Characterization of Plate Images Fact or Fantasy ?

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Abstract

Direct-to-Plate and Direct Imaging are becoming increasingly important to the graphic arts offset market. To predict printed results, accurate characterization of an image on a printing plate would be very advantageous. Several different densitometer manufacturers have released instruments that claim to measure the printable features on lithographic offset plates. This paper will describe the results of an evaluation of four commercial manufacturers' densitometers that are presently available.

Introduction

The viewpoint of this paper is that of a manufacturer and vendor of plate materials, and of the end user of imaged lithographic plates. Our position is that our most discriminating customers should have the capability to precisely, and consistently measure images on printing plates. Therefore, we may conclude that it is important to know what the level of instrument bias and consistency is for various manufacturers' densitometers in combination with a variety of plate materials and tonal variations.

To date, the primary use of hand-held reflection densitometers has been for the measurement of printed color bar solids, overprints, and tint patches on press sheets. The densitometric measurement of tint patch images on metal plates has been somewhat limited because of the belief that instrument bias and consistency may be adversely affected by the unpredictable scattering of light from plate grain structures, anodizing (rainbow effect), plate image color shifts that fall outside the densitometer's primary color sensitivity range, and low image contrast.

The traditional method of determining proper lithographic film/plate exposure uses a gray scale and/or microlines as an exposure determinate (3). Film dot area values are used as a reference for comparison to the printed sheet. The arrival of digital plate technology, without the benefit of lithographic films, is forcing the user to find alternative techniques for measuring plate images, in lieu of lithographic film, for comparison to the printed sheet.

This paper explores the practicality of using reflection densitometers, in a traditional "dot area mode", to quantify lithographic plate images. A summary and conclusions derived from the statistical values obtained from the data analysis will be presented.

Definitions

Angular Measurement refers to the angular reading position of the densitometer, relative to the grain direction of the plate, while performing a measurement at 0º, 45º, and 90º.

Angular Measurement, Repetitive refers to the angular reading position of the instrument, relative to the grain direction of the plate, while performing measurements, i.e., 1st reading at 0º, 0º, 0º; 2nd reading at 45º, 45º, 45º; and, 3rd reading at 90º, 90º, 90º.

Angular Measurement, Single refers to the angular reading position of the instrument, relative to the grain direction of the plate, while performing measurements, i.e., 1st reading at 0º, 45º, 90º; 2nd reading at 0º, 45º, 90º; and, 3rd reading at 0º, 45º, 90º.

Bias is used to describe proximity to a "true" or target value. This paper will use measurements from a nonphotometric computer image analysis device, using a proprietary **3M Computer Image Analysis System** protocol and procedure, as a set standard.

Consistency is used to describe the uniformity of successive measurements from an instrument.

Dot Gain refers to the difference in dot area obtained by subtracting the measured tint patch dot area value (subtrahend) of the proprietary **3M Computer Image Analysis System** device, from the tint patch dot area value (minuend) of a specific instrument.

Instruments (A, B, C, D) refers to a specific manufacturers densitometer.

Plates (V, W, X, Y, Z) refers to a specific plate sample.

Experimental

Instrument Sampling: As a continuation of earlier evaluations, (1) (2) (3), we asked four densitometer manufacturers to provide instruments for the purpose of evaluating measurement bias and consistency. Each manufacturer supplied two to three instruments, of the same model, from different production lots for evaluation. The random instrument lot numbers provided an opportunity to obtain a mean dot gain and standard deviation value for each densitometer manufacturer's lot of instruments. Instrument coding and characteristics are listed in Table I.

Table I. Instrument Characteristics

Instrument Code	Filter	Source	Geometry/Optics	Detector
A	Status T	Tungsten	0/45	Ring
B	Status T	Tungsten	0/45	Ring
C	N/A	Tungsten	0/45	Ring
D	StatusT (Polarized)	Tungsten	0/45	Mirror
3M Image Analysis	....	Tungsten	0/45	Mirror

For the purpose of anonymity, each manufacturers lot of instruments is identified by a single letter.

Measurement Design: During the instrument evaluation period, each of five different plates had singular and repetitive angular measurements for a total of 792 readings per plate sample: 216 readings for four tint patches from instruments A, B, and C, and 144 readings for four tint patches from instrument D. Plate measurement protocol included nine repetitive angular readings, and nine singular angular readings of each tint patch per sample period, 18 angular readings per tint patch total. Each plate has four tint patches for a total of 72 angular readings per plate sample. For the three manufacturers who supplied three instruments, each plate sample provided 216 readings. For the one instrument manufacturer who supplied two instruments, each plate sample provided 144 readings. **The total number of careful "hand held" instrument readings, from the five plate samples, was over 3,960.**

Measurement Samples: The single plate samples used for measurement included negative-acting metal plates from four major manufacturers, and one silver halide photo-direct digitally imaged plate from one major manufacturer (Table II). Plate selection criteria included a variety of base grain structures and image contrast, i.e., metal and silver halide photo-direct, smooth grain to rough grain, and low contrast to high contrast images. Plate samples were imaged and hand processed according to the manufacturer's instructions. The metal plates were not gummed so as not to introduce another variable in the test design.

Plate Test Target Imaging and Processing: An analog (film) test target (UGRA scale) was used when imaging the metal plates to ensure consistency. Metal plate exposure times were determined with an UGRA scale according to the manufacturer's instructions. The silver halide photodirect plate was digitally exposed and linearized according to (5).

