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An Investigation of the Effects Screen Ruling and Dot Structure have on Dot Gain on Offset Newsprint

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AN INVESTIGATION OF THE EFFECTS SCREEN RULING AND DOT STRUCTURE HAVE ON DOT GAIN ON OFFSET NEWSPRINT

by

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ABSTRACT

Dot gain is an inherent problem in printing on any substrate. Studies have been conducted in an effort to try to isolate the causes of the variables in the printing system to determine their influence on dot gain. The literature indicated some good reasons to suspect that course screen ruling would yield less dot gain than finer screen ruling. Investigations dealing with the effect that screen ruling has on dot gain have not yet been conducted. This study attempts to isolate the screen ruling which can yield the lowest amount of dot gain when printed on newsprint using square, round, and elliptical dot structures. It could benefit the newspaper industry to be able to control one of the many factors that influence dot gain.

A total of twelve screens were chosen for this thesis; including four screen rulings (65,85,100 and 150) and three dot structures (round, square, and elliptical). Based upon the data collected and a statistical analysis of that data, it was determined that a course (65-line) screen ruling yielded less dot gain that a fine (150-line) screen ruling when printed on newsprint on the Goss Community Press. Furthermore, it was determined that any dot structure could be used and would yield satisfactory printed results.

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CHAPTER I

INTRODUCTION

Newsprint has an inherent problem of dot gain associated with it due to its' high absorbency when compared to other papers used in the printing industry. Newsprint

> is highly absorbent to allow for the rapid penetration of news ink. Newsprint for web offset printing is designed to run with stiffer inks and in the presence of moisture, in order to minimize lint accumulation on offset blankets and still provide rapid absorption of news ink without the aid of heat set drying.[1]

Newsprint is the least expensive form of paper used in the printing industry and therefore the reproduction quality is much lower than other papers used.

> Certain quality standards are necessary for printability and runnability. The most important printability requirements are opacity, smoothness, and ink absorbency. A high rate of ink absorbency is needed, yet excessive ink penetration contributes to strike-through.[2]

Opacity is "that property which minimizes the 'show through' of printing from the back side or the next sheet."[3]

> Smoothness is a very important property for letterpress and gravure but has little effect on offset. Smooth surfaces have irregularities of the order of 0.005" to 0.010" apart. They cannot be seen by the naked eye, but can be detected by a magnifying glass and low angle illumination. As smoothness decreases, solids and halftones get sandy and rough in appearance but type is not affected much.[4]

Ink absorption in paper is that "property which causes it to take up liquids or vapors in contact with it.[5] Strike-through in printing is "the undesirable condition in which the printing on the reverse side of a sheet can be seen through the sheet under normal lighting conditions."[6] Newsprint is not the best paper to use for reproducing an image due to it being highly absorbent and not being a pure white paper. Newsprint is, however, the most economical of all substrates used in the printing industry and is well suited due to its' short term nature.

The purpose of this thesis is to investigate the effects that screen ruling has on dot gain when printed on newsprint. This report is intended to give preliminary background information on the topics of reproducing halftone images, a discussion on contact screens, and describe the methods used and conclusions reached in the experimental section of this thesis. In the section entitled "Conclusions, Observations, and Recommendations" will be recorded areas that need to be investigated further regarding dot gain.

A secondary aim of this thesis is to gain an understanding of dot gain and to determine what screen ruling yields the lowest amount of dot gain in a press run. Screen ruling is only one of many variables that effect dot gain. Screen ruling is also the most easily controlled or changed in a given operation, but for reasons of manageability. screen ruling will only be studied in this report.

It should also be stated that while those in industry have the belief that dot gain occurs more frequently in finer screen ruling, this report is intended to indicate just how much more dot gain occurs when using a fine (150-line) screen ruling on newsprint as compared to a course (65-line) screen ruling.

In order to obtain valid conclusions in this thesis, the only variable that was changed is the screen ruling of the round dot, square dot, and elliptical dot structure halftone contact screen. The paper and ink will remain constant throughout the press run.

FOOTNOTES FOR CHAPTER I

[1]William H. Bureau, <u>What the Printer Should Know About Paper</u> (Pittsburgh: Graphic Arts Technical Foundation, 1982). p.151.

[2]Ibid., p. 228.

[3]International Paper Company, <u>Pocket Pal</u> (New York: International Paper Company, 1081), p. 188.

[4]Ibid., p. 154.

[5]Ibid., p. 172.

[6]Ibid., p. 193.

CHAPTER II

BACKGROUND

Dot Gain

Dot gain can be defined as the increase in a halftone dot area that occurs during printing on the press as compared to the original halftone dot area on the plate. If dot gain were consistent from run to run, it would not be a major problem because compensation for it could be made in the pre-press area. The causes of dot gain are numerous and can range from ink film thickness, paper, dampening solution, press speed, offset blankets, etc. Dot reproduction can be carefully controlled and compensated for in the pre-press area but the pressmen has limited control over image quality after the plate is put on the press.

> Changes in size or shape (of dots) can affect tone reproduction, resolution, image sharpness, and overall appearance. The effect on tone reproduction includes a shift in values, condensed tonal range, loss of highlight and/or shadow detail and loss of contrast, resulting in a loss of reproduction quality.[1]

When printing only a black and white image, the effect of dot gain is apparent in the tonal reproduction whereas dot gain is more obvious in the hues produced with four color process printing.

Dot gain can have a tremendous effect in four color printing due to its influence in changing the dot sizes and therefore varying the colors of the original. It is beneficial for any printer to understand the variables that effect dot gain so as to help minimize waste. This knowledge will eventually lead the printer to learn to control and compensate for dot gain.

Dot gain can be further analyzed and reduced to physical dot gain and optical dot gain.

> Physical dot gain is an enlargement of mechanical dot size. It can occur between film generations, during the plate-making process, or during printing if there are changes in ink and paper characteristics or other printing. Physical dot gain during printing may be circumferential or it may be irregular due to printing defects such as slurring and doubling.[2]

Optical dot gain occurs when printing on a paper substrate. When light shines on a printed dot - some light enters, some is absorbed, some is trapped, and some emerges from the printed dot. (See Figure 1) Optical dot gain is caused by light that gets trapped beneath the dot. The change in dot area is not a uniform change throughout the tone range.

> The change takes place in border zones around each dot. Therefore the maximum change occurs on dots which have the greatest border zone or perimeter. The finer the screen ruling the greater will be the border zone.[3]

Printing in the area of a 50% dot, there is potential for more light to be trapped due to the diameter of the dot.

Screen ruling determines the number of dots per square linear inch to be printed. A course screen ruling (65-line) yields fewer dots per inch than a fine screen ruling (150-line) which results in less optical dot gain since there is a larger area for the light to pass through the paper without getting trapped. Changing the screen ruling will influence the dot size and therefore influence the amount of optical dot gain. Since optical dot gain is a more uniform increase in dot diameter, all printing dots are equally affected. The areas most effected are the midtone area of the halftone because it is the area of the largest dot diameter. (See Figure 2)

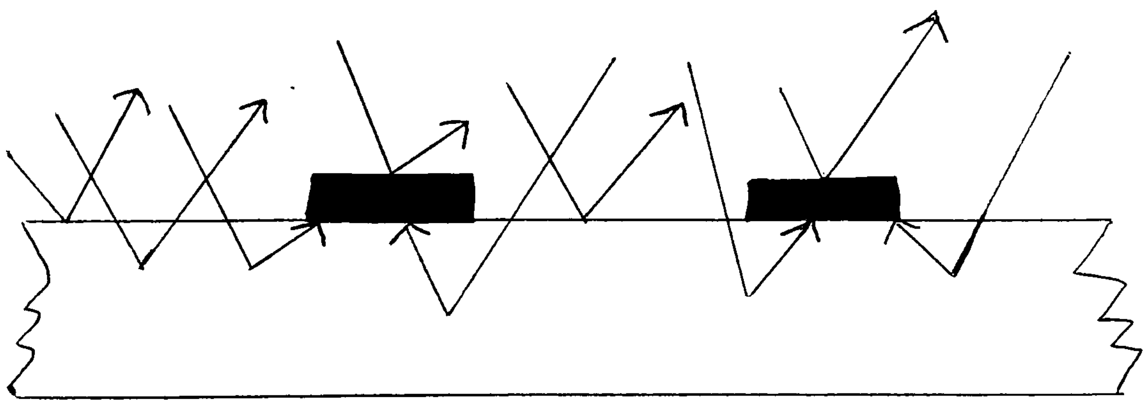
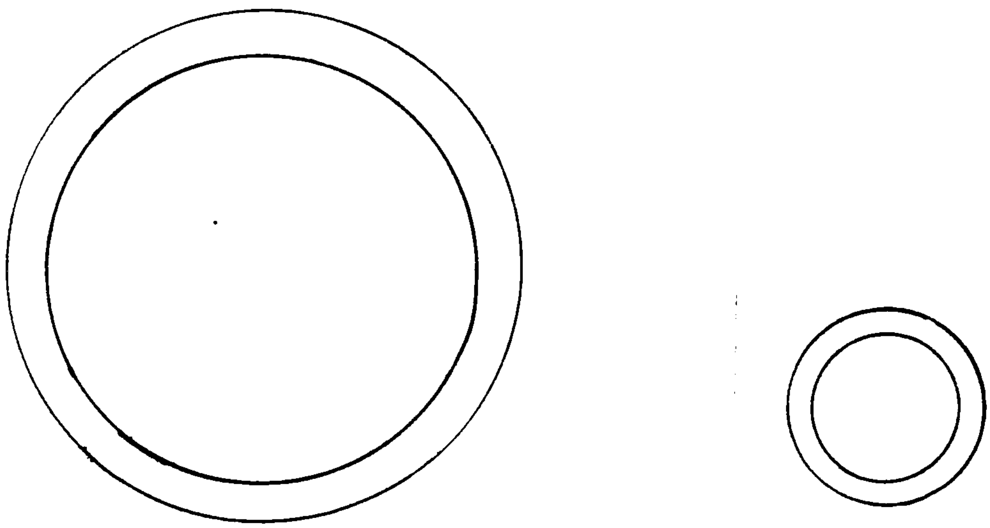


Figure 1. CAUSES OF OPTICAL DOT GAIN



Represents Optical Dot Gain on a 50% Dot

Represents Optical Dot Gain on a 5% Dot

Figure 2. ENLARGEMENT OF DOTS

Optical and physical dot gain affects the tone reproduction of an image especially in the midtone (50%) area of the reproduction. The quality of black and white images can suffer due to the variation in dot gain. "The variables that influence reproductions include the original image, the ink, the solid ink density, the screen ruling, the paper characteristics, the dot shape, and printing considerations such as dot gain, slur, trapping, and fill-in."[4] The object of any printed image is to visually match the original. This may be impossible if the density range of an original is greater than the density range that can be reproduced on any given press. It is also more difficult to reproduce the original density range as the quality of paper used decreases. This is the case when reproducing an image on newsprint. In order for the printer to alter the tones of the reproduction to visually match the tones of the original, tonal compression "is needed to alter the tones of the original such that the tones on the printed reproduction closely match the original tones. Whether you print on coated stock or newsprint, tone compression is the single most important step in determining the quality of a reproduction."[5]

Halftone Reproduction

When printing an image, the press can only print one uniform density of ink. In order to have many shades (tones) ranging from black to white, halftone photography is necessary. A halftone is produced by placing a piece of continuous-tone copy in a camera copyboard and photographing it using a high contrast film through a halftone screen placed in intimate contact with the film. A halftone screen

> breaks up the continuous tones of the original into an almost countless number of tiny dots. These dots are equally spaced. However, the size or diameter of the dots will vary according to the different amounts of light that were reflected from the different tones in the original.[6]
>
> The effect of tone results despite the uniform density of the ink because of the varying dot sizes. Because the dots are small enough (in most instances) to be beyond the resolving power of the eye, the visual effect is produced by the general dot formation of the continuous tone gradation. The success of the halftone process thus depends upon an optical illusion.[7]

Halftone Screens

There are two types of halftone screens presently used to make halftone images - the glass crossline screen and the more popular, contact screen.

> The glass crossline screen is made up of two flat pieces of glass. Each piece has a series of black parallel lines on one surface ruled at an angle of 45° to the edge. The two pieces are cemented together in such a way that the lines on them cross each other at an angle of 90°.[8]

In use, the glass crossline screen "must be kept at a definite predetermined distance from the surface of the sensitive emulsion on which the halftone image is projected."[9]

The contact screen on the other hand is used in intimate contact with the film, made possible through use of a vacuum board. The contact screen is made of a piece of continuous-tone film. It has a pattern of vignetted dots that "constantly vary in density from the middle of the dots to the middle of the clear area."[10]

Screen Ruling

Contact screens are produced with varying characteristics to suit the users needs. They may be purchased by specifying the screen ruling which identifies the number of rows of dots per linear square inch on a

contact screen. A screen with a ruling of 150 lines per inch has 150 x 150 lines to the linear square inch, producing 22,500 halftone dots in each square inch. The most popular screen rulings for use in newspapers are 65 and 85 line screens, commercial printers use 120 - 133 line screens and fine books and book insert printers use 150 - 175 line screens.

> Screen fineness can be manipulated to affect the appearance of the final print. Coarse screens give greater contrast but show less detail than finer rulings. The tone values of course halftones are not as faithful or delicate as those produced by finer screens.[11]

Screen Angles

Contact screens are also used according to their screen angle. "Halftone screens used in black and white reproductions are normally oriented with the screen lines at 45° and 135° to the horizontal. The reason most often cited is that at this angle the dot (line) structure is least noticeable."[12] In color separation work each of the four screened separations generally use a different screen angle. "The relationship between the angles of the screen and the separation negatives is important. The popular angles are 105° for cyan, 45° for magenta, 90° for yellow, and 75° for black."[13]

Screen Color

Contact screens are available in several colors depending on end use. They are available in magenta and gray, or neutral colored screens. The gray screens

> have a fixed maximum and minimum density, density range, and density distribution. With the magenta dyed screens, these properties can be changed by controlling the color of the exposing light. A more recent method of controlling contrast with a magenta-dyed screen is the use of color-compensating (cc) filters.[14]

Neutral gray contact screens are used in making direct color separations. "The magenta contact screens are generally used for screening indirect color separation negatives, and magenta and yellow compensating filters can be used to improve tone reproduction."[15]

> The curve shape of a contact screen is the critical characteristic as regards tone reproduction. The highlight and shadow dot sizes can be controlled through the two point exposure technique. The relationship of all the tones in-between, however, is a function of the screen's curve shape. The three point exposure technique (main, flash, and no screen bump) can be applied to influence the 50% dot placement and therefore highlight contrast. The degree of control that can be achieved, even with this method, is limited by the screen itself.[16]

Dot Shape

A final characteristic which this report will investigate is dot shape. Three dot shapes were investigated: square (conventional), elliptical, and round dot structure. "The dot shape which a screen produces in the halftone affects the smoothness of tones in the reproduction."[17]

The square dot is believed to exhibit the most dot gain because of the nature of the dot structure. As the square dots approach the 50% dot area the four corners will join yielding a checkerboard pattern. (See Figure 3) An increase in dot gain is believed to occur due to this joining at the four corners in the midtone area because of ink spreading.

The elliptical dot structure in the midtone area will have only two corners join and connect as the dots approach 50% with the appearance of links in a chain. (See Figure 4) Since only two out of the four corners join there is less of a tonal jump from highlights to shadows and less dot gain is found.

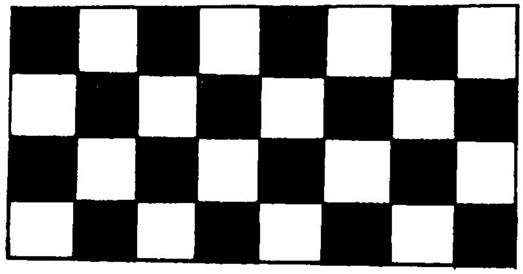


Figure 3. Square Dot Structure at 50% Dot Area

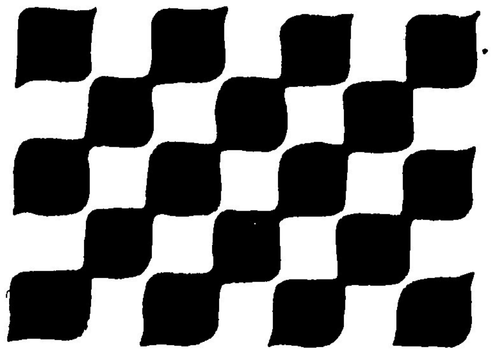


Figure 4. Elliptical Dot Structure at 50% Dot Area

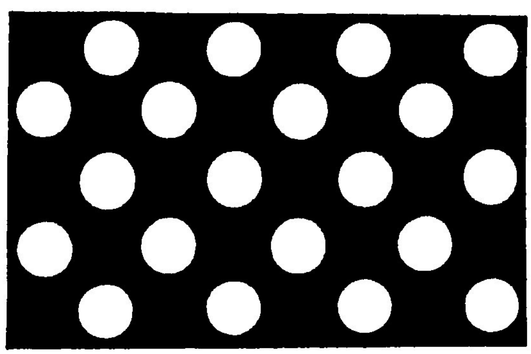


Figure 5. Round Dot Structure at 50% Dot Area

> When the four corners of the square dot join, the density of the middletone area jumps slightly, resulting in a small 'tone break' across the 50% dot. Because only two corners join between elliptical dots, the tone gradation across the 50% dot is smoother. Use the elliptical dot screen particularly for originals with soft middletone vignetting (flesh tones, for example). In the absence of soft middletone gradation, either square-dot or elliptical-dot screens work well.[18]

The round dot structure in the midtone area does not join and connect. (See Figure 5) This joining of dots will begin to occur in the area between midtone and shadow dots (70 - 80%). Since dot gain occurs more frequently in the midtone areas as the dot structures join, less dot gain should be attributed with round dot structure. Since the eye is less sensitive to tonal changes in the shadows, in theory, round dots should be preferred over square and elliptical dot structures in regards to dot gain and its' effects on the midtones.

> The round dot is presently widely used in Europe for high-speed web offset printing, and many color separation firms in the U.S. are experimenting with round dots. The reason for using round dot screens in high-speed web offset work is that they partially compensate for plugging, entrapment, and dot gain in the low middle tones. These occur in the printing process with square or elliptical dots since they join at about a 40% to 50% dot value. Round dots, on the other hand, do not begin to join until a 70% dot. In conventional printing, round-dot screens are presently not as commonly used as square and elliptical-dot screens because the resultant detail reproduction is not as good and it is more difficult to associate percentage values by eye in round-dot screens.[19]
>
> Regardless of the pattern selected, the screens will usually perform the same. The real difference lies in the finished piece. The conventional dot screen reproduction will appear to have slightly higher contrast. This is the result of dots meeting in the mid tones which render a more contrasting appearance between the highlight and shadow ends of the scale. The elliptical dot reproduction appears smoother, slightly flatter in contrast, almost favoring the shadow end of the scale.[20]

FOOTNOTES FOR CHAPTER II

[1]Alan DePaoli, "The Effects of Printing Conditions on Dot Gain: An Offset Newspaper Study", TAGA Proceedings, 1981, p.18.

[2]Miles Southworth, "Dot Gain: Causes and Cures", The Quality Control Scanner (Volume 2, Number 9) p. 1.

[3]Kelvin Tritton, "Dot Gain in Offset Lithography", Ink and Print (Autumn, 1982), p. 16.

[4]Miles Southworth, "Optimizing Tone Reproduction", The Quality Control Scanner (Volume 2, Number 2), p. 1.

[5]Ibid.

[6]Erwin Jaffe, Halftone Photography for Offset Lithography (New York: Lithographic Technical Foundation, Inc., 1980), p. 1.

[7]John W. Wesner, "Screen Patterns Used in Reproduction of Continuous-Tone Graphics", Applied Optics (July, 1974), p. 1703.

[8]Jaffe, Halftone Photography, p. 4.

[9]Ibid., p. 3.

[10]Ibid., p. 6.

[11]Wesner, "Screen Patterns", p. 1705.

[12]Ibid., p. 1706.

[13]Miles Southworth, Color Separation Techniques (Livonia, New York: Graphic Arts Publishing, 1979), p. 78.

[14]R. E. Mauer, "The Relationship of the Contact Screen to Picture Quality", TAGA Proceedings, 1959, pp. 124 - 125.

