An Evaluation of the Humidity Test Method ISO 18946

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Abstract

Humidity sensitivity is one of the potential degradation routes of digitally printed images. An ISO Working Group has been developing a test method for this sensitivity that is presently being published as ISO 18946. This work describes some practical experience in using the test method together with a treatment of errors from the results.

The paper first reviews some previously published work in this field as background to the development of this standard. It will then go on to illustrate some practical experience of the use of this method to test humidity sensitivity in a number of print / media combinations.

The paper gives details of the changes that result from humidity sensitivity of a number of print and media combinations, predominantly from inkjet printing. Combinations utilising a number of dye and pigment based inkjet inks and media types are used to illustrate the work. This paper also compares and contrasts the results from the different test conditions described in ISO 18946 and the differences in humidity sensitivity of various areas of the proposed test target. The results are presented in both colorimetric (numeric) terms and as photomicrographs.

Introduction

One of the potential causes of image quality deterioration for digital prints is their sensitivity to elevated humidity. A number of studies have been performed to examine the influence of humidity on image bleed and these have primarily focused on the behaviour of inkjet prints.[1,2,3,4] The sensitivity of prints produced with different inkjet inks has been found to vary with elevated humidity. While dye based inks are thought to be more susceptible, pigments are not immune.

The extent of colorant migration, both lateral and vertical, is a significant factor in determining loss of image quality. However, the substrate can also contribute to colour changes. Degradation of optical brighteners can lead to a colour shift towards the yellow end of the spectrum[5]. Yellowing of the substrate has also been reported at specific humidities and/or temperatures.[1]

Various test methods can be used to characterise the humidity sensitivity of colour prints. Some seek to define threshold levels of humidity below which prints can be kept without long-term visible change.[2] Others seek to compare materials under defined conditions.[3]

The various test patterns that can be used to characterise humid bleed have been summarised elsewhere.[3] In order to derive ISO standard test methods for humidity fastness the test chart and the exposure methodology were defined and fixed as a result of substantial experimental evidence and psychophysical scaling.[3]

The ISO standard test method has been published, currently as a Draft International Standard.[6] This test method uses the pattern similar to that illustrated in Figure 1 to best test the sensitivity of print systems to humidity exposure. It consists of a checkerboard pattern to monitor humid bleed, solid colours and flesh tones. It is designed to reveal both macro and fine line colour changes.[4]

ISO 18946 stipulates that the samples are measured for colour change and the change in ΔE space calculated. The results are then averaged over the whole 84 colour patches of the test chart to produce a final result.

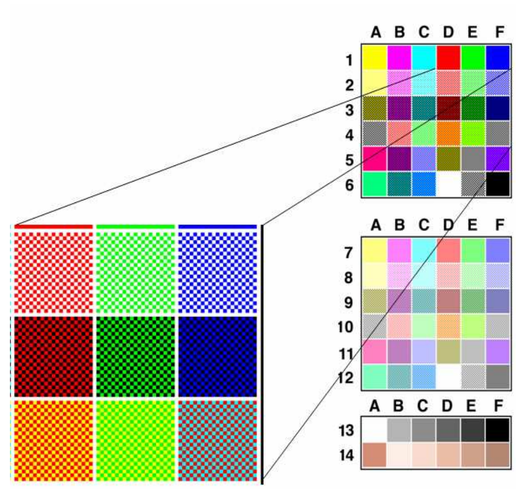

Figure 1 *Humidity test chart showing checkerboard patterning*

This paper describes work being performed to investigate the behaviour of inkjet prints with elevated humidity with reference to the methods laid out in ISO 18946.

Experimental detail

Prints were produced on a variety of substrates. The work disclosed here used the following media types.

- Plain uncoated papers with no UV brightening agents. These are typical of those used to produce security documents and archival prints.
- A synthetic paper containing no cellulose. This is an interesting test case as dyes appear to be non-substantive to the substrate, resulting in high humid bleed.
- Microporous commercial inkjet media.

These substrates were printed using a variety of commercially available printing systems, in all cases using the OEM inks. In all cases the print drivers were set to "plain paper" settings on the highest available print quality.

