Title

The Technology Behind the New *Kodak Ultima Picture Paper* – Beautiful Inkjet Prints that Last for Over 100 Years –Update – May 8, 2004

Authors

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Purpose of this Update

Testing of new *Kodak Ultima Picture Paper* has continued since the original publication of this paper. This update provides additional test results that substantiate our print life projections for this product. We also want to correct the Ilford Printasia catalog number erroneously listed before; that number should be 197 2108.

The following figures and tables have been updated with additional test data. Figures and tables are numbered the same as in our original paper for easy reference.

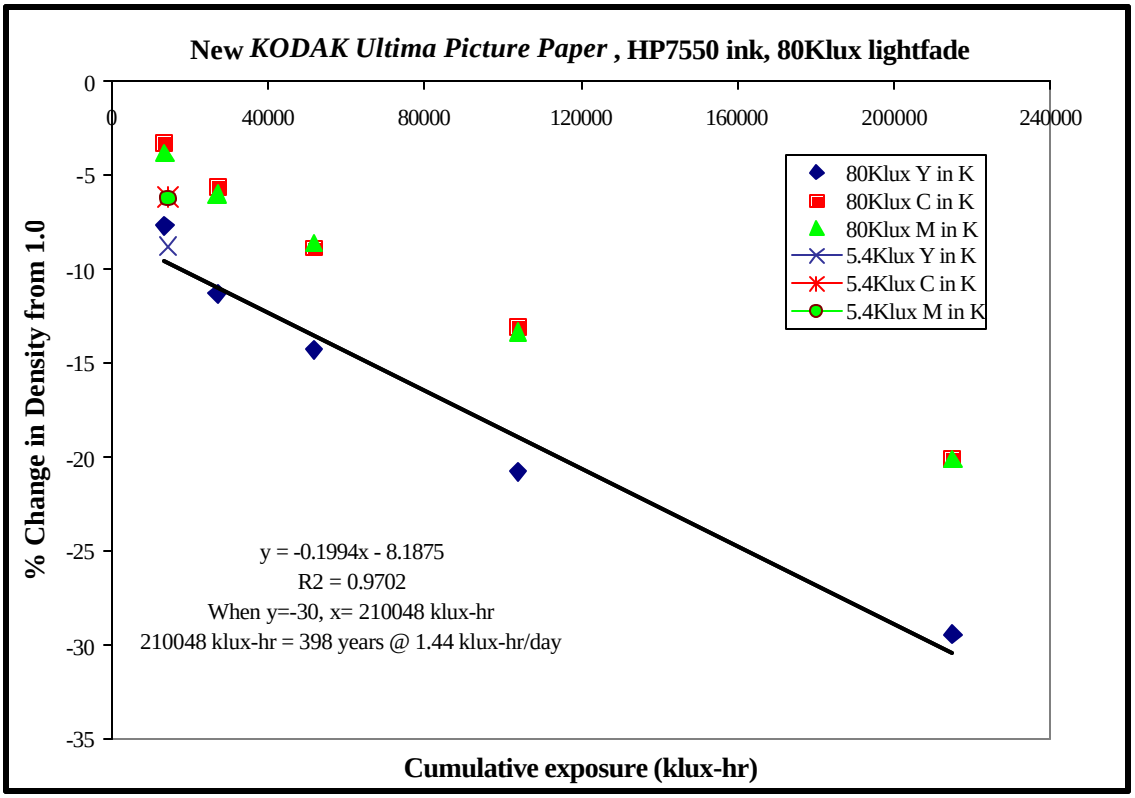

Figure 3. Plot of % density change for the yellow, magenta, and cyan components of a 1.0 initial density for a neutral gray patch printed with the HP 7550 inks on the new KODAK Ultima Picture Paper.

Table 2. Summary of current light fade results for the new *KODAK Ultima Picture Paper* printed on representative Hewlett Packard 3 ink and 6 ink printers.

