the function, Assign Profile, the RGB-values are the same for all working spaces, but the visual color appearance differs significantly among them (Figure 4). By using this test form with different working spaces, color appearance and separation can be evaluated. Figure 5 shows color conversions from RGB to CMYK using the same output profile (ISO coated) by using RGB-values from different working spaces; the commonly used function Assign Profile was used. However, the function Convert to Profile should be used for all conversion (from RGB to RGB, from RGB to CMYK) to avoid differences in color separation.

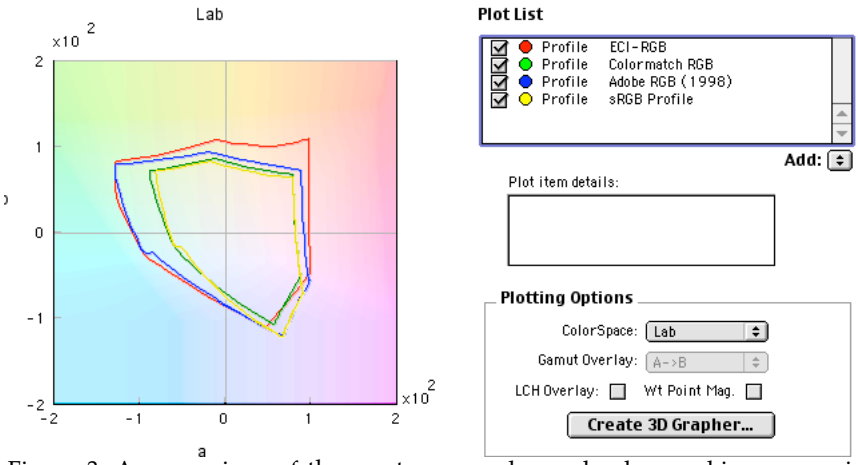


Figure 3: A comparison of the most commonly used color working spaces in Chromix Color Think application.

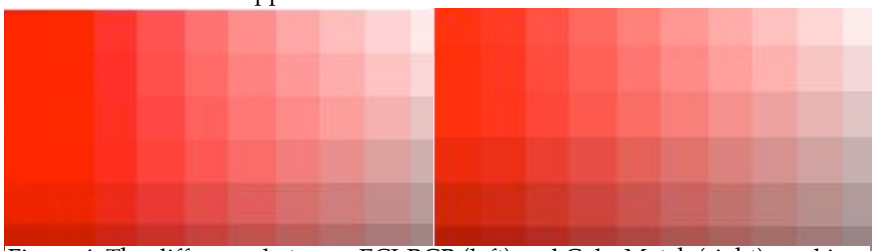


Figure 4: The difference between ECI-RGB (left) and ColorMatch (right) working spaces. The color areas have the same RGB-values in both examples, but we perceive them differently. The function Assign Profile was used because of the widespread use among customers.