Tint Sample Selection Criteria: The 5% highlight tint was selected for purposes of introducing the lowest signal to noise ratio. The 20%, 40% and 95% tint values were selected for purposes of detecting tendencies of instrument measurement skew.

Instrument Dot Area Benchmark: A proprietary **3M Computer Image Analysis System, capable of measuring dot area,** provided benchmark data to calculate plate dot area. Each of the plate sample tint patches was measured several times and averaged. Over a period of five days several hundred measurements were obtained from the five different plate samples. The dot area standard deviation for the benchmark device, measured over a five day period, was 0.25% or less.

Instrument and Plate Coding: Codes A, B, C, and D classify the four instrument manufacturers. Code's V, W, X, Y, and Z classify the five different plate constructions.

Calibration: Each instrument was used in a "non gathering" measurement mode to achieve familiarity with look, feel and protocol. After the familiarity session, all the instruments were then calibrated to their own standard "opaque white/black" calibration plaques.

Product Performance Comparisons: The paper will summarize and compare the statistical plate measurement data relative to instrument bias and consistency.

Reduction of Test Design Variability: This paper deals with the scientific study of densitometric instrument measurement accuracy of lithographic plate images. Therefore, the following test design factors were considered during the test design: **I.** A precision analog film test target was preferred over the inherent variability found in scanner generated test targets, i.e., manufacturer's RIP variability, focus, film, film processing, and exposure time. **II.** Microlines were not used as an evaluation tool since it was proven that they may respond differently with various manufacturers plates (5). **III.** Press test were not used because of the extensive variability in the lithographic offset printing process, i.e., pressure settings, press wear, ink/water interaction, blanket variation, press speed, paper, human factors, etc. **IV.** Single plate samples from each manufacturer were used to exclude the possibility of plate-to-plate variation.

Conclusions

Summary: Results of the overall test indicate that **extreme care** should be taken when attempting to measure images on lithographic printing plates. Measurement bias and consistency can be affected by many factors that can work in combination with each other, i.e., instrument model and configuration, instrument aperture, instrument calibration, instrument orientation to the plate grain direction, instrument measurement technique, plate graining characteristics, plate/image contrast, film test target attributes including screen tint selection and screen tint line ruling, plate and film processing conditions, sample preparation, etc. Refer to Table III for a listing of suggested plate measurement protocol.

It is assumed that the need for measuring the image on a printing plate is for the purpose of quality assurance. It is recommended that plate image measurement be used in combination with other quality assurance tools, i.e., gray scales, UGRA scales, GATF Star Targets, RIT scales, digital test targets, microlines, etc. The information available from a variety of quality assurance elements, in combination with statistical process control, will make it easier to judge quality and make more informed decisions.

Statistical Analysis: A standard Analysis of Variance was calculated from each instrument manufacturer's data. The model included terms relating to the individual and combined effects of different printing plates, percent tint patches, and test instruments. The fitted model was able to explain 90% of the variation among the dot gain readings. The analysis revealed that all the terms in the model have some effect on the dot gain readings. Refer to Figure 1 for additional detail and discussion.

Paired statistical comparisons of singular angular, and repetitive angular measurements were conducted for all instruments and all plates. The overall result produced mean dot gain differences that were 0.5% or less for all instruments. Although statistically significant, the resultant 0.5% difference indicates that the instruments are not practically impacted by the manner in which the measurements are collected, i.e., consecutive verses repetitive readings. Refer to Figure 2 for a detailed example of a paired, nonparametric, bivariate T Test of instrument A.

Dot Gain Analysis: All instruments were evaluated on an individual basis for measurement bias and consistency over the entire percent tint patch tonal range of each plate. Mean dot gains and standard deviations were calculated for each tint patch: 5 %, 20%, 40%, and 95%. The conclusion of this study is that different instruments have varying mean dot gain and standard deviation responses relative to percent tint patches and printing plate materials. Refer to Figures 3, 4, 5, 6 and 7 for mean dot gain plots, standard deviation plots, and summaries of each instrument.

Angular Measurement Analysis: Instrument angular mean dot gains and standard deviations were calculated at 0º, 45º, and 90º. The conclusion of this study is that the placement of an instrument on a plate surface, relative to the grain direction of the plate, will have an effect on the bias and consistency of the instruments response. Refer to Figure 8 for a detailed plot and discussion of densitometric angular response.

Specific plates produce varying mean dot gain and standard deviation responses from different instruments. The conclusion of this study is that the type of plate will have an effect on the bias and consistency of the instrument's response. Refer to Figures 9 and 10 for a comparison of different printing plates and how they produce different densitometric responses at varying angular placement to the plate's grain surface.

Plate Photomicrographs: Each plate's image area was enlarged approximately 300X magnification in order to illustrate the plate's grain structure. Refer to Table II for composite photomicrographs and a description of each plate type.

