TECHNICAL SUPPLEMENT

PlateScope™

Measurement Method, Process and Integrity

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(1.0) DOCUMENT PURPOSE

This document discusses the challenges of accurate modern plate measurement, how consistent dot value is obtained and how the PlateScope™ is able to achieve accurate results.

(2.0) ABSTRACT

Achieving the ability to accurately measure a variety of plate and screening technology across a wide range (2-98%) required fundamental re-engineering of how plates have been measured in the past. In addition to current camera technology being advanced enough to help achieve a very clear image of the area under consideration, a new method of plate verification and traceability was required in order to measure true dot coverage area.

With the capabilities of present day presses and client's pushing for higher quality standards, it is imperative that one had a device that can accurately help control dot gain and plate quality to avoid costly press errors, job rework or rejection

(3.0) CHALLENGES OF ACCURATE PLATE MEASUREMENT

It is well known that plate readers previously available give different results on the various plate technologies. Some plates tend to produce closer readings between plate reader devices than others.

Plate accuracy verification for actual dot area is a significant problem since there doesn't exist a direct output from plates that can accurately report a dot percentage. Plate reader manufacturers typically establish precise "chrome on glass standards" that have correlation back to a industry standards organization, but this still does not address the problem is a high contrast, large dot size and precise pattern while plates vary in contrast, dot area, screen pattern and physical characteristics.

All plate technologies have various textures and grain patterns that are different from one another. One thing in common, however, is that they are all on bare metal and tend to cause variation in the image when viewed through a high resolution camera similar to the contrast of dot area versus background area.

Dot patterns vary in size and shape between various screening technology and plate types. These variations create challenges for filtering texture noise from actual dot area. As dot percentage falls below 5% or above 95%, finding the dots from a single image becomes extremely difficult when plate texture is large (at least under microscopic viewing conditions) and emulsion to background contrast is low.

Compounding the challenge further, line screens add further to the complexity of the analysis. Line screens of 150 lpi and lower require a large aperture to avoid significant repeatability errors when lines of dots fall just within or outside the measured area. Line screen higher than 150 and 10 to 20 micron dots require high resolution from the image camera. In order to achieve the compromise a point must be reached between target aperture size, target resolution and workable camera pixel resolution.

Thus, a more traceable method needed to first be developed before a plate reader could claim to accurately read plates for true dot area coverage.

(4.0) TRACEABLE DOT ACCURACY AND VERIFICATION

When reviewing plate readers the accuracy specifications are often hard to prove or disprove. Typically, to establish a correlation to an unbiased standard, chrome on glass is used. This has the advantage of high contrast and is stable over time. However, this makes it easy to develop an instrument that reads a standard well but struggles to consistently produce the same readings across the gamut of plate types available.

(4.1) Current Procedures

Two current procedures are currently utilized for accuracy verification – standard device and planimeters.

(4.1.1) Standard Device

This is where a single plate reader has been selected and is utilized as a benchmark. While this is the easiest method, it is also the least reliable for reasons discussed in (4.0) above.

(4.1.2) Planimeters

Benchmarkers typically have used mechanical or electronic Planimeters as shown in Figure 1 to draw dot regions and then calculate dot coverage area (percent). Though this is one method of determining a neutral baseline, image quality, dot edge determination and processing are critical in determining accurate results. Additionally, the plate characteristics, especially in the highlight and shadow areas, also come into play in with camera technology and must be accounted for in the analysis.

Figure 1: *A sample Planimeter. Photo courtesy of Lasico, Inc.*

(4.2) Accurate Analysis Procedures

In order to make correlation credible and traceable, we developed a process using a high power microscope, trained lab technicians and a specific LabView application. This process can establish accurate dot coverage (percentage) values of different screening and plate technologies to verify accuracy correlation back to NIST. Utilizing this process permits all steps in the process to be stored and saved for review and analysis at any time.

In order to close the correlation loop, the chrome on glass is used to verify the calibration of the microscope (see 4.3 below) at the selected power and also to verify all base algorithms. Another benefit of this process is the ability to utilize this data in LUTS tables (see 5.3) for accurate analysis of plate through PlateScope.

