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A Comparison of staggered position one angle process color printing with four angle and one angle process color printing

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's Thesis of

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with a major in Printing Technology has been approved by the Thesis Committee as satisfactory for the thesis requirement for the Master of Science degree at the convocation of

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PROCESS COLOR PRINTING WITH

FOUR ANGLE AND ONE ANGLE PROCESS COLOR PRINTING

A COMPARISON OF STAGGERED POSITION ONE ANGLE PROCESS COLOR PRINTING WITH FOUR ANGLE AND ONE ANGLE PROCESS COLOR PRINTING

by

BLAIR RICHARDS, JR.

A thesis submitted in fulfillment of the requirements for the degree of Master of Science in the School of Printing Management and Sciences in the College of Graphic Arts and Photography of the Rochester Institute of Technology.

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ABSTRACT

The Staggered Position One Angle method of preparing color separations does not adjust the dot angle for each color. The dot pattern is **staggered** horizontally or vertically by half a row of dots for each separation maintaining the same angle.

The investigation compared the Staggered Position method to the four angle method and to the dot-on-dot method. Newsprint was the substrate, and 65, 85, and 100 lines per inch were the rulings. Experienced judges viewed the representative prints and scored each for sharpness, color variability, and overall acceptance. They were also asked to indicate the evidence of rosette and moiré patterns. Densitometric and spectrophotometer readings were used for objective analysis.

The judges found the Staggered Position to be equal or better than both four angle and dot-on-dot printing in most instances. A non existant rosette pattern and a minimal risk of moire´ patterns also resulted. The Staggered Position printing excelled in the ability to produce a sharp reproduction, and its tone reproduction was found to be equivalent to the four angle and dot-on-dot printing. The use of Delta E for the visual rejection or acceptance of an image was found not to be a good indicator in this particular study.

The study opens up a number of areas for further research into this new separation method, but because of its good performance on newsprint, it should be considered as an alternative to the four angle method for newspapers.

CHAPTER 1

INTRODUCTION

THE PURPOSE

The purpose of the research was to evaluate a new color separation screening method called the Staggered Position One Angle technique. To accomplish this, color printing produced from separation halftone negatives prepared by this new technique were compared to color printing produced from separation halftone negatives prepared by the four angle method and separation halftone negatives prepared by the single angle method.

The Staggered Position One Angle technique, from here on referred to as the Staggered technique, is a screening process developed to overcome the deficiencies that exist with both the four angle and the single angle method. The Staggered technique uses the same angle for all four separations. Rather than angling the screen to reposition the dots, as with the four angle technique, the screen is moved laterally so as to stagger the dot pattern for each color. The spacial integrity usually accomplished by angling the dots is achieved with the Staggered technique by moving the same angle screen horizontally or vertically 1/2 dot diameter distance.

This new concept was developed as a result of research done by James Rich into one angle dot-on-dot printing[1]. One angle dot-on-dot printing uses color separations of the same angle so that the dots of each color print on top of each other. It was found that dot-on-dot printing eliminated the rosette patterns and produced a sharper image, but it also confirmed the old problem of color shifts due to misregister. The Staggered technique, which will be described in detail later, modifies the one angle method so that its advantages are maintained and its shortcomings eliminated. The preliminary tests confirm its plausibility, but it was the

objective of this research to scientifically study and statistically analyze its performance.

A selection of judges were asked to view the printed results and judge for the visibility of rosettes and moirés. They were also asked to score the acceptability of images based on color shift, sharpness, and overall color reproduction quality.

THE BACKGROUND

Four color lithographic printing requires that four printing plates be produced from four halftone negatives, each one a photographic record of the yellow, magenta, cyan and black contained in an original. After all colors have been printed on the substrate, the collection of printed halftone values produce the illusion of continuous tone color. The different shades are a result of the varying dot sizes printed on the white paper.

The dots for these four separations can be produced by halftone screens or generated by a dot generating color scanner. Whichever method is used, the dots occur in parallel and perpendicular rows and at a specific frequency for all four halftones.

The four halftones, with this frequency of equally spaced rows of dots running in the cross-line pattern, create a situation where a visible moiré might occur. A visible moiré occurs whenever two regular patterns which differ in frequency or angle, or both, are superimposed.[2] As a result, the printing industry has used angled screens of 90, 75, 45, and 15 degrees to avoid a noticeable moiré when printing four colors.

PRIMARY AND SECONDARY MOIRES

John Yule, in his book Principles of Color Reproduction,[3] classifies moirés into primary and secondary types. A primary moiré is an objectionable light and dark area that appears when two screens of the same angle are not exactly in register to each other as in Figure 1. The most objectionable pattern appears as the screens approach their perfect registration point, and the least noticeable when they are 45 degrees to each other.

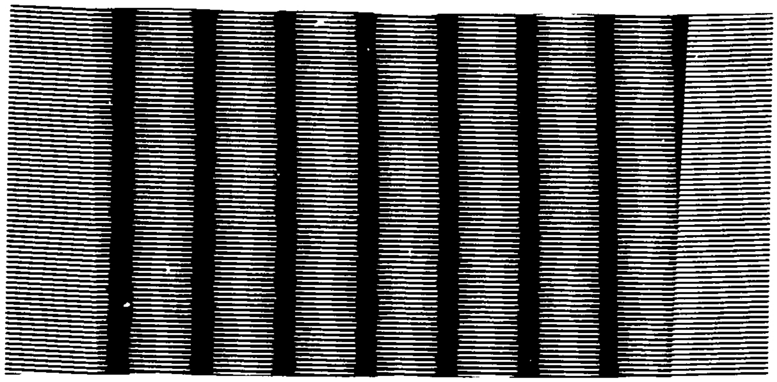

Figure 1
Primary Moiré Pattern[4]

A secondary moiré, commonly called the rosette, occurs when two to four screens are at 30 degrees to each other. It is the least objectionable at this 30 degree measure but is still noticeable, especially in neutral areas where yellow, magenta and cyan print 40 to 50 percent each. The rosette is most objectionable at 45 degrees, which unfortunately is the same degree measurement that the primary moiré is the least offensive. The term rosette describes a variety of rosette configurations. A rosette can be dot centered (Figure 2) or clear centered (Figure 3) or all the variations in between. They are the result of the screen angles and frequency, the variable dot sizes, and misregister of the printing.[5]

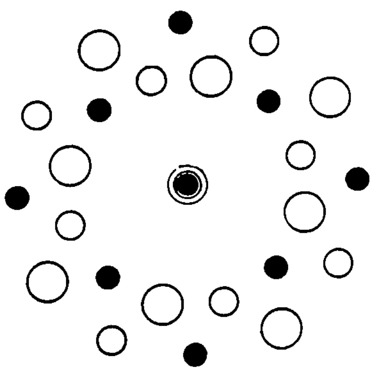

Figure 2
Dot Centered Rosette[6]

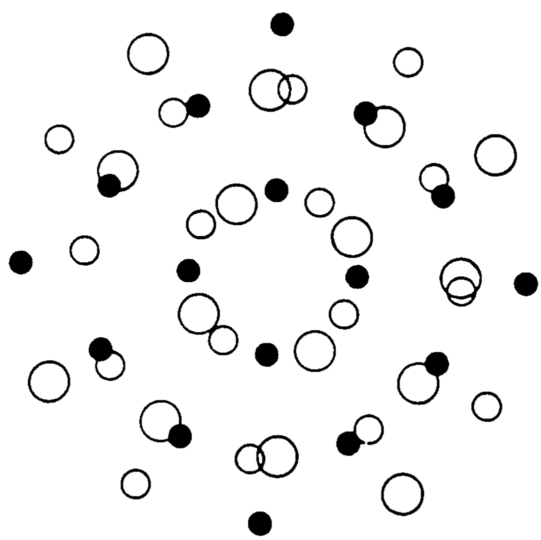

Figure 3
Clear Centered Rosette[7]

A compromise between these two moirés and the limitation of only 90 degrees to work with makes a 30 degree difference between three screens an agreeable differentiation. But, four screens are needed for the four color process. Fortunately, yellow is one of our four inks and will show very little moiré when placed halfway between two of the angles or 15° from each. Yellow is almost an ideal ink, meaning that it is very close to a perfect absorber. The significance of this will be explained next.

When a moiré occurs in multi color printing, what is actually occurring is a contrast of two overlapping inks, having a common absorption, occurring in the regular pattern of a halftone screen. The inks used in printing are not perfect absorbers. This means that each ink does not absorb all of the light in that region of the spectrum it is intended, nor does it perfectly transmit the remaining regions of the spectrum. All of the inks have overlapping absorbency regions and when printed over each other they produce light and dark patterned areas of a particular frequency.[8] Because of its close to ideal absorbency and transmittance, yellow ink has the least occurrence of overlapping abosrbency regions and can be printed at an angle less than the 30 degrees required for the other inks.

Even after all the screening has been carefully done, there are other factors that could promote a moiré condition--poor trapping, non-absorbent stock, regular patterns in the stock, and regular patterns in the image.[9] Conditions of poor trapping, as with coated paper and gloss inks with wet on wet printing, encourage dot spread which will violate the angle integrity and produce moiré.[10] Commercial items, such as fabric and shade material that have patterns themselves, will cause interference with the screen angles and may result in moirés.

DOT-ON-DOT PRINTING AND COLOR SHIFT

The alternative to printing four colors at four different angles has been to print them at the same angle. This method has many names: one angle, single angle, dot-on-dot, one angle dot-on-dot and single angle dot-on-dot. This method has been discarded for years

because of the inability to print all four colors in registration and the resulting color shift.

> . . the best way to avoid moire´ patterns would be to print all the halftones at exactly the same angle. This would not be satisfactory because the color produced would depend on whether the dots fell on top of each other or side by side. With dots on top of each other, a much lighter tone would be produced, because there would be a much larger area of unprinted white paper.[11]

However light the color, it would be very sensitive to variations in register. Misregister occurs in all four color printing and causes even a slight color shift with four angles. The color variation occurring with dot-on-dot is found within the image as well as from sheet to sheet and is often quite noticeable. The shift is most noticeable with dot-on-dot because of the dot placement and the large area of unprinted white paper that is exposed. The misregistration of one color, and the resulting dots printing off of their dot-on-dot position and onto the unprinted white paper, creates an exaggereated color change. The dot-on-dot area has lost some of its absorption, and the unprinted paper which before reflected all bands now absorbs some bands and reflects fewer than it did before. The color shift that exists with four angle printing is not noticeable because the amount of unprinted white paper is considerably less as a result of its dot configuration.

James Rich, in his 1982 "Comparison of Four Color Printing at One Angle and at Four Angles"[12], confirmed the existence of the color shift, but found the variation negligible in the realm of acceptable commercial printing. His study compared the two techniques printed wet on wet on 50 lb. coated stock using six different screen rulings from 100 to 200 lines per inch. All of the one angle printing, except for the 120 lpi was rejected for poor tone reproduction. Rich blamed registration and the resulting color shift for this rejection.[13]

Ideal tone reproduction is the ability to reproduce the tones of an original as closely as possible, given the limitations of the printing process. It is usually determined by the reproduction of a grey step tablet included in the color separations and its approximation to the original step tablet. A more precise evaluation of tone reproduction can be made by

graphing the original tones with the corresponding reproduced tones and noting the graph's approximation to an ideal tone reproduction curve.

Rich's[14] sharpness analysis compared one angle printing of a specific screen ruling, to four angle printing of the next finest screen ruling. For example; one angle 100 lpi was compared to four angle 120 lpi. One angle was unanimously considered sharper in the 100 and 120 lpi rulings. One angle screen rulings of 133, 150, and 175 were considered sharper 80, 60, and 70 percent of the time respectively. Sharpness or resolution refers to the ability to reproduce fine detail and clear cut images.

There was no noticeable rosette pattern in the one angle printing. A rosette pattern was noticed in the four angle printing in screen rulings of 175 lpi and coarser.[15] The eye is unable to resolve rosette patterns in the 200 lpi screen ruling.

Uncoated paper, especially newsprint, seems to work better with dot-on-dot color printing when using the coarser screen rulings. Tests of the Chemco Company's "Easy Color System"[16] show that dot-on-dot color on newsprint produces superior color, gives the impression of a finer line screen, eliminates the rosette and moiré patterns, and produces consistent flesh tones. Even deliberate misregistration did not produce a moiré pattern of any kind. When printing one angle dot-on-dot on newsprint with a coarse screen ruling, the color variation due to misregister appears to be minimal. This can be explained by the newsprint allowing the dots to spread, which causes them to be less sharp.[17]

As stated in the Introduction, the Staggered technique evolved from research done with dot-on-dot printing. This researcher, who was very familiar with the conventional four angle technique, was seeking an easier method to screen separations. Those experiments confirmed the problems that have existed with dot-on-dot for a long time. The Staggered technique is an attempt to overcome the problem of the color shift and maintain the improvements over the four angle method -- the removal of rosettes and increased sharpness.

The objective of this research was to compare this new method to the methods that have sufficed for many years. If Staggered printing is to be considered an alternative to conventionaly screened color printing, it must be comparable in aspects of tone reproduction and sharpness, with the added advantages of rosette elimination and an unnoticeable color shift. If the purported advantages can be met, and the technique can be performed with reasonable ease and accuracy, the Staggered technique may be considered a replacement for the techniques which have been used for many years.

FOOTNOTES FOR CHAPTER 1

[1]Interview with James S. Rich, January 1984.

[2]F.L. Wurzburg, "Understanding Moiré Screen Patterns, Gravure Magazine, September 1961, p. 17.

[3]J.A.C. Yule, Principles of Color Reproduction, (New York: John Wiley and Son, Inc., 1967) p. 330 - 344.

[4]Ibid., p. 331.

[5]Ibid., p. 339.

[6]Ibid., p. 340.

[7]Ibid.

[8]F. Pollack, "The Dependence of the Contrast of Moiré Patterns on the Colours of the Printing Inks", TAGA Proceedings, (Los Angeles, 1958) p. 44.

[9]Wursburg, p. 20.

[10]P. McKinney, "Screen Patterns in Printing", Photoplatemakers Bulletin, No. 11 (1958) p. 57.

[11]Yule, p. 335.

[12]James S. Rich, "A Comparison of Four Color Printing at One Angle and at Four Angles", TAGA Proceedings, (Toronto, 1982). p. 361 - 377.

[13]Ibid., p. 368.

[14]Ibid., p. 367.

[15]Ibid.

[16]"Color Separation Uses One Screen/One Angle", Editor and Publisher, June 7, 1980, p. 46.

[17]M.F. Southworth, "Single Screen-Angle Printing", The Quality Control Scanner, Volume 3, Number 6, (Livonia, New York: Graphic Arts Publishing Co., 1983), p. 4.

CHAPTER 2

THE TECHNIQUE

The Staggered Position One Angle Method

The Staggered technique screens color separation halftones using the same angle. The screen is repositioned horizontally or vertically (staggered) to a new position for each separation. The dot position is changed, the image remains stationary. The measure of the stagger is one half the side of the 50 percent dot for that screen ruling.[1] For this thesis experiment square dots were used. The screen ruling of a screen refers to the number of lines per inch measured along the screen angle (dot diagonal). With this in mind and referring to Figure 4, it can be stated that the printed dot diagonal and the distance between the screen dot centers are equal. This distance (d) is equal to one inch divided by the screen ruling, or d=1"/lines per inch.

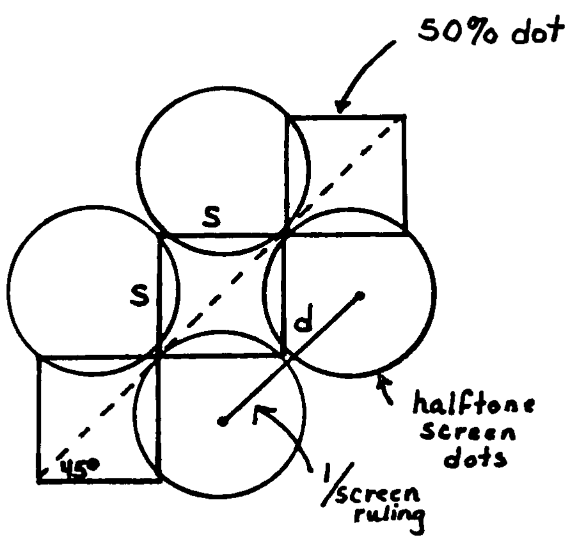

Figure 4.
Enlarged 45 degree halftone screen with 50 percent dots.

Again referring to Figure 4, and with the assumption that the four sides of a 50% dot are equal, the Pythagorean Theorem can be used to determine the measure of the sides(s) of the 50% dot:

$$s^2 + s^2 = d^2$$

$$2s^2 = d^2$$

$$s^2 = d^2/2$$

$$s = \sqrt{d^2/2}$$

$$s = \sqrt{(1''/\text{lines per inch})^2 \, (1/2)}$$

When screening the separations, 1/2 s is the distance the screens are moved in the direction parallel to the sides of the 50 percent dot. The screen position for the first separation is the starting point. The screen for the second separation is moved 1/2 s to the right parallel to the horizontal sides of the 50 percent dot. The screen for the third separation is moved 1/2 s down, parallel to the vertical sides of the 50 percent dot, or from the starting point 1/2 s horizontal, 1/2 s vertical. The screen for the fourth separation is moved 1/2 s to the left from the third separation parallel to the horizontal sides or 1/2 s down from the starting point parallel to the vertical sides.

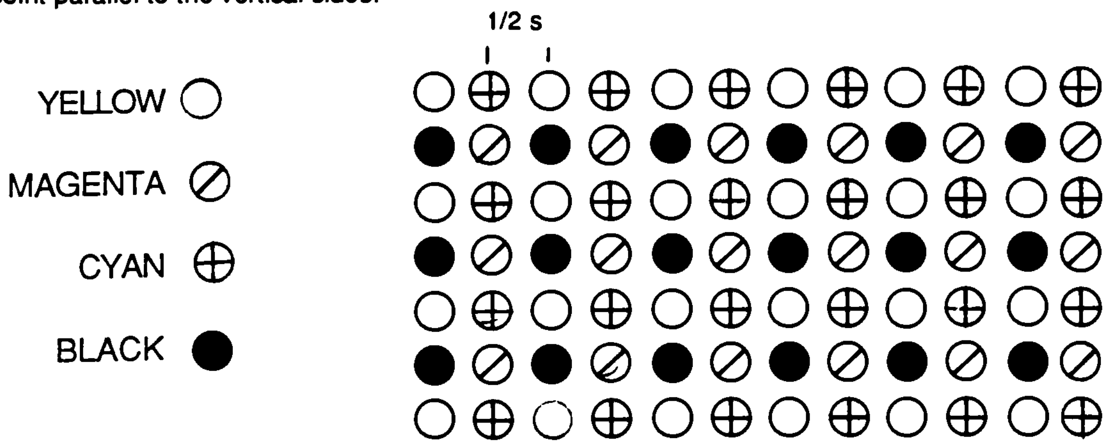

Figure 5.
Staggered Position Dot Center Configuration

Staggering, instead of angling, distributes the dots in a uniform pattern of consistent distances which will reproduce images that are sharper without a rosette. Like dot-on-dot, the elimination of the rosette pattern will give a sharper image.[2] Unlike dot-on-dot, the dots are not printed on top of each other but side by side. There will be less unprinted white paper exposed, making a color shift due to misregister less exaggerated. Ideally, the color shift should be as unnoticeable as it is with four angle printing.[3]

The above procedure has described the Staggered position technique in terms of manually adjusting the screen for each separation halftone. This author realizes that because of the predominance of color scanners in the industry, a new technique such as this must be adaptable to the scanner. To add credibility to both the technique and this research, the separations that were printed and evaluated were done on a color scanner. The details of this procedure are provided in the Methodology portion of this paper.

FOOTNOTES FOR CHAPTER 2

[1] Interview with James S. Rich, January, 1984.

[2] James S. Rich, "A Comparison of Four Color Printing at One Angle and at Four Angles", TAGA Proceedings, (Toronto, 1982). p. 368.

[3] Rich Interview, January, 1984.

CHAPTER 3

LITERATURE REVIEW

The majority of the pertinent work done in this area has been mentioned in previous chapters of this thesis. The selection of alternative methods to screening separations with four differently angled screens was limited. Brent Archer's 1963 patent, "Halftone Screen for Color Separation"[1], simplified the angled screen process by using the "tri-screen" This screen did not need to be rotated to a new angle for each color. It contained three individual dye screens, each of which was angled differently and each was sensitive to either green, red, or blue light. Only the filter and the film needed to be changed.

