# Improvement of the reproduction accuracy of spot colours in security printing by modifying the ink formula

## Abstract

There may occur serious difficulties with the mixing of spot colours for security production, and then the accurate reproduction of the same colours in any subsequent round of repeated production. There are several underlying reasons: on the one hand, the print medium does not contain any optical brightener unlike the ones that are taken into consideration in the formulas that are specified for the Pantone colour chart designed for general use in the printing industry, whole on the other hand problems may be caused by those colours applied in security printing that are hard to copy or scan. Towards the optimization of the costs of manufacturing, it is necessary to be aware of these deviations, and use correction factors in the course of the pre-mixing of colours. In our studies, we examined to what an extent we were to deviate from the formula determined for any specific colour when the spot colours for securities were mixed. We chose colours that could be blended from two process colours, and consequently we could observe the direction of changes without ambiguities. After a number of iterative steps, it was determined to what extent formulas were to be changed for the examined colours when the individual types of security papers were used, and it was also established that even from the same manufacturer subsequent supplies of inks can considerably differ from each other in terms of the process colours, and therefore this colour difference needs to be taken into account when modifying the formula.

**Keywords:** printing of securities, printing inks, spot colours, colour mixing, Pantone chart, colour difference

## 1 Objectives of the research

Initially, in the production of securities spot colours and successive numbering were used as protective elements. Yet, the use of colours in security production faces difficulties with the reproducibility of the selected colours. Furthermore, the value represented by the given product and its colour may become mutually identifying elements for users (for instance, banknotes, meal vouchers, corporate stocks, stamps). The spot colours used in the production of securities can be both half-toned colours and colours featuring high tonal values. Half-toned colours are used to make underprints, whereas large tonal values are suitable for presenting texts, figures and/or brand colours, logos.

The more process colour components any specific colour contains, the harder it is reproduced. This problem emerges with the production and printing of the colour. To exploit these characteristics, the use of spot colours as a particular option of protection occurs in the field of official document protection and the production of securities. If for the design of a value article or the image of an official document such a spot colour is chosen that cannot be reproduced by means of colour mixing, then the risks of counterfeiting by digital techniques can be excluded. On the other hand, the making of the underprint with very light colours renders the accurate scanning of the given underprint impossible or at least very difficult. With offset technologies, the application of spot colours yields continuous, sharp prints, while with the application of the

same technique in association with autotypical colour mixing the printed image and colour will be made up of the points of the process colours (raster). This difference also functions as an element preventing the image from being counterfeited.

To produce spot colours, the standard used by the printing industry is the set of Pantone colours, encompassing cc. 1300 colour samples. For official document protection, generally it is the spot colour collections compiled for painted and unpainted printing papers are used. The Pantone company defines the mixing ratios of any given colour in the form of percentage rates of 14+1 process colours, with these colours being the following: Yellow, Yellow 012, Orange 021, Warm Red, Red 032, Rubin Red, Rhodamine Red, Purple, Violet, Blue 072, Reflex Blue, Process Blue, Green, Black, Transparent White. These process colours are also defined by means of samples, and compliance with them is guaranteed by most of the ink manufacturers. It suggests that from the inks manufactured by any of the ink suppliers can be used to make colours that identical to the respective samples. Nonetheless, it does not always possible in practice: There are ink manufacturers who have compiled their own collections of formulas for the production of Pantone colours, and these are made available to the printers using their products. For printers, the production of spot colours causes a long-known problem. By today, most of the security printers have come to operate their own colour-mixing workshops. The actual colour is set jointly by a specialist of colour lending and operator of the printing press, because the correct colour does not solely depend on the proper selection of the formula.

The fundamental conditions of the reproducibility of any given colour are the following.

- Accurate addition and mixing of the constituents specified in the formula.
- Surface and colour theory parameters of the print medium.
- Level of development and technical conditions of the printing press.
- Composition and temperature of the wetting liquid.
- Stability of the temperature in the printing room.

The colour is set with the joint application of methods based on visual and instrumental measurements. For visual colour matching, CIE D65 illumination is used to avoid the occurrence of metamerism.

In the process of colour setting, the necessary changes of the formula are consistently documented. When in the security printing acceptable colour difference ($\Delta E<1$ value, $\Delta H<\pm 0.2$) is reached, both the accurate formula and the setting parameters of the machine are assigned to the ID of the given product.

The formulation of the colour of the inks is also influenced by the colour stimulus mixing method of spot colour offset printing used for the printing of securities. It is to be noted that a colour created with subtractive colour stimulus mixing will always be darker than any of the constituting colours. In the printing industry, this is the basis of the establishment of the coloration properties of the printing inks and print media.

In printing inks, the pigment and binders make up a colloidal system. The chemical composition of the binders determines the type of the drying of inks. Our studies have focused on the colour properties of the such printing inks drying after penetration and oxidation that match the print media of the manufacturing of securities.

The print medium has a key role in visually presenting the printed image, which is well demonstrated by the fact that on various papers different tone ranges (i.e. difference between the largest and smallest density of the print) can be achieved. The yellowish colour of papers can be

improved with the application of optical brightening. In this method, a fluorescent additive is blended into the paper pulp. The additive improves the apparent blue reflections, and thus betters whiteness. In the production of official documents and securities, optically brightened printing papers are not used, because they would eliminate or partly counteract the effects of various fluorescent protective elements that are present in the printing paper. Therefore, towards accurate colour reproduction, the Pantone or other formulas of manufacturers usually need to be modified on security papers, because on less white printing papers the size of the space for the reproducible colour stimulus is smaller than the corresponding range on white or brightened printing papers. This a fact that has to be accepted in the manufacturing of securities, and further considered when selecting the colours that are wished to be printed.

## 2 Research methods

The test form included two-coloured security graphic elements (guilloche pattern) and colour measurement fields, while printing was performed with colour tones that can be mixed from two basic colours of the green–orange and blue–red colour pairs.

Test prints were prepared on three types (Shil, Dipa, Fabriano) uncoated security papers under operating conditions. They were printed by using oxidative ink on offset printing machines of Heidelberg Printmaster 52-4 type. Ink coverage was adjusted in accordance with the recommendation specified in our standard for security printing ($D_{uncoted}$=1.45). Spot colours were mixed in the company's workshop, with the use of the Ink Mixing System manufactured by Pantone (Tabletint, GretagMacbeth Ink Formulation for Windows, etc). We mixed 400g ink for every test run. We used Huber Inkredible inks.

*Table 1: The formulas of the used colours corresponded to the Pantone Formula Guide sample book*

| | P Green | P Pro. Blue | P Rubin Red | P Yellow | P Ref. Blue | P Warm Red |
|---|---|---|---|---|---|---|
| P3275U Green | 14 pts | 2 pts | | | | |
| P199U Red | | | 12 pts | 4 pts | | |
| P293U Blue | | 8 pts | | | 8 pts | |
| P165U Orange | | | | 8 pts | | 8 pts |

The colour measurements were carried out on the solid tone patches by using X-Rite eXact spectrophotometer (measuring conditions: D50 illumination, 2° detection, 45/0 diffuse illumination, UV cut off and polarization filter), and the optical properties of the prints were analyzed.

After printing, the results of the colour measurements were used to calculate the difference between the spot colours of the print and the colours of the Pantone chart taken as the reference standard.

The differences in the colour stimulus were calculated with the use of the corrected formulas of CIE published in 2000 in order to achieve the closest possible correspondence between the measured and visually perceived colour differences. Wherever the colour difference exceeded the dE=1 value, the given formula for ink mixing was modified, and the printing operation was repeated; the colour measurement and calculation of the colour difference were carried out again. This sequence of tasks was performed iteratively as long as the targeted dE≤1 and dH≤±0.2) values were not reached.

## 3. Summary of the results

After the above-described series of printing, measurement, colour difference calculation and formula modification, in order to achieve the colour difference accepted in manufacturing practices, those process colour quantities, percentages were defined with which the ink mixing formula specified in the Pantone chart, but not specifically developed for security paper without optical brightening needs to be modified for the given paper and spot colour.

The most extensive modification of the formula was necessitated by the reproduction of the green colour when *Dipa* type security paper was used for printing. In this respect, the results are shown with highlights in the following table and figures.

*Table 2: Basic and modifications of the formula from the Pantone Formula Guide sample book after the 1-5th printing run were the following:*

| | Pantone Green | Pantone Process Blue | Mixing ratio |
|---|---|---|---|
| Sample 1 | 350 g | 50 g | 87.5% - 12.5% |
| Sample 2 | 350 g | 55 g | 86,42% - 13.58% |
| Sample 3 | 350 g | 65 g | 84.34% - 15,66% |
| Sample 4 | 345 g | 68 g | 83,53% - 16.47% |
| Sample 5 | 345 g | 70 g | 83,13% - 16.87% |

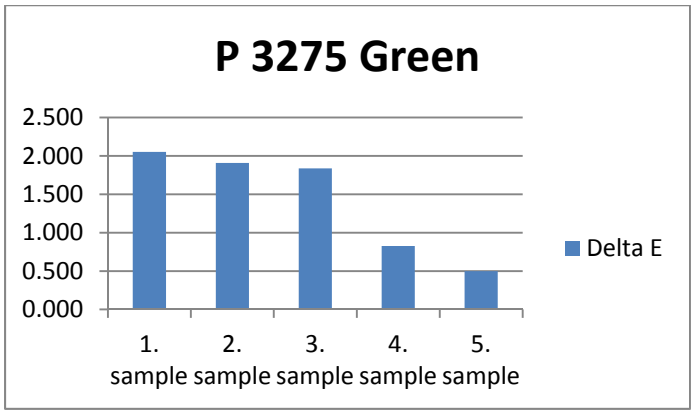


*Figure 1: Colour difference values after the 1-5th printing run – green*

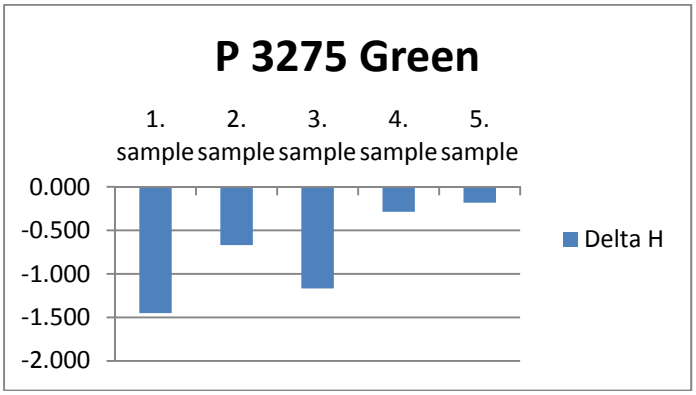


*Figure 2: Hue difference values after the 1-5th printing run – green*

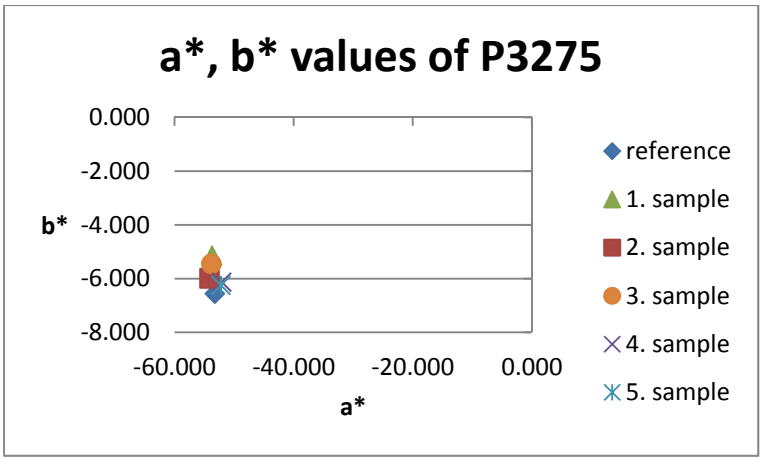


*Figure 3: The a*, b* values after the 1-5th printing run – green*

The formulas judged to be appropriate for the given colours were recorded in relation to the corresponding types of securities, security paper and printing circumstances for future use. Later on, these formulas can as well help the mixing of similar colours.

These studies found that even with the same manufacturer the perceived colours of the various ink supplies can significantly deviate from each other on the level of the process colours, and therefore this colour difference should also be taken into consideration in the modification of the formula.

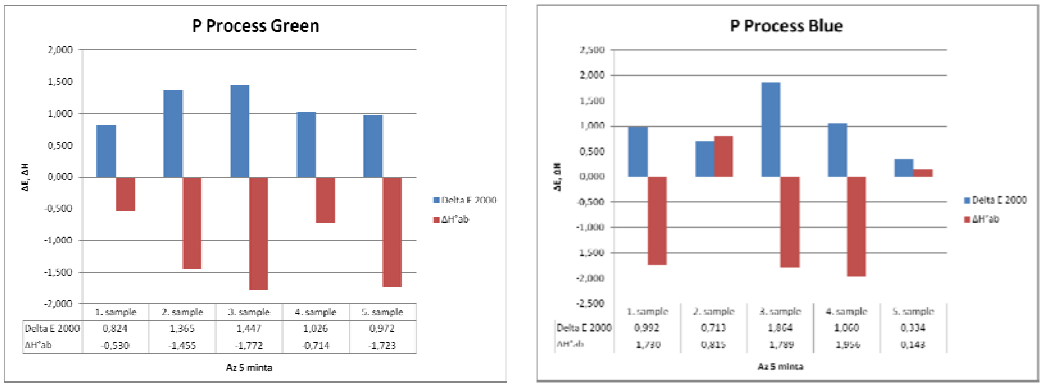


*Figure 4: Differences in the Pantone basic colours in the subsequent ink supplies (1-5th samples)*

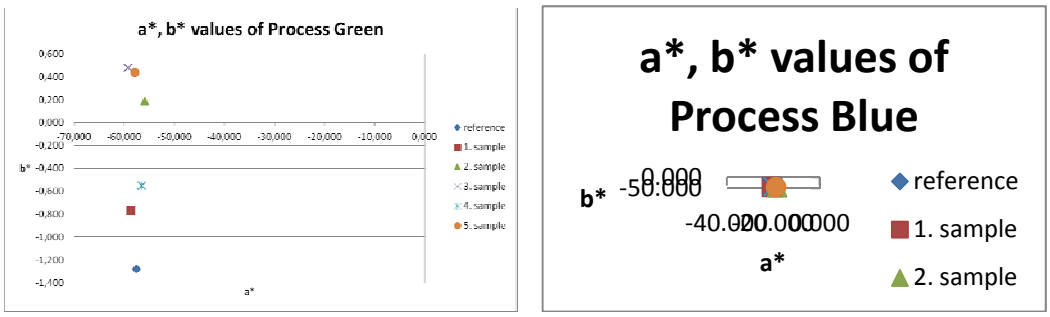


*Figure 5: The a*, b* values of the Pantone basic colours in the subsequent ink supplies (1-5th samples)*

## 4. Conclusions

Our studies have ascertained that in the course of mixing spot colours for securities some deviation has to be made from the formula determined by Pantone because of the nature of the given products and the applied print medium.

The required extent of deviation is considerable even for bi-component colours; the re-mixing of the ink or a fully new process of mixing may be necessary, which causes significant printing press stoppage during production.

Towards the cost-efficient printing of the spot colours of securities, the demands for the modification of the formulas have to be defined in advance, not only for the bi-component colours examined by this study, but for other, multi-component colours that are necessary for security printing, as well.

It has been found that the colours of the subsequent ink supplies may be considerably different even in the case of the same manufacturer, and therefore this colour difference cannot be ignored in the modification of the formulas.

Furthermore it would be helpful if the Pantone Company in addition to the coated and uncoated stock paper free of optical brighteners is also submitting their colors.

While we do not have such a range of colors, we should prepare the color-matching range of the colors often used in security printing.

## 5 References

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