Utilizing the high power microscope images are captured and stored, as shown in Figure 2a, in the LabView application for deeper analysis. The LabView application is used for determining actual dot coverage area and reducing subjective decision as much as possible while permitting the lab technician to evaluate various methods for arriving at the best solution based on the plate type. Figure 2b shows the same image as Figure 2a after processing to determine actual dot coverage area, as highlighted by the green lines. At any point the image can be evaluated for further quality verification and study.

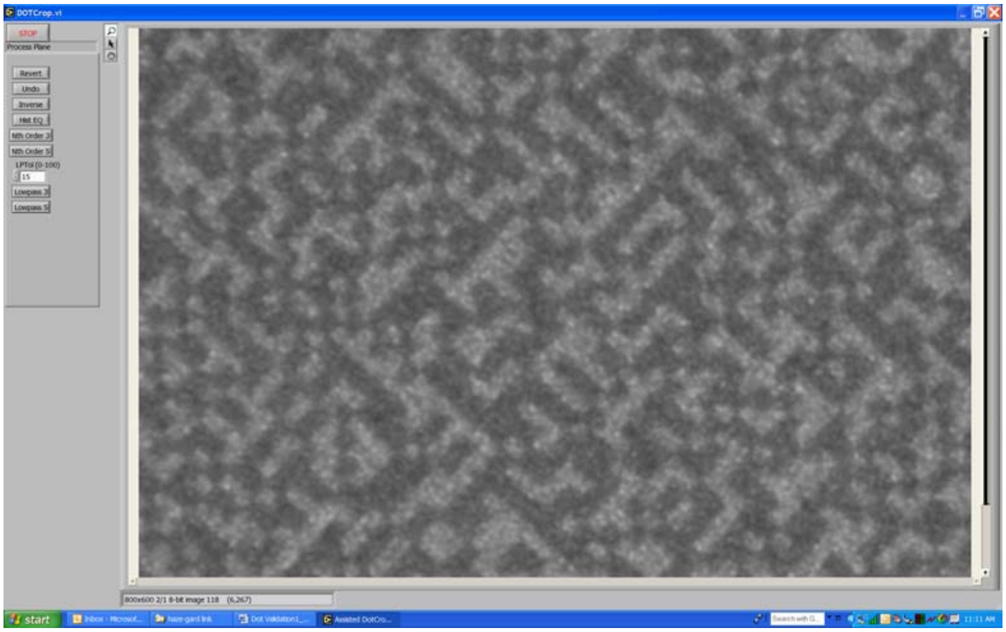

Figure 2a: *20 micron stochastic at 173 power on the high power microscope. This represents one of four quadrants of the total image.*

