Compensation by black (CB) – a new separation?

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Key words: Compensation, GCR, UCR, Separation

Astract

The aim of this paper is to examine the differences between UCR (Under Color Removal) and GCR (Gray Component Replacement) by testing these separation functions in three applications: Adobe Photoshop CS (an image editing application), Gretag Macbeth's Profile Maker 5.0 (profile maker), and Heidelberg's Print Open 4.0.5 (profile maker). A review of the literature pertaining to the different types of separation was made and compiled. An Internet search was also made to check what a prepress employee would find out if he or she was to search for a definition of one of these types of separation.

The conclusions of the tests made suggest two alternative proposals and indicate a need to either:

1) Discard the term UCR and use only GCR, as it really only concerns gray component replacement. This would make it easier for people in the business to focus on the process itself instead of trying to understand the difference between the two types of separations, a difference which actually cannot be seen visualy in reality.

2) Discard both terms and introduce a new term CB (Compensation by Black). The software should give the user the possibility of choosing how much black will be used and where it will replace the use of a combination of the CMY process colors. In addition, a single term would make the user more aware of the problems of separation and of how separation will affect the print result.

The suggestions imply an extensive review of accepted terms and abbreviations within the graphic arts industry with the aim of giving them a uniform scientific meaning and definition. Thus, it is strongly recommended that the term, CB (Compensation by Black) should be implemented.

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Objective

The purpose of this study has been to investigate whether it is possible simplify the definitions of terms in the graphic art industry and thereby make it easier to learn and understand the color separation processes.

Methodology

This study will explain the differences between GCR (Gray Component Replacement) and UCR (Under Color Removal). In order to find out what an ordinary user encounters if he/she chooses to improve their knowledge in these techniques by using literature and web searches, a literature search as well as a web based search was performed. The following software has been examined and compared with respect to the separations UCR and GCR: Adobe Photoshop CS, Gretag Macbeth´s ProfileMaker 5.0 and Heidelberg´s PrintOpen 4.0.5. These softwares were chosen as they are widely used in Sweden.

Historical background - The Black printer

Electronic scanning of images captured on photographic films is used less and less in the printing industry, because most photographers are using high resolution digital cameras today. These cameras capture the images in RGB color space which is the standard in the display of digital images. The RGB colour space, however, cannot be used in the printing industry and the transformation to CMYK colour space is performed at a later stage in the prepress workflow. Exactly when the transformation is done varies depending on the nature of the workflow. Nevertheless, in order to understand basic colour reproduction it might be prudent to present a short historical background to electronic scanning and how colour images were reproduced when no scanners were available, i.e. conventional methods of colour separations.

Conventional methods of colour separations

The demand for more colour in magazines, other periodical products and printed matters, in¬creased when colour television was introduced in the beginning of the 1950s. Until then most magazines were printed in either b/w or in two colours (called Duplex) when a more vivid impression was demanded. Colour was normally only found on the front cover page, because colour reproduction was slow and very labour intensive. Flexible reprographic materials were not available, and all reproduction work had to be done on rather heavy glass plates coated with photographic emul-

sions (continuous emulsions). Not until the beginning of 1960s did modern reprographic flexible films become commercially available.

The common conventional procedures of producing colour separations were basically a manual operation with many critical steps. The total procedure relied on highly skilled craftsmanship which was limited and hard to find - the conventional process is described in Color and Its Reproduction (1988), and by Kipphan (ed.) (2001). When reprographic films were introduced during the 1960s, many different methods for colour separations were developed (Yule 1967). All were based on photographic filters and masks in conjunction with a reproduction camera, and those masking systems were developed by the leading manufacturers of reprographic films.

The first electronic scanner by Time-Life (PDI)

There was always a shortage of skilled operators, be it retoucher or photographer, when the demand for colour increased in the 1950s. Many publishers became frustrated when their demand for more colour images could not easily be met by their printers. Time-Life Corporation in New York had great success with a new concept of news and life style magazines; however the demand for more editorial colour in the magazines was not easy to fulfil.

Time-Life management was informed that their major supplier of photographic film, Eastman Kodak, had patented an electronic scanner model in the 1930s, just prior to the war (Gravure Manual 2003). In 1946 Time-Life bought the patent from Eastman Kodak, and commissioned Kodak to develop a new photographic emulsion on a flexible backing suitable for a drum exposure device. A new subsidiary of Time-Life, Printing Development Inc. (PDI), was set-up in Springdale (outside New York), and Panatomic X negative continuous tone film became available for scanning in 1:1, exclusive to Time-Life.

There are no reliable figures reported, but it can be assumed that productivity was increased by 3-4 times in comparison with the manual method. In the Gravure Manual (2003) it is, however, suggested that already in 1950 about 60% of the editorial colour images were scanned using the new device (quoted from the Penrose Annual of 1951). However, Time and Life magazines were printed wet-in-wet on coated stock by heat-set letterpress. This printing technique did not allow more than 240% ink coverage, which created huge problems in the reprographic process. Hence, Dr Yule from Kodak was asked to assist, and the first practical Under Colour Removal (UCR) application in electronic scanners was developed (Bruno 1985).

Time-Life management took a strategic decision; they were not willing to license the technology to third parties but started their own scanner studio, both in North America and in Europe. A few years later in 1958, Sun Printers, one of the major publication gravure printers in the UK, commissioned both Dr Hell and John Crosfield (they were unaware of the other's commission) to build an electronic scanner (Fuchs and Onnasch 2005).

The Europeans catch up

The first series of electronic scanners built by Hell and Crosfield had flatbed exposure onto photo-emulsion on glass plates, because Kodak was not allowed to supply its flexible reprographic film to anybody except PDI. The Crosfield Scanatron and Dr Hell Colorgraph both came to the market in the beginning of the 1960s. These scanners were used primarily by European gravure printers and it is estimated that about 50 of those units were actually sold. The Colorgraph was a very heavy machine, and all the electronics were put in a large cupboard with a power consumption of about 8 kW. Warming up all the tubes, mechanical relays etc. took about one hour every morning. Nevertheless, according to Dr Jung in the Swiss journal the "print" (1984) the first Colorgraph units were also equipped with UCR.