Condition	Printer	Current Cumulative Exposure (Mlux-hr)	End-point Reached?	Light Fade Print-life Estimate (years)	End-point	R^2
A	7550	215	Yes	398	Y in K	0.970
B	7550	N/A*				
C	7550	134	No	321	Y in K (28% to date)	0.979
D	7550	14.5	No	N/A	not enough fade to extrapolate; no significant reciprocity failure observed (see figure 3)	
E	7550	N/A*				
A	3820	215	Yes	162	M in K	0.974
B	3820	N/A*				
C	3820	134	Yes	182	C in K	0.997
D	3820	14.5	No	N/A	not enough fade to extrapolate; slight reciprocity failure	
E	3820	N/A*				

*N/A – An equipment malfunction was encountered and the testing is being repeated.

Table 3. Summary of current ozone fade results for test prints made with the new *KODAK Ultima Picture Paper Glossy* on the Hewlett Packard 3 ink (3820) and 6 ink printers (7550).

Condition	Printer	Current Cumulative Exposure (ppm-hr)	End-point Reached?	Ozone Fade Print-life Estimate (years)	Comments
A	HP7550	3360	No	> 1000	M density loss at 18%; log extrapolation; R^2 = 0.990
B	HP7550	8760	No	413	Pure cyan; linear extrapolation; R^2 = 0.970
A	HP3820	2016	No	> 1000	C density loss at 10%; log extrapolation; R^2 =0.979
B	HP3820	8760	No	> 600	Magenta density loss at 12%; log extrapolation; R^2 = 0.98

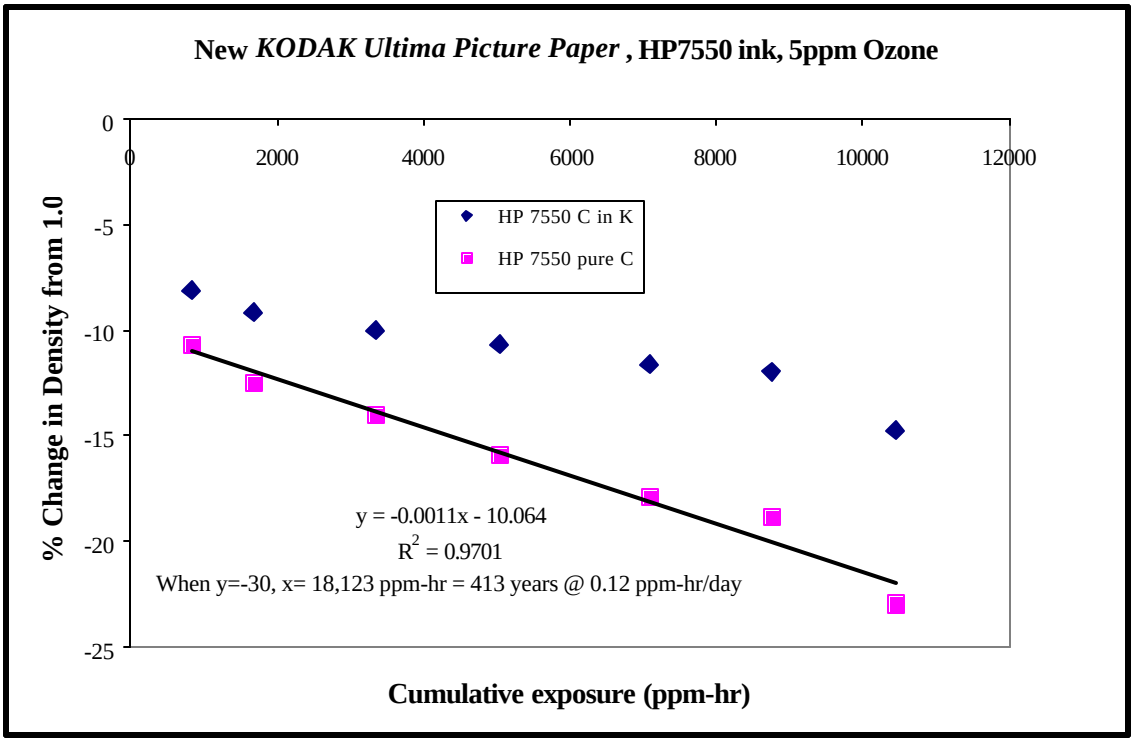

Figure 4. Plot of % density change (from 1.0 initial density) for the HP 7550 pure cyan and cyan in a neutral inks printed on the new KODAK Ultima Picture Paper.