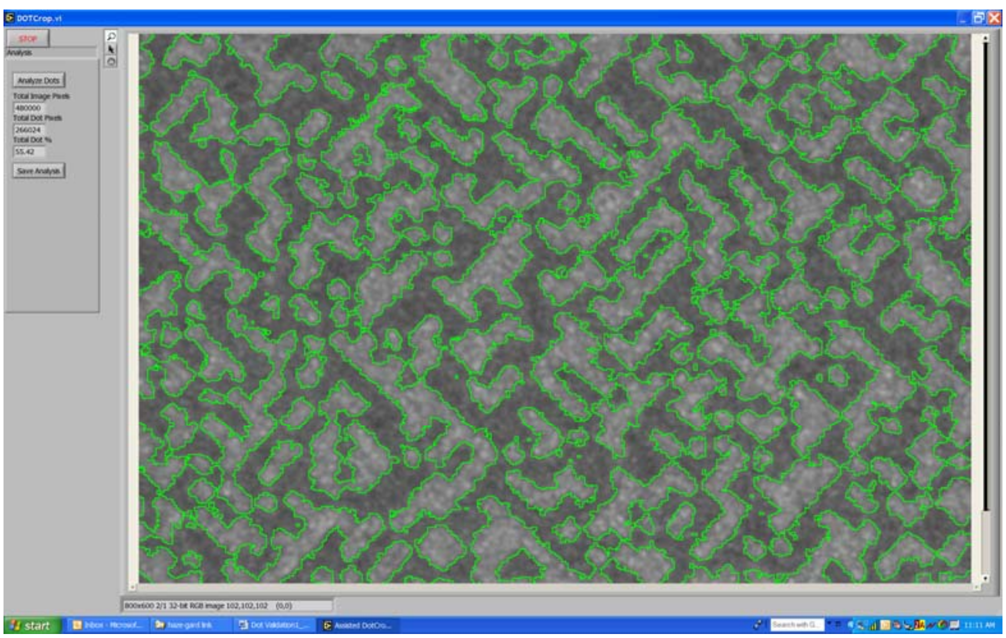

Figure 2b: *The same image after processing with a calculated dot area of 55.42%.*

The quality of these initial images is critical to the success of this process. X-Rite has chosen to utilize a Keyence VHX-100K with 25-175 and 500-1,000 zoom lenses. The camera itself is an RGB 2 megapixel with scan capability for deeper resolution. Resolution is normally limited to what is necessary to achieve clear results but can be utilized to view plates at higher resolutions under various illumination schemes.

(4.3) Traceable Verification Procedures

To accurately use a microscope for plate validation, the device itself must be validated regularly also. To validate the microscope, a NIST traceable chrome on glass standard is first used to calibrate the microscope at the selected power.

To generate accurate microscope results all readings are taken from a precisely located region of the plate. This region is further segregated into a minimum of 4 sub-regions so that there are a minimum of four dot percentage values to compare with on another. These individual values serve three distinct purposes:

- To determine plate consistency
- To detect poor microscope results
- To generate a single average value for instrument comparison and associated ‘grade’ to quality of comparison

The validation method follows a general rule that dot calculation techniques must be completely unique and more thorough than the techniques implemented in the PlateScope. On occasion, random plate samples are run back through the process to validate result consistency.

All results are also compared with the results for all plate readers currently available on the market. These comparisons are not used directly for accuracy determination but as an additional tool to highlight data that may require further evaluation due to significant differences in readings among devices. In general, if the differences are large we duplicate the validation process with multiple approaches For example, with changes in illumination or a different batch of similar samples.

This method permits accurate, traceable validation and precise accuracy evaluation and provides proper correlation back to standards while accounting for the different structural characteristics of a variety of plate technology.

(5.0) PLATESCOPE™ TECHNOLOGY

To accommodate the wide latitude of plate and screening technology on the market today while expanding on the measurement range, PlateScope utilizes several key technologies in unison to achieve its objectives.

(5.1) VHR Camera Technology

PlateScope utilizes two cameras within the architecture with each performing different tasks; an RGB camera and VHR B&W camera. The RGB is camera is utilized for viewing while the VHR camera is used for measuring.

An RGB camera is used for targeting and permits optimal viewing of the plate area with the appropriate resolution type. This is especially helpful when utilizing the Infra-red or Ultraviolet illumination settings.

The other camera is a very-high resolution (VHR) 15,000 ppi black & white camera used for capturing and processing the image area for measurement. The image area is approximately 1.5 micrometers. With this kind of resolution the contrast reading from the plate is 93% efficient compared with 75% efficiency of cameras used in other devices. In addition, this resolution level also permits the PlateScope to truly measure 10 micron dots.

The advantage of using a VHR B&W for measuring is the sharper depiction of dot edges while the RGB camera provides better plate viewing to the human eye. These differences are illustrated in Figure 3 below.

