A Pseudo Continuous Tone Step Wedge for Digital Platemaking

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Keywords: digital, platemaking, exposure, test

Abstract: The Agfa Digital Plate Control Wedge, or DPCW, provides a means of optimizing the exposure of direct digital platemakers by visual inspection. It does this by using a pseudo continuous tone step wedge consisting of an array of checkerboard patterns with varying screen rulings. The DPCW was tested on an Agfa Selectset Avantra 25 film/platesetter using polyester based Setprint media, and on another platesetter using aluminum based Lithostar Plus media. After the plates were made, the dot areas were measured with an image analysis system. These measurements show that there was zero platemaker dot gain and that the halftone reproduction for the system was linearized, but that aluminum and polyester media may differ in their response to exposure. The DPCW's use precludes the need for making dot area measurements of printing plates with densitometers, which has been shown to be unreliable for such applications. Regardless of the platesetter or media being used, the pseudo continuous tone step wedge is the most sensitive way to monitor platemaking variables.

Introduction

In the pre press industry, we are moving into the era of direct technologies. Specifically, we are moving away from film based systems to computer to plate and computer to press systems. In doing this, we are losing an important step in our process control. Without the opportunity to measure halftone films, there is concern over how to control halftone reproduction. Some printers have opted to measure the dot area on the plate with a densitometer, but this has not always proven to be consistent. The industry has a need for a tool or method which produces digital printing plates with at least the same degree of accuracy and precision, if not more, as is currently available in analog platemaking. This paper will show how a pseudo continuous tone step wedge, or checkerboard array, can provide an accurate and sensitive way to exposure and monitor a digital platemaking system.

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Theory

The pseudo continuous tone step wedge consists of an array of halftone dots, in checkerboard patterns, each with a different sensitivity to system exposure. The layout of this array is shown in figure 1. Along with the checkerboard is a halftone gray scale as well as horizontal and vertical lines having line to space ratios of 1:1, 2:2, 3:3, and 4:4. The size of the checkerboards continuously increases left to right from 1x1 pixels to 8x8 pixels, with the largest placed beside the array for comparison. The reference strip beside it may also be of a size other than 8x8, but it is always at least the size of the largest checkerboard.

Figure 1 The layout of the DPCW. The pseudo contone scale is in the center area and labeled 1x1 - 8x8.

Each checkerboard pattern posseses a different amount of sensitivity to a change in exposure. This is directly dependent on the number of pixels in the halftone dots. A 1x1 checkerboard is always the most sensitive because every dot is made of only 1 pixel, which grows or shrinks in all directions. This is not true for the other checkerboards. The 2x2 checkerboard is half as sensitive as the 1x1 because of adjacent spot overlap. For a given number of imaged pixels, the 2x2 will have one half the total perimeter of the 1x1. Since dots grow and shrink only at their edges, the 2x2 will be one half as sensitive.

Since it is a checkerboard pattern, the nominal percent coverage, or imaged area, is always 50%. Each dot in the checkerboard is the same size, consisting of the same number of pixels. A single dot in a 2x2 checkerboard is always made of 4 pixels, and a 4x4 checkerboard, always of 16 pixels and so on.

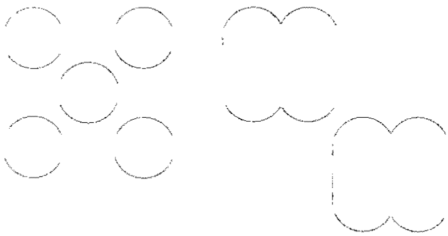
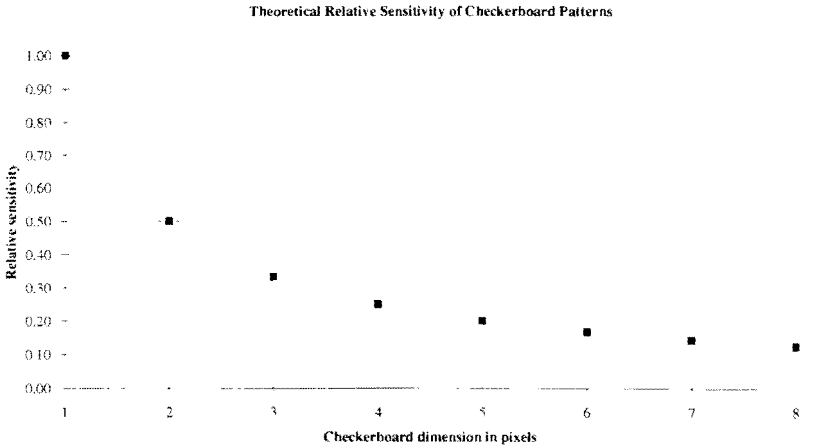


