The Importance of Dark Keeping Factors in Determining Overall Image Permanence of Photographs—2019 Update with Pigment Inkjet

Patrick Webber

Abstract

Traditional reporting of the image permanence of photographs has tended to primarily focus on light stability. The reality of how consumers use and store prints is that the vast majority of the print life is stored in the dark. The dark stability of traditional silver halide photographic paper was primarily driven by thermal affects. However, many of the newer digital materials used for photographic prints are susceptible to additional dark factors including humidity, and atmospheric pollutants, which can result in predicted life time's being significantly shorter than reported by light stability data alone. This paper will review these additional dark factors and provide comparisons to traditional silver halide photographic paper and provide an update to the 2018 paper. Additionally the paper will include the dark factor impact on pigment inkjet on porous media photographic products.

Introduction

Image permanence is driven by four environmental factors, light, heat, humidity, and atmospheric pollutants. Our previous paper [1] specifically discussed dye colorants on porous paper; this paper will extend the dark factor discussion for pigment colorants on porous paper. Dye colorant technologies are typically used in higher volume retail and professional applications while pigment colorants are found in lower volume large format fine art display applications. Pigment colorants tend to have better light stability compared to dye colorants but all four image permanence factors need to be considered. Of these four factors heat, humidity, and atmospheric pollutants are considered "dark" factors. As previously discussed, the dark factors are the most critical because typically consumer prints spend most of their lifetime in the dark. Even fine-art gallery prints on display, if they are sensitive to any of the dark factors, can degrade much more quickly than their light stability claim implies. This paper will discuss the atmospheric pollutants factor, its impact on image stability of various digital print technologies, and the importance of good dark factor stability for long term image preservation [2, 3].

Experimental Design

The experimental design consisted of testing two digital printing technologies. This included a pigment-on-porous inkjet system, and a silver halide system, in this case KODAK PROFESSIONAL ENDURA Premier paper. Printing systems were selected based on their common use in large format professional commercial labs serving the fine art display market. All samples were placed in an ozone chamber with an ozone concentration of 1.0 ppm and 50% relative humidity and tested in accordance with ISO 18941 [4]. The test was run to a cumulative exposure of 864 ppm-hr (36 days). Analytical test targets and professional commercial images were included in this test. Analytical data was obtained from the targets and the images were used to show the visual impact of the image degradation due to ozone. The test targets were measured periodically throughout the length of the test, with measurements taken at 0.40 density, 1.0 density and 2.0 density near D-max. Data was stored in Microsoft Excel and plotted and analyzed using JMP®.

Results

0.40 Density

Comparison of 0.40 density of the two printing technologies showed significant differences. Over the course of the test, Figure 1 shows significant density loss of the cyan and magenta in the pigment inkjet print system while Figure 2 shows little change in the silver halide print system. In this highlight region of the curve, the yellow-red bias caused by the ozone would be noticeable and likely objectionable, especially given the eye sensitivity to color biases in the highlights.

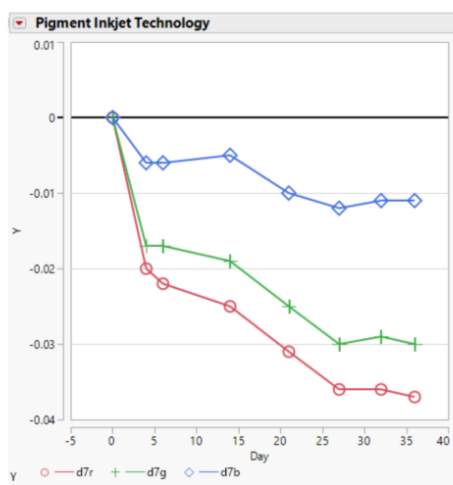

Figure 1: 0.40 density stability performance of the Inkjet technology

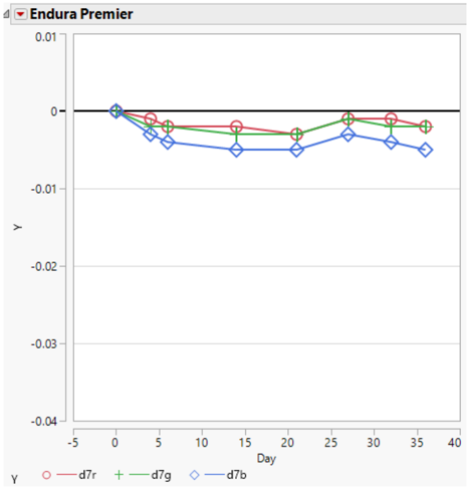

Figure 2: 0.40 density stability performance of the silver halide technology

Neutral Density 1.0

At a mid-scale neutral density of 1.0 the two technologies perform similarly to their performance in the lower scale. Figure 3 shows the same yellow-red bias with the pigmented inkjet technology as before, while Figure 4 again shows essentially no change in the silver halide technology. While the midscale yellow-red bias of the pigmented inkjet is not large in magnitude it would still be noticeable. But the silver halide technology shows no visible change at all.

