IMAGE: Accurate Full Color Image Aging

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Keywords: process color, profile, prediction, durability, fade

Abstract

The printing of images for durable applications began when simple exterior signs were being reproduced in multiples. Signage has moved into all areas of graphics where images are displayed outdoors and are expected to weather the elements for years. These images have traditionally been produced with the screen-printing process and are now being produced by the ink jet process. These two printing processes are capable of printing on durable substrates, in large formats, and with a heavy ink deposit that will endure the elements.

There are established ASTM methods for the weathering of paints, inks, coatings, and substrates to predict the exterior durability of a construction. The weathering prediction processes are all based on how solid single-color inks or coatings will fade. Images printed by ink jet are all produced with the four subtractive CMYK inks in a range of tonal percentages.

This paper outlines the process and the reasoning to create accurate weathering predictions for four color process printed images. This process will generate accurate aging profiles that can be applied to any image that may be used in exterior applications. The resulting color profiles can be applied to images on monitors, proofs, and full-size prints.

Introduction

The primary print specifications for color printing have been designed around offset lithography printing on paper substrates (Reference Print Conditions, Pantone, ANSI). These are non-durable printing applications. Durable printing applications have been part of the industrial printing area for years with end uses in the automotive, fleet marking, and signage segments of printing.

Nazdar Companies

The ink jet process allows printers to print on a wide range of medias (substrates will be used in place of media for simplicity in the rest of this document) which includes many durable substrates. These applications have exterior durability expectations based on the ink/substrate combinations. These expectations have been established through years of real time and accelerated time weather testing of ink and substrates constructions.

Durable graphics printers should be aware that there is not a standard testing method or practice that considers the entire process color image when reporting the weathering data of a durable graphic. Most durable graphics have exterior ratings of one to ten years depending upon the substrate and ink components used in the graphic's construction. Until now, these components have been weathered using the single solid color method. There is a new full color weathering process that will create an accurate full color representation of how each of the four subtractive colors (CMYK) will change throughout the entire tonal range. This is an introduction to the IMAGE process which creates an accurate rendition of a weathered full color image. The result is visual and has many benefits to durable graphic producers and buyers.

The IMAGE Process

The Screen and Ink Jet processes are the primary printing methods used to create durable graphics. This is attributed to the thicker ink deposit and the versatility to print on highly durable substrates. Printing on durable medias with durable inks has been the hallmark of screen printing since the development of plastics for commercial graphic applications.

In the durable signage industry, plastics, paints and inks were developed with exterior durability in mind. Eventually these products acquired exterior durability ratings. In the case of the screen-printing industry, the common expectation for most inks and substrates is to last outdoors for two to three years, with some construction being designed to last up to ten years. The definition of lasting up to a certain amount of years outdoors, will usually mean the ink or coating will not fade more than 20% of its' original color strength, or lose a certain amount of gloss as measured with a glossmeter. Most of this printing has been done with spot colors. As ink jet printing is not the most popular versatile printing process, it is being assumed that ink jet maintains the same exterior durability as screen printing because it prints on the many of the same substrates. Printing on similar substrates is only part of the story. The large ink deposit achievable in screen printing is a big part of the reason that this process can produce durable graphics Figure 1.

Average Dry Ink Film Thickness by Printing Process	
Offset Ink	0.5 - 2.0 Microns
Flexo Ink	0.5 - 2.0 Microns
Piezo Ink Jet Ink	9.0 - 11.0 Microns *
Screen Ink	5.0 - 200.0 Microns**
Non-Printed Clears	
Roller Coating Clears	8.0 - 10.0 Microns
Laminate Films	50.0 - 130.0 Microns
* An Average deposit for UV Ink Jet Ink	
** Thicker deposits are possible for special applications	

Figure 1: *Estimated ink deposit amounts for the primary printing processes*

When it comes to printing exterior graphics, customers want to know how long they can expect their graphics to last outdoors without fading to the point where their message loses its impact. It is common for substrates and inks to have a durability rating. A printer can then match up the expected durability of the products with their customer's expectations. The longer lasting a product, usually the higher the cost for the materials. Some product constructions may even be built around a written durability warranty.