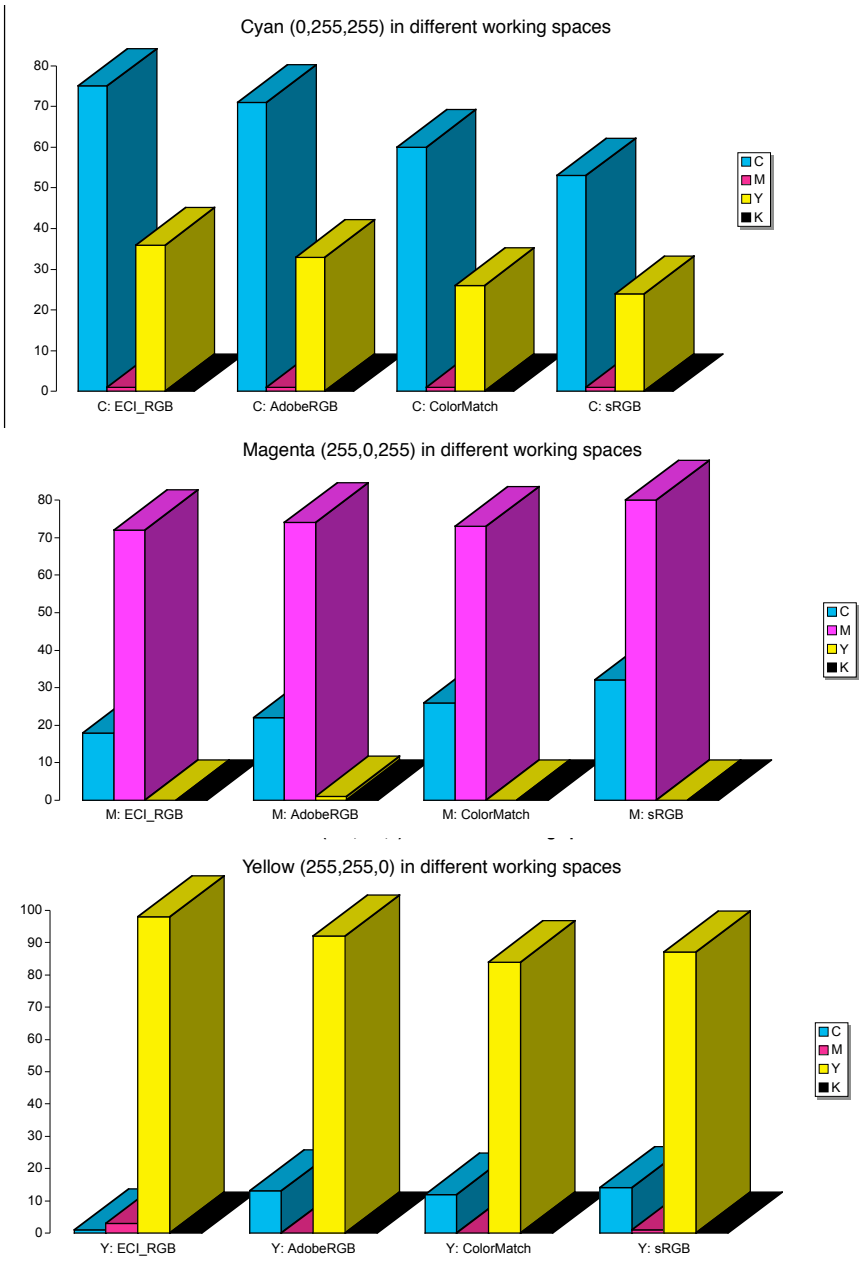


Figure 5: The graphs show the differences in color separation values for cyan, magenta and yellow after the conversion from RGB to CMYK by using respective RGB-working space (ECI-RGB, AdobeRGB, ColorMatch and sRGB). The conversion was performed with the profile, ISO Coated. The function Assign Profile was used when changing working space.

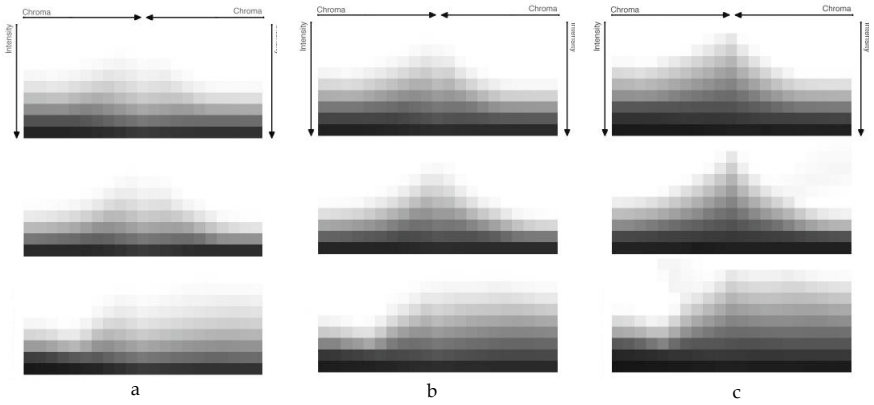
Total ink coverage (%)

The test form gives information about the total ink coverage in the profile (Figure 1). The total dot area is an important factor to take into consideration. A non-conforming total dot area can cause quality problems such as rub-off and set-off in print.

The level of achromatic reproduction, GCR, UCR (Gray Component Replacement, Under Color Removal)

The test form reveals in what way the black ink influences the image separation and the colors in an image. During the profile creation, two types of separations can be chosen: GCR or UCR. These separations can be combined with other functions in the profile making applications, such as black start and black width.