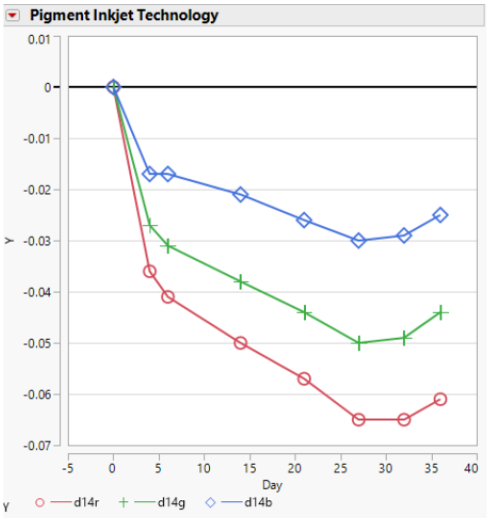

Figure 3: 1.0 Neutral density stability performance of the Inkjet technology

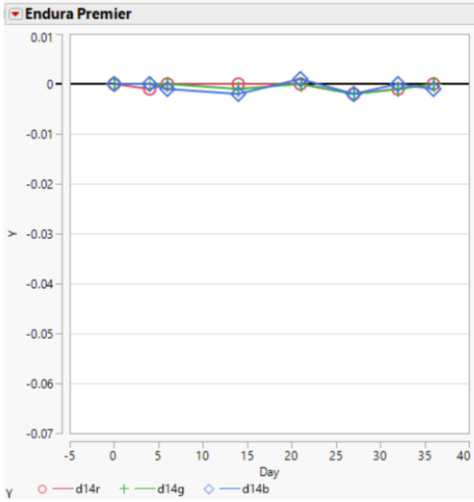

Figure 4: 1.0 Neutral density stability performance of the silver halide technology

Upper Scale

At a neutral density near D-max the two technologies continue their similar performance differences as seen in the mid and lower scale. Figure 5 continues to show the yellow red color bias with the pigmented inkjet technology but the magnitude is relatively small given the very high upper scale densities. The direction of the color balance change in the pigmented inkjet system is slightly less than in the mid scale and the visibility of this change would be low given the high density and low sensitivity of the eye in this region of the curve. The upper scale data for the silver halide system, shown in Figure 6, is noisy but very small, and again would show no visible change.

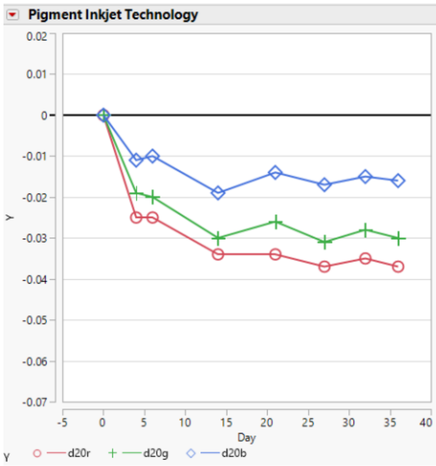

Figure 5: Near D-max stability performance of the Inkjet technology

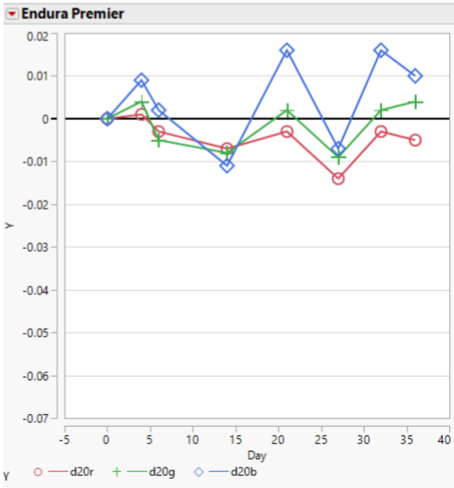

Figure 6: Near D-max stability performance of the silver halide technology

Discussion

The impact of poor image permanence to atmospheric pollutants can be severe, especially in fine art and gallery display environments where artists expect no change over decades of display. In addition, there are increasing trends in this market to display prints without any surface covering that may alter the appearance of the displayed print [5]. These coverings, such as glass, acrylic, or laminates would offer protection to the print from environmental factors including both light and pollutants. This makes sensitivity to ozone even more critical in these applications. Imaging technologies with even slight sensitivity to ozone will likely cause reactions over the long-term display of the print. These impacts are magnified by as little as five parts per billion, a level of ambient ozone often found in typical environmental display conditions [6, 7, 8]. High pollution areas, such as larger cities, can have ambient ozone levels significantly higher than five parts per billion.

At the five parts per billion ambient environmental concentration, an ozone test conducted at 1 part per million represents an ozone concentration 200X higher than in the ambient environment. Assuming reciprocity of concentration over time holds, the 36-day test described here would approximate 20 years of change in real time. See Figures 7 and 8 showing the assumed colorant change for these two technologies over time.