The first reference to dot-on-dot printing was in 1950 by W.P. Greenwood[2] in his report to TAGA. He examined color saturation for the different printing configurations of dot beside dot, dot-on-dot,and dots at 30 degrees to each other. He reported that dot beside dot exhibited very strong saturated color, dot-on-dot exhibited brighter but desaturated color, and dots at 30 degrees exhibited color falling between the two.

Further investigation into one angle color provided only references with no real scientific investigation. John Yule[3] acknowledged its attributes but realized the impossibility of perfect registration and avoiding the color shift. F. Pollack[4] felt that one angle color printing was possible only if transparent inks were used, and the possibility of a moiré eliminated. Only Rich's investigation, "A Comparison of Four Color Printing at One angle and at Four Angles"[5], investigated an actual one angle color press run with the results analyzed and published.

In 1968 Kenneth Rarey[6] patented a screening technique for Xerographic printing. His technique shifted hexagonal dot screens for three colors to positions not printed on by the previous two screen positions.

Hua-Kuang Liu holds a U.S. Patent, "Halftone Screen with Cell Matrix"[7], which is a

screen specifically designed for one angle color separation. Because of its unique array of concentric parallelograms which compose the individual dots, moiré patterns are not formed, rosettes are eliminated, and the manipulation of the single one angle screen simplifies the color reproduction process.

The 1982 master's thesis topic of Jang-Fun Chen studied the predictability of the color shift found with dot-on-dot printing.[8] Investigating the dot area levels of 25, 50, and 75 percent and misregistering one color at a time by 1/4, 1/2 and 3/4 of a dot, he determined the extent that a color could be misregistered before the color shift became objectionable. Chen also developed a mathematical model which was employed to indicate the direction of the color shift in terms of hue, saturation and lightness, as well as predicting the shift. Two years later, Christopher Vasko in his thesis "A Study of Chromaticity Change with Respect to Dot-on-Dot Multicolor Halftone Printing"[9] took Chen's work a step forward and analyzed chromaticity changes due to misregister in the three additive primaries of actual printed sheets.

Ted Chen's 1987 master's thesis compared the image quality of four angle reproductions and dot-on-dot reproductions with different variables of input image quality and screen frequency, with a quantification of their results.[10]

The Staggered technique is the first attempt to purposely change the dot position of same angle color separations to eliminate the color variation. If the color variation can be made unobjectionable with the added advantages of a sharper image and the removal of rosettes, a technique will exist to significantly improve newspaper color. The results of the experiment and the evaluations of the results, will indicate the reality of such a technique. The Staggered technique may perhaps be an alternative to the four angle method in commercial multi-color printing.

FOOTNOTES FOR CHAPTER 3

[1]H.B. Archer "Halftone Screen for Color Separation", United States Patent No. 3, 085,878, April 16, 1963.

[2]W.P. Greenwood, "The Color of Halftone Dot Patterns", TAGA Proceedings, (Rochester, 1950). p. 62.

[3]J.A.C. Yule, Principles of Color Reproduction (New York: John Wiley and Son, Inc., 1967). p. 335.

[4]F. Pollack, "The Dependence of the Contrast of Moiré Patterns on the Colours of the Printing Inks", TAGA Proceedings, (Los Angeles, 1958) p. 37 - 44.

[5]James S. Rich, "A Comparison of Four Color Printing at One Angle and at Four Angles", TAGA Proceedings, (Toronto, 1982). p. 361-377.

[6]K.W. Rarey, "Methods and Apparatus for Minimizing Screen Patterns in Xerography, Electrostatic Screen Process and Other Forms of Printing",United States Patent No. 3,363,552, January 16, 1968.

[7]H.K. Liu, "Halftone Screen with Cell Matrix", United States Patent No. 4, 188,225, February 12, 1980.

[8]J.F. Chen, "An Investigation of Color Variation as a Function of Register in Dot-On-Dot Multicolor Halftone Printing", (Master's Thesis, Rochester Institute of Technology, 1982).

[9]C.M. Vasko, "A Study of Chromaticity Change with Respect to Dot-on-Dot Multicolor Halftone Printing", (Master's Thesis, Rochester Institute of Technology, 1984).

[10]T.C. Chen, "A Study of Color Image Quality with Respect to Screen Angle Arrangements in Multicolor Halftone Printing", (Master's Thesis, Rochester Institute of Technology, 1987).

CHAPTER 4

HYPOTHESES

It is the objective of this research to compare Staggered Position printing with four angle and dot-on-dot printing. Thirty prints of each type were viewed by ten experienced judges. Each judge answered questions about the visibility of rosettes and moirés, and was asked to indicate the acceptability of the prints in areas of sharpness, color variability, and overall color reproduction quality.

Tone reproduction and spectrophotometer readings were made in addition to the previously mentioned subjective evaluations

The results of the above evaluations and measurements helped determine the statistical significance of the three methods for qualities of overall acceptability, sharpness, tone reproduction, color shifts, rosettes and moirés. It is hypothesized that there is no significant difference between Staggered position printing and either four angle printing or dot-on-dot printing in the above areas.

Specifically the hypotheses read:

- There is no significant difference in the exhibition of a **color shift** between Staggered Position One Angle printing and Four Angle printing.

- There is no significant difference in the exhibition of a **color shift** between Staggered Position One Angle printing and Single Angle Dot-on-Dot printing.

- There is no significant visual difference in the **overall acceptance** between Staggered Position One Angle printing and Four Angle printing.

- There is no significant visual difference in the **overall acceptance** between Staggered Position One Angle printing and One Angle Dot-on-Dot printing.

- There is no significant difference in **tone reproduction** between Staggered Position One Angle printing and Four Angle printing.

- There is no significant difference in **tone reproduction** between Staggered Position One Angle printing and One Angle Dot-on-Dot printing.

- There is no significant difference in **sharpness** between Staggered Position One Angle printing and Four Angle printing.

- There is no significant difference in **sharpness** between Staggered Position One Angle printing and One Angle Dot-on-Dot printing.

- Staggered Position One Angle printing does not exhibit a **moiré** pattern.

- Staggered Position One Angle printing does not exhibit a **rosette** pattern

- There is a correlation between the acceptance of a print's press run color shift and the Delta E value for that print.

CHAPTER 5

METHODOLOGY

The prevalence of four angle printing, in most if not all multi-color printing applications, confirms its eligibility for comparison in any printing situation. The previous work done in the area of dot-on-dot printing has determined when printing at the same angle does well and when it performs poorly. The specifications for my experimental comparison will be based on these previous results.

Chemco's success on newsprint, and Rich's rejection rate on coated stock made a newsprint substrate a logical choice. Screen rulings of 65, 85, and 100 lines per inch were chosen because of their use in the newspaper industry and the dot-on dot's success in the Chemco newspaper system.

The following steps were taken to produce the printing, to evaluate the results, and to test the hypotheses in this research.

Test Image: A transparency was photographed and used as the original copy for all separations made in this experiment. Along with a variety of colored objects there were objects contained in the transparency to aid the evaluators of the printing. Memory color items were included to aid the viewer in detecting a color shift. These included items that a viewer would recognize and have some idea of what color they should be, such as logos, fleshtones, fruits and vegetables. Also to aid the evaluators, a selection of neutral grey items and a neutral grey background were included. Color shifts and rosettes occur readily in these areas.

Objects, which themselves contain repeating patterns, were included to increase the probability of a noticeable moiré and help determine how each separation method handled moiré conditions.

The transparency was photographed in a studio with strobe lighting and a balance of low and high key objects on 4 x 5 Kodak Ektachrome Daylight film.

Color Separations: The transparency was mounted onto the color scanning drum of the Hell 299L direct screen scanner at Precision Color Plate of Plymouth, Michigan. Register marks were included on either side of the transparency as the top and bottom was taped. A gray scale was also included. For each screen ruling a patch of 50 percent dots produced from that screen was taped securely to one side at the top of the transparency. This was used for positioning the Staggered separations.

The four angle separations were made using a set of four screens of 15, 45, 75 and 0 degrees for black, magenta, cyan and yellow respectively. The dot-on-dot and Staggered separations were made with the 45 degree screen. When making the dot-on-dot separations the scanner operator carefully returned the scanning head and exposing head to the same position for the start of each color. This assured the dot-on-dot configuration.

The Staggered position separations required as much if not more attention to detail as the dot-on-dot sets. The starting point for across the scanning drum was the same as for the dot-on-dot separations. The circumferential starting point, or the around the drum starting position was set at the top of a specifically marked 50 percent dot that was previously taped to the top of the transparency. The cross hairs of the viewer and the magnifier aided the operator in this procedure. The exposing head stayed at the same starting point that was used for the one angle separations. The yellow separation was scanned for these points. The magenta separation was scanned as the first, except the circumferential starting point was moved to the middle of the designated 50 percent dot. This output the image on the exposing drum half of a dot from the yellow separation. The cyan separation was scanned as the second, except the exposing head was moved half a dot to the right. This output the cyan separation half a dot from the magenta separation. This small movement of the exposing head was accomplished by inserting a spacer between the starting block and the exposing

head when it was brought back to its starting point. This spacer was a piece of craft or press blanket packing paper whose thickness was equivalent to one half of a dot for that particular screen ruling. The starting block was then moved up to contact the exposing head and secured. The black separation was scanned as the cyan, except the circumferential starting point on the scanning drum was moved back to the top of the designated 50 percent dot. This output the black separation half a dot from the cyan separation.

This procedure was performed for each different screen ruling. Separations were negative, right reading on the base. All separations were scanned to newsprint specifications:

	C	**M**	**Y**	**K**
Highlight	4	2	2	0
Midtone	50	38	38	15
Shadow	97	90	90	80

The H-M range was .90. A UCR value of 300 was used along with a reduction of unwanted colors and an increase of wanted colors in the overall color correction settings.[3] All detail enhancement and grey balance knobs were at normal settings. Matchprint proofs were made for each set of separations.

Image Assembly: The author assembled the films so that the different screen rulings were across the web, and four angle, staggered and dot-on-dot were parallel to the web:

<u>65</u>	<u>85</u>	<u>100</u>	↑
4 angle	4 angle	4 angle	
stag.	stag.	stag.	WEB
d/d	d/d	d/d	DIRECTION

Figure 6.
Stripping Imposition

The author assembled the separations according to the above imposition. The register marks and the images themselves were used to strip-in-register the four angle separations. The assembly of the dot-on-dot images required not only the register marks in alignment but also the dots. The register marks were used initially to align the Staggered position steps but the established "stagger" configuration of each step determined their final position. A common set of register marks were included on each of the four flats.

Press Run: The press used for this study was the Goss Community Newspaper Press in the Newspaper Laboratory in the School of Printing at RIT. The press crew was instructed to treat the experiment as an ordinary four color job. Registration was done with the common register marks and color was matched to the Matchprint proofs as closely as possible after reaching the designated solid ink densities. After registration and color were OK'd the counter was activated. The run was approximately 3,000 impressions.

Sampling: From the run of 3,000, one sample was pulled every 300 impressions. This provided 10 sets of images per screen ruling. Within each screen ruling, the individual images were separated from each other and marked for identification on the back. This gave the judges 30 images per screen ruling to evaluate. Any more than this would have resulted in the judges becoming fatigued.

Subjective Judgements: For the subjective evaluations, ten experienced judges were selected from RIT's School of Printing's Faculty and Printing Technology Graduate class as well as from RIT's Technology and Education Center. Their familiarity with color shifts, rosettes, moirés, and color printing was essential. The images were judged under a standard light source of 5,000 degrees Kelvin. This requirement standardized the viewing conditions for all the judges.

The 10 judges viewed and scored the imagesone set at time. A set consisted of the four angle, the Staggered, and the dot-on-dot print of the same screen ruling from the same pulled sample.

An introduction to each set of judgements was read to each judge with a definition of the quality he or she was judging displayed during the session. A sample of this is found in the Appendix.

Their scores for acceptability or non acceptability of the prints for color shift, sharpness, and overall acceptance could range from 1 to 10. The score of 1 being unacceptable and the score of 10- being very acceptable. Their judgements for moiré and rosette patterns required either a yes or no response.

Objective Measurements: The objective evaluations consisted of densitometric readings of the 26 step grey scales included with each print. These assisted in the evaluation of tone reproduction capabilities.

Spectrophotometer readings were done in the grey and flesh patches found in the Macbeth Chart printed in each image. These assisted in the objective evaluation of color consistency of each method.

Statistical Analysis: Because the press run produced 3,000 impressions with nine images per impression, the analysis of all the images would be impractical. The best approach to a population of this size is to systematically select samples from the run and use these as the representatives of the entire run. Even with the 90 representative samples, the enormous quantity of data generated from the ten judges, the 26 step grey scales and the two color patches make an analysis of an average for each method the most practical approach.

By incorporating the Analysis of Variance[4] it can be said that if two populations have identical averages the averages of their selected representatives will also be identical. Therefore, any significant difference in the entire population will be mirrored by these representative samples.

It is quite normal for populations to have variability within themselves. It would be the exception for them not to have differences. This internal variability is termed random error. In

the analysis of variance this random error and the differences that might be a result of an introduced variable are computed together and expressed in a f-ratio. The similarity of populations are questioned when this f-ratio exceeds an established "critical value". The critical value takes into consideration the number of comparisons, the quantity of data, and the level of the measure. This level of measure is expressed as alpha and most scientific investigation as with this study is done with an alpha = .05. Therefore the f-ratio and its comparison to the critical value will either accept or reject the hypotheses that two populations are similar at a prescribed level of alpha.

Two analyses of variance were performed on the judges scores for overall acceptance, color shift and sharpness. The Staggered Position prints scores were compared to the four angle prints scores and they were compared again to the scores of the dot-on-dot prints. The analysis of variance expressed the significant difference, and the means determined which population scored higher or lower. This was done for scores at 65, 85, and 100 lines per inch. Three Analysis of Variance were performed to the scores for rosettes and moirés. Since these observations required a yes or no response, their results were compared to a normal set of data - a set of responses which would occur naturally. This set consisted of 50% yes responses and 50% **no** responses. The analysis consisted of this normal set compared separately to the Staggered Position, four angle, and dot-on-dot print scores. The analysis of variance determined the significant difference between the two and the mean score determined whether the significant difference meant yes or no. This was done for 65, 85, and 100 lines per inch.

The density readings for tone reproduction were also treated with an analysis of variance. Staggered Position readings compared to the four angle readings and Staggered Position readings compared to the dot-on-dot density readings. This determined the similarity of tone reproduction and was done at 65, 85, and 100 lines per inch. Spectrophotometer readings of the grey and flesh patches of the Macbeth chart found in the

image were taken. For each screen ruling 65, 85, and 100, average L, a, and b were derived. This average became the standard from which the Delta E values were based. The Delta E value is not an indicator of good or bad color, but an indication of its difference from an established standard. Previous studies of Delta E and subjective viewing have found a threshold Delta E value of six where color becomes objectionable. With this in mind a Pearson's Product Moment Correlation[5] was run between the Delta E values and the corresponding average judges' scores for color shift. The closer this correlation comes to one or negative one the stronger the correlation. The Pearson was done for each method four angle, Staggered, and dot-on-dot within the three screen rulings.

FOOTNOTES FOR CHAPTER 5

[1]James S. Rich, "A Comparison of Four Color Printing at One Angle and at Four Angles", TAGA Proceedings, (Toronto, 1982), p. 361-377.

[2]"Color Separation Uses One Screen One Angle", Editor and Publishes, 7 June 1980, p. 46.

[3]Miles Southworth, Advanced Color Separation Class Notes, Rochester Institute of Technology, Spring Quarter, 1984.

[4]Richard M. Jaeger, Statistics: A Spectator Sport (Beverly Hills: Sage Publications, Inc., 1984). p. 257-283.

[5]Gouri K. Bhattacharyya and Richard A. Johnson, Statistical Concepts and Methods (New York: John Wiley and Sons, 1977). p. 402-407.

CHAPTER 6

EQUIPMENT AND FACILITIES

HELL 299L Color Scanner-Precision Color Plate Plymouth, Michigan

Three Scanner Screen Sets: 65, 85, and 100 lines per inch

Kodak Ultratec Processing

Kodak Ultratec UHF Film

3M Matchprint Proofing System

3M Color Key Proofing Systems

Polychrome WGAN Offset Plates

Polychrome Plate Processor

Goss Community Newspaper Web Press

Flint Newspaper Inks

Abitibi Price Newsprint

Hunter Spectrophotometer

Graphic Arts Technology Densitometer Model 144

CHAPTER 7

RESULTS AND ANALYSIS

ROSETTE PATTERN

HYPOTHESIS: Staggered Position One Angle printing does not exhibit a rosette pattern.

Accepted for all screen rulings at the .05 alpha level.

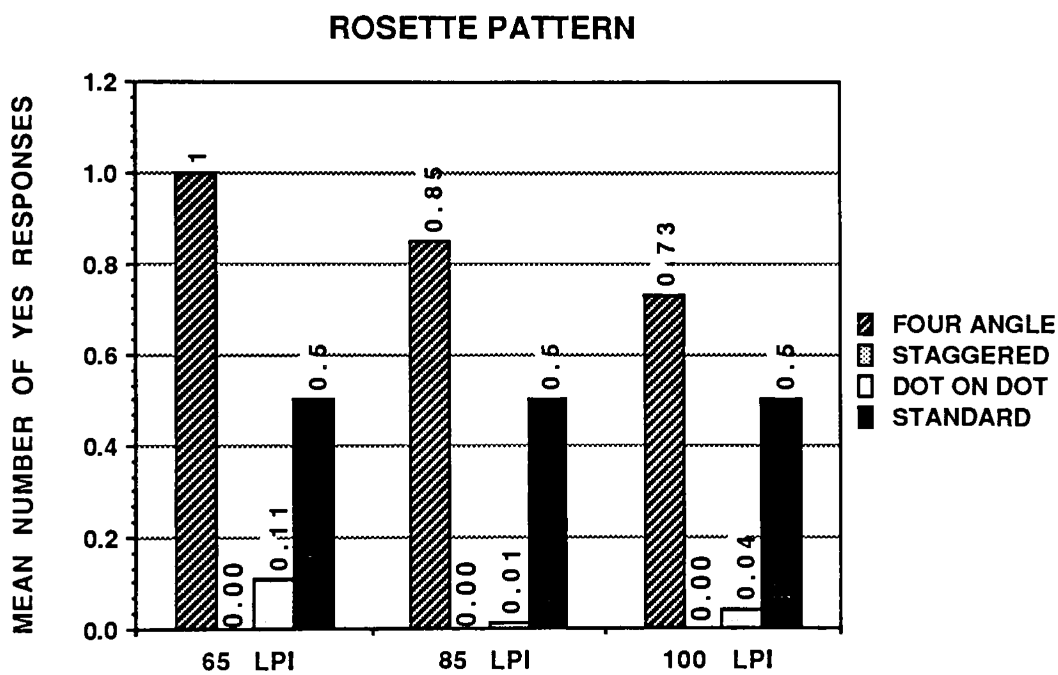

Figure 7

ROSETTE PATTERNS: Means of Judges' Yes Responses

TABLE 1

ROSETTE PATTERN

Analysis of Variance

		Four Angle and Standard				Staggered Position and Standard				Dot-on-Dot and Standard			
65 lpi	Source	DF	SS	MS	F	DF	SS	MS	F	DF	SS	MS	F
	Method	1	12.50	12.50	96.2 *	1	12.50	12.50	96.2 *	1	7.61	7.61	42.3
	Error	198	25.00	.13		198	25.00	.13		198	34.79	.18	
85 lpi	Source	DF	SS	MS	F	DF	SS	MS	F	DF	SS	MS	F
	Method	1	6.13	6.13	32.3 *	1	12.50	12.50	96.2*	1	12.01	12.01	92.4
	Error	198	37.75	.19		198	25.00	.13		198	25.99	.13	
100 lpi	Source	DF	SS	MS	F	DF	SS	MS	F	DF	SS	MS	F
	Method	1	2.65	2.65	11.5*	1	12.50	12.50	96.2 *	1	12.50	12.50	96.1
	Error	198	44.71	0.23		198	25.00	.13		198	25.0	.13	

* Significance at the .05 alpha level

The judges' scores for the evidence of rosette patterns were compared to a standard score set. The standard consisted of scores that would occur without an introduced variable. A significant statistical difference and the means determined the status of the hypothesis.