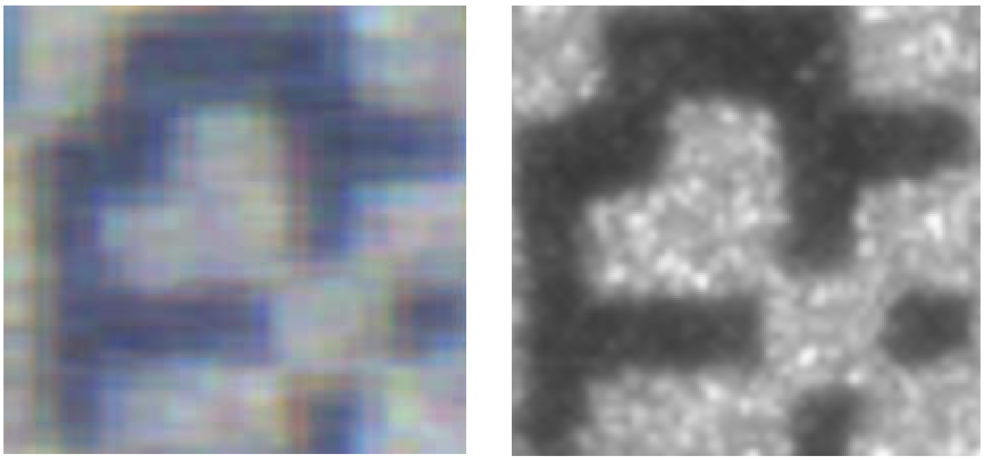

Figure 3: *RGB camera image versus B&W camera image. Note the difference in dot edge contrast.*

Lastly, the targeting camera allows for precise placement of the target while the instrument avoids pressure near the measurement area to avoid any kind of image distortion.

(5.2) Illumination Array

The patent-pending revolutionary illumination array offers six illumination options – Red, Green, Blue, White, Ultraviolet and Infra-Red. This allows the device to have the ideal illumination selection for the best contrast dependant on plate type. The addition of Ultraviolet and Infrared permit the capability to see tougher items such as low-latency plate images or highlight yellow areas of a press sheet.

(5.3) Aperture Size and Optical Path

PlateScope utilizes a large target aperture size. This gives the advantage of greater repeatability with line screens of 150 lpi and lower.

The optical path length is 190 millimeters using 2 internal precision mirrors. This permits greater height insensitivity than with most instruments with path lengths less than 25 millimeters.

(5.3) LUTS Database (Plate Offset Recognition)

As discussed in (3.1) every plate has different characteristics that, when exposed under VHR cameras, can produce different measurements for the same patch area with the same screens. To permit accurate measurement of the actual dot coverage area, especially in the highlights and shadows, it is necessary to inform the device of the plate and screening being measured so that the measurement algorithms can appropriately compensate for these unique characteristics.

In PlateScope, this is accomplished through a database known as LUTS tables. As each plate is validated under the procedures discussed in (4.2) & (4.3) it is available for addition to the LUTS database. These tables work in conjunction with the unique analysis algorithms to give an accurate measurement of the actual dot coverage area on the specific plate type. The LUTS tables also instruct the device how to configure optimal illumination and camera gain settings to best image this data from the plate.

LUTS tables also provide the advantage of allowing the PlateScope to be updated for custom or future plate and screening technologies without having to replace any hardware.

(6.0) PLATESCOPE™ MEASURING PROCEDURE

A robust procedure is utilized by PlateScope to ensure accurate measurement across the 2%-98% tonal range.

(6.1) Illumination Determination

You can either have an illumination color selected or have the PlateScope unit auto detect. If you wish to auto detect to determine the ideal illumination you first place the unit on a mid-tone patch and let it run a quick cycle of tests to determine the ideal illumination for optimal contrast and image processing. If you already have the device set on this illuminate, then this step isn't required.

(6.1.1) Background Illumination

It is worth noting here that the PlateScope 24-point LED illumination array and diffusion baffle are designed to provide even, consistent lighting over the measured area regardless of external light conditions. This provides an advantage in that measurements can be done on the same plate under different lighting conditions and still produce the same results.

(6.2) Tonal Patch Reading

Whenever a new plate or screen type is selected PlateScope will first prompt for a tonal patch read. By placing the unit over any mid-tone screen the device will learn the contrast and plate characteristics. This measurement provides a significant advantage over other methods of measurement as it helps to permit measurement of extreme highlight and shadow areas without reporting false values due to misinterpretation of plate texture as dot.

Figure 4 shows a 2% dot area partially processed. Without a tonal patch, it is difficult for the camera to distinguish between plate grain texture and actual dot area.