The test forms created in the RGB- and Lab-color modes can be converted to CMYK mode with an existing profile. Thereafter the black channel can be studied (in Adobe Photoshop) being equivalent to the black plate in print (Figure 6).



a b c

Figure 6: The black channel from the chroma matrix visualizes the black ink distribution for various levels of GCR in Adobe Photoshop (with perceptual rendering intent):

a) GCR medium, total ink limit 300, black limit 100 (standard),
b) GCR heavy, total ink limit 240, black limit 95
c) GCR max K, total ink limit 240, black limit 95

The evaluation of how the black ink influences an image can be complemented with the luminance circles being converted to CMYK-mode. This gives an overview in five different lightness levels (Figure 7).

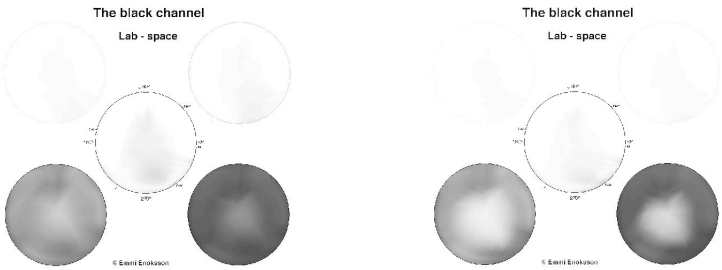


Figure 7: The black channel after the CMYK color conversion. The figure shows the difference between two separation methods: GCR (left) and UCR(right), perceptual rendering was chosen in both cases.
GCR level 3,0,280,95,100: 0=black start, 280=TIC, 95=black max, 100=black width
UCR,0,320,95,100 : 0=black start, 320=TIC, 95=black max, 100=black width
The profiles were created in ProfileMaker 5.0.

Effect on different tones, e.g. skin tones

Skin tones are affected in different ways depending on the separation used, which can be evaluated in the test form. Selected skin tones from portraits of people with varying skin color have been used in order to cover a wide spectrum of skin tones (Figure 8). Our eye is sensitive to even small hue changes in a reference color, such as a skin tone. After conversion with the printer's profile, the user can, for instance, check if the skin tones contain black ink.

Figure 8: Test areas of skin tones in the test form.

Comparison between different print profiles and the ISO standard concerning gamut warning

The test form can give the user information about differences between the profile tested and an ISO-standardized profile, for different paper stocks concerning gamut warning (Figure 9).

