CONTACT SCREENS AND THEIR APPLICATIONS

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Abstract: Glass crossline screens are explained as an introduction to the subject. Current contact screens are grouped into several basic types, and each type is described in terms of its application. The paper explains the process by which a contact screen modulates light to produce a halftone image, defines a contact screen's basic density range, and explains the effects of color and middletone dot shapes.

Introduction

The large variety of contact screens available today provides the user with the opportunity to obtain excellent graphic arts halftones by selecting the contact screen that is best suited to the type of original, process camera or scanner, light source, exposure mode, film, developer, and processing method involved. However, due to the large variety of originals and the currently available equipment and materials, it is often difficult to select the optimum type of contact screen that should be used. One manufacturer alone lists close to 200 contact screen types, and this quantity does not include the various screen rulings expressed in lines per inch and all the different sizes of contact screens usually available.

Glass Crossline Screens

Contact screens are often manufactured using glass crossline screens and many features of contact screens are described in terms that originated with glass crossline screens. Consequently, the definition and description of glass crossline screens should be helpful in understanding contact screens.

A glass crossline screen is made by cementing together two sheets of high-quality glass, each of which has precisely spaced, etched parallel grooves filled with a magenta or opaque black material. The two sheets of glass are cemented together so that the grooves of one plate are situated at right angles to those of the other. The grids formed are transparent squares precisely spaced and specified in terms of lines-per-inch or lines-per-centimetre. In order to simplify this presentation, references will be made only to lines-per-inch. A 1:1 ratio, 65-lines/inch glass crossline screen has 65 opaque lines and 65 spaces per inch, and each transparent square is 1/130 inch on each side. Glass crossline screens are made in many rulings, but the most commonly used screens range from 65 to 150 lines/inch. Since most contact screen manufacturers make use of glass crossline screens during manufacturing, the rulings in contact screens are also specified in terms of lines/inch.

Definition of a Contact Screen

A contact screen is an exposed and processed photographic film with a repeating, vignetted (i.e., soft-edged) image pattern, typically on a 0.007-inch-thick polyester support. Figure 1 shows a photomicrograph and a microdensitometer trace of a section of a contact screen. Note the soft-edge nature of contact screen dots. A contact screen is used in direct contact (preferably using vacuum) with a high-contrast, light-sensitive photographic material to make a halftone image. The purpose of a contact screen is to convert variations in density values in an original to variations in spatial values (dot-size variations) in the film. An area of low density in the original will be converted to an area consisting of relatively large dots, while an area of high density will result in an area consisting of relatively small dots.

A halftone image is a hard-edge pattern of different size elements (usually dots) of approximately equal density. Halftone reproduction is used extensively by the printing industry. It provides a printer with the capability of reproducing a range of densities with a single ink density by printing dots of varying size. Since the printed dots are microscopic in size, the eye cannot detect the dot, and interprets variations in dot size as variations in density.

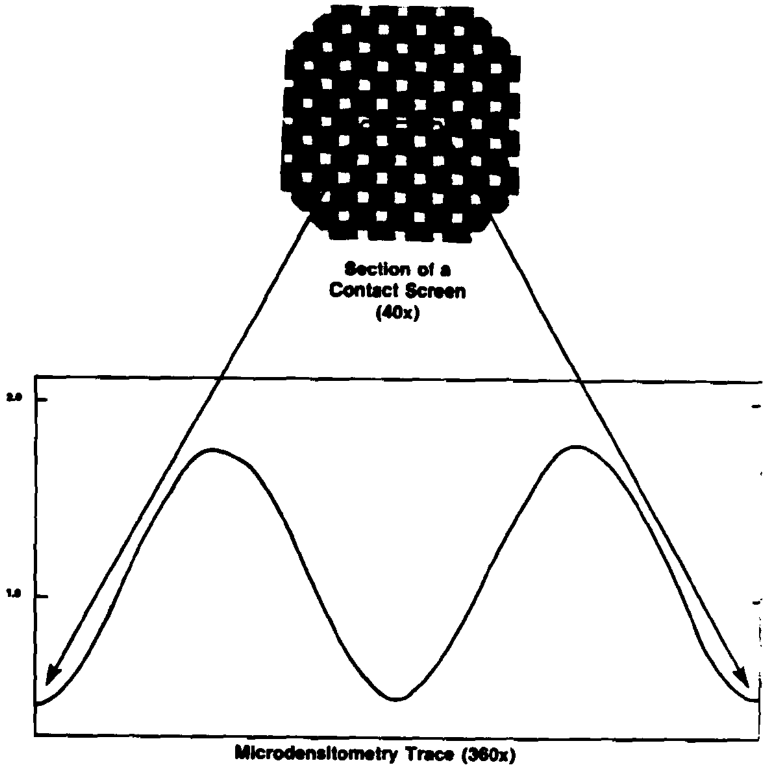


Figure 1. Photomicrograph and Microdensitometry Trace of a Section of a Contact Screen.

Halftone Reproduction Process

In its simplest form, halftone reproduction differs from continuous-tone photography in that it involves the use of halftone dots. The methods used in making halftone images are as varied as those used to make the continuous-tone originals, and different printing methods such as offset lithography, letterpress, or gravure require that halftone images be made differently. However, all contact screens utilize the same light-modulation process to produce a halftone.

The process by which a contact screen modulates light to produce a halftone image in a process camera may be described as follows. The densities of an original reflection photograph reflect varying amounts of light. A contact screen, placed with its emulsion side against the emulsion side of a high-contrast negative material in a process camera, acts like an array of attenuators.