From 1965 onwards, Agfa and Gevaert both supplied flexible continuous tone scanner films, and the first generation of European drum scanners became firmly established on the market. Dr Hell Chromograph 185, Crosfield Diascan and later KS Paul (PDI license) were the first units, outputting 1:1 continuous negatives/positives. However, they had one important feature - at last a reproducible black printer could be produced! These new drum scanners improved productivity by a factor of 4-6 in comparison to manual methods (Bjurstedt 2005)

Black printer – skeleton black and UCR (Under Colour Removal)

The theories for a black printer can be traced back to the first work done by Yule (Yule 1940). According to him the black printer separation had one primary function, i.e. to compensate for impurities in coloured inks, and produce a quality four colour image. According to the contemporary colour practise of the time equal amounts of Y, C, M should produce a neutral Black or Gray, but this was not always possible to achieve. Hence, most of the separations used three colours with only Black (Key) in the text. The achieved quality, however, lacked the contrast and full colour gamut. However, it was found that a skeleton black could be produced with some additional effort with the available masking technique, which did not interfere in the highlights but started in the mid-tones and

upward. Skeleton black produces an adequate quality for those technologies without trapping, i.e. publication gravure printing. (Even to-day, many publication gravure printers prefer a skeleton black separation, when the separation is done by third party - ed. comment!).

However, skeleton black was only an intermediate step and some printers wanted to improve the contrast even further in the shadow areas. In his later work Yule presented the first theoretical deliberations, and in this paper he differentiated between full and moderate amount of UCR (Yule 1967). Although much of his work concentrated on various masking methods for conventional reproduction in the application of UCR, he did not limit the UCR concept to neutral grays only. He then went on to say that applying an UCR facility on electronic scanners is a relatively easy task using the least square method (Yule 1967).

The first generation drum scanners from Dr Hell, Crosfield and KS Paul (later called Linoscan when Linotype bought the company) all had UCR facilities. It seems, however, that the use of UCR was quite limited during most of the 1970s. The reason may be quite simple. Most of the first users of electronic scanners were publication gravure printers, and they preferred a skeleton black with a very limited amount of UCR. The prepress specialists were rather conservative and were accustomed to judging "normal" separations visually on the light table. UCR produced separations were something completely different (the "print" 1984), and in addition continuous tone negatives/positives could not be preproofed. The standard preproof method in publication gravure was a special proofing press, where a wet proof could be produced. Hence, many specialists discarded everything but skeleton black separations.

At the end of the 1970s, a new generation of electronic scanners was introduced with more powerful computers. These scanners used lasers for halftone exposure and were very suitable for lithographic printing, commercial web-offset and sheet-fed offset. The new generation of electronic scanners was the start of using scanners outside the big publishers/printers in the gravure market. Within a decade several thousand electronic scanners were sold worldwide, and they improved the reproduction quality and productivity, meeting the demand for more colour in publication and commercial printing. Hence, the trapping problems in wet-in wet printing needed to be solved and the UCR concept became fashionable again.

Demand for a third generation of scanners for web-offset applications – the concepts of Gray Component Removal (GCR), Complimentary Color Reduction (CCR) or Polychromatic Colour Reduction (PCR)

The competition on the world market between the two main suppliers of electronic scanners, Dr Hell and Crosfield, developed their scanners further. They were both quite successful on the world market, but somehow in the marketing efforts of electronic reproduction the UCR concept was lost. It was stated by many reproduction specialists that UCR was only applicable in the neutral gray areas. In Germany, some specialists launched a "new" colour theory, the so-called achromatic colour theory or "Unbunt Aufbau". This was a completely new theory and would revolutionize printing (Johnson 1984) but Johnson stated that these claims were ludicrous and "an old idea resurrected as though it were brand new". Hence, the theories developed by Yule 1967 were, and still are, valid.

Nevertheless, within a few years marketing people had invented a number of new acronyms, with GCR (or Gray Component Replacement) as the common denominator. Every supplier launched their own acronym:

Crosfield used PCR (Polycromatic Colour Reduction)
Dr Hell used CCR (Complimentary Colour Reduction)
Dai Nippon Screen used ICR (Integrated Color Removal)

Present color separation processes

The use of ICC-profiles is continuously expanding in the graphic arts industry. Most of the software on the market is profile based. Today´s user must make more decisions which directly affect the final result. Therefore, it is of vital importance that one understands the settings in the software. A great knowledge is demanded of users in the different printing companies/pre-press companies in order to understand the different definitions and techniques in the software.

The conversion from RGB to CMYK is mostly done with the help of ICC-profiles. While creating the profiles, the user can choose separation type. There are basically two types of separation: UCR (Under Color Removal) and GCR (Gray Component Replacement). UCR and GCR are in other words two different types of separations, which can reduce or remove a gray component, made up of yellow, magenta and cyan inks and replace it with an amount of black ink. These definitions are still a major cause of confusion, as very few users actually know what these definitions mean and how these settings will affect the final result.

Why do we use UCR/GCR? In lithographic printing one must avoid having too much ink on the paper in order to reduce a risk of set-off and rub-off problems, trapping problems, and to obtain a quicker drying process.

Recent developments – what does the literature of today say?

An examination of literature published between 1998 and 2004 has been performed. Examples of explanations can be seen below:

Undercolor Removal. A technique used to reduce the magenta, cyan and yellow dot percentages in neutral areas by replacing them with increased amounts of black ink (Romano, 1998).

UCR/GCR. Removing equal amounts of yellow, magenta and cyan process color inks from shadows and replacing them with a corresponding amount of black ink began with the introduction of undercolor removal (UCR) with photographic separations. A related process, gray component replacement (GCR), is used to remove the gray component (equal CMY) in any area where all three are present. Both processes are termed achromatic color reduction (Adams II, 2000).

GCR - a means of producing more consistent color and increased shadow detail in a printed reproduction by reducing the sizes of the cyan, magenta and yellow halftone dots that contribute to the darkening effect-or gray component-of an image. This has the effect of lightening an image without changing the actual colors reproduced, as the size of the black dots is increased to compensate for the gray removal (Romano, 1998).

UCR separations use black only in the neutral and near-neutral areas while GCR is a more aggressive strategy that replaces the amount of CMY that would produce a neutral with K, even in colors that are quite a long way from neutral (Frasier, 2003).

Gray Component Replacement (GCR) differs from UCR in that the reduction of colors under black is not confined to dark, neutral tones (Field, 2004) .