[15]Kodak Publication No. Q-3, Halftone Methods for the Graphic Arts (Rochester, New York: Eastman Kodak Company, 1982), p. 6.

[16]J. C. McCracken, "Reading Screen Curves" (Rochester Institute of Technology), p. 1.

[17]R. E. Maurer, "The Relation of the Contact Screen to Picture Quality" TAGA Proceedings, 1959, p. 126.

[18]Al Sardone, "The Photographic Image", Screen Printing (January, 1982), p. 75.

[19]Arve Jenson and Stephen Schuster, "How to Select and Apply Contact Screens", Chemco Technical Bulletin No. 39, pp. 2 - 3.

[20]Larry Kehres, "Camera Clinic: Screening the Dot Choices of Screens", In-Plant Reproduction, (November, 1983), p. 10.

CHAPTER III

LITERATURE SEARCH

In conducting a literature search on dot gain it was observed that few pertinent studies have been conducted regarding the relationship between contact screen ruling and dot gain. Ink and offset blankets have proven to have the greatest effect on dot gain.

Dot Gain

In 1955, Warren L. Rhodes used the term "poor definition" to describe the change or growth in image size when the image transferred from the plate to paper. "Poor definition can occur in two ways: by a general increase in the size of the print, sometimes called 'fill-in' or by a directional increase, called 'slur' which is proabl̄y caused by a slippage of the printing surfaces at the moment of transfer."[1] Rhodes' research revealed that

> certain images are more sensitive to definition effects than others. Fine screen tints 'fill-in' more readily than course screen tints. Resolution test objects perpendicular to the direction of sheet travel are affected by slur more than those oriented parallel to sheet travel.[2]

Rhodes tried to design a test object which would be "sensitive to definition effects and which could be measured with a densitometer."[3] To determine the effects of slur, Rhodes took a 175 line single-ruled screen and cut 1/2 inch squares of the film and stripped them at right angles to each other. Because slur is more obvious in the lines that run perpendicular to sheet travel when compared with lines running parallel to sheet travel, the difference between the densities of each object can be measured on a reflection densitometer.

Rhodes used a solid ink patch and a 300 line screened batch to measure fill-in. Since the dots are so closely spaced together in a 300 line screen this patch will increase in numeric value while the solid patch will not increase in numeric value. The ratio of measured solid patch density and 300 line screened patch density will then be used for measuring fill-in.

Rhodes' study was important because he was one of the first to determine or pinpoint a method which could be used to measure dot gain. His test objects were good because development was occurring in the printing industry to attach a value to the phenomenon of slur and fill-in. There does exist a need, however, to have a more tangible method for determining each.

It seemed that both researchers and people working in the printing industry believed that light entered a halftone dot, was absorbed by that dot, and then emerged from that dot at the exact same spot it entered. However, J.A.C. Yule and W.J. Nielson conducted some experiments which proved that the relationship between light and the halftone dot was more complicated than it at first appeared. They showed that if a 50% dot was printed on perfectly white paper, instead of the paper absorbing less than 50% of the light, which was assumed to be true because of the black ink, it instead absorbed more than 50% of the light.

> This discrepancy has quite an appreciable effect on photomechanical tone reproduction. It has been suggested that this discrepancy may be caused by the penetration of ink vehicles into the paper between the dots. It is true that this may contribute to it in some cases, but it seems likely that the penetration of light into the paper may be the chief reason.

Since "the light is diffused by the paper, it is likely to spread sideways to about the same extent that it penetrates through."[5]

Murray and Davies in 1935 published the following equation which gives the relationship between dot area and density. It also indicates the total light reflected by the tint to the total light reflected by the solid.

$$A = \frac{1 - 10^{-D_t}}{1 - 10^{-D_s}} \quad \text{or} \quad \frac{1 - R_t}{1 - R_s}$$

Where: A = area of dot

D_t = density of the tint

D_s = density of the solid ink

R_t = reflectance of the printed halftone tint

R_s = reflectance of the printed solid

"A major problem with the Murray-Davies equation is the assumption that the white paper surrounding the dots completely reflects all the light falling on it directly."[6]

Yule and Nielson expanded the Murray-Davies equation to take into account the absorption of light by the paper. Thus the equation is now:

$$A = \frac{1 - 10^{-D_t/n}}{1 - 10^{-D_s/n}} \quad \text{or} \quad \frac{1 - R_t^{1/n}}{1 - R_s^{1/n}}$$

Where: n = factor compensating for the effect of internal light scattering in the paper, screen ruling, and tint value.

N-Value

If n = 1 then the Yule-Nielson equation is the same as the Murray-Davies equation and "if n = ∞, then density would be proportional to dot area, so that a straight line would be obtained."[7] "A low value of n indicates that the spreading of light in the paper is small, compared with the dot size, so it is lowest for coated papers and coarse screens."[8]

> In order, however, for the Yule-Nielson equation to achieve accurate determination of dot area, the correct value of n for the conditions of measurement must be known. All these variables affecting n result in making accurate determinations of the value difficult, if not practically impossible. A different value of n is required for every measurement made. The values of dot area vary accordingly.[9]

Milton Pearson conducted an experiment in 1980 to determine an n-value to use for general printing conditions. Pearson chose eighteen different printing conditions in which he used newsprint, coated paper, uncoated paper, 65 line screen, 150 line screen, and dot areas of 35%, 46%, and 70%. His results showed that an n-value of 1.4 - 1.8 can be used in the Yule-Nielson equation and are still more efficient than using the Murray-Davies equation in which an n-value of one is assumed.

> Although it is known that for a unique set of conditions a specified value of n is required, this experiment shows that the use of n between 1.4 and 1.8 can result in greater accuracy of calculations over a wide range of general conditions. At no time for any specific condition will the error be greater than that obtained by using an n-value of 1.00.[10]

> Of the factors contributing to a correct value of n for a given condition, dot area level is the least significant contributor. Screen frequency is the most significant. This implies that the value of n changes faster with changes in

in frequency than with any other parameter. However, in practice the frequency is usually fixed which leaves variation in the substrate as the biggest factor affecting n.[11]

Measuring Dot Gain

In 1979, Milton Pearson, Irving Pobboravsky, and Chester Daniels developed a method of measuring slur and fill-in using instrumentation on a lithographic press. From their tested results they were able to make some conclusions regarding dot gain. It was found that

> solid ink density has the greatest effect on fill-in and a small, inverse effect on slur; packing has a small effect on both fill-in and slur on the top of the web but not on the bottom; water, paper tension, press speed and number of units on impression and all interactions have no effect on fill-in and slur; and that fill-in is the largest component of dot gain. Until these experiments are verified on other presses these conclusions should not be considered to apply to all presses.
>
> The image area on the plate and the actual-printed image area on some prints were measured microscopically. These areas were used in the determination of n-values and as a calibration check for the densitometric method (Froslev-Nielson). A micrometer-adjustable crosshair eyepiece works satisfactorily on images that are parallel lines or well formed circles or squares, but not if the images are irregularly shaped. Another method is to photograph the image through the microscope, using a Polaroid camera attachment. This not only provides a hard copy which can be measured, but provides a useful record of the image for evaluation. The photos used in this experiment represented an 80x magnification. Once the photo has been made, measurements can be made by several means. A scale can be used on regularly shaped images. For more complex shapes, a planimeter can be used. A simple means of measuring dots which were not too roughly shaped was to use a circle template which is graduated in hundredths of an inch. Typically, a photograph would contain only 6 dots.[13]

Screen Ruling

For the less sophisticated printer a very frequent question to ask is "What screen ruling should we use to make our halftones?"

> We are tempted to say that the finest screen that can be made should be used because the dot pattern will become less recognizable with an increasing number of lines per inch. The most widely used screens are in the neighborhood of 150 lines per inch. Coarser screens are used quite often, finer screens rather seldom. Some of the commonly known reasons for the infrequent use of fine screens are highlights and vignettes are much more difficult to handle, manual correction of tone reproduction is more to keep the dots free from ink. This list shows that the use of fine screens is not impossible; it just makes everything more critical.[14]

Paper and It's Effects

In closing this section on literature search, there are two more topics that need to be covered. The first is that

> different kinds of paper will not only change the size and character of your dot, but can also change the density of your color. There are three main properties of paper that can change the color value of your dot. One is texture, another, the gloss; another, absorbency. When running a halftone on rough surfaced paper, the dots will be broken up. When running on high-gloss, smooth surfaced paper, the dots will be solid and round. An absorbent paper will produce a dull looking dot, while a non-absorbent paper will give you a dot much stronger in color value. An absorbent paper absorbs too much of the ink and ink vehicle below the surface of the paper. A non-absorbent paper will retain the ink on the surface, giving you a stronger value or color, with same size dot. The halftone dots on the rough paper will not have solid dots. The edges will be broken up and appear ragged. Even the center of the dot may have a white spot in it. The solid areas on the rough textured paper are much lighter than those of the smooth glossy paper. This is not only due to the absorbency of the rough paper, but also because the rough surface scatters the light in many directions and reduces the intensity of your color. The solid areas on the rough paper, when viewed through a magnifying glass, have hundreds of tiny white specks. These are specular reflections from the tips of the rough paper. They only reflect light and do not reflect the color of your ink.[15]

The final topic which needs to be covered concerns newsprint itself. "Newsprint, whose fibrous composition is mostly groundwood or the mechanical type of pulp with a small percentage of chemical wood fiber for strength, is designed specifically for newspaper printing."[16]

> Paper for offset lithography must be carefully made. The surface must be tightly bonded so as to withstand the pull of the blanket and short, tacky inks. The surface must not react with the acids used in the dampening solution because, if it did and the acidity of the press-dampening solution were neutralized, saponification of the ink would take place, resulting in a tint ink condition. And lastly, but perhaps most important of all, the fact that water actually contacts the sheet must be taken into account and the surface designed to withstand it. The sheet itself must carry as closely as possible, an amount of moisture that is in proper balance with the humidity of the pressroom air.[17]
>
> Freedom from defects in rolls and webs is a critical requirement. Since newsprint is an inherently weak paper, roll defects can easily precipitate web breaks on high-speed presses. Moisture content must be maintained at a high level, near 8% - to prevent brittleness and minimize web breaks.[18]
>
> The brightness of newsprint is limited to that of groundwood pulp and the small amount of unbleached or semi-bleached chemical fiber that constitutes its furnish. Little or no filler is used. The exceptionally high opacity of newsprint is important in minimizing the printed show-through of news ink. The reduction in basic weight (grammage) that occurs tends to reduce opacity and increase show-through.[19]

Due to the highly absorbent nature of newsprint coupled with the fact that printers are not beginning with a pure white paper it is not possible to print with the brilliance as is associated with other types of paper. Coarse screen rulings are widely used in newspaper. When coarse screen rulings are used, much of the original detail is lost.

FOOTNOTES FOR CHAPTER III

[1]Warren L. Rhodes, "Study of Objective Methods for Evaluating Sharpness in Lithography", TAGA Proceedings, 1955, p. 109.

[2]Ibid., p. 110.

[3]Ibid.

[4]J.A.C. Yule and W.J. Nielson, "The Penetration of Light into Paper and its Effects on Halftone Reproduction", TAGA Proceedings, 1951, p.66.

[5]Ibid., p. 67

[6]Kelvin Tritton, "Dot Again in Offset Lithography", (Fall 1982), p.16.

[7]Yule and Nielson, "Penetration of Light", p. 72.

[8]Ibid., p. 73.

[9]Milton Pearson, "n-Value for General Printing Conditions", TAGA Proceedings, 1980, p. 416.

[10]Ibid., p. 423.

[11]Ibid., p. 424.

[12]I. Pobboravsky, M. Pearson, C. Daniels, "Status Report: Identification of Causes of Dot Gain in Web Offset Lithography", (October, 1979), p. 12.

[13]Alan DePaoli, "The Effects of Printing Conditions on Dot Gain: An Offset Newspaper Study", TAGA Proceedings, 1981, p. 22.

[14]H.E.J. Neugebauer, J.T. Bickmore, and W.L. Rhodes, "Experimental Investigation of the Effect of Screen Size on the Appearance of Multicolor Prints", TAGA Proceedings, 1962, p. 2.

[15]Clarence W. Lahde, "Does the Value of a Halftone Dot Change on Different Kinds of Paper", Printing Magazine/National Lithographer (July 1968), p. 74.

[16]William H. Bureau, What the Printer Should Know About Paper, (Pittsburgh, Pennsylvania: Graphic Arts Technical Foundation, 1982), p. 151.

[17]Lithographic Technical Foundation, Inc., Paper for Offset Lithography (New York: Lithographic Technical Foundation, Inc.), 0. 7.

[18]Ibid., p. 228.

[19]Ibid.

CHAPTER IV

MATERIALS

TR and PC Graph Paper

Two types of graph paper were used to analyze the data from the final press run. Printing Characteristic (or PC) graph paper was used to analyze the amount of dot gain and slur produced. Tone Reproduction (or TR) graph paper was used to analyze the final characteristic curve of each of the four screen rulings used.

Both the TR and PC graph paper used in this thesis

> contain non-linear scales calibrated in density which provide linear spacing of brightness, as defined by Bartleson and Brenenan (1967). A linear relationship between the brightness of the original and the brightness of the reproduction correspond closely to established experience regarding preferred tone reproduction.[1] (See Figures 6 and 7)

The special TR graph paper "converts density data to brightness as defined by Bartleson and Breneman (1967). A straight line on this paper establishes a suitable relationship between the tones of the original and the tones of the reproduction for originals with normal tone distribution."[2]

On the PC graph paper "the vertical scale is non-linear to provide equal brightness spacing. This scale is exactly the same as that used for the Tone Reproduction graph paper."[3]

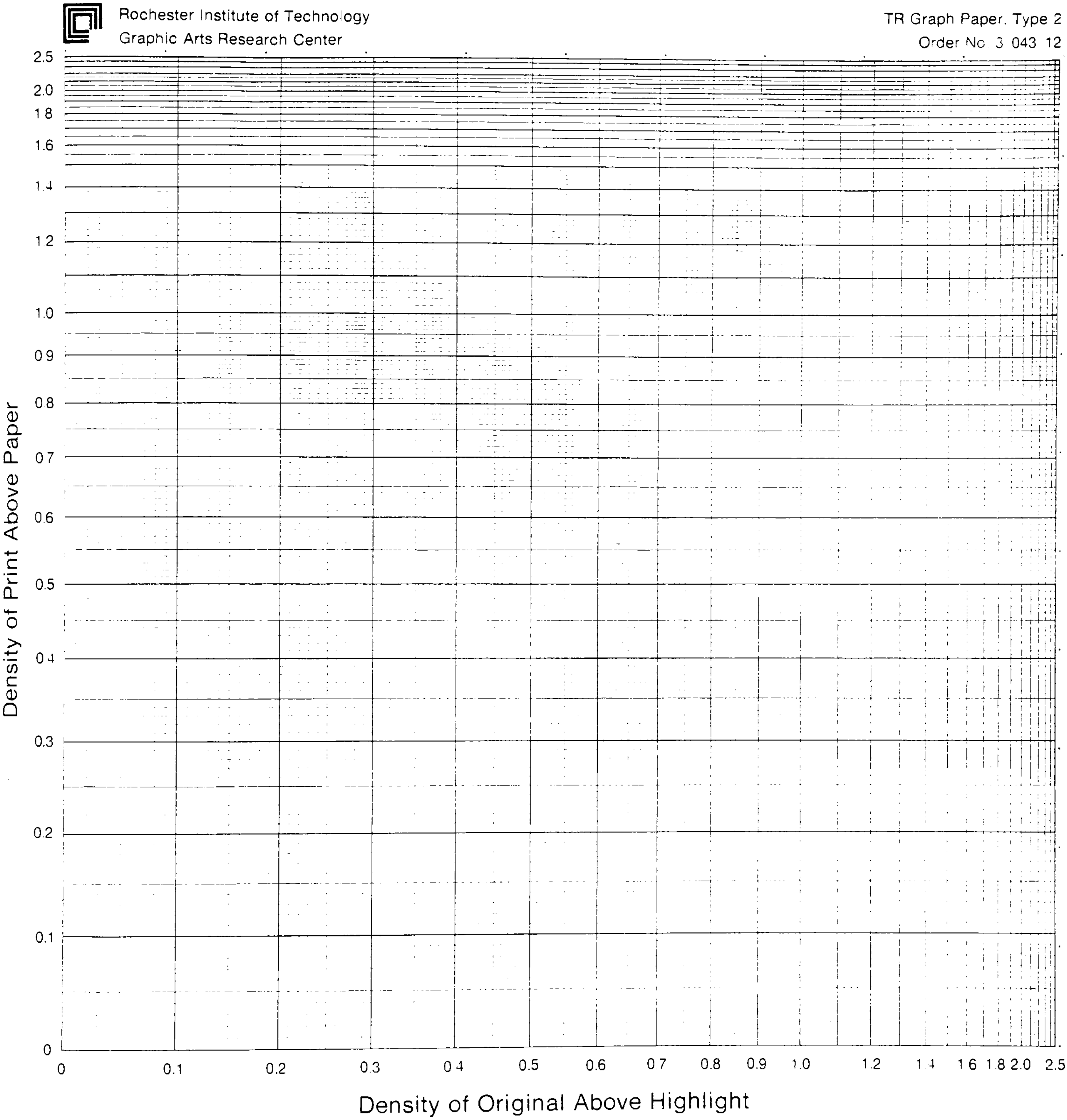


Figure 6. TR Graph Paper

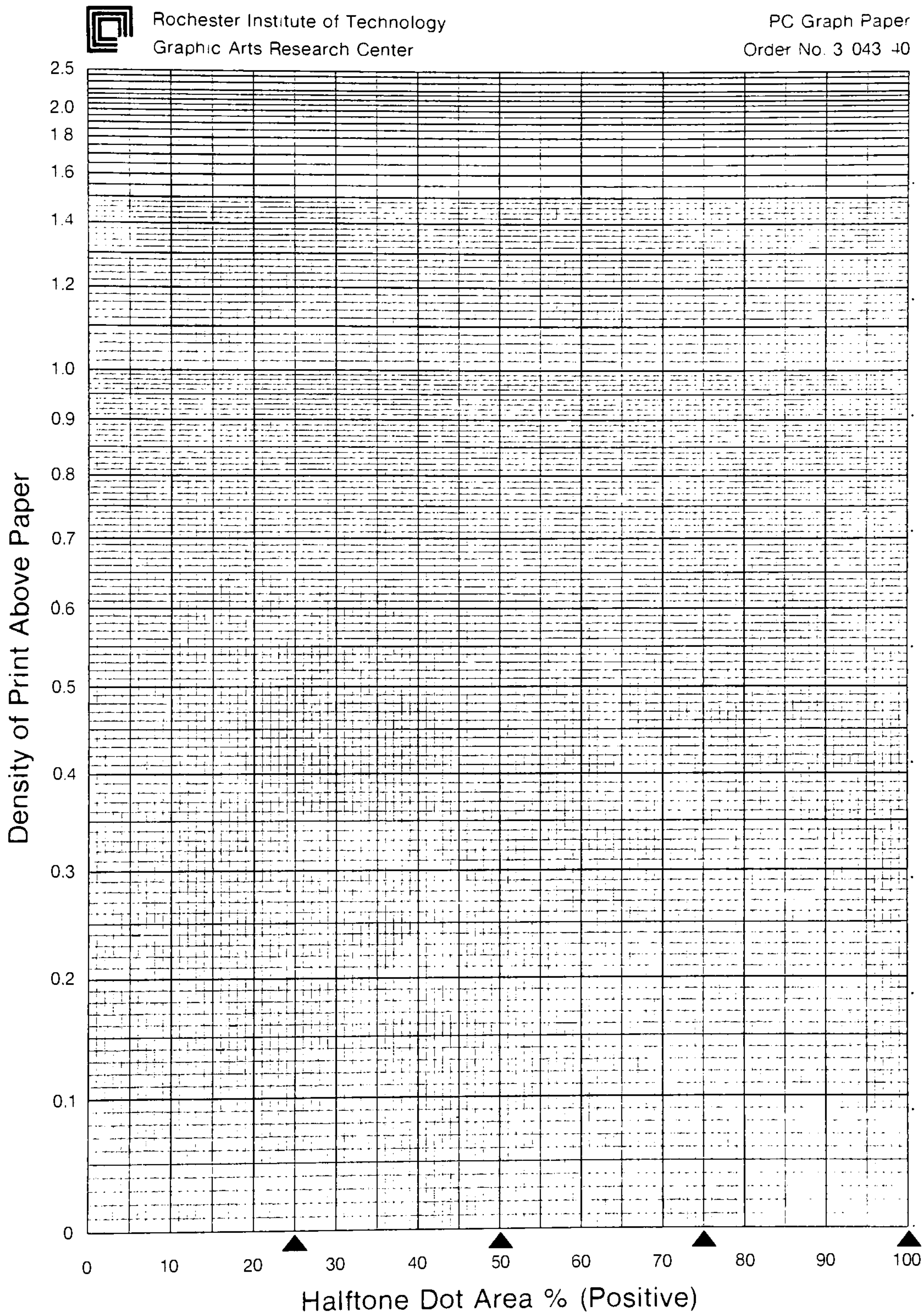


Figure 7. PC Graph Paper

RIT Symmetrical Scale

The symmetrical scale contains two 25% patches and two 75% patches which are round dot areas made from a conventional contact screen. The assumption is that there is no difference between the elliptical and square dot structure in these areas. (See Figure 8.)

