# Properties of Digital Presses and Their Prints

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## Abstract

The aim of this project was to establish the basic target values and tolerances for the technical and coloritmetric properties of digital printing systems like achievable tone value range and colour gamut, evenness over the printed sheet and print run, reproducibility, register accuracy, streaking and toner bonding. The results of this project can be used to develop quality criteria for the evaluation of digital presses and may be incorporated into the planned standard on process control ISO 12647-7.

## Introduction

Digital printing customers are happy to take advantage of the flexibility and short turn round times for the production of printed matter but at the same time they would like a print quality that matches that of conventional printing systems. Whereas quality standards for offset (ISO 12647-2[1]) and other printing processes already exist, comparable ones for digital colour printing have not yet beeing established.

This project was carried out, in order to develop the foundations for sensible and achievable quality criteria for digital printing through printing trials on different digital printing systems, with the results being used in quality standards like the planned ISO 12647-7. As electrophotographic printing systems are still the most widespread form of digital printing system used for production runs, only these systems were investigated.

## Investigation

Digital test formes in the format A3 were distributed to vendors of digital printing systems and to printing houses that use such systems. They were defined in four colours and contained various elements used for the determination of technical and colorimetric properties.

Printing was carried out on coated and uncoated paper, that could be chosen by the company. A screen ruling of 60/cm was specified but if the system uses a different standard screen ruling then this was employed. When setting the coloration, participating printers were allowed to use their regular standard setting.

The following systems were investigated as part of this project:

- NexPress 2100 (3 companies)
- Océ CPS900
- Xerox Docucolor 12
- Xerox Docucolor 6060
- hp indigo press 3000

## Results

**Tone Value Range**

The inks and substrates that were used were crucial for the highlight limit. So, for example, 60% of the prints achieved a tonal value of 3% with coated papers but with uncoated papers this was only achieved by around 5%. A tonal value of 5% was cleanly reproduced on nearly all coated papers but only on half the uncoated papers. Printing systems with liquid toner offered a somewhat better tonal value reproduction in the highlight zone than printing systems with dry toner.

Around 50% of the digital prints on coated paper printed a 96% halftone patch as a solid but prints on uncoated paper were open in the shadows.

**Colour Gamut**

More than two thirds of digital prints on coated paper that were checked agree with the aim values of ISO 12647-2 for the K, M and C colours. Their colour difference lies within $\Delta E^*_{ab} = 5$. Only yellow displayed greater differences. In some cases the cause of this was a somewhat greener appearance and a lower chromaticity of the solid patch.

Prints on uncoated paper demonstrated a major advantage of digital printing systems over offset printing. Since the toner is fused by heat and pressure to the paper surface, the ink particles cannot be absorbed into the substrate. The consequence of this is that the colour range of digital prints on uncoated paper is as great as on coated paper and digital prints on uncoated paper appear to be more colourful than offset prints.

**Evenness Over the Printed Sheet**

The maximum value for the differences in solid densitiy across the sheet was less than 5% in only 1% of the printed sheets. Not quite 30% displayed density differences of 10% or less and for another 30% the differences were greater than 15%. Around 83% of the series of measurements displayed a standard deviation for solid densities over the sheet of ± 5% or less.

The corresponding colour fluctuations yielded $\Delta E^*_{ab}$ values for most digital prints that to an observer would be percieved as moderate rather than large colour differences.

The maximum tone value fluctuations in the mid tones were greater than 5% for more than 40% of the prints. However, a statistical analysis gave a better picture of the results. For 18 out of a total of 80 series of measurements the tonal value of one colour in the mid tones fluctuated by only ± 1% (standard deviation) around the mean value. In a further 57 series of measurements the

values fluctuated by ± 2% and in the remaining 5 sets of measurement by ± 3%.

A combination of the maximum values and the standard deviation would seem to be the most appropriate as the criterion for assessing the evenness of solid colouring and tonal value reproduction.