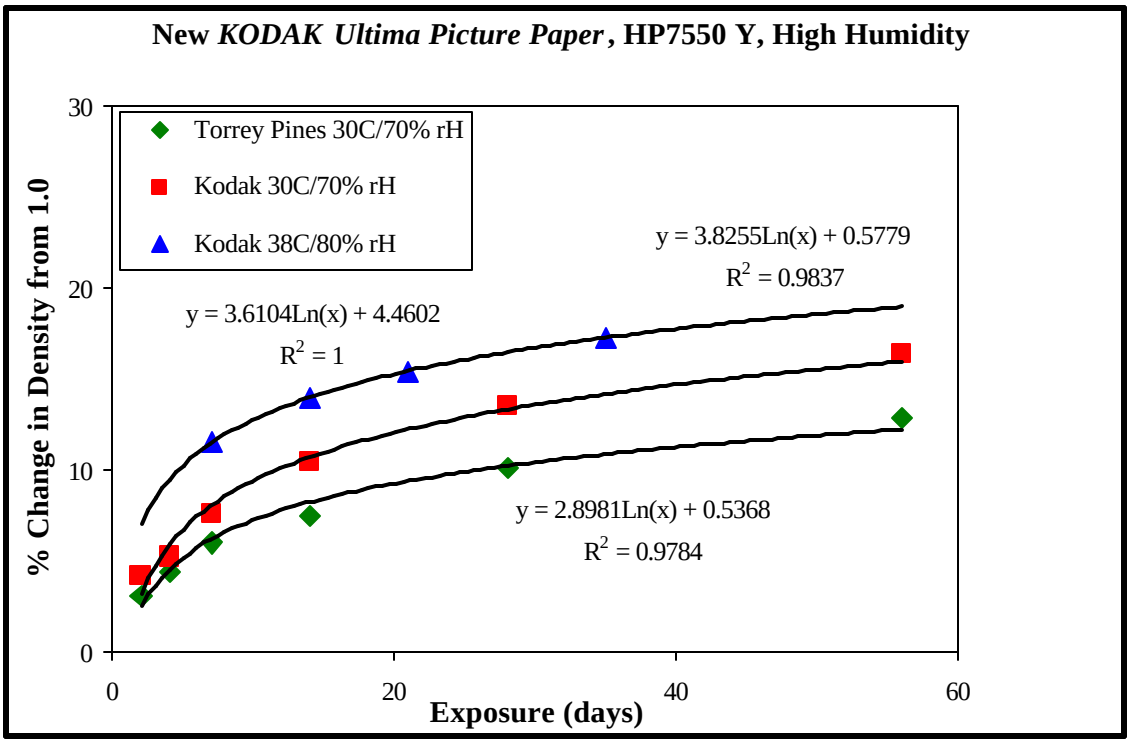

Figure 5. Plot of % density change for a 1.0 initial density for the HP 7550 yellow ink on the new KODAK Ultima Picture Paper *observed in the high humidity treatment test.*

Table 4. Summary of current high humidity keep results for test prints made with the new *KODAK Ultima Picture Paper Glossy* on the HP 7550 printer.

Test Condition	Days to fail	Humidity Keep Print-life Estimate (years)	Limiting color
A	2188	>>100	Yellow
B	1180	>>100**	Yellow
C	>10000	>>100	Yellow

** The 38°C/80% RH dew point falls outside the distribution of typical home display conditions. No acceleration factor exists for this condition. Applying the acceleration factor used for the 30°C/70% RH condition still yields a print life well over 100 years.