As durable product manufacturers send their products to different parts of the world, it is becoming more important to consider the weathering conditions where the products will be used, and not where they were manufactured. This complicates things for the manufacturer and requires them to develop products for the most extreme conditions, or to regionalize their products. Weathering data can now be regionalized in weathering zones. The closer you get to the equator, the more intense the Sun's damaging UV rays become. This map Figure 2 of UV intensity would be one way to define different world weathering zones.

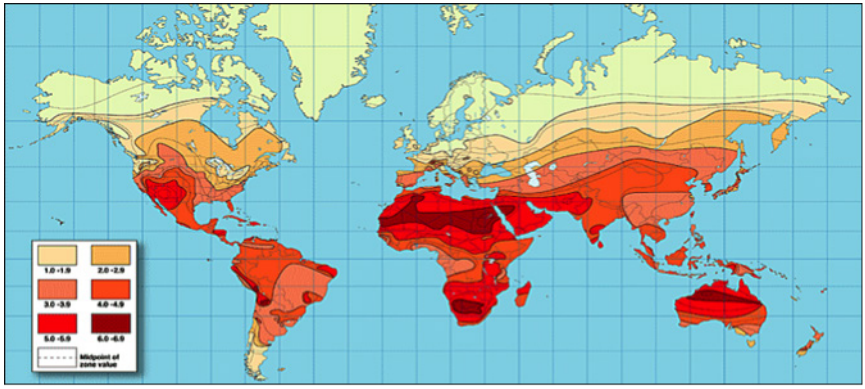

Figure 2: *World map showing areas with the highest exposure of the suns UV rays.*

The weathering of products has become a precise business in an unprecise world where the weather changes constantly. There are companies like Atlas and Q-Lab that provide weathering products and services. These two specific companies are based in the USA and have weathering farms all around the world in different weathering zones. These zones will include high UV arid and high UV humid zones. Ink and substrate manufacturers will contract these companies to do controlled real time weathering of their products. Once the samples have been exposed to the outside elements, they will be analyzed to determine what the best combination of raw materials is to make the most durable inks and substrate. These services are used by all kinds of manufacturers in automotive, fencing, roofing, house paint, signage, and graphic products.

Real time weathering is the best and most accurate. Yet it takes years to complete. As product development cycles becomes shorter and shorter, real time weathering can become unrealistic in the development stages. Accelerated weathering machines were developed in the early 20th Century, but did not come into common use by printers until the 1970's. The early machines focused on automotive applications that were being improved to make a car last longer and look better over time. Once this became verified to correlate with real time weathering, the practice of accelerated weathering became accepted as common practice in product development and testing.

Accelerated weathering is a standard practice for most manufacturers of durable products. There are ASTM standard weathering cycles or protocols that dictate how accelerated weathering machines should be set up with the hours of light, moisture, heat, and cool down phases to represent specific outdoor conditions associated with certain geographical areas.

It is accepted that the thicker the ink deposit, the better the integrity and durability of the ink layer. Adding an overprint clear to the ink layer will extend the exterior durability one to three years. A laminate will increase the durability even more due to the thickness of the film as a UV protector.

Sometimes these samples are compared visually and sometimes they are measured. The most common measurements made on these samples are:

- Gloss which is measured with a glossmeter. A reduction in gloss is usually the first sign of degradation of a coating.
- Color which is measured with a spectrophotometer. This is usually measured in L*a*b* color. The before and after measurements are calculated using one of the four common color tolerancing formulas.
- Color density is measured with a densitometer. This is measured only on transparent process colors, whites, and blacks.

If a CMYK ink / substrate construction is weathered and measured using the standard method of measuring solid ink areas only, they are measured and calculated down to a simple number difference using a delta e formula. The chart below Figure 3 shows measurements taken from five different sets of process color inks being weathered.