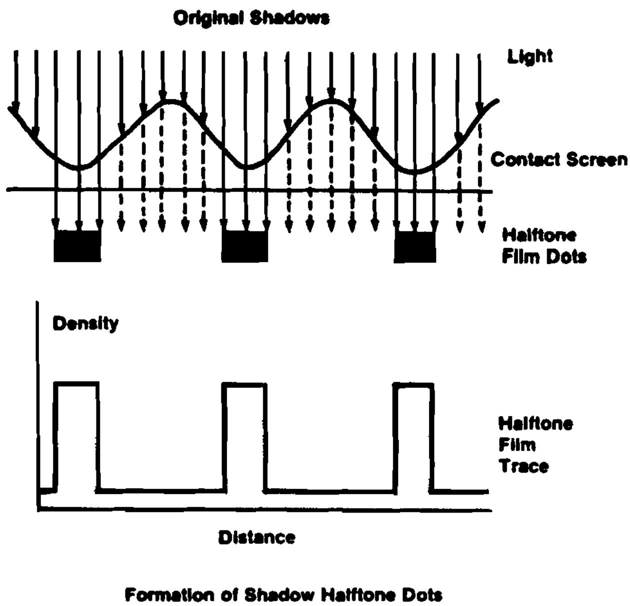
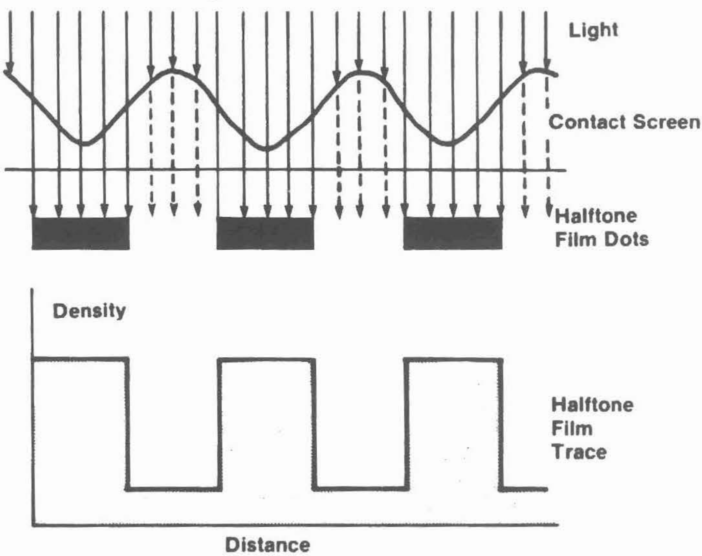


Figure 2. Sketch Showing Formation of Shadow Halftone Dots.

These attenuators modulate the light such that the light pattern at any given intensity level forms various size areas. The high-contrast negative material, in combination with a high-contrast developer, truncates these intensity patterns and produces areas of approximately equal density that are proportional in size to the relative intensity of the light passing through the contact screen. Figure 2 shows schematically how the shadows in an original contribute the least amount of light. Ideally, very little of the low-intensity light can pass through the lowest density zones in the contact screen. The high-contrast negative material receives enough exposure to produce small-diameter dots in the resulting halftone negative. Midrange densities in an original reflect greater amounts of light than do the shadows. Figure 3 illustrates how more of this higher-intensity light can pass through higher-density zones in the contact screen with sufficient energy to expose a larger area of the negative material and produce dots of intermediate size. (The shape of these dots will vary, depending on the type of contact screen used, as will be shown later.) Finally, the highlights in the original reflect the greatest amount of light, and more of this light can pass through all but the highest-density zones in the contact screen. The correctly exposed light-sensitive material receives enough exposure everywhere, except at the points corresponding to the highest density in the screen elements, as shown in Figure 4, to form highlight dots. This area in the exposed and processed films appears opaque except for small clear dots.



Formation of Middletone Halftone Dots

Figure 3. Sketch Showing Formation of Middletone Halftone Dots.

In describing the halftone reproduction process, the assumption was made that the range of densities in the original matched the range of densities which the contact screen was capable of reproducing in the halftone negative. Unfortunately, due to the large variety of originals, this is rarely the case. Thus, in addition to the dot sizes described, a halftone negative may show completely clear areas, and/or completely opaque areas. Such halftone images would make poor reproductions, and would print the shadows as solid black and/or produce no details in the highlights. If, as a result of using the wrong screen, the small dots are too large and the large dots are too small, the shadows and the highlights will lack contrast, resulting in a poor, muddy reproduction. These reproductions could be improved by selecting a contact screen capable of reproducing a longer range of densities in the halftone film. However, it should also be noted that a contact screen will be capable of reproducing a longer range of densities only if the contact screen dots have a higher density-variation profile. Such a contact screen will also require a higher exposure to overcome the attenuation that produces a 95 percent dot.

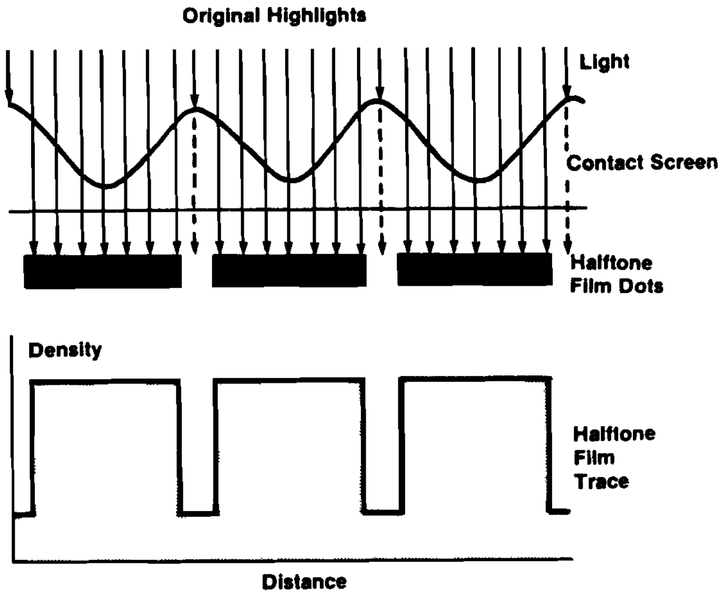


Figure 4. Sketch Showing Formation of Highlight Halftone Dots.

