# CS Digital Sampler

# CS Digital Sampler

## December 2011

## Walton Mendelson

Download the test images, 17MB PDF, from  http://www.12on14.com/pages/createspace.htm

The goal of this book is to demonstrate various graphics issues vis à vis CreateSpace's digital printing capabilities.

I believe that CS can print great art, photography, and illustrated books. But to commit the time, energy, and resources necessary, you have to know what is possible.

The conclusions, are based on my observations—qualitative and subjective, not quantitative and objective. The tests and demonstrations may or may not tell the same story to you, but with *CS Digital: Sampler,* your decisions will be based on what you observe, not what you read on-line or guess, whether from me or anyone else. Proof everything: all images are different and our definitions of "good printing" probably vary from person to person.

Perhaps most important for *CS Digital Sampler* to be an effective working tool, download the test images used on pages 22-23 and 26-27 from http://www.12on14.com/pages/createspace. htm. Compare what was printed to what was submitted. Compare them to your printer.

This book is based on *CS Digital: A Practical Guide to CS Digital Possibilities*. I have taken only the most significant examples that most people will encounter in designing their covers or working on color interiors.

Please let me know if you experience something different from what is in this book, have a an image or test that might be of value, or if some conclusion is just impossible or preposterous. .

Walton Mendelson
November, 2011

CS Digital: Sampler

**Text size[1]—Printability & Readability**

*Intention: to show the minimum size of serif type using two different blacks. Because Photo-Shop black is a composite of four colors, it requires perfect registration, unlike plain black.*

This is set in Time New Roman.

The type is printing in Photoshop black, C75 M68 Y67 K90, left (see pages 18-19), and Black, C00 M00 Y00 K100 (K-only) right.

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1 Note: the sizes of type and leading (line spacing) are given in points (standardized at 72 points/inch). The first number is the body height of the font, the second is the body height plus leading, that is, additional space between lines of type. Thus 12/14 (read "twelve on fourteen") means 12pt type with 2pt line spacing.

Type size/body Size

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| PhotoShop Black    | Black    |

**Reversed Type**

*Intention: to show the minimum size of serif type reversed out of two different blacks. Because PhotoShop black is a composite of four colors, it requires perfect registration.*

Several issues present themselves with type that is reversed out. First, if the ink spreads (dot gain) the letters are filled in, thus the smallest type sizes that are legible with black type on white paper are likely to not work when reversed out. Second, with 4 ink colors, there are additional paper wetness (TIC)) and registration problems. On the left, is rich black (C70 M35 Y40 K100); on the right is Black, C00, M00, Y00 K100 (K-only)

Note: the reversed type is a little clearer in the Photoshop Black than black.

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| Type size/body Size | |
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| 12/14 | 0.153" |
| 10/12 | 0.131" |
| 9/11 | 0.114" |
| 8/10 | 0.103" |
| 7/9 | 0.089" |
| 6/8 | 0.075" |
| 5/7 | 0.064" |
| 4/6 | |
| 3/5 | 0.039" |
| 2/4 | 0.025" |
| 0.75 pt | |
| 0.50 pt | |
| 0.25 pt | |
| 0.15 pt | |

| Photoshop Black | Black |

**Rasterized Type—1200 dpi**

*Intention: to show the minimum size of type reversed out of Photoshop Black and type printed in Photoshop Black from a 1200 dpi rasterized type sample.*

Several issues present themselves with type that is rasterized, because it is an image file (not editable, vector, type as in the previous examples), it will be screened. This image was made at 1200 dpi.

Rasterized type is always less sharp than vector type, using PhotoShop Black is an attempt to exacerbate a problem with high ink coverage.

Type size/body Size

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2/4    0.024"

0.010" ≈ 0.75 pt.
0.007" ≈ 0.50 pt.
0.003" ≈ 0.25 pt.
0.002" ≈ 0.15 pt.

Registration Black    |    Type is Photoshop Black

**Rasterized Type—300 dpi**

*Intention: to show the minimum size of type reversed out of Photoshop Black and type printed in Photoshop Black from a 300 dpi rasterized type sample.*

Several issues present themselves with type that is rasterized, because it is an image file (not editable, vector, type as in the previous examples), it will be screened. This image was made at 300 dpi.

Rasterized type is always less sharp than vector type, using PhotoShop Black is an attempt to exacerbate a problem with high ink coverage.

Type size/body Size

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0.010" ≈ 0.75 pt.
0.007" ≈ 0.50 pt.
0.003" ≈ 0.25 pt.
0.002" ≈ 0.15 pt.

Registration Black | Type is Photoshop Black

**Resolution—Monochromes**

*Intentions: to test how the increased resolution of monochromes increase their detail.*

Usually, monochrome images can be included up to 1200dpi. Here a monochomatic image (C00 M00 Y00 K100) of line art was printed from 2400, 1200, 900, 600, and 300dpi images. Although the color is K-only, the curves have been softened (antialiased) with grays.

Here the differences in resolution are insignificant.

**Resolution—1 Bit Color**

One bit color, $2^1$, is two colors, black and white—each pixel is either on or off.

The last two rows are the same image converted to bitmap (although all raster images are bit-mapped, Photoshop uses "bitmap" to mean black and white with no grays: that is, 1 bit color.

Here the differences in resolution are significant.

(Vector images, such as type or images from Illustrator, are resolution independent, and are always sharp.)

The 300dpi monochrome is 763K, whereas the 1 bit 4800dpi is 407K, and the 1 bit 2400 is 193K.

2400 dpi          1800 dpi          1200 dpi

Monochrome
(8 bit)

900 dpi          600 dpi          300 dpi

4800 dpi          3600 dpi          2400 dpi

1 Bit

1200 dpi          800 dpi          300 dpi
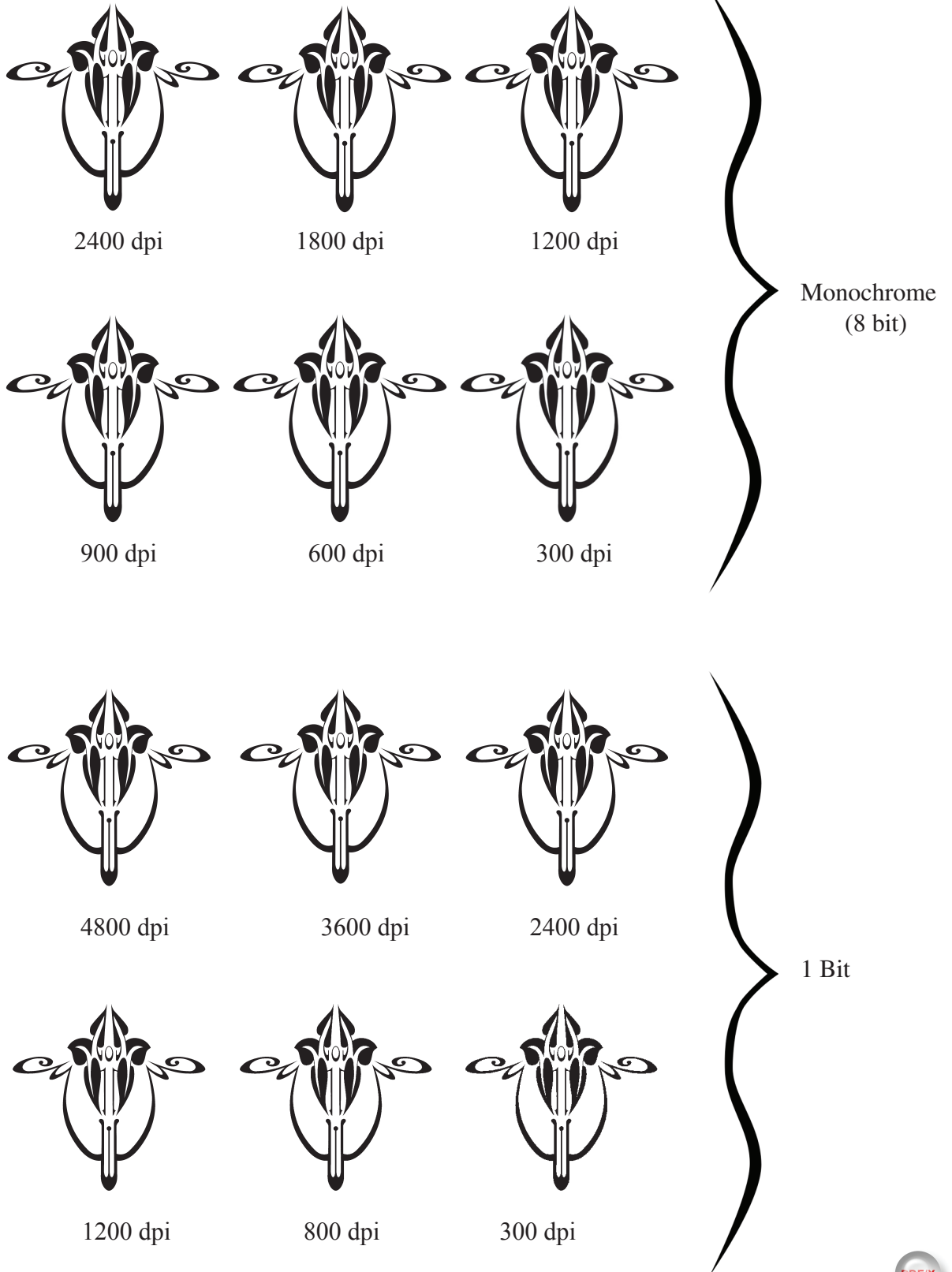
**Rich Black vs Black**

*Intention: to show examples of Registration black,[1] Photoshop black, five rich blacks, and black.*

The top six examples are rich blacks, all are CMYK blacks. The bottom is straight black only. Rich black is only possible in full color printing. Black only is how B&W work is printed.

PhotoShop black varies depending on the PS version number or region. The version used in the book is C75 M68 M67 K90.[2] GIMP's default black is also C75 M68 C67 K90.

Beneath each solid color is a grayscale in 10% increments (10% to 100%), called a step wedge. Note that tints of the rich blacks show characteristics of the color components.[3] Traditionally, to avoid over inking, also referred to as paper wetness, the maximum coverage should be under 245-320% (called TAC, Total Area Coverage, or TIC, Total Ink Coverage, see Glossary). Registration black is 400%; black is 100%. There is no simple maximum TAC or TIC. The actual maximum number would be unique to the type of press, ink, paper, humidity, driers . . .

On screen (monitor, RGB) all of the rich blacks are typically R0 G0 B0. On some monitors, basic black is also shown as R0 G0 B0.

*Rich blacks offer a lot and they print well. Do not use different rich blacks in the same document. Be careful using tints.*

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1  Here and on page 27, I used registration black. It appears different from the other blacks, and I have no reason to believe that CS is not printing at a full  400% TIC. This may be a contentious assumption, however, and not knowing their profiles and procedures, it is possible they are not.

2  Several printers in the UK, for example, report Photoshop black as C75 M68 Y67 K100

3  Because with CS, any additional color to black is treated as full color, using duotones, shades, and tints is not likely to be used much—if you are paying for full color, why not use full color? Tints are, nonetheless effective in graphic design. So if you use them, be aware that some colors when tinted can become surprising unattractive. If this happens, you should know that there are often many color formulations that produce the same final color, and you might find a better one in terms of tints.
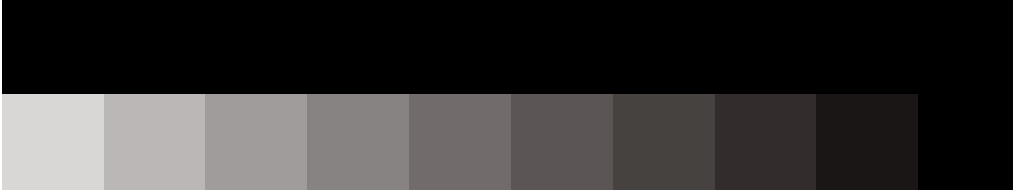
# Rich Black vs Black

C100 M100 Y100 K100
Registration
400% coverage

C75 M68 Y67 K90
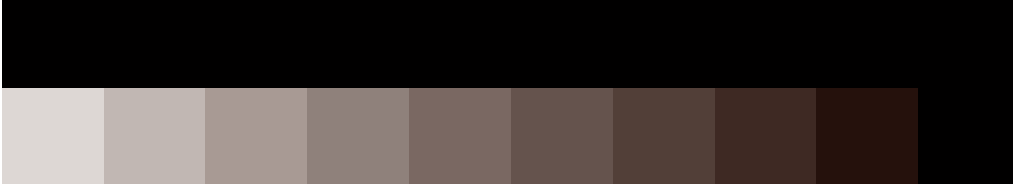Photoshop Black
300% coverage

C65 M52 Y51 K100
Rich Black
265% coverage

C50 M50 Y50 K100
Rich Black
250% coverage

C70 M50 Y30 K100
Rich Black
250% coverage

C35 M60 Y60 K100
Warm Black
255% coverage

C70 M35 Y40 K100
Cool Black
245% coverage

C00 M00 Y00 K100
Black
100% coverage

**PDF/X-1a CMYK Conversion:**

*Intention: to show RGB converted to CMYK and printed by CS versus CMYK converted when a PDF/X-1a is made from RGB.*

In creating a PDF you may have the option of using a preset. PDF/X-1a converts all images to CMYK using, by default, which preserves the embedded intent of the original or the settings in PhotoShop (see pages 32-35).

For these examples, I've kept the defaults, which are most appropriate for general commercial printing in the US. Therefore these examples compare a typical PDF/X-1a conversion of RGB to CMYK to CS's conversion of RGB to CMYK.

Unless marked PDF/X, , the PDF conversions were made using High Quality, which preserves the original RGB files [1] and the actual RGB to CMYK conversions were made by CS,  .

This RGB image is available in a free PDF from http://www.12on14.com/pages/createspace. htm. Download it to compare the original art with the printed piece. You can also use it to compare your monitor and printer to a known standard.

This CMYK conversion used the default North American General Purpose No. 2

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1  Two PDFs were made, one using PDF/X-1a and the other High Quality. The pages that were to be PDF/X-1a compliant were extracted and substituted for their counterparts in the High Quality PDF.
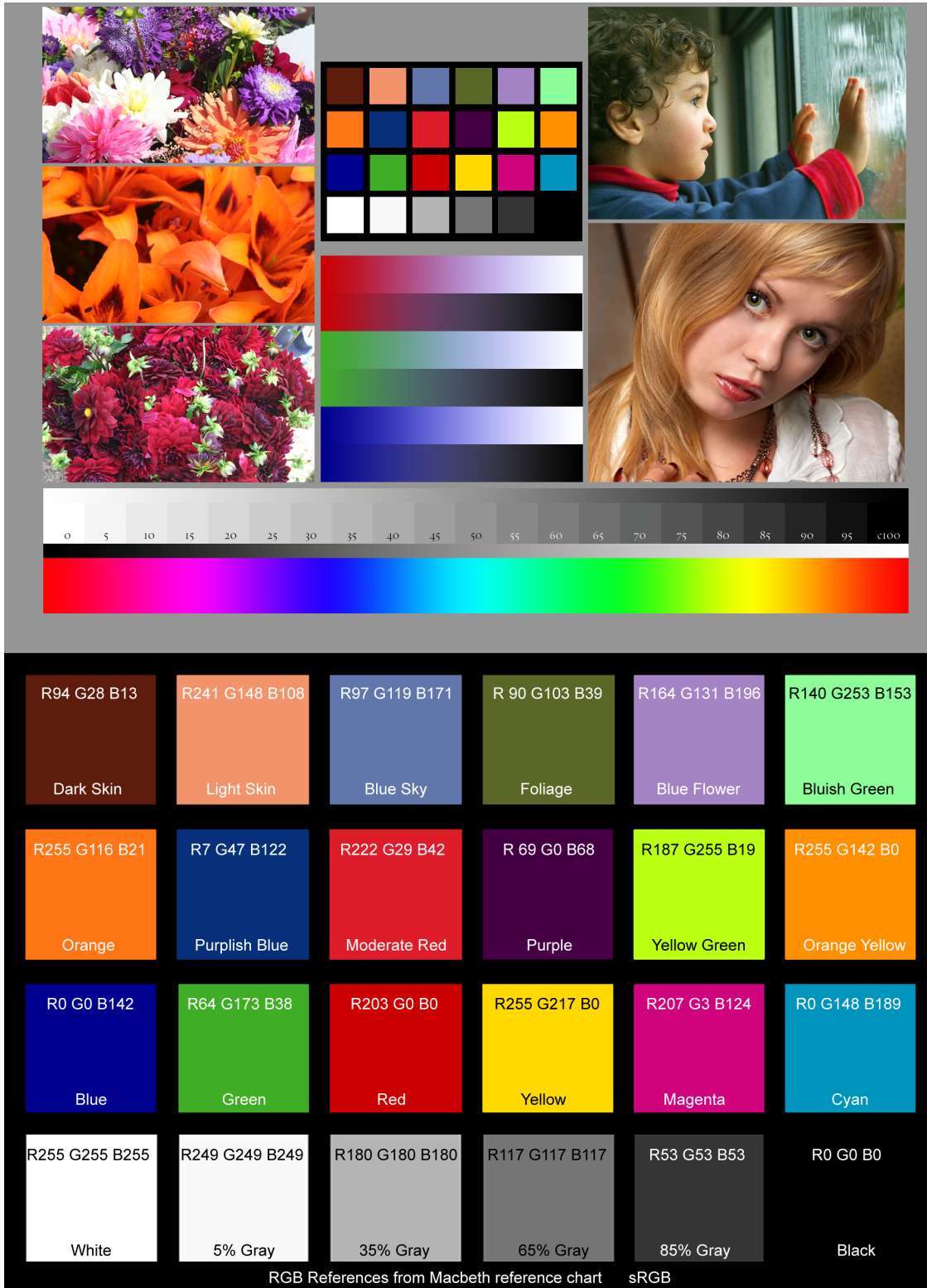
*PDF/X1a > CMYK*

[examples follow]

| R94 G28 B13 | R241 G148 B108 | R97 G119 B171 | R 90 G103 B39 | R164 G131 B196 | R140 G253 B153 |
|---|---|---|---|---|---|
| Dark Skin | Light Skin | Blue Sky | Foliage | Blue Flower | Bluish Green |
| R255 G116 B21 | R7 G47 B122 | R222 G29 B42 | R 69 G0 B68 | R187 G255 B19 | R255 G142 B0 |
| Orange | Purplish Blue | Moderate Red | Purple | Yellow Green | Orange Yellow |
| R0 G0 B142 | R64 G173 B38 | R203 G0 B0 | R255 G217 B0 | R207 G3 B124 | R0 G148 B189 |
| Blue | Green | Red | Yellow | Magenta | Cyan |
| R255 G255 B255 | R249 G249 B249 | R180 G180 B180 | R117 G117 B117 | R53 G53 B53 | R0 G0 B0 |
| White | 5% Gray | 35% Gray | 65% Gray | 85% Gray | Black |

RGB References from Macbeth reference chart    sRGB

PDF/X-1a conversion with relative colorimetric intent.

| 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | c100 |

| R94 G28 B13 Dark Skin | R241 G148 B108 Light Skin | R97 G119 B171 Blue Sky | R 90 G103 B39 Foliage | R164 G131 B196 Blue Flower | R140 G253 B153 Bluish Green |
|---|---|---|---|---|---|
| R255 G116 B21 Orange | R7 G47 B122 Purplish Blue | R222 G29 B42 Moderate Red | R 69 G0 B68 Purple | R187 G255 B19 Yellow Green | R255 G142 B0 Orange Yellow |
| R0 G0 B142 Blue | R64 G173 B38 Green | R203 G0 B0 Red | R255 G217 B0 Yellow | R207 G3 B124 Magenta | R0 G148 B189 Cyan |
| R255 G255 B255 White | R249 G249 B249 5% Gray | R180 G180 B180 35% Gray | R117 G117 B117 65% Gray | R53 G53 B53 85% Gray | R0 G0 B0 Black |

RGB References from Macbeth reference chart          sRGB

sRGB Profile (original)

**PDF/X-1a CMYK Conversion**

*Intention: to show how a PDF/X-1a conversion to CMYK differs from how CS makes that conversion on the fly when it prints an RGB image.*

In creating a PDF you may have the option of using a preset. PDF/X-1a converts all images to CMYK using, by default, the embedded intent of the original or the settings in PhotoShop (pages 32-35).

For these examples, I've kept the defaults, which are most appropriate for general commercial printing in the US. Therefore these examples compare a typical PDF/X-1a conversion of RGB to CMYK to CS's conversion of RGB to CMYK.

This RGB image is available in a free PDF from http://www.12on14.com/pages/createspace. htm.

Following Left to right
Top: *Ships,* by Stanko Mravljak, *Little Girl*, Noam Armonn, *Cute Little Girl*, Anna Karwowska
Middle: *Groom and Bride*, Sergiy Koshevarov, *Mother & Son*, Iofoto, *Korean Baby*, Gina Smith
Bottom: *Flamingo*, Dace Pjanova, *Punk Girl*, Thomas Reiner, *Old House*, Ramon Grosso Dolare

[examples follow]

PDF/X-1a conversion

sRGB original

**Miscellaneous Test**

*Intention: to show various graphics and printing issues*

**28-29:** *Test Forms*—A. The colors formed by the vertical lines should match the color of the horizontal lines. B. This tests the registration. These shapes were constructed in Illustrator using no trap. If the registration of one of the color separations is off a small amount of white will show around one or more of the graphic elements—in all combinations of process colors. C This tests both registration and precision in positive and reverse, in Registration Black (C100, M100 Y100 K100), so all four colors must line up. D. This tests highlight and shadow detail in process colors. Black is K-only. A-C were prepared in Illustrator. D was made in InDesign.

**30-31:** *Banding and Banding Streaks*—are possible in colors with 2 or more of the process colors below 30%, at its darkest the color is (C25 M10 Y12 K0); and long gradients are susceptible to banding. Two common are the introduction of noise, pg. 30, or increasing the resolution, p. 31. Because the problem is erratic, there is no way of knowing if either method worked, only if it failed or how it might alter the appearance of the gradient.

**32:** *Neutral grays*—ranging from 10% to 90%, are in K only, C00 M00 Y00 K0-100, and in CMYK  gray values. They should all be neutral, no color or shift. It takes very little for a gray to appear warm or cold.

**33:** *Pastels*—are, like the issue in 30-31, difficult to print evenly. These Pantone Pastels are the lightest of the pastels in the series. Each Pantone Pastel number is followed by the total ink coverage (400% is maximum).

| | | |
|---|---|---|
| 9060 (19.6%) | 9280 (19.2%) | 9320 (18.4%) |
| 9340 (19.2%) | 9460 (20.8%) | 9520 (23.1%) |
| 9064 (15.7%) | 9285 (15.7%) | 9061 (13.9%) |
| 9345 (16.1%) | 9062 (16.2%) | 9063 (15.3%) |

**34:** *Highlight detail*—from 0% to 15% in K only (C00 M00 Y00 K0-100).

**35:** *High Ink Coverage*—All of the colors are 290% on a 400% background.

| | | |
|---|---|---|
| C60 M80 Y70 K80 | C76 M85 Y55 K74 | C80 M83 Y54 K73 |
| C85 M80 Y55 K70 | C85 M70 Y60 K75 | C85 M63 Y64 K78 |
| C82 M60 Y70 K78 | C75 M60 K75 K80 | C73 M57 Y85 K75 |
| C65 M60 Y90 K75 | C65 M65 Y80 K80 | C62 M77 Y67 K84 |

**36:** *Shadow detail*—detail from 100% to 85% on Photoshop Black (C75 M68 Y67 K90), with Photoshop Black details.

**37:** *RGB to CMYK*—A. The RGB image has a lot a bit of out-of-gamut color, see below. CS will convert this to CMYK during the RIP. B. The same image as A. was converted to CMYK and worked on to perceptually match the original. It took about forty-five minutes. Here are the out-of-gamut colors in green:



Example A, the RGB version should be noticeably inferior—the out-of-gamut colors flat and lackluster—compared to B because a normal RGB to CMYK conversion with most commercial printers or in Photoshop cannot in and of itself create the masks and curves, hue and saturation, and color balance adjustments to offset the out-of-gamut colors above..

If A and B look the same, then CS is printing sRGB files to match, and the 45 minutes I spent, you will per image, is unnecessary.
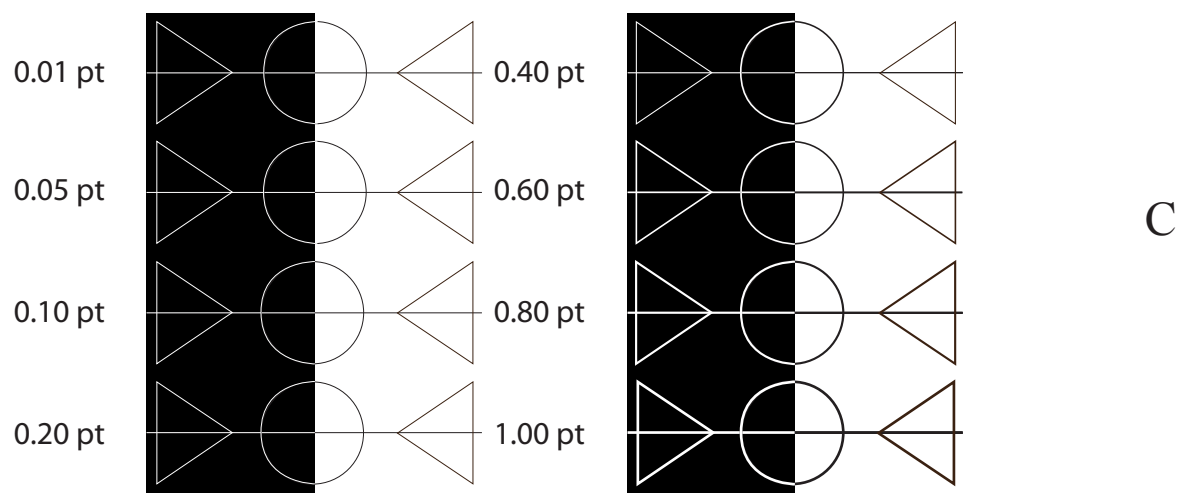
A

B

0.01 pt       0.40 pt

0.05 pt       0.60 pt

0.10 pt       0.80 pt

0.20 pt       1.00 pt

C

| 95 | | | | 5 |
| 96 | | | | 4 |
| 97 | | | | 3 |
| 98 | | | | 2 |
| 99 | | | | 1 |
| 100 | | | | 0 |

D
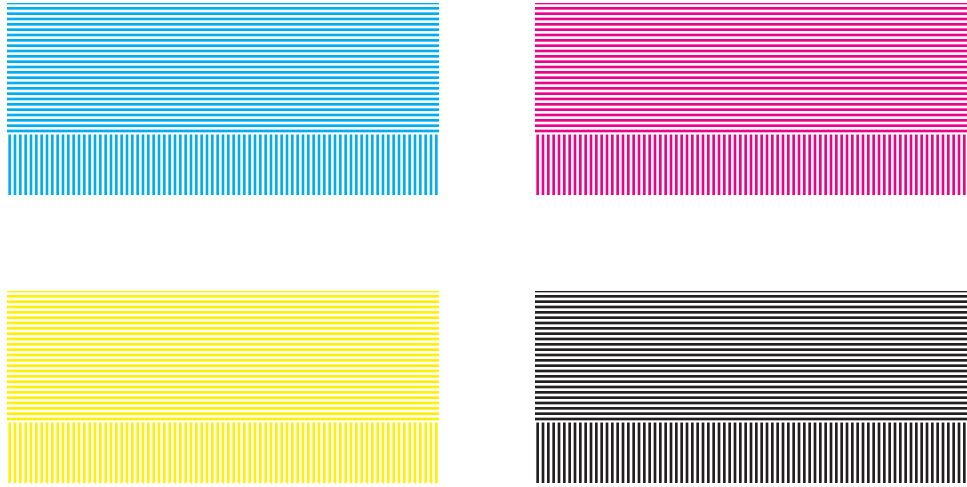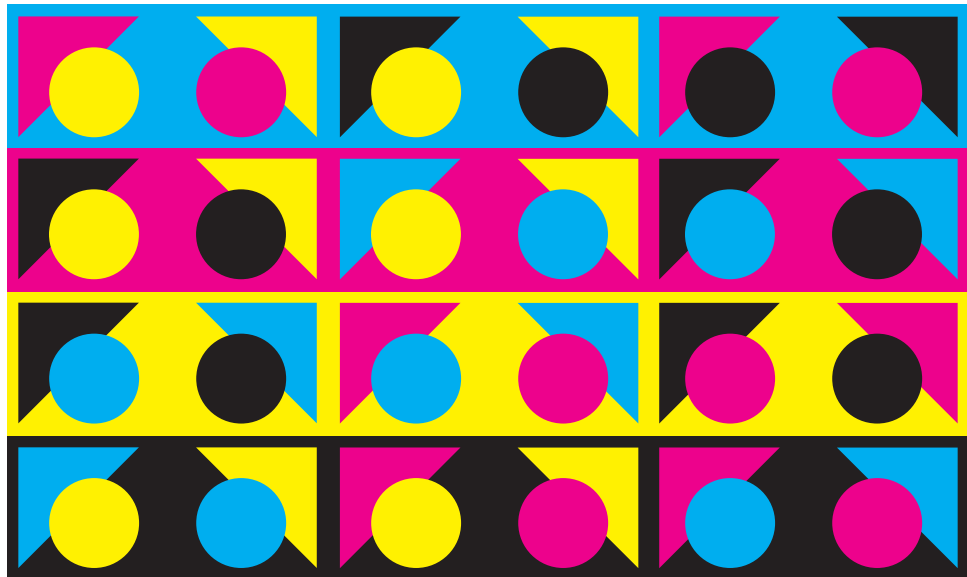
# CS Digital Sampler

## Noise

0%

1%

2%

4%

# Miscellaneous Tests

## Resolution

DPI

300

600

900

1200

|  | C0 M0 Y0 K90 | C0 M0 Y0 K80 | C0 M0 Y0 K70 |
|---|---|---|---|
| **90%, 80% 70%** | | | |
|  | C71 M65 Y64 K70 | C67 M60 Y58 K42 | C61 M52 Y52 K22 |

|  | C0 M0 Y0 K60 | C0 M0 Y0 K50 | C0 M0 Y0 K40 |
|---|---|---|---|
| **60%, 50%, 40%** | | | |
|  | C53 M44 Y44 K9 | C44 M36 Y37 K2 | C34 M27 Y28 K0 |

|  | C0 M0 Y0 K30 | C0 M0 Y0 K20 | C0 M0 Y0 K10 |
|---|---|---|---|
| **30%, 20%, 10%** | | | |
|  | C24 M19 Y19 K0 | C15 M11 Y12 K0 | C6 M5 Y5 K0 |
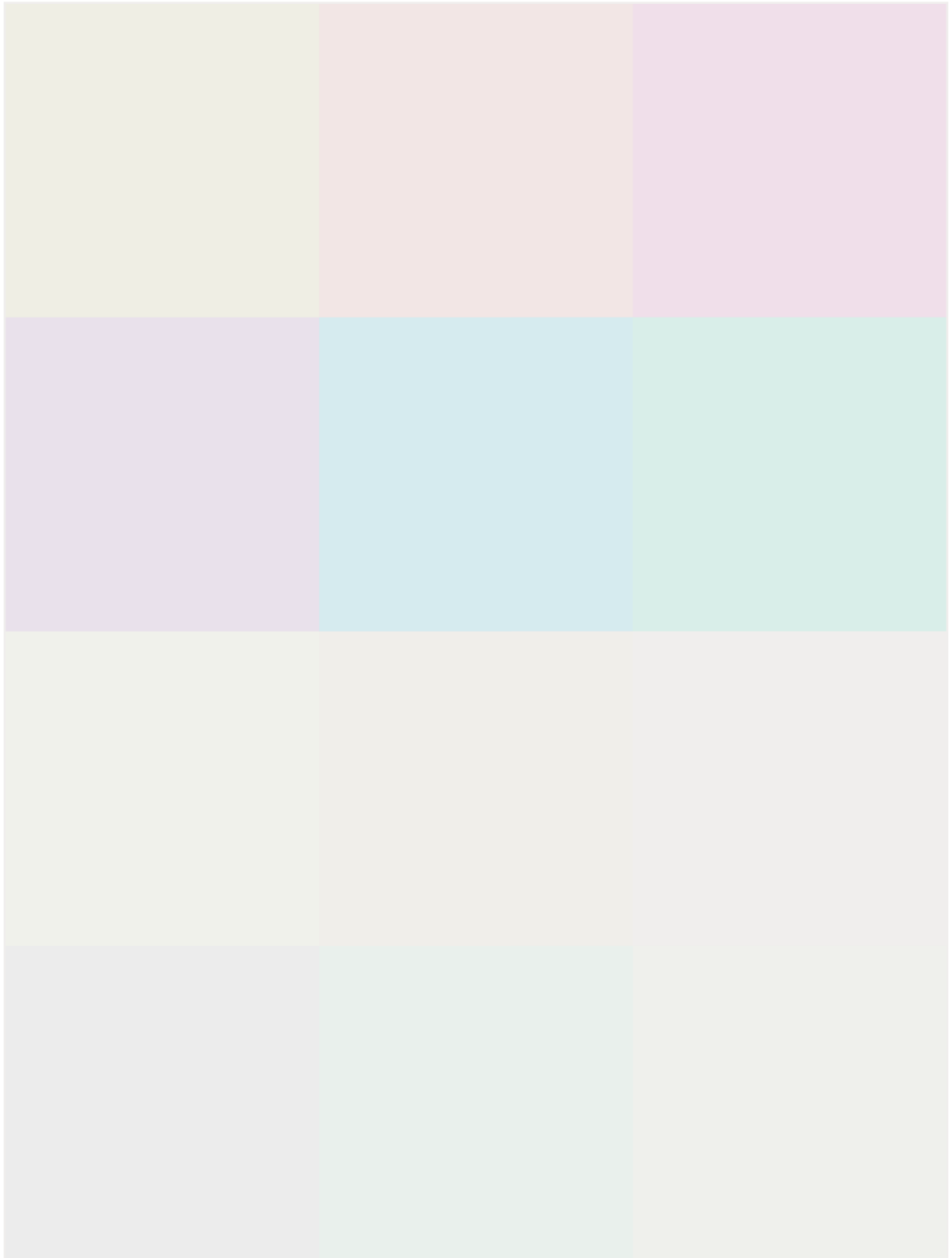
# CS Digital Sampler

## Grayscale

0%                                                                3%

4%                                                                7%

8%                                                               11%

12%                                                              15%

100%

97%

96%

93%

92%

89%

88%

85%

A
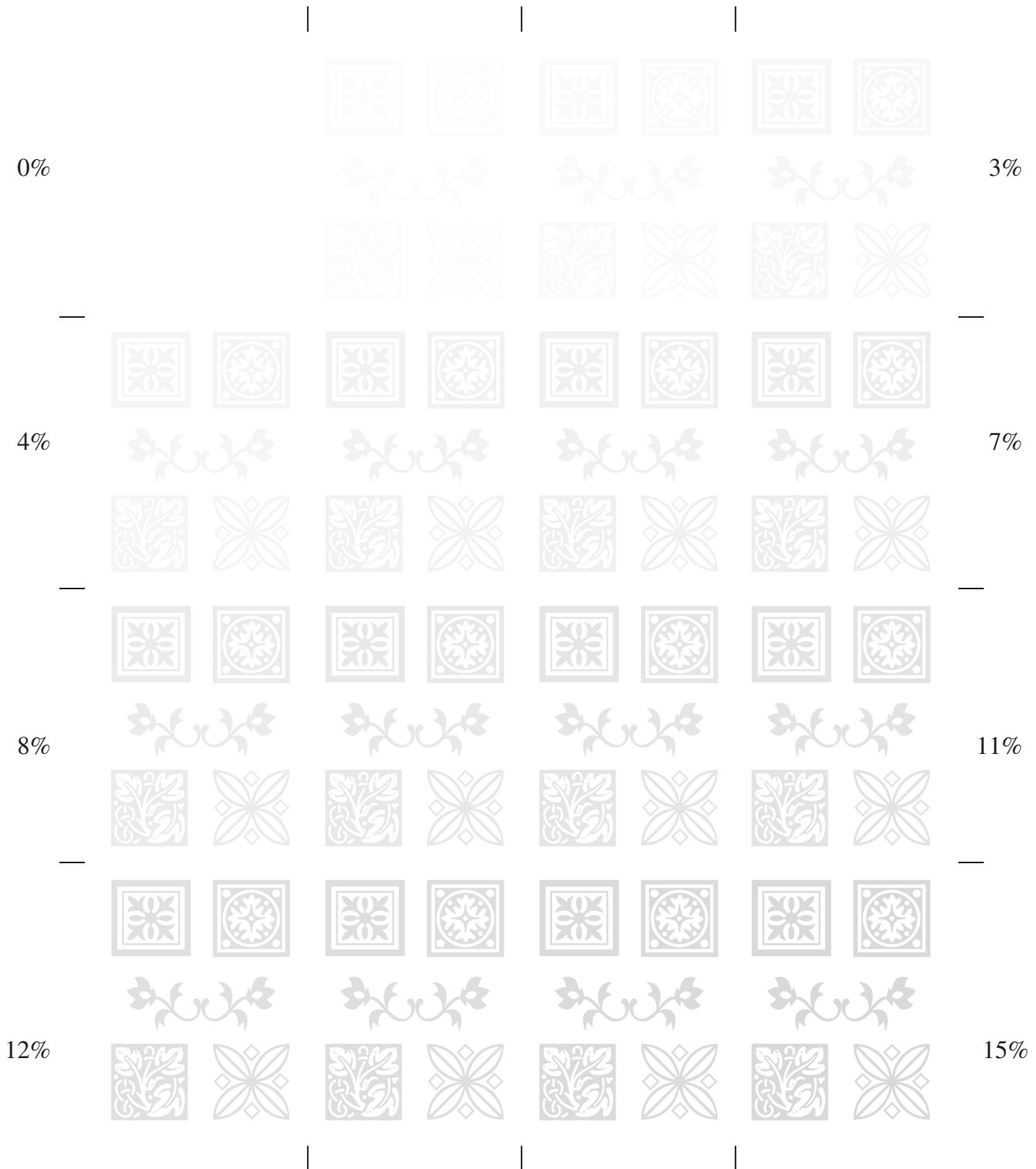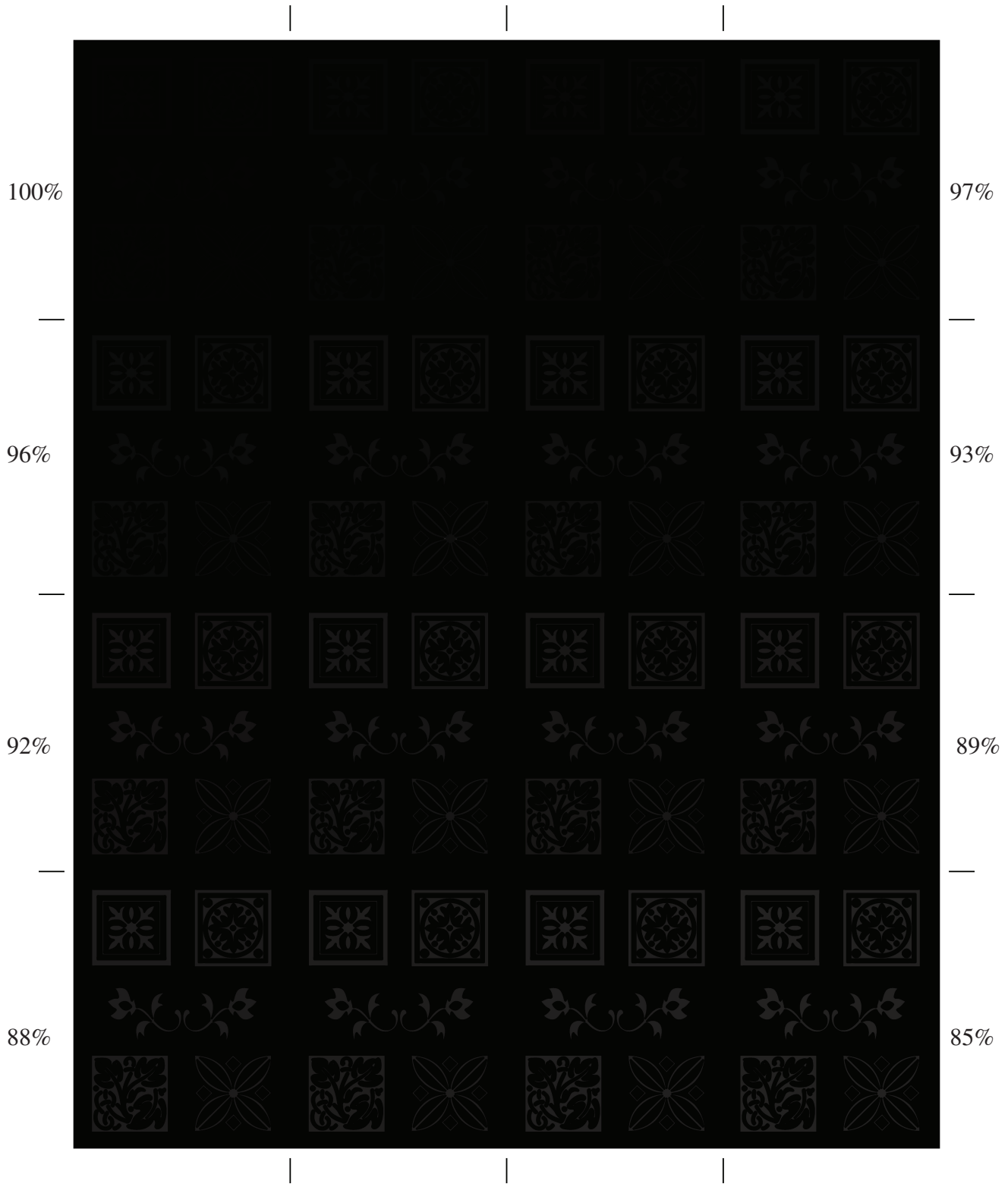
RBG original



B

CMYK conversion, with curves applied to bring the image closer to the RGB original.

# Conclusions

**Assumptions:**

- Scanners, cameras, monitors, and most graphics software are in sRGB, or default to sRGB.[1]
- CS's printing is geared to receiving work from all sorts of members, who may or may not have commercial graphics art or print production experience.
- Most CS members submit work that might or might not be tagged.
- Most of the images sent to CS are in sRGB, since that is what most people work in.
- CS uses Indigo[2] digital presses. Indigo controls the entire print environment.[3]
- CS strips the profiles off RGB images and uses it's own profiles.[4]
- Indigo process colors, CMYK, are significantly brighter than traditional CMYK colors—closer to and able to create perceptual RBG values.
- The profile CS uses produces perceptually dead-on color matching for RGB files.
- Most CS members do not use Acrobat Pro or InDesign.
- Most PDF uploads are generic PDF's or PDF/A's—not from Acrobat Pro.

**Conclusions: Color Images**

**General:** Work in RGB (sRGB). Submit your file in RGB (sRGB). Use JPGs. Do not convert to CMYK: therefore use High Quality, PDF/A (OpenOffice) or PDF/A-1b (RGB) conver-

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1 At the consumer level, sRGB is virtually universal. At the high-end, even when a drum produces a CMYK image, it was produced initially in RGB.

2 <http://h41131.www4.hp.com/sg/en/press/A_New_Chapter__books_printed_on-demand.html> (2009 news release) connects Amazon, BookSurge, Amazon's on-demand and self-publishing book printing to the Indigo 5000 series. The main location of BookSurge was Charleston, SC. BookSurge was acquired by Amazon in 2005, the same year it acquired CustomFlix (on-demand videos): renamed CreateSpace. In other words, CreateSpace did not come with book printing equipment, experience, or expertise: that came from BookSurge. All of the color work I have received from BookSurge and CreateSpace (2003-2011) was printed in Charleston, and appears to use the same paper, ink, and printing process. It is possible that CreateSpace, also in Charleston, uses entirely different presses, and that once BookSurge was merged (2009-2010) into CreateSpace, all of its Indigo presses were thrown away in favor of something else. But the way the ink sits on the paper, the screening, the image quality, and the fact that Amazon and BookSurge own many Indigo presses argues that Indigo is what CreateSpace uses. Representatives from both Indigo and Chromix (a color management company) have confirmed that Amazon and CreateSpace have Indigo presses.

3 Paper, proprietary ICC profiles, digital separations, proprietary inks (composition and color), ink temperature, paper handling, etc.

4 In a situation where a printer (CS) has no idea what sort of profiles, if any, will be used by its clients, and each project could be printed one-off, the most effective way of handling this sort of "chaos" is to strip all or most profiles and printing intents from images and use either Indigo's profiles or ones modified by CS. (I believe CS also alters CMYK profiles, but not as much.) For example, Photoshop default dot gain is 20%. Indigo varies from 9% to 12%: this is probably stripped from the images or simple overridden. GRC and URC would be different too.

sion presets;[5] do not use PDF/X,[6] Press Quality, or PDF/A (CMYK) PDF presets.

**CMYK:** unless you adjust the CMYK image to look as good as its RGB original, printing from CMYK PDFs will preserve the defects of most RGB to CMYK conversions. (CMYK has a smaller gamut than RGB; therefore some colors, usually very saturated ones, are outside what CMYK can reproduce. These colors are often flat when reproduced in CMYK. CS prints CMYK well, but the burden falls on the preparation to make it as good as RGB.

**Out-of-gamut colors:** out-of-gamut colors in RGB are not a problem.[7] Submit RGB PDFs.

**PDF/X:** converts RGB to CMYK. Only use it 1) if you have converted and adjusted each CMYK image to make it match the RGB original prior to converting to PDF; 2) if you are having work printed by another printer besides CS and only want one print-ready file; 3) for Black & White books where you did not do any image enhancement and are submitting color images to be converted by CS; 4) there are times when problems with transparency or stitching lines that using PDF/X is the best solution, outweighing color fidelity.

**Proofing:** use your desktop inkjet to proof your work. Softproof, or convert a copy to CMYK, to see the differences. For softproofing to be accurate as it is intended: 1) your monitor must be correctly profiled and calibrated, 2) your lighting conditions must be appropriate, and 3) you must know the CS profile, which must also include a factor for the paper. At a minimum, we do not know 3, CS's profiles; therefore softproofing can only be close at best—simply viewing as a CMYK image either by converting or proofing is and printing, which is for most people much more accurate, is the best we can do.

**Resolution:** 300dpi is the optimum image resolution. Higher resolutions gain virtually nothing, especially when the images are screened. The exception is 1-bit, black and white, art.

**RGB:** prepare your art in RGB (sRGB). Keep your files in RGB.[8] Make the best looking RGB images possible. Do not convert to CMYK.

**Rich Black & Black Backgrounds:** in larger areas, the differences between rich blacks and between any of them and black is significant. Make sure your blacks are consistent.[9]

**Rich Black & Black Type:** there is no perceptible differences.[10]

**Screens:** color halftones are screened at 170 lpi., black and white books at 106 lpi.

**Surprints:** are best with editable type (vector), not jpgs of type on a background or image.

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5  Many free and low cost PDF conversion programs appear to preserve the color modes but do not meet or offer established presets. Based on testing a few programs: some work for some people, some don't (probably due to software conflicts; if one fails, rather than spend a week fussing, try another conversion program).

6  Although PDF/X-1a is the standard graphics PDF preset for commercial printing, its benefits (less potential problems printing because of an automatic compliance with accepted standards and pre-defined output devices) are offset by often poor CMYK image conversion.

7  They are not a problem if your images stay in RGB in your PDF. Out-of-gamut colors are a problem if the files are converted to CMYK in the PDF. Do not specify specialty colors or inks (opalescent, metallic, etc.)

8  Do not convert to CMYK. Do not waste time finessing a CMYK image to print better.

9  The proofs for this book varied. The blacks, were virtually identical in one proof, although they  changed over a few weeks, and like the black in another proof, are different. The color work did not appear to vary over time. If you want to play with different blacks together, I'd advise exaggerating the  differences a little.

10  It makes sense, however, to use black consistently, type too.

**TAC/TIC:**[11] does not appear to be a problem.

**Transparency:** can be a problem and CS may pause a submission for it. Although PDF/X and PDF/A both remove transparency, saving images a JPGs guarantees that they won't be a problem.

**Trapping:** because of a tight registration control, misregistration is not a problem and trapping is not necessary.

**Type:** can be set as small as 2 points and still be legible.

**Type Reversed Out:** type can be set as small as 3 points and still be legible in color work.

**Type Screened:** 5-6 point type is legible when it is screened, although it depends on whether there is a background or not.

There are CS members who disagree with me. Download the test images, 17MB PDF, from http://www.12on14.com/pages/createspace.htm, and compare what you see and what you print out to what CS printed.

This book is a portion of *CS Digital: A Practical Guide to CS DIgital Possibilities*. It does not show all the tests that were used to arrive at some of the above conclusions.

My conclusions could be wrong. I have consulted with industry experts, and I have run tests. The consensus is that without knowing the ICC profiles CS uses, we can only guess how CMYK images will look printed during prepress. I believe that if we keep our images in sRGB, CS will do the rest.

The RGB > CMYK problem is one that experienced graphic artists have, not the average CS user. All of this sounds more complicated than it is because it is counter to what most of us have experienced for years.

> ***Beginners make beginner mistakes. The mistakes that experienced artists make can be so sophisticated that a beginner would easily avoid them.***
> Dan Margulis, *Makeready: A Prepress Resource.*

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11  TAC: Total Area Coverage/TIC: Total Ink Coverage: for example, registration black is 400% (C100 M100 Y100 K100); whereas Photoshop black is 300% (C75 M68 Y67 K90).