**Evenness Over the Print Run**

The evenness of the colouring and the dot gain over the run were evaluated out of 20 100-sheet runs. They showed fluctuations that were generally smaller than the variations across the format.

21% of the assessed solid patches displayed maximum density fluctuations of less than 5%; in 75%, the colours fluctuated by a maximum of 10% and in only a few cases did the solid densities fluctuate by more than 15%. Approximately 97% of the series of measurements had standard deviations of ± 5% or less. That means that the ± 8% stated in ISO 12647-2 for offset printing can be adopted for digital presses.

75% of the examined print runs showed fluctuations for the tone values in the midtone of ± 1% and the other 25% displayed ± 2%. This is a very good performance compared to the ISO 12647-2, which lays down an allowed fluctuation tolerance of ± 4%.

**Reproducibility**

The reproducibility of a printed result was checked by printing the ECI colour chart at different times. With the exception of one printing sytem, a large proportion of the colour differences between the print runs lies between $\Delta E^*_{ab} = 1$ and 4. These low values indicate that the reproducibility of the printed result is good with digital presses.

**Register Accuracy**

According to ISO 12647-2 a maximum deviation between the image centres of any two printed colours shall not be larger than 0,08 mm for middle format presses. Approximately 90% of 62 digital print runs lied within this tolerance in the direction of sheet movement for K/C and K/M, but for K/Y it was only 74%. At right angles to the direction of travel the result was somewhat better, with 97% meeting the requirement for K/C and K/M and 85% for K/Y.

Inadequate positional accuracy during duplex printing can result in the top and under sides not lying precisely above one another. This can result in the image beeing cropped when the sheets are trimmed. On average the distance between the image and the sheet edge on both sides differs by only 0.2 to 0.4 mm. This indicates a really good standard of accuracy. However, in individual instances the distance of the printed image to the sheet edge varied by up to 1.2 mm.

**Streaking**

All of the submitted digital prints showed visible streaks in and across the printing direction, which occurred in even half-tone patches. Most of them appeared as disruptive. Although some manufacturers apply proprietary solutions for their evaluation, there is at present no broadly recognized method.

**Toner Bonding**

Testing of toner bonding involved the use of the FOGRA WIKAT.[2] By switching between uses, this device allows both the rub resistance and the set off behaviour to be investigated. 16 of 19 examined digital print runs resulted in traces being transferred through rubbing to an unprinted paper that were classed as 4 or 5 on the scale, which corresponds to an excessive, visible change. The results of the set off test yielded a contrary result with no ink beeing transferred by any of the digital prints to the unprinted paper.

The results of these two tests indicate that digital prints are quite insensitive to pressure without rubbing movements. However, if a rubbing movement is combined with the pressure then the amount of toner that is rubbed off can have a visible impact on the printed image and also result in soiling of the finishing equipment.

## Conclusion

In companies that operate in parallel with conventional and digital printing systems, it is a good idea to adjust the digital printing sytems to match the conventional ones. This allows the same prepress routines to be used for both productions processes.

Digital printing on uncoated paper is capable of a much larger colour space than offset printing on the same stock. This feature should be borne in mind when specifying CIELAB target values for the coloration of the solids. Like offset printing, deviation tolerances for digital printing are best given as statistical data, which take into account both, the magnitudes of the colour deviations and their frequency.

It is necessary to consider whether the reproducibility of a printed result is something that needs to be checked when assessing a digital system. Good reproducibility of a printed result is a pre-requisite for printing on demand in order to ensure that the printed products do not differ in terms of their colour from each other, regardless of when they are output.

## References

1. Standard ISO 12647-2, Graphic technology - Process control for the production of half-tone colour separations, proof and production prints – Part 2: Offset lithographic processes, 2004.
2. FOGRA rub off and carbonating test device (FOGRA WIKAT), München, FOGRA, 2004.

## Biography

**Karl Traber** joined FOGRA in 1982 with an engineering degree specializing in printing techniques. Since then he has been carrying out numerous research projects in the fields of offset printing, colour measurement, process control and platesetting. Furthermore he worked on different projects about digital printing.