The Basic Density Range of a Contact Screen

The range of densities that a contact screen can reproduce in the halftone film under given circumstances is called the screen range or the basic density range (BDR). This BDR depends on many factors, including the type of camera or scanner, amount of flare, light source, film characteristics, developer, and method of development. The BDR is determined by measuring the density intervals in a plot of a halftone film between a 5 percent and a 95 percent dot. An illustration of this procedure is shown in Figure 5. The term "percent dot" is a measure of dot size which refers to the size of the black dots in a halftone film and can be measured with a special densitometer. Dot sizes in halftone films can be measured with this densitometer, which has a linear scale of transmittance instead of a scale of density. The term "percent dot" is related to the integrated density of the halftone image by the formula

$$\text{Percent Dot} = 100 \left(\frac{1 - 10^{-(\text{density} - \text{Dmin})}}{1 - 10^{-(\text{Dmax} - \text{Dmin})}} \right)$$

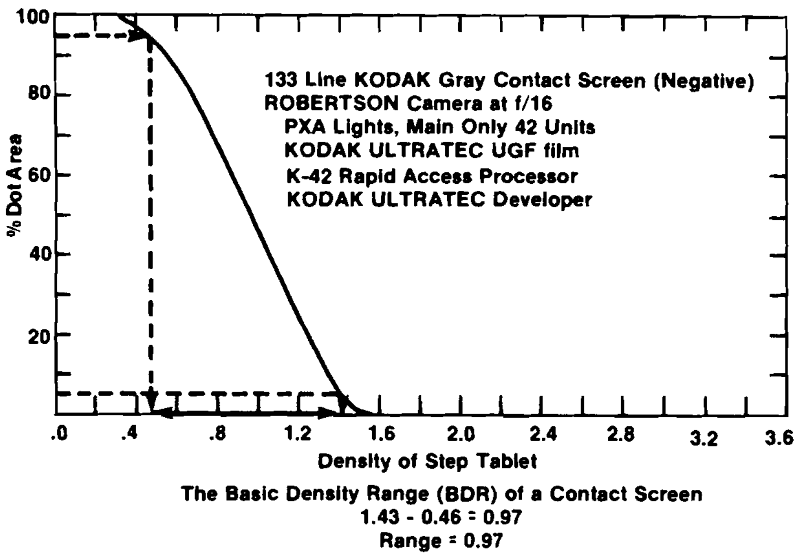


Figure 5. The Basic Density Range of a Contact Screen.

Due to the many variables affecting the basic density range (BDR) of a contact screen, the BDR and tone-reproduction characteristics of a contact screen can only be specified if all the variables affecting it are identified. Thus, contact screens produce optimum results when used with the light source, film, and developer for which they are designed. This is an important reason for the large variety of screens manufactured today.

Special Exposure Techniques

Special exposure techniques are also available to modify the range of tones a contact screen can reproduce. These exposures are known as the flash exposure and the bump exposure. The flash exposure is a nonimage exposure made through the contact screen, while a bump, or highlighting, exposure is an image exposure without the contact screen. Figure 6 shows a series of flash exposures and illustrates how flash exposures increase the basic density range by forming extreme shadow dots without significantly affecting the middletones or the highlights. A flash exposure extends the shadow range and reduces contrast in that portion of the halftone film. Figure 7 illustrates how bump exposures have the effect of increasing highlight contrast, resulting in increased highlight detail and reduced BDR in the halftone film. Excessive bump exposures deteriorate dot quality in highlight dots.

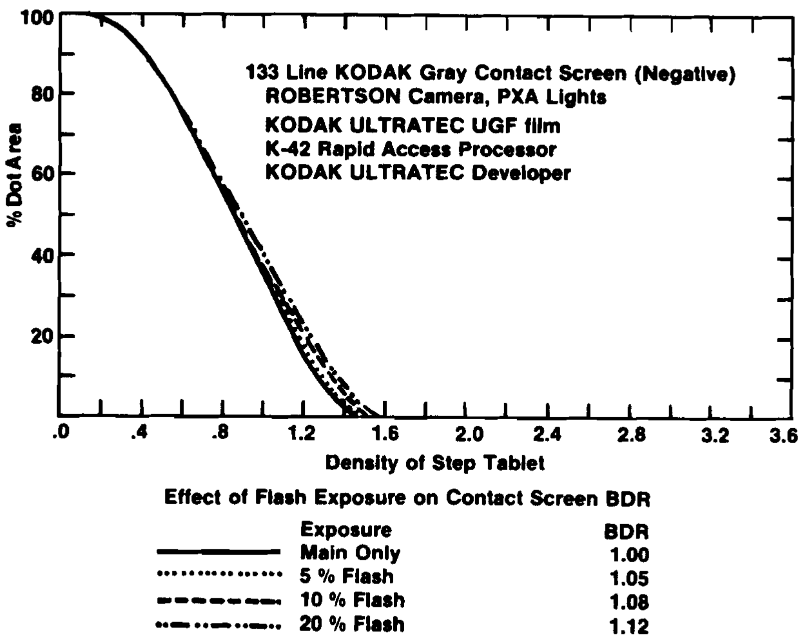


Figure 6. Effect of Flash Exposures on a Contact-Screen Basic Density Range.