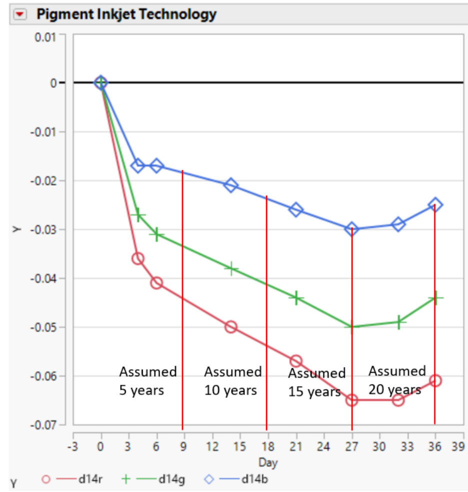

Figure 7: Assumed Colorant Change over Time for Inkjet technology (see text)

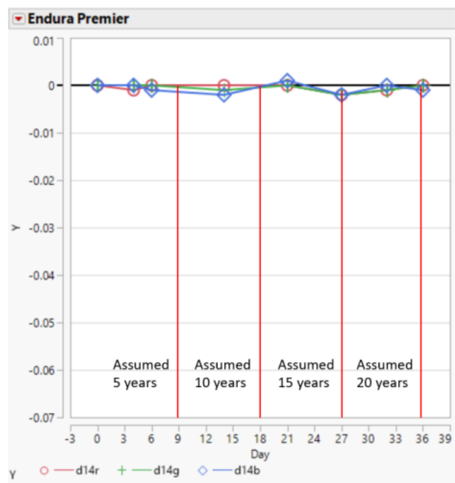

Figure 8: Assumed Colorant Change over Time for silver halide technology (see text)

For atmospheric pollutants such as ozone, silver halide technology, in this case Endura Premier, shows virtually no change compared to pigment inkjet.

Conclusion

Fine art prints are often found in unprotected display environments where atmospheric pollutants can be critical. Image permanence is driven by four environmental factors, light, heat, humidity, and atmospheric pollutants. Of these four factors heat, humidity, and atmospheric pollutants are considered "dark" factors because they can impact print permanence both in the light on display, and in the dark. In this paper we discussed how ozone, a common atmospheric pollutant, can have an effect on image permanence. The two printing technologies each reacted differently from the impact of ozone. The pigment ink-on-porous paper inkjet technology showed a noticeable color balance shift over a predicted 20 years. Finally, the silver halide technology was unaffected by ozone. With virtually no loss of colorant due to ozone, the silver halide technology, as shown in the KODAK PROFESSIONAL Endura Premier paper, is the superior choice for stability against atmospheric pollutants.

In conclusion, when choosing a print technology for long print life, it is critical to consider all four environmental factors. This includes the dark factors, heat, humidity, and atmospheric pollutants, which are critical in all display and dark storage environments.

References

[1] Webber, P. 2018 The Importance of Dark Keeping Factors in Determining Overall Image Permanence of Photographs *Proc. IS&T's 9th International Symposium on Technologies for Digital Photo Fulfillment*

[2] LaBarca J. 2011 Preservation of Documents and Photographic Images: Long Term Strategies for Future Generations *Proc. IS&T Archiving Conf.* pp 136-143

[3] LaBarca, J. 2013 Preservation of Photographic Images for Future Generations: New Opportunities for Prints and Photo Books with a Conservator's Perspective; *Proceedings of the AIC & ICOM-CC Photographs Conservation Meeting, Wellington, New Zealand*

[4] ISO 18941:2017 – Imaging Materials -- Colour Reflection Prints -- Test Method for Ozone Gas Fading Stability

[5] Aardenburg Imaging & Archives, Technical Article, www.aardenburg-imaging.com/portfolio/gas-fade-testing-unit/

[6] Bugner, D., LaBarca, J., Phillips, J., and Kaltenbach, T. 2006 A Survey of Environmental Conditions Relative to the Storage and Display of Photographs in Consumer Homes; *Journal of Imaging Science and Technology* 50(4): 309–319, 2006

[7] Y. Shibahara, H. Ishizuka, N. Muro, Y. Kanazawa, and Y. Seoka, Image Stability of Digital Photographic Printing Materials *Proc. IS&T's NIP18* (IS&T, Springfield, VA, 2002) pp. 330-333.

[8] Y. Kojima, H. Ogino, and T. Yamamoto, Study on Gas Fastness of Ink Jet Prints *Proc. IS&T's NIP20* (IS&T Springfield, VA, 2004) pp. 724-728.

Author Biography

Patrick Webber is a principal scientist at Kodak. He has worked in the industry for over 35 years and has held a variety of positions in silver halide paper including manufacturing, research, and development of color products at Eastman Kodak and now Sino Promise Group. His primary focus for the last 26 years has been the development and commercialization of professional silver halide media products for digital use. He is certified as a six-sigma black belt. He has been awarded two U.S. patents and is the author of many technical papers. Pat currently is the world-wide color paper product manager. He also leads the systems team for the design and development of new color output media.