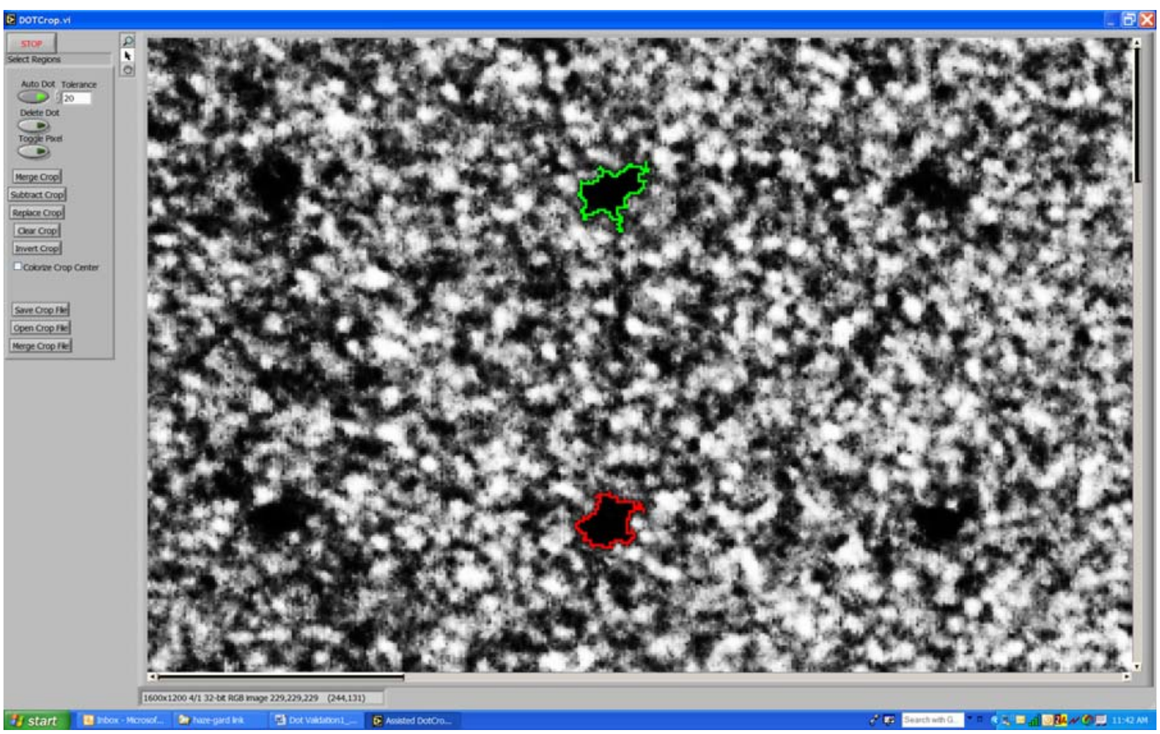

Figure 4: *The images shows a 2% dot area partially processed. Without a tonal patch reading it would be difficult for the image processing to distinguish plate texture from dot area.*

(6.3) Image Capture

PlateScope utilizes an optimized planimetric measuring system that captures an image on a two-dimensional VHR CMOS receiver array. The following all factor into the quality of the captured image.

(6.3.1) Resolution

As listed in (5.1), PlateScope has a resolution of 15,000 ppi so that an individual pixel equals an image area of 1.5µm×1.5µm. The resolution of the measurement system should be substantially larger than the resolution of the image. Modern CTP technology reaches a maximum of 10µm, with 20µm being more commonly used, meaning the measurement is done at 6.6 to 13.3 times the resolution

(6.3.2) Image Sharpness

The depth of image sharpness is related to the length of the optical path combined with the resolution of the camera. The quality of the optics and precision of the mechanics is designed so that a sharp image exists for further analysis. Figure 5 shows a sample of the grey scale image captured by the PlateScope.

