An Investigation on the Reduction of the Measurements for Quality Control in Four-Colour Newspaper Offset Printing Concerning Colour Deviation and Colour Variation

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Abstract

The four-color content is constantly growing in newspaper offset printing. Quality demands on the newspaper require the monitoring of color deviations on the printed product. The measurement of such deviations by the pressmen can only be stochastic and do not give an overall view of the color deviations that occur during the print run. The suggestion is made to print a highly sensitive color patch on the four-color page as a signal area for color deviations. This signal patch is continuously to be measured with a colorimeter and to be evaluated with regard to the ΔE^*_{ab} value.

Principal tests with chromatic gray and skin tone show that the ΔE^*_{ab} value of the gray patch clearly reacts on color deviations in cyan, magenta and/or yellow. Skin tone signals magenta and yellow deviations well, but leaves out cyan.

The continuous monitoring of the ΔE^*_{ab} value of the signal patch makes it possible to signal the inadmissible color deviation to the pressmen as soon as a limit value has been overstepped. Following this signal a sample should be taken and the control strip should be measured in order to determine the nature and extent of the color deviation and to correct the machine settings.

Body text

The trends in newspaper printing are clearly towards an increase of color in the newspaper both in the editorial section and in the ads. Customers demand four-color prints with good image quality. The appearance of the newspaper as compared with its competitors and the demands especially of the big advertising customers call for perfect and stable image rendering over the whole run, if quality complaints, declining sales and the loss of interesting advertising customers are to be avoided. More and more newspaper printers see the necessity to measure the color quality during the print run. The high measuring-technical effort on the one hand, the high productivity of modern newspaper printing plants on the other and the problem of having to arrange measuring strips in the typographical layout of the newspaper at the required location set limits to this task.

As generally known control strips are printed for the quality control in offset. They contain control patches for solids and dot percentage in cyan, magenta, yellow and black and other measuring patches. These patches are measured with a densitometer or a colorimeter and the comparison with the values of the proof or the o. k. sheet makes it possible to evaluate the printed sheets. Color corrections possibly required are indicated by the measured values.

Does this mean that the offset printing process is controllable? Yes and no!

Yes, because measuring results regarding the quality of color rendition are available from which countermeasures could be taken. Comfortable automation solutions are, for instance, offered by Heidelberg (Becker 1998), KBA (Deutscher Drucker 1998) and other manufacturers.

No, because the measurement efforts are very high in multi-web offset printing and especially so in newspaper printing, since firstly, the measuring strips must be arranged on each four-color printed web side, secondly, evaluation with running production is possible only in form of random samples at big intervals and thirdly, the required working volume increases with every other four-color page. Furthermore the measuring strips need space and cannot be removed from products which are not to be trimmed.

In newspaper printing there is no time available for such permanent and time-consuming measurement.

Very often we have to rely on the trained eye of the printer, who from time to time takes samples and evaluates the image quality.
From observations of the production conditions in several newspaper printing houses made by our institute during various IFRA projects, deficiencies in the stability of inking during the print run were to be expected. Due to the stochastic type of controls carried out by the pressmen such deficiencies are unavoidable. Moreover measurements are principally much too rare, despite the fact that most of the printing houses have the technical preconditions for density measurement.

Figures 1 to 3 show the fluctuations of the solid density of the process colors subsequently measured on samples taken out of the running production. Samples of three different printing houses have been presented. The great band width of variations over the whole run without any recognizable attempts to restore the conditions of the o. k. sheet is clearly perceptible. The curves represent the measured values of the color deviations, which later-on will be dealt with. In accordance with the recommended IFRA procedure (Ruokosuo 1993) the first copy after the permission to print was used as o. k. sheet. In the figures it is always indicated as sample 1. This means that the quality evaluation of the o. k. sheet for the permission to print acquires central importance for the complete run. Every 5,000 copies a sample is taken. They are consecu-tively numbered on the abscissa.
These examples can be considered representative for most of the modern newspaper printing houses in Europe.
The stochastic control by the pressman, in most of the cases with his naked eye and without densitometer, must therefore be seen as an unsuitable means to achieve high color stability over the whole print run.

Figure 1, figure 2, figure 3

Problem

The existing problem in newspaper printing is obvious:

- The four-color content of the newspaper is growing; in some cases high-grade color images are printed with the demands on the quality of color rendition growing at the same time.