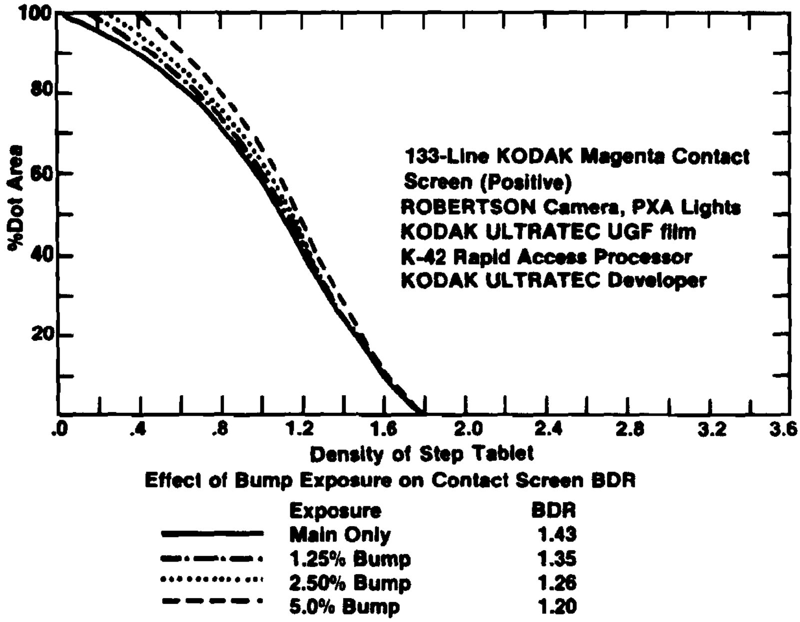


Figure 7. Effect of Bump Exposures on a Contact-Screen Basic Density Range.

Gray and Magenta Contact Screens

Figure 8 is a spectral transmittance plot of a KODAK Gray Contact Screen (Negative). It shows that gray contact screens are neutral in color. Gray contact screens do not significantly alter the spectral characteristics of the light used to expose the film. Further, the light-modulating effects of the gray contact screens cannot be significantly altered by varying the spectral characteristics of the exposing light. This is evident in the similar halftone results produced by a gray contact screen when halftones are made using either pulsed-xenon or quartz sources.

The spectral transmittance plot of a magenta contact screen is shown in Figure 9. Magenta contact screens absorb green, and produce halftones whose tone-reproduction characteristics depend on the nature of the light source and/or exposing filter used. Magenta contact screens produce a longer halftone range with quartz sources, which emit about twice as much yellow as blue energy, than with pulsed-xenon or carbon-arc sources. Magenta filters are used to increase the contrast of the halftone characteristic curve (reduce BDR), while yellow filters will decrease contrast by extending the halftone range.

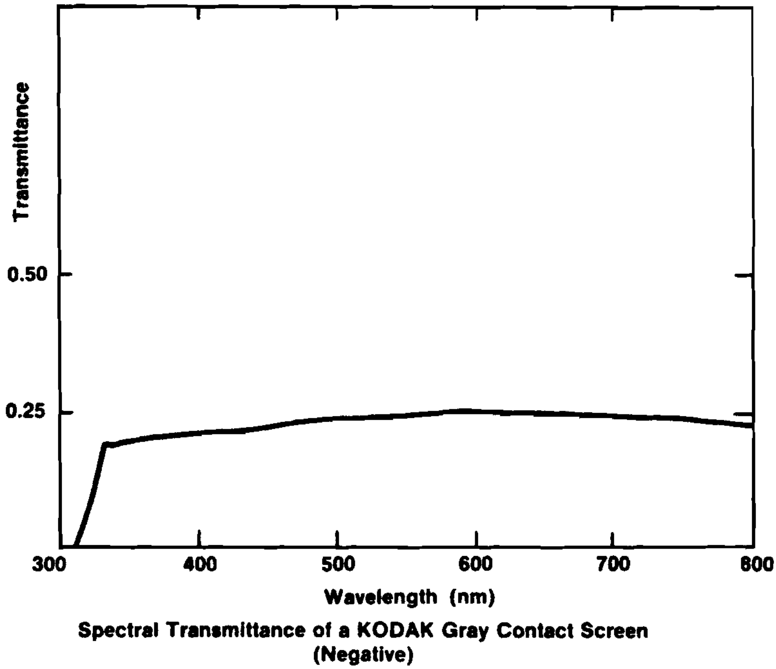
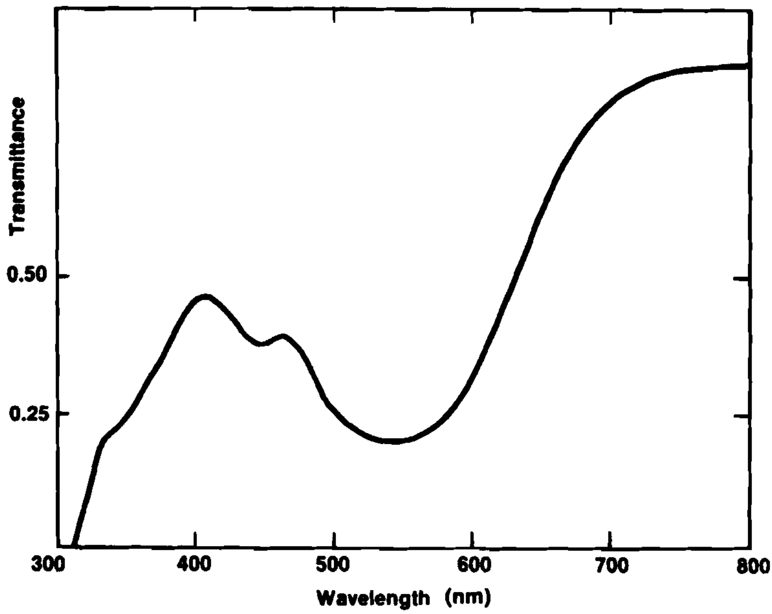


Figure 8. Spectral Transmittance Plot of a KODAK Gray Contact Screen (Negative).