Figure 2 1x1 and 2x2 checkerboard dots. The size of the 1x1 is adjusted so that it equals 50% coverage. Note that the area of the 2x2 dot is actually more than 4 single pixels and greater than 50% dot area. All checkerboards larger than the 2x2 also theoretically have more than 50% coverage, but this deviation from 50% decreases with checkerboard size.

The spacing of the pixels, and a coarse adjustment of their size, is determined by the addressability of the exposure device. Finer adjustment of the pixel size, and therefore also to the size of each halftone dot, is accomplished by changing the exposure intensity and/or degree of processing. It is this adjustment which the pseudo continuous tone scale seeks to determine.

The relative sensitivity of the checkerboard is approximately equal to the inverse of its size. For example, at 2400 dpi, a 150 lpi 50% dot is constructed of 11x11 pixels. Therefore, the 1x1 checkerboard (really a 50% dot at 1697 lpi) is about 11 times more sensitive to exposure. This is somewhat of an approximation because platesetter pixels are round rather than square. Figure 2 plots this change as y = 1/x. The 1x1 checkerboard is always the most sensitive, so it has a sensitivity of 1.0.

Figure 2



Correct exposure is defined as the exposure which yields a similar visual appearance between the checkerboard patterns. When this criteria is met, dot area will equal the nominal value of 50%. Figure 3 shows that there is some inherent difference in the dot areas of the checkerboards even though they all are theoretically 50%. This was demonstrated in figure 2. There are 5 sample exposures represented in figure 3. At the lowest exposure, the 1x1 does not cover 50%. As exposure increases, the 1x1 eventually covers 50%, but the 2x2 and 3x3 are then marginally greater than 50%. This simulation does not consider many important variables such as the resolving power of the plate and recording engine variables such as electronic rise and fall time and it assumes the laser spot is perfectly hard and is matched to the addressability.

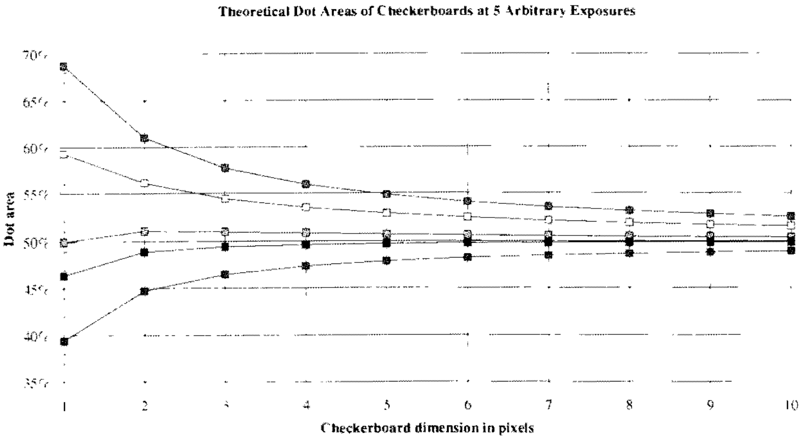


Figure 3 Theoretical dot areas of checkerboards at different arbitrary exposures

Practice

Historically, positive and negative plate exposure analysis has been based upon the evaluation of the plates' rendering of a continuous tone step wedge. The DPCW acts as a replacement for the above mentioned wedge. Because the DPCW looks and behaves similarly to a continuous tone wedge, the user can expose plates in a manner which he or she is accustomed to. The only difference is that the exposure is correct when the checkerboards look the same, not when one of them is solid or clear. This is effective for both positive and negative plate users. The DPCW was tested on polyester based Setprint and aluminum based Lithostar Plus plates. A series of exposures was made on each plate and the checkerboard densities were measured with a non polarized X-Rite 418 densitometer.