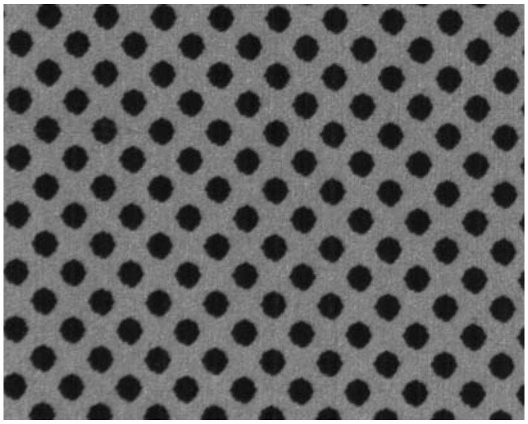

Figure 5: *Sample grey scale image captured during measurement.*

The sharpness of the image is a substantial factor in the ability to produce proper edge detection. It also helps to distinguish plate noise from actual dots so the result of the measurement reflects actual dot area.

(6.3.3) Image Area

The application of the measuring procedure for digital plates requires an image area which covers sufficient objects so that a good average value can be determined from the individual dots. To cover this range, PlateScope has an image area of 1.9mm×1.5mm. The measurement accuracy and repeatability are reached in the lower screen rulings by the size of the objects and in the upper range by the total number of dots.

(6.4) Image Analysis
Once the image has been captured it is quickly analyzed. This is performed at a binary level and therefore returns much more accurate measurement than a densitometer will. Edge (shoreline) determination. Noise reduction.

(6.4.1) Object Recognition and Noise Reduction
As listed in (5.1), PlateScope has a resolution of 15,000 ppi so that an individual pixel equals an image area of 1.5µm×1.5µm. The resolution of the measurement system should be substantially larger than the resolution of the image. Modern CTP technology reaches a maximum of 10µm, with 20µm being more commonly used, meaning the measurement is done at 6.6 to 13.3 times the resolution.

(6.4.2) Shoreline Determination
The depth of image sharpness is related to the length of the optical path combined with the resolution of the camera. The quality of the optics and precision of the mechanics is designed so that a sharp image may be captured but it still results in an area around the dot that appear to reside between dot and background, this is what is referred to as a "shoreline". An example is provided in Figure 6 below.

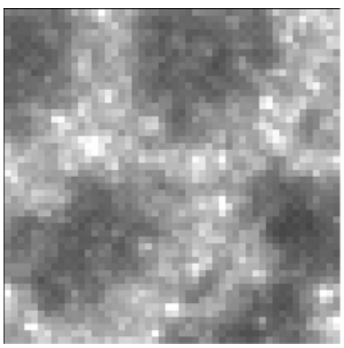

Figure 6: *Grey scale enlargement of the image area*.

As part of the analysis a determination is made of the area of the shoreline which is attributed to dot area and which falls into the background. Since analysis is of 2D images and plate emulsion layers vary from manufacturer to manufacturer, the LUTS tables direct the device to compensate the shoreline value depending on the plate. Normally, this usually falls within an area that bisects the mid-points between the firm dot area and the actual plate background. This will vary dependant on the screening technology, but again is compensated for in via the LUTS tables.

(6.4.3) Value Returns
Once shoreline determination is complete, actual dot coverage area over measurement area is determined. These values are returned in the device to the main screen.

Figure 7: *Sample of value return on the PlateScope viewing screen.*

(7.0) PLATE READING VERSUS DENSITOMETRY

Many questions arise from the fact that densitometers can be used to measure dot area and thus the value of a plate meter. This section provides an overview of the differences between dot determination and therefore accuracy reliability.

(7.1) Dot Structure

The nature of the offset production process results in dots being produced physically larger than first intended on the preproduction digital file. Figure 8 shows an example of the change from first being output in film to the actual size of the dot on the printed sheet.

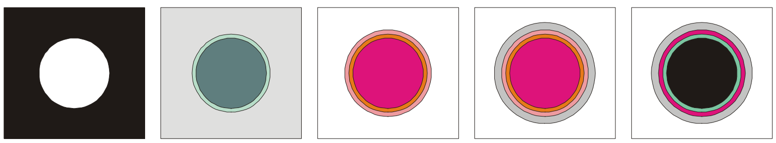

Figure 8: *Dot gain through the production process in this example shows a cumulative 20% gain. In this case, a 40% actual dot will appear as a 60% dot on the printed sheet.*

Note that with modern CtP systems, a better dot is generated on the plate as a result of direct imaging resulting in less of a total dot gain on press, but a dot gain none the less.