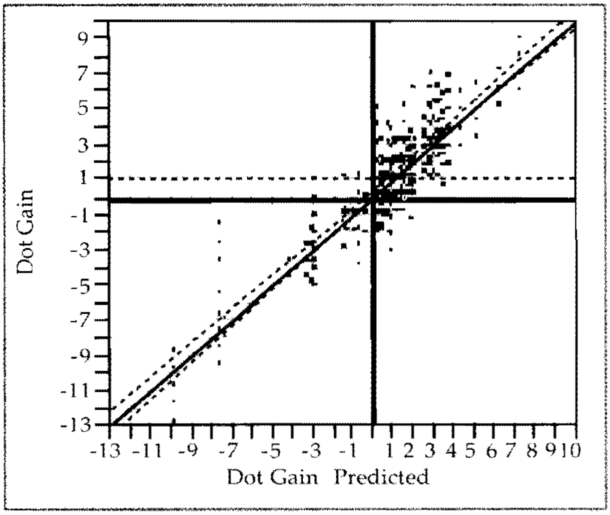


Figure 1. Summary of Fit:
Dot Gain Analysis of Variance

RSquare	**0.89537**
RSquare Adj	0.89324
Root Mean Square Error	0.808499
Mean of Response	0.966548
Observations (or Sum Wgts)	3960

Source	**Nparm**	**DF**	**Squares**	**F Ratio**	**Prob>F**
Plate Code	4	4	13035.901	4985.656	0.0000
Tint (n)	3	3	196.250	100.0757	<.0001
Plate Code*Tint (n)	12	12	4769.585	608.0518	0.0000
Inst Code	3	3	224.621	114.5432	<.0001
Plate Code*Inst Code	12	12	3182.798	405.7599	0.0000
Tint (n)*Inst Code	9	9	921.755	156.6802	<.0001
Plate Code*Tint (n)*InstCode	36	36	947.419	040.2607	<.0001

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Ratio**
Model	79	21703.824	274.732	420.2913
Error	3880	2536.241	0.654	**Prob>F**
C Total	3959	24240.064		0.0000

Figure 1 illustrates the Analysis of Variance table for the dot gain response. Plate type, plate type and tint, plate type and instrument (in that order), had the greatest effect on the test results. The fitted model includes responses relating to the individual and combined effects of plates, tints, and instruments. The high RSquare of 0.895 illustrates that the fitted model was able to explain virtually all of the variation inherent in the dot gain readings.

The RSquare rating for the 40% tint response, all plates, was 0.94. The RSquare rating for the 20% tint response, all plates, was 0.92. The RSquare rating for the 5% tint response, all plates, was 0.77.

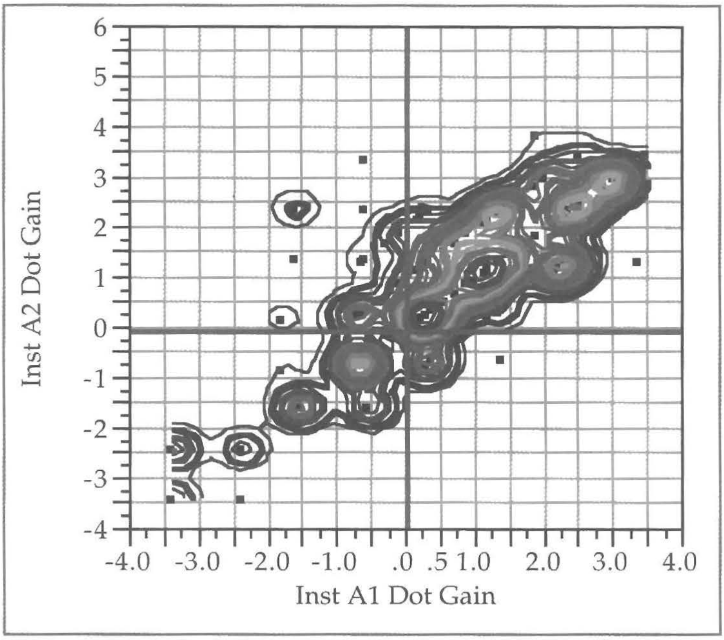


Figure 2. Paired T Test - Quantile Density Contours Inst. A1 Dot Gain By Inst. A2 Dot Gain

Paired T-Test

Inst. A2 Dot Gain - Inst. A1 Dot Gain

Mean Difference	0.255556	Prob > |t| <.0001
Std Error	0.036827	Prob > t<.0001
t-Ratio	6.939444	Prob < t 1.0000
DF	539	

Nonparametric Bivariate Density

Variable	**Kernel Std**
Inst A2 Dot Gain	0.262676
Inst A1 Dot Gain	0.255583

Figure 2 illustrates a nonparametric bivariate density paired comparison contour plot of 1080 measured tint patches for instrument A over the entire tonal range for all plates that were evaluated. The analysis compared two conditions of measurement technique; i.e., 3 consecutive angular measurements of the same patch verses 3 repetitive angular measurements of the same patch at 0°, 45°, and 90° orientation to the grain surface of each plate sample. Although the mean dot gain difference of the two measurement techniques indicates that they are significantly different, their differences are only 0.5%. The same is true for the other instruments; i.e., differences of 0.5% or less. The conclusion is that, multiple readings do not significantly affect the dot gain values obtained.