The GCR/UCR process is used to reduce the process colors (cyan, magenta, and yellow) and replace them with an "equivalent" amount of black (Sharma, 2004).

In order to find out what a pre-press worker in Sweden finds out if he/she tries to find a definition in Swedish concerning the different types of separations, an Internet-based search was performed. Examples of explanations from the web:

http://www.photoshopfocus.com/cool_tips/tips_color_basics_p4.htm
The UCR technique affects only the neutral shadow areas of the reproduction. The GCR technique interacts with two areas of the reproduction, the neutrals and colors areas.

http://glossary.ippaper.com/default.asp?req=glossary/term/998&catitemid
GCR: A technique used in the color separation process that replaces the neutral gray portion in cyan, magenta, and yellow with black. Instead of the cyan, magenta and yellow to producing these grays, they are produced with the black.

UCR: The technique of reducing the cyan, magenta and yellow ink in the darkest neutral areas of the image reproduction and replacing them with a controlled amount of black.

Summary - literature and web searches

The literature does not provide a clear and common explanation of the definitions regarding these two separation methods even though it is possible, in most cases, to understand that UCR only affects the neutral dark areas, while GCR affects all areas where the CMY-colors are present. Sometimes, the reader might consider the two separations equivalent.

The Internet search generated a more consistent picture regarding these separations. The conclusion from the Internet search is that UCR only affects the neutral dark areas, while GCR affects "the entire image".

What does the software and their manuals say?

Adobe Photoshop is the software which is most commonly used in image processing in the graphic arts industry. Most people in this line of business are familiar with this software.

Two other software have been chosen for investigation: Gretag Macbeth´s ProfileMaker 5.0 and Heidelberg´s PrintOpen 4.1. These software have been used in the actual creating of the profiles due to their spread use in Sweden. How do these software explain the different separations which appear in this field?

From the manual of Adobe Photoshop CS:

> *In undercolor removal (UCR), black ink is used to replace cyan, magenta, and yellow ink in neutral areas only (that is, areas with equal amounts of*

cyan, magenta, and yellow). This results in less ink and greater depth in shadows. Because it uses less ink, UCR is used for newsprint and uncoated stock, which generally have greater dot gain than coated stock.
In gray component replacement (GCR), black ink is used to replace portions of cyan, magenta, and yellow ink in colored areas as well as in neutral areas. GCR separations tend to reproduce dark, saturated colors somewhat better than UCR separations do and maintain gray balance better on press.

Comment: In Adobe Photoshop, it is possible to convert images from the RGB setting to the CMYK setting not only by using profiles, but also by using the included function, see fig. 1. This function provides access to these two separations (GCR/UCR).

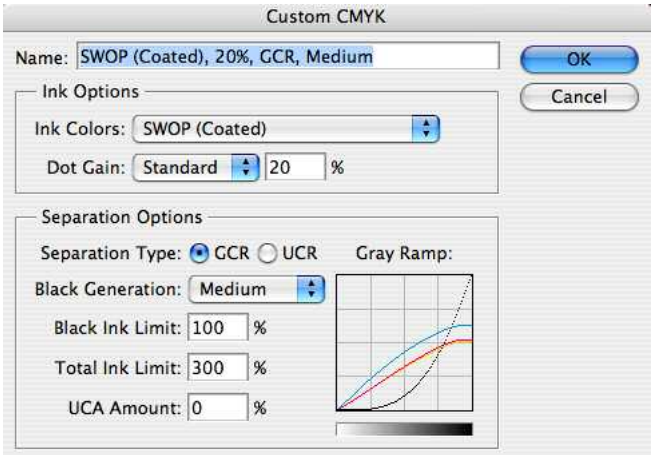

Figure 1: Color settings from Adobe Photoshop CS

From the manual of PrintOpen 4.0.5, see figure 2 and 3.

UCR (= Under Color Removal) is an additional setting option in chromatic reproduction. In this process, the gray component of the chromatic printing inks is replaced by black in neutral image shadow (p.216).
UCR can also be set together with GCR (p.216).

The GCR (= Gray Component Replacement) function permits the gray component of the chromatic printing inks to be replaced by black process color, with an effect in the entire color space (p.217).

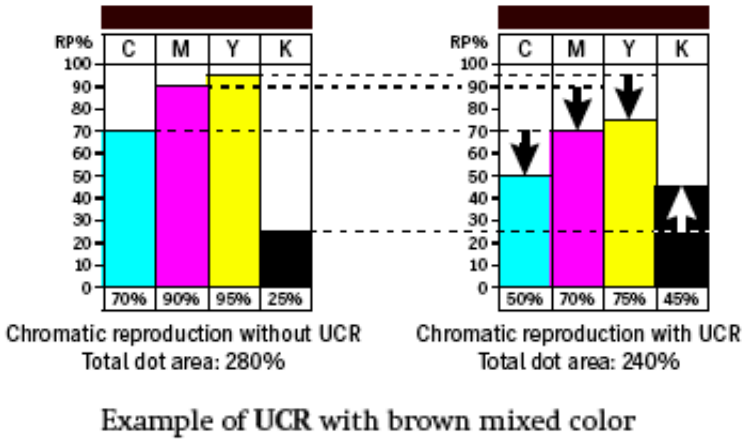

Figure 2. A screen dump from PrintOpen 4.0.5 manual. The picture and the text in the manual are in conflict: the text says that UCR works in neutral image shadow but the example shows not the neutral tone but a tertiary brown color.

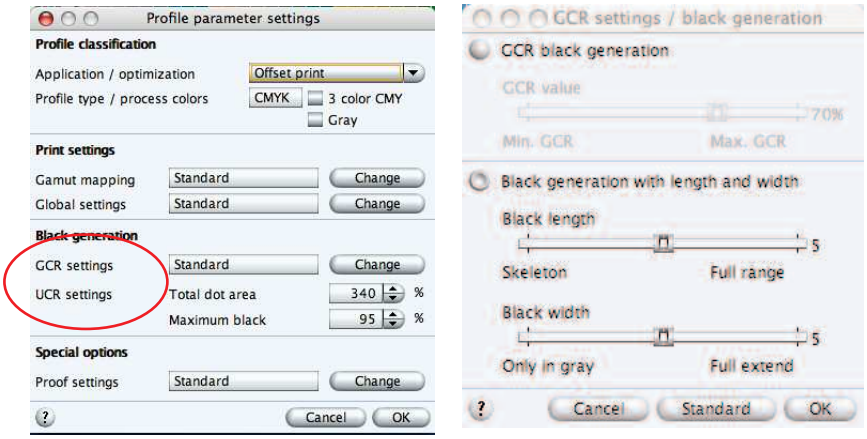

Figure 3: Color settings from PrintOpen 4.0.5

From the manual of ProfileMaker 5.0

ProfileMaker Pro Help (accessible in the software) does not explain the different separations.