Ink Jet Weather Testing with Special Orange									
	X-Rite Advanced Spectrophotometer MO setting D50 10 Degrees ΔE00 tolerancing								
	L*	a*	b*	DELTA E	DELTA E	DELTA E	DELTA E	DELTA E	DELTA E
		Standard		6 MO	12 MO	18 MO	24 MO	30 MO	36 MO
				250 Hours	500 Hours	750 Hours	1,000 Hours	1,250 Hours	1,500 Hours
SET A									
Y	85.95	2.42	96.53	0.57	1.00	1.54	2.87	4.22	26.08
C	51.34	-39.01	-48.77	0.99	1.76	2.06	3.22	3.50	11.08
M	45.05	66.24	11.37	0.19	0.74	0.79	1.25	2.28	6.53
K	18.40	0.44	0.95	1.02	1.23	3.25	7.14	6.95	10.32
O	63.43	57.83	86.47	0.88	1.41	1.61	2.28	3.13	11.51
SET B									
Y	89.44	-6.60	78.08	0.66	0.74	1.17	2.03	2.61	10.03
C	55.43	-41.96	-47.88	1.03	2.02	2.75	3.80	5.21	15.48
M	54.01	60.19	-0.09	0.70	1.55	2.14	4.14	6.86	18.36
K	21.87	0.49	0.86	0.46	0.58	2.72	5.28	7.76	10.49
O	68.77	49.14	67.81	1.40	1.40	1.49	2.03	3.28	15.39
SET C									
Y	87.37	-3.53	80.77	0.66	0.68	0.78	2.88	6.57	35.66
C	52.50	-37.49	-46.31	1.38	1.85	2.40	3.58	3.67	14.13
M	50.85	61.13	-7.62	1.53	2.94	3.96	4.95	5.19	11.91
K	20.49	0.20	0.19	1.41	1.75	2.23	2.15	3.32	3.34
O	68.08	49.98	70.94	0.28	0.68	0.75	0.54	1.58	8.93
SET D									
Y	84.79	-3.04	81.83	1.30	2.10	2.06	4.70	9.09	43.55
C	52.48	-37.06	44.08	1.34	2.01	2.54	3.34	4.80	14.55
M	48.64	61.69	-8.33	1.85	2.64	4.09	5.34	5.91	14.78
K	19.68	0.41	0.65	1.67	1.07	1.20	1.44	2.98	5.56
O	64.93	51.57	66.89	0.71	0.75	1.08	1.56	2.26	6.71
SET E									
Y	83.82	0.91	93.21	0.57	0.80	1.04	1.33	3.11	20.72
C	52.17	-43.46	-49.75	0.75	1.66	2.54	3.53	4.56	14.12
M	47.06	66.82	-13.08	0.54	1.08	1.51	2.53	4.33	14.44
K	19.43	0.59	2.01	1.24	1.74	3.24	7.96	9.54	14.14
O	64.52	54.86	73.95	0.88	1.55	1.73	2.03	2.41	13.15
V	35.12	32.58	-56.76	0.89	1.42	2.57	5.21	7.89	28.07

Figure 3: *Traditional weathering method resulting in a spreadsheet of numbers.*

All measurements were taken on a 100% patch of CMYK and (O orange, V violet) over an accelerated 36 - month period. This data supports the fact that all the subtractive colors do not fade or weather the same. In the end, you are left with a number to represent a color difference. This makes the results very subjective based on a person's knowledge of the delta e tolerancing math which can produce different numbers depending upon which formula is used. It is very common for printers or buyers to simplify this series of numbers to use a single number as a cutoff of what is and is not acceptable. A common delta e color tolerance of acceptability is a delta

e of two or less. Using that criteria as a guide, none of these ink sets will weather past 12 months. What this chart cannot tell us is, how does an image appear after 12 months outside? Is it unacceptable? There is no visual connection.

The weathering of inks and coatings has always been done with a solid 100% coverage of a color which is appropriate for spot colors. This practice has continued even though most of the printing done today is full color CMYK printing. This method is not accurate for full color images because it is not common for full color images to have solid 100% areas of coverage of C, M, or Y. Our testing indicates Magenta and Yellow inks will fade faster than Cyan and Black inks Figure 5 and when we weather a tonal ramp with the different dot percentages of CMY, the lighter tones will fade much faster than the solid areas Figure 6. Most full color images have a near infinite number of colors trapping each other in varying tonal percentages. All this combined means that the traditional solid color weathering method is not applicable to process color images for accuracy in the business of reproducing full color images.

