G7 for every print device?

Martin Habekost, Vanessa Blum

Keywords: Inkjet, G7, gray balance, NPDC

Abstract

The G7 process is well known throughout the graphic arts industry and there are more than 800 print companies certified to be in compliance with the G7 process.

The G7 process is based on grey-balance control of the four-color printing process. This grey-balance is achieved through the Neutral print density curve (NPDC), which is used for determining the correct amount of cyan, magenta and yellow to achieve a neutral three-color grey depending on the printed ink density for black. The evaluation of achieving this grey balance can be done through the measurement of the P2P25X test target. This test target contains gradation scales for the four process colors and also for three-color grey.

G7 can be used for sheetfed printing, flexography and screen printing. The question that comes to mind is the following: Can the G7 process not only be applied to professional proofing systems, but also to small office/home office printers?

There is a vast number of home/small office printers on the market and many documents get printed in color, but the outcome is quite different from printer to printer. This study is aiming to see if it is possible to determine the feasibility to apply the G7 process to the small office/home office print market. Some of these printers are using 4 or more colors for printing any document. This could influence also the capabilities of the printer to be able to conform to the G7 process.

Some printers come with predefined pre-sets in regards to printing on different kinds of papers from plain office type paper to photo paper. It will be determined how close these predefined pre-sets are in regards to a neutral grey balance.

Besides using small office/home office inkjet printers the study will also include toner-based printing systems. These can include desktop laser printers and professional toner-based printers.

Ryerson University

The evaluation will mainly be done with the P2P25X target and the Curve3 software.

It is the goal of this study to include devices that are aimed at the consumer, prosumer and professional market for inkjet and toner-based printing devices.

The big difference between consumer, prosumer and professional print devices is the way that the color and print information is transferred from the computer to the output device. Most likely the consumer and prosumer devices will be addressed as RGB devices, although the colors that are used for printing are CMYK. Professional device quite often have a software-based RIP system as digital front end, which addressed the device as a CMYK device. It will be interesting to see if it is possible to apply the G7 method to print devices that are addressed as RBG devices.

The study will take a snapshot at the current state of these devices in regards to the applicability of the G7 process and also to see if there might be a simpler way to improve the print consistency between small office/home office printers on similar types of paper.

The consumer device used in this study and the two professional print devices were able to achieve G7 conformance.

Introduction

Almost everyone has on inkjet printing device at home. Until you print out the same document that you printed at home on another inkjet printer you notice that the colors look different even if the other person used the same paper. You attribute that to the different printers and that may be that the inks used in each printer are also slightly different.

During the installation of the printer driver the user might be asked to run a head alignment program that makes sure that the print out is crisp and sharp and not fuzzy. What if during the printer installation routine there would be another step that allows you to adjust the colors so the print is gray balanced for the most commonly used paper, plain 20lb bond paper? This research paper will look at four printer that represent different markets. These markets are: consumer, home office/small office and professional. The consumer market will be represented by a Canon MX522 printer, the home office/small office market will be represented by a HP OfficejetPro 8600 and the professional market by two printers: an Epson 8600 and a Xerox Phaser 7880. The G7 gray balance test target, P2P25X, will be used to evaluate the conformance or non-conformance of the initial default settings of the printer drivers that are installed with the operating system. Through the selection of various printer driver settings it will be tried to see if the initial default settings can be modified in such a way that they allow a more G7 conform printout of the each tested printer.

Theory

Don Hutcheson invented in 2006 the G7 gray balance control method and it is based on the Neutral Print Density Curve or NPDC. According to Idealliance (Idealliance, 2015) the following are definitions that help with understanding the G7 method:

- G7 is both a definition of grayscale appearance, and a calibration method for adjusting any CMYK imaging device to simulate the G7 grayscale definition.

- It yields a visual match between different imaging systems using simple 1-dimensional curves, and enables shared appearance between different printing devices or specifications when additional color management is not available.

- The G7 method is the basis for GRACoL on #1 paper (TR006), SWOP on #3 paper (TR003), SWOP on #5 paper (TR005) and FIRST's Flexo on white polyester substrate (TR007). G7 utilizes one of the implementation methods of the new ISO 10128 standard for near-neutral calibration.

- G7 is device independent. The G7 neutral print density curve (NPDC), gray balance definitions and calibration methodology are the same for any imaging technology, regardless of substrate, colorants, screening technologies, etc.

- The NPDC at the heart of the G7 grayscale definition was derived by analyzing the neutral tonality of typical ISO Standard commercial offset printing using computer-to-plate technology.

- G7 should not be confused with GRACoL7, which is the 7th edition of the GRACoL Specification

The G7 method has been adopted for sheetfed printing, flexo printing, screen-printing and is also adopted for digital printing technologies. In the previous list it is said that the G7 method is device independent and can be used for any imaging technology regardless of substrate, colorants and screening technologies being used. The gray patches used in the G7 method are quantified by CIE L*a*b* values, as the gray defined in G7 uses a combination of cyan, magenta and yellow at certain ratios as defined by ISO 12647-2 (Rong, 2008). The main benefit of the G7 method being a more consistent gray scale appearance compared to traditional calibration methods. Any limitations to the G7 method are that it controls gray balance but not color reproduction, therefore gray tones across devices may be the same, however color may be different due to any variation in ink colors. Also, G7 cannot guarantee to simulate a reference CMYK color space – requiring some additional color management aside from G7 to compensate for these limitations (Idealliance, 2007).

In 2013 Donevski et al. (Donevski et al, 2013) used the gray balance method to calibrate a HP Deskjet 940c on plain office paper with the help of an i1iPro spectrophotometer. Donevski et al. did not have the Curve3 software at their disposal to determine the G7 compliance of the printed gray balance patches. They used a different mathematical method to manipulate the output of their printing device so it will be compliant to the G7 method.