This is confronted by the following facts:

- Color deviations are unavoidable during the print run, they can only insufficiently be recognized and corrected by the pressmen, result in quality reductions which provoke customers' complaints. (Sometimes big advertising customers place their own quality control elements in their ads)

It is therefore an urgent task to search for possibilities to detect color devia-tions during the print run. The problem is becoming even more acute due to the fact that with the control of the solid density and the dot gain alone color deviations cannot always be recognized.

Suggested solutions

Principally several different possibilities seem to be applicable in order to tackle color deviations:

1. All parameters required are measured inline using densitometric or colorimetric procedures.
2. Random samples are taken from the running production and the required parameters are immediately measured.
3. The four-color pages to be evaluated are provided with one or few more additional highly sensitive control patches, which are to be printed and measured inline with a colorimeter. After the determination of characteristic deviations the pressmen receive a signal asking them to take a sample and to continue according to 2.

The procedure according to 1. is extremely time-consuming and expensive, especially so with large newspaper plants and high four-color contents.
The procedure according to 2. largely represents common practice, as far as random samples are really measured. The main critical point is, that a measurement is performed (or should be performed) also if the color deviation is within the permissible tolerances. This is unnecessary effort. And the probability is high that the important moment when the deviation begins is missed, because just then no sample is being taken. An additional shortcoming is the fact that always only one single copy or one cylinder revolution can be evaluated, whereas for a relevant quality judgement trends and averages are required.
The procedure according to 3. does away with the above two disadvantages. The decisive moment can be determined and it can further be acted according to procedure 2. without unnecessary measurements.

For this purpose it is urgently necessary to search for possibilities to detect color deviations during the print run and to signal them to the pressmen as soon as a set limit is achieved. They are then in the position to start a selective analysis to find out the causes – for instance through checking the dot gain and the solid density. Here it is necessary to print test elements and to evaluate them continually. The number of such test elements should be kept as low as possible. For the evaluation of the color fidelity it seems to be recommendable to measure the color deviation ΔE^*_{ab}, but not for all separated colors as provided for in the ISO standard 12647-3 or newspaper printing with the limits of $\Delta E^*_{ab} = 3$ to 5 for the individual separated colors, but for the contin-uous measurement of special highly sensitive superimposition patches. These patches are to take over the role of indicators.

Sensibility tests

This suggestion to continuously monitor the running production with the help of special test patches is in the first place based on the knowledge that in the printed image special color combinations and tonal values react more sensitively to fluctuations in the technological process than others. Therefore, they seem to be especially well-suited as control patches. As generally known

chromatic gray tones in the upper middle tone range and skin tones are very sensitive and to keep them constant is a horror for the pressmen.
FOGRA investigations (Paul 1997) into colorimetric fluctuations during the print run show that under standard conditions with regard to dot gain and solid density extreme high color deviations ΔE^*_{ab} occur in chromatic gray in the upper middle tone as compared to other mixed colors. This confirms the extreme sensibility of this color tone to deviations in the separated colors cyan, magenta and yellow.

For the black which is not contained in such tertiary colors another control procedure must be chosen. The common densitometric measurement seems to be fully sufficient.

According to Schläpfer (1993) the color difference is to be evaluated as follows:

Color difference ΔE^*_{ab}	Evaluation
< 0.2	invisible
0.2 to 1.0	very low
1.0 to 3.0	low
3.0 to 6.0	medium
> 6.0	high

It is above all the dot gain $\Delta\varphi$ and the change of the solid density ΔD_v of the process colors that influence the color deviation. According to the ISO draft for newspaper printing a dot gain of $\Delta\varphi$=27% with a permissible tolerance of 5% has been fixed for φ=40% dot percentage on the film.

For newspaper printing the tolerances of the solid density of the process colors are given as follows:

ΔE^*_{ab} = 3 for cyan
= 5 for magenta
= 4 for yellow

For checking the sensibility test prints were carried out with a test forme. The following color tones were chosen:

gray (φ_{cyan} =40%, $\varphi_{magenta}$ =40%, φ_{yellow} =40%) and
skin (φ_{cyan} = 7%, $\varphi_{magenta}$ =30%, φ_{yellow} =40%)

The figures of the dot percentages correspond to the digital data. The gray tone was chosen for its high sensibility, which among others was proven by Paul (1997) with the help of measuring equipment.
The skin tone was chosen for its properties as recognition color. The test prints were made with newsprint on a sheet-fed press with a dot gain and solid density for cyan, magenta and yellow according to newspaper standard (measured with Techkon densitometer).