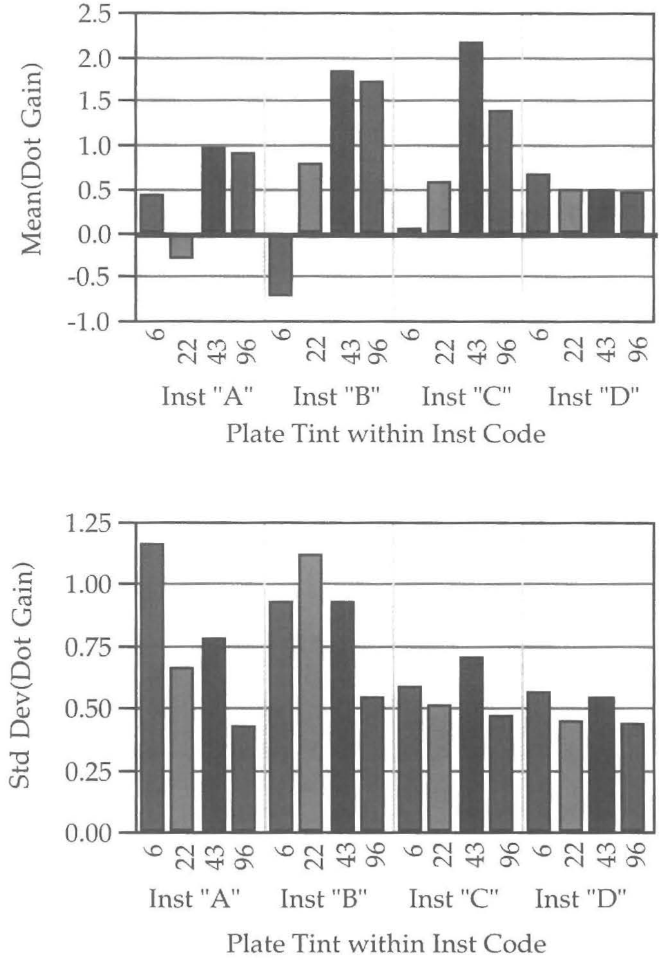
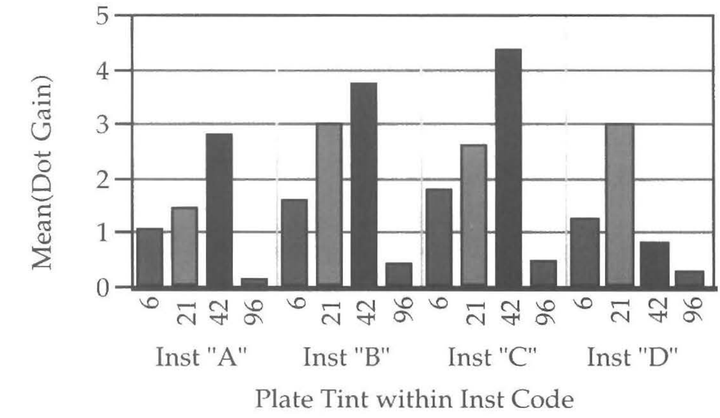


Figure 3. Plate V Dot Gain Variation as a Function of Instrument and Tint Value

Figure 3 illustrates comparative tonal range mean dot gain measurements obtained from plate V and four groups of instruments (A, B, C, D). Instrument D demonstrates the most uniform mean dot gain across the tonal range, and has the least amount of standard deviation as compared to the other instruments. Instrument A also has a fairly uniform mean dot gain, but the standard deviation for highlights and midtones is somewhat high. The mean dot gain for instruments B and C changed appreciably across the tonal range; however, instrument B's overall 3 sigma standard deviation of +/- 3% dot gain (6% range), is nearly twice that of instrument C in the quarter tone and midtone regions that has a 3 sigma standard deviation of 1.5 % to 2% dot gain.



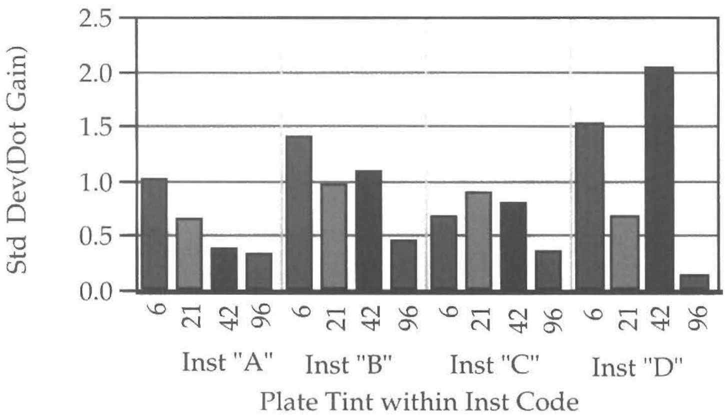
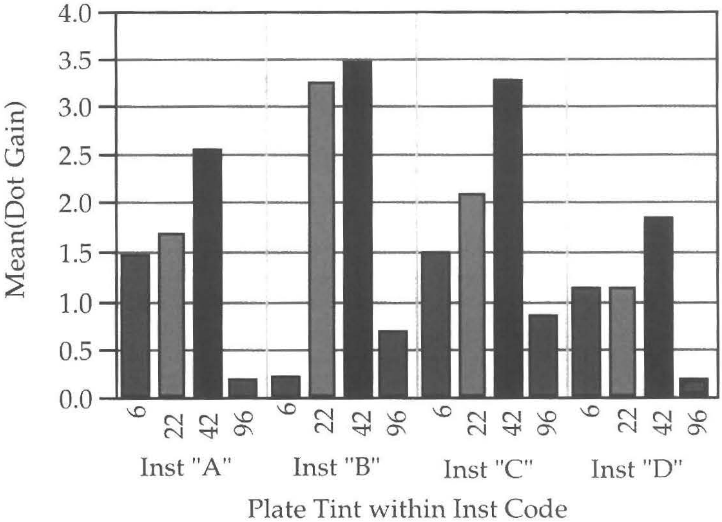