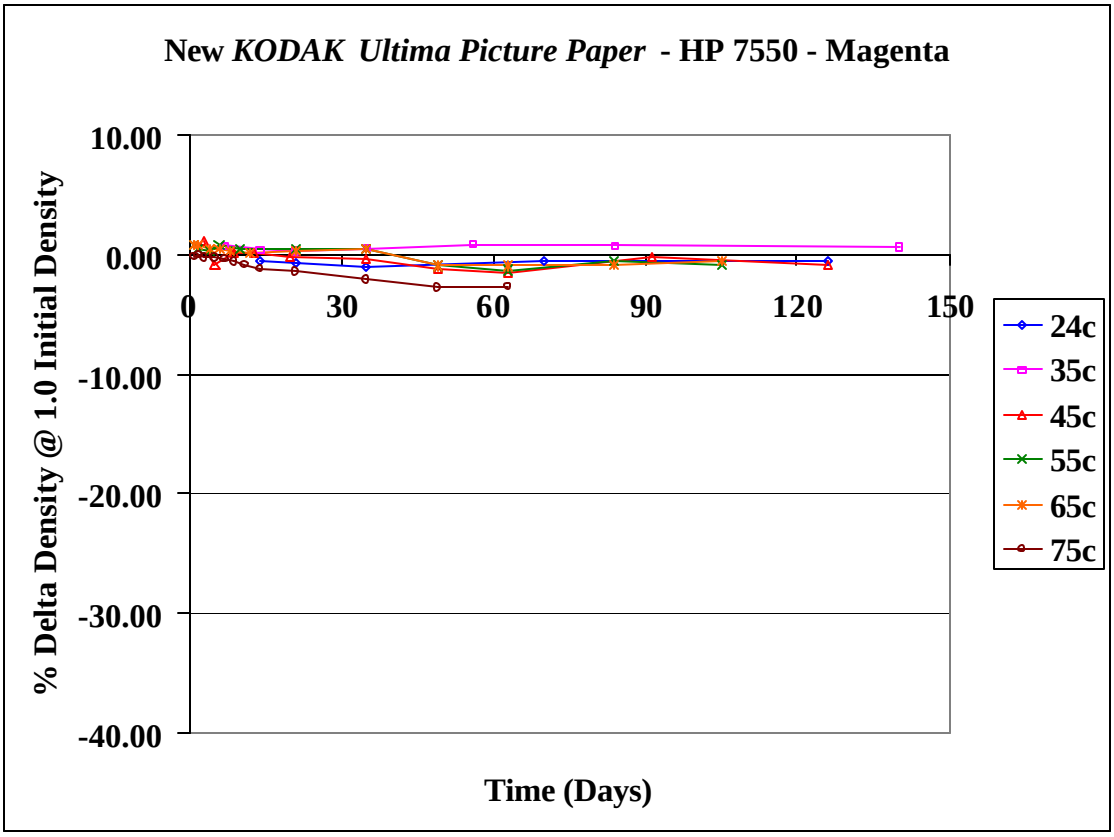

Figure 6. Current Arrhenius fade data for the HP 7550 magenta ink on the new KODAK Ultima Picture Paper.