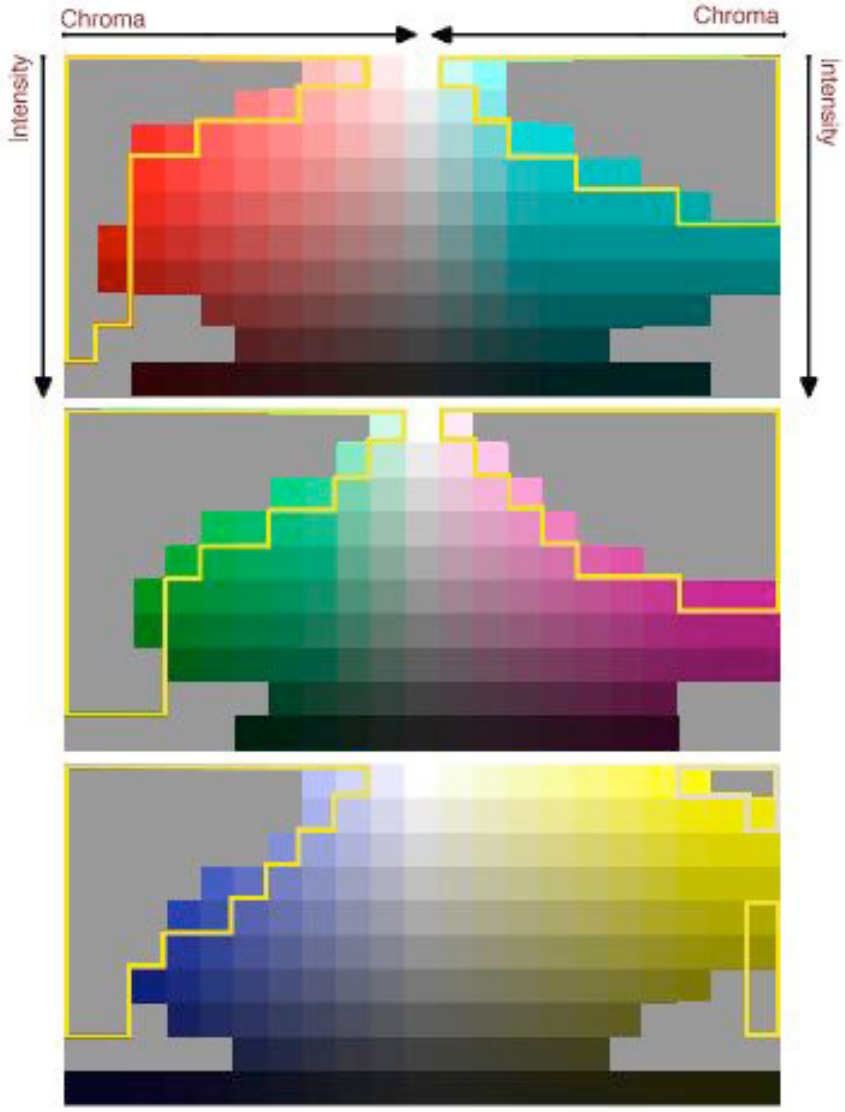


Figure 9: A comparison between the ISO profile (yellow line) and the tested profile (gray area). The Gamut Warning setting in Adobe Photoshop 7.0 is activated.

Gamut mapping

The most common application for profile creation in Sweden is Gretag Macbeth´s ProfileMaker. This application allows the user to choose gamut mapping (Figure 10). To better understand the differences in gamut mapping settings, a declaration part has been created with the test form (Figure 11).

Different gamut mappings - Gretag Macbeth´s ProfileMaker 5.0

- LOGO Colorful
- LOGO Chroma Plus
- LOGO Classic (default)

Figure 10: Different settings in ProfileMaker 5.0

Different rendering intents

When converting from RGB- to CMYK-mode in Adobe Photoshop, the user can decide which rendering intent to use (Figure 12). The rendering intent decides how a color management system handles the color conversion from one color gamut to another.

Converting colors to a different color space usually involves an adjustment of the colors to accommodate the gamut of the destination color space. Different translation methods use different rules to determine how the source colors are adjusted; for example, colors which fall inside the

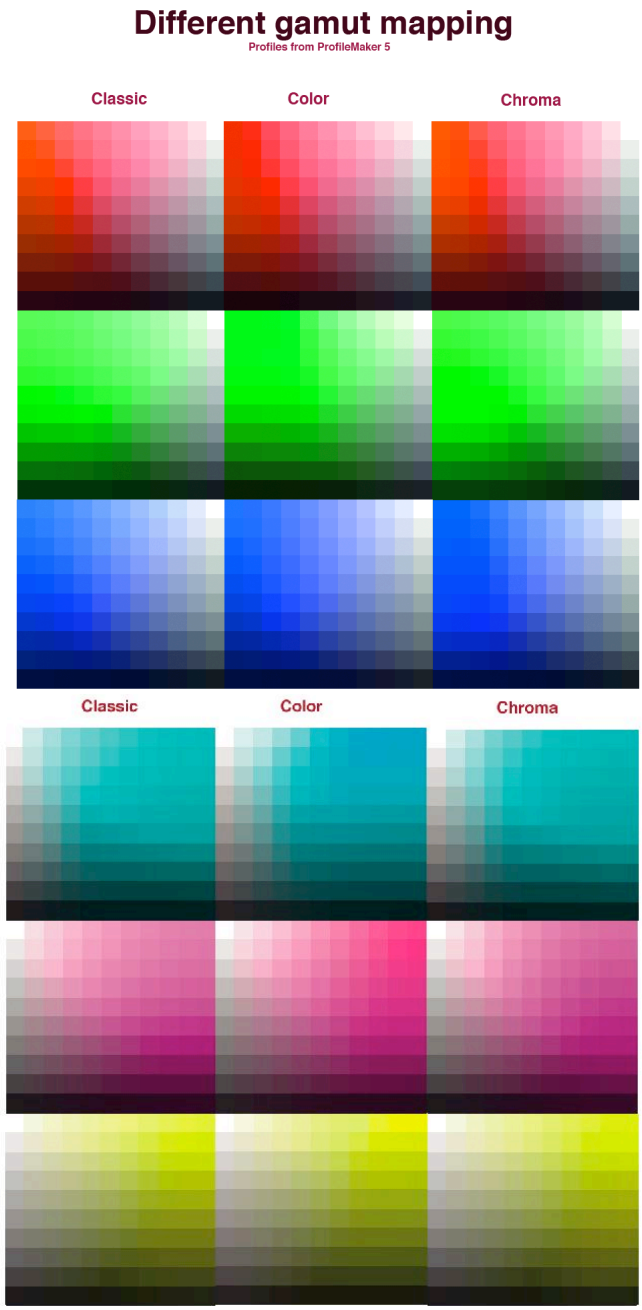


Figure 11: A higher chroma value can be seen for the gamut mappings Color and Chroma compared to the default setting Classic after conversion from the same RGB file. The only difference between the print profiles is the gamut mapping. ProfileMaker 5.0 was used for creation of the profile. Perceptual rendering intent was chosen in all cases.

destination gamut may remain unchanged, or they may be adjusted to preserve the original range of visual relationships as translated to a smaller destination gamut. These translation methods are known as rendering intents because each technique is optimized for a different intended use of color graphics (Manual Adobe Photoshop).

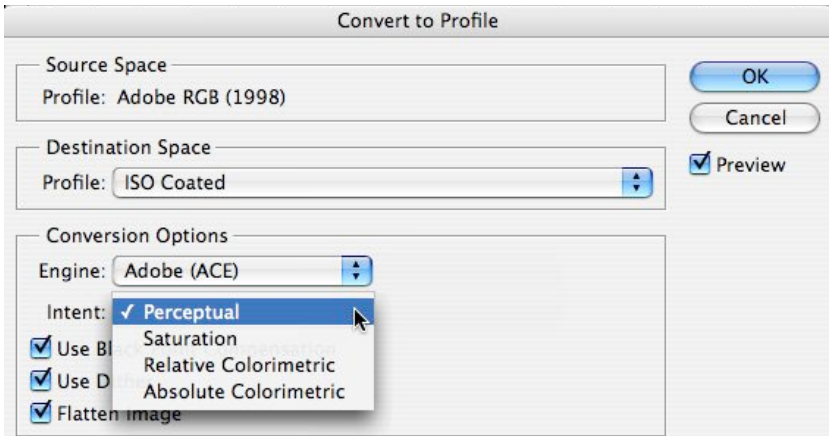


Figure 12: Adobe Photoshop's dialog window for setting the rendering intent.

Tests have been completed to better understand how the rendering options affects the image's colors. Two of the most commonly used rendering intents were used, perceptual (often used for photographic images) and relative (often used for proofing and CMYK-to-CMYK conversion), (Figure 13 and 14).

Perceptual aims to preserve the visual relationship between colors in a way which perceived as natural to the human eye, although the color values themselves may change. This intent is most suitable for photographic images (Manual Adobe Photoshop).

Relative rendering This intent is identical to Absolute Colorimetric except for the following difference: Relative Colorimetric compares the white point of the source color space to that of the destination color space and shifts all colors accordingly. (Manual Adobe Photoshop).

*C*hroma shift when converting to CMYK

When converting images from RGB color mode to CMYK, a chroma shift is often seen. Chroma shift is often hard to explain and prove to the customer. The test form will help to point out this already in the RGB color mode and avoid misunderstandings after print.

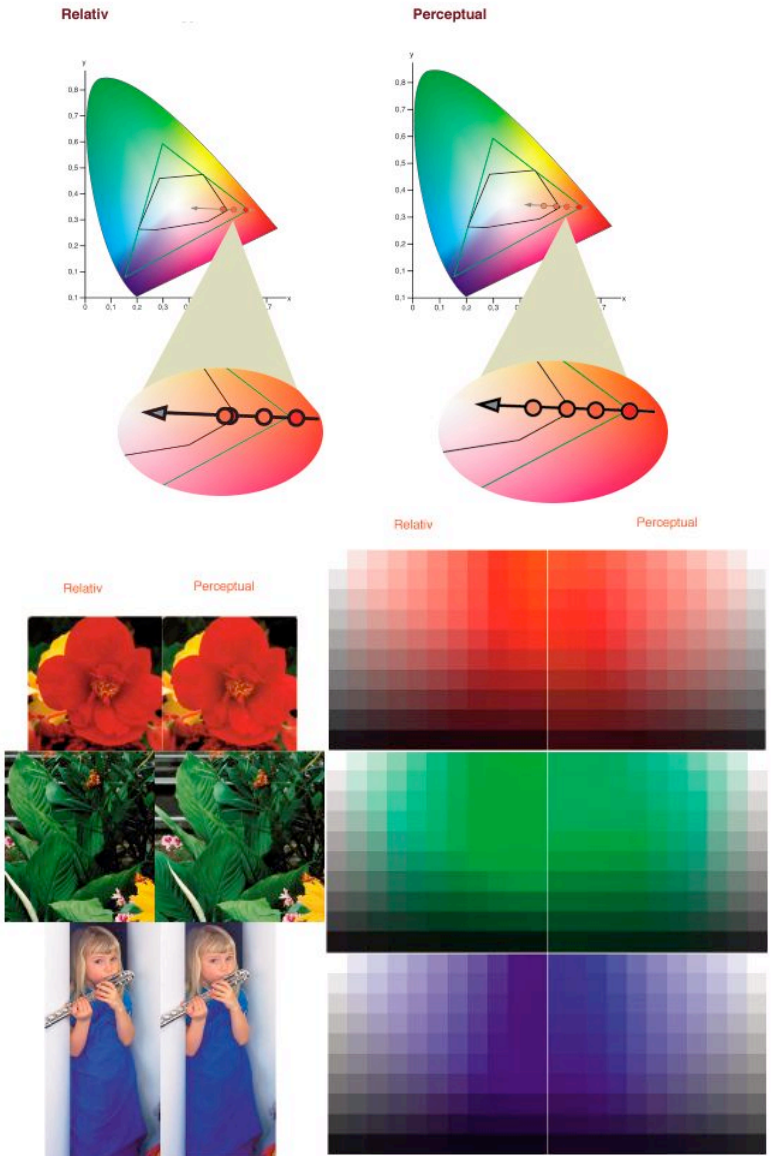


Figure 13 and 14: Explanation of relative and perceptual rendering.

A color with maximum chroma value in RGB-mode will not have the highest chroma value when converted into offset. Reasons for this are: high lightness level in RGB-mode, trapping in CMYK print, different gamut mappings, the spectral impurity in the color inks used (Figure 15).