- Desktop inkjet printers using wholly dye based colorants or dye colours and pigmented black.
- Desktop inkjet printers using wholly pigment based inksets.

ISO 18946 allows for a number of humidity conditions.[6] Two exposure conditions were used in this work. These were 25°C, 85% RH and 40°C, 80% RH. These were found to produce humid bleed results that separated the performance of different ink / media combinations within an acceptable time frame.

Practical experience with ISO 18946

The criteria laid down in ISO 18946 are by necessity stringent. However, some of these make it difficult to realise in practical circumstances such as this academic / industrial collaboration. It should therefore be noted that the test methods used here do not conform to all the criteria in ISO 19846. The methods used here are also probably more representative of typical print production where the print is made on one site and then transferred to another.

The samples were printed in an environment at 23°C and 50% RH on substrates that had been allowed to acclimatise. They were dried in this environment for 24 hours as stipulated in ISO 18946. Samples were then transported in sealed enclosures to the environmental chambers.

The samples were treated by placing them in a Weiss Gallenkamp environmental chamber. Two chambers were used, each holding a maximum of 80 samples. The samples were then exposed to one of two humidity conditions for periods of 1, 2 or 4 weeks. The samples were suspended from the shelves using metal spring clips. It was observed during treatment that the positioning of the samples and movement of air within the chamber resulted in occasional contact between samples or the chamber door. Some samples were also observed to have curled during treatment, especially at the higher humidity condition. Measures were taken to reduce the possibility of samples touching the door, including weights attached to some samples to reduce the extent of curl.

After removal from the chambers, the samples were allowed to return to room temperature and humidity over a period of 24 hours. The environmental conditions during acclimatisation and measurement were uncontrolled. Colorimetric measurements were performed using a Gretag Macbeth Spectrolino, with 45:0 degree geometry and D50 illuminant. Colorimetric computation to give average ΔE values was performed as per ISO 18946. The aperture used for these measurements has a diameter of 4mm, previously shown to produce good integration of the area of the checkerboard samples.[4] Measurements were also performed on control samples that had not undergone any treatment. Where samples had curled during treatment, some difficulties were encountered with the automated colorimetric measurement. Any measurements affected by sample contact were removed from the analysis.

Visual examination of the samples was also performed to look for evidence of lateral or vertical migration. Photomicrographs were captured using a Zeiss Axioskop microscope fitted with an AxioCam digital camera.

Ozone considerations

The chambers used for the incubation of the printed samples do not have carbon filters and therefore samples may be susceptible to pollutants. In order to provide some indication of the potential effect of ozone on the samples, test prints were positioned close to the air inlet of the chamber. These were then analysed after 4 weeks and no discernable change was found.

General results

Humid bleed was visible on a number of samples when viewed through a microscope. Figure 2 shows a typical example of the humid bleed observed on the synthetic substrate printed with a dye based inkset.

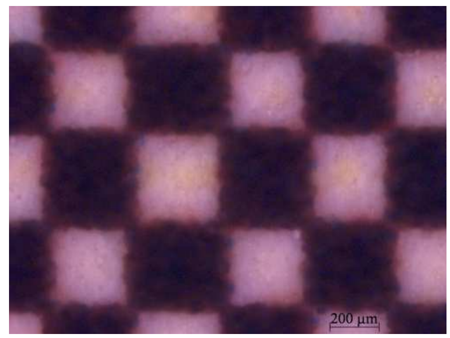

Figure 2 *Image of the black checkerboard, printed with wholly dye based inkset on the synthetic substrate and incubated for 4 weeks at 25°C, 85%RH*

The test method is good at differentiating systems with very different performance. As an example Figure 3 shows some results comparing one dye and 3 pigmented inksets on a porous coated paper. A dramatic difference in performance of the systems is revealed by this test.

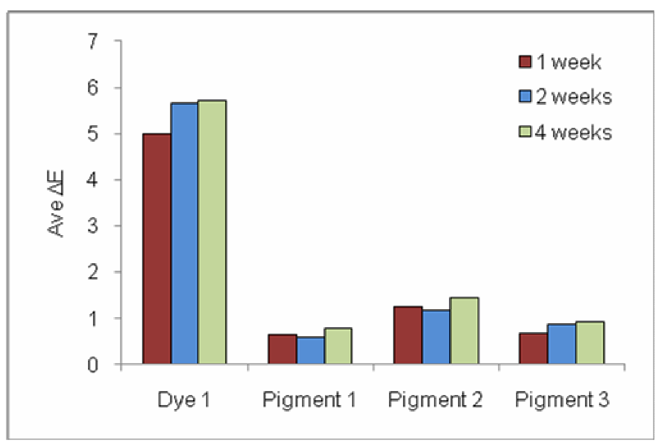

Figure 3 *Dye and pigment based ink results on porous coated paper and incubated at 25°C, 85%RH*

As defined by the test method the results in Figure 3 are presented in terms of ΔE averaged over all 84 swatches illustrated in Figure 1. While this is intended to give a good overall value for the extent of the humid bleed it does hide some substantial differences across the colour swatches. This is illustrated in Figure

4 for the 1, 2 and 4 week data from 4 inksets printed onto plain paper, again exposed using the 25°C, 85% RH condition.

Some of these differences are even more pronounced in the case of inksets containing pigment black inks and dye based colours.

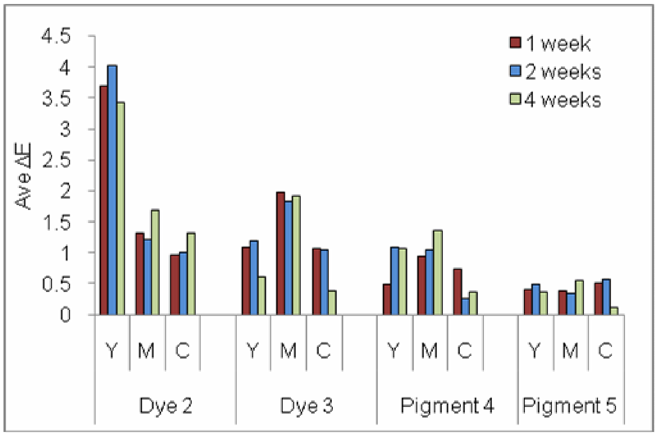

Figure 4 *Differences across different colours in row 8 of the chart printed on plain paper*

Differences with humidity conditions

As noted previously this study has utilised two different humidity conditions: 25°C, 85%RH and 40°C, 80%RH. These can be used to separate the performance of different systems. In some cases these differences can be attributed to the fact that the conditions approach a phase transition point in either the ink or the media. In other cases the differences can be shown to stem from more subtle performance differences.

An example is shown in Figure 5 where dye and pigment based inks are shown to react differently to changes in conditions. We are presently collecting further data sets on these differences.

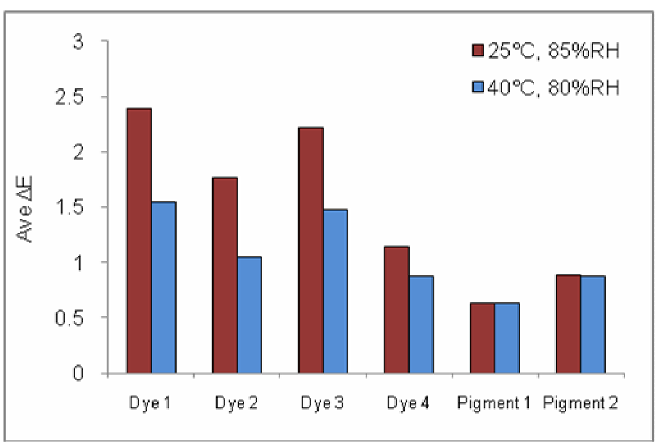

Figure 5 *Different inksets printed onto plain paper and incubated for 4 weeks*

Statistical treatment of results

One of the purposes of this work is to clarify the fluctuation in the results and therefore quantify the potential errors in the measurements of humid bleed using the average ΔE measure. This is ongoing work but initial results are reported here.

Humidity exposures were repeated for a number of the ink / media combinations. Figure 6 shows the variation in Ave ΔE for a plain uncoated paper printed with a single dye based inkset and incubated at conditions of 25°C, 85%RH. The variation in the ensuing Ave ΔE values from separate incubation periods can clearly be seen.

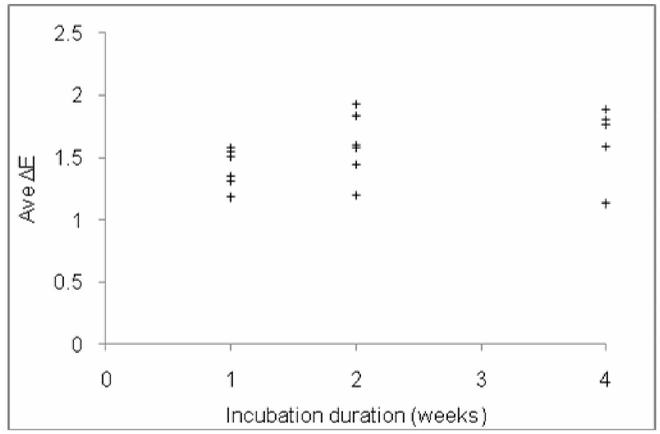

Figure 6 *Variation in Ave ΔE for plain uncoated paper printed with a single dye based inkset*

The average ΔE values for 4 week samples printed on plain uncoated paper and the synthetic substrate are shown in Figure 7. This shows a greater variation in the Ave ΔE values calculated for the synthetic substrate. This is to be expected as the substrate demonstrated increased humid bleed. These results give some indication of the potential errors in humid bleed results.

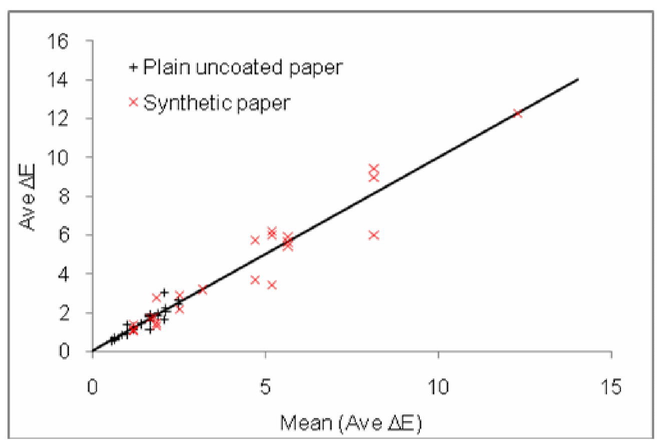

Figure 7 *Variation of Ave ΔE with the mean (Ave ΔE) for 4 week exposures at 25°C, 85% RH*

The range of some of these repeated test results is illustrated in Table 1.

Range	0.5	1.4	2.8	3.5
Mean (Ave ΔE)	1.0	2.1	5.2	8.1

Table 1 *Estimated range of results*

Conclusions

The test method as used in this work is capable of differentiating the performance of different ink / media systems. In addition to its use in inkjet systems development, the test method is also of interest in fields such as Conservation Science.

The statistics of multiple repeats of the same evaluation are of interest and warrant further investigation. Table 1 appears to show that the variations inherent in the method are significant. This may be important when comparing different systems.

Further work

This work is ongoing. We are currently working in the following areas.

- Further quantification of the experimental errors associated with this test method and the uncertainties in the ensuing results.
- Examination of the ΔE values for the solid and checkerboard swatches for incubated samples. This may provide further information about humid bleed. Changes in hue may be more readily observed from the solid swatches while the checkerboard areas provide information about lateral migration.
- A wide printed sample set using other aqueous inkjet inksets and substrates. The effect on optical brighteners could be a valuable area for investigation.
- Other printing methods such as toners, phase change and oil based inkjet systems.
- The potential effects of retained solvents on humid bleed. This has been shown to make a difference to light fastness.[7,8] Such solvents could conceivably change humid bleed performance.

Acknowledgements

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Author Biography

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