Figure 4. Plate W Dot Gain Variation as a Function of Instrument and Tint Value

Figure 4 illustrates comparative tonal range mean dot gain measurements, obtained from plate W and four groups of instruments (A, B, C, D). Instrument D demonstrates the least amount of midtone (42%) mean dot gain, 1%, and the highest amount of 3 sigma standard deviation, +/- 6%. Overall highlight (6 %) mean dot gain measurements are in the 1% to 2% range, with an approximate 3 sigma standard deviation range of 2% to 4.5%. Overall quarter tone (21%) mean dot gain measurements are in the 1.5% to 3% range, with an approximate 3 sigma standard deviation range of 2% to 3%. Overall shadow (96%) mean dot gain measurements are less than 0.5%, with a 3 sigma range of 0.5% to 1.5%.



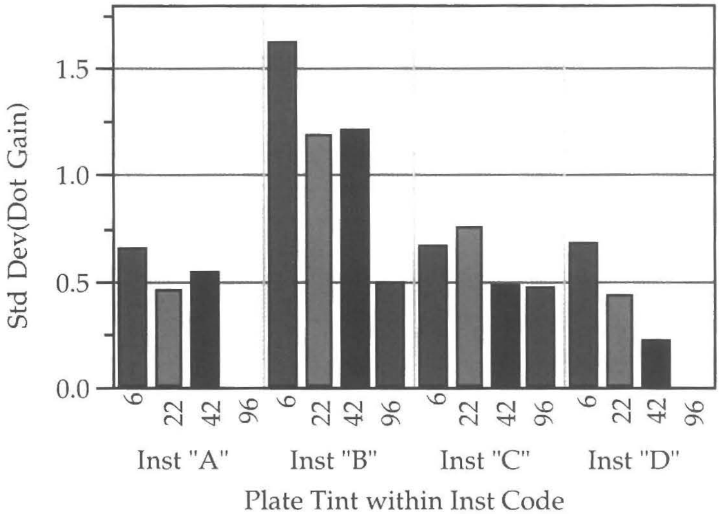


Figure 5. Plate X Dot Gain Variation as a Function of Instrument and Tint Value

Figure 5 illustrates comparative tonal range mean dot gain measurements, obtained from plate X and four groups of instruments (A, B, C, D). Instrument B demonstrates nearly twice the standard deviation compared to the other instruments in the highlight, quarter tone, and midtone regions. With the exception of instrument B, midtone mean dot gains range from approximately 2% to 3% with an approximate 3 sigma standard deviation range of 3% to 4%. *Instrument A's low standard deviation value is due to similar dot area values in the high DMax of the 96% shadow dot.*

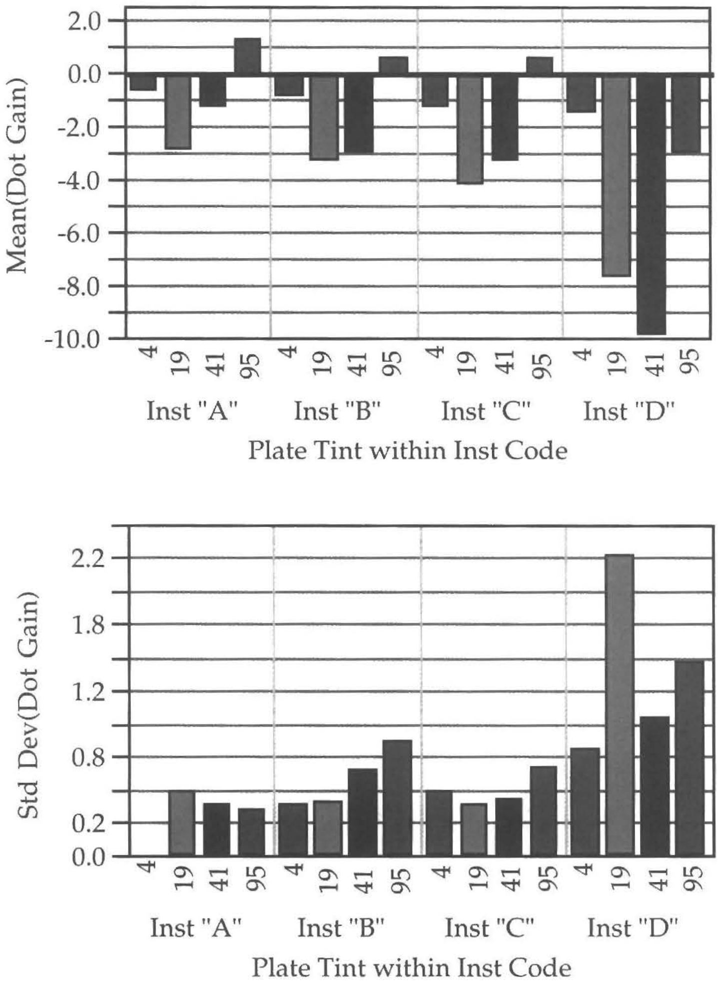
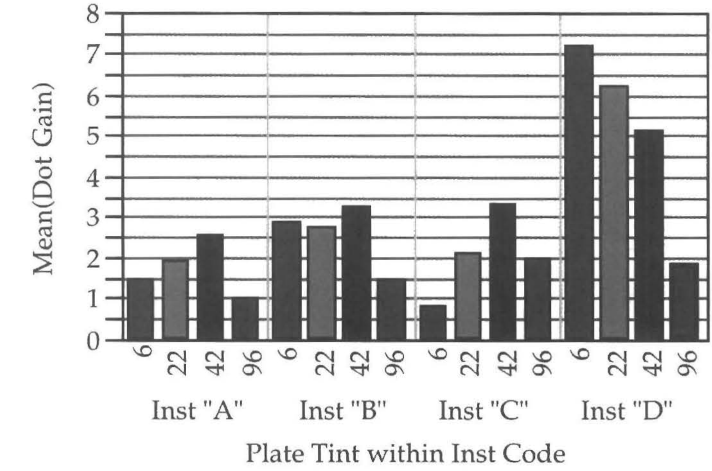