Separation Method, see figure 4.

In the Separation popup, select a chromatic composition procedure. You can choose UCR, GCR 1-4, NoK (no black), or MaxK (maximum black).

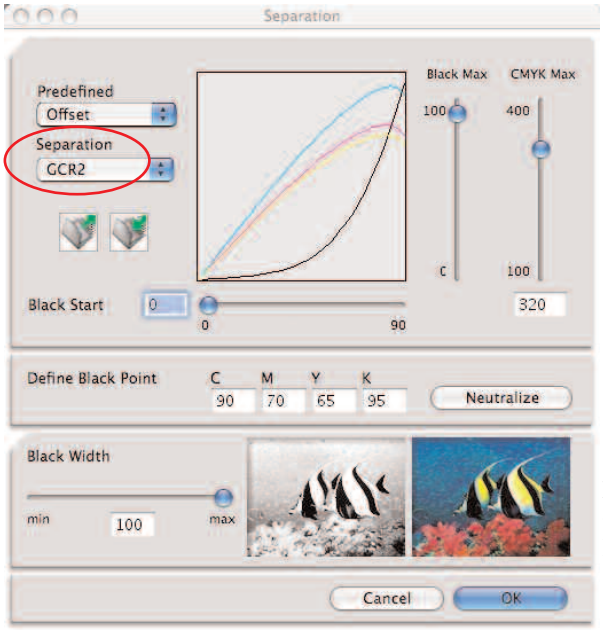

Figure 4:
Color settings from ProfileMaker 5.0

Summary – manuals

The explanations of the different separations are often complicated and difficult to understand which makes it hard to get a good comprehension of these functions.

PrintOpen's manual describes UCR and GCR on several pages, sometimes in combination with other functions such as, black width. These functions provide the user with the opportunity to, for instance, create a GCR from a UCR. The figure (figure 2) which describes the differences between GCR and UCR is very misleading, as it does not show the descriptive text in the manual. The text says that UCR works in neutral image shadow, but the figure shows a brown shade which is not a neutral tone.

The manual form ProfileMaker 5.0 does not explain what they mean by these settings at all.

Practical investigation of the separation types

Does the explanations in the manuals, supported as they are by literature, agree with the actual result in the image?

In order to more easily understand how the black color works in an image, a digital test form has been developed (Enoksson, 2005) see figure 5. The layout of this test form simplifies understanding, with the help of the visual result obtained after converting the test form to CMYK with the help of profiles. With the help of this test form, the separation settings were inves-

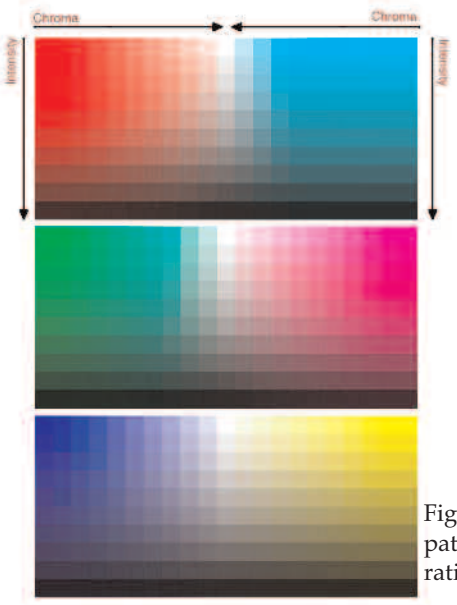

Figure 5: The test form. Moving from one patch to the next represents a change in saturation and lightness by ten percent.

According to the literature and the manuals, the UCR should only work in the central areas of the test form, in the actual gray scale, or in close vicinity to the gray scale. GCR should not only work in the darker areas of the gray scale, but also in the lighter areas of the gray scale as well as in tertiary color areas.

In order to evaluate this, several settings / profiles have been created in different software and tested in the test form.
The test consisted of three parts:

1) test with Adobe Photoshop's settings
2) test with ProfileMaker's settings
3) test with PrintOpen's settings

1) Test with Adobe Photoshop

In the program´s function for separation settings, different variants of settings have been chosen. Theses settings were chosen in agreement with consultants in the graphic arts industry as well as the normal praxis in this field:

a) UCR, total ink limit 320, black limit 100

b) GCR light, total ink limit 320, black limit 100

c) GCR medium, total ink limit 300, black limit 100
- this setting is the default setting in the software

d) GCR heavy, total ink limit 240, black limit 95

e) GCR maxK, total ink limit 240, black limit 95

By using these settings, the test form was converted from RGB to CMYK. The black channel was analyzed after the conversion. The results from these studies can be seen below, figure 6 and 7. The test shows that UCR works not only in the neutral areas but even in the color areas, see figure 6. The red circles show the area where UCR should work according to the manual.

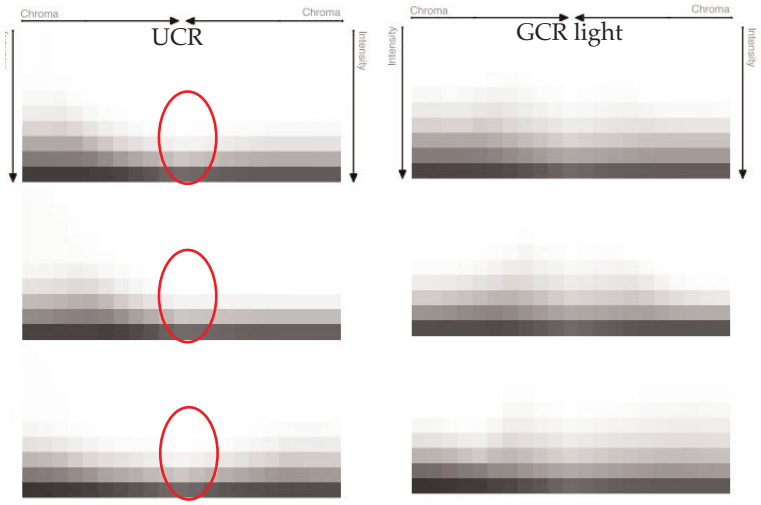

Figure 6: The difference between UCR (total ink limit 320, black limit 100) and GCR light (total ink limit 320, black limit 100)11. The red circles show the area where UCR should work according to the manual. For more information about values see appendix 1, 2 and 3.