On the test forme 10 * 10 mm color patches were arranged in form of a matrix in such a way that around the gray patch cyan, magenta and yellow patches were placed with variations through the reduction and increase of the tonal values by always 1% in five steps. The variations were made as follows:
The cyan tonal value on the vertical axis in increasing order, the magenta value in the horizontal axis and the yellow value in the vertical axis in decreasing order. This means that in the quadrants between the axes the combination of two colors was always varied, with the third color remaining constant. The variation of the skin tone followed the same scheme.
Figure 4 shows the structure of such a test print.

Figure 4

For checking the maintenance of constant inking over the printing width and for monitoring the dot gain additional solid strips for cyan, magenta and yellow were mounted over the width of the forme together with 40 and 80% dot percentage patches.

With this printing forme a stepwise dot gain or reduction of always one percent for each separated color was simulated. Since this happens in a range of ±5% the standardized tolerance limits for the dot gain have fully been made use of.

For experimental reasons the solid density of cyan, magenta and yellow was not varied despite the fact that ISO 12647-3 demands solid tonal values with corresponding tolerance values.
According to the studies by Dolezalek (1992) dot gain has considerably greater influence on the printing result than the solid density, which is proved by an estimate calculation with the aid of the Murray-Davies relation. Since it is a matter of a tendency estimate and small variation ranges of $\Delta\varphi \leq 5\%$ it can be considered to be the first approximation. We got the following picture for each separated color in terms of figures for the screen percentage D_R due to the variation of the solid density by ΔD_V with an assumed unchanged dot gain:

$$D_R = lg(1/(1-\varphi*(1-10\wedge(-D_V))$$

$$\varphi_{print} = \varphi_{digital} + \Delta\varphi_{ISO}$$
$$= 40\% + 27\% = 67\%$$

$$D_V = 0.84 \pm 10\%$$
$$= 0.84 \pm 0.084$$
$$= 0.756 ...0.924$$

Figure 5

Results of the sensibility test

A print run was carried out from the test forme. For the evaluation such sheets were selected which showed a good concurrence of the solid density of the separated colors with the nominal values and where the dot gain was within the standard limits.

For all test patches the color deviation ΔE^*_{ab} was measured and calculated with the Gretag SPM 50 spectrophotometer.

The result for a single sheet is shown in figure 6 in which mean:

White patches:	$0 \leq \Delta E^*_{ab} \leq 2$
Green patches:	$2 < \Delta E^*_{ab} \leq 3$
Red patches:	$\Delta E^*_{ab} > 3$

Average values for 11 test sheets are shown in the figures 7 and 8. The ΔE^*_{ab} ranges are well differentiated.

Figure 7, figure 8

The gray tone reacts clearly on variations in each separated color with a ΔE^*_{ab} of 2 to 3. As could be expected there was no reaction of the skin tone on a variation in cyan, since this color is represented with only 7% in the skin patch. The reactions on magenta or yellow changes, however, are very obvious.

Conclusions

The test prints have proven that gray as mixed color in the upper middle tone is well suited as an indicator for color deviations. This seems to be a precondition for the suggested measuring strategy in inline monitoring of the color deviation in newspaper printing.

If required an additional skin tone should be used as a control patch depending on the subject to be printed. Yellow which is obviously less supervised during printing is well included in the supervision by the control patch via its great impact on the color deviation.

The question of the development of a measuring device for the continuous inline measurement of the color deviations was not the subject of this study. It will be left to another project.

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Figure 1: Density, Delta E Variation Skin(Orange)/Gray(K3/40)

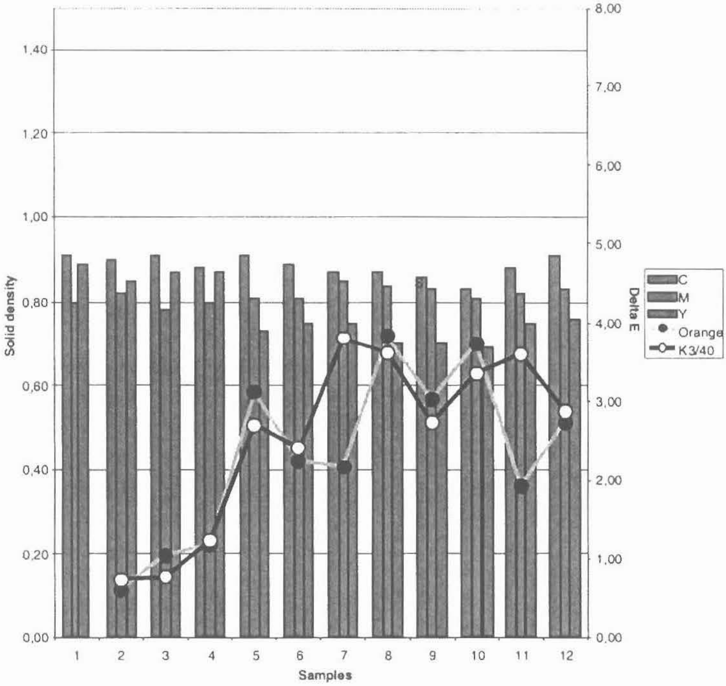


Figure 2: Density, Delta E Variation Skin (Orange) / Gray (K3/40)

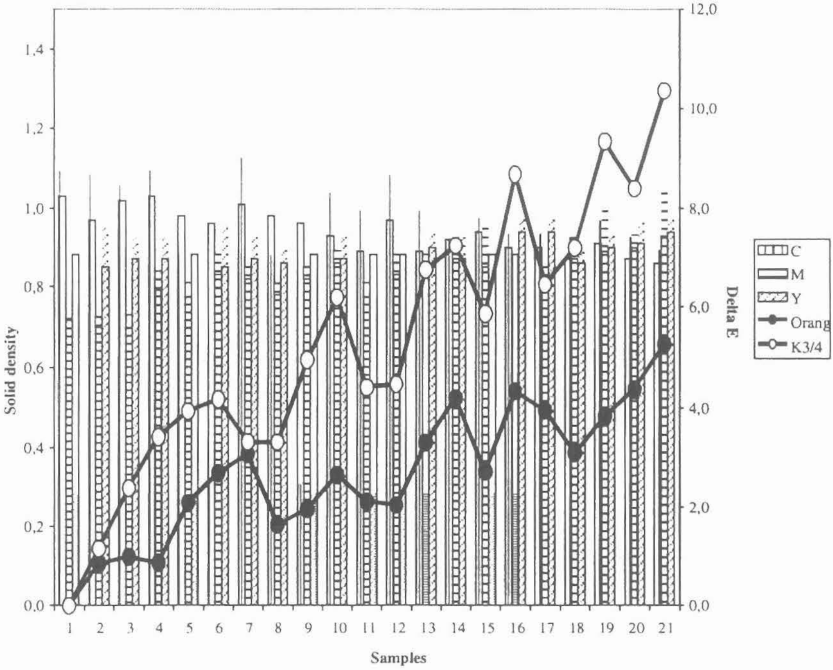


Figure 3: Density, Delta E Variation Skin (Orange) /Gray (K3/40)

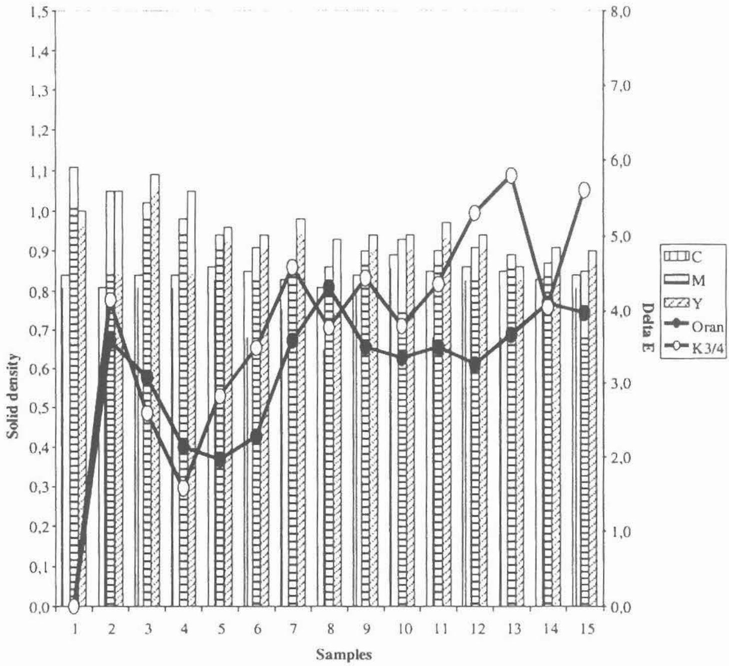


Figure 4: Sensibility Test with Problem Colors, IFRA-TUC

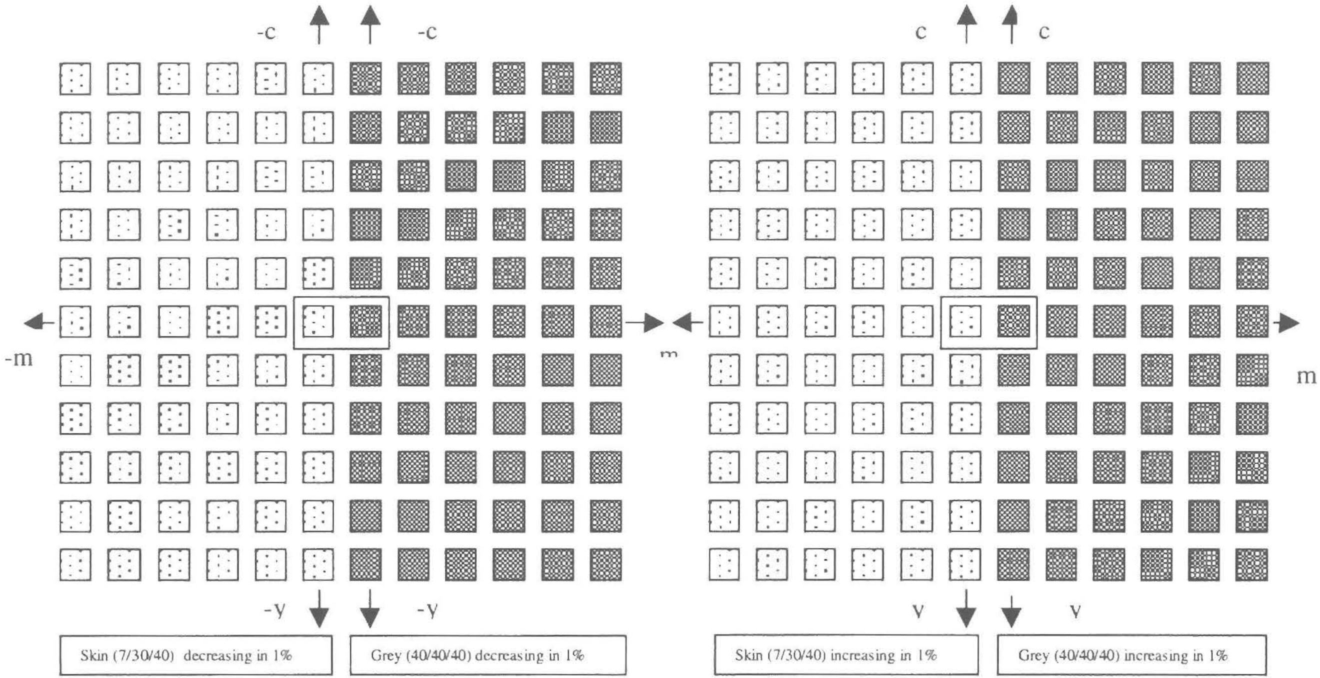


Figure 5: Halftone density as a funktion of Solid density (Parameter: Screen value Phi=0.67)