Figure 6. Plate Y Dot Gain Variation as a Function of Instrument and Tint Value

Figure 6 illustrates comparative tonal range mean dot gain measurements, obtained from plate Y and four groups of instruments (A, B, C, D). When compared to the other instruments, instrument D demonstrates nearly twice the negative mean dot gain and standard deviation, in the quarter tone and midtone regions. With the exception of instrument "D", midtone negative mean dot gains range from 2% to 4% with an approximate 3 sigma standard deviation range of 1% to 3%. Note: Plate Y is a silver halide photo-direct plate imaged from a laser scanner. Negative mean dot gain values are the result of scanner linearization. *Plate Y is a positive acting silver halide photo-direct plate. The 4% dot has a high DMax value that resulted in a low standard deviation for instrument A.* (5) (6)



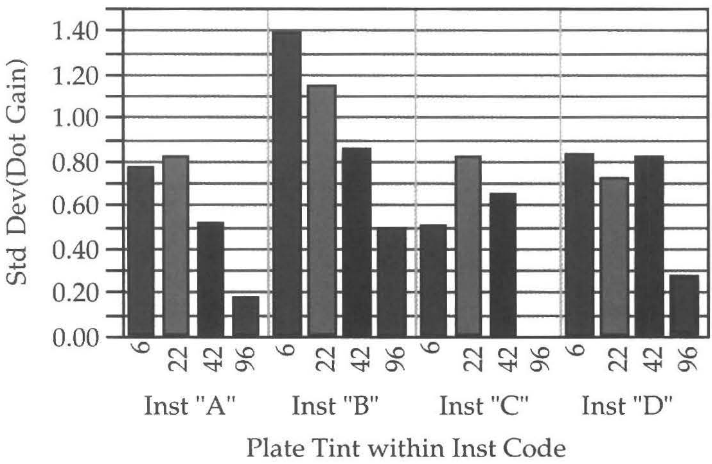
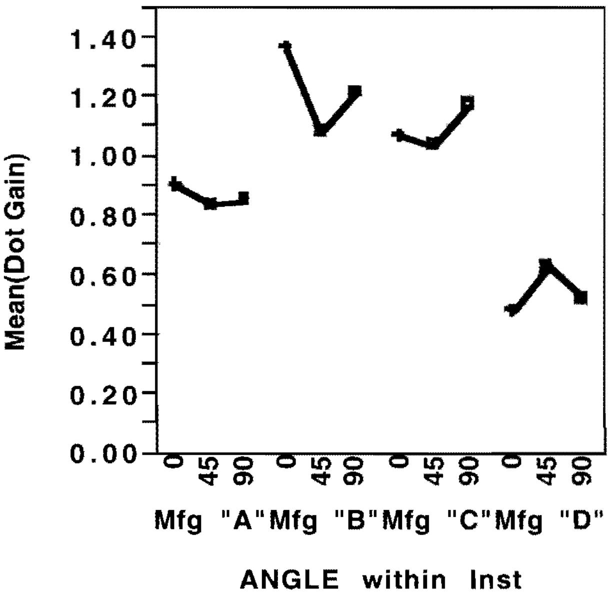


Figure 7. Plate Z Dot Gain Variation as a Function of Instrument and Tint Value

Figure 7 illustrates comparative tonal range mean dot gain measurements, obtained from plate Z and four groups of instruments (A, B, C, D). When compared to the other instruments, instrument D demonstrates nearly twice the mean dot gain in the highlight, quarter tone, and midtone regions. Instrument B, compared to instruments A, and C demonstrates similar mean dot gains and nearly twice the standard deviation. *Instrument C's low standard deviation value is due to similar dot area values in the high DMax of the 96% shadow dot.*