What is the NPDC and how does it work? The NPDC compares density readings of single color black tints and three color grey. Depending on the final maximum printed density for black and three-color grey the corresponding NPDC curve is selected. The NPDC is introduced to simplify press control and reduce the number of measurements required, where the intention behind this curve is to replace TVI control (Rong, 2008). The Curve3 software will automatically select the correct NPDC curve depending on the maximum density achieved with single and three-color grey. The software than calculates the difference between the ideal and the measured curve. The measurement data comes from the P2P25X target. It is not the intention of this research paper to analyze and explain the G7 method, but to use it a research tool.

Although the G7 method is aimed mainly at the commercial print sector it would be interesting to see how the home/small office market is, to a degree, in compliance or partial compliance.

This research paper and also the observation of the author when printing lecture slides at home and in the office from the same MacBookPro resulted in a different color output. It is not a new finding that home office inkjet printers will print the same colored document in slightly different colors. Most users either install the printer drivers that come with the printer, or sometimes the operating system automatically configures the printer when it is connected to the computer for the first time.

For this research project a home office inkjet printer, a small office inkjet printer, a commercial inkjet printer and a toner-based color laser printer will be evaluated in regards to G7 compliance, or if the non-existing compliance could be improved.

Experimental & Results

For this research project four different type of printing devices were selected. They represent the home office, small office and professional print market. Three of the four devices are inkjet-based, while one is a toner-based professional printer. The list of print devices is as follows:

- Canon MX522
- HP OfficejetPro 8600
- Epson 3880
- Xerox Phaser 7800

All test prints were made on uncoated Husky offset, 20lb, 75 g/m2 and Epson Presentation Paper Matte, 27 lb, 102 g/m2. The M0 (UV-included) measurement condition was used for all measurements. The main test target that was used for the evaluation of the gray balance compliance was the P2P25X target. Although it was the intention to use the original layout of the P2P target the i1iSis refused to read the target through i1Profiler. Therefore the target was imported into i1Profiler and custom layout of the patches generated by the software. The custom layout can be seen in figure 1.

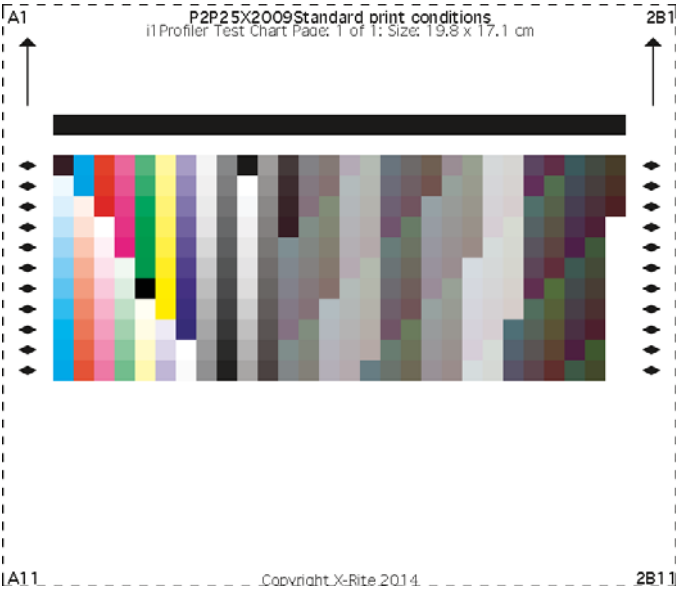

Figure 1: *Custom layout of the P2P25X target*

Other targets that were measured were the IT8.7/4 and iSis default RGB printer target. Due to the number of patches (957) the target was split up into two printouts as can be seen below.

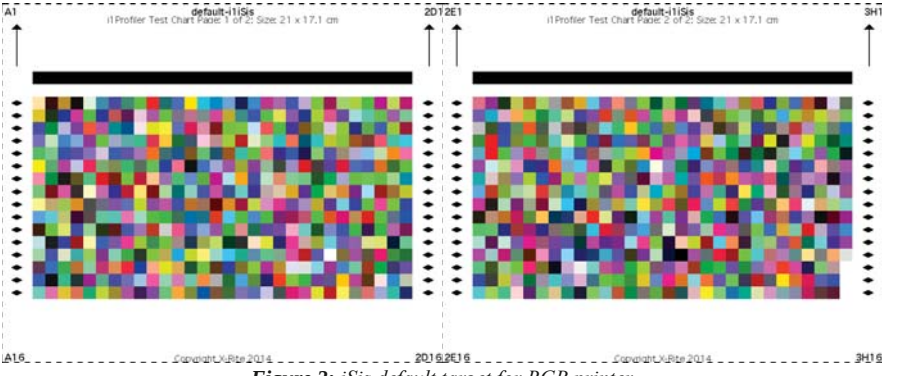

Figure 2: *iSis default target for RGB printer*

As a measurement device an i1iSis was used and the measurement data was collected with i1Profiler v.1.5.6. using M0 measurement conditions. Although the i1Profiler allows certain options in the print driver to be available, other options are not available. Therefore the P2P target was exported from i1Profiler as a TIFF image and placed into InDesign CS6 V8.1. Through the print dialogue in InDesign all the software features of certain print drivers became available. All the software operations were done on Mac computers with OSX 10.10.2 and 10.9.4, as computers with the Windows OS offered even fewer print driver options.

All tested printing devices were addressed as RGB devices, while the print driver for the Xerox Phaser 7800 addresses the device as a CMYK device.

In InDesign the profile US web uncoated was used. Also the IT8.7/4 target was printed on the Canon and the HP printer and a large ICC profile for both printers created in order to see if this improved the gray balance of the printouts.