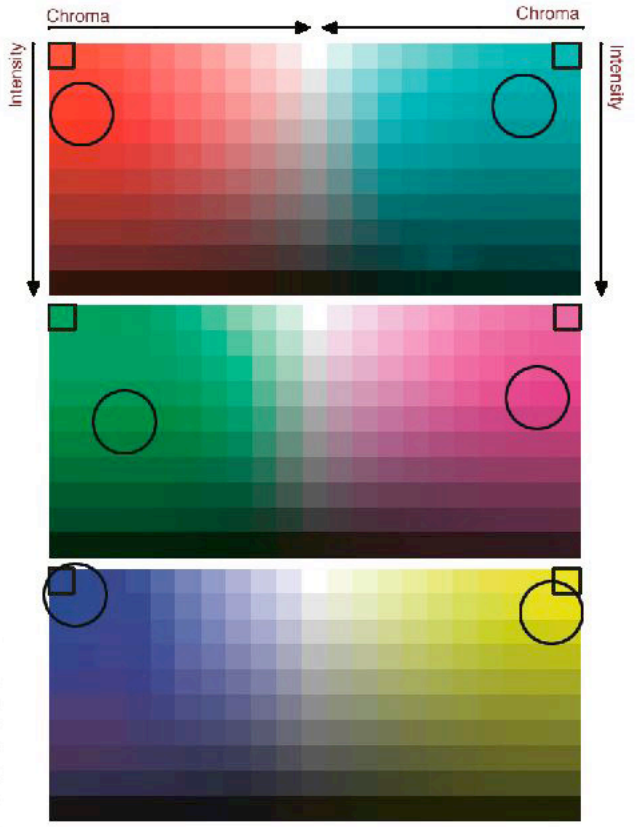


Figure 15: The upper left and right corners of the test form have the highest chroma-value in RGB-mode, marked with black square frames. After a CMYK-conversion, here with the ISO uncoated profile, a chroma shift can be seen (marked with black circles).

Control of gray balance

To achieve high print quality, gray balance is an important parameter and must be considered. An image printed with an inaccurate gray balance causes color cast and will affect the entire image. The balance between the dot percentage value of the three process colors must be reproduced neutrally in print from a neutral gray scale.

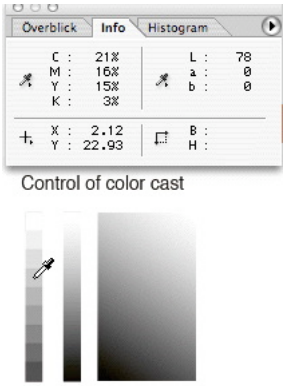
Theoretically the gray balance is built from equal parts of cyan, magenta and yellow. Since the printing inks have some unwanted absorptions, adaptions must be performed. To produce neutral tones, cyan must be printed with a higher percent value than magenta and yellow because of spectral impurity, especially in the cyan pigment. The 1/4-tone areas have

the smallest difference between cyan and the other colors. The major difference is in the midtones and decrease in the 3/4-tone areas. It is crucial, for the separation, to have control of the CMY-balance throughout the tone scale. This can prevent unwanted color shifts in the image.

According to ISO 12647-2 these values can be used:

	cyan	magenta	yellow
1/4-tone	25%	19% (18%)	19% (18%)
1/2-tone	50%	40% (40%)	40% (40%)
3/4-tone	75%	64% (64%)	64% (64%)

Suggested gray balance values according to ISO 12647-2. The figures in parenthesis are newspaper values according to ISO 12647-3



The test form helps the user to control the gray balance in a profile, by converting the test form into CMYK-mode by the profile. The CMYK-values can be controlled after the conversion. Lab-values can also indicate color casts (Figure 16).

Figure 16: Control of gray balance and color cast. The test form was separated into CMYK with an ISO-profile. After the separation, the CMYK-values (or LAB-values) can be verified.

Control of settings in different applications

Three folders, for different profile settings, have been created, to organize the settings in the profiling applications: ProfileMaker and PrintOpen.

In these folders, a set of functions for each application, can be found. The settings tested are:

- total ink coverage
- black start
- black width
- different separation settings

These settings were created with different values, so the company can validate optimum settings for the specific production. All profile data, created for this task, is ISO- profile data.

Evaluation

Eight graphic consultants, three printers and their customers have been contacted to evaluate this test form, both on screen and in printed form.

The contacted **consultants** work in the graphic arts industry with profile creation and internal courses at printers. The evaluation was done on a PowerBook G4 in Adobe Photoshop 7.0. The evaluation was complemented with a number of questions concerning profile specifications/settings and their effect on image perception. The most important settings in the profile creation were tested. Parameters such as working spaces, renderings, gamut warnings were also tested. The consultants had a positive attitude to this test form, quoted following:

"A good pedagogic tool, simplifying the explanation of graphic terms."

"Good, having all data in one test form, being used in different ways."

"I have for a long time been thinking about how to prove the fact of hue shifts in the image."

"There are several things in the test form, which I have not reflected upon how it affects the print."

The printers´ prepress representatives were contacted to evaluate the test form in respective computer environments. Prepress personnel do often test their own profiles on ordinary images which is difficult to analyze; parameters such as separation and black width can be hard to read from ordinary images. The simple and pedagogic way to visualize and analyze the profile's effect on the image appearance was appreciated by the prepress staff.