On the right hand side of the solid ink density patch there are two 50% patches constructed from parallel lines. They are at 90 degree angles to each other to detect slurring problems. "The slur produced assumes that it occurs at right angles to the press sheet direction, which admittedly is not always the case. For example, if slur occurs at 45 degrees then the two parallel line patches will print the same density regardless of the amount of slur."[4]

The two 50% patches to the left of the center solid ink density patch consist of halftone dots. One is made from a square (conventional) contact screen and the other is made from an elliptical contact screen.

The dot percentages are guaranteed to be consistent to within 1% of the given dot areas. The test object, when printed without slur, gives a symmetrical appearance.

The symmetrical scale test object was used to plot densities produced for each patch (25%, 50% - for the corresponding dot structure, 75% and solid ink density) on the PC graph paper. The graph gave the corresponding dot gain for each screen ruling and for the elliptical and square dot structure. A more detailed explanation of how to use the PC graph paper will be given in the Methodology Chapter.

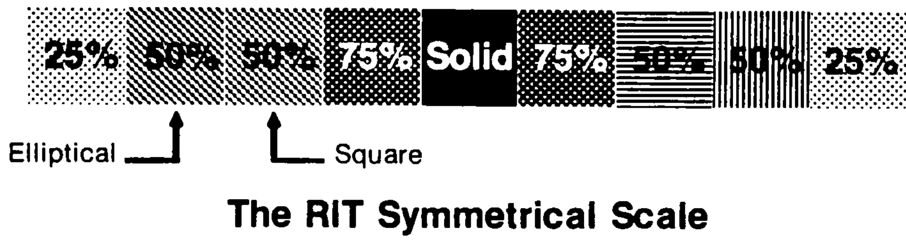


Figure 8. RIT Symmetrical Scale

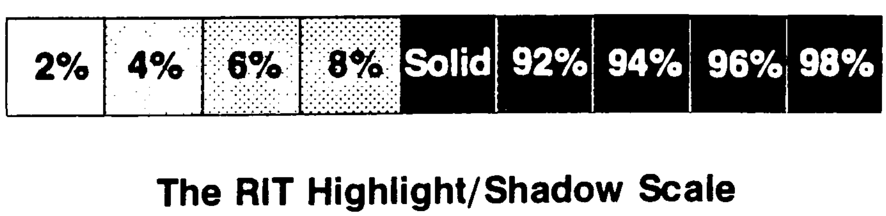


Figure 9. RIT Highlight/Shadow Scale

RIT Highlight/Shadow Scale

This test object was used to determine the highlight and shadow minimum dot which a printing system can reproduce. (See Figure 9.)

The scale consists of nine patches. The middle patch is the solid ink density (SID) patch. To the left of the SID patch are four highlight dot areas ranging from 2-8% in increments of 2%. To the right of the SID patch are four shadow dot areas ranging from 92% to 98% in increments of 2%.

The highlight/shadow scale was used to determine what dot area the Goss Community press was able to print. This scale is guaranteed to be within a 0.5% accuracy.

ByChrome Percentage Calibrated Screen Tints

Since the round dot structure was also being investigated in this thesis, a test object was needed. The ByChrome device was selected because the dot areas were similar to that of the RIT Symmetrical Highlight/Shadow Scales dot areas. (See Figure 10.) The 25%, 50%, and 80% patches were used on the PC graph paper to determine the dot gain for the round dot structure.

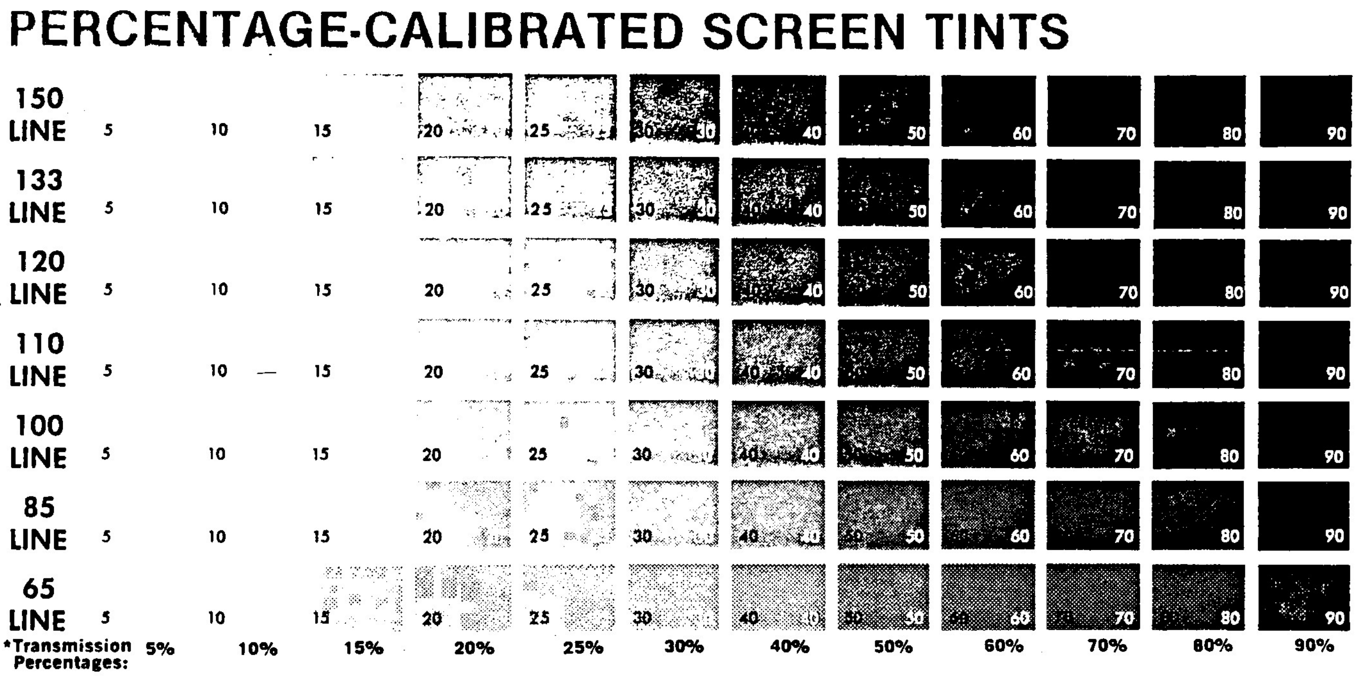


Figure 10. ByChrome Percentage Calibrated Screen Tints

FOOTNOTES FOR CHAPTER IV

[1] H. Brent Archer, "A Miniature Test Form for Press Evaluation", TAGA Proceedings, 1978, p. 131.

[2] Ibid., p. 119.

[3] Ibid., p. 123.

[4] Ibid., p. 130.

CHAPTER V

HYPOTHESIS

During the experimentation portion of this thesis, one roll of newsprint was run on the Goss Community Newspaper Production Press at Rochester Institute of Technology. This thesis investigated the effects screen ruling had on dot gain on offset newsprint. All other variables remained constant. The hypotheses that were used for this thesis are as follows:

Hypothesis 1: Coarse screen ruling (65 line) yields less dot gain than fine screen ruling (150 line) when printed by web offset lithography on newsprint.

Hypothesis 2: Elliptical dot structure yields less dot gain than square (conventional) dot structure when printed by web offset lithography on newsprint.

Hypothesis 3: Round dot structure yields less dot gain than elliptical dot structure when printed by web offset lithography on newsprint.

CHAPTER VI

METHODOLOGY

To determine the effects screen ruling and dot structure had on dot gain on offset newsprint, the following steps were necessary:

Pre-Testing

To determine the capabilities of the Goss Community press in the Rochester Institute of Technology's newspaper production laboratory, a press run was completed to locate the highlight and shadow dot aimpoints for each of the four selected screen rulings and the three dot structures. The same roll of newsprint (Abitibi-Price, 30 lb. standard offset newspirnt) and the same ink (Flint Arrow Web Black) were used for this study and the final press run on printing unit number four of the Goss Community press.

A screened gray scale at 65, 85, 100 and 150 screen ruling for the round, square, and elliptical dot structure was used to visually determine which step on the gray scale the press was able to print a highlight and shadow dot. Also included in the press run were three test objects: all of which contained the four required screen rulings of 65, 85, 100 and 150; the RIT Symmetrical Scale, the RIT Highlight/Shadow scale, and the ByChrome Percentage Calibrated Screen Tints.

The screened gray scale halftones were made under optimum conditions (processor in control, calibrated camera, etc.) in the Reproduction Photography laboratory at RIT. (Appendix B contains the exposure data for this portion of the thesis. Appendix A contains the information for the equipment used.) The original twelve screened gray

scales were then duped onto 3MLOD4 duplicating film to create a second generation hard dot structure. The plate was made in the RIT Technical and Education Center using the twelve screened gray scales duplicating films and the twelve test objects. The plate was then properly mounted on printing unit number four of the Goss Community Press in the RIT newspaper production laboratory.

After the press began printing at a density of 1.2, with a tolerance level of ±.10, across the press sheet, the press counter was monitored. One press sheet was pulled at every 100 impressions until the counter indicated a total of 3000 impressions had been run. The press was constantly monitored and adjusted to maintain the required density of 1.2 (within the tolerance level). A total of thirty samples were pulled from this press run and used to evaluate the capabilities of this Goss Community Press.

Each of the samples were read using a MacBeth RD512 reflection densitometer. Each step on the gray scales and test targets were read. Appendix D lists the averages of all the thirty sample press sheets.

As stated earlier, the press sheets were examined to determine at which step in the highlight end of the scale there was a visual change from no density produced to a step where density was maintained. This step was the highlight density aimpoint. At the shadow end of the scale, the step right before the gray scale visually indicated the same density printed, was the shadow density aimpoint. These density aimpoints were then traced backwards to the duplicating screened gray scales to determine the dot percent areas that produced the density aimpoints. (See Appendix B for dot size aimpoint data.)

The purpose of this pre-testing was not only to determine the highlight and shadow dot size requirements but through a two-point exposure to extend these dot requirements to yield a printed gray scale without plugging the shadows or sacrificing the highlights. This would allow more middletone steps to be printed and aid in the final evaluation of the effects on dot gain.

Preparation for Production

The gray scale and test targets used in pre-testing were also used for the final press run to ensure valid results. A black and white continuous-tone copy was introduced for a final graphic evaluation to show the effect dot gain had on the reproduction as the screen ruling was changed. There were a total of 12 screened black and white continuous-tone images with their corresponding screened gray scales - one for each screen ruling (65, 85, 100, and 150) and for each dot structure within the screen rulings (round, elliptical, and square). The black news ink and roll of newsprint that were used in pre-testing were also used here. The only changes made were in the screen ruling and dot structures during the final press run.

Making the Halftones

The halftones were also made in the same darkroom as previously used in the RIT reproduction laboratory for pre-testing. (See Appendix A for equipment.) The halftones were made such that the highlight dot aimpoint was placed in step 1 of the gray scale. This was accomplished by making a calibration negative using a main exposure of the

reflection gray scale and locating that step on the gray scale which would yield both the highlight and shadow dot aimpoint. (See Appendix E for Calibration Negative Information.)

The next step was to determine the basic density range (BDR) of the screen. This is done by locating the highlight and shadow dot aimpoints on the calibration negative and recording their corresponding density from the gray scale. The BDR is found by then subtracting the highlight density from the shadow density. The BDR is the range of tones that a contact screen can produce.

A basic flash test was made to locate the shadow dot aimpoint as determined in the pre-testing. Using the Kodak Graphic Arts Exposure Computer, the main and flash exposures, if needed, were determined for each screen.

To use the Kodak Graphic Arts Exposure Computer the aperture and magnification that were used for making the calibration negative were set opposite one another. The highlight density of that step on the reflection gray scale which gave the highlight dot aimpoint was placed opposite the main exposure units used for the calibration negative.

In order to achieve the new main exposure time for the halftone, a log shift was needed. In order to accomplish this, the highlight density of step 1 on the gray scale was used since this is the desired step for the highlight dot aimpoint. By looking opposite the highlight density the new main exposure was indicated.

A flash exposure was needed in each of the twelve screens used since the density range of the copy was greater than the basic density range (BDR). The density range remained constant with all twelve halftones since the piece of continuous- tone copy never changed.

Density range is the shadow density minus the highlight density of the copy. The excess density range is found by subtracting the basic density range of the screen from the density range of the illustration. This excess density range is then used to determine the flash exposure for the halftone.

The Kodak Graphic Arts Exposure Computer was also used to determine the flash exposure for the halftone. By locating the basic flash test exposure units and the excess density range required on the flash exposure table, that point where the two columns intersected gave the required controlled flash exposure.

By combining both the main exposure and controlled flash exposure, all twelve halftones were made with the highlight dot aimpoint in step 1 and the shadow dot aimpoint as far down the gray scale as possible without plugging up the highlights. The data and exposure for all twelve halftones are in Appendix B.

Preparation for Press Run

The twelve original halftones were contacted with duplicating film to create a second generation hard dot structure and then exposed onto the Polychrome plate. The plate was also made in the RIT Technical and Education Center using the twelve duplicates and twelve test targets. (Exposure times for the duplicating films are in Appendix B. Platemaking information is in Appendix A.)

Press Run

The printing plate was carefully mounted on printing unit number four of the Goss Community press in the RIT newspaper production laboratory. After a printing density of 1.2, within a tolerance level of ±.10, was achieved, the samples were pulled every 100 impressions to yield a total sample size of thirty.

The thirty sample sheets were read using a MacBeth RD512 reflection densitometer on each of the steps of the twelve gray scales and the twelve test targets. Appendix D contains the averages of each of the steps for the thirty samples.

Plotting the PC Graphs

From these average reflection density readings a PC (Printing Characteristics) graph was drawn for each screen ruling and each dot structure to determine the amount of dot gain and slur. (See Appendix F for the twelve PC graphs.)

To draw the PC graph curve the solid ink density was marked on the vertical axis and plotted above the 100% dot area on the horizontal axis. A straight line was drawn from the 0% dot area on the horizontal axis, as the starting point, to the solid ink density point.

A second curve was drawn for the actual reproduction. To do this the densities determined from the 25%, 50%, and 75% patches of the RIT Symmetrical scale were plotted and a curve was drawn connecting these points. For the elliptical and square dots the RIT Symmetrical scale has two 50% patches - one for the elliptical and one for the square - this RIT Symmetrical scale was used for these two dot structures. The ByChrome Percentage Calibrated Screen Tints was used to determine the actual reproduction curve for the round dot structure.

To determine the dot gain, a horizontal straight line was drawn from the density of the 50% patch of the actual reproduction until it intercepted the diagonal straight line. Next, two vertical straight lines were drawn - one from the 50% dot to its corresponding density and the other from the 50% density interception on the diagonal straight line until it intercepted the horizontal axis. The difference between these two vertical lines was the amount of dot gain in this printing process.

To determine the amount of slur, the densities of the two slur targets were plotted from the RIT Symmetrical scale on the 50% vertical scale. Drawing two vertical lines the same as above for dot gain indicated the amount of slur, also in this printing system.

Plotting the TR Graph

To graphically show how dot gain has affected the black and white reproduction a TR graph was constructed. In order to plot this graph the reflection density of the original gray scale was plotted against the reflection density of the printed gray scale.

A total of four TR graphs were constructed for the 65, 85, 100 and 150 line screen ruling. The round, elliptical, and square dot structures were plotted on the same graph paper for each screen ruling to aid in the evaluation process. (See Appendix F for TR Graphs.)

CHAPTER VII

STATISTICAL ANALYSIS

ANOVA

Analysis of variance (ANOVA) is a statistical technique for evaluating the relationship between one or more independent variables. The basic idea "is to express a measure of the total variation in a set of data as a sum of terms, which can be attributed to specific sources, or causes, of variation."[1]

For this particular study ANOVA was chosen to test the significance of certain variables and their effect on dot gain. A total of three ANOVAs were performed to either prove or disprove the three hypotheses of this thesis. One was performed to determine the significance that screen ruling has on dot gain. The second and third ANOVAs were performed to test the relationships between dot structure and dot gain. All three ANOVAs are presented in a step by step format. The treatment table that was used for analysis is shown in Table 1.

Before performing an ANOVA, two hypotheses need to be defined regarding the testing of the significance of specific variables on dot gain. They can be expressed as follows:

$H_o \quad A \neq B$

$H_1 \quad A = B$

Table 1: Treatment Table

Dot Gain

	65-line	85-line	100-line	150-line
Square	12%	18%	23%	30%
Elliptical	14%	17%	23%	26.5%
Round	9%	16%	20%	30%

If H_0 is expressed verbally rather than mathematically, it means that the screen ruling or screen type has no significance on dot gain. The second hypothesis, H_1 , is read to mean that the screen ruling or screen type has a significant effect on dot gain.

An explanation will be given for each step of the first ANOVA. For all preceeding ANOVAs, only the calculations will be repeated.

HYPOTHESIS I

To begin the analysis of variance (ANOVA), sum totals of the recorded values are needed for each variable.

$$T_1 = 12 + 14 + 9 = 35$$

$$T_2 = 30 + 26.5 + 30 = 86.5$$

From these totals, the correction for the mean (CM) can be derived.

$$CM = \frac{(T_1 + T_2)^2}{n} = \frac{(35 + 86.5)^2}{6} = \frac{(121.5)^2}{6} = \frac{14762.25}{6} \quad 2460.375$$

Total sums of the squares are also determined using the square of each individual variable as follows:

$$\text{Total SS} = (12)^2 + (14)^2 + (9)^2 + (30)^2 + (26.5)^2 + (30)^2 - CM$$

$$= (144 + 196 + 81 + 900 + 702.25 + 900) - CM$$

$$= 2923.25 - 2460.375$$

$$462.875$$

The following two calculations were performed to yield the sums of the squares for the treatment variable and for the error variable.

$$SST = \frac{(T_1)^2}{n_1} + \frac{(T_2)^2}{n_2} - CM$$

$$= \frac{(35)^2}{3} + \frac{(86.5)^2}{3} - CM$$

$$= \frac{1225}{3} + \frac{7482.25}{3} - 2460.375$$

$$= 2902.41 - 2460.375$$

$$= 442.035$$

$$SSE = \text{Total SS} - SST$$

$$= 462.875 - 442.035$$

$$= 20.84$$

The degrees of freedom are equal to the number of levels of each factor minus one. The total degrees of freedom is equal to the total number of levels minus one.

The mean square calculations for the treatment and error variables are found by dividing the sums of the squares by the degrees of freedom.

$$MST = \frac{SST}{DF} = \frac{442.035}{1} = 442.035$$

$$MSE = \frac{SSE}{DF} = \frac{20.84}{4} = 5.21$$

The calculated F ratio is found by dividing the mean square for the treatment by the mean square for error. These values are then compared with the Fischer F-distribution.

$$F \text{ calculated} = \frac{MST}{MSE} = \frac{442.035}{5.21} = 84.84$$

$$F \text{ critical at } \sigma = .05 = 7.71$$

$$F \text{ critical at } \sigma = .01 = 21.2$$

The calculated F ratio was compared to two levels of confidence (95% and 99%) against the F- distribution. Table 2 shows a summary of the totals of each calculation in the ANOVA and indicates the level of significance of the variable.