Below is an example of the color settings print dialogue for the Canon MX522.

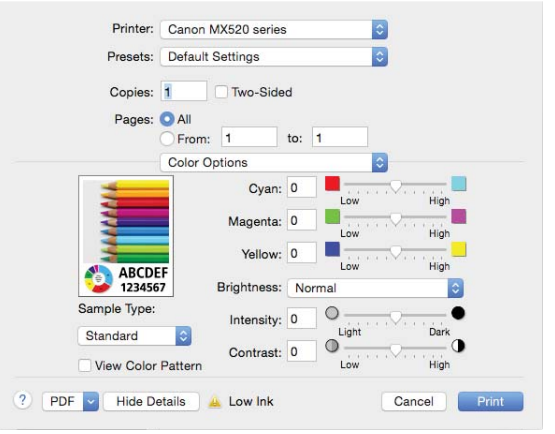

Figure 3: *Color options for the Canon MX522*

In figure 4 the color option for the HP OfficeJetPro 8600 are shown:

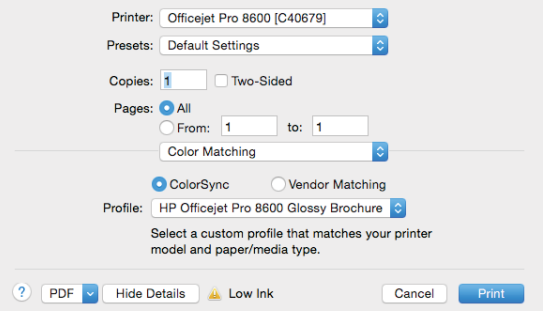

Figure 4: *Color option for the HP OfficejetPro 8600*

The comparison of figure 3 and 4 shows that the Canon MX522 home office printer offers a variety of color settings that allow the user to influence the printed result. The small office printer HP OfficeJetPro 8600 offers only two options to influence the color output by either using the ColorSync function of Mac OSX with two predefined profiles and they vendor matching which uses predefined settings in the printer driver that are not accessible to the user. The HP printer comes with two profiles, one is called “Glossy Brochure” and the other is called “Advanced Photo”. The profile selection menu through ColorSync offers the use of custom profiles that have been created by the user through the use of software like i1Profiler and the measurement data from either the default RGB printer target or the IT 8.7/4 target. These professional solutions will only play a lesser role in this project since it was the aim of this project to see what the normal/non-color savvy user can do to improve the color output of this home desktop printer.

The Epson 3880 gives a wide range of predefined profiles, since it is a professional color-proofing device. The range of choices can be seen in the figure below.

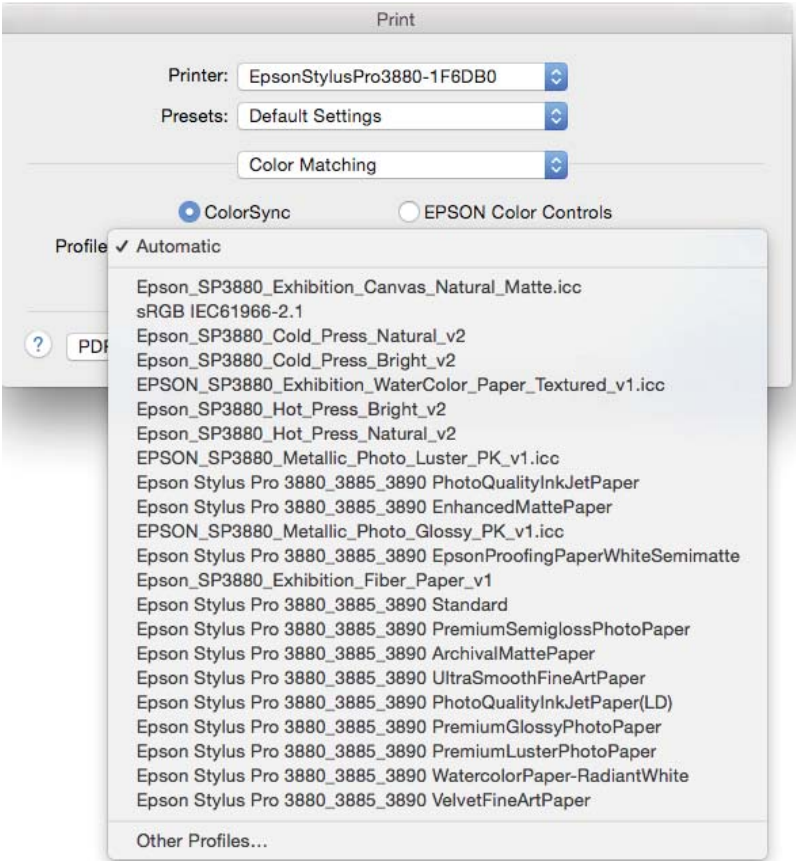

Figure 5: *Print dialogue Epson 3880 with ColorSync options*

For printing on uncoated bond paper the settings were left to automatic, since this is what most user would do.

The Xerox Phaser 7800 color matching in the print dialogue is very limited as can be seen in the screenshot below:

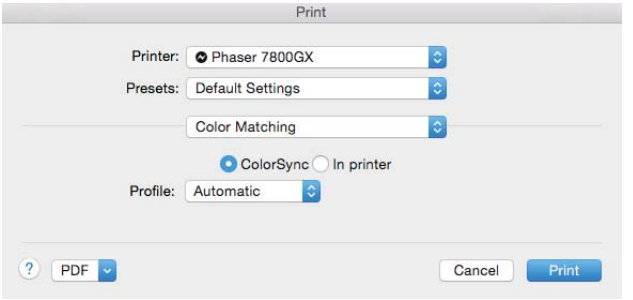

Figure 6: *Xerox Phaser print dialogue*

Print devices that are not addressed by a software RIP are usually addressed as an RGB device. This was also the case for the Canon, HP and Epson devices tested in the research project. The Xerox Phaser 7880 was addressed as CMYK devices. We found this out when we were working with i1Profiler. When selecting the Xerox Phaser 7880 on the home screen of i1Profiler, the workflow changed from CMYK to RGB. Under the print dialogue "Xerox features" a large number of options for color corrections are available. There are basically three options; change the "Color by words","Colorcorrections"and"ColourAdjustments".The"Colorcorrections"option offers 17 predefined changes, and the custom automatic function opens another subset of color adjustment dialogues. Exploring all these various options on the Phaser 7880 would have taken up the most of the time of this project. This might be done in a future project.

Results for the Canon MX522 printer

The Canon MX522 printer is representing the home office market and not a great deal of G7 compliance was expected with this print device, particularly because it offers so many adjustment options for color.

The results from the standard print conditions without changing any colour settings can be seen in the figure below.

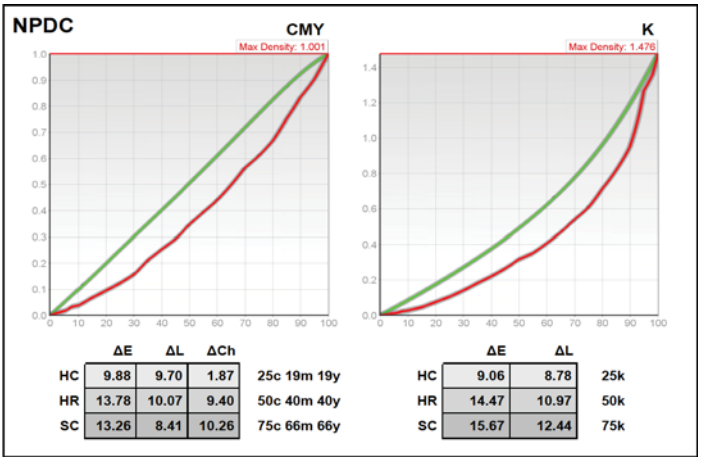

Figure 7: *G7 curve result for standard print conditions Canon MX522 printer*

From this figure it can clearly be seen that this printer is definitely not gray balanced and that there are quite some color differences the highlight contrast (HC), highlight range (HR) and shadow contrast (SC).

Further analysis from the Curve3 session can be seen in figure 8.

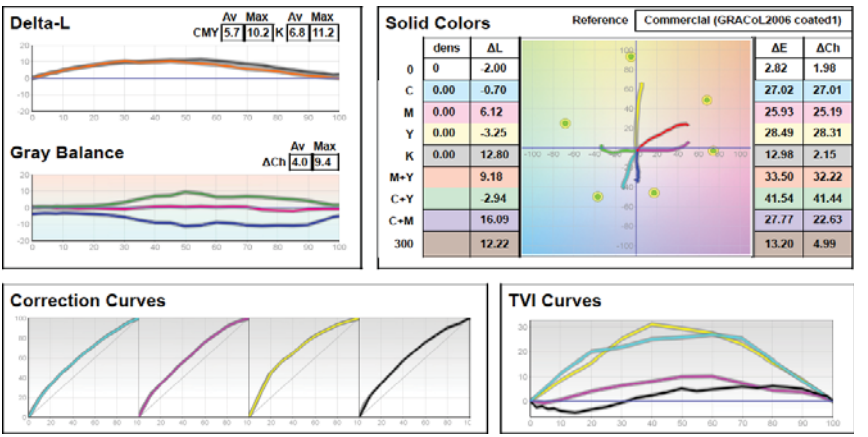

Figure 8: *Further G7 gray balance analysis of the MX 522 printer*

The correction curves for all four process colors show that a strong increase is required through the entire range of tint values.

Overall 25 different combinations of print conditions were tested and analyzed. The strongest influence came from changing the intensity and contrast settings. Please refer to figure 3 in regards to the print menu. The best result in regards to gray balance on uncoated paper could be achieved by setting the intensity of the print to 20. The Curve3 analysis results can be seen in the following two figures.

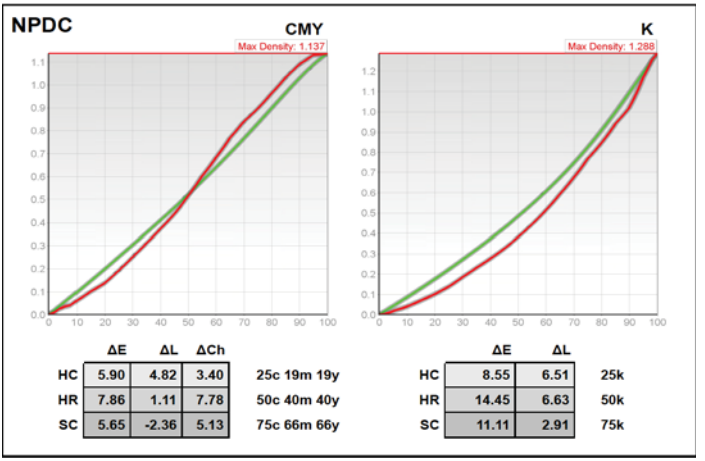

Figure 9: *Curve3 results for Canon MX522 with intensity setting 20*

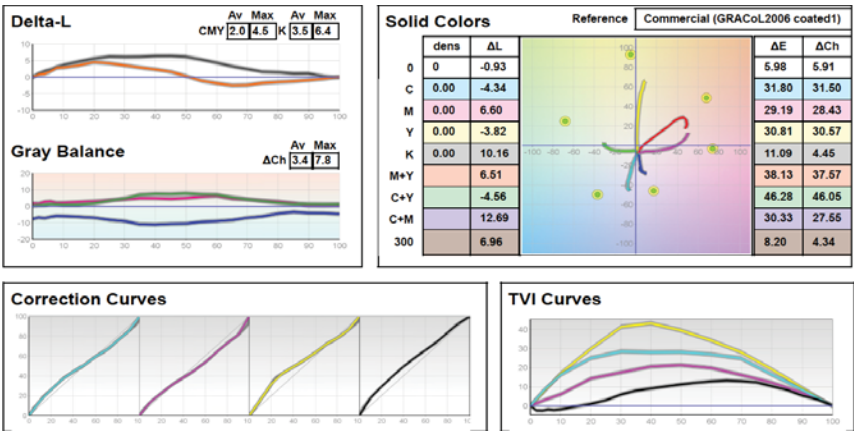

Figure 10: *Further gray balance results for the MX522 printer with intensity 20 setting*

The next results are in relation to the prints made on the Epson presentation paper. Based on the results obtained printing on uncoated paper four different settings were selected to see if they offer better results. These settings were:

- Standard settings, paper type: presentation paper
- Standard settings, paper type: presentation paper, intensity 20
- Standard settings, paper type: presentation paper, contrast 30
- Standard settings, paper type: presentation paper, brightness: dark

The Curve 3 results showed that the last set of settings listed above gave the best results. The following figures are illustrating this.

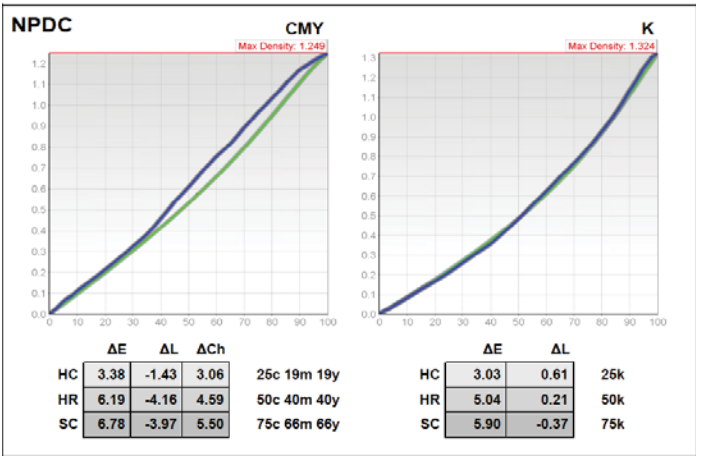

Figure 11: *Curve3 results for Canon MX522 on presentation paper with dark intensity setting*

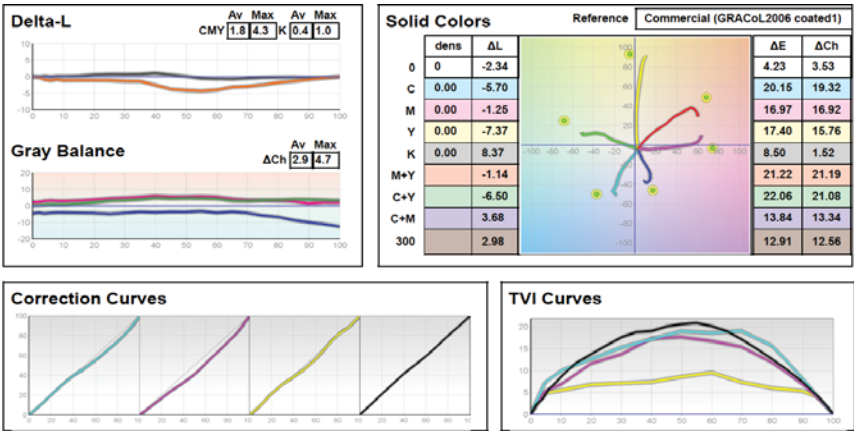

Figure 12: *Further gray balance analysis of the MX 522 on presentation paper with dark brightness* ***settings***

From figure 11 and 12 it can be seen that the prints are quite gray balanced and that the correction curves only want minor corrections for CMY, while the black correction curve is almost perfect. Also the Delta L-line is quite straight, which means that the printout is quite gray balanced.

Results for the HP OfficejetPro 8600 printer

The HP OfficejetPro 8600 is representing the small office print market. Prints were made on both papers and 16 different combinations of printer driver settings and pre-installed profiles were used to print the P2P target. The first two figures show the results from the standard print settings, when nothing is changed.

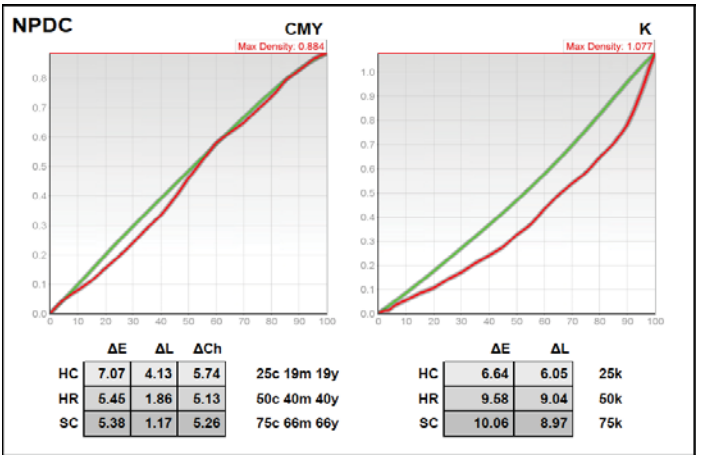

Figure 13: *Curve 3 results for HP OfficejetPro8600 with standard print settings*

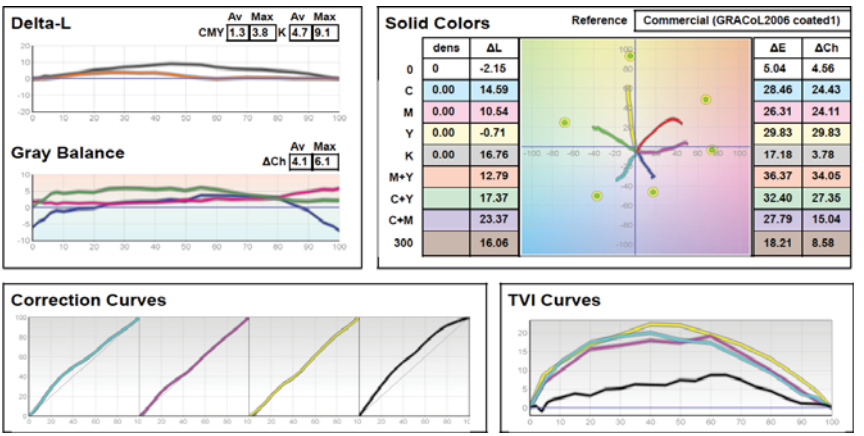

Figure 14: *Further G7 gray balance analysis results of the HP OfficejetPro 8600 using standard print conditions*

From figure 113 and 14 it can be seen that under standard print conditions, meaning nothing was changed in the print dialogue, the print is not gray balanced and needs most adjustments for cyan and black.

From all the various combination of print settings the option “Preserve RGB numbers” from the InDesign print dialogue in the color management tab gave to best results in regards to gray balance and somewhat conformance to the NPDC. This is more for the CMY NPDC curve than the K-curve. This can be seen in figure 15.

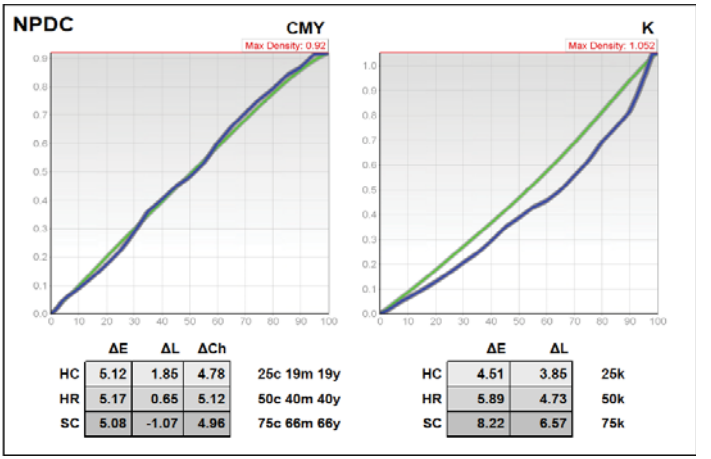

Figure 15: *Curve3 results for HP OfficejetPro 8600 with print option "Preserve RGB numbers"*

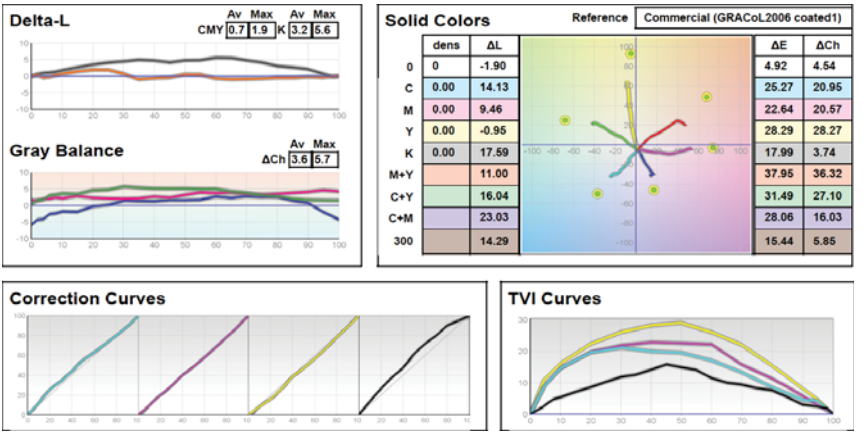

Figure 16: *Further gray balance resutls from the HP OfficejetPro 8600 with "Preserve RGB numbers" option*

From the correction curves it can be seen that most of the correction is needed in cyan and black, like in was with the standard print settings, but the correction requirements were not as drastic. Any further experimentation with various print options did not results in any improvement in regards to a more gray-balanced output of the HP OfficejetPro 8600. Even settings for printing on the matte presentation paper did not result in an improvement for a more gray-balanced printout.

Results for the Epson 3880 printer

The Epson 3880 printer is an inkjet proofing device that is usually addressed by a software RIP for color accuracy. This route was not taken and settings from the printer driver were explored to see what the results in regards to gray balance would be.

In the next figure the results for printing on plain office paper can be seen.

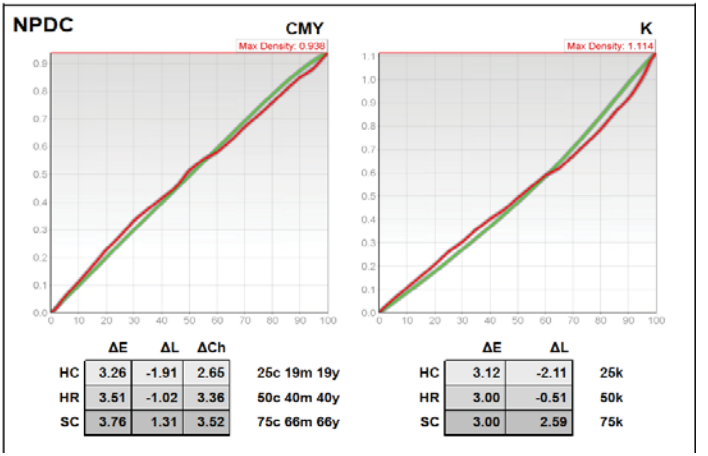

Figure 17: *Curve3 results for the Epson 3880 on plain paper*

Although the measurement curves cross the NPDC curve for CMY gray and K-only gray, this is so far the best gray-balanced print from the tested devices. One should not forget that this is professional proofing device, so a more gray balanced printout should be expected.

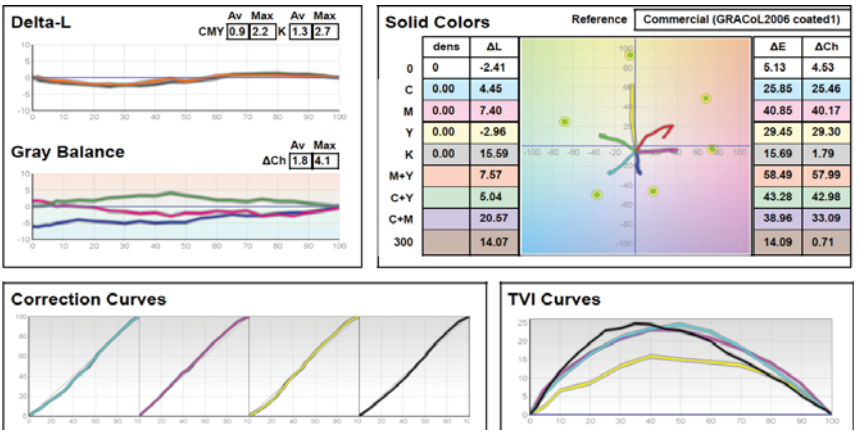

Figure 18: *Further gray balance results for the Epson 3880 on plain paper*

The correction curves show only minor corrections for the CMYK inks.

The next two figures show the results on presentation paper. Since Epson manufactured the printer and the matte presentation paper is also sold under the Epson brand it is expected that the results will be quite good in results to gray balance.

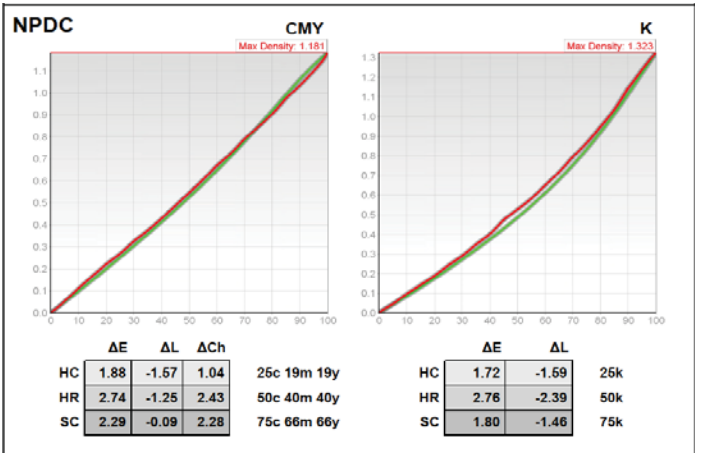

Figure 19: *Curve3 results for the Epson 3880 on presentation paper default settings*

A look at the curves in figure 19 shows an almost perfect match of the CMY gray and the K-only curves to the NPDC curve. The ΔE values also show a very small color difference for the HC (highlight contrast), HR (highlight range) and SC (shadow contrast).

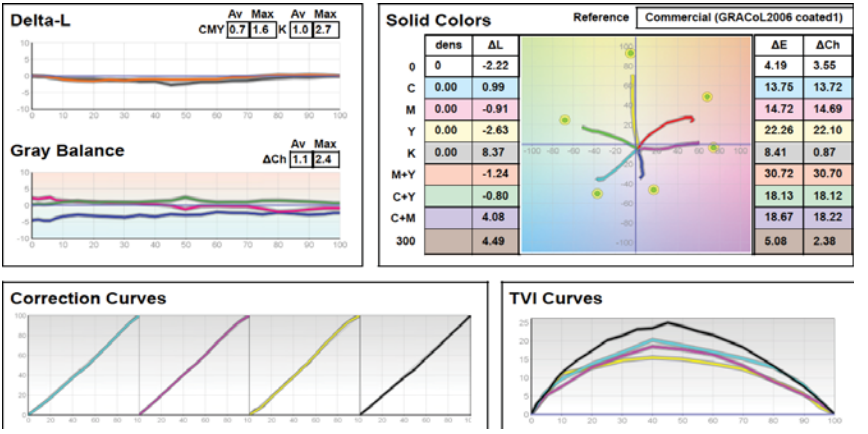

Figure 20: *Further gray balance results for the Epson 3880 on presentation paper*

Figure 20 shows in all the various graphs how well the color quality on presentation paper is. The correction curves are almost identical to the target line, the gray balance is almost a straight line from 0 to 100% and the same goes for the Delta-L values. The TVI curves also look like the TVI curves what one would expect from a press sheet.

Results for the Xerox Phaser 7880 printer

The Xerox 7880 Phaser printer stands out from the line up of the printing devices. First of all it is a toner-based printing device and not an inkjet device and second the printer driver addresses the Phaser as a CMYK device, while the inkjet printers were addressed as RGB devices. This became evident when the P2P25X test patches were printed from the i1Profiler software and the respective printers were selected.