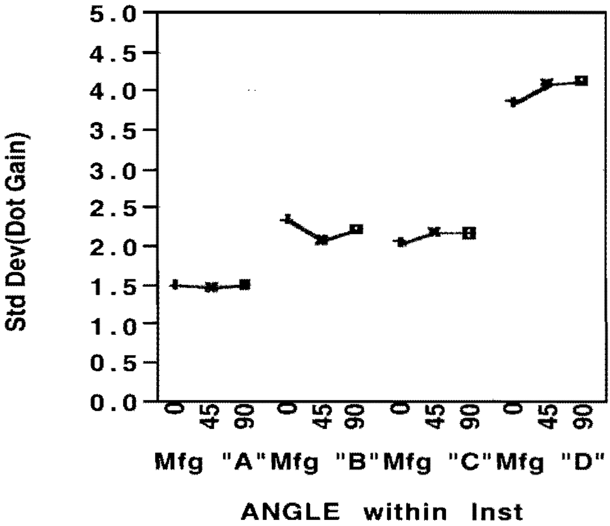
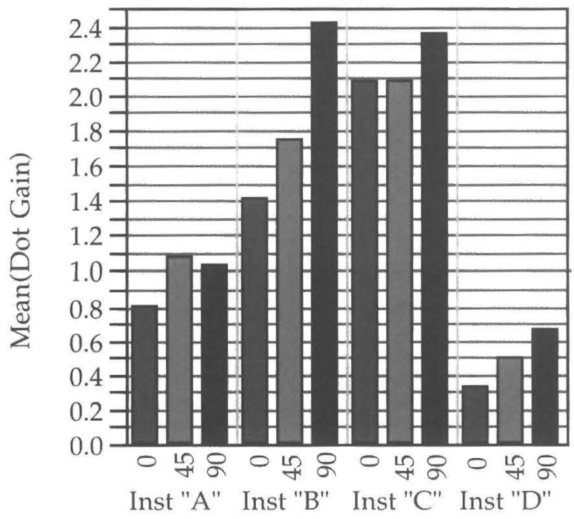


Figure 8 Dot Gain Variation as a Function of Instrument Type and Grain Direction. Figure 8 illustrates the comparative sum effect, over the entire tonal range, of mean dot gain and standard deviation variation relative to instrument type, plate type, and grain direction. Refer to Figures 9 and 10 for comparative examples that illustrate and discuss this phenomena.



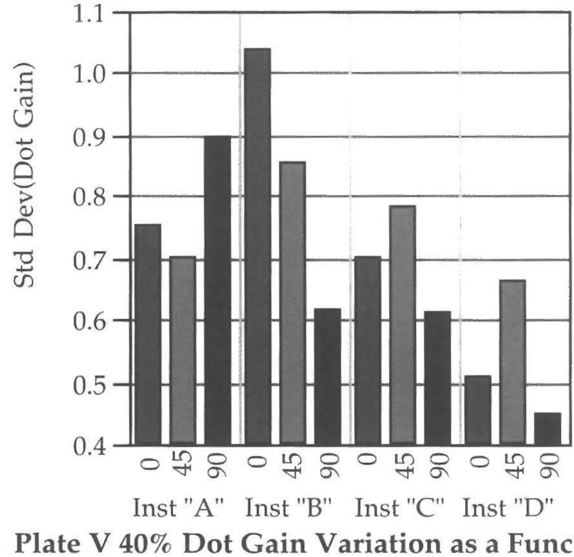


Figure 9. Plate V 40% Dot Gain Variation as a Function of Instrument and Tint Angle

Figure 9 illustrates comparative 40% angular mean dot gain measurements obtained from plate V at 0°, 45°, and 90°. Instrument B has a mean dot gain range from 1.4% to 2.4% and a 3 sigma range from +/-1.8% to approximately +/-3%. Instrument C has a rather uniform mean dot gain range of 2.1% to 2.4% at 0°, 45°, and 90° with a 3 sigma standard deviation range from +/-1.8% to approximately +/-2.4%.

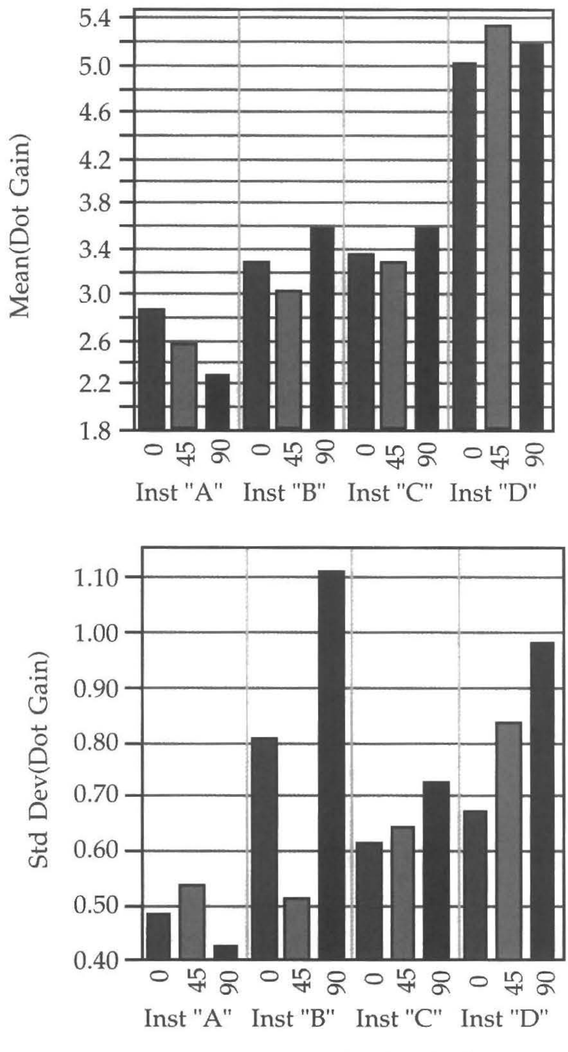
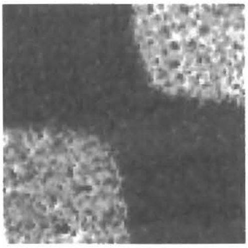


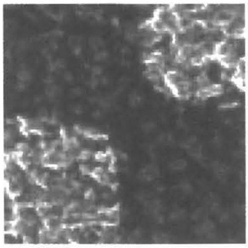
Figure 10. Plate Z 40% Dot Gain Variation as a Function of Instrument and Tint Angle

Figure 10 illustrates 5% to 5.3% mean midtone 40% mean dot gain for instrument "D", with a standard deviation of +/-1.9% to approximately +/-2.5%. Instrument B has a varying 3 sigma standard deviation of +/-1.5% to +/-3.3% for a 40% mean midtone dot gain of approximately 3.2%. Instruments [Compare the dramatic differences of measured values obtained from plate V, Figure 9, to the measured values of plate Z Figure 10. These differences may be due to instrument D's use of polarization. Refer to plate photomicrographs in Table II.]

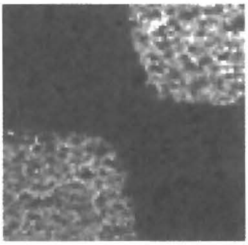
Table II. Plate Photomicrographs and Descriptions



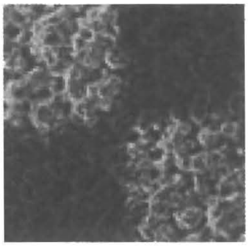
(V)Neg. Metal-Fine Electro Chemical
Grain Anodized -Bluish
DMin .26 D Max .79*



(W)Neg Metal-Heavy Chemical
Anodized-Greenish Blue
DMin .16 DMax .97*

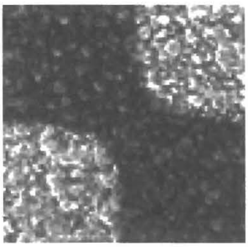


(X)Neg. Metal-Electro Chemical
Digital
Grain Anodized-Greenish Blue
DMin .27 D Max .97*



(Y)Silver Halide-Photo-Direct

Granular Base-Silver Image-Matte
DMin .54 D Max. 1.23*



(Z) Neg. Metal-Chemical Grain
Anodized-Light Greenish Blue
DMin .19 D Max .93*

* *Measurement from a single manufacturer's densitometer to illustrate typical DMin, DMax. values..*

Table III. Suggested Plate Measurement Protocol

Instrument Parameters:

- Use wide aperture, 3.4mm minimum, to reduce reading error.
- Use Status T for measuring a broader range of plate image colors.
- Measure with the Dot Area function.
- Multiplying factor of X10 for one more decimal point precision.
- Calibrate to the instruments calibration plaque.
- Use the instrument color filter appropriate to plate image color.
- Use the Murray Davies dot area function. [N=1.0]

Test Target Parameters:

- Use a quality test target as a reference point, i.e., UGRA scale, Digital Test Image, RIT Scale, etc.
- Include tint patches from the production film for comparison.
- Control film imaging and processing conditions.
- Strip film into flats with care; i.e., no thick layers, bulges, kinks, etc.
- Use adequate film-to-plate vacuum drawdown.
- Expose plate according to instrument's instructions.
- Soft dot film will produce more plate dot gain than hard dot film.

Plate Parameters:

- Machine process plates.
- Optimize plate processing conditions.
- Avoid scratches, kinks, fingerprints, and streaks when measuring.
- Remove the plate gum coating with water and buff dry.
- Higher contrast plates may produce less measurement variation.
- Plate grain and anodizing may cause measurement variation.

Measurement Parameters:

- Work on a clean flat surface.
- Zero the instrument for DMin and DMax closest to the tint area. (For optimum results, there should be a DMin patch next to each tint patch measured. Re-read DMin for each tint value.)
- Always align the instrument in the same plate grain direction.
- Measure in the same proximity of the tint patch, DMin, DMax., and tint.
- Check instrument calibration frequently.
- Do not change instrument settings; i.e., Status T, X10, Dot Area.

Data

- Establish SPC and statistical analysis for specific plates, targets, and test films. Take corrective action when indicated
- Utilize microline and gray scale response as a part of the SPC.

Cautions

- Maintain plate manufacturers recommended plate exposure time for optimum press life.
- Avoid changing the plate dot size by adjusting plate exposure. Correct the film, plate, or process conditions.
- Base metal characteristics may effect reading.
- Highlight dot areas have more S/N (signal-to-noise) and will not provide accurate densitometric readings.

References

Literature Cited:

1. Colestock, R.O. 1991 "An Evaluation of Errors in Reflection Densitometry".TAGA Proceedings pg. 654 to 665

2. Colestock, R.O. 1994 "A Performance Comparison of Portable Spectrophotometers" TAGA Proceedings pg. 130 to 140

3. Fisch. R.S., Cavin R.D. 1986 "Microline Evaluation of Negative Acting Printing Plates. Journal of Imaging Technology Vol. 5 #13 pg. 158-163

4. Fisch. R.S., Cavin R.D. 1986 "A Report on the Percent Image Area Measurements Taken from Plates used in the GCA Print Properties Test." TAGA Proceedings 1986 pg. 267 to 277

5. Bartels, S.A., Fisch, R.S. 1990 "A Tone Reproduction Study of Desktop Publishing Images When Printed by Direct Laser Exposure and Conventional Camera Means".

6. Bartels, S.A., A. Mentzer "Image Setting Exposure and Calibration" (TAGA video tape)