Lithostar Plus

For Lithostar Plus media, exposure is set solely by matching the checkerboards, as there is no target Dmax for the plate. Figure 4 shows how checkerboard densities change with exposure. Paired with this is the DLogE curve for the Lithostar Plus emulsion. The x-axis is incremented in relative log exposures of .05 and the y-axis in density. Correct exposure for this plate is found at -.55 LogE. Since Lithostar Plus is positive working, density decreases with exposure. Minimum exposure can be defined either:

1. At the point where the Dmin is fully reduced, exp.= -.75
2. At the point where the Dmin is too low to accept ink, exp. = -.95

The Dmin of the plate begins to accept ink at a density of about .60. So, correct exposure is .40 to .20 LogE more than minimum exposure and there is no risk of underexposing the plate when using the checkerboard method.

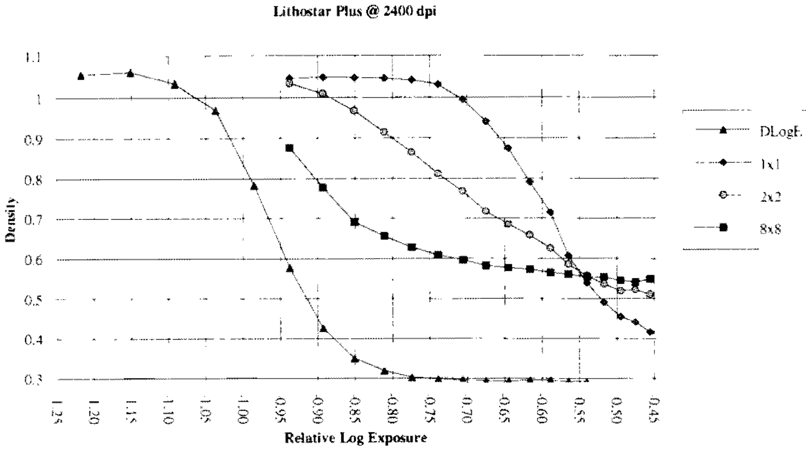


Figure 4. Lithostar Plus DLogE curve with checkerboard response. Correct exposure is found where checkerboard response is equal.

SetPrint

SetPrint media is similar to Lithostar Plus in that both are silver based and operate by the diffusion transfer process. The exposure criterion for SetPrint is more like film than Lithostar Plus, However in this case, density increases with exposure, and a Dmax of 1.22 must be reached for optimal press performance.

Dmax is the most important exposure criteria for SetPrint, but the checkerboards are still a very important quality control target. The exposure is set first by reaching a Dmax of at least 1.22 and is subsequently optimized for checkerboard similarity.

Figures 5 and 6 show how different checkerboards respond to exposure on Lithostar Plus and SetPrint plates. On the x-axis, 0.0 is the exposure that resulted in the 1x1 checkerboard pattern matching the 8x8. Both figures omit the 5x5 - 7x7 checkerboards for the sake of legibility. The SetPrint data shows an underexposure limit of -.12 LogE because this was the exposure that rendered a Dmax of 1.22. Further underexposure would have lead to a predictable change in checkerboard density, but would have also underexposed the Dmax areas.