The appearance of rosettes is still a direct result of angling the dots for each process color. As expected, rosettes were not significantly visible in either of the methods using one angle, although there was a single judge who saw rosettes in some of the dot-on-dot images. The rosette pattern in the four angle prints is significantly visible and becomes less noticeable as the screen frequency increases. The previous studies on coated stock indicated a disappearance of the rosette pattern at the 175 lpi ruling. Rosettes would probably become less noticeable at a coarser ruling when printed on newsprint than on coated substrates. The absorbency of the newsprint, the resulting softening of the dot pattern, and the newsprint's

grayness would be the cause of this. A more direct and controlled study of rosette patterns on newsprint is needed to specifically define the ruling at which rosettes are no longer visible.

MOIRÉ PATTERNS

HYPOTHESIS: Staggered Position One Angle printing does not exhibit a moiré pattern.

Accepted for all screen rulings at the .05 alpha level.

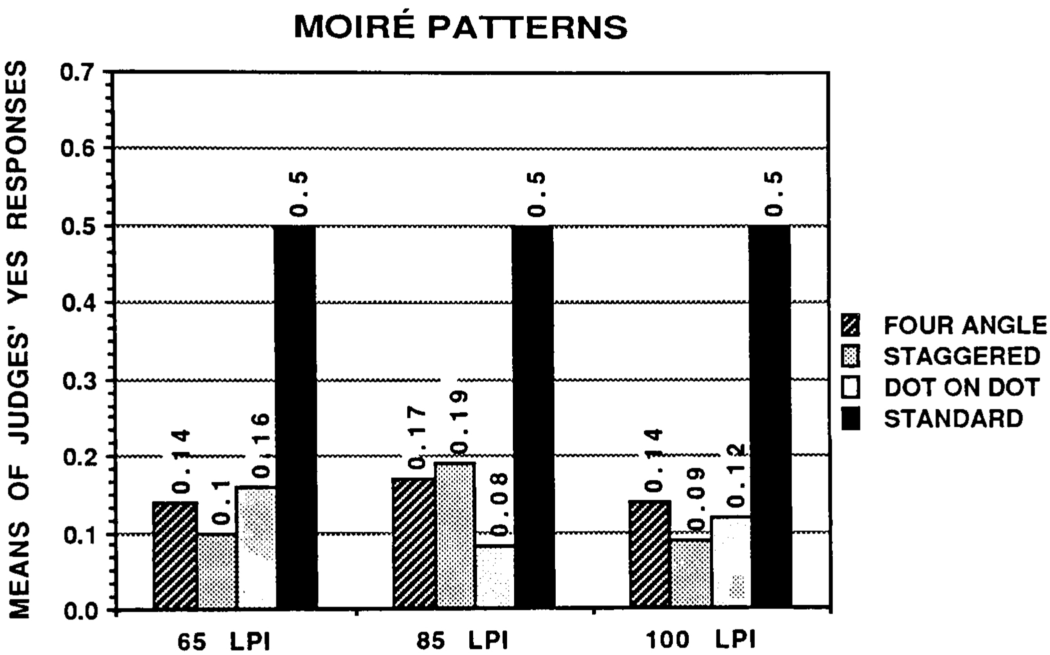

Figure 8

MOIRÉ PATTERNS: Means of Judges' Yes Responses

TABLE 2

MOIRE´ PATTERNS

Analysis of Variance

		Four Angle and Standard				Staggered Position and Standard				Dot-on-Dot and Standard			
65 lpi	Source	DF	SS	MS	F	DF	SS	MS	F	DF	SS	MS	F
	Method	1	6.48	6.48	34.1 *	1	8	8	47.1 *	1	5.78	5.78	30.4*
	Error	198	37.04	.19		198	34	.17		198	38.44	.19	
85 lpi	Source	DF	SS	MS	F	DF	SS	MS	F	DF	SS	MS	F
	Method	1	5.45	5.45	27.3 *	1	4.81	4.81	24.1 *	1	8.82	8.82	55.1*
	Error	198	39.11	.20		198	40.39	.20		198	32.36	.16	
100 lpi	Source	DF	SS	MS	F	DF	SS	MS	F	DF	SS	MS	F
	Method	1	7.22	7.22	40.1 *	1	8.41	8.41	49.5 *	1	7.22	7.22	40.1*
	Error	198	35.56	.18		198	33.19	.17		198	35.56	.18	

* Significance at .05 alpha level.

The judges' scores for the appearance of a moire´ pattern were compared to a standard score set. The standard consisted of scores that would occur without an introduced variable. A significant statistical difference and the means determined the status of the hypothesis.

Many of the judges felt that the appearance of a rosette pattern was equivalent to the appearance of a moire´ pattern and scored the prints accordingly. This could explain the high scores for moire´ patterns in the four angle printing. Nevertheless, the appearance of moire´ patterns is significantly minimal for all three methods in all three rulings. The chance of encountering a moire´ with either Staggered Position or dot-on-dot separations appears to be the same as with four angle separations.

TONE REPRODUCTION

HYPOTHESIS: There is no significant difference in tone reproduction between Staggered Position One Angle printing and Four Angle printing.

There is no significant difference in tone reproduction between Staggered Position One Angle printing and Single Angle Dot-on-Dot printing.

Both hypotheses accepted for all screen frequencies at the .05 alpha level.

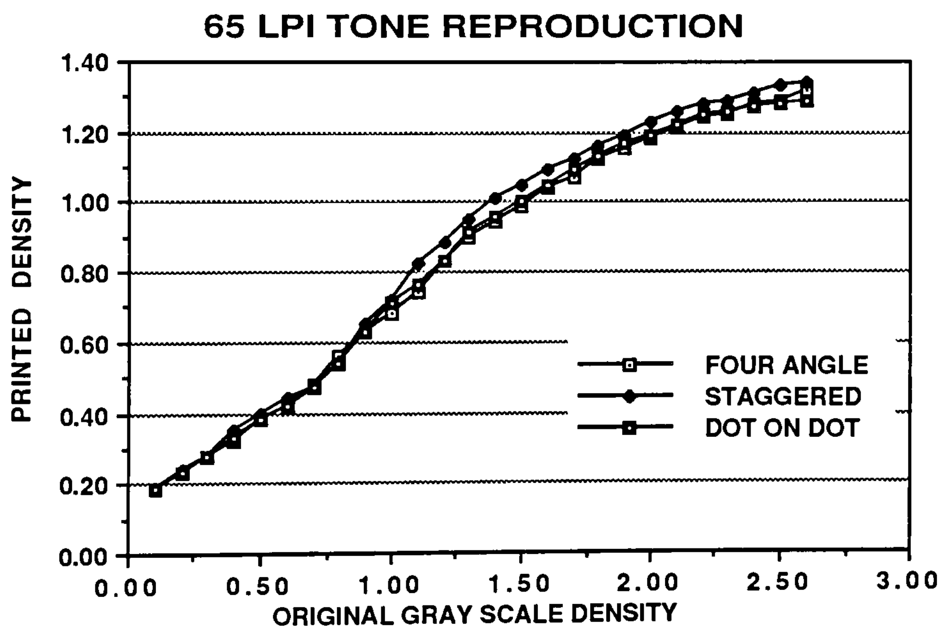

Figure 9

65 LPI - Tone Reproduction

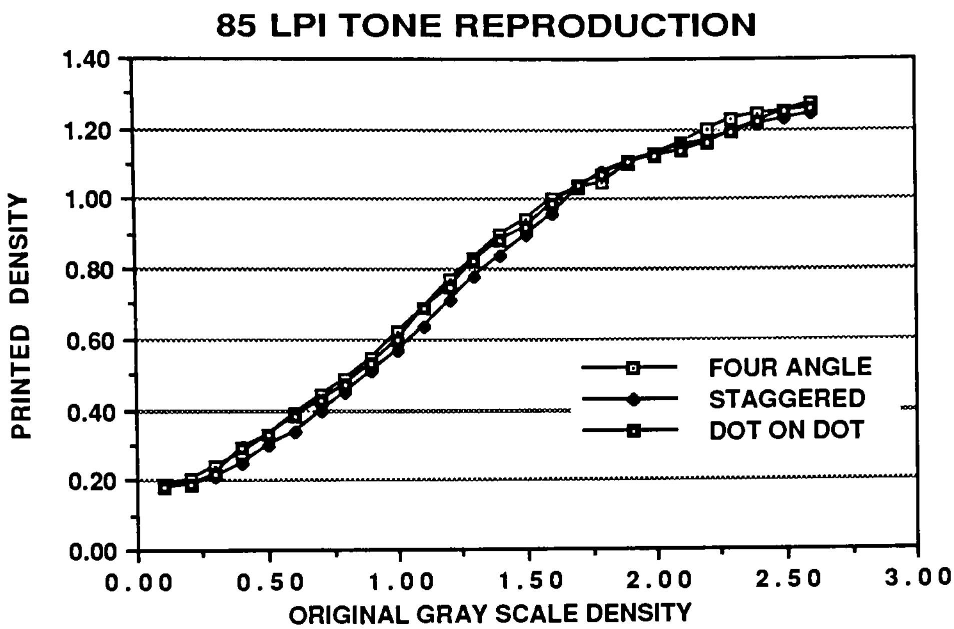

Figure 10

85 LPI - Tone Reproduction

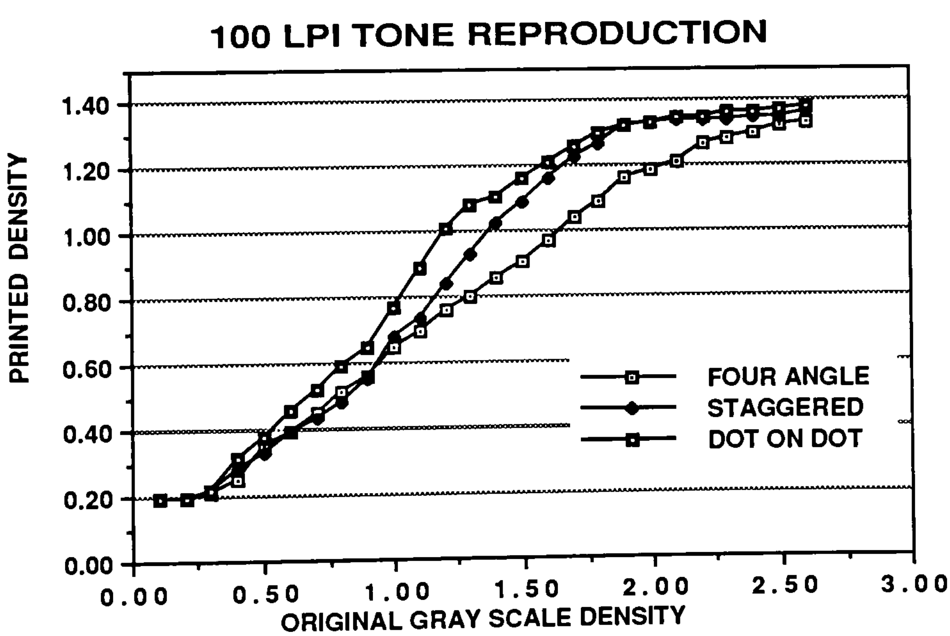

Figure 11

100 LPI - Tone Reproduction

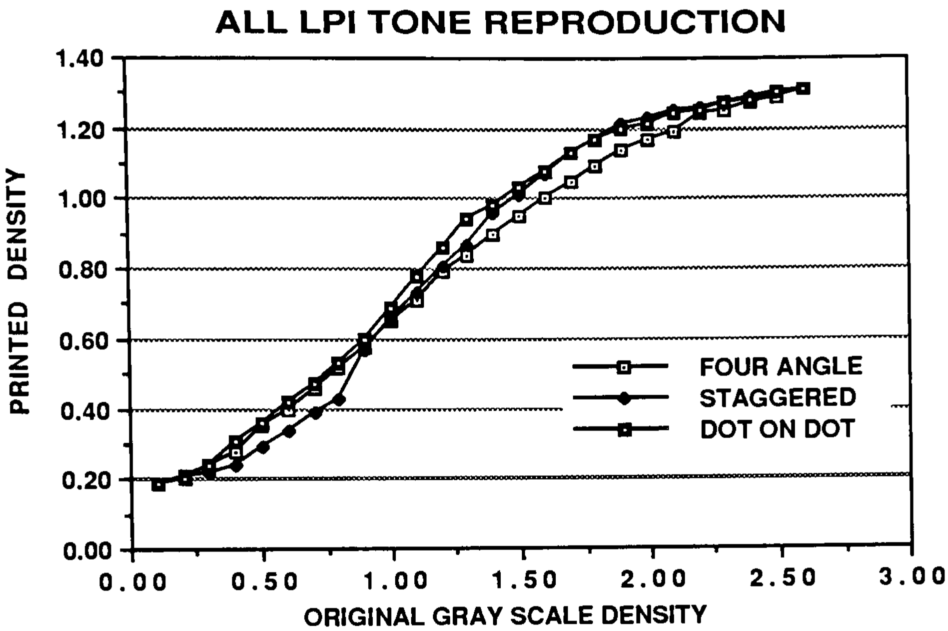

Figure 12

All LPI - Tone Reproduction

TABLE 3

TONE REPRODUCTION

Analysis of Variance

	Four Angle and Staggered Position					Dot-on-Dot and Staggered Position				
65	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	.15	.15	1.07	Method	1	.11	.11	.79
	Error	518	74.46	.14		Error	518	74.81	.14	
85	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	.10	.10	.71	Method	1	.03	.03	.20
	Error	518	73.40	.14		Error	518	74.97	.15	
100	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	.63	.63	3.70	Method	1	.37	.37	1.95
	Error	518	89.33	.17		Error	518	97.39	.19	
All	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	.25	.25	1.62	Method	1	.07	.07	.44
	Error	1558	239.59	.15		Error	1558	252.76	.16	

* Significant difference at .05 alpha level

Tone reproduction is affected very little by the angling or the positioning of the halftone dots. The lightening and color variation, which occured in other studies of dot-on-dot printing and caused their rejection for tone reproduction, did not appear in either the Staggered Position or the dot-on-dot printing. The 100 lpi prints did show a measurable difference, but the difference is statistically insignificant. A darkening of the tones occured in the Staggered Position and dot-on-dot printing at this screen frequency, instead of their being a lightening of the images.

SHARPNESS

HYPOTHESIS: There is no significant difference in visual sharpness between Staggered Position One Angle printing and Four Angle printing.

Accepted for the 85 lpi at the .05 alpha level.

There is no significant difference in visual sharpness between Staggered Position One Angle printing and Single Angle Dot-on-Dot printing.

Accepted for 85 and 100 lpi at the .05 alpha level.

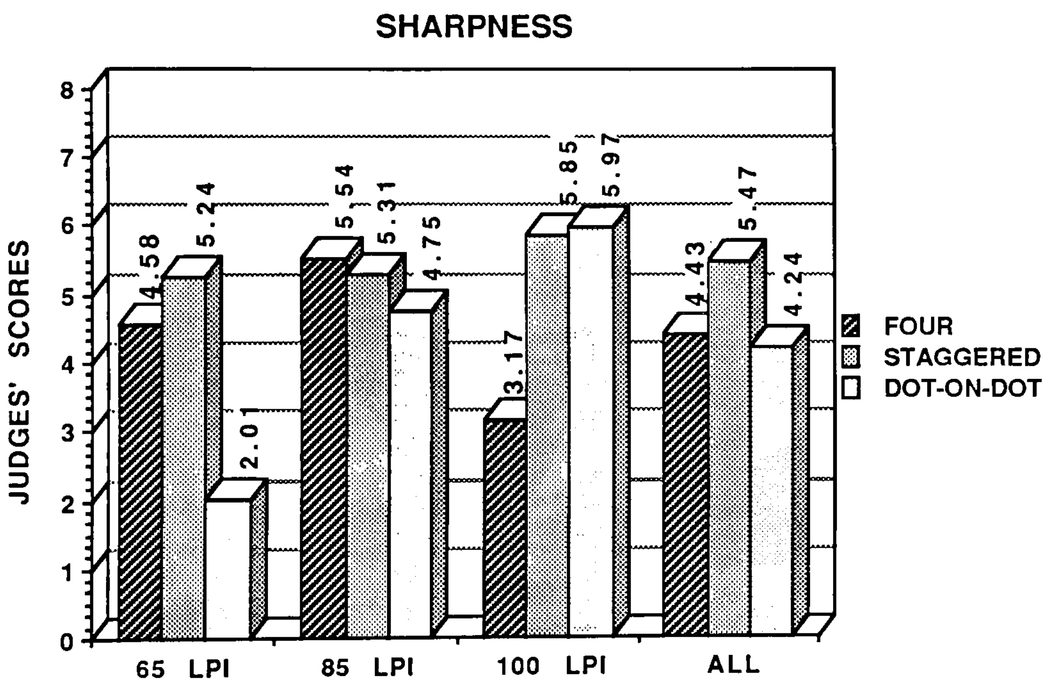

Figure 13

SHARPNESS: Means of Judges' Scores

TABLE 4

SHARPNESS

Analysis of Variance

	Four Angle and Staggered Position					Dot-on-Dot and Staggered Position				
65	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	21.78	21.78	4.94*	Method	1	521.64	521.64	161.50*
	Error	188	828.60	4.41		Error	188	607.23	3.23	
85	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	2.64	2.64	.48	Method	1	15.68	15.68	2.36
	Error	188	1028.23	5.47		Error	188	1250.14	6.65	
100	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	359.12	359.12	105.31*	Method	1	.72	.72	.17
	Error	188	640.86	3.41		Error	188	818.28	4.35	
ALL	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	161.2	161.2	33.80*	Method	1	224.47	224.47	37.47*
	Error	588	2804.2	4.77		Error	588	3519.91	5.99	

* Significant difference at .05 alpha level.

When Staggered Position printing was developed, it was assumed that some sharpness would be lost as a result of the lateral movement of the dot. The result was not as anticipated. The Staggered Position printing performed better than both the four angle and the dot-on-dot printing.

The diminished rosette pattern was not enough to help the four angle prints perform as well as the Staggered Position prints, and the dot-on dot printing, which usually prints sharp in the coarse screen frequencies, printed less sharp as the ruling became coarser.

COLOR SHIFT

HYPOTHESIS: There is no significant difference in the exhibition of a color shift between Staggered Position One Angle printing and Four Angle printing.

Accepted for the 85 and 100 lpi rulings at the .05 alpha level.

There is no significant difference in the exhibition of a color shift between Staggered Position One Angle printing and Single Angle Dot-on-Dot printing.

Accepted for the 85 and 100 lpi rulings at the .05 alpha level.

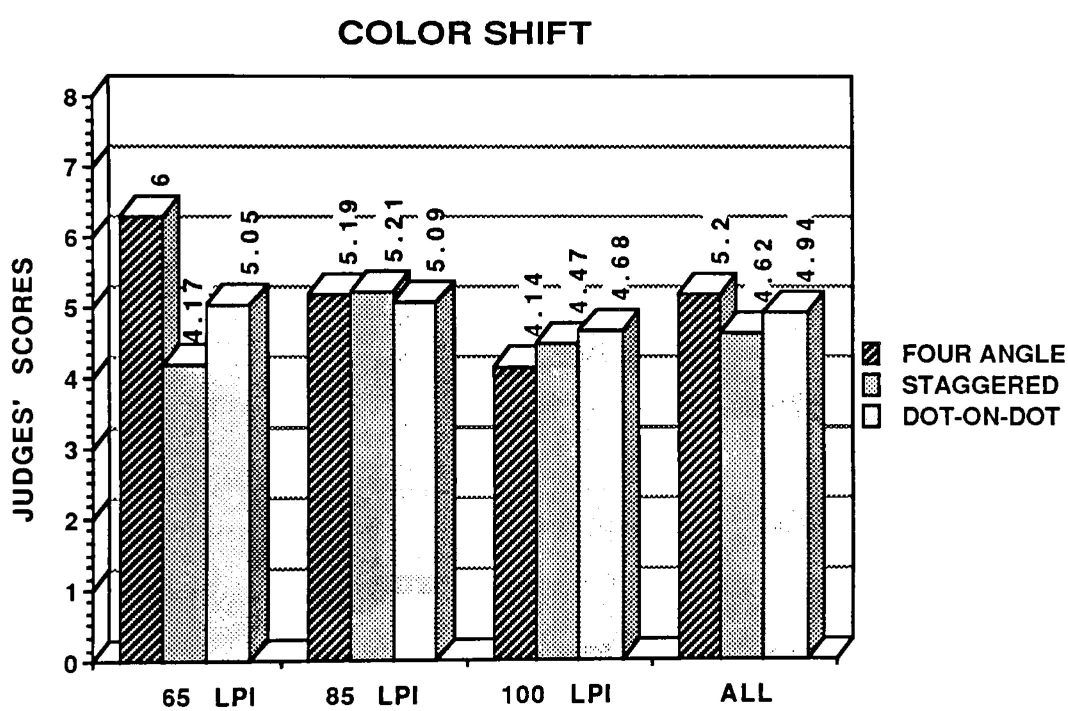

Figure 14

COLOR SHIFT: Means of Judges's Scores

TABLE 5

COLOR SHIFT

Analysis of Variance

	Four Angle and Staggered Position					Dot-on-Dot and Staggered Position				
65	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	222.60	222.60	49.25 *	Method	1	38.72	38.72	8.42 *
	Error	188	850.27	4.52		Error	188	864.86	4.60	
85	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	.02	.02	.00	Method	1	.02	.02	.14
	Error	188	919.98	4.89		Error	188	950.78	5.06	
100	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	5.44	5.44	1.12	Method	1	2.2	2.2	.44
	Error	188	910.95	4.85		Error	188	930.67	4.95	
ALL	Source	DF	SS	MS	F	Source	DF	SS	SS	F
	Method	1	51.62	51.62	10.22*	Method	1	15.68	15.68	3.27
	Error	588	2967.52	5.05		Error	588	2813.84	4.79	

* Significant difference at the .05 alpha level

Staggered Position printing was developed to minimize the color variability which existed in dot-on-dot printing. The results do not show a dramatic improvement by the Staggered Position over the dot-on-dot method, but they do show Staggered Position printing's comparability to four angle printing. The exception to this is the 65 lpi screen frequency. The Staggered Position prints scored significantly lower than the four angle and dot-on-dot prints in this ruling. Possible causes for the significantly poor performance of both the single angle methods in this screen frequency could be a combination of the coarse screen ruling, the resulting white space and poor registration.