Table 2: Summary Table

Hypothesis	F Ratio	Fo=.05	Results	Fo=.01	Results
65 vs 15-line screens	84.84	7.71	Reject	21.2	Reject
Elliptical vs Round Dot	0.07	5.99	Accept	13.7	Accept
Elliptical vs Square Dot	0.02	5.99	Accept	13.7	Accept

HYPOTHESIS 2

1. $T_1 = 14 + 17 + 23 + 26.5 = 80.5$

$T_2 = 9 + 16 + 20 + 30 = 75$

2. $$CM = \frac{(T_1 + T_2)^2}{n} = \frac{(80.5 + 75)^2}{8} = \frac{(155.5)^2}{8}$$

$$= \frac{24180.25}{8} = 3022.53$$

3. $$\text{Total SS} = [(14)^2 + (17)^2 + (23)^2 + (26.5)^2 + (9)^2 + (16)^2 + (20)^2 + (30)^2] - CM$$

$$= [196 + 289 + 529 + 702.25 + 81 + 256 + 400 + 900] - CM$$

$$= 333.53.25 - 3022.53$$

$$= 330.72$$

4. $$SST = \frac{(T_1)^2}{n} + \frac{(T_2)^2}{n} - CM$$

$$= \frac{(80.5)^2}{4} + \frac{(75)^2}{4} - CM$$

$$= \frac{6480.25}{4} + \frac{5625}{4} - CM$$

$$= 3026.31 - 3022.53$$

$$= 3.78$$

$$SSE = \text{Total SS} - SST$$

$$= 330.72 - 3.78$$

$$= 326.94$$

5. $$MST = \frac{SST}{DF} = \frac{3.78}{1} = 3.78$$

$$MSE = \frac{SSE}{DF} = \frac{326.94}{6} = 54.49$$

6. $$F \text{ calculated} = \frac{54.49}{378}$$

$$= 14.42$$

F critical at $\sigma = .05 = 5.99$

F critical at $\sigma = .01 = 13.7$

HYPOTHESIS 3

1. $T_1 = 14 + 17 + 23 + 26.5 = 80.5$

$T_2 = 12 + 18 + 23 + 30 = 83$

2. $$CM = \frac{(80.5 + 83)^2}{8} = \frac{(163.5)^2}{8} = \frac{26732.25}{8}$$

$$= 3341.53$$

3. $$\text{Total SS} = [(14)^2 + (17)^2 + (23)^2 + (26.5)^2 + (12)^2 + (18)^2 + (23)^2 + (30)^2] - CM$$

$$= [196 + 289 + 529 + 702.25 + 144 + 324 + 529 + 300] - CM$$

$$= 3613.25 - 3341.53$$

$$= 271.72$$

$$SST = \frac{(T_1)^2}{n} + \frac{(T_2)^2}{n} - CM$$

$$= \frac{(80.5)^2}{4} + \frac{(83)^2}{4} - CM$$

$$= 3342.31 - 3341.53$$

$$= 0.78$$

$$SSE = \text{Total SS} - SST$$

$$= 271.72 - 0.78$$

$$= 270.94$$

5. $$MST = \frac{SST}{DF} = \frac{.78}{1} = 0.78$$

$$MSE = \frac{SSE}{DF} = \frac{270.94}{6} = 45.16$$

6. $$F \text{ calculated} = \frac{45.16}{0.78} = 57.90$$

F critical at $\sigma = .05 = 5.99$

F critical at $\sigma = .01 = 13.7$

CONCLUSIONS

Based upon an ANOVA statistical analysis, the following conclusions can be derived, at both confidence levels of 95% and 99% for each of the three hypotheses.

1. There was a significant difference in dot gain found between the 65-line and 150-line screen ruling. The fact that the F- ratio was significantly higher than the F- table values indicates that there is less of a doubt that it was merely by chance that this particular experiment yielded less dot gain for the coarser screen ruling.
2. No significance was found between elliptical and round dot structure as regards dot gain.
3. There also was no significant difference in dot gain values whether the elliptical or square dot structures are used.

FOOTNOTES FOR CHAPTER VII

[1] John E. Freund, Modern Elementary Statistics, (Prentice-Hall Inc., 1979), p. 417.

CHAPTER VIII

CONCLUSIONS, OBSERVATIONS, AND RECOMMENDATIONS

Conclusions

Based upon the results of this report, the following conclusions can be drawn from the statistical analysis and the graphic analysis.

The author agrees with the conclusions of Warren L. Rhodes' research in 1955 in which he found that fine screen tints filled in faster than course screen tints. Based upon this experiment, it was found that fine screen ruling yields more dot gain than course screen ruling.

It was determined through experimentation that Hypothesis 1, "course screen ruling (65 line) yields less dot gain than fine screen ruling (150 line) when printed by web offset lithography on newsprint" is valid. The author found through analysis of the statistical and graphic data that screen ruling has a significant influence on the amount of dot gain. As the screen ruling gets finer (150 versus 65) more dot gain will appear, which can be traced to the number of dots per square inch. As the screen ruling increases (65 versus 150), so do the number of dots per linear inch. Because there are more dots to the inch, it is obvious that the space between the dots will decrease, therefore, dot gain is more noticeable due to overlapping of these dots.

Through statistical analysis Hypothesis 2, "elliptical dot structure yields less dot gain than square (conventional) dot structure when printed by web offset lithography on newsprint" is not valid. Also, Hypothesis 3, "round dot structure yields less dot gain than elliptical dot structure when printed by web offset lithography on newsprint" is also statistically invalid.

It was found statistically that there was no relationship between dot structure and dot gain. However, graphically, the round dot structure did yield less dot gain but only in the 65, 85, and 100-line screen ruling. The round dot structure did yield more dot gain than the elliptical dot structure for the 150-line screen ruling only.

This proved to be an interesting result because in theory one would assume that the round dot structure would yield the least amount of dot gain in all screen rulings. Round dot structure is thought to yield less dot gain because in the midtone area, which is the largest dot area, the dots are not touching any other dot and therefore there is more room and less overlapping of the dots.

The elliptical dot structure did yield less dot gain than the square dot structure but only in the 85 and 150-line screen ruling. Elliptical dot structure and square dot structure produced the same amount of dot gain in the 100-line screen ruling. In the 65-line screen ruling, the elliptical dot structure produced more dot gain than the square dot structure.

In theory, one would assume that the elliptical dot structure would yield the least amount of dot gain in all screen rulings as compared to the square (conventional) dot structure. In the midtone area, the elliptical dot structure has only two corners joined therefore the dot gain should not be as apparent as with the square dot structure which has all four corners joined in the midtone area.

Graphically, on the TR Graph Paper, the 65 and 100-line screen ruling yielded the same results. The square dot structure in both screen rulings produced a curve with more contrast as compared with the elliptical and round dot structures. The elliptical dot structure in both

the 65 and 100-line screen ruling produced a curve with the least amount of contrast as compared with the square and round dot structures.

On the other hand, with the 85 and 150-line screen ruling, the square dot structure yielded less contrast than the round and elliptical dot structure. The round dot structure produced a curve with more contrast than either the square or elliptical dot structure.

Observations

An interesting result was found regarding this particular press run on the Goss Community press. The manner in which impositions of the form was made yielded data which indicated that one side of the press was producing significantly more slur than the other side of the press. The 65 and 100-line screen ruling yielded more slur than the 85 and 150-line screen ruling. This could also be the reason the TR graphs plotted identical for the 65 and 100-line screen ruling and identical graphs for the 85 and 150-line screen ruling.

Recommendations

Based upon the results of this experiment, the author would recommend that any of the round, square, or elliptical dot structures could be used on newsprint and would yield satisfactory printed results. It is also recommended that a course screen ruling (65-line) be used instead of a finer screen ruling (150-line) to produce better results regarding dot gain.

The author would like to see this study carried further in the area of four color printing. More could be done through a visual test to decide if one could detect dot gain. Because dot gain has a more appreciable affect on four color printing, the hue difference alone might be sufficient evidence of dot gain.

CHAPTER IX

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APPENDIX A

EQUIPMENT

Equipment Used in Pre-testing and Final Testing

Pre-testing

Darkroom H in RIT Reproduction Photography Laboratory

GAM II Integrator

Robertson Camera F/11 - 100% magnification

Quartz Light Source

3M Orthchromatic Lith Film QA4

Film Emulsion for 65, 85, 100-line screen

662056-9

Film Emulsion for 150-line screen

669491-504

Policrom Contact Screens, Gray, negative, 9x11 screen, 45° inclination

150 Square	F0145
150 Elliptical	F0215
150 Round	ER207
100 Square	LU940
100 Elliptical	LU765
100 Round	LU850
85 Square	LU912
85 Elliptical	LU742
85 Round	LU832
65 Square	KP391
65 Elliptical	LU712
65 Round	LU817

LogE Lith Processor

98 - developing speed

Status B

8 x 10 Film Size

Exposure Percentage - 50%

Temperature - 80^{o}

Dupe Info

Graphic Technology Inc., Expo 19 - Digital Light Integrator

NuArc Exposure Unit

3M LOD4 Duplicating Film - emulsion #443728-4

Kodak Readymatic Processor - rapid access

Final Testing

Darkroom H in RIT Reproduction Photography Laboratory

GAM II integrator

Robertson Camera F/11 - 100% magnification

Quartz light source

3M Orthchromatic Lith Film QA4

emulsion #669491-504

Polychrom Contact Screens - Gray, Negative, 9 x 11 screens

45° inclination

150 Square	F0145
150 Elliptical	F0215
150 Round	ER207
100 Square	LU940
100 Elliptical	LU765
100 Round	LU850
85 Square	LU912
85 Elliptical	LU742
85 Round	LU832
65 Square	KP391
65 Elliptical	LU712
65 Round	LU817

LogE Lith Processor

Developing speed - 90 seconds

Status B

8 x 10 film size

Exposure Percentage - 50%

Temperature - 80°

Chemistry - DuPont CLBD

Dupe Info

Graphic Technology Inc., Expo 19 - Digital Light Integrator

NuArc Exposure Unit

3M LOD4 Duplicating Film emulsion # 443728-4

Kodak Readymatic Processor - rapid access

Kodak Graphic Arts Exposure Computer

Ink, Press and Paper used for pre-testing and final testing

Goss Community Press

Printing unit #4 (top unit)

10,000 impressions per hour

Alkaline fountain solution

Black news ink

Flint Arrow Web Black

Batch #1508

Abitibi-Price Standard Newsprint - Offset

Roll # - HD00004

Size - 30"

Basic Weight - 30 lb.

Gross Weight - 934 lb.

Equipment used for platemaking in pre-testing and final testing

NuArc Plus Fliptop Platemaker

Model FT40V2UP-3KP

250 unit exposure

4000 metal halide bulbs

Polychrome Offset Plates

23½ x 35

Emulsion # K2766559

Plate Chemistry

Polychrome Fotomer Developer 922

Polychrome image subtractive plate gun 963

Densitometer used in pre-testing and final testing

MacBeth TD-504 transmission densitometer

MacBeth RD-512 reflection densitometer

Equipment and exposure used to make print of final testing press sheet

Chemco Roll Film Camera

F/22 - 37% magnification

18 unit exposure

LogE Lith Processor

Developing speed - 90 seconds

Status B

10 x 12 film size

Exposure Percentage - 75%

Temperature - 80°

Chemistry - DuPont CLBD

Contact Information

Exposure 11 seconds

Filter 18A

Paper Ektamatic Type T

Print processing - stabilization process

APPENDIX B

EXPOSURE TIMES AND DOT SIZE AIMPOINTS

EXPOSURE TIMES FOR PRE-TESTING HALFTONES

	Main Exposure
65 Square	75 units
65 Elliptical	75 units
65 Round	75 units
85 Square	80 units
85 Elliptical	80 units
85 Round	80 units
100 Square	75 units
100 Elliptical	75 units
100 Round	75 units
150 Square	45 units
150 Elliptical	45 units
150 Round	45 units

EXPOSURE TIME FOR DUPLICATING FILMS

10 second exposure

Dot Size Aimpoints for Final Halftones

(Step 1 and Step 30 on the Gray Scale)

Screen	Highlight Aimpoint	Shadow Aimpoint
65 Square	97%	15%
65 Elliptical	97%	13%
65 Round	96%	19%
85 Square	97%	28%
85 Elliptical	97%	26%
85 Round	96%	22%
100 Square	97%	32%
100 Elliptical	97%	29%
100 Round	96%	35%
150 Square	97%	49%
150 Elliptical	97%	46%
150 Round	96%	40%

Exposure Times for Final Testing Halftones

	Main Exposure	Flash Exposure
65 Square	36 units	27 units
65 Elliptical	42 units	11 units
65 Round	32 units	30 units
85 Square	40 units	33 units
85 Elliptical	36 units	34 units
85 Round	27 units	24 units
100 Square	26 units	36 units
100 Elliptical	31 units	33 units
100 Round	36 units	44 units
150 Square	17 units	78 units
150 Elliptical	21 units	60 units
150 Round	21 units	52 units

Exposure Time for Duplicating Films

24 seconds

APPENDIX C

DOT AREA PERCENTAGES

65-Line Screen Ruling

Dot Sizes for Originals in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3	100		
4	99		
5	99	100	
6	98	99	100
7	97	98	99
8	94	96	97
9	92	93	95
10	88	90	92
11	86	88	90
12	81	85	87
13	77	81	84
14	71	76	80
15	65	71	76
16	58	65	70
17	50	58	64
18	43	52	58
19	37	44	51
20	31	37	44
21	26	31	36
22	19	23	27
23	13	17	20
24	8	11	13
25	3	5	9
26			3
27			
28			
29			
30			

85-Line Screen Ruling
Dot Sizes for Originals in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4		100	
5	100	99	
6	99	98	100
7	97	97	99
8	95	95	98
9	93	92	96
10	91	90	94
11	88	87	92
12	86	84	90
13	83	81	88
14	79	76	84
15	73	70	80
16	68	64	75
17	61	58	68
18	53	52	62
19	47	44	54
20	39	37	45
21	33	30	37
22	26	24	28
23	21	18	20
24	12	11	13
25	6	5	7
26			
27			
28			
29			
30			

100-Line Screen Ruling
Dot Sizes for Originals in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4		100	100
5		99	99
6	100	98	97
7	99	97	95
8	98	95	92
9	95	92	89
10	93	90	86
11	90	88	83
12	87	85	80
13	83	81	77
14	79	77	71
15	74	71	67
16	68	65	60
17	61	59	55
18	54	52	48
19	46	44	42
20	39	39	34
21	32	32	28
22	26	25	20
23	19	18	14
24	12	21	8
25	5	6	3
26			
27			
28			
29			
30			

150-Line Screen Ruling
Dot Sizes for Originals in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4		100	100
5	100	98	99
6	98	96	97
7	95	94	95
8	92	91	92
9	89	89	87
10	86	86	84
11	83	83	81
12	79	79	76
13	73	75	72
14	66	69	66
15	59	62	60
16	50	55	53
17	42	47	47
18	35	40	39
19	30	34	32
20	24	28	24
21	20	24	19
22	15	19	15
23	10	12	10
24	4	6	5
25			
26			
27			
28			
29			
30			

65-Line Screen Ruling
Dot Sizes for Dupes in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4			
5	100		
6	98	100	
7	96	98	100
8	94	95	98
9	89	92	94
10	86	89	90
11	82	86	88
12	76	82	85
13	72	77	80
14	66	74	75
15	59	68	74
16	51	62	66
17	42	55	60
18	37	50	53
19	29	40	49
20	28	34	40
21	19	29	34
22	15	22	22
23	11	17	17
24	7	13	11
25	5	7	7
26			2
27			
28			
29			
30			

85-Line Screen Ruling
Dot Sizes for Dupes in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4			
5			
6	100	100	
7	98	97	100
8	95	94	98
9	92	92	95
10	90	89	93
11	86	86	90
12	83	81	87
13	79	77	84
14	75	71	80
15	68	66	75
16	65	60	68
17	56	54	63
18	50	48	56
19	41	40	49
20	34	34	40
21	31	28	34
22	22	22	26
23	19	17	19
24	11	11	15
25	7	9	9
26	2	2	3
27			
28			
29			
30			

100-Line Screen Ruling
Dot Sizes for Dupes in Pre-Testing

Step on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4			
5		100	100
6		99	99
7	100	97	96
8	99	94	94
9	95	91	90
10	92	87	87
11	89	86	83
12	85	82	79
13	82	78	76
14	77	74	71
15	71	67	65
16	64	61	60
17	58	53	52
18	50	46	46
19	42	38	41
20	35	31	32
21	29	26	26
22	24	21	21
23	17	15	15
24	13	9	9
25	5	7	7
26	2	2	2
27			
28			
29			
30			

150-Line Screen Ruling
Dot Sizes for Dupes in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4			
5	100	100	100
6	99	96	98
7	96	94	96
8	93	91	92
9	89	87	87
10	85	84	83
11	82	82	80
12	76	77	74
13	71	74	70
14	65	65	64
15	54	58	58
16	47	52	52
17	37	45	45
18	29	38	37
19	26	32	28
20	21	26	22
21	15	21	15
22	11	17	11
23	7	11	9
24	2	7	5
25		2	2
26			
27			
28			
29			
30			

65-Line Screen Ruling
Dot Sizes for Press-Sheets in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4	2	2	
5	2	2	2
6	5	2	2
7	9	5	2
8	13	11	7
9	19	15	13
10	22	21	17
11	28	24	22
12	34	28	28
13	38	32	31
14	46	38	37
15	53	43	41
16	61	51	49
17	67	59	55
18	72	64	64
19	75	71	71
20	78	76	77
21	82	80	82
22	84	82	85
23	86	85	87
24	88	87	89
25	89	89	90
26	90	90	
27			
28			
29			
30			

85-Line Screen Ruling
Dot Sizes for Press Sheets in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4			
5	2	2	2
6	2	5	2
7	9	11	5
8	17	17	7
9	22	21	11
10	28	28	15
11	32	31	17
12	37	37	21
13	42	42	24
14	50	50	28
15	56	58	32
16	66	65	40
17	71	71	48
18	76	76	55
19	80	81	64
20	85	85	72
21	87	87	77
22	90	89	79
23	90	90	82
24	91	90	85
25	92	91	87
26			
27			
28			
29			
30			

100-Line Screen Ruling
Dot Sizes for Press Sheets in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4			
5	2	2	2
6	2	5	7
7	2	11	13
8	7	15	19
9	13	19	22
10	17	24	28
11	21	28	32
12	28	32	39
13	34	37	45
14	38	45	53
15	48	52	60
16	55	61	68
17	64	68	74
18	71	74	78
19	76	78	82
20	80	82	86
21	83	85	87
22	85	86	89
23	86	87	90
24	88	89	
25	89	90	
26	90		
27			
28			
29			
30			

150-Line Screen Ruling
Dot Sizes for Press Sheets in Pre-Testing

Steps on Gray Scale	Square	Elliptical	Round
1			
2			
3			
4			
5	2	5	2
6	7	15	7
7	19	21	15
8	24	28	22
9	35	35	28
10	44	41	34
11	51	47	40
12	60	53	47
13	68	60	52
14	77	70	59
15	83	78	66
16	87	83	72
17	89	86	76
18	90	88	80
19	91	89	83
20	91	90	85
21	91	90	86
22	92	91	86
23			86
24			87
25			
26			
27			
28			
29			
30			

65-Line Screen Ruling
Dot Sizes for Originals in Final Testing

Steps on Gray Scale	Square	Elliptical	Round
1	97	97	97
2	95	96	96
3	94	95	94
4	92	92	90
5	90	90	89
6	86	87	85
7	83	83	82
8	78	80	79
9	72	76	76
10	69	74	73
11	65	71	71
12	60	66	66
13	56	64	64
14	52	59	59
15	45	53	55
16	41	48	50
17	37	42	46
18	32	37	41
19	28	31	37
20	24	28	32
21	22	24	28
22	19	21	22
23	17	15	17
24	11	11	11
25	7	7	9
26	5	5	5
27	2	2	2
28			
29			
30			

85-Line Screen Ruling
Dot Sizes for Originals in Final Testing

Steps on Gray Scale	Square	Elliptical	Round
1	97	97	96
2	96	96	95
3	95	95	94
4	94	94	92
5	90	91	90
6	87	87	87
7	86	85	84
8	82	82	82
9	80	78	78
10	76	76	74
11	74	74	71
12	71	69	68
13	67	66	65
14	64	62	59
15	58	58	54
16	53	53	49
17	48	48	43
18	42	43	39
19	38	41	32
20	34	34	29
21	29	29	22
22	26	26	21
23	21	21	15
24	13	17	13
25	11	11	7
26	7	7	5
27	6	5	2
28		2	
29			
30			