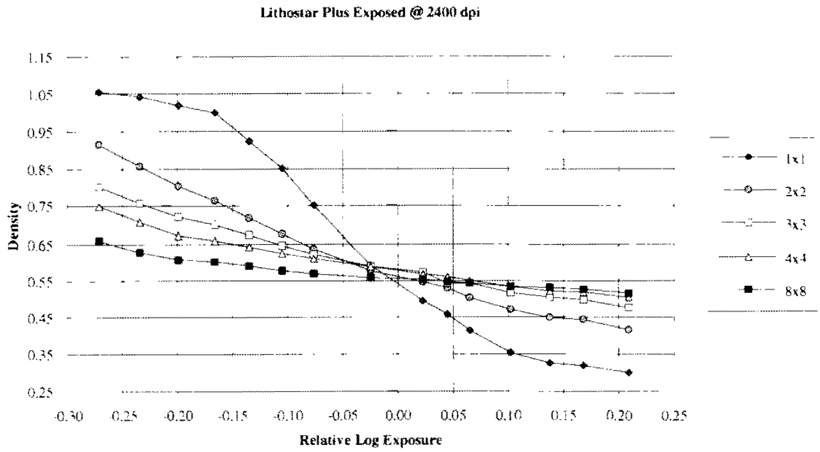


Figure 5 Checkerboards imaged at 2400 dpi on Lithostar Plus

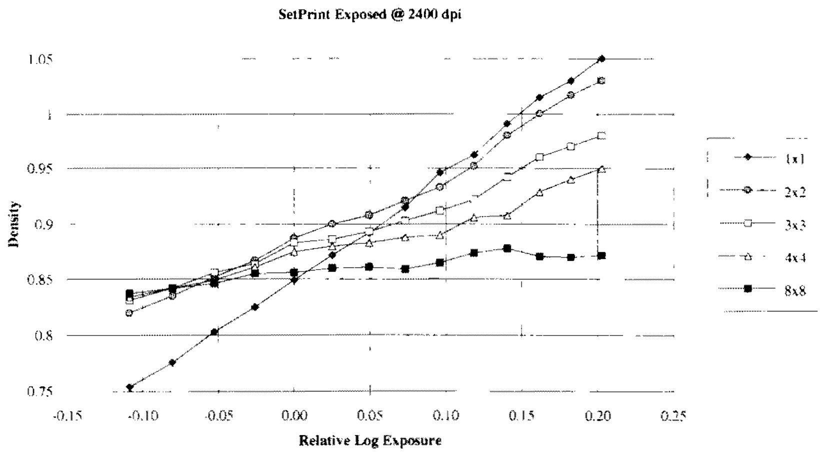


Figure 6 Checkerboards imaged on SetPrint

Halftone Reproduction on the plates

After the exposures were made, the plates were measured on an image analysis system in order to determine the quality of the halftone reproduction. It was found that the halftone grayscale was linearized and that platemaker dot gain was zero for all screen rulings. For the Lithostar Plus plates, halftones of 100, 140, 150 and 200 lpi were tested. They were imaged at 1200, 1800, 2400 and 3600 dpi, respectively. Setprint was tested only at 133 lpi. The plate measurements are found in figure 7.

Plate	10%	20%	30%	40%	50%	60%	70%	80%	90%
Lithostar Plus @ 200 lpi	9.1	19.8	30.1	40	50.6	60.6	70.5	80.6	90.7
Lithostar Plus @ 150 lpi	9.9	19.5	30.0	39.5	49.7	60.3	70.3	80.2	90.0
Lithostar Plus @ 140 lpi	9.4	19.5	29.9	40	50.1	60	70.2	80	90
Lithostar Plus @ 100 lpi	9.8	19.7	29.9	40.1	50.3	59.7	69.6	79.5	89.5
SetPrint @ 133 lpi	11	21.4	31.5	41.6	51.5	61.3	71	80.7	90.4

Figure 7 Plate dot areas measurements made with image analysis system are ±0.75% at the 50% dot.

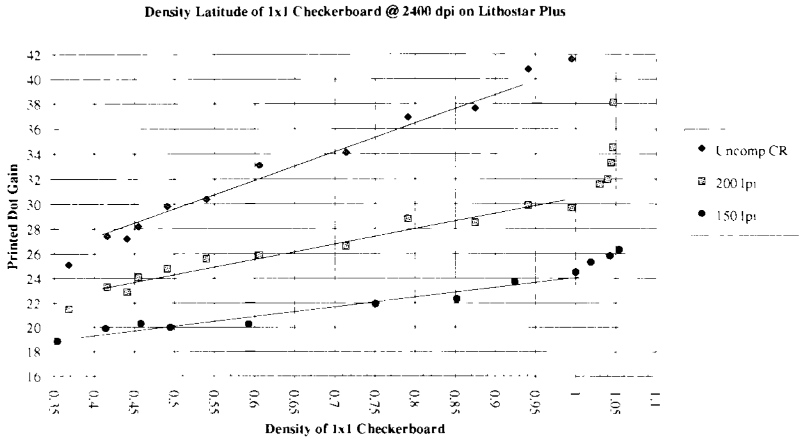
The image analysis system included a microscope fitted with coaxial illumination, a polarizer and an analyzer, and a CCD camera capturing 640x480 pixel frames at a magnification of 1.3 microns per pixel. Grayscale calibration was done prior to measuring each image to ensure that the illumination was even across the frame. The images were then thresholded at the half way point between the average gray value of the dots and the average gray value of the background.

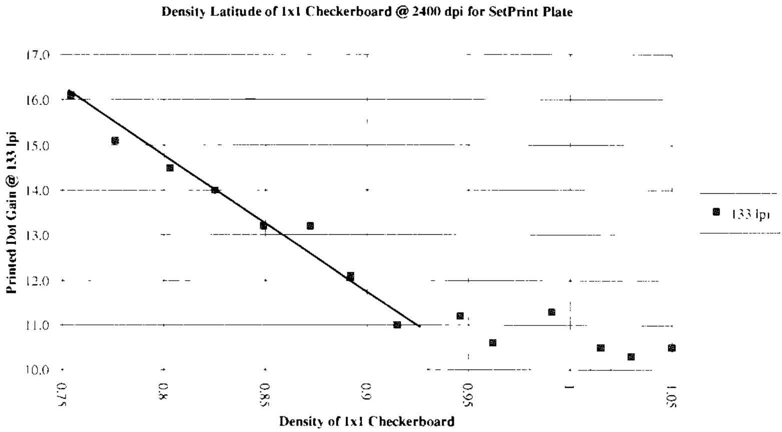
Halftone reproduction on the prints

So far we have seen how checkerboard patterns provide an accurate way to regulate plate exposure. What can they tell us about how the plate will print though? An obvious question to ask is "How close do the checkerboards have to match"? and "How do I know I made the same plate twice"?

It has been said that the pseudo continuous tone step wedge can replace the transmission densitometer and the continuous tone step wedge for the production of digital printing plates. We have seen that the checkerboard array can provide a linearized grayscale at all screen rulings. This was also shown previously by Sigg and Romano to be true for imagesetter films.[1] How sensitive are the checkerboards in terms of predicting print quality? Since the 1x1 checkerboard is the most sensitive element in the array, it is the best indicator for changes in dot area. How does its sensitivity compare to that of the analog continuous tone step wedge? Compare the slopes of the DlogE curve and the 1x1 checkerboard response in figure 4. The DLogE curve itself essentially maps the response to the contone scale. The popular analog UGRA wedge increments density in steps of

.15 LogE. For this amount of exposure change, the 1x1 checkerboard changes by about .50 density. The same change in exposure would affect the UGRA wedge by about .60 density. This means that the 1x1 is about 5/6 as sensitive. Since the 1x1 is a single patch and not incremented like the contone wedge, changes are more visually obvious. Figures 8 and 9 show how the 1x1 checkerboard can be used to track the dot gain of different screen rulings for Lithostar Plus and SetPrint plates.





Figures 8 and 9 The density of the 1x1 checkerboard can be used to predict changes in dot gain on press. Correct exposure was found at a 1x1 density of .55 for Lithostar Plus and at .85 for SetPrint. These reference densities form the baseline for statistical process control.

Given this sort of information, the user of a digital platemaker can evaluate a plate in a reliable, consistent manner with a readily available instrument. Depending on the screen ruling being imaged, a change in the density of the 1x1 checkerboard from the reference can determine whether the plate should go to press or should be remade.

Other advantages to the pseudo continuous tone step wedge

The advent of exposure control loops on platesetters presents a new use for the checkerboard methodology. An exposure control loop is a sub-system of a platesetter that continuously monitors and adjusts the laser beam power. This ensures that each plate is exposed in the same manner. Given this degree of control over the recording engine, a pseudo continuous tone step wedge can be an effective way to monitor the processing of the plate.

Recorded dot area on the plate is influenced by several factors. The most important of these are exposure and development. Exposure variations can be compensated for in the recording engine, leaving the processor as the remaining variable. By imaging a pseudo continuous tone step wedge on every plate while utilizing an exposure control loop, changes in checkerboard density will be processor related.

Conclusions

We have arrived at a crossroads in our industry. The emerging direct to plate technologies are allowing us the opportunity to get out from under the primitive burden of contact plate making. They are offering all the advantages of a seamless interface from desktop imposition direct plate and subsequently press. Our challenge is to control these new technologies in a manner that empowers the user to make intelligent and informed decisions about plate exposure.

The earlier processes of plate analysis must make way for new techniques without objectifying the human element in the process. We continue to be reliant on human intervention despite the industry's efforts to convince us otherwise. The visual response methodology of evaluation gives the plate room personnel a powerful and important and important role in the QC of the direct to plate work flow.

We have stated that the technical effect and consistency of these tools as we have tested and qualified them. The true test for these accurate tools will be brought home when the craftsmen of our industry use and prove that the visual techniques cited herein, are in fact utilizing the very same internalized visual techniques that we have been using for years.

References

[1] Sigg, Franz, and Romano, David J.
1995. "How to Calibrate and Linearize an Imagesetter Using the Digital UGRA/FOGRA Wedge," IS&T fourth technical symposium, pp. 88-92.