Figure 7 shows the differences between the different levels of GCR in Adobe Photoshop: GCR medium. GCR heavy and GCR maxK.

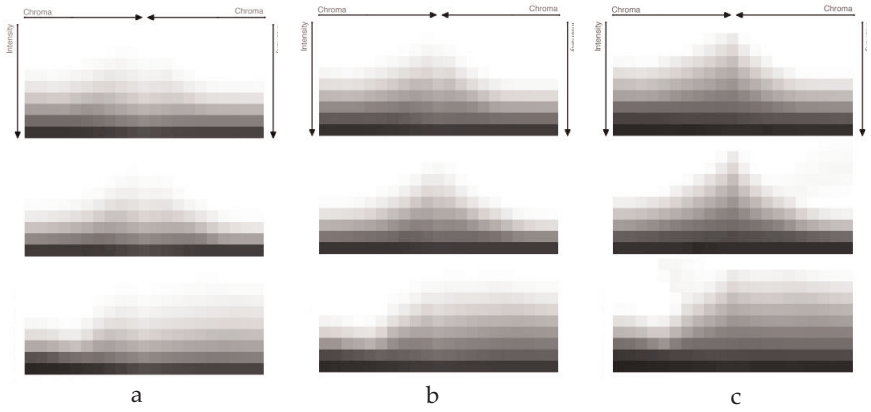

Figure 7: The differences between the different levels of GCR in Adobe Photoshop:
a) GCR medium, total ink limit 300, black limit 100 (standard),
b) GCR heavy, total ink limit 240, black limit 95
c) GCR maxK, total ink limit 240, black limit 95

Result - Adobe Photoshop

The GCR function works according to Adobe Photoshop's manual (and also according to literature), while the UCR function disagrees with both the manual and the current literature. UCR should have worked only in the neutral dark areas, but as the test form reveals, a substitution of CMY with black takes place in color areas as well.

2) Test with ProfileMaker's settings

A coated ISO profile, modified in ProfileMaker with the settings described below, was chosen as a standard profile for the tests:

gcr2 , black start 0, tic 320 , black max 95, black width 100 default
gcr1, , 0, 320, 95, 100
gcr3, 0, 280, 95, 100
gcr4, 0, 240, 95, 100
max k, , 0, 240, 100, 100
ucr, 0, 320, 95, 100

black width 100% (default) - 0%:

gcr2 , black start 0, tic 320 , black max 95, black width 100 standard
gcr1, , 0, 320, 95, 0
gcr3, 0, 280, 95, 0
gcr4, 0, 240, 95, 0
max k, , 0, 240, 100, 0
ucr, 0, 320, 95, 0

The differences between UCR and GCR1 at the current settings are small, see fig. 8. The black ink is active in the neutral tones as well as in the color areas.

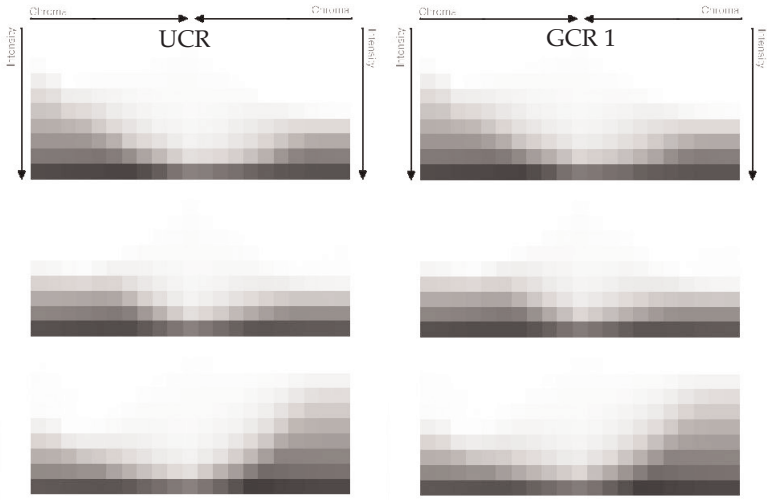

Figure 8: The difference between UCR and GCR1 by same settings for TIC=320, black start=0, black max=95 and black width=100.

The settings for GCR and UCR can be combined and completed with the function **Black width**, see figure 8 and 9.

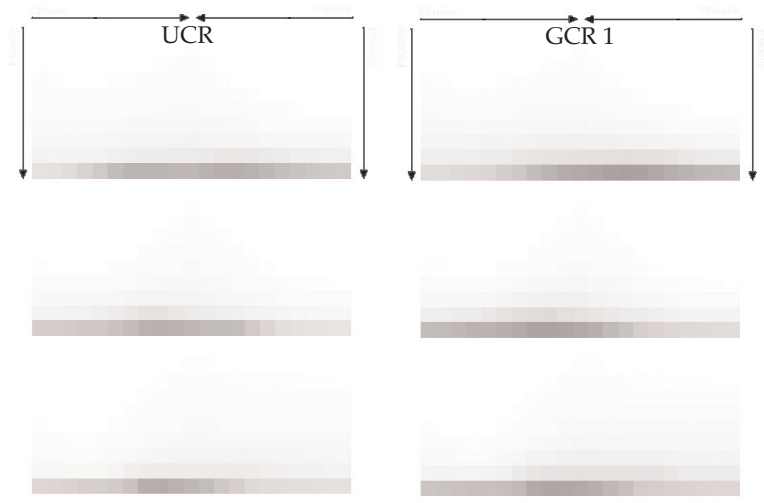

Figure 9: The setting at black width=0 for UCR and GCR 1. Other settings: black start=0, TIC=320, black max=95. The black channel shows a very little difference between UCR and GCR1.