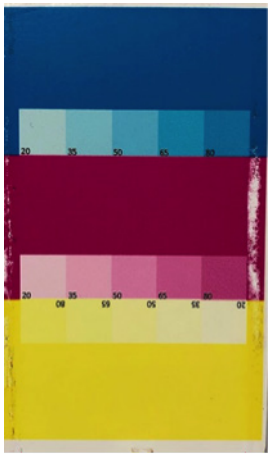

Figure 4: *control panel*

Figure 5: *M&Y fading first*

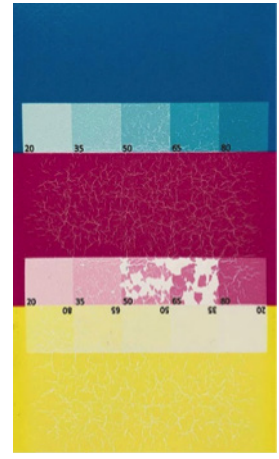

Figure 6: *tones fading first*

The IMAGE process has taken years to prove accurate as the work was done with both real time and accelerated weathering samples. Figure 7 We have used our color management experience to generate accurate IMAGE profiles. Instead of weathering solid patches of color, we weather the full tonal range of CMYK color and color traps in order to create a full color, full tonal range rendering of how color will degrade in all colors, at all different tonal and color build ranges for a particular ink and substrate construction.

Figure 7: *Tim Quinn and Bruce Ridge check on the real time weathering samples.*

Full color weathering data is now real and most importantly, visual. The IMAGE process is created by applying weathering profiles that have been created from actual weathering data showing six-month or one-year increments of weathering for an ink and substrate construction.

Figure 8: *Control patches compared patches exposed to one-year outdoor exposure*

Figure 9: *Weathered patches are scanned to generate weathered profiles*

Once the patch sets have been weathered, they are scanned to create media configurations based on a construction and weathering duration. Figure 9 These profiles can now be used in various ways to bring weathering data into a visual world. In the art department, a designer can apply an IMAGE profile to images in the design stages Figure 10 in order to make the best choice of colors in backgrounds, skin tones, foods, and product placement that will have the longest lasting acceptable color for any application out of doors.

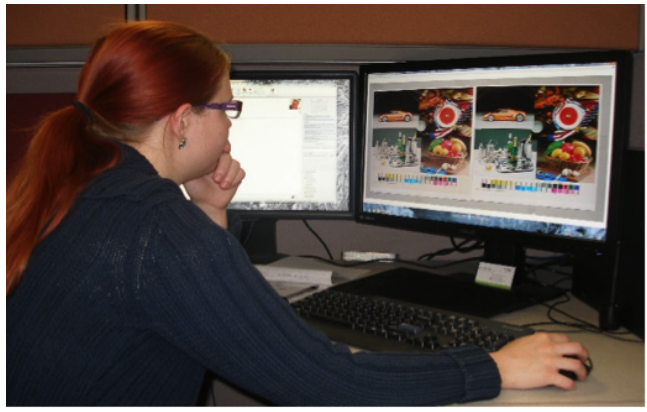

Figure 10: *The graphic designer applies an IMAGE profile to view the graphic weathered.*

Accurate IMAGE proofs can be generated prior to approving a job for sales presentations. Figure 11 This can help the sales group to visually sell more durable constructions, or maybe sometimes lesser durable ones when costs are the primary focus.

Figure 11: *A two-year IMAGE profile is applied to a proof for a visual representation color change*

IMAGE profiles can also allow a printer to replace a damaged panel on an older installation Figure 12 with predictability based on the real data collected on the changes in different colors and tonal areas will experience in the outdoors.

Figure 12: *Digitally printed multi-panel outdoor murals can get accurate replacement panels.*

Conclusions

IMAGE profiles show us the future of today's images after they have been exposed to the outdoors. The weathering of inks and coatings is an accurate and accepted practice through out graphic and industrial printing applications. The practice of controlling the reproduction of full color images through the media configuration process is established throughout all the printing processes. This outlines the work that has been done to prove these two processes can be combined to create accurate visual representation of a weathered full color printed image. The benefits can be summarized as:

- Creating a visual representation of weathering information.
- IMAGE profiles can create soft and hard proofs for previewing
- CGATS data can be used from the IMAGE profile to generate data only spreadsheets with color and delta e numbers for traditional uses.
- Simple ideas that seem obvious can have impact once tested and proven.
- There is no ownership or patient on this process, it is for public use.

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Acknowledgements

The author acknowledges the contribution of the following individuals for their help with the development of this project. Tim Quinn, Josh Lutz, Paul Christensen, Darrell Willis, Travis Barcelona, from the Nazdar Technical Service group, Roxi Patriquin and Cyan Ridge for the marketing ideas.