The actual dot gain present from plate to printed sheet has a tremendous effect on the final quality of the piece. If gain is too high, the sheet will appear darker and, depending on the makeup of the color combinations, can cause a subjective color shift. It is subjective because the solid patch areas of a sheet may match the numeric values of the proof, but it appears different on the sheet because of the dot gain.

(7.2) Dot Variation

Depending on the material being imaged (plate, film or printed sheet) the structure of a dot can change. Figure 9a through 9d show different dot structure changes.

- **Mechanical Dot Gain** (Figure 9a): The dots become bigger or smaller due to the effects of the image creation process. Laser intensity, plate emulsion makeup, exposure speeds, etc. The dot change takes place evenly around the dot creating a hard shoreline

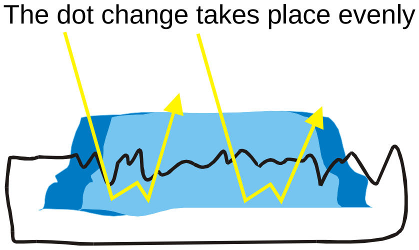

Figure 9a: *Mechanical dot gain.*

- **Optical Plate Dot Gain** (Figure 9b): The dot captured the light and is appears larger than it mechanically is. The size of the effect depends on the structure of the substrate layer; rougher surfaces have a stronger light catching effect than smoother surfaces

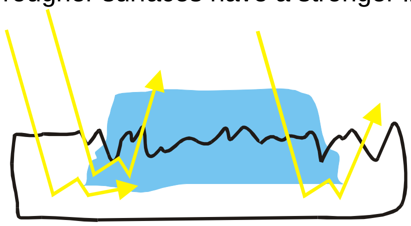

Figure 9b: *Optical dot gain on plate.*

- **Optical Print Dot Gain** (Figure 9c): In this case, the ink color absorbs into the printed sheet and produces the appearance of a larger dot. The color entrance into the media depends on the type of media (coated versus uncoated) and the mix of the ink.

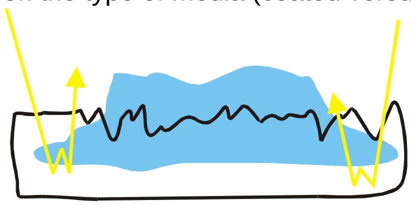

Figure 9c: *Optical dot gain on printed matter.*

- **Density Variations** (Figure 9d): The color order and/or coating of plates are not homogeneous resulting in density variations within the dot. For planimetric measuring systems, such as PlateScope, there is no change in the measurement value since the measurements are not calculated from density (i.e., surface area either belongs to the dot or the background). With densitometric measuring systems, this is an effect which impacts accuracy.

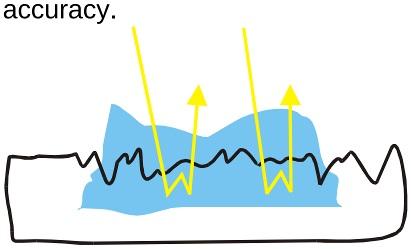

Figure 9d: *Density variation in a dot.*

(7.3) Planimetric Versus Densitometric Dot Measurement
PlateScope utilizes custom algorithms and offset tables to determine the actual mechanical coverage area of the dot. When working to achieve systematic gray balance or exact color control on press, especially with modern screening technology and press capabilities, this is a critical factor in overall quality control and helps reduce waste and time on press.
With densitometry, a middle gray tone is determined and set in relationship to the gray tone of the full area and that of the background. The percentage is determined by means of the Yule Nielson formula, which is built from the Murray Davis formula:

Yule Nielson:

$$\text{Dot\%} = \frac{1-10^{Dr-Dz}}{1-10^{Dv-Dz}} \times 100$$

Working from a straight formula and taking into account the variations discussed in (7.2), this results in densitometric values being good for optical gain but planimetric values provide best results for mechanical coverage area.