Middletone Dot Shapes in a Halftone Image

The shape of the middletone dots in a halftone image is determined by whether the contact screen used is designed to produce square, round, or elliptical dots. A square-dot contact screen produces a checkerboard pattern in the 50 percent dot area of the halftone scale. Halftone images made with square-dot contact screens sometimes produce a visible tone-break in the reproduction in the area where all four corners of the dots are joined. This tone change varies depending on the subject being reproduced, the reproduction process being used, and the quality of the paper selected. Smooth flesh-tones and highly reflective surfaces with gradually changing image tones show this tone break when printed on high-quality coated paper.



Spectral Transmittance of a KODAK Magenta Contact Screen

Figure 9. Spectral Transmittance Plot of a KODAK Magenta Contact Screen (Negative).

Elliptical-dot contact screens produce an elliptical dot shape in the middletones of the halftone film. The dots are essentially parallelograms that join first in two opposed corners instead of all four, thus reducing the harshness of the break in tonal value. This property of elliptical-dot contact screens provides for a smoother transition of tones in the middletones than is the case with square-dot contact screens. Elliptical-dot contact screens are recommended for use with copy which has subtle blends in the middletones. Round-dot contact screens are popular for printing with high-speed web presses. Halftones made with round-dot contact screens produce dots that remain separated up to the 80 percent dot-area portion of the halftone scale. This characteristic of round-dot screens minimizes slurring problems in high-speed web presses.

Characterizing Seven Types of Contact Screens

The many types of contact screens manufactured today can be grouped into seven basic types according to their applications. These seven basic types of contact screens are:

1. Negative Contact Screens
2. Positive Contact Screens
3. Photomechanical-Transfer Contact Screens
4. Rapid-Access Contact Screens
5. Photogravure Contact Screens
6. Electronic Scanner Contact Screens
7. Special-Effects Contact Screens

A pulsed-xenon light source and a contact exposure were selected to characterize the relative speeds and basic density ranges that samples of these contact screens would produce when the film and process were kept constant. KODAK ULTRATEC™ UGF Film processed in KODAK ULTRATEC Developer and Replenisher in a KODALITH Processor, Model 324™, was used in all the tests made. The speed of a 133-line KODAK Gray Contact Screen (Negative) was selected as the reference speed and assigned a 0.00 value.

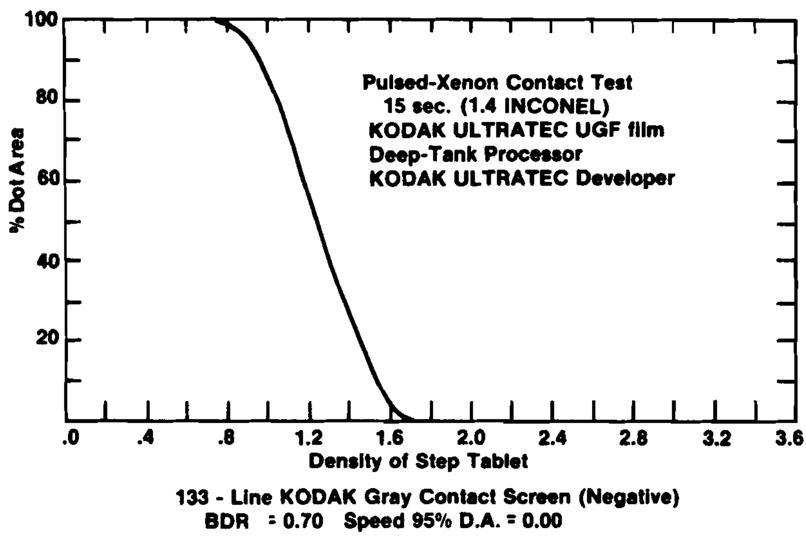


Figure 10. Halftone Plot Characterizing a Gray Negative Contact Screen.

1. Negative Contact Screens (Gray)

Gray negative contact screens are recommended for making halftone negatives from black-and-white originals, and would produce optimum tone-reproduction results when used with pulsed-xenon lights. Pre-angled gray contact screens are recommended for making direct-screen halftone-negative separations from color originals. Gray contact screens are easy to use, produce a short basic density range, and are fast in speed. They generally have about a 7 percent built-in highlight effect. A controlled flash exposure is recommended with gray contact screens to adjust the halftone film range to the copy range. Figure 10 is a plot of the halftone film obtained from a contact test of a KODAK Gray Contact Screen (Negative). It produced a 0.70 BDR and was assigned a 0.00 reference speed at the 95 percent dot area of the halftone film.

1B. Negative Contact Screens (Magenta)

Magenta contact screens (negative) are used for making halftone negatives from black-and-white originals. These contact screens are relatively fast in photographic speed and are particularly suited to use with pulsed-xenon lights and KODAK Color Compensating Filters because of their magenta color. The highlight contrast in a halftone reproduction can be increased by placing CC magenta

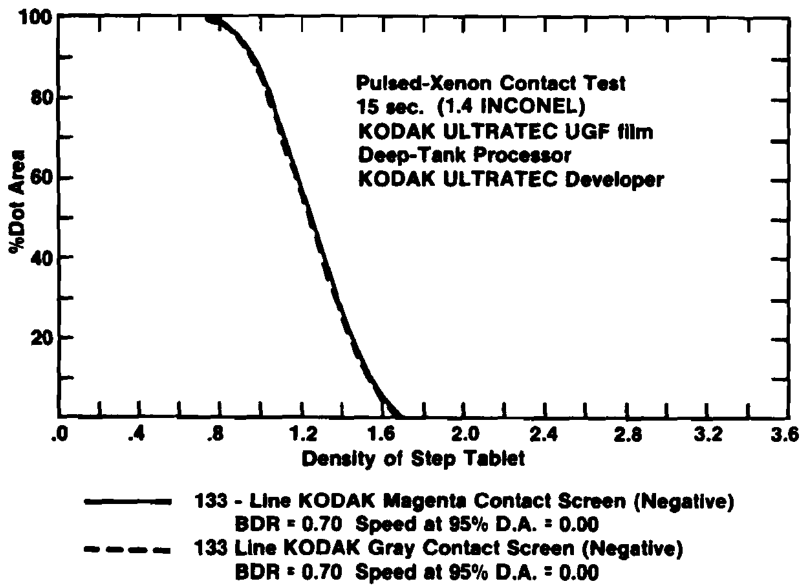


Figure 11. Halftone Plot Characterizing a Magenta Negative Contact Screen.

filters or a KODAK WRATTEN Gelatin Filter No. 80B over the camera lens. The highlight contrast can also be decreased by replacing the magenta or blue filters with a yellow filter over the camera lens. Figure 11 shows that magenta negative and gray negative contact screens produce similar results when halftone negatives are exposed with pulsed-xenon or carbon-arc lights.

2. Positive Contact Screens (Magenta)

These medium-speed contact screens are recommended for making halftone-film separation positives from continuous-tone separation negatives for color reproduction work. Most positive contact screens are magenta color to allow for contrast adjustments with color compensating filters. Continuous-tone color separation negatives which are higher in contrast than desired may produce lower-contrast, halftone-film separation positives using these screens with a yellow CC filter. Similarly, low-contrast, continuous-tone color separations may be screened using a magenta CC filter to increase the contrast of the halftone film positives.

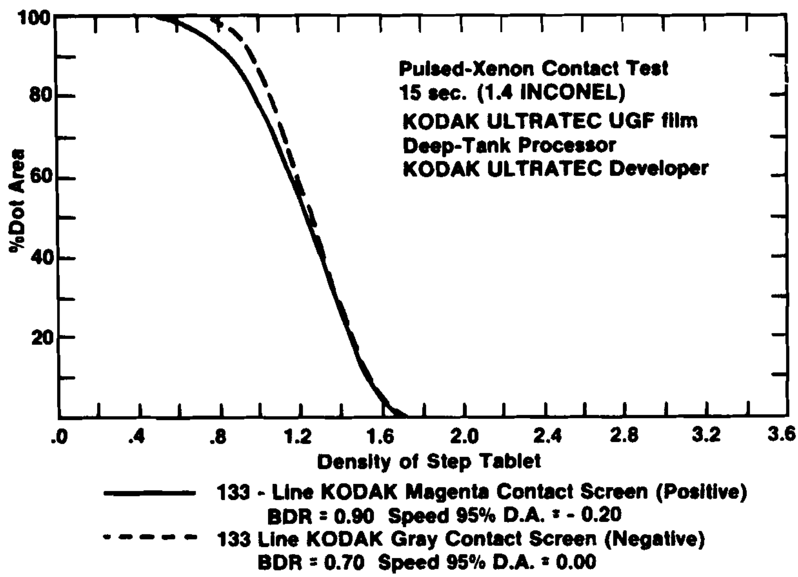


Figure 12. Halftone Plot Characterizing a Magenta Positive Contact Screen.

Even though they have been designed for making halftone positives, positive contact screens can also be used for making halftone negatives from black-and-white originals if a no-screen bump exposure is added to increase highlight contrast in the halftone film. A pulsed-xenon source used in a contact test to characterize these contact screens shows that, as Figure 12 illustrates, a KODAK Magenta Contact Screen (Positive) produced a 0.20 longer BDR and was 0.20 log exposure slower in speed than a KODAK Gray Contact Screen (Negative).

3. Photomechanical-Transfer Contact Screens

These contact screens are designed specifically for use with diffusion-transfer processes for making halftone paper or transparent prints from continuous-tone negatives and/or positives. Photomechanical-transfer contact screens are usually slow because of the very long basic density range required to maintain tone separation and detail in the shadows of a halftone print. Figure 13 shows the results of a pulsed-xenon contact test of a KODAK PMT Gray Contact Screen. This contact screen produced a 0.65 longer BDR and was 0.65 log

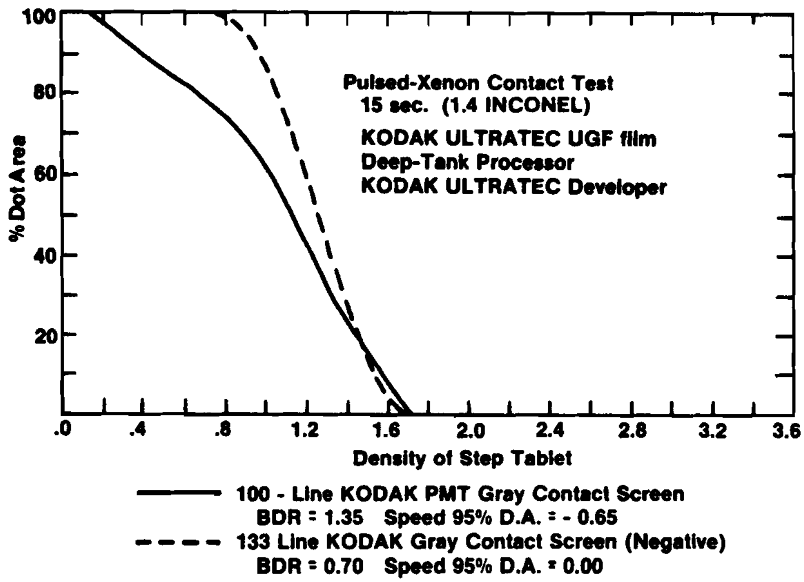


Figure 13. Halftone Plot Characterizing a Photomechanical-Transfer Contact Screen.

exposure slower in speed than a KODAK Gray Contact Screen (Negative). Examples of these are KODAK PMT®, AGFA GEVAERT COPYPROOF, and CHEMCO POWERDOT Products.

4. Rapid-Access Contact Screens

Rapid-access contact screens are used for making halftone negatives from black-and-white originals, using rapid-access processing. These contact screens are usually medium in speed and produce a medium basic density range in the halftone film. They are designed for non-lith rapid-access developers which, prior to KODAK ULTRATEC Products, were the only alternatives to lith developers for rapid-access processing. A pulsed-xenon contact test used to characterize these contact screens produced a 0.35 longer BDR and was 0.45 log exposure slower in speed than a KODAK Gray Contact Screen (Negative). These results are shown in Figure 14. Examples of rapid-access developers include KODAK 55 Developer and CHEMCO Powermatic Developer.

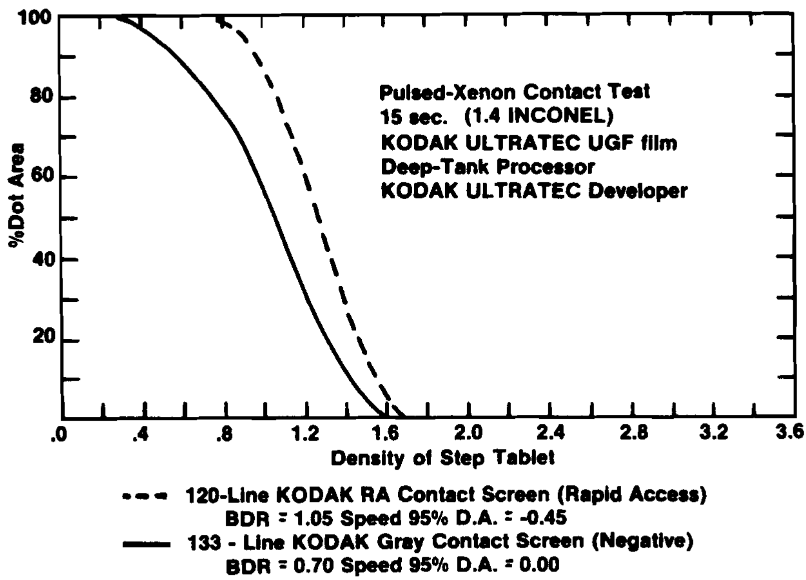


Figure 14. Halftone Plot Characterizing a Rapid-Access Contact Screen.

5. Pre-Angled Magenta Contact Screens (for Photogravure)

Pre-angled magenta contact screens (for Photogravure) are used in color work for making intermediate halftone negatives from color-corrected, continuous-tone positives by contact printing. These contact screens can also be used in a process camera or for screening directly onto a resist film. The halftone negatives are characterized by having a lateral-dot formation that consists of dots in the highlight areas and grid lines or cells in the shadow areas. The Gravure Technical Association recommends a 60 percent dot-area shadow dot and a 93 percent dot-area highlight dot. These percent dot values were used to characterize a KODAK Magenta Contact Screen (for Photogravure). The results of a pulsed-xenon contact test of these contact screens are shown in Figure 15. They show that a magenta contact screen for Photogravure produced a 0.43 longer BDR and was 0.35 log exposure slower in speed than a KODAK Gray Contact Screen (Negative).

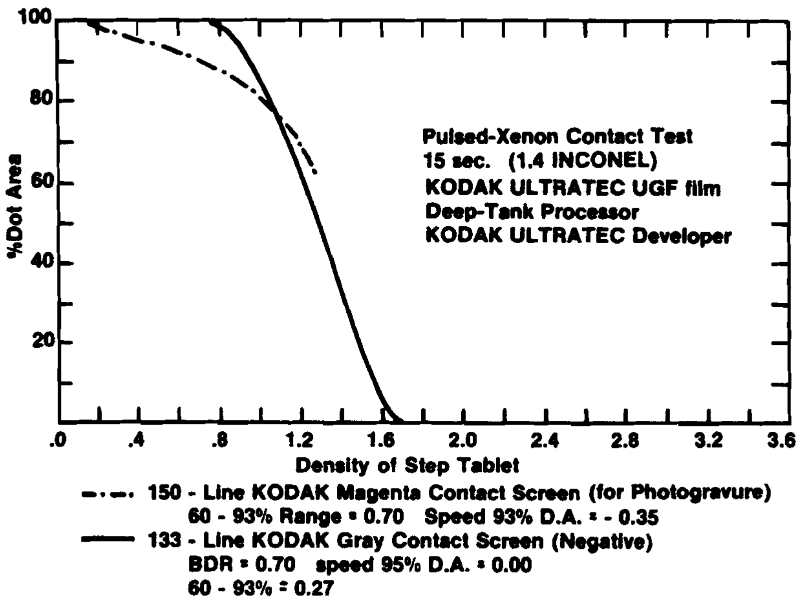


Figure 15. Halftone Plot Characterizing a Magenta Photogravure Contact Screen.

6. Contact Screens for Electronic Scanners

These specialty screens are available for CROSFIELD, HELL, DAINIPPON, and ROYAL ZENITH Scanners. Contact screens for scanners are square-dot, elliptical-dot, or round-dot screens of special size to conform to the particular scanner requirements. Pre-angled round or square-dot screens for the HELL CHROMAGRAPH Scanners (C299, C299L, or C399L) are angled at 21 degrees, 51 degrees, 81 degrees, and 96 degrees for the cyan, magenta, black, and yellow color separations. Pre-angled elliptical-dot screens are angled at 51 degrees, 96 degrees, 111 degrees, and 171 degrees. Some pre-angled screens are preassembled with adhesive tape and some are assembled photographically. All scanner screens are prepunched and precut to fit individual scanner requirements. Figure 16 shows that, in a pulsed-xenon contact test, a POLICROM Scanner Contact Screen for the DC-299 scanner produced a 0.10 longer BDR and was 0.06 log exposure slower in speed than a KODAK Gray Contact Screen (Negative).

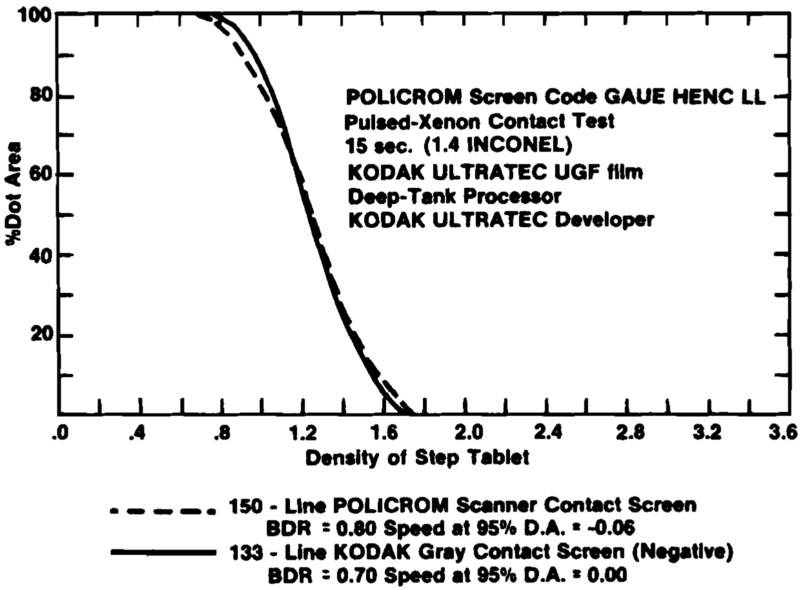


Figure 16. Halftone Plot Characterizing a Contact Screen for Electronic Scanners.

7. Special-Effects Contact Screens

In addition to contact screens for special processes, there are a great variety of special-effects screens. Most of these contact screens produce a short basic density range and are fast in speed. Figure 17 shows that, in a pulsed-xenon contact test, a POLICROM Random Dot Special-Effects Contact Screen produced a very short BDR (0.35) and was 0.03 log exposure faster in speed than the KODAK Gray Contact Screen (Negative). Some patterns used in these contact screens are: concentric circles, wavy lines, straight lines, steel etch, fine-grain, crack, herringbone, ovals, raffia, and rosette. As their names imply, these screens are used for special effects, particularly in advertising and artistic illustrations.

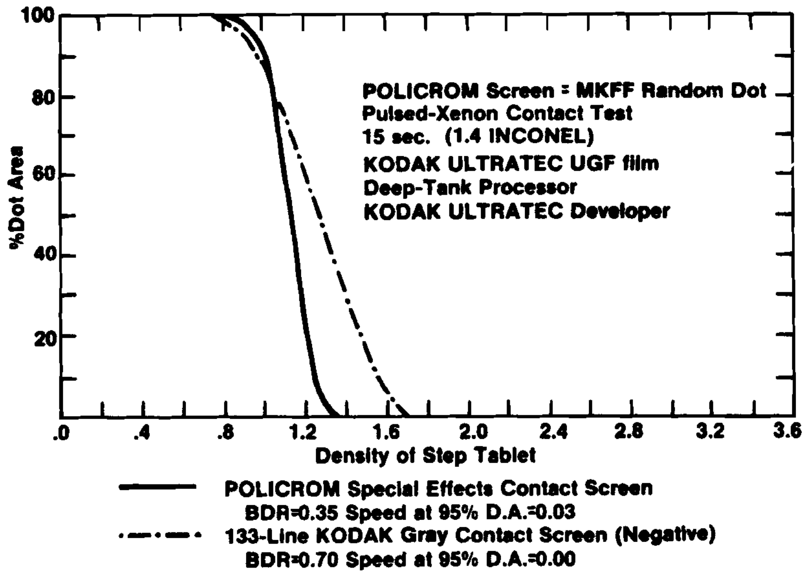


Figure 17. Halftone Plot Characterizing a Special-Effects Contact Screen.

Conclusion

A pulsed-xenon light source and a contact exposure were used to characterize the tone reproduction and relative speeds of seven basic types of contact screens. An understanding of these procedures and the effects of contact screen color, middletone dot shapes, light sources, filters, and auxiliary exposures will result in improved halftone reproductions and increased productivity.