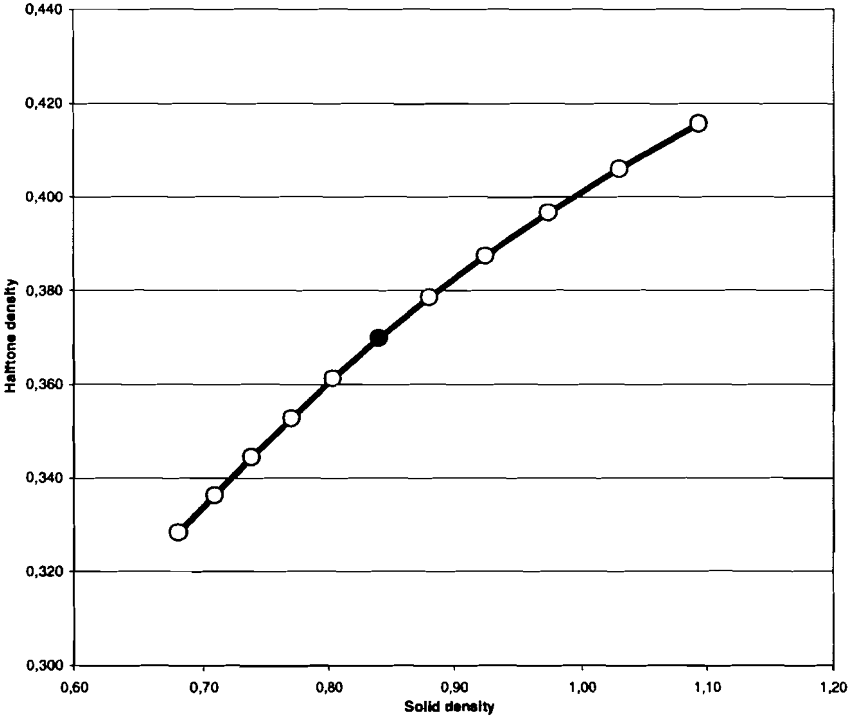
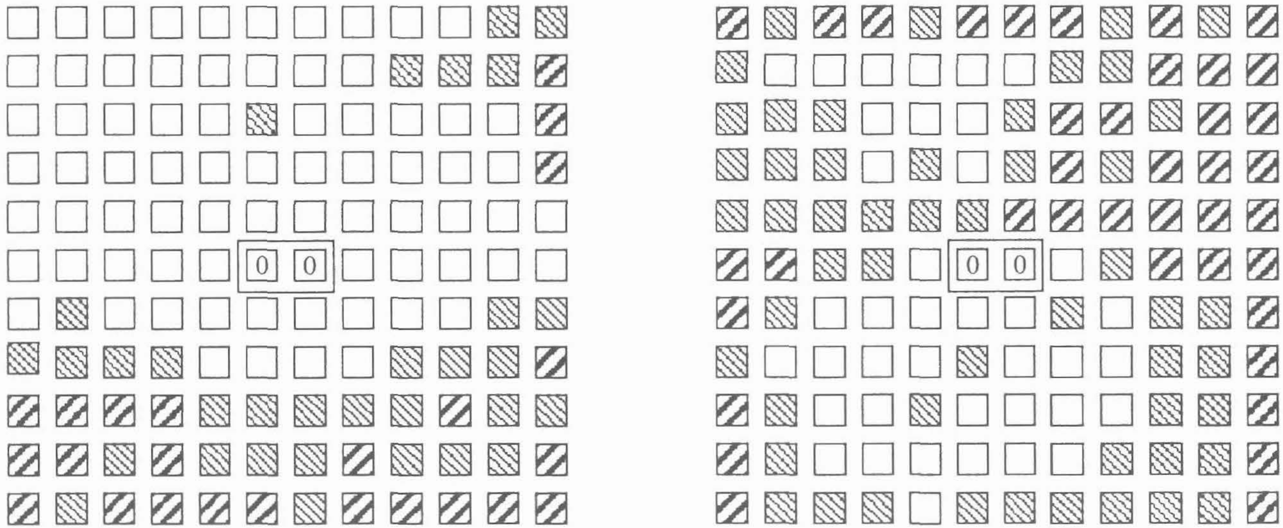