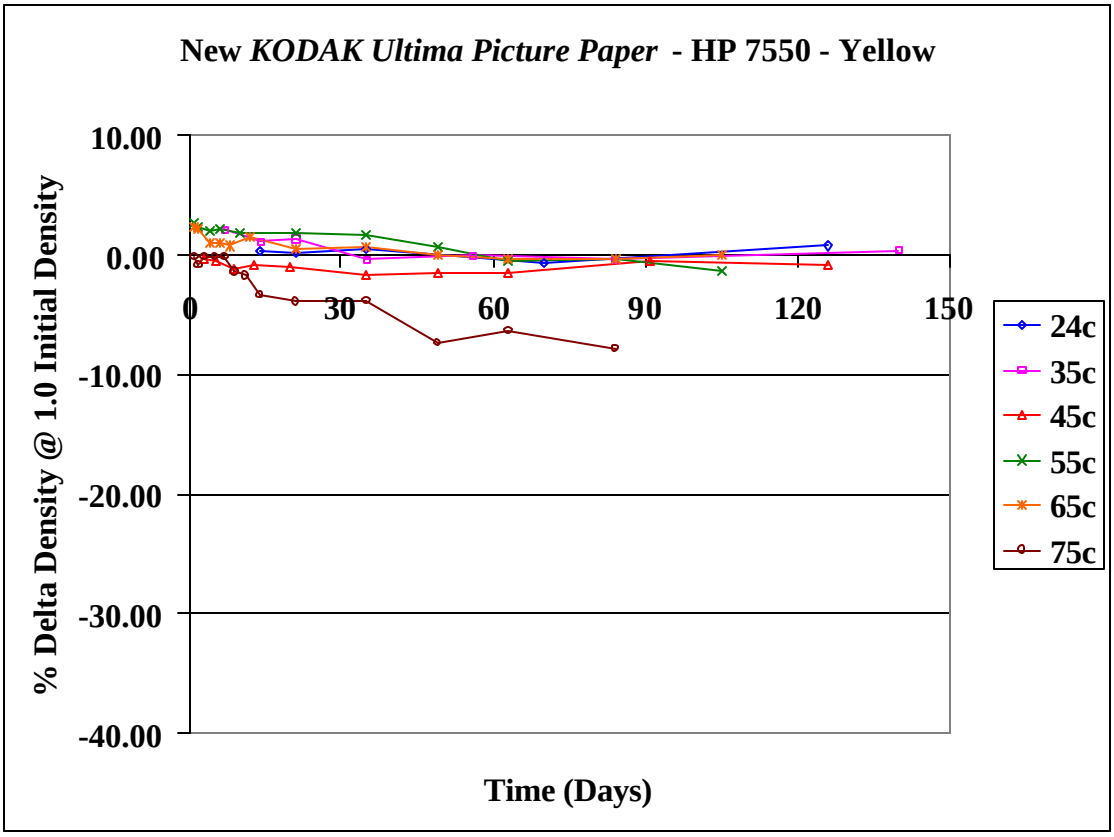

Figure 7. Current Arrhenius fade data for the HP 7550 yellow ink on the new KODAK Ultima Picture Paper.