Both graphic consultants and printers appreciated this test form, which increased the knowledge in the subject color management, i.e. profile handling. Printers´ representatives have, in contact with their customers, experienced a better way to explain graphic terms with the test form as a mutual tool and thereby set a good base for discussions. The test form does not give the base information for the ICC-profile creation, which is a disadvantage with the test form.

Graphic terms (separations, hue shifts etc.) were explained to the printers' customers with the aid of this test form. Their positive judgement concerned the simple explanation and the direct visual result. Even customers use ordinary images for profile analyzing which makes it harder to analyze aspects other than image details. The test form contains parts of the color space not often seen in an image. This provides a way to predict how an image with another color distribution will appear in print.

The test print was performed in conventional sheetfed offset and gravure printing.

- three paper stocks were used for the sheetfed offset printing: LWC 90g/m^2, WFC 115 g/m^2 and WFU 80 g/m^2. The two color spaces' (Adobe RGB and ColorMatch) effect on the CMYK-values together with the Assign Profile function was evaluated. The purpose was to prove to the customers how different settings in Adobe Photoshop affect the result.
  Both the color spaces receive a decreased gradation, but Adobe RGBs higher chroma remains.

- The color rendering effects on the colors were tested in the gravure printing. The used was paper "EXO68" 49g/m^2.
  The result showed that a higher chroma remains for the relative rendering method. Both methods gave a decreased gradation. The choice between these two methods depends on the image. If a colorful image has many values outside the printer gamut, the perceptual rendering is best. However, if there is few data outside the printer gamut, the relative colorimetric method will probably produce a better print result in practise.

The evaluation result of the created test form:

- it is a pedagogic tool
- the test form covers a larger number of colors than ordinary images
- it is foreseeable
- it is manageable
- clear and easy in use
- good layout with all-important details in one page
- standard graphic applications can be used for evaluation

Conclusions

The developed digital test form fulfills the demands set by increasing the practical understanding in color management – ICC-profiles for print. All contacted participants in the graphic process appreciated the test form. Several participants wanted to use the test form for teaching purposes.

The user can control several important parameters in the graphic industry by using this test form. Different settings such as black start, black width and type of separation can be tested and the user can finally choose the best settings for the specific production. The user will have a better understanding of the effects these settings will have on an image.

The test form can be complemented with: a basic color theory, the origin of RGB and CMYK-colors, the ISO standard recommendations, e.g. gray balance values, and interactive functions to facilitate the learning process.

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References

Enoksson Emmi
2004 "Image Reproduction Practices"
TAGA Proceedings 2004

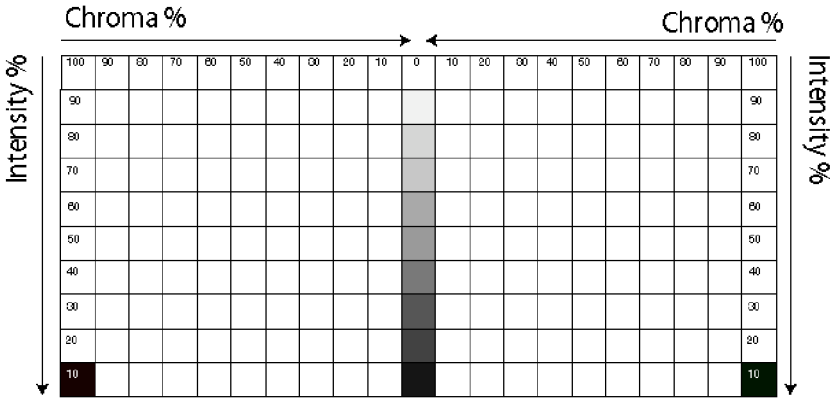
Field Gary G.
2004 "Color and Its Reproduction", Third Edition,
GATF *Press* Pittsburgh, USA

Sharma Abhay
2004 "Understanding Color Management"
Thomson Delmar Learning, USA

Proceedings of the 28th IARIGAI Research Conference
2001 "Advance in Color Reproduction"
GATF *Press* Pittsburgh, USA

Manuals from Adobe Photoshop 7.0, ProfileMaker 5.0 and PrintOpen 4.0

Appendix



Appendix: The digital test form setup. The x-axis represents the chroma level in ten percent steps. The y-axis represents the luminance level in ten percent steps.