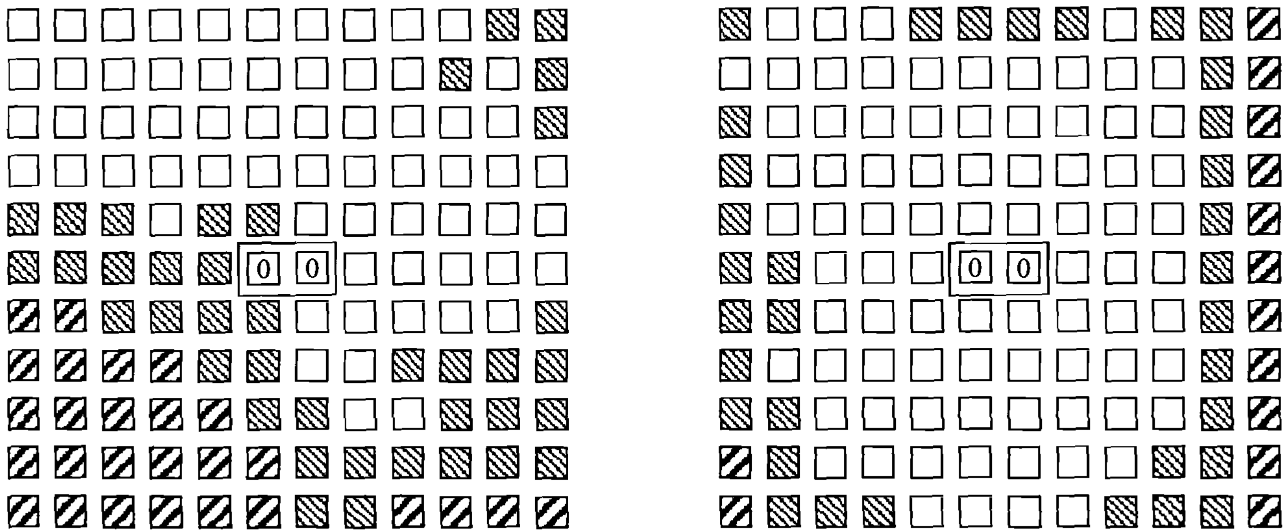
Figure 6: Evaluation Sheet Sensibility Test with Problem Colors IFRA - TUC



Presentation of the Delta E Value:

0 ≤ Delta E ≤ 2,0
2,0 < Delta E ≤ 3,0
Delta E > 3,0

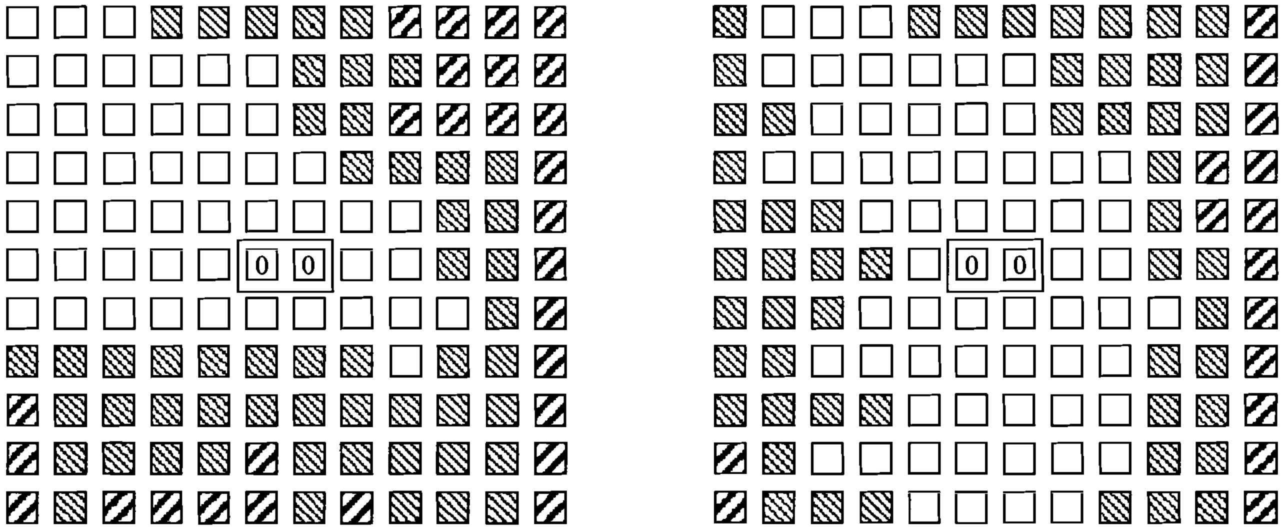
Figure 7: Evaluation Sheet Sensibility Test with Problem Colors IFRA - TUC



Presentation of the Delta E Value:

0 ≤ Delta E ≤ 2,0
2,0 < Delta E ≤
3,0

Figure 8: Evaluation Sheet Sensibility Test with Problem Colors IFRA – TUC



Presentation of the Delta E Value:

$0 \leq$ Delta E $\leq 2{,}0$

$2{,}0 <$ Delta E $\leq 3{,}0$

Delta E $> 3{,}0$