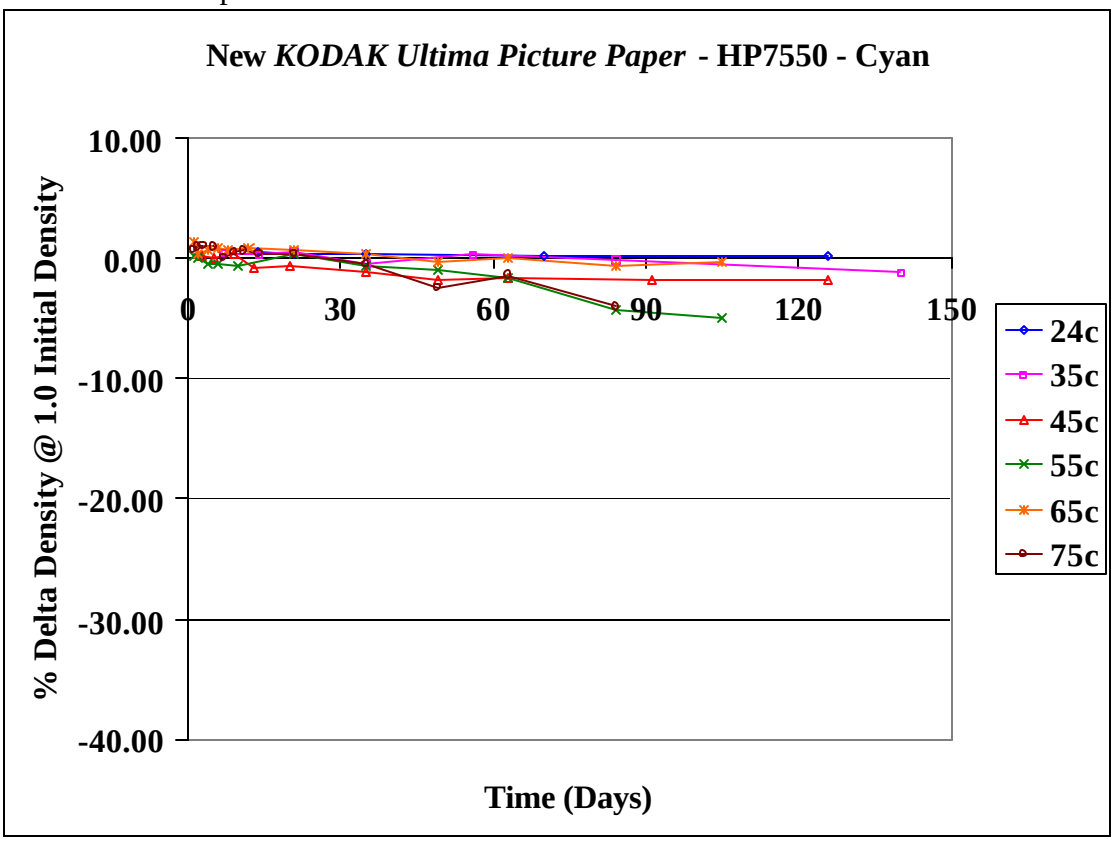

Figure 8. Current Arrhenius fade data for the HP 7550 cyan ink on the new KODAK Ultima Picture Paper.

Additional test results on the Humidity Keep of New *KODAK Ultima Picture Paper*:

A psychophysical evaluation was performed on practical images made on untreated control prints and compared to prints treated at the 30°C/70% RH condition. The prints have been treated for 28 days to date (simulating 54 years of home display) and will be further tested to 52 days. For more details on the methodology, please see p. 8 of our original paper. The results are shown in Figure 9. The perceived loss of quality is a result of hue shifts, density gains, and/or loss of sharpness. New *KODAK Ultima Picture Paper* shows relatively minor changes in perceived quality, confirming that new *KODAK Ultima Picture Paper* will not be limited in terms of overall print-life by humidity. The observed differences between the untreated and treated prints are considered to be less than a "just noticeable difference" (JND), single stimulus, when averaged across the 6 scenes used for this study.