From the manual:

> *Black Width (Enhanced Mode)*
> *With the Black Width slider, you specify whether more or less black is to be used in the saturated zones of the image. The slider is used to control the relative quantity of black in the saturated areas, which have a higher chroma. This means that less black is used in the areas where the hue has greater saturation/chromaticity.*
>
> *In the sample images in the Separation dialog, it is very easy to see the effects of changing the black width. The change to the black width is evident in the saturated areas of the image, but not in the black strips on the fish.*
>
> *The default setting, which is also the recommended setting, is maximum black width.*
>
> *Note: This option is provided mainly to allow flexibility of separation control in gravure printing. Reducing the black width may also lead to a reduction in the printable gamut in dark image zones.*
> *You should only make use of the option to reduce the black width if you need to use as little black as possible. In general, it may be said that printing procedures that are capable of producing a deep black using CMY even without black can produce dark colors that are less smudged if the black width is reduced.*

Comment: An examination of this function together with five consultants generated three separate opinions regarding how this function works. This shows how complex this question is. An ordinary pre-press worker has difficulties in understanding the contents, and thereby it is hard to interpret.

The differences between the levels for GCR - GCR1, GCR2, GCR3 and GCR4 can be seen in figure 10.

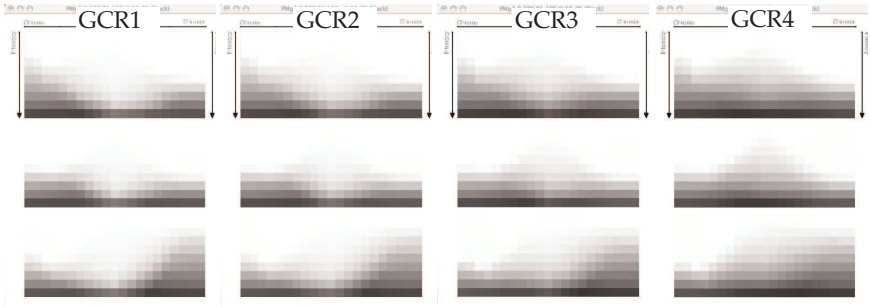

Figure 10: Different levels for GCR (GCR1, GCR2, GCR3 och GCR4). Other settings: TIC=320, black start=0, black limit=95 and black width=100.

Result - ProfileMaker

As can be seen, the differences between the settings for UCR and GCR1 are minimal at the same setting for black start, black max and black width. UCR does not only work in the neutral gray areas, but also in the color areas.

ProfileMaker gives the user the opportunity to change several settings which are part of the separation settings, for instance black width. This function is available both for GCR and UCR and makes it possible to limit/expand the amount of black in the tertiary colors. The default setting is at black width=100.

3) Test with PrintOpen's settings

A coated ISO was chosen as a standard profile here as well.
PrintOpen has a default setting for offset printing UCR with total dot area=340%, maximum black= 95%, black lenght=7 and black width=7.
The test contains:

a) comparison between different levels for black width - UCR, figure 11
b) comparison between different levels for GCR, figure 12

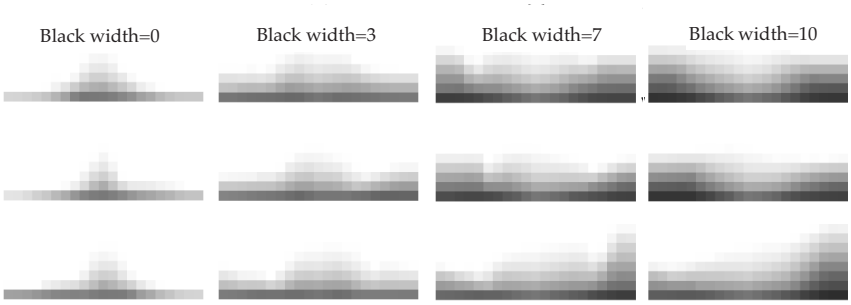

Figure 11: Comparison between different levels for black width: 0, 3, 7, 10. Other settings: total dot area 340, maximum black 95, black length 7.

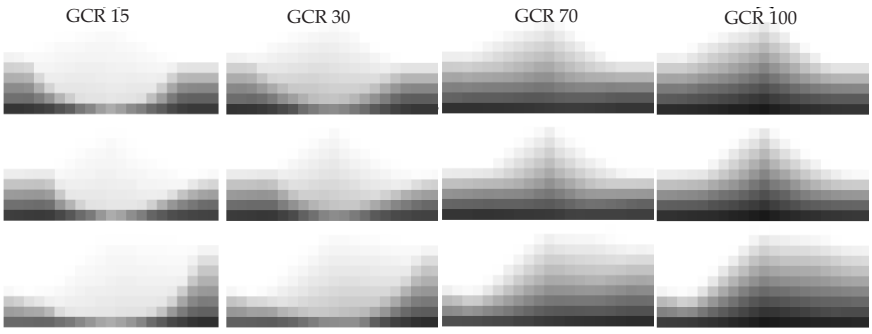

Figure 12: Different levels for GCR in PrintOpen.
Total dot area=340, K95, gcr15
Total dot area=340, K95, gcr30
Total dot area=340, K95, gcr70 (default setting for GCR))
Total dot area=240, K98, gcr100

The UCR setting at black width=0 is most equivalent to the explanation that UCR works in dark areas of neutral tones. Default settings for black width is black width=7.

Result - PrintOpen

The profile software PrintOpen says in its manual that UCR works in neutral areas, but this is only true when the settings for black width=0, see figure 11. In other words, one can complete the UCR function with other functions such as black length and black width, which provides an opportunity for the user to direct the amount of black in his image reproduction. The effect of black width on UCR makes this setting to behave more and more as the definition of GCR would, meaning that the overprint of CMY is replaced not only in neutral areas, but also in color areas.

Sumary of the tests and comparisons

The investigation of both recent literature (1989 - 2004) and manuals from frequently used software describes two different types of separation, GCR and UCR. The difference that UCR only works in the neutral dark areas and that GCR seems to be working in the entire tone range (where the three CMY-colors are present) is explained.

The tests, where the test form was used, generated a similar result for UCR and the lowest level of GCR. To draw a border between these two separation types is difficult. This means that UCR really is a “light type” of GCR or “GCR level 1”. Previously this had been pointed out in an article in the RIT T&E Center Bulletin (September-October 1984) written by Franz Sigg and Patty Cost in 1984 (American Printer, 1985): “The term UCR would therefore no longer be used, because its function would be fully covered by GCR”.

Conclusions

Contemporary literature and Internet searches have revealed that the general opinion is that UCR works in the neutral gray areas and that GCR works within the entire tone range and the entire image. However, it has been shown in this paper that the original meaning of UCR was lost about 25 years ago when the third generation of electronic scanners targeted the lithographic printing industry (publication and commercial printing). The first theoretical principles of UCR were developed by Yule, and his theories were first attributed to conventional separations, and later to the first electronic scanner, the Time-Life/PDI scanner in the early 1950s. The lim-

itation of conventional masking methods in applying UCR to neutral tones only later became the standard opinion about UCR.

In a later paper Yule expressed his regrets that the initial scope of UCR had been perceived to be limited to neutral tones. He then went on to say that this had become the "standard opinion" in the industry, and therefore he introduced his concept about "Extended UCR". Later Extended UCR became known as GCR or Gray Component Replacement, and inventive marketing from the leading electronic scanner manufacturers in the beginning of the 1980s has attributed to the confusion. In any case, the achromatic synthesis or "Unbuntaufbau" was and will ever be the new color theory. Hence, one must not forget the real function of the black printer as pointed out by Birkenshaw et. al. as early as 1977 (Birkenshaw 1977, abstract).

Nevertheless, one must not forget the real function of the black printer. In a paper by Birkenshaw et. al. in 1977 (Birkenshaw et. al 1977), the functions of the black printer were summarized in the following four points:

- To make the control of the other three colors less critical as to ink balance
- To produce better blacks and shadow detail than the other three colors alone can alone. This is probably the main reason why black printers are currently used. The improvement that results in a reproduction from using a good black printer is considerable
- To substitute a relatively inexpensive black ink for a part of the more costly colored inks
- In wet on wet printing, to avoid the piling up of several ink layers which do not print satisfactorily on top of each other and may give ink drying problems

Further, practical tests conducted when preparing this paper have also verified that these new definitions are not correct. This suggests, in turn, that the different views between GCR and UCR are unnecessary and misleading for those willing to learn more about the different separations methods. People within the field agree with the fact that there are difficulties in understanding all definitions and abbreviations. In the case of GCR and UCR, the theory does not agree with reality at all which causes increased confusion and misunderstanding.

The conclusions of the tests carried out suggest two alternative proposals and indicate a need to either:

1) Discard the term UCR and use only GCR, as it really concerns gray component replacement. This should make it easier for people in the business to understand the difference between the two types of separations, a difference which actually cannot be seen in reality.

2) Discard both terms and introduce a new term CB (Compensation by Black). The software should give the user the possibility of choosing how much black will be used and where it will replace the use of a combination of the CMY process colors. In addition, a single term would make the user more aware of the problems of separations and of how separations will affect the print result.

Thus, it is strongly recommended that the term, CB (Compensation by Black) should be implemented.

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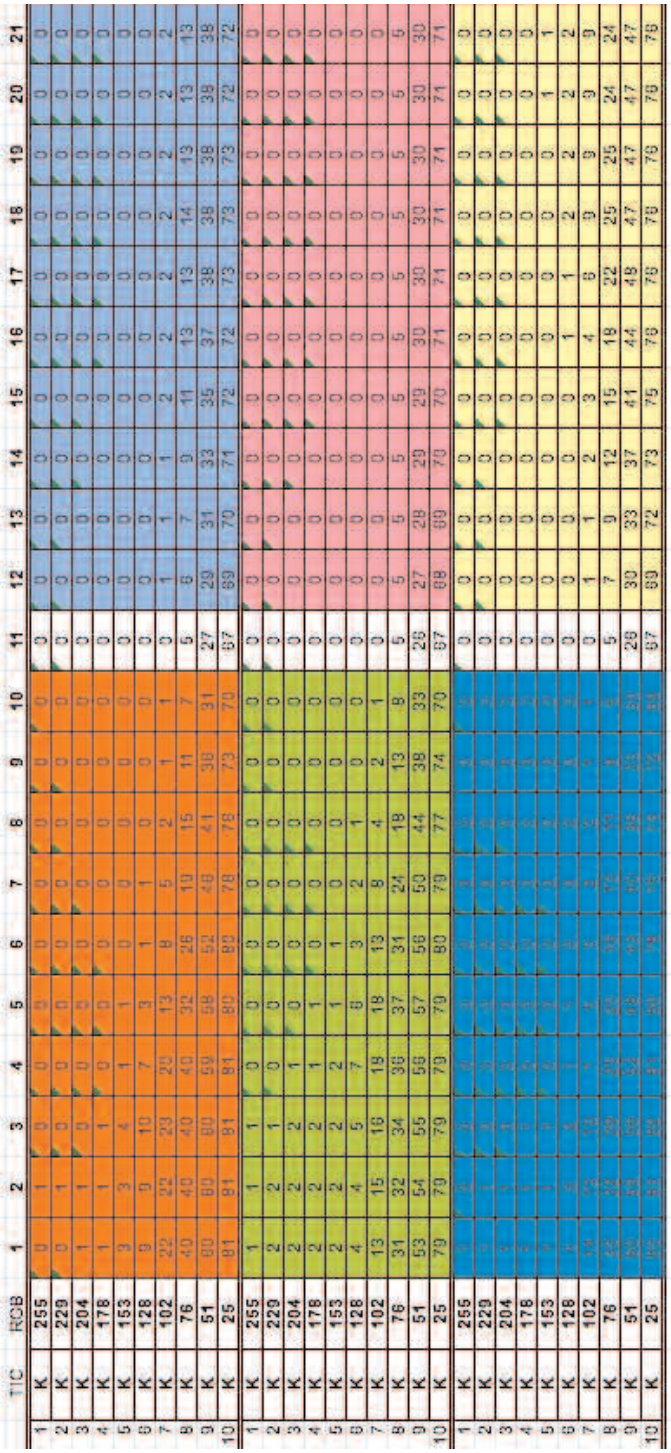
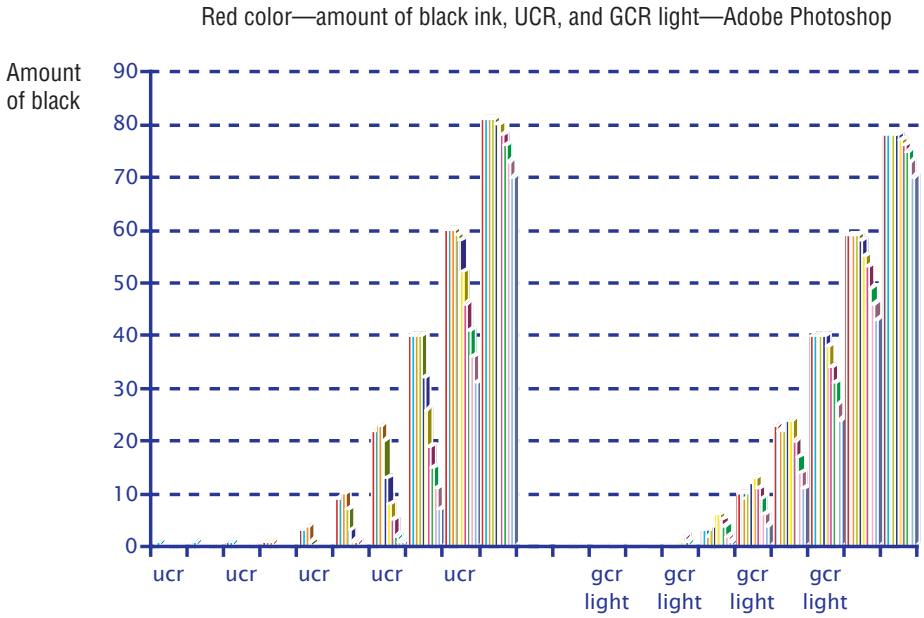


	TIC	RGB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	K	255	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	K	229	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	K	204	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	K	178	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	K	153	3	3	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	K	128	9	9	10	7	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	K	102	22	22	23	20	13	8	5	2	1	1	0	1	1	1	2	2	2	2	2	2	2
8	K	76	40	40	40	40	32	26	19	15	11	7	5	6	7	9	11	13	13	14	13	13	13
9	K	51	60	60	60	59	58	52	48	41	36	31	27	29	31	33	35	37	38	38	38	38	38
10	K	25	81	81	81	81	80	80	78	78	73	70	67	69	70	71	72	72	73	73	73	72	72
1	K	255	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	K	229	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	K	204	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	K	178	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	K	153	2	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	K	128	4	4	5	7	6	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7	K	102	13	15	16	18	18	13	8	4	2	1	0	0	0	0	0	0	0	0	0	0	0
8	K	76	31	32	34	36	37	31	24	18	13	8	5	5	5	5	5	5	5	5	5	5	5
9	K	51	53	54	55	56	57	56	50	44	38	33	26	27	28	29	29	30	30	30	30	30	30
10	K	25	79	79	79	79	79	80	79	77	74	70	67	68	69	70	70	71	71	71	71	71	71
1	K	255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	K	229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	K	204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	K	178	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	K	153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
6	K	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	2	2
7	K	102	0	0	0	0	0	0	0	0	0	0	0	1	1	2	3	4	6	9	9	9	9
8	K	76	0	0	0	0	0	0	0	0	0	0	5	7	9	12	15	18	22	25	25	24	24
9	K	51	0	0	0	0	0	0	0	0	0	0	26	30	33	37	41	44	48	47	47	47	47
10	K	25	0	0	0	0	0	0	0	0	0	0	67	69	72	73	75	76	76	78	76	78	78

A overview of values for the black channel after conversion to CMYK in the test form - from figure 6.
The conversion was performed in Adobe Photoshop with settings for UCR, black limit=100, ink limit=320.

	TIC	RGB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	K	255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	K	229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	K	204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	K	178	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	K	153	3	3	2	3	4	6	5	4	2	1	0	1	1	1	2	0	0	0	0	0	0
6	K	128	10	10	9	10	12	13	11	9	6	4	3	4	4	5	5	4	3	2	2	2	2
7	K	102	23	22	22	22	24	24	20	17	14	11	9	10	11	13	14	14	13	12	12	12	12
8	K	76	40	40	40	40	40	38	34	31	27	24	22	22	24	25	27	28	28	28	28	28	28
9	K	51	59	59	59	59	58	55	53	49	46	43	40	42	43	44	45	46	46	46	46	46	46
10	K	25	78	78	78	78	78	77	76	75	73	70	68	69	71	71	72	72	72	72	72	72	72
1	K	255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	K	229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	K	204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	K	178	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	K	153	0	0	0	0	0	1	2	4	2	1	0	1	1	1	0	0	0	0	0	0	0
6	K	128	1	1	1	2	4	5	8	9	7	5	3	4	4	5	4	2	0	0	0	0	0
7	K	102	8	9	10	11	13	16	20	18	15	12	9	10	11	12	13	10	6	2	1	1	0
8	K	76	24	25	26	28	31	34	35	32	28	24	21	22	24	25	26	24	21	16	13	11	10
9	K	51	49	49	51	53	54	55	53	50	47	43	40	41	42	44	45	45	42	39	38	38	38
10	K	25	76	76	76	76	76	77	76	74	73	76	68	69	71	72	73	74	74	75	75	74	74
1	K	255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	K	229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	K	204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	K	178	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1
5	K	153	0	0	0	0	0	0	3	3	2	1	0	1	1	1	2	3	3	3	4	3	3
6	K	128	4	3	2	1	1	4	8	8	6	4	3	4	4	5	6	7	7	8	8	8	8
7	K	102	15	14	12	8	8	13	18	16	14	11	9	11	12	13	14	15	16	17	17	16	16
8	K	76	35	35	32	28	25	30	33	30	27	24	21	23	24	26	27	29	30	31	30	29	29
9	K	51	68	67	64	60	58	53	52	49	46	43	40	42	43	45	46	47	48	48	47	47	46
10	K	25	84	84	83	82	81	79	78	75	73	70	68	69	70	71	72	72	72	73	72	72	72

A overview of values for the black channel after conversion to CMYK in the test form - from figure 6.
The conversion was performed in Adobe Photoshop with settings for GCR light, black limit=100, ink limit=320.



The comparison between UCR and GCR light in the red area of test form—Adobe Photoshop. From figure 6.