SPECTROPHOTOMETER MEASUREMENTS

HYPOTHESIS: There is a correlation between the acceptance of an image's color shift and the Delta E value for that image.

Hypothesis is rejected.

TABLE 6

DELTA E AND JUDGES' SCORES CORRELATION

		Grey Patch Correlation	Flesh Patch Correlation
65	Four Angle	-.40	.60
	Staggered	-.13	-.03
	Dot-on-Dot	-.34	-.56
85	Four Angle	-.41	-.34
	Staggered	-.10	.03
	Dot-on-Dot	.35	.76
100	Four Angle	.10	-.50
	Staggered	-.63	.42
	Dot-on-Dot	.51	-.02

There is no correlation between Delta E and the judges scores for either of the color patches. It was speculated that the derived Delta E values of the gray and flesh patches would provide an objective indication of the judges' perceptions of color variability. A correlation between the Delta E values and the judges scores was anticipated but did not materialize. Further study along these lines might investigate other patches of color or perhaps the standard deviation of the Delta E measurements as better measures of color variation.

OVERALL ACCEPTANCE

HYPOTHESIS: There is no significance difference in the overall visual acceptance between Staggered Position One Angle printing and Four Angle printing.

Accepted for the 85 lpi at the .05 alpha level.

There is no significant difference in the overall visual acceptance between Staggered Position One Angle printing and Single Angle Dot-on-Dot printing.

Accepted for the 85 and 100 lpi rulings at the .05 alpha level.

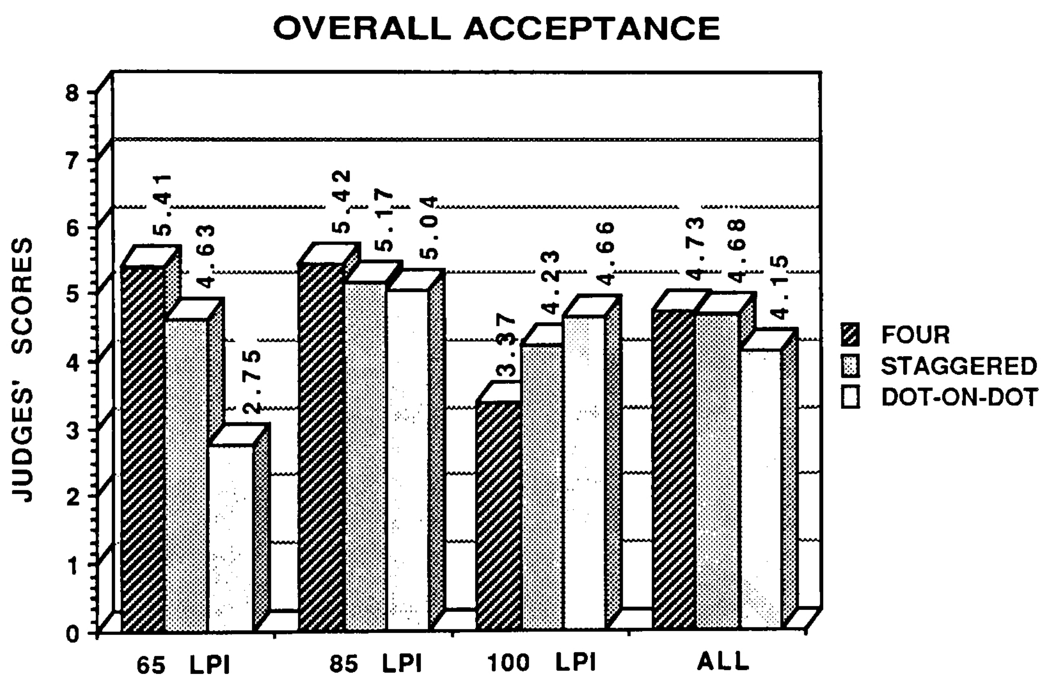

Figure 15

OVERALL ACCEPTANCE: Means of Judges' Scores

TABLE 7

OVERALL ACCEPTANCE

Analysis of Variance

	Four Angle and Staggered Position					Dot-on-Dot and Staggered Position				
65	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	30.42	30.42	6.10 *	Method	1	176.72	176.72	37.20 *
	Error	188	937.50	4.99		Error	188	892.06	4.75	
85	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	3.12	3.12	.64	Method	1	.84	.84	.15
	Error	188	912.47	4.85		Error	188	1045.95	5.56	
100	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	36.98	36.98	8.78 *	Method	1	9.24	9.24	1.87
	Error	188	791.02	4.21		Error	188	930.15	4.95	
ALL	Source	DF	SS	MS	F	Source	DF	SS	MS	F
	Method	1	.47	.47	.093	Method	1	41.6	41.6	7.61*
	Error	588	2964.31	5.04		Error	588	3213.89	5.47	

* Significant difference at .05 alpha level

The Staggered Position printing was scored significantly better than four angle printing at 100 lpi and it was significantly unacceptable at 65 lpi.

The Staggered Position printing was scored significantly better than dot-on-dot at 65 lpi and was significantly unacceptable at 100 lpi.

If the judges' scores for Sharpness and Color Shift were to be averaged together the results would parallel the judges' scores for Overall Acceptability. Color variability and sharpness together are good indicators of how the judges evaluated the images for overall acceptance, even though other criteria may have been utilized for their evaluations.

CHAPTER 8

CONCLUSIONS

A number of conclusions can be made about Staggered Position printing based on the analysis of both the subjective judgements and objective measurements. These conclusions are applicable to the parameters used for this investigation-65, 85, and 100 lpi screen frequencies on newsprint.

1. Staggered Position printing does not exhibit a **moiré pattern**. Moiré patterns were not significantly observed in either four angle or dot-on-dot printing. The possibilities of encountering moiré patterns with one angle printing and four angle printing are equal.
2. Staggered Position and dot-on-dot printing do not exhibit a **rosette pattern**. Four angle printing exhibits a clearly identifiable rosette.
3. Staggered Position printing's **tone reproduction** capabilities are equivalent to both four angle printing's and dot-on-dot printing's tone reproduction capabilities.
4. Staggered Position printing is equivalent in **sharpness** to four angle printing at 85 lpi and significantly sharper than four angle printing at 65 and 100 lpi.
5. Staggered Position printing is equivalent in **sharpness** to dot-on-dot printing at 85 and 100 lpi and significantly sharper at 65 lpi.
6. The **color variability** (color shift) exhibited by Staggered Position printing is equivalent to the color variability in four angle and dot-on-dot printing in the 85 and 100 lpi screen frequencies. The color variability in

Staggered Position printing at 65 lpi is significantly more visible.

7. Staggered Position printing is equivalent to four angle printing for **overall visual appearance** at 85 lpi, more acceptable at 100 lpi and less acceptable at 65 lpi.

8. Staggered position printing is equivalent to dot-on-dot printing for **overall visual acceptance** at both 85 and 100 lpi and more acceptable at 65 lpi.

9. There is no correlation between Delta E values and the observers' perception of a color shift.

10. Staggered Position printing is equivalent to four angle and dot-on-dot printing based on the cummulative results of this study.

CHAPTER 9

DISCUSSION

The rosette pattern is considered by many to be distracting and objectionable, often times blamed for the loss of sharpness, but becoming less noticeable as the screen frequency becomes finer. The results of this investigation support these observations. This thesis investigation also confirmed the elimination of the rosette pattern as an option with few disadvantages. The rosette pattern is avoided by generating separations with the same angle for all four colors. The result is a sharper reproduction at even the coarse screen rulings. Staggered Position or dot-on-dot separations are a safe option, with the risk of moiré patterns being minimal. Further investigation in this area could study the screen ruling on newsprint at which rosettes are unnoticed, or the correlation between the perception of sharpness and the visibility of rosette patterns.

The obvious strength of the Staggered Position process is its ability to produce an image with superior sharpness. Dot-on dot printing had produced such sharp images in previous studies that any alteration to its dot configuration was believed to compromise this ability, however, Staggered Position printing enhanced this ability. This enchancement is more than just the elimination of rosettes. The dot configuration in Staggered position separations provides matrices of dots that describe the same detail in an original with four dots in four different positions. The dot-on-dot separations confine the dots to the same dot-on-dot position for the four colors and therefore describe the detail of the original at a single position.The four angle separations hold the dot positions to the four angle configuration describing detail in a manner subject to the angles of the screens.

A diagonal line passing through an image will more than likely result in "stair stepping" with the four angle method and a loss of detail with the dot-on-dot method. The same

diagonal line reproduced by the Staggered position method will be smooth because more dots have been used to reproduce its form.

The effectiveness of Staggered Position printing to produce sharper images on newsprint is a significant result. Generally, a reproduction on newsprint will look soft and unsharp. To compensate for this, increased edge enhancement or unsharp masking is built into the separations, but this often times results in objectionable lines in and around the subject of the image. The Staggered Position method provides a means to increase sharpness without this excessive detail enhancement. Further study could compare Staggered Position printing with normal detail enhancement and four angle printing done with different degrees of detail enhancement.

Color variation or color shift does not appear to be as significant a problem for either Staggered Position or dot-on-dot printing on newsprint as in past investigations. The images in the previous studies of dot-on-dot printing were rejected for tone reproduction because of the color shift. These studies were done on coated stock. In this study on newsprint, the tone reproduction was measured to be equivalent, and the judges found the methods equal for color shift in two of the three screen frequencies. Newsprint seems to be an agreeable substrate for the single angle methods in two of the three screen rulings. The absorbency of the newsprint is certainly a factor, but the results of the 65 lpi printing suggest that both Staggered Position and dot-on-dot printing are affected more by misregistration at the coarser screen rulings. In comparison, four angle printing was not significantly affected.

Investigation of the run found fluctuations of register in the images positioned on the outside edges of the web sheet. These images were the 65 and 100 lpi prints of the three methods. The Staggered Position printing and the dot-on dot printing at the 65 lpi screen frequency were both scored significantly lower than the four angle printing for visual color shift and overall acceptance due to the combination of the coarse ruling, the fluctuations of register and the large amount of white space. The color shift was exagerated and noticed by

the judges. As a result, the two methods were rejected for overall acceptance.

The 100 lpi Staggered Position and dot-on-dot printing(on the opposite outside edge of the web) performed generally better than the four angle printing. A noticeable color shift in both the Staggered Position and dot-on dot printing was probably avoided because of the less white space in the finer screen frequency. The judges responded accordingly and scored the color variations as equivalent to the four angle printing. The Staggered Position and dot-on-dot printing were thus scored "overall more acceptable" than the four angle printing because of their equivalent color variation and their superiority in sharpness.

The low scores for overall acceptability in the 100 lpi printing presented a curious inconsistency. Work done by Y.S. Lu in 1987 showed that improvement in image quality is the result of finer screen frequencies.[1] In this Staggered position study, the finer 100 lpi printing scored lower than the coarser ruling prints. The 100 **LPI Tone Reproduction** graph (Figure 11) provides the key to this inconsistency. The tone reproductions were measured as statistically equivalent, but, as the graph shows, there are slope/gamma differences among the three methods. The low overall acceptance scores can be attributed to these gamma differences.

Chi-Wei Wu's study[2] found that increasing solid ink density improved image quality. Since gamma changes are a direct result of solid ink density manipulations, a higher gamma will generate a higher image quality. When comparing the gammas of the three methods in this study to the mean scores of the judges for overall acceptance, the correlation between gamma and image quality is evident.

If the dot-on-dot printing gamma is considered the optimum, a compensatory factor can be derived for the Staggered position and four angle printing. This factor can then be applied to the judges' scores for overall acceptability, resulting in higher mean scores for these two methods. The scores for all three methods are now indicative of a higher screen frequency. These adjusted scores will more closely reflect the results of the other two screen frequencies as well.

The registration in the center of the web was reasonably stable. The 85 lpi printing scored generally higher and equivalent to each other for the three methods. When comparing Staggered Position to four angle or Staggered position and dot-on-dot, the judges found no significant difference for any of the criteria at the 85 lpi screen frequency. Good registration and the right amount of white space contributed to these consistent results. The performance of the three methods at 85 lpi in a misregistration situation would be an area for further study.

The analysis up to now has focused on the comparisons in terms of the individual screen rulings. When the Analysis of Variance is performed on the entire collection of data (ten judges, 90 images, three screen rulings, sharpness, color shift, and overall acceptability) the cummulative result is that **Staggered Position printing is equivalent to both four angle and dot-on-dot printing.** The analysis of all the density measurements yields the same conclusion for tone reproduction. (While not significant, the total score given by the judges for Staggered Position printing was the highest of the three methods.).

The Staggered Position method for producing separations should be considered a serious alternative for newspapers, based on its ability to produce a superior sharp image and color variability only a serious problem in the 65 lpi rulings. The characteristics of the newsprint seem to be well suited to the Staggered Position method. The Staggered Position's success on other substrates should be investigated further.

FOOTNOTES FOR CHAPTER 9

[1]Y. S. Lu, "An Investigation of Quantification of Image Quality with Respect to Screen Ruling on the Appearance of Multicolor Print", (Master's Thesis, Rochester Institute of Technology, 1987).

[2]C. W. Wu, "A Study of the Relationship Between the Black and White Solid Ink Density and Image Quality in Lithography", (Master's Thesis, Rochester Institute of Technology, 1986).

CHAPTER 10

RECOMMENDATIONS FOR FURTHER INVESTIGATION

A number of recommendations have been mentioned in the DISCUSSION Chapter. Those and some others are listed below.

1. A comparison of Staggered Position printing to four angle printing and dot-on-dot printing on other substrates-brighter, coated, uncoated.
2. Rosettes are objectionable to some, especially at the coarser screen frequencies. At what screen frequency do rosettes become unobjectionable or unnoticeable on newsprint?
3. Is there a correlation between the perception of sharpness and the visibility of rosette patterns?
4. Using a single angle separation technique, Staggered Position or dot-on dot, does a different angle choice yield different, better, worse results?
5. Compare the sharpness of Staggered Position printing to four angle printing whose separations have increased detail enhancement.
6. For newsprint, determine the Delta E value at which the color is perceived as significantly different to a standard.
7. Does the standard deviation of the L,a,b measurements of a certain standardized patch indicate the color variability within a press run?
8. What color patch is best used for measuring color variation when using a spectrophotometer?
9. What effect does misregistration have on the sharpness of an image prepared with separations of one angle?

10. What effect does different degrees of misregistration have on the three methods investigated in this thesis at 85 lpi screen frequency.

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APPENDIX A

INSTRUCTION SHEET

You have been asked to be a judge for this thesis because of your experience in the area of process color printing. I will present you several images, three at a time. You are to score these three images according to specific criteria which will be explained to you prior to each set of judgements. Your scores may range from 1 to 10. The score of 1 being unacceptable and the score of 10 being very acceptable. The same score may be given to more than one image.

The first set of judgements will be the acceptability or non acceptability of the images on the basis of color shift. A color shift is a noticeable change in hue in a particular area of the reproduction. Disregarding all other criteria for good color, please score the following on the basis of color shift only.

The second set of judgements will be for the "overall" acceptability of the images based on your personal criteria for good color reproduction. Taking into consideration all those attributes that you use to determine a good reproduction, please score the images.

The third set of judgements will be for the acceptability or non acceptability of the images based or sharpness. Sharpness is the resolution of fine detail and clear cut images, particularly in edges, lines and corners. Disregarding all other criteria for good color reproduction please score the following based on sharpness only.

The next two sets of judgements require only yes and no responses.

Please indicate a yes or no response for each image based on the appearance of a moiré. A moiré is an objectionable pattem of light and dark blotches at a regular frequency. Do you see a moiré, yes or no.

Please indicate a yes or no response for each image based on the appearance of rosette patterns. Rosettes are circular flower like configurations of dots. Do you see rosettes, yes or no.

COLOR SHIFT

F1	1 2 3 4 5 6 7 8 9 10	S1	1 2 3 4 5 6 7 8 9 10	D1	1 2 3 4 5 6 7 8 9 10
F2	1 2 3 4 5 6 7 8 9 10	S2	1 2 3 4 5 6 7 8 9 10	D2	1 2 3 4 5 6 7 8 9 10
F3	1 2 3 4 5 6 7 8 9 10	S3	1 2 3 4 5 6 7 8 9 10	D3	1 2 3 4 5 6 7 8 9 10
F4	1 2 3 4 5 6 7 8 9 10	S4	1 2 3 4 5 6 7 8 9 10	D4	1 2 3 4 5 6 7 8 9 10
F5	1 2 3 4 5 6 7 8 9 10	S5	1 2 3 4 5 6 7 8 9 10	D5	1 2 3 4 5 6 7 8 9 10
F6	1 2 3 4 5 6 7 8 9 10	S6	1 2 3 4 5 6 7 8 9 10	D6	1 2 3 4 5 6 7 8 9 10
F7	1 2 3 4 5 6 7 8 9 10	S7	1 2 3 4 5 6 7 8 9 10	D7	1 2 3 4 5 6 7 8 9 10
F8	1 2 3 4 5 6 7 8 9 10	S8	1 2 3 4 5 6 7 8 9 10	D8	1 2 3 4 5 6 7 8 9 10
F9	1 2 3 4 5 6 7 8 9 10	S9	1 2 3 4 5 6 7 8 9 10	D9	1 2 3 4 5 6 7 8 9 10
F10	1 2 3 4 5 6 7 8 9 10	S10	1 2 3 4 5 6 7 8 9 10	D10	1 2 3 4 5 6 7 8 9 10

OVERALL ACCEPTABILITY

F1	1 2 3 4 5 6 7 8 9 10	S1	1 2 3 4 5 6 7 8 9 10	D1	1 2 3 4 5 6 7 8 9 10
F2	1 2 3 4 5 6 7 8 9 10	S2	1 2 3 4 5 6 7 8 9 10	D2	1 2 3 4 5 6 7 8 9 10
F3	1 2 3 4 5 6 7 8 9 10	S3	1 2 3 4 5 6 7 8 9 10	D3	1 2 3 4 5 6 7 8 9 10
F4	1 2 3 4 5 6 7 8 9 10	S4	1 2 3 4 5 6 7 8 9 10	D4	1 2 3 4 5 6 7 8 9 10
F5	1 2 3 4 5 6 7 8 9 10	S5	1 2 3 4 5 6 7 8 9 10	D5	1 2 3 4 5 6 7 8 9 10
F6	1 2 3 4 5 6 7 8 9 10	S6	1 2 3 4 5 6 7 8 9 10	D6	1 2 3 4 5 6 7 8 9 10
F7	1 2 3 4 5 6 7 8 9 10	S7	1 2 3 4 5 6 7 8 9 10	D7	1 2 3 4 5 6 7 8 9 10
F8	1 2 3 4 5 6 7 8 9 10	S8	1 2 3 4 5 6 7 8 9 10	D8	1 2 3 4 5 6 7 8 9 10
F9	1 2 3 4 5 6 7 8 9 10	S9	1 2 3 4 5 6 7 8 9 10	D9	1 2 3 4 5 6 7 8 9 10
F10	1 2 3 4 5 6 7 8 9 10	S10	1 2 3 4 5 6 7 8 9 10	D10	1 2 3 4 5 6 7 8 9 10

SHARPNESS

F1	1 2 3 4 5 6 7 8 9 10	S1	1 2 3 4 5 6 7 8 9 10	D1	1 2 3 4 5 6 7 8 9 10
F2	1 2 3 4 5 6 7 8 9 10	S2	1 2 3 4 5 6 7 8 9 10	D2	1 2 3 4 5 6 7 8 9 10
F3	1 2 3 4 5 6 7 8 9 10	S3	1 2 3 4 5 6 7 8 9 10	D3	1 2 3 4 5 6 7 8 9 10
F4	1 2 3 4 5 6 7 8 9 10	S4	1 2 3 4 5 6 7 8 9 10	D4	1 2 3 4 5 6 7 8 9 10
F5	1 2 3 4 5 6 7 8 9 10	S5	1 2 3 4 5 6 7 8 9 10	D5	1 2 3 4 5 6 7 8 9 10
F6	1 2 3 4 5 6 7 8 9 10	S6	1 2 3 4 5 6 7 8 9 10	D6	1 2 3 4 5 6 7 8 9 10
F7	1 2 3 4 5 6 7 8 9 10	S7	1 2 3 4 5 6 7 8 9 10	D7	1 2 3 4 5 6 7 8 9 10
F8	1 2 3 4 5 6 7 8 9 10	S8	1 2 3 4 5 6 7 8 9 10	D8	1 2 3 4 5 6 7 8 9 10
F9	1 2 3 4 5 6 7 8 9 10	S9	1 2 3 4 5 6 7 8 9 10	D9	1 2 3 4 5 6 7 8 9 10
F10	1 2 3 4 5 6 7 8 9 10	S10	1 2 3 4 5 6 7 8 9 10	D10	1 2 3 4 5 6 7 8 9 10

ROSETTES

F1	1 0	S1	1 0	D1	1 0
F2	1 0	S2	1 0	D2	1 0
F3	1 0	S3	1 0	D3	1 0
F4	1 0	S4	1 0	D4	1 0
F5	1 0	S5	1 0	D5	1 0
F6	1 0	S6	1 0	D6	1 0
F7	1 0	S7	1 0	D7	1 0
F8	1 0	S8	1 0	D8	1 0
F9	1 0	S9	1 0	D9	1 0
F10	1 0	S10	1 0	D10	1 0

MOIRE

F1	1 0	S1	1 0	D1	1 0
F2	1 0	S2	1 0	D2	1 0
F3	1 0	S3	1 0	D3	1 0
F4	1 0	S4	1 0	D4	1 0
F5	1 0	S5	1 0	D5	1 0
F6	1 0	S6	1 0	D6	1 0
F7	1 0	S7	1 0	D7	1 0
F8	1 0	S8	1 0	D8	1 0
F9	1 0	S9	1 0	D9	1 0
F10	1 0	S10	1 0	D10	1 0

SPECTROPHOTOMETER MEASUREMENTS

FLESH PATCH

ruling	color	type	l	a	b
65	F	F1	70.060	5.230	14.850
65	F	F2	69.910	5.160	14.680
65	F	F3	69.450	5.000	16.990
65	F	F4	69.310	4.690	16.390
65	F	F5	69.050	4.540	17.490
65	F	F6	68.670	4.770	17.340
65	F	F7	68.540	5.390	16.500
65	F	F8	69.360	4.470	16.860
65	F	F9	69.940	3.830	17.040
65	F	F0	69.650	4.140	16.610
65	F	S1	69.040	5.270	17.060
65	F	S2	70.070	4.600	18.170
65	F	S3	68.880	4.260	19.780
65	F	S4	68.620	4.960	18.280
65	F	S5	68.720	4.500	19.330
65	F	S6	69.010	4.340	19.110
65	F	S7	69.400	4.390	18.740
65	F	S8	69.340	4.960	17.910
65	F	S9	70.230	2.960	20.820
65	F	S0	68.620	4.960	18.280
65	F	D1	69.540	4.800	14.020
65	F	D2	70.590	4.660	15.280
65	F	D3	69.650	3.760	16.990
65	F	D4	68.820	5.750	13.050
65	F	D5	68.510	4.950	12.940
65	F	D6	69.370	4.070	18.550
65	F	D7	69.190	4.620	18.750
65	F	D8	69.140	5.140	13.830
65	F	D9	71.010	2.670	17.540
65	F	D0	70.690	2.820	16.710
85	F	F1	70.860	3.910	12.880
85	F	F2	71.000	3.500	12.800
85	F	F3	71.330	3.810	12.540
85	F	F4	69.230	3.340	15.440
85	F	F5	69.050	2.990	16.870
85	F	F6	69.000	2.500	16.010
85	F	F7	69.630	2.820	15.760
85	F	F8	70.850	2.260	15.610
85	F	F9	70.500	2.120	15.480
85	F	F0	70.350	2.020	15.300
85	F	S1	71.780	6.960	9.680
85	F	S2	72.000	6.850	10.020
85	F	S3	72.330	6.380	10.220
85	F	S4	71.050	5.630	15.220
85	F	S5	70.150	5.760	16.710
85	F	S6	70.350	5.880	16.500
85	F	S7	70.760	5.920	16.140
85	F	S8	72.190	4.710	14.700
85	F	S9	71.890	4.880	14.400
85	F	S0	72.010	4.750	14.550
85	F	D1	72.120	5.250	13.840
85	F	D2	72.150	5.300	13.000
85	F	D3	72.220	5.300	12.850
85	F	D4	71.290	4.520	15.410
85	F	D5	70.620	5.650	12.820
85	F	D6	70.600	5.950	13.220
85	F	D7	70.570	6.060	13.610
85	F	D8	72.370	3.940	14.920
85	F	D9	72.440	3.840	15.410
85	F	D0	73.000	4.000	13.000

00	F	F1	66.100	10.110	21.000
00	F	F2	65.930	10.210	20.380
00	F	F3	64.800	11.910	20.440
00	F	F4	68.550	6.610	22.150
00	F	F5	67.880	7.420	20.690
00	F	F6	68.660	6.870	21.040
00	F	F7	68.700	6.660	21.480
00	F	F8	69.300	7.020	19.530
00	F	F9	69.100	8.560	14.210
00	F	F0	68.740	9.160	15.160
00	F	S1	65.560	8.470	22.080
00	F	S2	66.030	8.930	20.800
00	F	S3	64.590	11.910	16.420
00	F	S4	67.970	6.540	19.680
00	F	S5	67.430	6.000	20.420
00	F	S6	67.800	5.230	19.970
00	F	S7	67.890	6.070	19.600
00	F	S8	68.620	5.980	17.550
00	F	S9	68.570	8.540	10.600
00	F	S0	68.690	7.590	13.200
00	F	D1	65.960	8.440	19.480
00	F	D2	65.470	9.870	15.990
00	F	D3	64.210	10.840	21.140
00	F	D4	68.040	5.430	19.530
00	F	D5	66.960	6.840	15.600
00	F	D6	67.890	5.800	15.960
00	F	D7	68.420	5.070	18.940
00	F	D8	67.700	6.650	15.800
00	F	D9	68.400	7.150	14.120
00	F	D0	68.720	6.930	14.370

SPECTROPHOTOMETER MEASUREMENTS

GRAY PATCH

65	G	F1	43.400	0.000	4.300
65	G	F2	44.830	0.270	4.300
65	G	F3	42.430	0.150	4.770
65	G	F4	42.890	-0.300	4.530
65	G	F5	43.240	-1.230	5.430
65	G	F6	42.880	-0.680	5.310
65	G	F7	43.070	-0.100	5.310
65	G	F8	43.330	-0.570	5.030
65	G	F9	43.790	-2.470	5.130
65	G	F0	43.350	-2.270	4.590
65	G	S1	42.160	7.780	2.650
65	G	S2	42.840	3.930	1.310
65	G	S3	44.240	-0.900	9.950
65	G	S4	42.660	-3.520	7.580
65	G	S5	42.050	4.780	6.500
65	G	S6	42.450	3.170	6.000
65	G	S7	41.430	2.670	4.120
65	G	S8	41.790	4.110	7.360
65	G	S9	43.560	-0.590	5.450
65	G	S0	44.540	-1.190	7.970
65	G	D1	43.560	1.100	-1.800
65	G	D2	46.660	0.040	2.640
65	G	D3	43.820	-1.130	2.220
65	G	D4	40.800	0.130	4.840
65	G	D5	41.700	-4.040	-1.300
65	G	D6	42.610	-3.140	1.710
65	G	D7	42.950	-2.770	2.440
65	G	D8	41.900	-1.630	-1.030
65	G	D9	46.300	-3.990	3.060
65	G	D0	45.360	-4.730	0.520
85	G	F1	43.570	-1.460	0.890
85	G	F2	44.060	-1.160	1.400
85	G	F3	44.060	-1.160	1.400
85	G	F4	40.940	-2.220	4.200
85	G	F5	40.960	-1.590	5.080
85	G	F6	42.160	-5.680	3.840
85	G	F7	40.240	-1.660	4.360
85	G	F8	41.810	-5.790	4.040
85	G	F9	42.160	-5.680	3.840
85	G	F0	40.240	-1.660	4.360
85	G	S1	46.530	-2.620	-3.300
85	G	S2	43.210	0.070	7.300
85	G	S3	47.680	-1.330	-1.120
85	G	S4	40.790	-2.030	2.760
85	G	S5	43.210	0.070	7.300
85	G	S6	46.530	-2.620	-3.300
85	G	S7	43.200	-3.060	4.670
85	G	S8	44.870	-4.320	1.250
85	G	S9	45.560	-5.230	2.040
85	G	S0	46.280	-2.630	-3.370
85	G	D1	44.350	-0.720	-2.350
85	G	D2	41.040	3.240	3.800
85	G	D3	45.470	-1.010	-1.690
85	G	D4	43.820	-5.550	4.730

85	G	D5	41.040	1.890	3.540
85	G	D6	43.350	1.900	3.500
85	G	D7	40.900	3.080	3.800
85	G	D8	44.880	-6.000	0.570
85	G	D9	43.950	-6.130	0.260
85	G	D0	43.800	-6.300	0.600
00	G	F1	36.860	-1.550	4.420
00	G	F2	36.470	-2.230	3.790
00	G	F3	36.170	-1.910	2.950
00	G	F4	40.320	-5.870	7.050
00	G	F5	39.110	-6.800	5.210
00	G	F6	39.260	-7.090	5.450
00	G	F7	40.290	-6.140	6.500
00	G	F8	40.760	-5.440	4.570
00	G	F9	41.440	-2.370	-2.350
00	G	F0	42.100	-1.190	-0.620
00	G	S1	37.010	-2.740	6.340
00	G	S2	38.240	-3.540	7.030
00	G	S3	36.130	-1.590	3.500
00	G	S4	38.280	-2.310	2.850
00	G	S5	36.870	-3.500	2.610
00	G	S6	37.450	-5.600	1.760
00	G	S7	38.850	-3.730	4.220
00	G	S8	38.560	-1.540	0.780
00	G	S9	39.450	-1.410	-5.440
00	G	S0	40.230	-0.380	-2.710
00	G	D1	34.290	-2.190	3.210
00	G	D2	35.320	-0.060	2.900
00	G	D3	35.180	1.230	3.530
00	G	D4	38.880	-7.010	4.640
00	G	D5	37.600	-4.860	1.280
00	G	D6	37.940	-4.250	2.460
00	G	D7	39.910	-6.690	5.250
00	G	D8	38.590	-5.920	0.290
00	G	D9	38.870	-5.390	-6.380
00	G	D0	41.760	-4.850	1.510

DENSITIES OF THE ORIGINAL GRAY SCALE

STEP	INPUT
1	0.100
2	0.200
3	0.300
4	0.400
5	0.500
6	0.600
7	0.700
8	0.800
9	0.900
10	1.000
11	1.100
12	1.200
13	1.300
14	1.400
15	1.500
16	1.600
17	1.700
18	1.800
19	1.900
20	2.000
21	2.100
22	2.200
23	2.300
24	2.400
25	2.500
26	2.600

MEANS OF THE DENSITY MEASUREMENTS

65 LPI PRINTING

65	D	A		0.188
65	D	B		0.232
65	D	C		0.282
65	D	D		0.326
65	D	E		0.376
65	D	F		0.423
65	D	G		0.474
65	D	H		0.539
65	D	I		0.630
65	D	J		0.707
65	D	K		0.761
65	D	L		0.832
65	D	M		0.905
65	D	N		0.955
65	D	O		0.999
65	D	P		1.051
65	D	Q		1.093
65	D	R		1.129
65	D	S		1.169
65	D	T		1.194
65	D	U		1.222
65	D	V		1.245
65	D	W		1.259
65	D	X		1.272
65	D	Y		1.281
65	D	Z		1.285
65	F	A		0.192
65	F	B		0.230
65	F	C		0.276
65	F	D		0.317
65	F	E		0.376
65	F	F		0.422
65	F	G		0.478
65	F	H		0.556
65	F	I		0.631
65	F	J		0.684
65	F	K		0.743
65	F	L		0.826
65	F	M		0.898
65	F	N		0.941
65	F	O		0.993
65	F	P		1.037
65	F	Q		1.066
65	F	R		1.116
65	F	S		1.153
65	F	T		1.176
65	F	U		1.212
65	F	V		1.244
65	F	W		1.253
65	F	X		1.276
65	F	Y		1.290
65	F	Z		1.315
65	S	A		0.187
65	S	B		0.239
65	S	C		0.281
65	S	D		0.347
65	S	E		0.404
65	S	F		0.440
65	S	G		0.465
65	S	H		0.540
65	S	I		0.645
65	S	J		0.721
65	S	K		0.821
65	S	L		0.881
65	S	M		0.954
65	S	N		1.008
65	S	O		1.046
65	S	P		1.094
65	S	Q		1.124
65	S	R		1.160
65	S	S		1.194
65	S	T		1.228
65	S	U		1.257
65	S	V		1.277
65	S	W		1.291
65	S	X		1.306
65	S	Y		1.325
65	S	Z		1.338

MEANS OF DENSITY MEASUREMENTS

85 LPI PRINTING

85	D	A	0.183
85	D	B	0.187
85	D	C	0.220
85	D	D	0.288
85	D	E	0.325
85	D	F	0.381
85	D	G	0.425
85	D	H	0.473
85	D	I	0.530
85	D	J	0.595
85	D	K	0.689
85	D	L	0.750
85	D	M	0.820
85	D	N	0.876
85	D	O	0.922
85	D	P	0.986
85	D	Q	1.035
85	D	R	1.071
85	D	S	1.105
85	D	T	1.121
85	D	U	1.142
85	D	V	1.161
85	D	W	1.191
85	D	X	1.223
85	D	Y	1.245
85	D	Z	1.260
85	F	A	0.186
85	F	B	0.197
85	F	C	0.238
85	F	D	0.280
85	F	E	0.328
85	F	F	0.389
85	F	G	0.441
85	F	H	0.494
85	F	I	0.552
85	F	J	0.617
85	F	K	0.685
85	F	L	0.770
85	F	M	0.832
85	F	N	0.897
85	F	O	0.942
85	F	P	1.001
85	F	Q	1.026
85	F	R	1.054
85	F	S	1.099
85	F	T	1.125
85	F	U	1.163
85	F	V	1.204
85	F	W	1.226
85	F	X	1.239
85	F	Y	1.249
85	F	Z	1.268
85	S	A	0.186
85	S	B	0.192
85	S	C	0.208
85	S	D	0.254
85	S	E	0.302
85	S	F	0.342
85	S	G	0.397
85	S	H	0.450
85	S	I	0.507
85	S	J	0.573
85	S	K	0.642
85	S	L	0.708
85	S	M	0.782
85	S	N	0.838
85	S	O	0.902
85	S	P	0.960
85	S	Q	1.033
85	S	R	1.078
85	S	S	1.107
85	S	T	1.132
85	S	U	1.152
85	S	V	1.172
85	S	W	1.191
85	S	X	1.207
85	S	Y	1.232
85	S	Z	1.237

MEANS OF THE DENSITY MEASUREMENTS

100 LPI PRINTING

100	D	A	0.186
100	D	B	0.191
100	D	C	0.224
100	D	D	0.313
100	D	E	0.376
100	D	F	0.462
100	D	G	0.522
100	D	H	0.587
100	D	I	0.652
100	D	J	0.773
100	D	K	0.893
100	D	L	1.010
100	D	M	1.079
100	D	N	1.111
100	D	O	1.163
100	D	P	1.211
100	D	Q	1.259
100	D	R	1.296
100	D	S	1.316
100	D	T	1.334
100	D	U	1.345
100	D	V	1.350
100	D	W	1.358
100	D	X	1.365
100	D	Y	1.371
100	D	Z	1.375
100	F	A	0.186
100	F	B	0.191
100	F	C	0.206
100	F	D	0.250
100	F	E	0.350
100	F	F	0.388
100	F	G	0.451
100	F	H	0.508
100	F	I	0.564
100	F	J	0.651
100	F	K	0.700
100	F	L	0.758
100	F	M	0.803
100	F	N	0.856
100	F	O	0.909
100	F	P	0.971
100	F	Q	1.040
100	F	R	1.092
100	F	S	1.161
100	F	T	1.187
100	F	U	1.209
100	F	V	1.266
100	F	W	1.283
100	F	X	1.301
100	F	Y	1.317
100	F	Z	1.331
100	S	A	0.189
100	S	B	0.194
100	S	C	0.215
100	S	D	0.278
100	S	E	0.331
100	S	F	0.389
100	S	G	0.430
100	S	H	0.481
100	S	I	0.553
100	S	J	0.681
100	S	K	0.741
100	S	L	0.835
100	S	M	0.930
100	S	N	1.026
100	S	O	1.094
100	S	P	1.158
100	S	Q	1.226
100	S	R	1.273
100	S	S	1.315
100	S	T	1.332
100	S	U	1.336
100	S	V	1.337
100	S	W	1.342
100	S	X	1.350
100	S	Y	1.352
100	S	Z	1.357

DENSITY MEASUREMENTS
65 LPI

65 1 F A 0.18	65 3 F P 1.06	65 6 F E 0.37	65 8 F T 1.18	65 1 S I 0.63	65 3 S X 1.32	65 6 S M 0.97
65 1 F B 0.22	65 3 F Q 1.08	65 6 F F 0.43	65 8 F U 1.23	65 1 S J 0.74	65 3 S Y 1.32	65 6 S N 1.02
65 1 F C 0.27	65 3 F R 1.11	65 6 F G 0.48	65 8 F V 1.26	65 1 S K 0.85	65 3 S Z 1.33	65 6 S O 1.02
65 1 F D 0.31	65 3 F S 1.16	65 6 F H 0.54	65 8 F W 1.26	65 1 S L 0.91	65 4 S A 0.19	65 6 S P 1.10
65 1 F E 0.36	65 3 F T 1.17	65 6 F I 0.62	65 8 F X 1.29	65 1 S M 0.98	65 4 S B 0.24	65 6 S Q 1.14
65 1 F F 0.41	65 3 F U 1.21	65 6 F J 0.68	65 8 F Y 1.31	65 1 S N 1.04	65 4 S C 0.24	65 6 S R 1.16
65 1 F G 0.47	65 3 F V 1.25	65 6 F K 0.72	65 8 F Z 1.34	65 1 S O 1.08	65 4 S D 0.33	65 6 S S 1.18
65 1 F H 0.52	65 3 F W 1.26	65 6 F L 0.81	65 9 F A 0.19	65 1 S P 1.13	65 4 S E 0.39	65 6 S T 1.23
65 1 F I 0.62	65 3 F X 1.26	65 6 F M 0.86	65 9 F B 0.24	65 1 S Q 1.15	65 4 S F 0.42	65 6 S U 1.25
65 1 F J 0.67	65 3 F Y 1.29	65 6 F N 0.91	65 9 F C 0.28	65 1 S R 1.18	65 4 S G 0.42	65 6 S V 1.27
65 1 F K 0.67	65 3 F Z 1.29	65 6 F O 0.96	65 9 F D 0.33	65 1 S S 1.22	65 4 S H 0.54	65 6 S W 1.28
65 1 F L 0.82	65 4 F A 0.19	65 6 F P 1.01	65 9 F E 0.38	65 1 S T 1.25	65 4 S I 0.66	65 6 S X 1.28
65 1 F M 0.88	65 4 F B 0.23	65 6 F Q 1.03	65 9 F F 0.44	65 1 S U 1.27	65 4 S J 0.75	65 6 S Y 1.31
65 1 F N 0.91	65 4 F C 0.28	65 6 F R 1.09	65 9 F G 0.51	65 1 S V 1.28	65 4 S K 0.86	65 6 S Z 1.32
65 1 F O 0.97	65 4 F D 0.33	65 6 F S 1.13	65 9 F H 0.57	65 1 S W 1.30	65 4 S L 0.92	65 7 S A 0.20
65 1 F P 1.02	65 4 F E 0.38	65 6 F T 1.15	65 9 F I 0.63	65 1 S X 1.31	65 4 S M 1.00	65 7 S B 0.24
65 1 F Q 1.04	65 4 F F 0.43	65 6 F U 1.20	65 9 F J 0.70	65 1 S Y 1.32	65 4 S N 1.08	65 7 S C 0.29
65 1 F R 1.09	65 4 F G 0.48	65 6 F V 1.22	65 9 F K 0.76	65 1 S Z 1.33	65 4 S O 1.11	65 7 S D 0.35
65 1 F S 1.15	65 4 F H 0.57	65 6 F W 1.22	65 9 F L 0.76	65 2 S A 0.18	65 4 S P 1.15	65 7 S E 0.40
65 1 F T 1.20	65 4 F I 0.63	65 6 F X 1.26	65 9 F M 0.93	65 2 S B 0.23	65 4 S Q 1.18	65 7 S F 0.44
65 1 F U 1.21	65 4 F J 0.69	65 6 F Y 1.27	65 9 F N 0.97	65 2 S C 0.27	65 4 S R 1.20	65 7 S G 0.44
65 1 F V 1.23	65 4 F K 0.76	65 6 F Z 1.31	65 9 F O 1.01	65 2 S D 0.34	65 4 S S 1.23	65 7 S H 0.57
65 1 F W 1.23	65 4 F L 0.85	65 7 F A 0.20	65 9 F P 1.06	65 2 S E 0.40	65 4 S T 1.26	65 7 S I 0.65
65 1 F X 1.25	65 4 F M 0.89	65 7 F B 0.22	65 9 F Q 1.07	65 2 S F 0.43	65 4 S U 1.29	65 7 S J 0.73
65 1 F Y 1.29	65 4 F N 0.93	65 7 F C 0.29	65 9 F R 1.15	65 2 S G 0.46	65 4 S V 1.29	65 7 S K 0.80
65 1 F Z 1.29	65 4 F O 0.99	65 7 F D 0.32	65 9 F S 1.15	65 2 S H 0.46	65 4 S W 1.32	65 7 S L 0.88
65 2 F A 0.18	65 4 F P 1.05	65 7 F E 0.37	65 9 F T 1.18	65 2 S I 0.60	65 4 S X 1.32	65 7 S M 0.93
65 2 F B 0.22	65 4 F Q 1.06	65 7 F F 0.43	65 9 F U 1.18	65 2 S J 0.70	65 4 S Y 1.34	65 7 S N 1.00
65 2 F C 0.27	65 4 F R 1.13	65 7 F G 0.48	65 9 F V 1.27	65 2 S K 0.76	65 4 S Z 1.34	65 7 S O 1.05
65 2 F D 0.31	65 4 F S 1.17	65 7 F H 0.55	65 9 F W 1.27	65 2 S L 0.82	65 5 S A 0.18	65 7 S P 1.08
65 2 F E 0.36	65 4 F T 1.18	65 7 F I 0.62	65 9 F X 1.31	65 2 S M 0.90	65 5 S B 0.24	65 7 S Q 1.08
65 2 F F 0.41	65 4 F U 1.22	65 7 F J 0.69	65 9 F Y 1.31	65 2 S N 0.93	65 5 S C 0.29	65 7 S R 1.14
65 2 F G 0.46	65 4 F V 1.24	65 7 F K 0.75	65 9 F Z 1.31	65 2 S O 0.97	65 5 S D 0.36	65 7 S S 1.19
65 2 F H 0.51	65 4 F W 1.24	65 7 F L 0.83	65 10 F A 0.19	65 2 S P 1.01	65 5 S E 0.42	65 7 S T 1.19
65 2 F I 0.59	65 4 F X 1.28	65 7 F M 0.88	65 10 F B 0.23	65 2 S Q 1.04	65 5 S F 0.47	65 7 S U 1.2
65 2 F J 0.64	65 4 F Y 1.29	65 7 F N 0.93	65 10 F C 0.29	65 2 S R 1.09	65 5 S G 0.47	65 7 S V 1.2
65 2 F K 0.69	65 4 F Z 1.32	65 7 F O 0.98	65 10 F D 0.29	65 2 S S 1.11	65 5 S H 0.58	65 7 S W 1.2
65 2 F L 0.78	65 5 F A 0.20	65 7 F P 1.02	65 10 F E 0.40	65 2 S T 1.19	65 5 S I 0.67	65 7 S X 1.3
65 2 F M 0.84	65 5 F B 0.25	65 7 F Q 1.06	65 10 F F 0.40	65 2 S U 1.20	65 5 S J 0.77	65 7 S Y 1.3
65 2 F N 0.87	65 5 F C 0.29	65 7 F R 1.11	65 10 F G 0.45	65 2 S V 1.22	65 5 S K 0.85	65 7 S Z 1.3
65 2 F O 0.92	65 5 F D 0.33	65 7 F S 1.15	65 10 F H 0.59	65 2 S W 1.24	65 5 S L 0.92	65 8 S A 0.1
65 2 F P 0.98	65 5 F E 0.38	65 7 F T 1.17	65 10 F I 0.68	65 2 S X 1.26	65 5 S M 0.97	65 8 S B 0.2
65 2 F Q 1.01	65 5 F F 0.45	65 7 F U 1.20	65 10 F J 0.72	65 2 S Y 1.28	65 5 S N 1.04	65 8 S C 0.3
65 2 F R 1.05	65 5 F G 0.50	65 7 F V 1.22	65 10 F K 0.78	65 2 S Z 1.29	65 5 S O 1.06	65 8 S D 0.3
65 2 F S 1.05	65 5 F H 0.58	65 7 F W 1.25	65 10 F L 0.87	65 3 S A 0.19	65 5 S P 1.12	65 8 S E 0.4
65 2 F T 1.12	65 5 F I 0.65	65 7 F X 1.26	65 10 F M 0.95	65 3 S B 0.24	65 5 S Q 1.16	65 8 S F 0.4
65 2 F U 1.16	65 5 F J 0.65	65 7 F Y 1.27	65 10 F N 0.99	65 3 S C 0.30	65 5 S R 1.20	65 8 S G 0.4
65 2 F V 1.20	65 5 F K 0.77	65 7 F Z 1.31	65 10 F O 1.04	65 3 S D 0.35	65 5 S S 1.23	65 8 S H 0.5
65 2 F W 1.21	65 5 F L 0.85	65 8 F A 0.19	65 10 F P 1.09	65 3 S E 0.40	65 5 S T 1.27	65 8 S I 0.5
65 2 F X 1.22	65 5 F M 0.92	65 8 F B 0.22	65 10 F Q 1.11	65 3 S F 0.44	65 5 S U 1.28	65 8 S J 0.6
65 2 F Y 1.22	65 5 F N 0.97	65 8 F C 0.22	65 10 F R 1.15	65 3 S G 0.48	65 5 S V 1.31	65 8 S K 0.7
65 2 F Z 1.28	65 5 F O 1.03	65 8 F D 0.33	65 10 F S 1.20	65 3 S H 0.54	65 5 S W 1.31	65 8 S L 0.8
65 3 F A 0.19	65 5 F P 1.06	65 8 F E 0.38	65 10 F T 1.20	65 3 S I 0.66	65 5 S X 1.33	65 8 S M 0.8
65 3 F B 0.24	65 5 F Q 1.10	65 8 F F 0.38	65 10 F U 1.25	65 3 S J 0.74	65 5 S Y 1.35	65 8 S N 0.9
65 3 F C 0.29	65 5 F R 1.15	65 8 F G 0.51	65 10 F V 1.27	65 3 S K 0.81	65 5 S Z 1.37	65 8 S O 0.9
65 3 F D 0.29	65 5 F S 1.19	65 8 F H 0.57	65 10 F W 1.30	65 3 S L 0.88	65 6 S A 0.19	65 8 S P 1.0
65 3 F E 0.38	65 5 F T 1.21	65 8 F I 0.64	65 10 F X 1.32	65 3 S M 0.93	65 6 S B 0.24	65 8 S Q 1.0
65 3 F F 0.44	65 5 F U 1.26	65 8 F J 0.71	65 10 F Y 1.33	65 3 S N 0.98	65 6 S C 0.29	65 8 S R 1.1
65 3 F G 0.44	65 5 F V 1.28	65 8 F K 0.78	65 10 F Z 1.35	65 3 S O 1.05	65 6 S D 0.34	65 8 S S 1.1
65 3 F H 0.56	65 5 F W 1.29	65 8 F L 0.84	65 1 S A 0.18	65 3 S P 1.09	65 6 S E 0.41	65 8 S T 1.1
65 3 F I 0.63	65 5 F X 1.31	65 8 F M 0.92	65 1 S B 0.22	65 3 S Q 1.12	65 6 S F 0.43	65 8 S U 1.2
65 3 F J 0.69	65 5 F Y 1.32	65 8 F N 0.96	65 1 S C 0.22	65 3 S R 1.15	65 6 S G 0.48	65 8 S V 1.2
65 3 F K 0.75	65 5 F Z 1.35	65 8 F O 1.02	65 1 S D 0.33	65 3 S S 1.20	65 6 S H 0.54	65 8 S W 1.2
65 3 F L 0.85	65 6 F A 0.21	65 8 F P 1.02	65 1 S E 0.37	65 3 S T 1.23	65 6 S I 0.65	65 8 S X 1.2
65 3 F M 0.91	65 6 F B 0.23	65 8 F Q 1.10	65 1 S F 0.40	65 3 S U 1.27	65 6 S J 0.65	65 8 S Y 1.3
65 3 F N 0.97	65 6 F C 0.28	65 8 F R 1.13	65 1 S G 0.44	65 3 S V 1.28	65 6 S K 0.82	65 8 S Z 1.3
65 3 F O 1.01	65 6 F D 0.33	65 8 F S 1.18	65 1 S H 0.51	65 3 S W 1.29	65 6 S L 0.88	65 9 S A 0.1

65 9 S B 0.23	65 1 D Q 1.02	65 4 D F 0.43	65 6 D U 1.19	65 9 D J 0.75
65 9 S C 0.30	65 1 D R 1.06	65 4 D G 0.48	65 6 D V 1.20	65 9 D K 0.80
65 9 S D 0.36	65 1 D S 1.11	65 4 D H 0.55	65 6 D W 1.22	65 9 D L 0.89
65 9 S E 0.42	65 1 D T 1.14	65 4 D I 0.61	65 6 D X 1.23	65 9 D M 0.97
65 9 S F 0.46	65 1 D U 1.19	65 4 D J 0.67	65 6 D Y 1.26	65 9 D N 1.00
65 9 S G 0.50	65 1 D V 1.22	65 4 D K 0.73	65 6 D Z 1.26	65 9 D O 1.04
65 9 S H 0.57	65 1 D W 1.24	65 4 D L 0.79	65 7 D A 0.20	65 9 D P 1.11
65 9 S I 0.65	65 1 D X 1.26	65 4 D M 0.86	65 7 D B 0.23	65 9 D Q 1.15
65 9 S J 0.65	65 1 D Y 1.26	65 4 D N 0.92	65 7 D C 0.29	65 9 D R 1.19
65 9 S K 0.83	65 1 D Z 1.26	65 4 D O 0.96	65 7 D D 0.33	65 9 D S 1.22
65 9 S L 0.83	65 2 D A 0.19	65 4 D P 1.00	65 7 D E 0.37	65 9 D T 1.24
65 9 S M 0.94	65 2 D B 0.22	65 4 D Q 1.05	65 7 D F 0.42	65 9 D U 1.26
65 9 S N 0.98	65 2 D C 0.27	65 4 D R 1.08	65 7 D G 0.46	65 9 D V 1.27
65 9 S O 1.04	65 2 D D 0.32	65 4 D S 1.14	65 7 D H 0.53	65 9 D W 1.28
65 9 S P 1.08	65 2 D E 0.36	65 4 D T 1.15	65 7 D I 0.62	65 9 D X 1.29
65 9 S Q 1.12	65 2 D F 0.40	65 4 D U 1.20	65 7 D J 0.70	65 9 D Y 1.30
65 9 S R 1.16	65 2 D G 0.46	65 4 D V 1.21	65 7 D K 0.75	65 9 D Z 1.30
65 9 S S 1.19	65 2 D H 0.52	65 4 D W 1.24	65 7 D L 0.82	65 10 D A 0.19
65 9 S T 1.23	65 2 D I 0.62	65 4 D X 1.25	65 7 D M 0.89	65 10 D B 0.24
65 9 S U 1.26	65 2 D J 0.70	65 4 D Y 1.27	65 7 D N 0.93	65 10 D C 0.28
65 9 S V 1.27	65 2 D K 0.76	65 4 D Z 1.29	65 7 D O 0.98	65 10 D D 0.34
65 9 S W 1.30	65 2 D L 0.85	65 5 D A 0.19	65 7 D P 1.04	65 10 D E 0.39
65 9 S X 1.31	65 2 D M 0.89	65 5 D B 0.22	65 7 D Q 1.08	65 10 D F 0.43
65 9 S Y 1.33	65 2 D N 0.95	65 5 D C 0.28	65 7 D R 1.12	65 10 D G 0.49
65 9 S Z 1.35	65 2 D O 0.99	65 5 D D 0.33	65 7 D S 1.17	65 10 D H 0.56
65 10 S A 0.19	65 2 D P 1.04	65 5 D E 0.38	65 7 D T 1.18	65 10 D I 0.64
65 10 S B 0.26	65 2 D Q 1.08	65 5 D F 0.43	65 7 D U 1.21	65 10 D J 0.72
65 10 S C 0.31	65 2 D R 1.11	65 5 D G 0.48	65 7 D V 1.25	65 10 D K 0.77
65 10 S D 0.36	65 2 D S 1.11	65 5 D H 0.57	65 7 D W 1.26	65 10 D L 0.77
65 10 S E 0.43	65 2 D T 1.18	65 5 D I 0.68	65 7 D X 1.26	65 10 D M 0.92
65 10 S F 0.46	65 2 D U 1.20	65 5 D J 0.77	65 7 D Y 1.28	65 10 D N 0.98
65 10 S G 0.50	65 2 D V 1.22	65 5 D K 0.81	65 7 D Z 1.28	65 10 D O 1.00
65 10 S H 0.57	65 2 D W 1.23	65 5 D L 0.89	65 8 D A 0.19	65 10 D P 1.04
65 10 S I 0.69	65 2 D X 1.25	65 5 D M 0.96	65 8 D B 0.23	65 10 D Q 1.10
65 10 S J 0.79	65 2 D Y 1.25	65 5 D N 1.01	65 8 D C 0.29	65 10 D R 1.12
65 10 S K 0.88	65 2 D Z 1.25	65 5 D O 1.07	65 8 D D 0.33	65 10 D S 1.17
65 10 S L 0.94	65 3 D A 0.19	65 5 D P 1.11	65 8 D E 0.37	65 10 D T 1.18
65 10 S M 1.03	65 3 D B 0.24	65 5 D Q 1.14	65 8 D F 0.42	65 10 D U 1.24
65 10 S N 1.06	65 3 D C 0.28	65 5 D R 1.19	65 8 D G 0.47	65 10 D V 1.25
65 10 S O 1.10	65 3 D D 0.28	65 5 D S 1.23	65 8 D H 0.54	65 10 D W 1.26
65 10 S P 1.15	65 3 D E 0.39	65 5 D T 1.27	65 8 D I 0.67	65 10 D X 1.29
65 10 S Q 1.18	65 3 D F 0.44	65 5 D U 1.27	65 8 D J 0.77	65 10 D Y 1.30
65 10 S R 1.21	65 3 D G 0.48	65 5 D V 1.29	65 8 D K 0.84	65 10 D Z 1.31
65 10 S S 1.23	65 3 D H 0.54	65 5 D W 1.31	65 8 D L 0.95	
65 10 S T 1.25	65 3 D I 0.61	65 5 D X 1.31	65 8 D M 1.04	
65 10 S U 1.29	65 3 D J 0.68	65 5 D Y 1.31	65 8 D N 1.07	
65 10 S V 1.33	65 3 D K 0.72	65 5 D Z 1.31	65 8 D O 1.13	
65 10 S W 1.33	65 3 D L 0.79	65 6 D A 0.18	65 8 D P 1.16	
65 10 S X 1.34	65 3 D M 0.89	65 6 D B 0.23	65 8 D Q 1.19	
65 10 S Y 1.36	65 3 D N 0.91	65 6 D C 0.28	65 8 D R 1.20	
65 10 S Z 1.38	65 3 D O 0.98	65 6 D D 0.32	65 8 D S 1.24	
65 1 D A 0.18	65 3 D P 1.02	65 6 D E 0.37	65 8 D T 1.25	
65 1 D B 0.24	65 3 D Q 1.08	65 6 D F 0.42	65 8 D U 1.25	
65 1 D C 0.27	65 3 D R 1.14	65 6 D G 0.47	65 8 D V 1.29	
65 1 D D 0.33	65 3 D S 1.16	65 6 D H 0.53	65 8 D W 1.29	
65 1 D E 0.36	65 3 D T 1.19	65 6 D I 0.60	65 8 D X 1.31	
65 1 D F 0.41	65 3 D U 1.21	65 6 D J 0.67	65 8 D Y 1.31	
65 1 D G 0.46	65 3 D V 1.25	65 6 D K 0.73	65 8 D Z 1.31	
65 1 D H 0.51	65 3 D W 1.26	65 6 D L 0.79	65 9 D A 0.19	
65 1 D I 0.59	65 3 D X 1.27	65 6 D M 0.79	65 9 D B 0.24	
65 1 D J 0.64	65 3 D Y 1.27	65 6 D N 0.90	65 9 D C 0.30	
65 1 D K 0.70	65 3 D Z 1.28	65 6 D O 0.90	65 9 D D 0.34	
65 1 D L 0.78	65 4 D A 0.18	65 6 D P 0.99	65 9 D E 0.39	
65 1 D M 0.84	65 4 D B 0.23	65 6 D Q 1.04	65 9 D F 0.43	
65 1 D N 0.88	65 4 D C 0.28	65 6 D R 1.08	65 9 D G 0.49	
65 1 D O 0.94	65 4 D D 0.34	65 6 D S 1.14	65 9 D H 0.54	
65 1 D P 1.00	65 4 D E 0.38	65 6 D T 1.16	65 9 D I 0.66	

DENSITY MEASUREMENTS
85 LPI

	85 1 F Y 1.30	85 4 F N 0.96	85 7 F C 0.25	85 9 F R 0.99	85 2 S G 0.41
	85 1 F Z 1.30	85 4 F O 0.96	85 7 F D 0.29	85 9 F S 1.03	85 2 S H 0.47
	85 2 F A 0.18	85 4 F P 1.07	85 7 F E 0.34	85 9 F T 1.03	85 2 S I 0.54
	85 2 F B 0.18	85 4 F Q 1.07	85 7 F F 0.40	85 9 F U 1.09	85 2 S J 0.66
	85 2 F C 0.20	85 4 F R 1.11	85 7 F G 0.46	85 9 F V 1.14	85 2 S K 0.72
	85 2 F D 0.26	85 4 F S 1.13	85 7 F H 0.52	85 9 F W 1.16	85 2 S L 0.81
	85 2 F E 0.33	85 4 F T 1.13	85 7 F I 0.52	85 9 F X 1.18	85 2 S M 0.91
	85 2 F F 0.38	85 4 F U 1.20	85 7 F J 0.61	85 9 F Y 1.18	85 2 S N 1.01
	85 2 F G 0.44	85 4 F V 1.22	85 7 F K 0.76	85 9 F Z 1.22	85 2 S O 1.07
	85 2 F H 0.50	85 4 F W 1.26	85 7 F L 0.85	85 10 F A 0.19	85 2 S P 1.17
	85 2 F I 0.56	85 4 F X 1.27	85 7 F M 0.85	85 10 F B 0.21	85 2 S Q 1.23
	85 2 F J 0.63	85 4 F Y 1.28	85 7 F N 0.94	85 10 F C 0.24	85 2 S R 1.26
	85 2 F K 0.69	85 4 F Z 1.29	85 7 F O 1.03	85 10 F D 0.24	85 2 S S 1.30
	85 2 F L 0.74	85 5 F A 0.19	85 7 F P 1.10	85 10 F E 0.28	85 2 S T 1.31
	85 2 F M 0.78	85 5 F B 0.20	85 7 F Q 1.10	85 10 F F 0.37	85 2 S U 1.31
	85 2 F N 0.82	85 5 F C 0.24	85 7 F R 1.12	85 10 F G 0.41	85 2 S V 1.31
	85 2 F O 0.89	85 5 F D 0.29	85 7 F S 1.17	85 10 F H 0.46	85 2 S W 1.34
	85 2 F P 0.94	85 5 F E 0.29	85 7 F T 1.17	85 10 F I 0.52	85 2 S X 1.34
	85 2 F Q 1.02	85 5 F F 0.40	85 7 F U 1.20	85 10 F J 0.57	85 2 S Y 1.34
	85 2 F R 1.07	85 5 F G 0.45	85 7 F V 1.25	85 10 F K 0.57	85 2 S Z 1.34
	85 2 F S 1.12	85 5 F H 0.51	85 7 F W 1.25	85 10 F L 0.71	85 3 S A 0.19
	85 2 F T 1.15	85 5 F I 0.58	85 7 F X 1.28	85 10 F M 0.78	85 3 S B 0.19
	85 2 F U 1.19	85 5 F J 0.63	85 7 F Y 1.28	85 10 F N 0.84	85 3 S C 0.21
	85 2 F V 1.25	85 5 F K 0.70	85 7 F Z 1.29	85 10 F O 0.89	85 3 S D 0.25
	85 2 F W 1.28	85 5 F L 0.80	85 8 F A 0.19	85 10 F P 0.94	85 3 S E 0.29
	85 2 F X 1.28	85 5 F M 0.80	85 8 F B 0.21	85 10 F Q 0.97	85 3 S F 0.33
	85 2 F Y 1.29	85 5 F N 0.93	85 8 F C 0.25	85 10 F R 0.97	85 3 S G 0.37
	85 2 F Z 1.32	85 5 F O 1.00	85 8 F D 0.29	85 10 F S 0.97	85 3 S H 0.42
	85 3 F A 0.19	85 5 F P 1.03	85 8 F E 0.36	85 10 F T 1.06	85 3 S I 0.46
	85 3 F B 0.19	85 5 F Q 1.03	85 8 F F 0.39	85 10 F U 1.08	85 3 S J 0.51
	85 3 F C 0.26	85 5 F R 1.06	85 8 F G 0.45	85 10 F V 1.13	85 3 S K 0.57
	85 3 F D 0.31	85 5 F S 1.12	85 8 F H 0.45	85 10 F W 1.16	85 3 S L 0.63
	85 3 F E 0.31	85 5 F T 1.14	85 8 F I 0.55	85 10 F X 1.18	85 3 S M 0.68
	85 3 F F 0.40	85 5 F U 1.17	85 8 F J 0.62	85 10 F Y 1.18	85 3 S N 0.72
	85 3 F G 0.43	85 5 F V 1.22	85 8 F K 0.67	85 10 F Z 1.23	85 3 S O 0.79
	85 3 F H 0.51	85 5 F W 1.23	85 8 F L 0.78	85 1 S A 0.17	85 3 S P 0.83
	85 3 F I 0.51	85 5 F X 1.23	85 8 F M 0.85	85 1 S B 0.18	85 3 S Q 0.90
	85 3 F J 0.62	85 5 F Y 1.26	85 8 F N 0.92	85 1 S C 0.21	85 3 S R 0.92
	85 3 F K 0.70	85 5 F Z 1.28	85 8 F O 0.96	85 1 S D 0.26	85 3 S S 0.96
	85 3 F L 0.78	85 6 F A 0.18	85 8 F P 1.02	85 1 S E 0.26	85 3 S T 0.99
	85 3 F M 0.84	85 6 F B 0.18	85 8 F Q 1.03	85 1 S F 0.32	85 3 S U 1.01
	85 3 F N 0.88	85 6 F C 0.21	85 8 F R 1.05	85 1 S G 0.41	85 3 S V 1.05
	85 3 F O 0.92	85 6 F D 0.27	85 8 F S 1.10	85 1 S H 0.46	85 3 S W 1.06
85 1 F A 0.18	85 3 F P 0.94	85 6 F E 0.34	85 8 F T 1.12	85 1 S I 0.52	85 3 S X 1.10
85 1 F B 0.20	85 3 F Q 0.97	85 6 F F 0.34	85 8 F U 1.16	85 1 S J 0.58	85 3 S Y 1.15
85 1 F C 0.25	85 3 F R 0.97	85 6 F G 0.43	85 8 F V 1.20	85 1 S K 0.68	85 3 S Z 1.16
85 1 F D 0.28	85 3 F S 1.05	85 6 F H 0.50	85 8 F W 1.23	85 1 S L 0.75	85 4 S A 0.19
85 1 F E 0.35	85 3 F T 1.09	85 6 F I 0.56	85 8 F X 1.24	85 1 S M 0.82	85 4 S B 0.19
85 1 F F 0.42	85 3 F U 1.14	85 6 F J 0.64	85 8 F Y 1.25	85 1 S N 0.88	85 4 S C 0.21
85 1 F G 0.46	85 3 F V 1.16	85 6 F K 0.70	85 8 F Z 1.25	85 1 S O 0.97	85 4 S D 0.27
85 1 F H 0.51	85 3 F W 1.19	85 6 F L 0.75	85 9 F A 0.19	85 1 S P 1.04	85 4 S E 0.33
85 1 F I 0.60	85 3 F X 1.21	85 6 F M 0.80	85 9 F B 0.21	85 1 S Q 1.04	85 4 S F 0.37
85 1 F J 0.67	85 3 F Y 1.21	85 6 F N 0.85	85 9 F C 0.24	85 1 S R 1.15	85 4 S G 0.43
85 1 F K 0.75	85 3 F Z 1.21	85 6 F O 0.85	85 9 F D 0.28	85 1 S S 1.15	85 4 S H 0.48
85 1 F L 0.84	85 4 F A 0.19	85 6 F P 0.96	85 9 F E 0.33	85 1 S T 1.19	85 4 S I 0.54
85 1 F M 0.91	85 4 F B 0.20	85 6 F Q 1.01	85 9 F F 0.38	85 1 S U 1.22	85 4 S J 0.58
85 1 F N 0.99	85 4 F C 0.24	85 6 F R 1.08	85 9 F G 0.41	85 1 S V 1.22	85 4 S K 0.65
85 1 F O 1.03	85 4 F D 0.29	85 6 F S 1.15	85 9 F H 0.46	85 1 S W 1.23	85 4 S L 0.71
85 1 F P 1.07	85 4 F E 0.35	85 6 F T 1.18	85 9 F I 0.52	85 1 S X 1.26	85 4 S M 0.77
85 1 F Q 1.09	85 4 F F 0.41	85 6 F U 1.20	85 9 F J 0.52	85 1 S Y 1.27	85 4 S N 0.83
85 1 F R 1.12	85 4 F G 0.47	85 6 F V 1.22	85 9 F K 0.58	85 1 S Z 1.28	85 4 S O 0.90
85 1 F S 1.15	85 4 F H 0.52	85 6 F W 1.24	85 9 F L 0.63	85 2 S A 0.18	85 4 S P 0.96
85 1 F T 1.18	85 4 F I 0.60	85 6 F X 1.25	85 9 F M 0.79	85 2 S B 0.19	85 4 S Q 1.02
85 1 F U 1.20	85 4 F J 0.66	85 6 F Y 1.26	85 9 F N 0.84	85 2 S C 0.19	85 4 S R 1.08
85 1 F V 1.25	85 4 F K 0.73	85 6 F Z 1.29	85 9 F O 0.89	85 2 S D 0.27	85 4 S S 1.09
85 1 F W 1.26	85 4 F L 0.82	85 7 F A 0.18	85 9 F P 0.94	85 2 S E 0.32	85 4 S T 1.14
85 1 F X 1.27	85 4 F M 0.92	85 7 F B 0.19	85 9 F Q 0.97	85 2 S F 0.37	85 4 S U 1.17

85 4 S V 1.17	85 7 S K 0.72	85 9 S Z 1.16	85 2 D O 1.14	85 5 D D 0.29	85 7 D S 1.16
85 4 S W 1.22	85 7 S L 0.76	85 10 S A 0.20	85 2 D P 1.17	85 5 D E 0.33	85 7 D T 1.17
85 4 S X 1.23	85 7 S M 0.84	85 10 S B 0.20	85 2 D Q 1.23	85 5 D F 0.38	85 7 D U 1.20
85 4 S Y 1.25	85 7 S N 0.88	85 10 S C 0.21	85 2 D R 1.27	85 5 D G 0.43	85 7 D V 1.21
85 4 S Z 1.25	85 7 S O 0.98	85 10 S D 0.25	85 2 D S 1.31	85 5 D H 0.48	85 7 D W 1.25
85 5 S A 0.18	85 7 S P 1.04	85 10 S E 0.25	85 2 D T 1.32	85 5 D I 0.53	85 7 D X 1.26
85 5 S B 0.18	85 7 S Q 1.09	85 10 S F 0.33	85 2 D U 1.33	85 5 D J 0.59	85 7 D Y 1.27
85 5 S C 0.21	85 7 S R 1.09	85 10 S G 0.37	85 2 D V 1.33	85 5 D K 0.63	85 7 D Z 1.27
85 5 S D 0.27	85 7 S S 1.16	85 10 S H 0.41	85 2 D W 1.33	85 5 D L 0.69	85 8 D A 0.19
85 5 S E 0.31	85 7 S T 1.18	85 10 S I 0.46	85 2 D X 1.35	85 5 D M 0.77	85 8 D B 0.19
85 5 S F 0.35	85 7 S U 1.20	85 10 S J 0.51	85 2 D Y 1.35	85 5 D N 0.80	85 8 D C 0.22
85 5 S G 0.40	85 7 S V 1.22	85 10 S K 0.56	85 2 D Z 1.35	85 5 D O 0.87	85 8 D D 0.28
85 5 S H 0.46	85 7 S W 1.23	85 10 S L 0.56	85 3 D A 0.19	85 5 D P 0.96	85 8 D E 0.32
85 5 S I 0.51	85 7 S X 1.24	85 10 S M 0.68	85 3 D B 0.19	85 5 D Q 0.99	85 8 D F 0.36
85 5 S J 0.57	85 7 S Y 1.26	85 10 S N 0.73	85 3 D C 0.20	85 5 D R 1.03	85 8 D G 0.40
85 5 S K 0.63	85 7 S Z 1.26	85 10 S O 0.73	85 3 D D 0.26	85 5 D S 1.08	85 8 D H 0.46
85 5 S L 0.70	85 8 S A 0.19	85 10 S P 0.73	85 3 D E 0.30	85 5 D T 1.10	85 8 D I 0.50
85 5 S M 0.76	85 8 S B 0.20	85 10 S Q 0.92	85 3 D F 0.30	85 5 D U 1.13	85 8 D J 0.57
85 5 S N 0.83	85 8 S C 0.20	85 10 S R 0.95	85 3 D G 0.37	85 5 D V 1.16	85 8 D K 0.65
85 5 S O 0.87	85 8 S D 0.21	85 10 S S 0.97	85 3 D H 0.41	85 5 D W 1.20	85 8 D L 0.69
85 5 S P 0.93	85 8 S E 0.31	85 10 S T 0.99	85 3 D I 0.45	85 5 D X 1.24	85 8 D M 0.76
85 5 S Q 1.02	85 8 S F 0.31	85 10 S U 0.99	85 3 D J 0.53	85 5 D Y 1.30	85 8 D N 0.79
85 5 S R 1.07	85 8 S G 0.41	85 10 S V 1.06	85 3 D K 0.58	85 5 D Z 1.30	85 8 D O 0.87
85 5 S S 1.09	85 8 S H 0.45	85 10 S W 1.06	85 3 D L 0.65	85 6 D A 0.19	85 8 D P 0.87
85 5 S T 1.13	85 8 S I 0.52	85 10 S X 1.06	85 3 D M 0.71	85 6 D B 0.20	85 8 D Q 0.96
85 5 S U 1.14	85 8 S J 0.56	85 10 S Y 1.09	85 3 D N 0.75	85 6 D C 0.23	85 8 D R 1.01
85 5 S V 1.17	85 8 S K 0.64	85 10 S Z 1.09	85 3 D O 0.75	85 6 D D 0.34	85 8 D S 1.05
85 5 S W 1.19	85 8 S L 0.69	85 1 D A 0.18	85 3 D P 0.85	85 6 D E 0.34	85 8 D T 1.06
85 5 S X 1.21	85 8 S M 0.76	85 1 D B 0.19	85 3 D Q 0.90	85 6 D F 0.47	85 8 D U 1.09
85 5 S Y 1.24	85 8 S N 0.76	85 1 D C 0.25	85 3 D R 0.94	85 6 D G 0.54	85 8 D V 1.11
85 5 S Z 1.25	85 8 S O 0.90	85 1 D D 0.31	85 3 D S 0.97	85 6 D H 0.58	85 8 D W 1.16
85 6 S A 0.18	85 8 S P 0.90	85 1 D E 0.31	85 3 D T 0.97	85 6 D I 0.65	85 8 D X 1.19
85 6 S B 0.20	85 8 S Q 1.03	85 1 D F 0.37	85 3 D U 0.99	85 6 D J 0.65	85 8 D Y 1.23
85 6 S C 0.22	85 8 S R 1.05	85 1 D G 0.38	85 3 D V 1.04	85 6 D K 0.90	85 8 D Z 1.24
85 6 S D 0.22	85 8 S S 1.10	85 1 D H 0.44	85 3 D W 1.06	85 6 D L 1.01	85 9 D A 0.18
85 6 S E 0.34	85 8 S T 1.11	85 1 D I 0.51	85 3 D X 1.10	85 6 D M 1.09	85 9 D B 0.19
85 6 S F 0.39	85 8 S U 1.14	85 1 D J 0.56	85 3 D Y 1.14	85 6 D N 1.09	85 9 D C 0.21
85 6 S G 0.44	85 8 S V 1.14	85 1 D K 0.65	85 3 D Z 1.18	85 6 D O 1.15	85 9 D D 0.27
85 6 S H 0.49	85 8 S W 1.18	85 1 D L 0.70	85 4 D A 0.18	85 6 D P 1.23	85 9 D E 0.31
85 6 S I 0.55	85 8 S X 1.20	85 1 D M 0.78	85 4 D B 0.18	85 6 D Q 1.28	85 9 D F 0.35
85 6 S J 0.66	85 8 S Y 1.24	85 1 D N 0.86	85 4 D C 0.22	85 6 D R 1.29	85 9 D G 0.38
85 6 S K 0.74	85 8 S Z 1.24	85 1 D O 0.91	85 4 D D 0.28	85 6 D S 1.32	85 9 D H 0.38
85 6 S L 0.85	85 9 S A 0.19	85 1 D P 0.97	85 4 D E 0.34	85 6 D T 1.35	85 9 D I 0.47
85 6 S M 0.92	85 9 S B 0.20	85 1 D Q 1.06	85 4 D F 0.38	85 6 D U 1.35	85 9 D J 0.55
85 6 S N 1.01	85 9 S C 0.21	85 1 D R 1.11	85 4 D G 0.42	85 6 D V 1.35	85 9 D K 0.60
85 6 S O 1.01	85 9 S D 0.26	85 1 D S 1.14	85 4 D H 0.48	85 6 D W 1.35	85 9 D L 0.65
85 6 S P 1.16	85 9 S E 0.29	85 1 D T 1.17	85 4 D I 0.53	85 6 D X 1.36	85 9 D M 0.73
85 6 S Q 1.24	85 9 S F 0.33	85 1 D U 1.19	85 4 D J 0.62	85 6 D Y 1.37	85 9 D N 0.77
85 6 S R 1.27	85 9 S G 0.37	85 1 D V 1.21	85 4 D K 0.68	85 6 D Z 1.37	85 9 D O 0.82
85 6 S S 1.28	85 9 S H 0.40	85 1 D W 1.23	85 4 D L 0.68	85 7 D A 0.17	85 9 D P 0.88
85 6 S T 1.29	85 9 S I 0.45	85 1 D X 1.28	85 4 D M 0.80	85 7 D B 0.17	85 9 D Q 0.91
85 6 S U 1.32	85 9 S J 0.51	85 1 D Y 1.28	85 4 D N 0.86	85 7 D C 0.22	85 9 D R 0.95
85 6 S V 1.33	85 9 S K 0.51	85 1 D Z 1.29	85 4 D O 0.92	85 7 D D 0.29	85 9 D S 0.95
85 6 S W 1.34	85 9 S L 0.62	85 2 D A 0.17	85 4 D P 0.99	85 7 D E 0.35	85 9 D T 0.99
85 6 S X 1.34	85 9 S M 0.68	85 2 D B 0.18	85 4 D Q 1.04	85 7 D F 0.39	85 9 D U 0.99
85 6 S Y 1.34	85 9 S N 0.73	85 2 D C 0.21	85 4 D R 1.06	85 7 D G 0.44	85 9 D V 1.02
85 6 S Z 1.34	85 9 S O 0.80	85 2 D D 0.29	85 4 D S 1.10	85 7 D H 0.50	85 9 D W 1.05
85 7 S A 0.19	85 9 S P 0.84	85 2 D E 0.38	85 4 D T 1.11	85 7 D I 0.56	85 9 D X 1.10
85 7 S B 0.19	85 9 S Q 0.84	85 2 D F 0.46	85 4 D U 1.15	85 7 D J 0.56	85 9 D Y 1.10
85 7 S C 0.21	85 9 S R 0.94	85 2 D G 0.51	85 4 D V 1.17	85 7 D K 0.73	85 9 D Z 1.17
85 7 S D 0.28	85 9 S S 0.97	85 2 D H 0.56	85 4 D W 1.22	85 7 D L 0.79	85 10 D A 0.19
85 7 S E 0.32	85 9 S T 0.99	85 2 D I 0.63	85 4 D X 1.24	85 7 D M 0.79	85 10 D B 0.19
85 7 S F 0.32	85 9 S U 1.02	85 2 D J 0.78	85 4 D Y 1.26	85 7 D N 0.98	85 10 D C 0.22
85 7 S G 0.36	85 9 S V 1.05	85 2 D K 0.88	85 4 D Z 1.26	85 7 D O 0.98	85 10 D D 0.27
85 7 S H 0.46	85 9 S W 1.06	85 2 D L 0.98	85 5 D A 0.19	85 7 D P 1.06	85 10 D E 0.27
85 7 S I 0.52	85 9 S X 1.09	85 2 D M 1.04	85 5 D B 0.19	85 7 D Q 1.10	85 10 D F 0.35
85 7 S J 0.59	85 9 S Y 1.14	85 2 D N 1.09	85 5 D C 0.22	85 7 D R 1.10	85 10 D G 0.38

85	10	D	H	0.44
85	10	D	I	0.47
85	10	D	J	0.54
85	10	D	K	0.59
85	10	D	L	0.66
85	10	D	M	0.73
85	10	D	N	0.77
85	10	D	O	0.81
85	10	D	P	0.88
85	10	D	Q	0.88
85	10	D	R	0.95
85	10	D	S	0.97
85	10	D	T	0.97
85	10	D	U	1.00
85	10	D	V	1.01
85	10	D	W	1.06
85	10	D	X	1.11
85	10	D	Y	1.15
85	10	D	Z	1.17