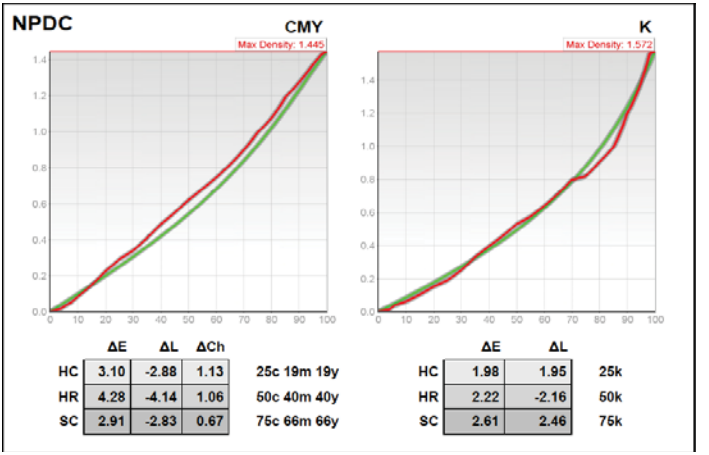

Figure 21: *Curve3 results for the Phaser 7880 on plain paper*

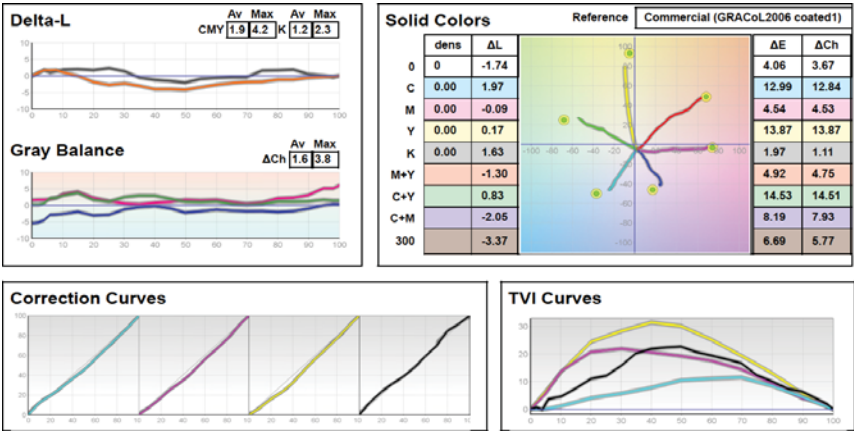

Figure 22: ***F****urther gray balance results for the Phaser 7880 on plain paper*

The results for printing on the presentation paper are not much different from the plain paper results. All the prints were made with automatic profile selection under ColorSync or with the “In printer” color correction function. There were not large difference between the various settings. As mentioned before all the different color correction options that are available under “Xerox Features” dialogue would have taken up the majority of time of this project.

Conclusions

The main goal of this project was to take a snapshot of how gray-balanced inkjet printers are and if any settings in the print dialogue can help to improve the gray balance. The printers chosen for this project present the home office, small office and the professional inkjet printer market. For the home office printer Canon MX 522 changing the print settings to a darker intensity setting improved the gray balance conformances. This comes with the drawback of increased ink comsuption, which will not sit well with the average consumer who already complains about high inkjet ink costs. Prints done with MX522 with very high intensity and contrast settings resulted in unreadable test targets for the iSis device.

For the OfficejetPro 8600 selecting the "Preserve RGB" numbers gave the best achievable result. The professional Epson 3880 addressed through the printer driver gave very good results on plain paper and presentation paper by simply selecting the correct paper type in the print dialogue.

The Xerox Phaser 7880 gave also quite good print results in relation to gray balance regardless of the chosen paper. For this printing device the selection of the correct paper type resulted also in quite gray balanced prints. This is probably due to presets within the device.

Outlook

During our discussions we said to ourselves: "Does the home user really care about this if the printout is gray balanced or not?" Most likely the answer is not, but I am sure that there are users that would like to have the option to have more gray-balanced prints, so it doesn't matter on which device the printout is made and that the colors will look the same. Would it be possible to create a simple test chart like the nozzle check printout or print head alignment test chart? Each printer will come with a gray balance card that has a few test fields on it and the user will have the option to print out a test chart on plain paper and compare the results to the test card. The results, comparably to a print head alignment chart, could than be compared to the gray balance card and the user would enter some adjustment values and the printer driver will be adjusted for a more gray balanced printout.

–

We are grateful to the School of Graphic Communications Management and the Faculty of Communications & Design at Ryerson University for their support.

We would like to thank Vanessa Blum, Research Assistant at the School of Graphic Communications Management, for all her hard work in making this study possible.

References:

Cheydleur, R., O'Connor, K., The M Factor…What Does It Mean?, X-Rite white paper, accessed February 19, 2015

Doveski, D., Micic, D. Borkovic, J. Properties of Printer Calibration Targets, International Circular of Graphic Education and Research, Vol. 6, 2013, pp. 70 – 79

G7 how to guide, http://files.idealliance.org/G7/howto/G7%20How%20To%20 2009.pdf , accessed October 2, 2014

Hutchcolor, Curve3 User guide, Second Edition, http://www.hutchcolor.com/ CurveGuide.htm, accessed October 2, 2014

IDEAlliance, G7 Proof-to-Process 2007, http://www.aptec.hkprinters.org/ IDEAlliance-China/resource_centre/free_resources/05 IDEA_G7%20only_spec2007.pdf, accessed January 9, 2015.

IDEAlliance, What is G7?, http://idealliance.org/specifications/g7/what-g7, accessed March 9, 2015

ISO, ISO 13655-2009 Spectral Measurement and Colorimetric Computation for Graphic Arts Images

Rong. X., G7 method for Indigo Press Calibration and Proofing, NIP & Digital Fabrication Conference, 2008 International Conference on Digital Printing Technologies. Pages 459-931., pp. 603-606(4)