100-Line Screen Ruling
Dot Sizes for Originals in Final Testing

Steps on Gray Scale	Square	Elliptical	Round
1	97	97	96
2	96	96	95
3	95	95	94
4	92	94	92
5	90	90	90
6	86	88	87
7	83	86	83
8	78	82	80
9	75	78	76
10	71	75	74
11	68	71	71
12	65	68	68
13	61	64	65
14	57	58	61
15	52	54	57
16	46	49	52
17	42	45	49
18	38	39	43
19	34	35	40
20	29	29	35
21	24	28	31
22	21	21	24
23	15	17	21
24	13	13	15
25	9	9	9
26	7	7	7
27	5	5	5
28	2	2	2
29			
30			

150-Line Screen Ruling
Dot Sizes for Originals in Final Testing

Steps on Gray Scale	Square	Elliptical	Round
1	97	97	97
2	96	94	96
3	94	93	94
4	92	91	92
5	89	89	90
6	86	86	87
7	83	83	83
8	78	79	80
9	76	76	76
10	71	72	74
11	68	69	69
12	65	66	66
13	60	63	62
14	56	58	58
15	51	54	53
16	45	48	49
17	41	42	45
18	35	39	41
19	29	34	37
20	26	28	31
21	21	24	29
22	19	21	22
23	13	17	19
24	11	15	15
25	7	11	11
26	5	9	7
27	2	7	5
28		5	2
29		2	
30			

65-Line Screen Ruling
Dot Sizes for Dupes in Final Testing

Steps on Gray Scale	Square	Elliptical	Round
1	95	96	95
2	94	95	94
3	92	92	90
4	90	90	87
5	86	87	86
6	81	83	82
7	77	79	78
8	71	76	75
9	66	72	71
10	62	69	68
11	58	67	67
12	54	61	63
13	51	57	59
14	45	51	54
15	39	46	50
16	35	42	48
17	31	35	41
18	28	31	37
19	24	24	32
20	19	21	28
21	17	19	21
22	13	15	15
23	11	13	11
24	9	9	7
25	7	5	5
26	5	2	5
27			2
28			
29			
30			

85-Line Screen Ruling
Dot Sizes for Dupes in Final Testing

Steps on Gray Scale	Square	Elliptical	Round
1	96	96	95
2	94	95	94
3	93	94	92
4	92	92	90
5	88	90	87
6	85	86	83
7	82	82	82
8	78	80	78
9	75	75	74
10	71	74	71
11	69	69	67
12	66	66	64
13	63	62	60
14	58	58	53
15	53	53	49
16	49	49	42
17	43	45	37
18	38	40	31
19	34	37	26
20	29	31	21
21	26	26	17
22	22	22	13
23	17	19	11
24	13	15	9
25	9	11	5
26	7	7	2
27	2	5	
28		5	
29		2	
30			

100-Line Screen Ruling
Dot Sizes for Dupes in Final Testing

Steps on Gray Scale	Square	Elliptical	Round
1	96	95	95
2	95	94	94
3	94	93	92
4	90	91	90
5	87	88	87
6	83	85	83
7	79	83	80
8	76	79	77
9	71	74	74
10	68	71	71
11	65	67	68
12	61	64	64
13	58	57	62
14	53	53	58
15	48	50	53
16	42	44	50
17	39	38	46
18	34	34	41
19	29	29	38
20	26	26	32
21	22	21	26
22	19	19	22
23	15	13	17
24	11	11	13
25	9	7	7
26	7	5	5
27	5	2	2
28	2		
29			
30			

150-Line Screen Ruling
Dot Sizes for Dupes in Final Testing

Steps on Gray Scale	Square	Elliptical	Round
1	95	94	96
2	93	92	95
3	92	91	94
4	90	89	90
5	86	87	89
6	83	83	85
7	79	79	82
8	75	74	78
9	72	71	74
10	68	68	71
11	66	66	67
12	61	62	63
13	57	58	59
14	52	53	54
15	49	48	50
16	43	42	46
17	37	35	42
18	31	32	37
19	26	26	34
20	21	22	29
21	15	19	26
22	13	17	21
23	11	13	17
24	7	9	13
25	5	7	7
26	5	5	5
27	2	2	2
28			
29			
30			

65-Line Screen Ruling
Dot Sizes for Press Sheets in Final Testing

Steps in Gray Scale	Square	Elliptical	Round
1	11	9	11
2	13	11	13
3	17	13	17
4	21	17	21
5	26	21	24
6	32	26	29
7	37	31	34
8	42	34	39
9	48	37	42
10	53	41	47
11	57	46	49
12	62	51	54
13	68	57	56
14	71	62	61
15	76	67	66
16	78	71	71
17	80	76	74
18	83	79	78
19	85	82	82
20	86	83	83
21	87	84	86
22	88	86	87
23	89	87	88
24	90	89	90
25	90	90	90
26	90	90	90
27	90	90	91
28	90	90	91
29	91	90	91
30	99	90	92

85-Line Screen Ruling
Dot Sizes for Press Sheets in Final Testing

Steps in Gray Scale	Square	Elliptical	Round
1	9	11	13
2	11	13	15
3	13	15	19
4	17	19	22
5	21	24	26
6	26	28	31
7	29	34	37
8	34	37	41
9	38	42	46
10	41	46	50
11	46	50	54
12	49	53	58
13	54	59	63
14	59	63	68
15	64	68	74
16	69	71	78
17	76	75	83
18	80	78	85
19	83	82	88
20	85	85	89
21	87	85	90
22	89	87	91
23	90	87	91
24	91	88	91
25	91	90	91
26	91	90	92
27	92	91	
28			
29			
30			

100-Line Screen Ruling
Dot Sizes for Press Sheets in Final Testing

Steps on Gray Scale	Square	Elliptical	Round
1	13	11	11
2	15	13	15
3	19	15	17
4	24	17	21
5	29	21	26
6	37	22	32
7	41	28	40
8	45	34	44
9	49	38	48
10	53	42	51
11	56	49	55
12	61	52	58
13	65	58	61
14	68	63	65
15	74	68	70
16	77	69	73
17	80	74	76
18	83	78	80
19	85	80	82
20	86	81	84
21	87	83	86
22	89	85	87
23	89	85	89
24	90	87	90
25	91	89	91
26		89	91
27		90	92
28			
29			
30			

150-Line Screen Ruling
Dot Sizes for Press Sheets in Final Testing

Steps in Gray Scale	Square	Elliptical	Round
1	11	15	11
2	13	19	15
3	17	21	19
4	19	22	21
5	24	28	24
6	29	32	32
7	35	37	37
8	39	42	44
9	41	48	49
10	45	52	55
11	49	55	58
12	55	60	62
13	58	65	67
14	64	68	72
15	68	75	76
16	73	78	78
17	77	82	82
18	82	82	85
19	85	86	86
20	86	87	87
21	87	88	89
22	89	89	89
23	89	89	90
24	90	90	90
25	90	90	91
26	90	91	
27	90		
28	90		
29	91		
30			

APPENDIX D

PRESS SHEET REFLECTION DENSITIES OF TEST TARGETS AND GRAY SCALES

Average Reflection Density Readings for Pre-Testing from Press Sheets
RIT Symmetrical Scale

	65-line	85-line	100-line	150-line
25%	.23	.40	.30	.53
50%E	.56	.79	.72	.94
50%S	.58	.70	.71	.84
75%	.88	.97	.98	1.02
SID	1.09	1.08	1.10	1.08
75%	.90	.96	1.00	1.04
50%	.54	.86	.65	.99
50%	.45	.84	.54	1.01
25%	.22	.41	.28	.57

RIT Highlight/Shadow

	65-line	85-line	100-line	150-line
2%	.03	.04	.04	.06
4%	.07	.07	.07	.10
6%	.09	.10	.10	.13
8%	.11	.14	.13	.17
SID	1.12	1.14	1.12	1.14
92%	1.12	1.14	1.12	1.14
94%	1.12	1.14	1.12	1.14
96%	1.12	1.14	1.12	1.14
98%	1.12	1.14	1.12	1.14

Average Reflection Density Readings for Pre-Testing from Press Sheets
ByChrome Percentage Calibrated Screen Tints

	65-line	85-line	100-line	150-line
5%	.06	.09	.08	.10
10%	.09	.17	.10	.20
15%	.11	.24	.14	.30
20%	.21	.36	.27	.47
25%	.27	.37	.34	.53
30%	.41	.47	.50	.69
40%	.56	.60	.71	.83
50%	.67	.77	.83	.96
60%	.74	.80	.93	.96
70%	.92	.83	1.03	.98
80%	1.01	.77	1.08	.83
90%	1.09	.83	1.09	.85

Average Reflection Density Readings for Pre-Testing from Press Sheets
Gray Scales 65-Line

Step	Square	Elliptical	Round
1			
2			
3			
4	.01		
5	.01		
6	.02	.01	
7	.04	.02	.01
8	.06	.05	.03
9	.09	.07	.06
10	.11	.10	.08
11	.14	.12	.11
12	.18	.14	.14
13	.21	.17	.16
14	.27	.21	.20
15	.33	.25	.23
16	.41	.31	.29
17	.48	.39	.35
18	.55	.45	.44
19	.61	.54	.54
20	.67	.61	.64
21	.74	.69	.74
22	.80	.75	.83
23	.87	.82	.91
24	.93	.86	.96
25	.97	.96	1.02
26	.98	.98	1.04
27			
28			
29			
30			

Average Reflection Density Readings for Pre-Testing from Press Sheets
Gray Scales 85-Line

Step	Square	Elliptical	Round
1			
2			
3			
4			
5		.01	
6	.01	.02	.01
7	.04	.05	.02
8	.08	.08	.03
9	.11	.10	.05
10	.14	.14	.07
11	.17	.16	.08
12	.20	.20	.10
13	.24	.24	.12
14	.30	.30	.14
15	.36	.38	.17
16	.47	.46	.22
17	.53	.54	.28
18	.63	.62	.35
19	.71	.72	.45
20	.81	.81	.55
21	.91	.90	.64
22	.99	.95	.68
23	1.04	1.00	.75
24	1.07	1.04	.81
25	1.09	1.05	.86
26		1.07	.89
27			.90
28			
29			
30			

Average Reflection Density Readings for Pre-Testing from Press Sheet Gray Scales 100-Line

Step	Square	Elliptical	Round
1			
2			
3			
4			
5		.01	.01
6		.02	.03
7	.01	.05	.06
8	.03	.07	.09
9	.06	.09	.11
10	.08	.12	.14
11	.10	.14	.17
12	.14	.17	.21
13	.18	.20	.26
14	.21	.26	.33
15	.28	.32	.40
16	.35	.41	.49
17	.44	.50	.58
18	.54	.58	.67
19	.62	.67	.75
20	.69	.75	.84
21	.76	.81	.90
22	.82	.85	.95
23	.84	.90	.99
24	.93	.95	1.02
25	.96	.98	1.04
26	.98	.99	
27			
28			
29			
30			

Average Reflection Density Readings for Pre-Testing from Press Sheet Gray Scales 150-Line

Step	Square	Elliptical	Round
1			
2			
3			
4			
5	.01	.02	.01
6	.03	.07	.03
7	.09	.10	.07
8	.12	.14	.11
9	.19	.19	.14
10	.25	.23	.18
11	.31	.27	.22
12	.40	.33	.27
13	.50	.40	.32
14	.64	.52	.39
15	.78	.66	.47
16	.89	.76	.55
17	.97	.85	.62
18	1.02	.93	.70
19	1.05	.98	.79
20	1.06	1.01	,82
21	1.08	1.03	.84
22	1.09	1.05	.85
23		1.06	.87
24			.89
25			
26			
27			
28			
29			
30			

Average Reflection Density Readings for Final Testing from Press Sheets
RIT Symmetrical Scale

	65-Line	85-Line	100-Line	150-Line
25%	.23	.26	.34	.33
50%E	.53	.57	.64	.70
50%S	.51	.58	.63	.74
75%	.80	.91	.92	1.01
SID	1.07	1.09	1.06	1.09
75%	.82	.93	.92	1.03
50%	.47	.60	.65	.78
50%	.47	.61	.60	.78
25%	.23	.34	.31	.44

RIT Highlight/Shadow Scale

	65-Line	85-Line	100-Line	150-Line
2%	.03	.04	.04	.05
4%	.05	.06	.05	.08
6%	.07	.08	.08	.11
8%	.09	.11	.10	.13
SID	1.07	1.09	1.07	1.09
92%	1.05	1.07	1.06	1.07
94%	1.06	1.07	1.07	1.07
96%	1.07	1.07	1.07	1.07
98%	1.07	1.07	1.07	1.07

Average Reflection Density Readings for Final Testing from Press Sheets
ByChrome Percentage Calibrated Screen Tints

	65-Line	85-Line	100-Line	150-Line
5%	.06	.06	.07	.09
10%	.10	.12	.12	.17
15%	.14	.17	.18	.23
20%	.20	.26	.27	.34
25%	.25	.30	.34	.41
30%	.35	.44	.48	.61
40%	.41	.48	.59	.72
50%	.50	.56	.60	.74
60%	.56	.65	.68	.79
70%	.69	.76	.77	.93
80%	.85	.93	.95	1.00
90%	1.04	1.05	1.05	1.06

Average Reflection Density Readings for Final Testing from Press Sheet Gray Scales 65-Line

Step	Square	Elliptical	Round
1	.05	.04	.05
2	.06	.05	.06
3	.08	.06	.08
4	.10	.08	.10
5	.13	.10	.12
6	.17	.13	.15
7	.20	.16	.18
8	.24	.18	.21
9	.28	.20	.24
10	.33	.23	.27
11	.37	.27	.29
12	.42	.31	.34
13	.49	.37	.36
14	.55	.42	.41
15	.61	.48	.47
16	.66	.53	.54
17	.71	.62	.59
18	.77	.68	.67
19	.81	.74	.74
20	.85	.78	.78
21	.90	.81	.84
22	.93	.87	.90
23	.97	.90	.93
24	1.00	.94	.98
25	1.00	.99	1.01
26	1.00	1.01	1.03
27	1.01	1.02	1.06
28	1.03	1.02	1.07
29	1.06	1.02	1.07
30	1.08	1.03	1.08

Average Reflection Density Readings for Final Testing from Press Sheet
Gray Scales 85-Line

Step	Square	Elliptical	Round
1	.04	.05	.06
2	.05	.06	.07
3	.06	.07	.09
4	.08	.09	.11
5	.10	.12	.13
6	.13	.14	.16
7	.15	.18	.20
8	.18	.20	.23
9	.21	.24	.27
10	.23	.27	.30
11	.27	.30	.34
12	.29	.33	.38
13	.34	.39	.43
14	.39	.43	.51
15	.44	.50	.59
16	.52	.54	.67
17	.62	.60	.76
18	.70	.67	.83
19	.76	.74	.92
20	.83	.81	.96
21	.88	.83	.98
22	.94	.89	1.03
23	.99	.90	1.03
24	1.03	.93	1.05
25	1.05	1.00	1.06
26	1.06	1.02	1.08
27	1.08	1.06	1.08
28	1.08	1.06	1.09
29	1.10	1.07	
30			

Average Reflection Density Readings for Final Testing from Press Sheet
Gray Scales 100-Line

Step	Square	Elliptical	Round
1	.06	.05	.05
2	.07	.06	.07
3	.09	.07	.08
4	.12	.08	.10
5	.15	.10	.13
6	.20	.11	.17
7	.23	.14	.22
8	.26	.18	.25
9	.29	.21	.28
10	.33	.24	.31
11	.36	.29	.35
12	.41	.32	.38
13	.46	.38	.41
14	.51	.43	.46
15	.57	.50	.52
16	.64	.52	.55
17	.70	.58	.62
18	.76	.65	.69
19	.81	.70	.74
20	.86	.72	.80
21	.89	.77	.85
22	.94	.84	.91
23	.96	.88	.95
24	.98	.90	1.00
25	.99	.95	1.06
26	1.00	.97	1.07
27	1.01	.97	1.08
28	1.01	.97	1.08
29	1.02	.98	1.08
30	1.06	1.00	1.09

Average Reflection Density Readings for Final Testing from Press Sheet
Gray Scales 150-Line

Step	Square	Elliptical	Round
1	.05	.07	.05
2	.06	.09	.07
3	.08	.10	.09
4	.09	.11	.10
5	.12	.14	.12
6	.15	.17	.17
7	.19	.20	.20
8	.21	.24	.25
9	.23	.28	.29
10	.26	.32	.35
11	.29	.35	.38
12	.35	.40	.42
13	.38	.45	.48
14	.44	.50	.55
15	.50	.60	.62
16	.56	.66	.66
17	.64	.73	.73
18	.74	.78	.81
19	.81	.84	.85
20	.85	.87	.88
21	.91	.93	.94
22	.94	.97	.96
23	.97	.97	.99
24	.98	1.02	1.01
25	.98	1.02	1.04
26	.99	1.03	1.05
27	.99	1.04	1.06
28	1.01	1.04	1.06
29	1.03	1.05	1.07
30	1.05		

APPENDIX E

CALIBRATION NEGATIVE INFORMATION

	65-Line Square	Elliptical	Round
Calibration Exposure Info			
Main Exposure	80	80	80
Aperature	F/11	F/11	F/11
Magnification	100%	100%	100%
Basic Flash Test	55	46	55
Shadow Density	1.36	1.46	1.36
Highlight Density	.40	.35	.46
Basic Density Range	.96	1.11	.90
Copy Information			
Shadow Density	1.33	1.33	1.33
Highlight Density	.09	.09	.09
Density Range	1.24	1.24	1.24
Basic Density Range	.96	1.11	.90
Excess Density Range	.28	.13	.34
Final Halftone Exposure Info			
Lens Aperature	F/11	F/11	F/11
Magnification	100%	100%	100%
Main Exposure	36	42	32
Controlled Flash Exposure	27	11	30

	85-Line		
	Square	Elliptical	Round
Calibration Exposure Info			
Main Exposure	80	80	80
Aperature	F/11	F/11	F/11
Magnification	100%	100%	100%
Basic Flash Test	64	64	52
Shadow Density	1.26	1.26	1.36
Highlight Density	.30	.35	.53
Basic Density Range	.96	.91	.83
Copy Information			
Shadow Density	1.33	1.33	1.33
Highlight Density	.09	.09	.09
Density Range	1.24	1.24	1.24
Basic Density Range	.96	.91	.83
Excess Density Range	.28	.33	.41
Final Halftone Exposure Info			
Lens Aperature	F/11	F/11	F/11
Magnification	100%	100%	100%
Main Exposure	40	36	27
Controlled Flash Exposure	33	34	24