DENSITY MEASUREMENTS
100 LPI

	100 2 F W 1.27	100 5 F L 0.78	100 8 F A 0.19	100 10 F P 0.91	100 3 S E 0.34
	100 2 F X 1.30	100 5 F M 0.83	100 8 F B 0.19	100 10 F Q 1.03	100 3 S F 0.39
	100 2 F Y 1.30	100 5 F N 0.87	100 8 F C 0.19	100 10 F R 1.07	100 3 S G 0.39
	100 2 F Z 1.31	100 5 F O 0.93	100 8 F D 0.30	100 10 F S 1.13	100 3 S H 0.43
	100 3 F A 0.18	100 5 F P 1.00	100 8 F E 0.35	100 10 F T 1.15	100 3 S I 0.54
	100 3 F B 0.19	100 5 F Q 1.05	100 8 F F 0.40	100 10 F U 1.20	100 3 S J 0.66
	100 3 F C 0.21	100 5 F R 1.05	100 8 F G 0.46	100 10 F V 1.26	100 3 S K 0.75
	100 3 F D 0.21	100 5 F S 1.17	100 8 F H 0.52	100 10 F W 1.29	100 3 S L 0.84
	100 3 F E 0.35	100 5 F T 1.20	100 8 F I 0.56	100 10 F X 1.29	100 3 S M 0.92
	100 3 F F 0.40	100 5 F U 1.20	100 8 F J 0.67	100 10 F Y 1.30	100 3 S N 1.02
	100 3 F G 0.44	100 5 F V 1.28	100 8 F K 0.72	100 10 F Z 1.33	100 3 S O 1.10
	100 3 F H 0.52	100 5 F W 1.30	100 8 F L 0.77	100 1 S A 0.18	100 3 S P 1.17
	100 3 F I 0.57	100 5 F X 1.32	100 8 F M 0.81	100 1 S B 0.19	100 3 S Q 1.25
	100 3 F J 0.64	100 5 F Y 1.33	100 8 F N 0.85	100 1 S C 0.22	100 3 S R 1.28
	100 3 F K 0.64	100 5 F Z 1.36	100 8 F O 0.90	100 1 S D 0.29	100 3 S S 1.31
	100 3 F L 0.76	100 6 F A 0.19	100 8 F P 0.97	100 1 S E 0.38	100 3 S T 1.35
	100 3 F M 0.81	100 6 F B 0.19	100 8 F Q 1.03	100 1 S F 0.43	100 3 S U 1.35
	100 3 F N 0.86	100 6 F C 0.22	100 8 F R 1.10	100 1 S G 0.48	100 3 S V 1.35
	100 3 F O 0.91	100 6 F D 0.28	100 8 F S 1.16	100 1 S H 0.55	100 3 S W 1.35
100 1 F A 0.19	100 3 F P 0.97	100 6 F E 0.35	100 8 F T 1.18	100 1 S I 0.63	100 3 S X 1.35
100 1 F B 0.19	100 3 F Q 1.02	100 6 F F 0.40	100 8 F U 1.18	100 1 S J 0.76	100 3 S Y 1.35
100 1 F C 0.19	100 3 F R 1.09	100 6 F G 0.45	100 8 F V 1.26	100 1 S K 0.85	100 3 S Z 1.35
100 1 F D 0.30	100 3 F S 1.16	100 6 F H 0.50	100 8 F W 1.29	100 1 S L 0.95	100 4 S A 0.19
100 1 F E 0.38	100 3 F T 1.19	100 6 F I 0.50	100 8 F X 1.29	100 1 S M 1.04	100 4 S B 0.19
100 1 F F 0.44	100 3 F U 1.21	100 6 F J 0.65	100 8 F Y 1.31	100 1 S N 1.11	100 4 S C 0.19
100 1 F G 0.50	100 3 F V 1.25	100 6 F K 0.71	100 8 F Z 1.31	100 1 S O 1.11	100 4 S D 0.28
100 1 F H 0.58	100 3 F W 1.27	100 6 F L 0.76	100 9 F A 0.19	100 1 S P 1.24	100 4 S E 0.34
100 1 F I 0.58	100 3 F X 1.30	100 6 F M 0.82	100 9 F B 0.20	100 1 S Q 1.27	100 4 S F 0.34
100 1 F J 0.72	100 3 F Y 1.32	100 6 F N 0.82	100 9 F C 0.22	100 1 S R 1.31	100 4 S G 0.42
100 1 F K 0.72	100 3 F Z 1.34	100 6 F O 0.92	100 9 F D 0.22	100 1 S S 1.34	100 4 S H 0.49
100 1 F L 0.85	100 4 F A 0.18	100 6 F P 0.98	100 9 F E 0.36	100 1 S T 1.34	100 4 S I 0.49
100 1 F M 0.88	100 4 F B 0.19	100 6 F Q 1.04	100 9 F F 0.36	100 1 S U 1.34	100 4 S J 0.69
100 1 F N 0.93	100 4 F C 0.21	100 6 F R 1.10	100 9 F G 0.46	100 1 S V 1.34	100 4 S K 0.69
100 1 F O 0.98	100 4 F D 0.21	100 6 F S 1.16	100 9 F H 0.54	100 1 S W 1.34	100 4 S L 0.84
100 1 F P 1.03	100 4 F E 0.33	100 6 F T 1.19	100 9 F I 0.60	100 1 S X 1.35	100 4 S M 0.92
100 1 F Q 1.11	100 4 F F 0.40	100 6 F U 1.22	100 9 F J 0.66	100 1 S Y 1.35	100 4 S N 1.02
100 1 F R 1.14	100 4 F G 0.44	100 6 F V 1.28	100 9 F K 0.66	100 1 S Z 1.35	100 4 S O 1.08
100 1 F S 1.21	100 4 F H 0.50	100 6 F W 1.29	100 9 F L 0.72	100 2 S A 0.18	100 4 S P 1.08
100 1 F T 1.23	100 4 F I 0.57	100 6 F X 1.31	100 9 F M 0.81	100 2 S B 0.19	100 4 S Q 1.24
100 1 F U 1.26	100 4 F J 0.65	100 6 F Y 1.33	100 9 F N 0.84	100 2 S C 0.19	100 4 S R 1.30
100 1 F V 1.29	100 4 F K 0.71	100 6 F Z 1.34	100 9 F O 0.89	100 2 S D 0.28	100 4 S S 1.33
100 1 F W 1.30	100 4 F L 0.76	100 7 F A 0.19	100 9 F P 0.98	100 2 S E 0.35	100 4 S T 1.33
100 1 F X 1.32	100 4 F M 0.80	100 7 F B 0.20	100 9 F Q 1.04	100 2 S F 0.39	100 4 S U 1.35
100 1 F Y 1.33	100 4 F N 0.85	100 7 F C 0.21	100 9 F R 1.08	100 2 S G 0.44	100 4 S V 1.35
100 1 F Z 1.34	100 4 F O 0.85	100 7 F D 0.21	100 9 F S 1.14	100 2 S H 0.50	100 4 S W 1.35
100 2 F A 0.18	100 4 F P 0.96	100 7 F E 0.34	100 9 F T 1.17	100 2 S I 0.56	100 4 S X 1.35
100 2 F B 0.18	100 4 F Q 1.03	100 7 F F 0.40	100 9 F U 1.20	100 2 S J 0.68	100 4 S Y 1.35
100 2 F C 0.18	100 4 F R 1.10	100 7 F G 0.45	100 9 F V 1.25	100 2 S K 0.76	100 4 S Z 1.36
100 2 F D 0.28	100 4 F S 1.17	100 7 F H 0.45	100 9 F W 1.25	100 2 S L 0.85	100 5 S A 0.19
100 2 F E 0.35	100 4 F T 1.20	100 7 F I 0.55	100 9 F X 1.27	100 2 S M 0.85	100 5 S B 0.20
100 2 F F 0.39	100 4 F U 1.20	100 7 F J 0.65	100 9 F Y 1.30	100 2 S N 1.00	100 5 S C 0.23
100 2 F G 0.45	100 4 F V 1.28	100 7 F K 0.70	100 9 F Z 1.31	100 2 S O 1.09	100 5 S D 0.29
100 2 F H 0.50	100 4 F W 1.29	100 7 F L 0.77	100 10 F A 0.19	100 2 S P 1.16	100 5 S E 0.35
100 2 F I 0.57	100 4 F X 1.31	100 7 F M 0.77	100 10 F B 0.19	100 2 S Q 1.24	100 5 S F 0.40
100 2 F J 0.64	100 4 F Y 1.33	100 7 F N 0.87	100 10 F C 0.21	100 2 S R 1.27	100 5 S G 0.44
100 2 F K 0.70	100 4 F Z 1.33	100 7 F O 0.91	100 10 F D 0.21	100 2 S S 1.30	100 5 S H 0.49
100 2 F L 0.70	100 5 F A 0.18	100 7 F P 0.96	100 10 F E 0.34	100 2 S T 1.32	100 5 S I 0.57
100 2 F M 0.70	100 5 F B 0.19	100 7 F Q 1.02	100 10 F F 0.34	100 2 S U 1.32	100 5 S J 0.69
100 2 F N 0.84	100 5 F C 0.22	100 7 F R 1.11	100 10 F G 0.40	100 2 S V 1.33	100 5 S K 0.69
100 2 F O 0.89	100 5 F D 0.28	100 7 F S 1.16	100 10 F H 0.46	100 2 S W 1.33	100 5 S L 0.85
100 2 F P 0.95	100 5 F E 0.35	100 7 F T 1.21	100 10 F I 0.56	100 2 S X 1.34	100 5 S M 0.95
100 2 F Q 1.03	100 5 F F 0.35	100 7 F U 1.23	100 10 F J 0.56	100 2 S Y 1.35	100 5 S N 1.02
100 2 F R 1.08	100 5 F G 0.46	100 7 F V 1.27	100 10 F K 0.71	100 2 S Z 1.35	100 5 S O 1.12
100 2 F S 1.15	100 5 F H 0.51	100 7 F W 1.28	100 10 F L 0.71	100 3 S A 0.21	100 5 S P 1.20
100 2 F T 1.15	100 5 F I 0.58	100 7 F X 1.30	100 10 F M 0.80	100 3 S B 0.21	100 5 S Q 1.24
100 2 F U 1.19	100 5 F J 0.67	100 7 F Y 1.32	100 10 F N 0.83	100 3 S C 0.23	100 5 S R 1.24
100 2 F V 1.24	100 5 F K 0.73	100 7 F Z 1.34	100 10 F O 0.91	100 3 S D 0.28	100 5 S S 1.33

100 5 S T 1.34	100 8 S I 0.57	100 10 S X 1.34	100 3 D M 1.09	100 6 D B 0.19	100 8 D Q 1.25
100 5 S U 1.35	100 8 S J 0.67	100 10 S Y 1.34	100 3 D N 1.15	100 6 D C 0.21	100 8 D R 1.30
100 5 S V 1.35	100 8 S K 0.72	100 10 S Z 1.36	100 3 D O 1.19	100 6 D D 0.31	100 8 D S 1.33
100 5 S W 1.36	100 8 S L 0.83	100 1 D A 0.18	100 3 D P 1.22	100 6 D E 0.31	100 8 D T 1.34
100 5 S X 1.37	100 8 S M 0.93	100 1 D B 0.19	100 3 D Q 1.28	100 6 D F 0.41	100 8 D U 1.35
100 5 S Y 1.37	100 8 S N 1.02	100 1 D C 0.23	100 3 D R 1.30	100 6 D G 0.52	100 8 D V 1.35
100 5 S Z 1.37	100 8 S O 1.10	100 1 D D 0.33	100 3 D S 1.31	100 6 D H 0.59	100 8 D W 1.35
100 6 S A 0.19	100 8 S P 1.16	100 1 D E 0.44	100 3 D T 1.35	100 6 D I 0.65	100 8 D X 1.36
100 6 S B 0.19	100 8 S Q 1.24	100 1 D F 0.53	100 3 D U 1.35	100 6 D J 0.82	100 8 D Y 1.36
100 6 S C 0.22	100 8 S R 1.24	100 1 D G 0.59	100 3 D V 1.35	100 6 D K 0.95	100 8 D Z 1.37
100 6 S D 0.28	100 8 S S 1.31	100 1 D H 0.64	100 3 D W 1.35	100 6 D L 1.05	100 9 D A 0.19
100 6 S E 0.28	100 8 S T 1.34	100 1 D I 0.74	100 3 D X 1.35	100 6 D M 1.12	100 9 D B 0.19
100 6 S F 0.39	100 8 S U 1.34	100 1 D J 0.88	100 3 D Y 1.37	100 6 D N 1.14	100 9 D C 0.22
100 6 S G 0.42	100 8 S V 1.34	100 1 D K 0.98	100 3 D Z 1.37	100 6 D O 1.19	100 9 D D 0.31
100 6 S H 0.47	100 8 S W 1.34	100 1 D L 1.06	100 4 D A 0.18	100 6 D P 1.23	100 9 D E 0.31
100 6 S I 0.57	100 8 S X 1.34	100 1 D M 1.13	100 4 D B 0.18	100 6 D Q 1.26	100 9 D F 0.47
100 6 S J 0.68	100 8 S Y 1.35	100 1 D N 1.18	100 4 D C 0.21	100 6 D R 1.31	100 9 D G 0.54
100 6 S K 0.76	100 8 S Z 1.35	100 1 D O 1.21	100 4 D D 0.31	100 6 D S 1.31	100 9 D H 0.59
100 6 S L 0.84	100 9 S A 0.19	100 1 D P 1.27	100 4 D E 0.40	100 6 D T 1.34	100 9 D I 0.64
100 6 S M 0.93	100 9 S B 0.19	100 1 D Q 1.30	100 4 D F 0.40	100 6 D U 1.35	100 9 D J 0.74
100 6 S N 1.03	100 9 S C 0.22	100 1 D R 1.31	100 4 D G 0.51	100 6 D V 1.36	100 9 D K 0.83
100 6 S O 1.09	100 9 S D 0.29	100 1 D S 1.34	100 4 D H 0.57	100 6 D W 1.36	100 9 D L 0.93
100 6 S P 1.18	100 9 S E 0.35	100 1 D T 1.34	100 4 D I 0.65	100 6 D X 1.36	100 9 D M 1.01
100 6 S Q 1.24	100 9 S F 0.39	100 1 D U 1.36	100 4 D J 0.83	100 6 D Y 1.37	100 9 D N 1.01
100 6 S R 1.28	100 9 S G 0.44	100 1 D V 1.37	100 4 D K 0.83	100 6 D Z 1.38	100 9 D O 1.10
100 6 S S 1.31	100 9 S H 0.49	100 1 D W 1.37	100 4 D L 1.06	100 7 D A 0.19	100 9 D P 1.15
100 6 S T 1.33	100 9 S I 0.49	100 1 D X 1.37	100 4 D M 1.11	100 7 D B 0.19	100 9 D Q 1.20
100 6 S U 1.34	100 9 S J 0.65	100 1 D Y 1.37	100 4 D N 1.17	100 7 D C 0.23	100 9 D R 1.26
100 6 S V 1.34	100 9 S K 0.73	100 1 D Z 1.37	100 4 D O 1.19	100 7 D D 0.31	100 9 D S 1.26
100 6 S W 1.34	100 9 S L 0.82	100 2 D A 0.18	100 4 D P 1.24	100 7 D E 0.40	100 9 D T 1.30
100 6 S X 1.37	100 9 S M 0.93	100 2 D B 0.18	100 4 D Q 1.27	100 7 D F 0.46	100 9 D U 1.32
100 6 S Y 1.37	100 9 S N 1.02	100 2 D C 0.22	100 4 D R 1.31	100 7 D G 0.53	100 9 D V 1.33
100 6 S Z 1.38	100 9 S O 1.10	100 2 D D 0.30	100 4 D S 1.34	100 7 D H 0.59	100 9 D W 1.38
100 7 S A 0.19	100 9 S P 1.15	100 2 D E 0.39	100 4 D T 1.35	100 7 D I 0.59	100 9 D X 1.38
100 7 S B 0.19	100 9 S Q 1.15	100 2 D F 0.46	100 4 D U 1.36	100 7 D J 0.81	100 9 D Y 1.38
100 7 S C 0.23	100 9 S R 1.26	100 2 D G 0.50	100 4 D V 1.37	100 7 D K 0.81	100 9 D Z 1.39
100 7 S D 0.28	100 9 S S 1.30	100 2 D H 0.57	100 4 D W 1.37	100 7 D L 1.02	100 10 D A 0.19
100 7 S E 0.28	100 9 S T 1.32	100 2 D I 0.63	100 4 D X 1.37	100 7 D M 1.09	100 10 D B 0.20
100 7 S F 0.39	100 9 S U 1.32	100 2 D J 0.75	100 4 D Y 1.38	100 7 D N 1.09	100 10 D C 0.24
100 7 S G 0.43	100 9 S V 1.32	100 2 D K 0.89	100 4 D Z 1.38	100 7 D O 1.18	100 10 D D 0.31
100 7 S H 0.43	100 9 S W 1.34	100 2 D L 0.94	100 5 D A 0.18	100 7 D P 1.21	100 10 D E 0.39
100 7 S I 0.56	100 9 S X 1.34	100 2 D M 1.02	100 5 D B 0.20	100 7 D Q 1.26	100 10 D F 0.47
100 7 S J 0.67	100 9 S Y 1.34	100 2 D N 1.02	100 5 D C 0.21	100 7 D R 1.30	100 10 D G 0.52
100 7 S K 0.72	100 9 S Z 1.35	100 2 D O 1.13	100 5 D D 0.32	100 7 D S 1.30	100 10 D H 0.56
100 7 S L 0.79	100 10 S A 0.19	100 2 D P 1.19	100 5 D E 0.41	100 7 D T 1.33	100 10 D I 0.65
100 7 S M 0.90	100 10 S B 0.20	100 2 D Q 1.24	100 5 D F 0.47	100 7 D U 1.33	100 10 D J 0.79
100 7 S N 1.00	100 10 S C 0.20	100 2 D R 1.28	100 5 D G 0.47	100 7 D V 1.33	100 10 D K 0.90
100 7 S O 1.08	100 10 S D 0.22	100 2 D S 1.31	100 5 D H 0.61	100 7 D W 1.33	100 10 D L 0.99
100 7 S P 1.17	100 10 S E 0.35	100 2 D T 1.32	100 5 D I 0.68	100 7 D X 1.35	100 10 D M 1.04
100 7 S Q 1.23	100 10 S F 0.38	100 2 D U 1.33	100 5 D J 0.68	100 7 D Y 1.35	100 10 D N 1.11
100 7 S R 1.28	100 10 S G 0.42	100 2 D V 1.33	100 5 D K 0.98	100 7 D Z 1.36	100 10 D O 1.15
100 7 S S 1.31	100 10 S H 0.48	100 2 D W 1.34	100 5 D L 1.05	100 8 D A 0.19	100 10 D P 1.19
100 7 S T 1.33	100 10 S I 0.55	100 2 D X 1.37	100 5 D M 1.12	100 8 D B 0.19	100 10 D Q 1.25
100 7 S U 1.33	100 10 S J 0.66	100 2 D Y 1.37	100 5 D N 1.12	100 8 D C 0.24	100 10 D R 1.29
100 7 S V 1.33	100 10 S K 0.74	100 2 D Z 1.37	100 5 D O 1.12	100 8 D D 0.32	100 10 D S 1.32
100 7 S W 1.33	100 10 S L 0.74	100 3 D A 0.20	100 5 D P 1.24	100 8 D E 0.40	100 10 D T 1.32
100 7 S X 1.35	100 10 S M 0.93	100 3 D B 0.20	100 5 D Q 1.28	100 8 D F 0.47	100 10 D U 1.34
100 7 S Y 1.35	100 10 S N 1.02	100 3 D C 0.23	100 5 D R 1.30	100 8 D G 0.52	100 10 D V 1.35
100 7 S Z 1.35	100 10 S O 1.07	100 3 D D 0.31	100 5 D S 1.34	100 8 D H 0.58	100 10 D W 1.36
100 8 S A 0.18	100 10 S P 1.07	100 3 D E 0.31	100 5 D T 1.35	100 8 D I 0.64	100 10 D X 1.37
100 8 S B 0.19	100 10 S Q 1.16	100 3 D F 0.48	100 5 D U 1.36	100 8 D J 0.64	100 10 D Y 1.38
100 8 S C 0.22	100 10 S R 1.27	100 3 D G 0.52	100 5 D V 1.36	100 8 D K 0.87	100 10 D Z 1.38
100 8 S D 0.29	100 10 S S 1.31	100 3 D H 0.57	100 5 D W 1.37	100 8 D L 0.99	
100 8 S E 0.29	100 10 S T 1.32	100 3 D I 0.65	100 5 D X 1.37	100 8 D M 1.06	
100 8 S F 0.39	100 10 S U 1.32	100 3 D J 0.79	100 5 D Y 1.38	100 8 D N 1.12	
100 8 S G 0.42	100 10 S V 1.32	100 3 D K 0.89	100 5 D Z 1.38	100 8 D O 1.17	
100 8 S H 0.48	100 10 S W 1.34	100 3 D L 1.01	100 6 D A 0.18	100 8 D P 1.17	

APPENDIX B

STAGGERED POSITION PRINTING SAMPLES

65 LPI

85 LPI


Genesee
RBR
Coke
Kodak
T-120
IVORY
Campbell's
Chicken Broth
SOUP
Pure Baking Soda

100 LPI

FOUR ANGLE PRINTING SAMPLES

65 LPI

85 LPI


RBR
Coke
Kodak
T420
IVORY
Pure Baking Soda
Campbell's
Chicken Broth
SOUP

100 LPI

DOT-ON-DOT PRINTING SAMPLES

65 LPI

85 LPI


Pure Baking Soda
RBR
Coke
Kodak
T-120
IVORY
Genesee
Campbell's
Chicken Broth
SOUP

100 LPI