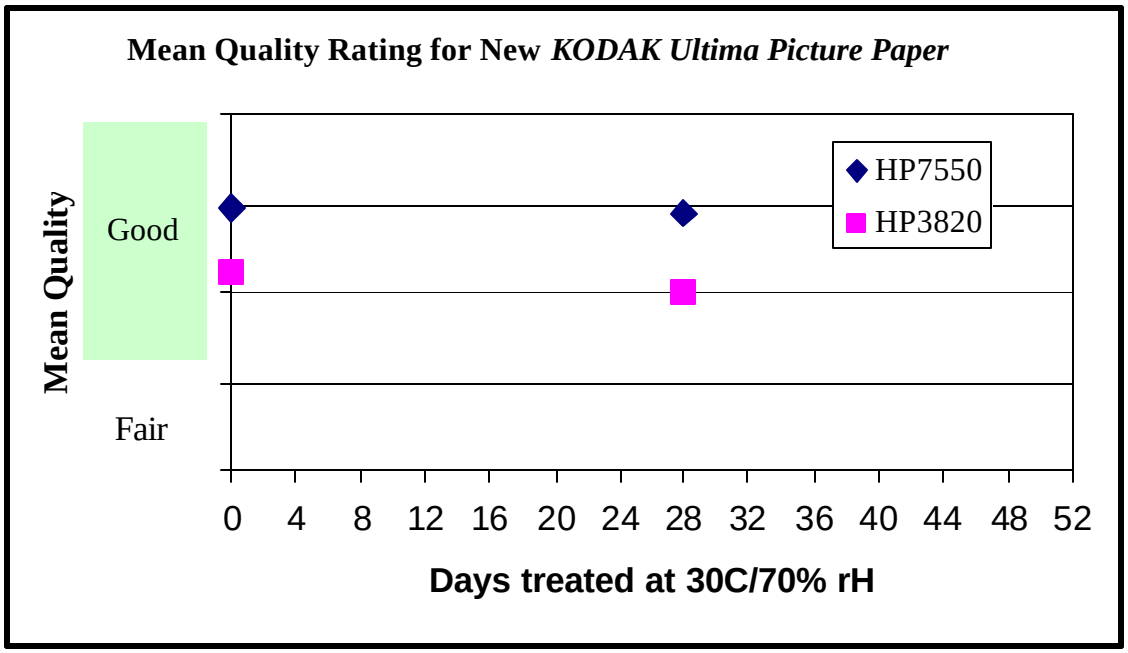

Figure 9. Subjective image quality assessment of the new KODAK Ultima Picture Paper *before and after treatment at 30°C/ 70% RH.*

Summary

Continued accelerated image stability testing of the *KODAK Ultima Picture Paper* has confirmed the earlier print life projections that were made in the original paper. In most cases the projections have actually increased. For example, it appears that when used in combination with the HP 7550 ink set, our print life projection based on light fade as the weakest link is now over 300 years. This was not unexpected given our conservative approach of assuming worst-case linear fade rates based on the preliminary data.

We have been monitoring the 5.4 klux light fade condition for evidence of reciprocity failure. The only evidence of light fade reciprocity failure appears to be with the HP 3820 inks. The deviation from reciprocity is slight, and is observed with most of the media in the study. No significant reciprocity failure has been observed to date for the new *KODAK Ultima Picture Paper* on any of the other printers included in this study.

We will continue to treat the all of the ink-media combinations at 5.4 klux until either end-points have been reached or it is no longer practical, e.g., it is currently projected to take over 3 years of continuous treatment at 5.4 klux to reach an end-point for new *KODAK Ultima Picture Paper* in combination with the HP 7550 ink set.

Continued ozone testing at both 1.0 and 5.0 ppm has confirmed our earlier conclusion that ozone is not a limiting environmental factor for the new *KODAK Ultima Picture Paper* on any of the printers included in this study. We also continue to monitor the Arrhenius study for thermal fade and find no evidence that this factor will limit the life of a print made with the *KODAK Ultima Picture Paper* that is displayed continuously. The same cannot be said of some of the other ink-media combinations included in this study. In particular, significant thermal fade that appears to follow the Arrhenius equation continues to be observed for the Epson yellow dye used in both the Epson 825 and 960 ink sets on several manufacturers' media. These samples are now approaching end-points at some of the higher temperatures. In addition, at least one of the manufacturers' inkjet papers is also showing substantial D_{min} yellowing. If the current trends continue, thermal fade for these ink-media combinations will approach ozone as the limiting environmental factor for print life. The implication of this result is that even if prints made with these inks and media are protected from ozone, they will still exhibit rapid thermal fade which will likely lead to unacceptable loss of image quality even before the effects of light fade are encountered.

We have now completed the psychophysical portion of the high humidity accelerated test. As was mentioned in our original paper, humidity can cause multiple forms of image quality degradation, including changes in density, hue shift, and loss of sharpness. Given the lack of guidance on end-point metrics for complex image quality changes that involve more than just dye fade, we designed a psychophysical study to better understand the overall impact of humidity on image quality. As shown in figure 9, the impact on the perceived image quality of practical prints treated for 28 days for the new *KODAK Ultima Picture Paper* printed with either of the HP ink sets was barely detectable. Similar results were observed for the new *KODAK Ultima Picture Paper* on the other printer/ink sets.

Testing in Progress

Inkjet printer manufacturers are continually updating their printer models and ink sets. For example, Lexmark has just launched a new 6-ink photo printer (model Z816) with claims of dramatically improved print life. Additional print life testing on the new *KODAK Ultima Picture Paper* is in progress on the inkjet printer models listed below.

Kodak PPM200	HP Photosmart 7960 (B&W mode)
Epson Stylus Photo 2200	Canon i860
Epson Stylus C84	Canon i470D
Epson Stylus C82	Canon i560
Epson Stylus Photo R300	Lexmark Z705
Epson R800	Lexmark Z816
Epson Stylus Photo 820	