100-Line

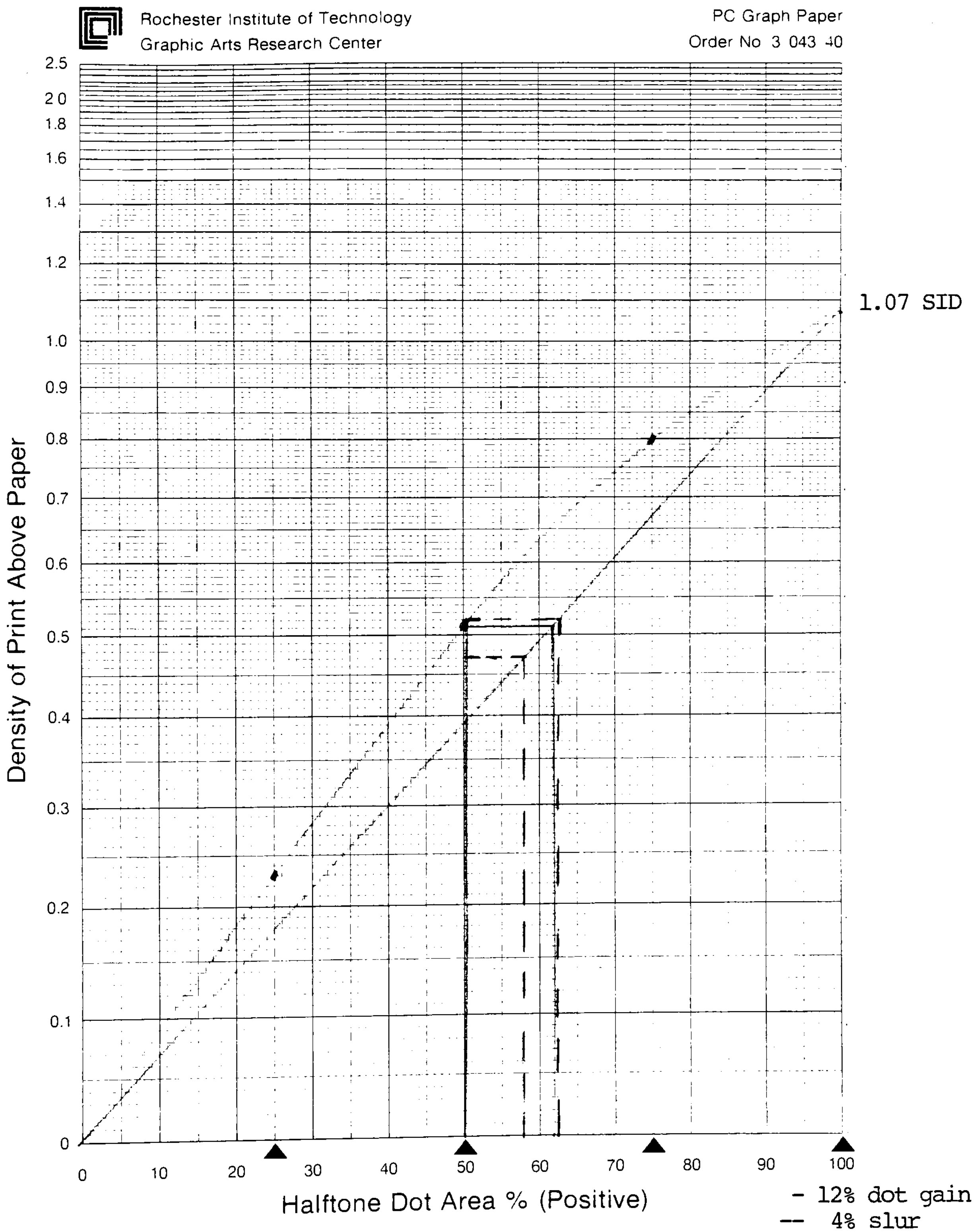
	Square	Elliptical	Round
Calibration Exposure Info			
Main Exposure	80	80	80
Aperature	F/11	F/11	F/11
Magnification	100%	100%	100%
Basic Flash Test	64	58	73
Shadow Density	1.31	1.36	1.14
Highlight Density	.51	.46	.35
Basic Density Range	.80	.91	.79
Copy Information			
Shadow Density	1.33	1.33	1.33
Highlight Density	.09	.09	.09
Density Range	1.24	1.24	1.24
Basic Density Range	.80	.91	.79
Excess Density Range	.44	.33	.45
Final Halftone Exposure Info			
Lens Aperature	F/11	F/11	F/11
Magnification	100%	100%	100%
Main Exposure	26	31	36
Controlled Flash Exposure	36	33	44

	150-Line		
	Square	Elliptical	Round
Calibration Exposure Info			
Main Exposure	70	70	70
Aperature	F/11	F/11	F/11
Magnification	100%	100%	100%
Basic Flash Test	48	42	67
Shadow Density	1.05	1.14	1.17
Highlight Density	.51	.51	.58
Basic Density Range	.54	.63	.59
Copy Information			
Shadow Density	1.33	1.33	1.33
Highlight Density	.09	.09	.09
Density Range	1.24	1.24	1.24
Basic Density Range	.54	.63	.59
Excess Density Range	.70	.61	.65
Final Halftone Exposure Info			
Lens Aperature	F/11	F/11	F/11
Magnification	100%	100%	100%
Main Exposure	17	21	21
Controlled Flash Exposure	78	60	52

APPENDIX F

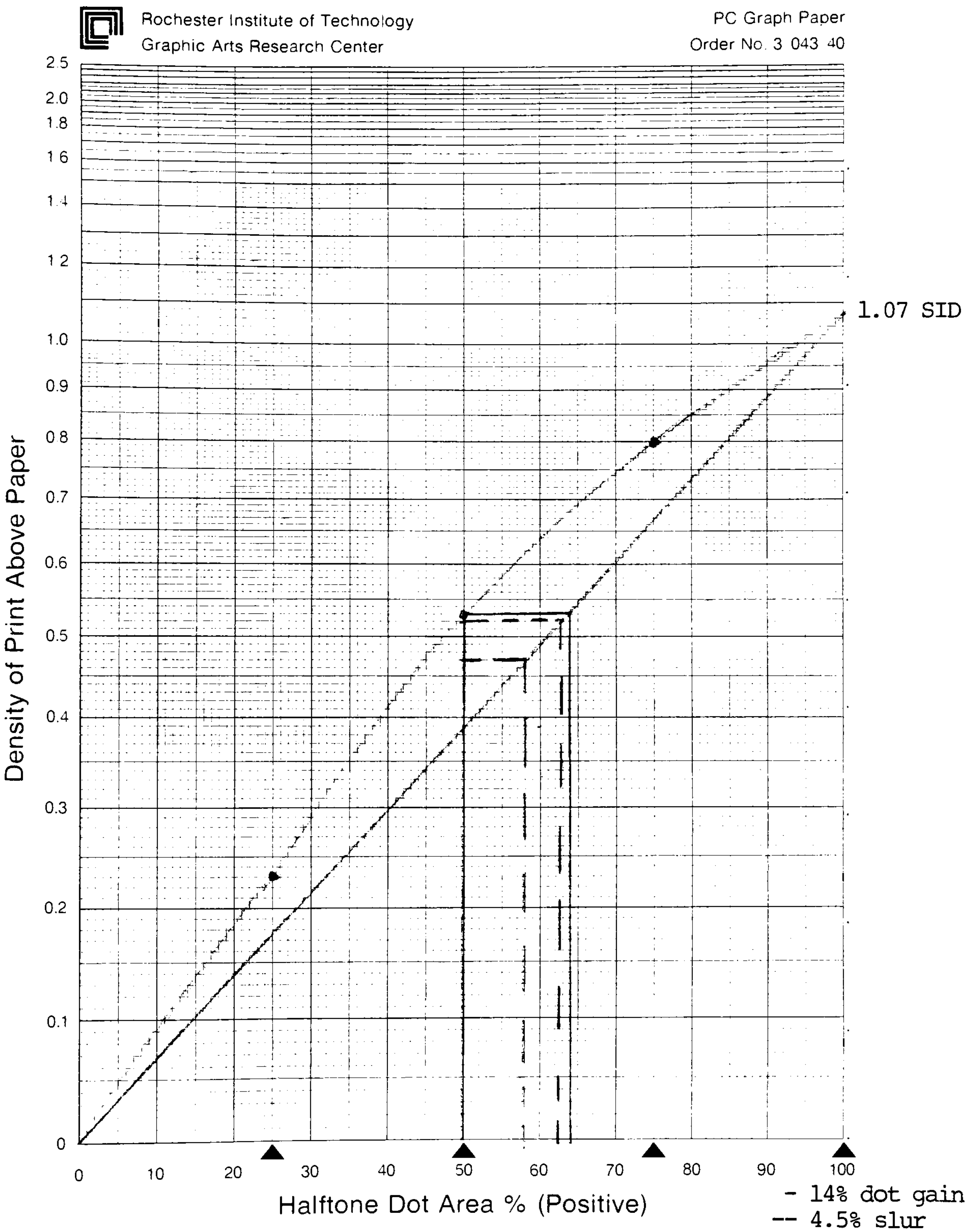
GRAPHS

65-line Square dot



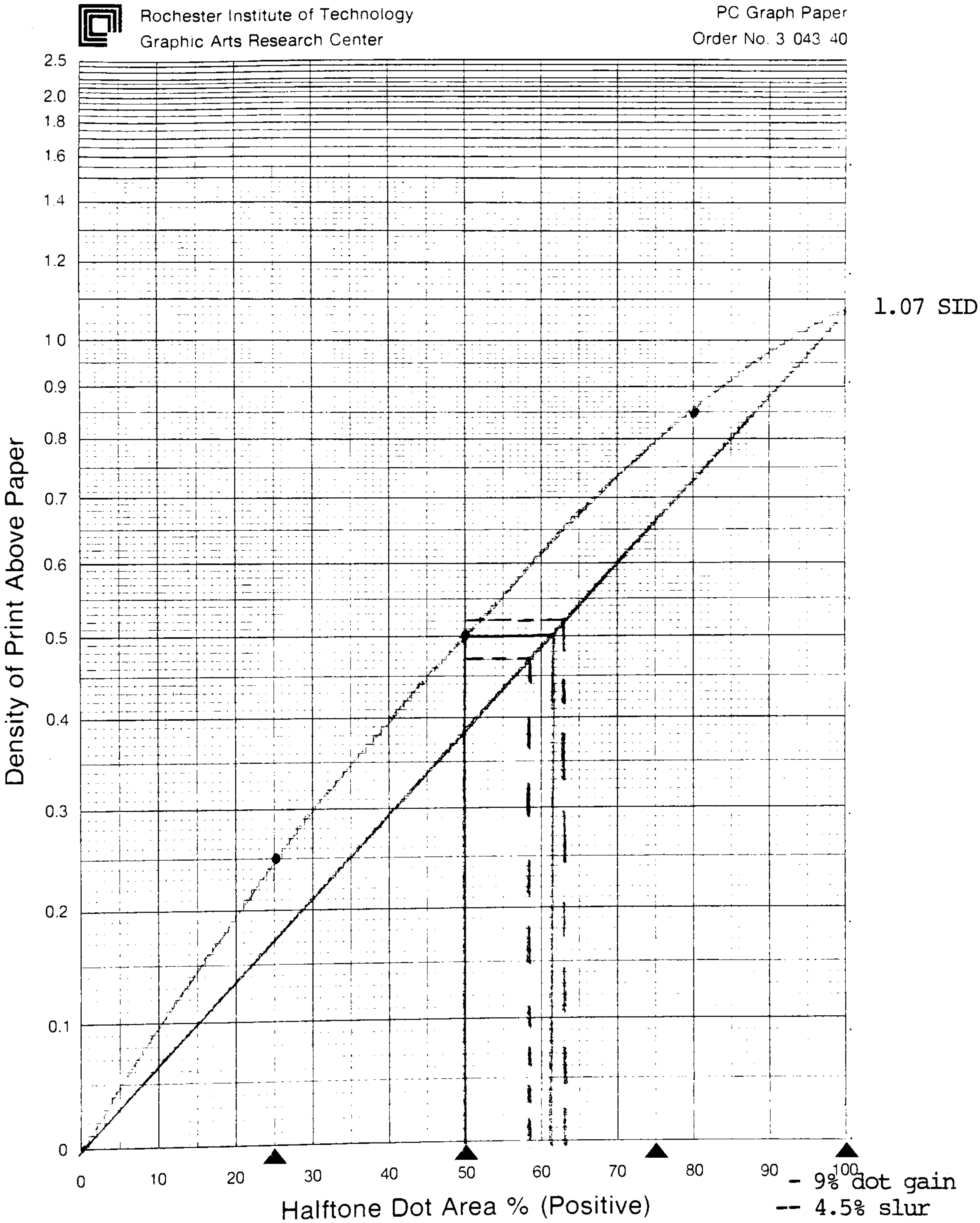
Notes:

65-line Elliptical dot



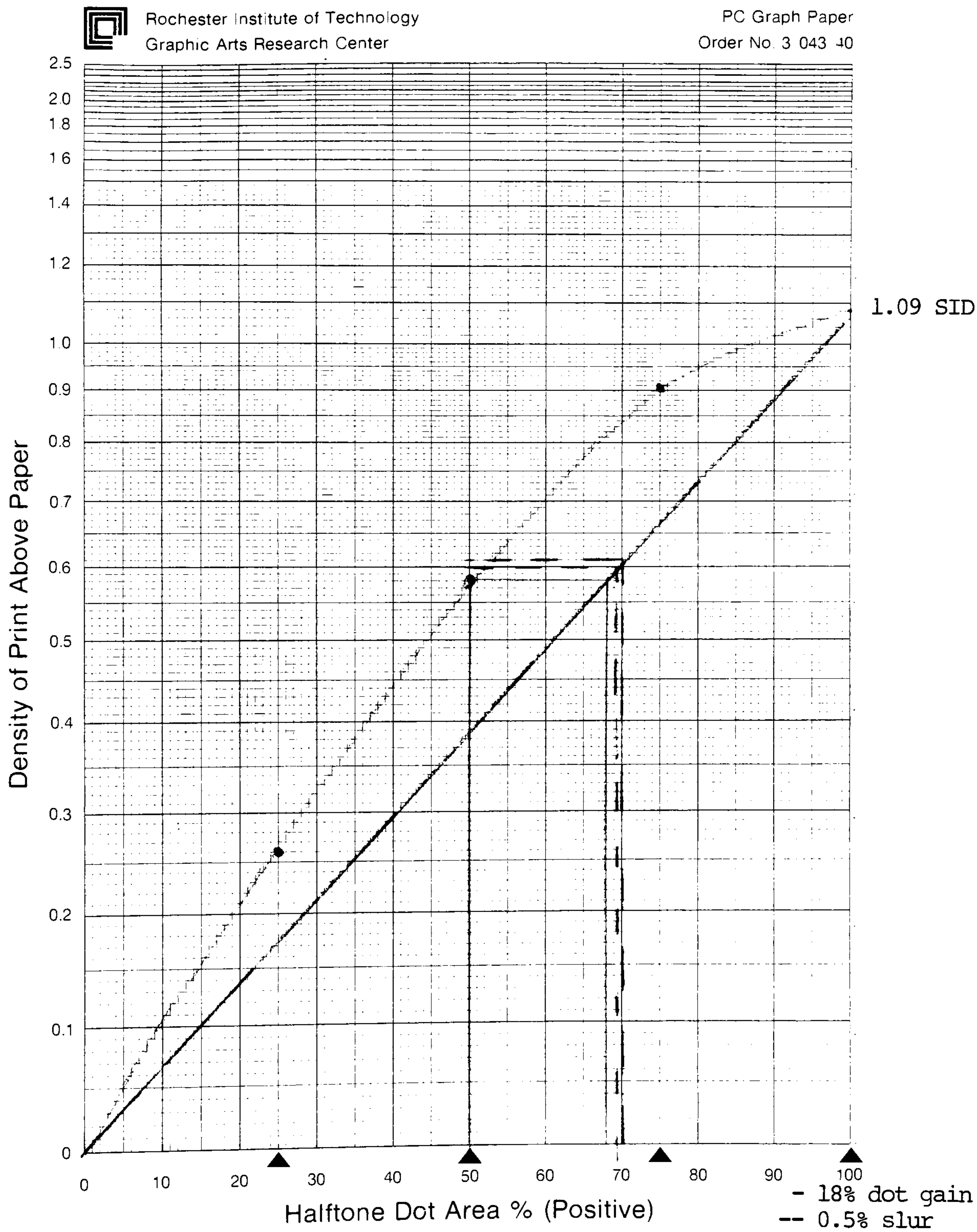
Notes:

65-line Round dot



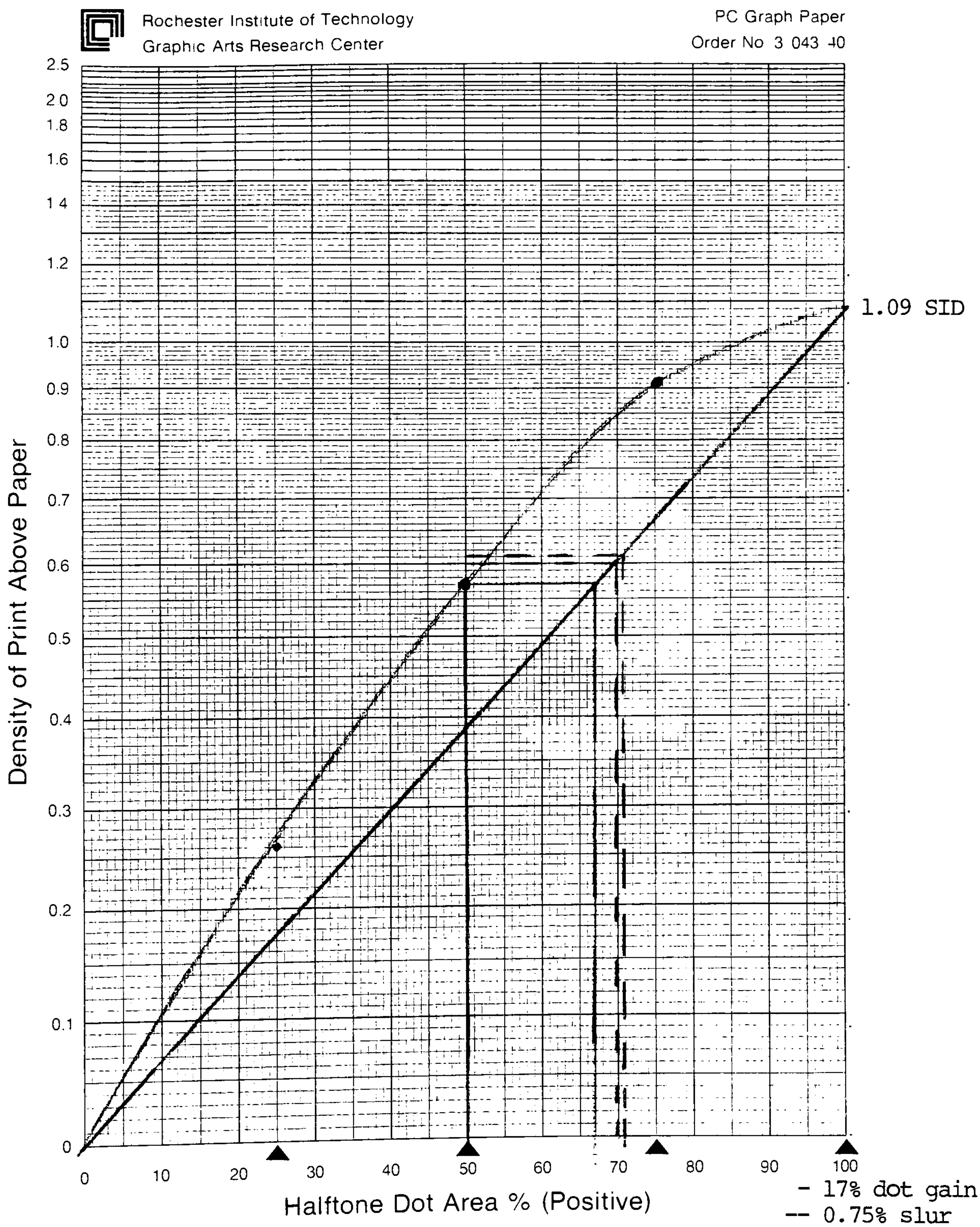
Notes:

85-line Square dot



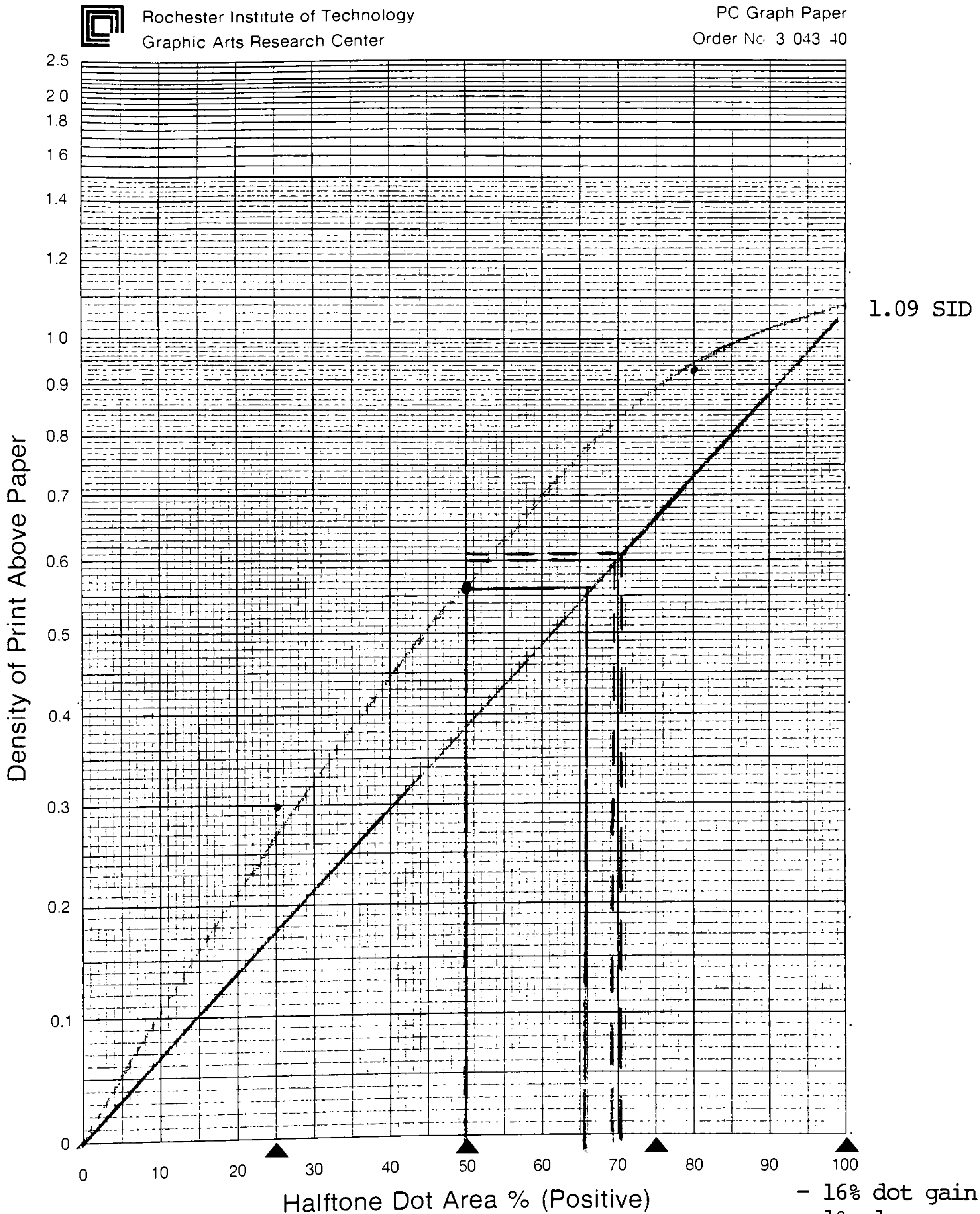
Notes: ______

85-line Elliptical dot



Notes:

85-line Round dot

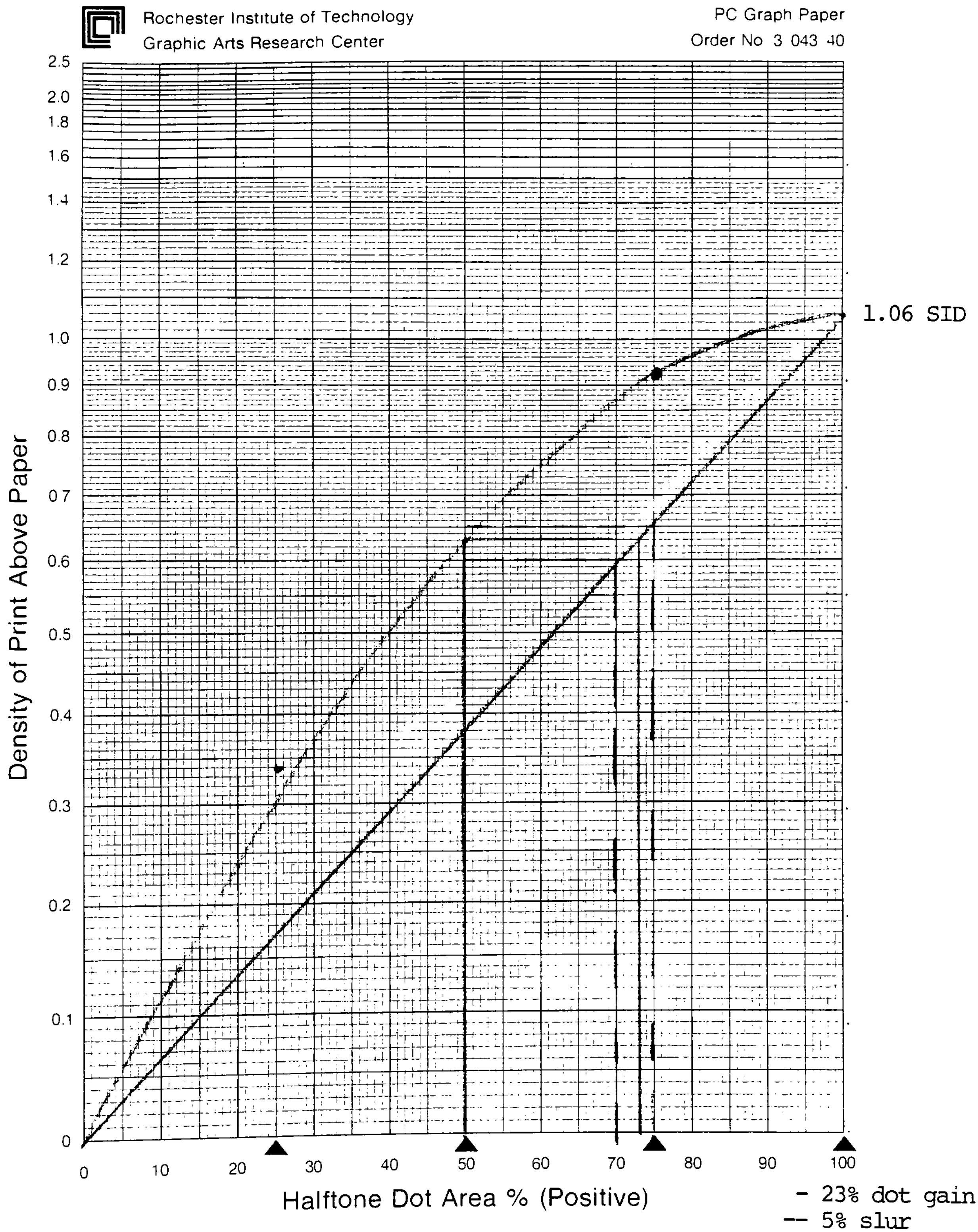


- 16% dot gain

-- 1% slur

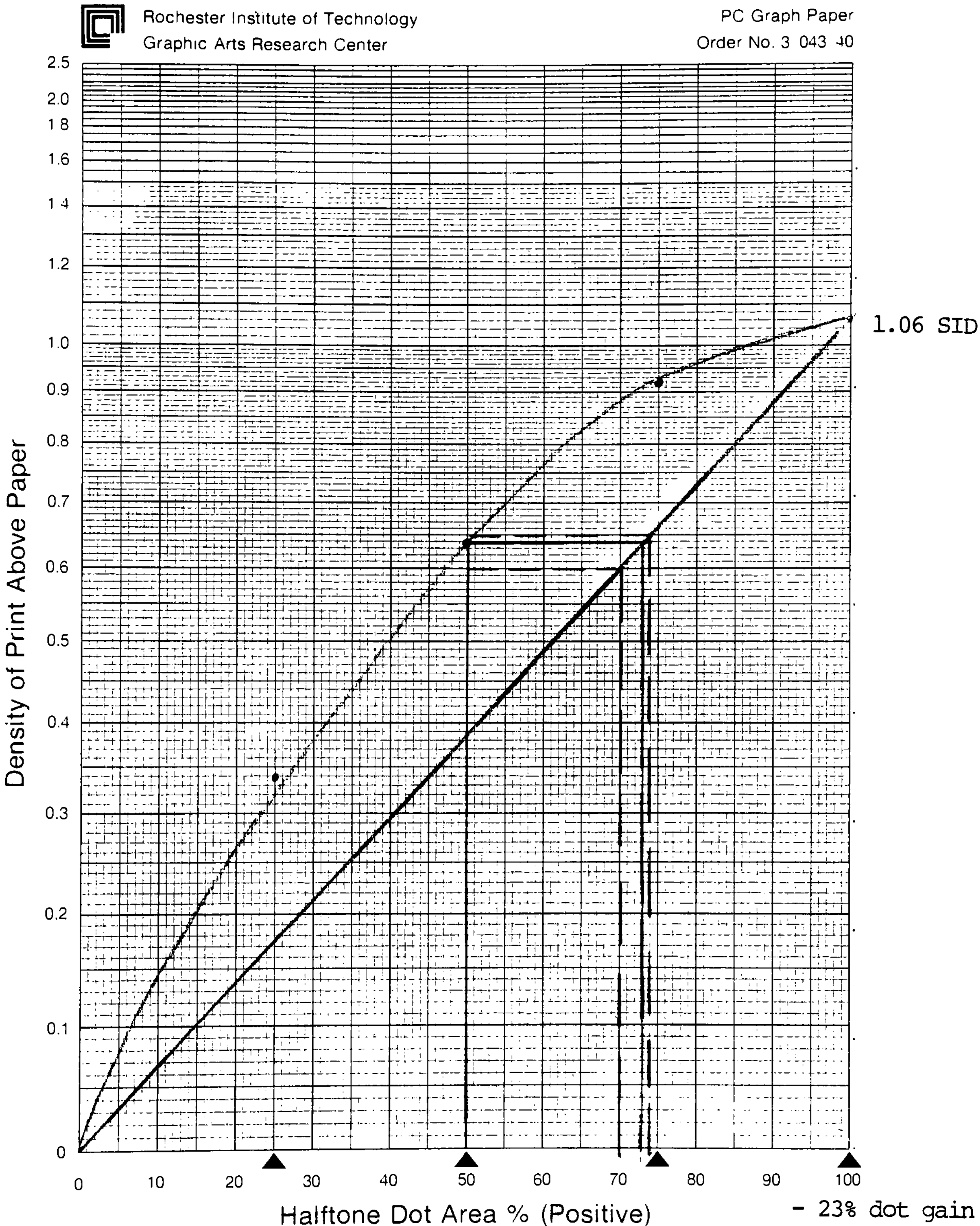
Notes:

100-line Square dot



Notes:

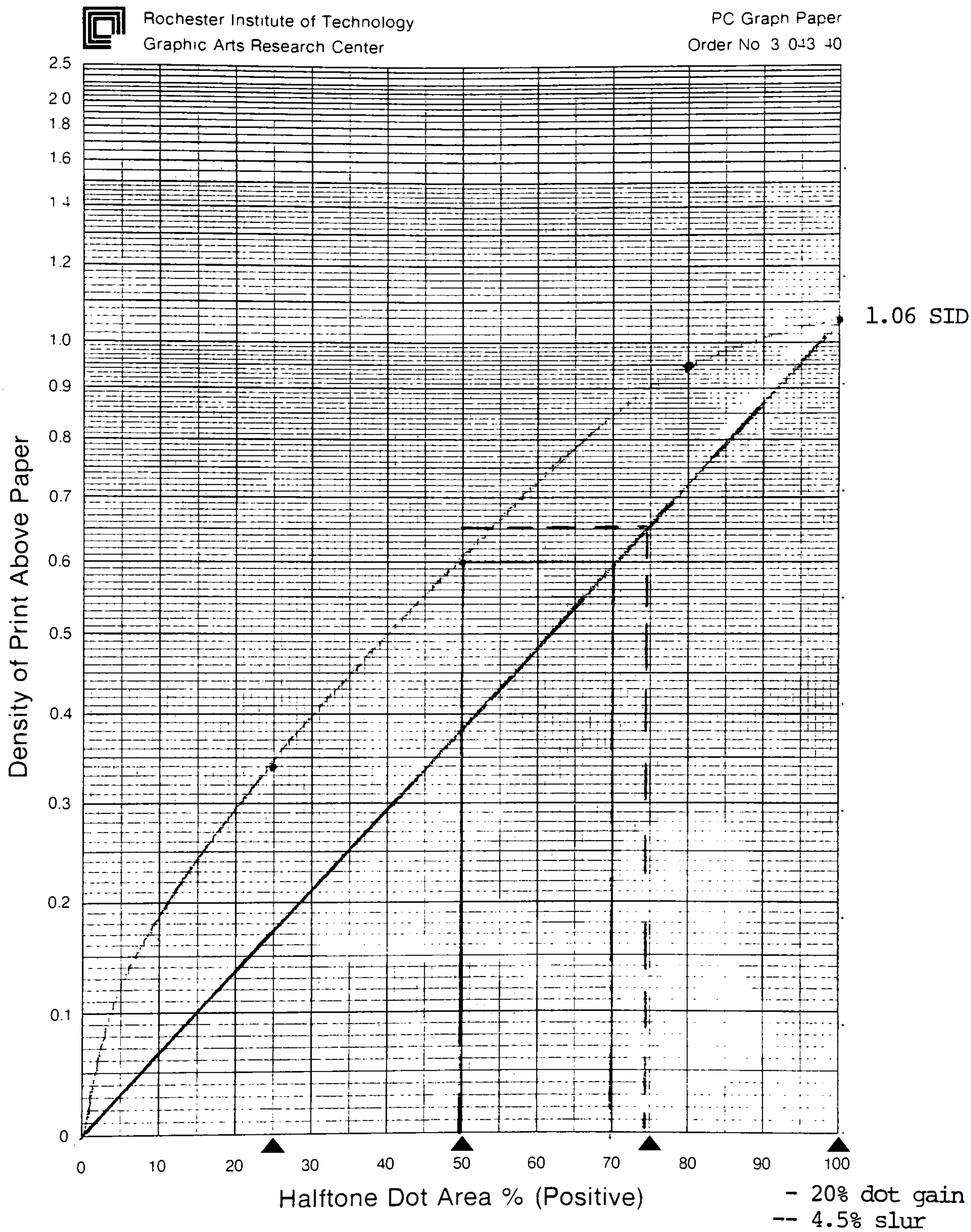
100-line Elliptical dot



- 23% dot gain
-- 4% slur

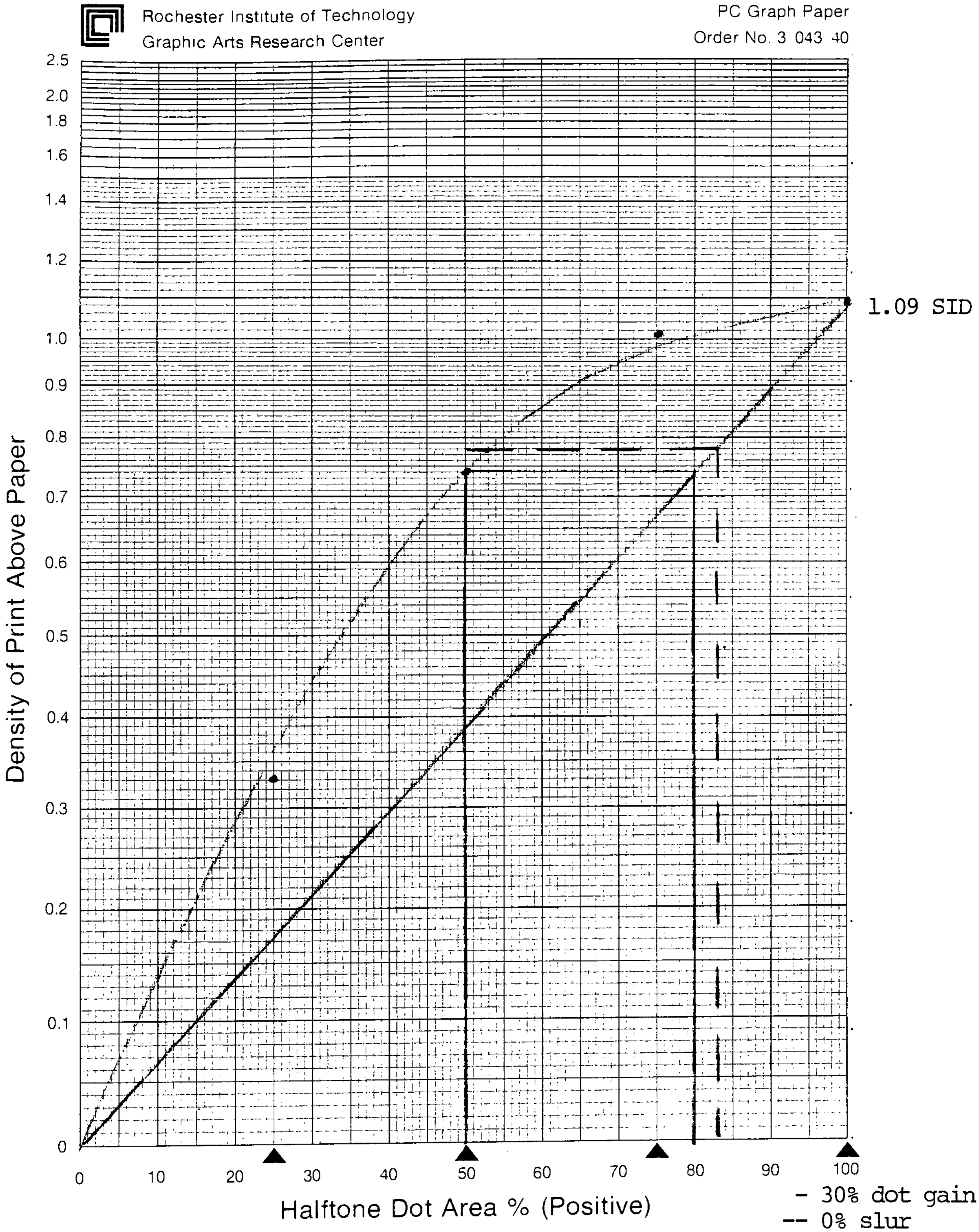
Notes:

100-line Round dot



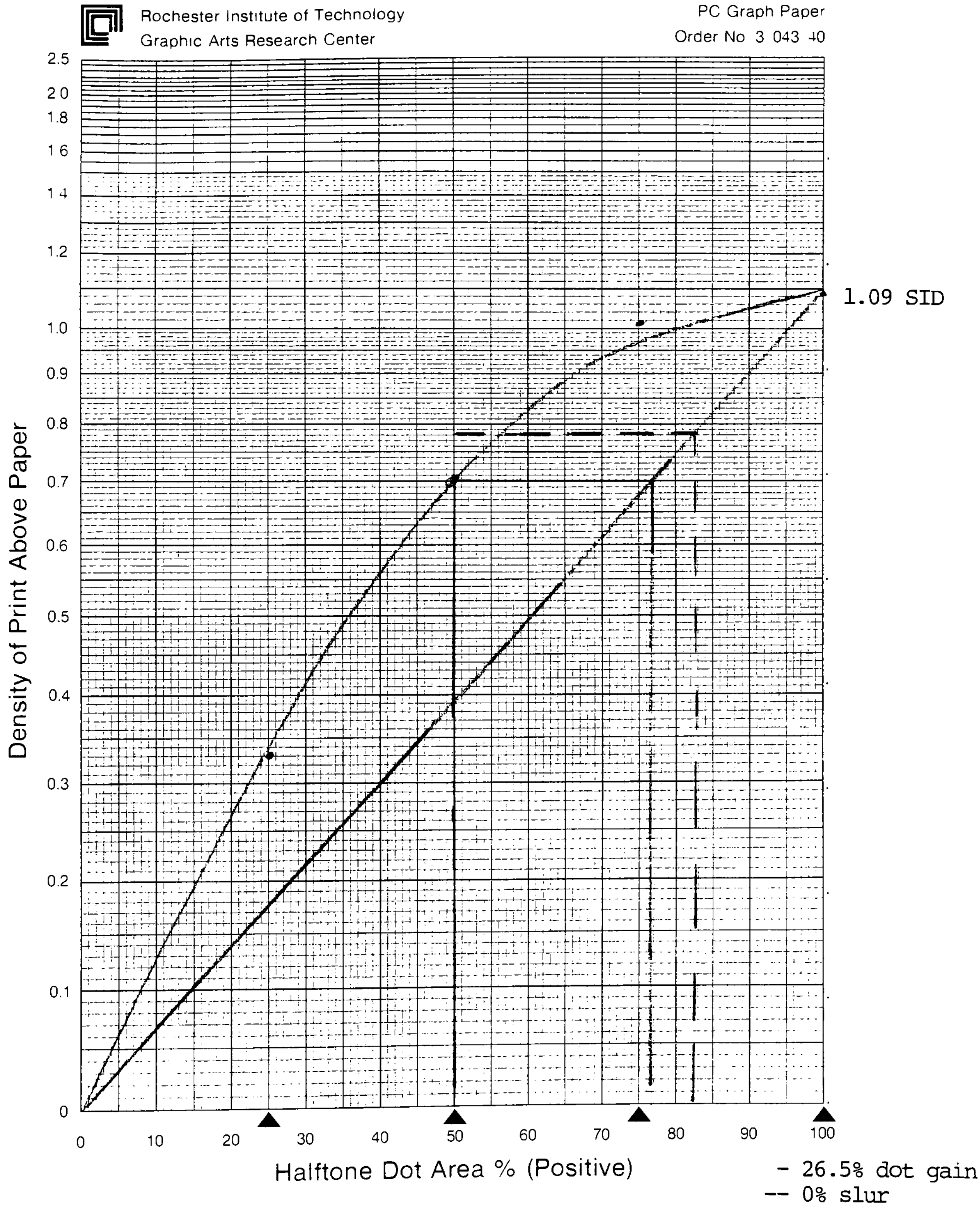
Notes: ______

150-line Square dot



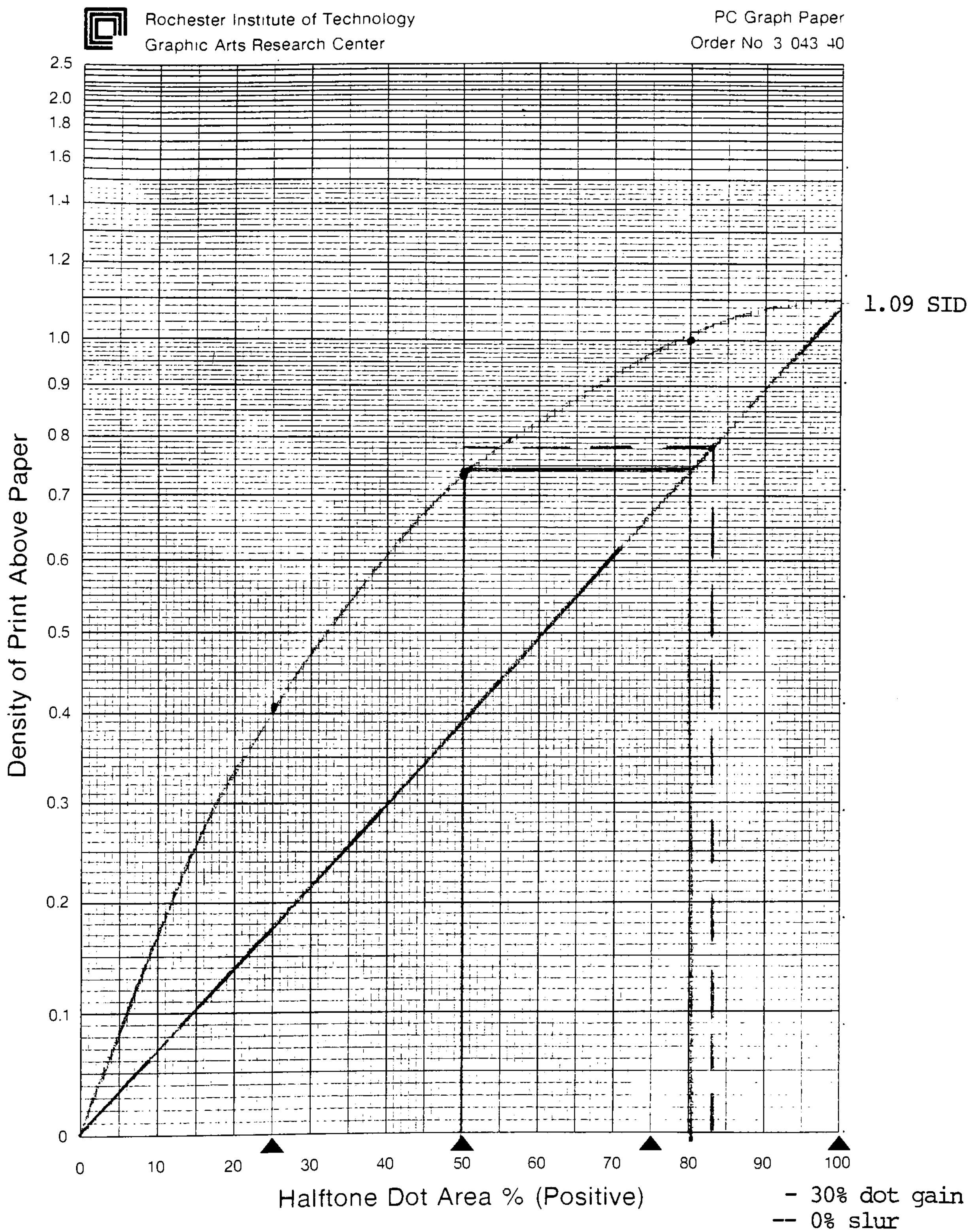
Notes:

150-line Elliptical dot



Notes:

150-line Round dot



Notes:

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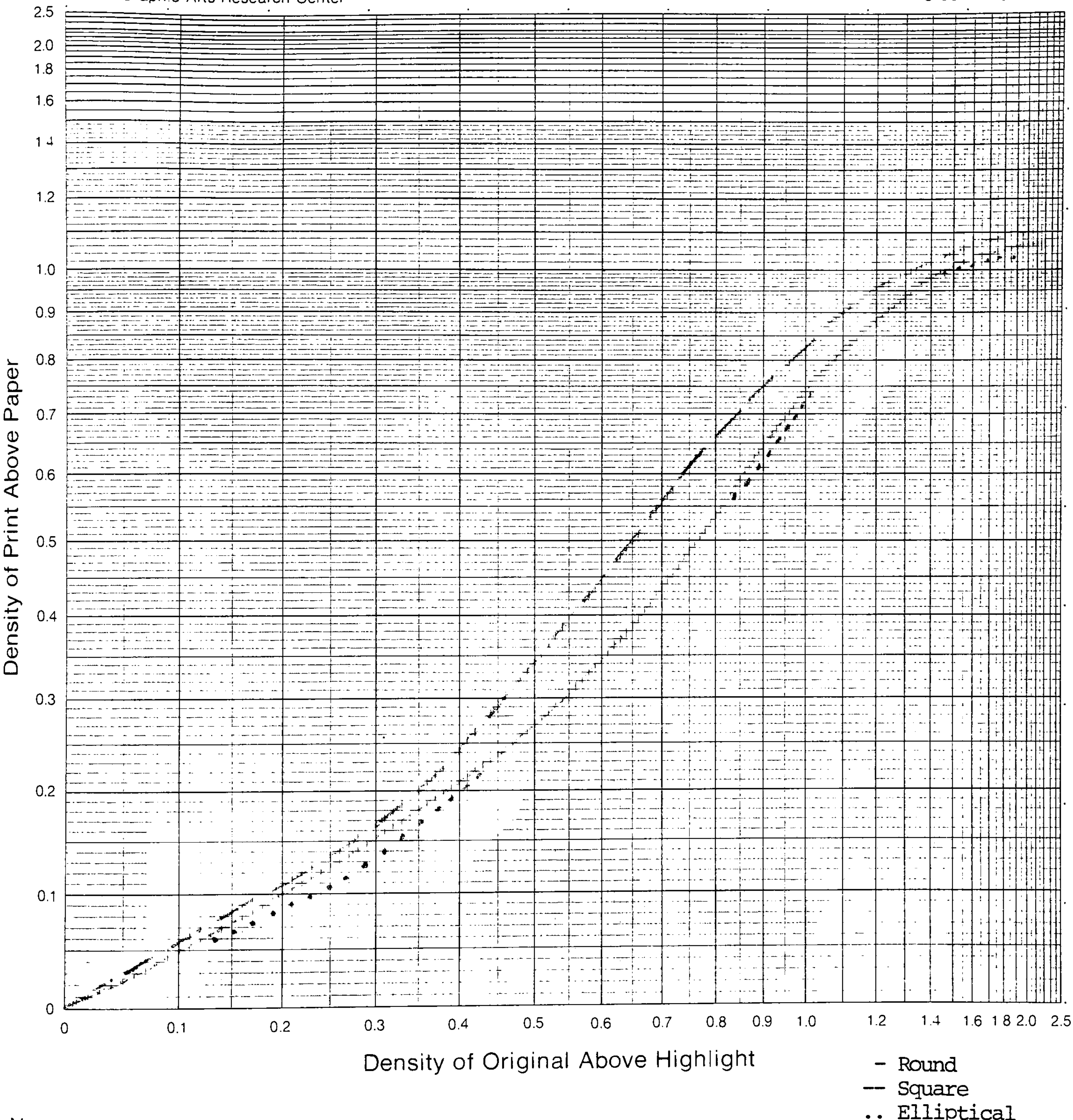
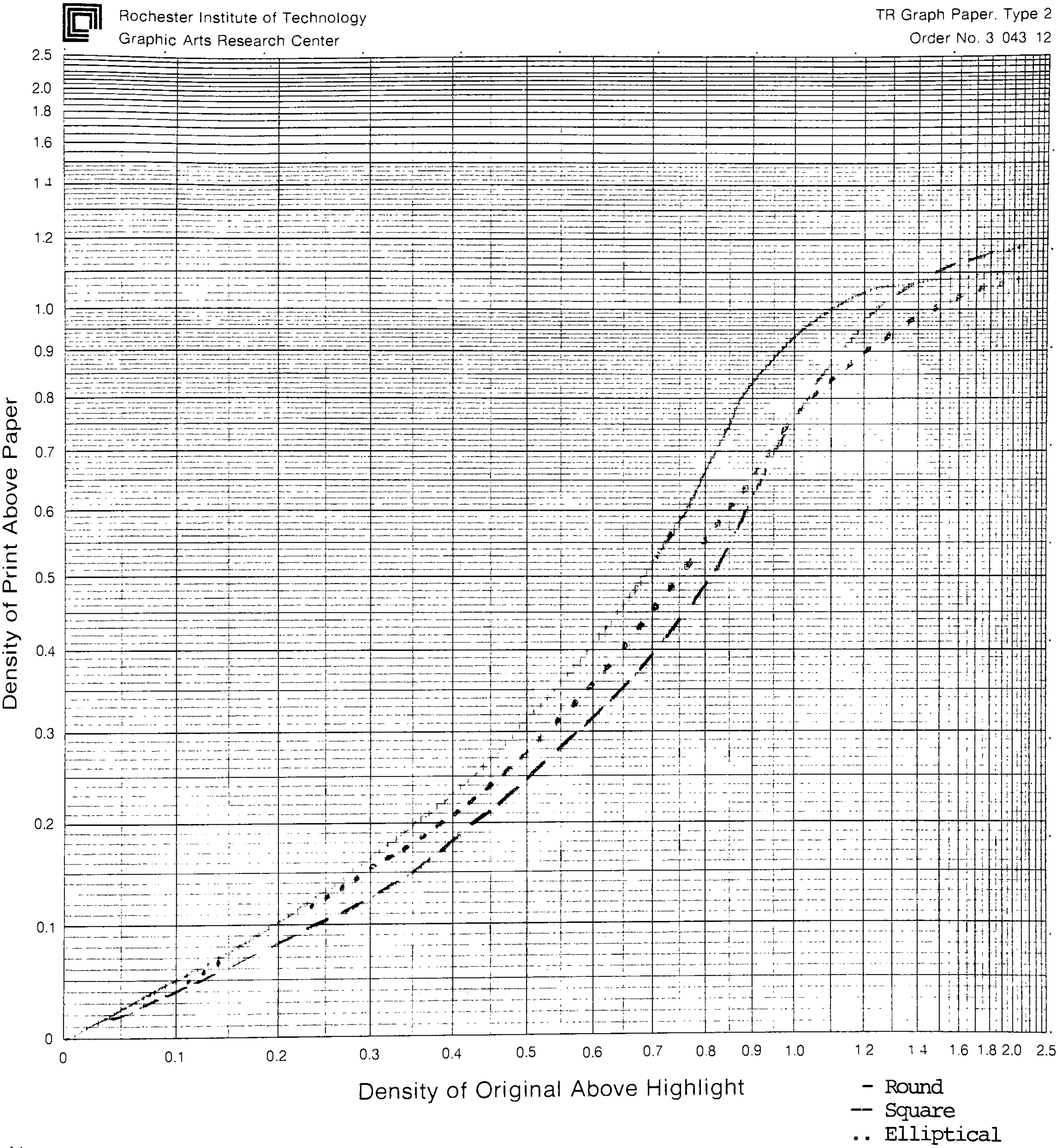


Notes:

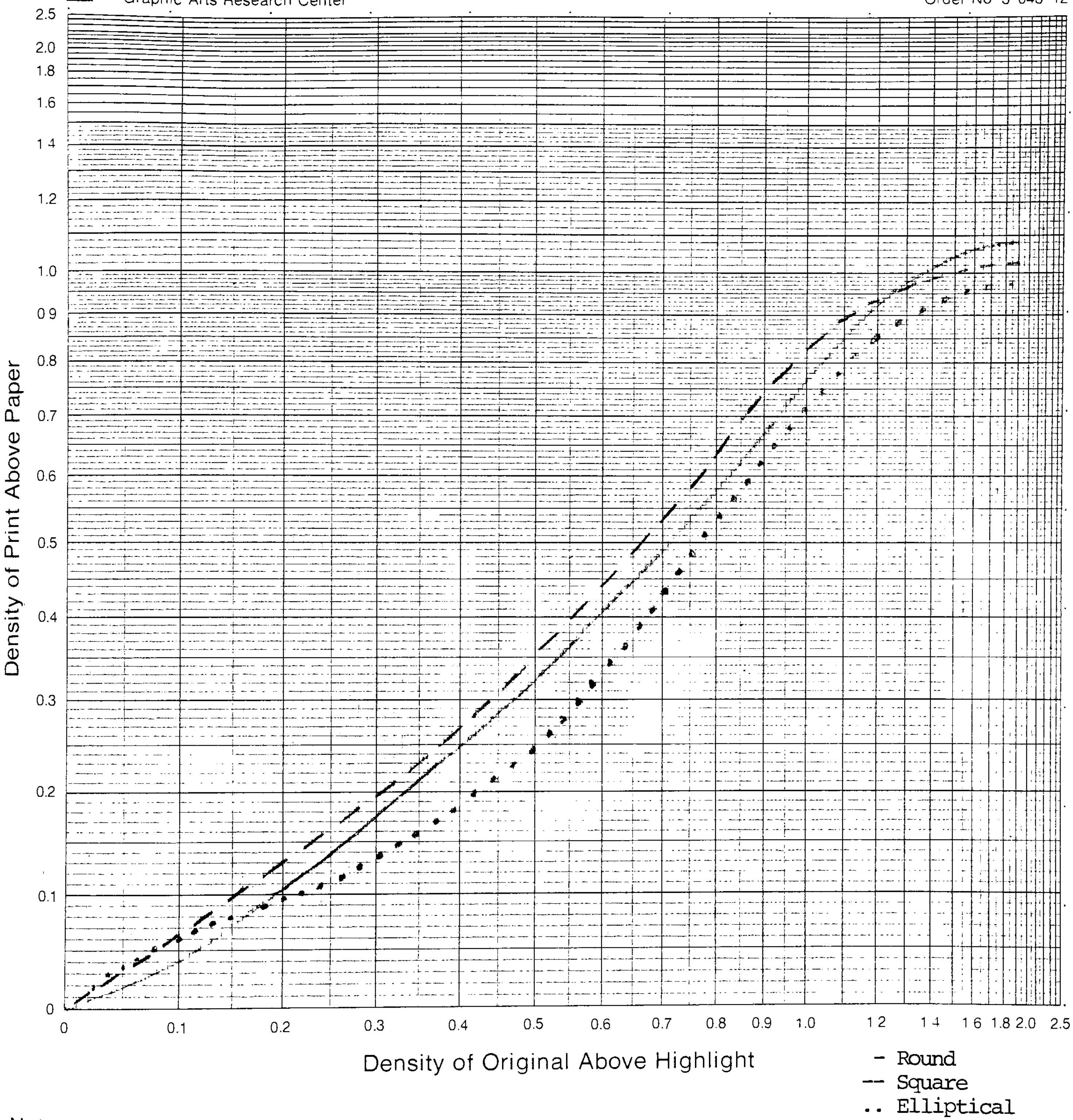
85-line



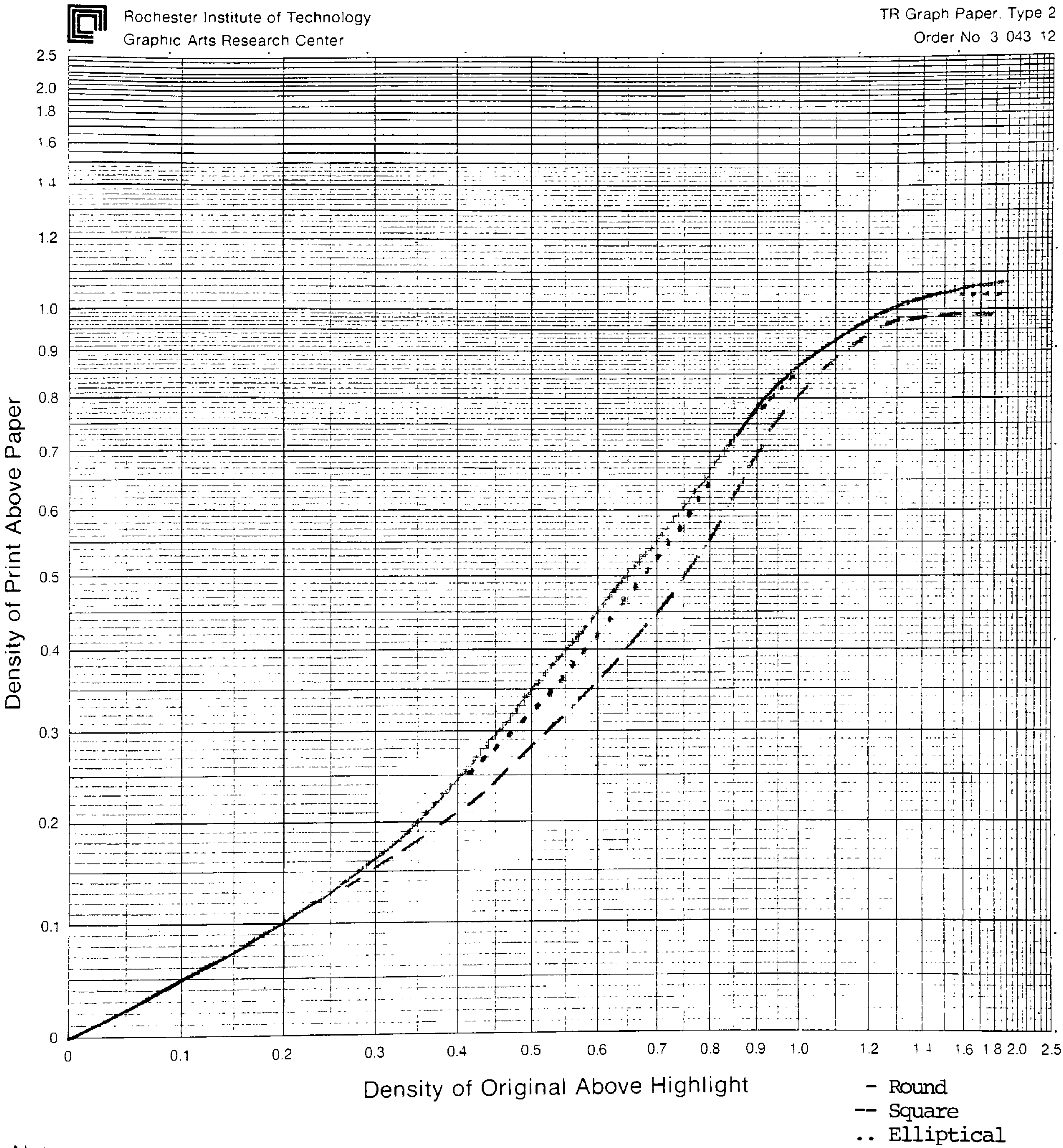
Notes:

Rochester Institute of Technology
Graphic Arts Research Center

TR Graph Paper, Type 2
Order No 3 043 12



Notes:


Rochester Institute of Technology
Graphic Arts Research Center
TR Graph Paper, Type 2
Order No 3 043 12
Density of Print Above Paper
2.5
2.0
1.8
1.6
1.4
1.2
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.2
1.6
1.8
2.0
2.5
Density of Original Above Highlight
- Round
-- Square
.. Elliptical

Notes: